The EU Emissions Trading Directive: Opportunities and Potential Pitfalls

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Resources for the Future
1616 P Street, NW
Washington, D.C. 20036
Telephone: 202–328–5000
Fax: 202–939–3460
Internet: http://www.rff.org

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Abstract

The European Union is on the verge of establishing an emissions trading program ten times the size of the Acid Rain trading program in the United States. Its design takes advantage of many lessons from existing experience with trading programs, as well as economic theory, and innovates in important ways. While we view this as an impressive development, concerns about equity, enforcement, and efficiency remain. Specifically, a lack of data and weaker environmental institutions in some EU Member States raises questions about both allowance allocations and compliance and enforcement. Although much attention has focused on whether prices will be "too low" in the first phase of the program, a greater risk is that uncertainty about program elements, technology and behavioral response, and external events could create volatile markets and costly compliance in the second phase. Regardless of outcome, the EU trading system will be influential in future international efforts to reduce greenhouse gases.

Key Words: European Union, climate change, emissions trading

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1. Introduction

Almost a decade has passed since the United States began operating the first large-scale emissions trading program in 1995. The SO_2 cap-and-trade program has been studied extensively and has become the benchmark for evaluating subsequent emissions trading proposals. Based on the success of this "Grand Policy Experiment"[1], emissions trading has become an increasingly accepted approach for addressing air emissions.

Beginning in 2005, however, Europe will launch a cap-and-trade program for greenhouse gases (GHGs) that is substantially larger and more complex than the pioneering U.S. effort. Although strongly influenced by the design of the U.S. SO_2 trading program (Delbeke, 2003), the EU Emissions Trading System (EU ETS) will dwarf existing U.S. trading programs in size and complexity and will encompass a variety of new features. Because of its size, scope, and multi-jurisdictional political structure—and because it is the first large-scale attempt to regulate greenhouse gases—the EU program is in many ways the "New Grand Policy Experiment." As such, it has the opportunity to advance the role of market-based policies in environmental regulation and to form the basis for future European and international climate change policies. For example, the EU ETS will be the first emissions trading program to grapple with the many issues associated with linking different domestic emissions trading programs. Yet there are also many pitfalls along the way and, should it not work out as planned—or, worse yet, outright

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[*] Kruger and Pizer are, respectively, Visiting Scholar and Fellow at Resources for the Future. We are grateful to Dallas Burtraw, Reid Harvey, Bill Irving, Jurgen Lefevere, Richard Morgenstern, and Peter Zapfel for their valuable comments.

[1] This term was coined by Stavins (1998) in his assessment of the U.S. SO_2 Trading Program.

fail—it could set back both efforts to advance market-based policies and to address global climate change.

This paper has three purposes: to summarize key features of European Union Emissions Trading Directive, to assess these features against other existing programs and the economic literature on market-based policy design, and to draw conclusions about key opportunities and pitfalls. All of this is with an eye toward helping current and future policymakers design more successful policies. The paper will begin with a description of the program and will compare key design elements to those in U.S. SO_2 and NO_x cap-and-trade programs and to benchmarks discussed in the economic literature. Next, we will examine some of the unique implementation challenges faced by the EU ETS as it goes from a written blueprint to an operating cap-and-trade program. In particular, we will explore the issues associated with implementing an emissions trading program that is significantly more decentralized than past efforts in the United States. We will evaluate the most recent economic analysis of the EU ETS and will assess some of the cost uncertainties faced by EU Member States and their industries. Finally, we will conclude with observations about the prospects of the EU ETS along with key opportunities and pitfalls.

In brief, we see the EU ETS as an impressive political and institutional development taking advantage of many lessons gleaned from past market-based policies while innovating to address the unique multijurisdictional nature of the EU. Perhaps the most significant challenges faced by the EU Member States are the tight timetable they have given themselves to implement the trading program and the uncertainties surrounding the future international climate regime. Moreover, issues of equity and enforcement raised by the design of the EU ETS are particularly difficult in countries with weaker environmental institutions. Allocation, for example, may be difficult in the absence of dependable data on historical emissions, fuel use, and output. Enforcement may be difficult in Member States, particularly among Accession Countries, that have less experience with environmental regulation. Although the EU has harmonized enforcement provisions to an unprecedented degree through common penalties and emissions measurement guidelines, further harmonization may be necessary to ensure a level playing field for emissions trading. The program is well designed with respect to efficiency except that considerable uncertainty remains about implementation, technology and behavioral response, and external events. This could lead to considerable volatility in allowance markets and extremely expensive efforts to meet the cap. Such concerns could be alleviated through the penalty mechanism if nations choose to use this as an effective "safety valve" on the system. Like all new, major initiatives the risks and rewards are quite high. Our view is that the EU ETS has in its framework all the elements of a successful program, but it is unclear whether it can be pieced together on schedule and whether a variety of uncertainties will allow European industry to plan effectively.

2. Summary of Provisions

The EU program will begin on January 1, 2005, and apply to 25 countries, including the 10 Accession Countries that will enter the EU in May 2004. The program is to be implemented in multiyear phases. The first phase will run from 2005 until 2007 and is sometimes referred to by EU officials as a "warm-up" phase (Runge-Metger, 2003). The second phase will begin in 2008 and continue through 2012, coinciding with the five-year Kyoto compliance period. The program continues in five-year phases thereafter. Following is a brief description of the main elements of the EU ETS.[2] A more thorough analysis of key elements will follow later in the paper.

2.1 Emissions and Sectors Covered

Initially, the EU ETS will cover only CO_2 emissions from four broad sectors: production and processing of iron and steel, minerals (such as cement, glass, or ceramic production) energy (such as, electric power, direct emissions from oil refineries), and pulp and paper. Installations[3] are included in the program if they exceed industry-specific production or capacity thresholds

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[2] There are a variety of other provisions in the EU Directive that are not addressed in this paper, including an "opt-out" provision for installations and a provision for installations to pool their allowances. For a complete description of the Directive see European Commission (2003a).

[3] An installation is defined as "a stationary technical unit where one or more activities listed in Annex I (industry sectors covered by the trading program) are carried out and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution" (EC 2003a). Member States are responsible for compiling a list of applicable installations in their National Allocation Plans.

specified in the Directive. Current estimates are that more than 12,000 installations will be included in the program[4], covering 46% of EU CO_2 emissions. Table 1 provides a breakdown of this number by Member State. The EU may subsequently add additional emissions, sectors, and installations in the second phase of the program.

2.2 Allocation

Each Member State has an overall target for its national emissions under the European Union burden sharing agreement associated with the Kyoto Protocol. A portion of this national target must be assigned to the installations participating in the EU ETS, with the remainder of the national target available for emissions outside the EU ETS (and presumably addressed by other policies). This suggests a three-step process. First, Member States must decide how much of their allowable Kyoto emissions will be assigned to the sectors included in the EU ETS (note that the choice of installations covered by the EU ETS is *not* part of this process). Next, Member States may devolve this national ETS target into targets for each of the sectors included in the program. Finally, national program administrators must develop methodologies to allocate these sectoral targets to individual installations.

Member States must submit National Allocation Plans (NAPs) for review and approval by the European Commission by the end of March 2004. Although Member States have some flexibility in determining their allocations, they must comply with common criteria contained in the Directive. The criteria are intended to prevent unfair competitive advantage and to encourage progress towards meeting the Kyoto targets. In addition, the Directive requires that the allocation of emission allowances will be largely free, though up to 5% of allowances may be auctioned in the first period and up to 10% may be auctioned in the second period. The Commission will review the National Allocation Plans and has three months to decide whether it will reject those plans. Member States must finalize their allocations for the first compliance period by October 1, 2004.

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[4] As will be discussed later, because of incomplete databases, the total number of installations must be estimated. More definitive numbers of installations will be available when all National Allocation Plans are final.

2.3 Monitoring and Registries

The Commission has released proposed monitoring and reporting guidelines for installations in the EU ETS (EC 2004a). Continuous emissions monitors are optional; most installations are expected to use emission factors coupled with fuel use or production data to calculate their emissions. To track emissions allowances, each Member State must have its own national allowance registry, although it may join with other Member States to combine registries. The Commission will operate a computerized independent transaction log that will serve as a centralized clearinghouse to verify allowance transfers between national registries (EC 2003a). Thus, a bilateral trade between two different Member States involves communication between three different electronic data systems.

2.4 Offsets

The Commission has proposed that Kyoto offsets (CDM and JI) would be allowed to meet Member State caps in the second phase of the EU ETS (EC, 2003b). According to the proposal, there is an initial limit on the use of offsets at 6% of the total EU ETS cap. However, if offsets reach the 6% limit, there will be an automatic review of the role of offsets to determine whether the limit on the use of offsets should be raised to 8%. Clean development mechanism (CDM) and Joint Implementation (JI) credits would be converted into EU allowances, and they will be completely fungible with other allowances in the program. The exact rules for the integration of CDM and JI credits into the EU ETS are still under negotiation.

2.5 Banking and Borrowing

Banking and some degree of borrowing are possible within any compliance period. Banking between the first two compliance periods is allowed in principle. However, each Member State can decide whether and how this will occur, including any restrictions on the number of allowances that may be banked. Member States must allow banking from the second period (2008–2012) and thereafter to any subsequent period.

2.6 Enforcement and Compliance

The EU Directive provides penalties for emissions in excess of surrendered allowances of €40/ton CO_2 in the first period, and €100/ton CO_2 in the second period.[5] Excess emissions must also be offset in the following compliance period. Additional administrative and criminal penalties (for example, for fraudulent reporting) are left to the Member States, with only general guidance from the Directive. The Directive also requires the publication of the names of operators who are not in compliance.

2.7 Linkages to Non-Kyoto Regimes

The EU directive raises explicitly the possibility that it can be linked to other national domestic GHG trading schemes. The directive makes it clear, however, that the EU ETS will only link with parties that have ratified the Kyoto Protocol. Countries that link with the EU ETS will have their allowances recognized in the EU system on the basis of a bilateral agreement between the European Union and that country.[6]

3. The EU ETS versus Benchmarks and U.S. Cap-and-Trade Programs

The design of the EU ETS builds upon the experience of earlier emissions trading programs, but the scope and complexity of the program is far greater than past efforts. The EU Trading Program will require Member States to develop the administrative infrastructure to implement a complex trading program in a relatively short period. By any measure, EU member countries have an enormous job ahead of them to pull together all of the pieces necessary to run a cap-and-trade program. In this section, we will first briefly review some of the literature on cap-

[5] Currently \$50 and \$123/ton CO_2, \$180 and \$450/ ton carbon, respectively.

[6] Norway, Iceland, and Switzerland have been mentioned as possible candidates for linkage. Non-European countries such as Japan or Canada could also link to the EU ETS. However, numerous issues would have to be resolved, such as whether there could be linkage where emissions targets take a different form than the absolute targets used within the EU ETS. For example, it is uncertain whether the EU would link to a scheme like Canada's, which has relative targets and a price cap. (For a discussion of issues associated with linking domestic schemes, see Baron and Bygrave, 2003.)

and-trade implementation and summarize the U.S. SO_2 and NO_x trading programs. We will begin our comparison with a look at the size and scope of EU ETS versus these U.S. programs. Next, we will provide a more in-depth analysis of the target setting, allocation, and compliance features of the EU ETS and compare them to similar features in past cap-and-trade programs. In particular, we will focus on the multijurisdictional nature of the EU ETS and explore the differences between the federal U.S. multi-state programs and the less centralized EU structure.

3.1 Benchmarks in the Literature

The economics literature is rife with discussions of emissions trading and how market-based policies offer environmental protection at a lower cost to various regulatory alternatives (see Tietenberg, 1985). The literature becomes a bit thinner when one considers more practical concerns about how such policies ought to be implemented. Project 88 was an effort more than a decade ago to bring together academic economists, stakeholders, and policymakers to discuss and address such concerns (Stavins, 1989). Out of that effort came a list of criteria against which proposals could be measured, including: will the approach achieve the environmental goals at the lowest cost; how easily or costly will monitoring and enforcement be; will the policy be flexible in the face of change; will the policy give dynamic incentives to innovate; will the purpose and nature of the policy be broadly understandable to the general public; will the economic effects be equitably distributed; and will the policy be politically feasible?

A more recent discussion of practical concerns was discussed in CEA (2002). Chapter six of this book deals with institution building related to environmental issues. Through a series of case studies of successes and failures, they emphasize the need for a large market, the absence of restrictions on trade, flexibility in the face of unexpected shocks, and low monitoring costs. They also draw attention not just to the formal rules, regulations, markets, monitoring, and administrative features associated with a policy, but also the informal knowledge, experience, and norms that are necessary for a successful outcome. That is, they emphasize the need for market participants to be prepared for the market-based policy.

The question of flexibility in the face of unexpected shocks was first addressed by Weitzman (1974). Weitzman pointed out that when marginal benefits are relatively flat—which tends to be the case for a long-lived stock pollutant like CO_2—and marginal costs are relatively steep, price-based mechanisms are preferred. This point has been made more specifically for stock pollutants by Newell and Pizer (2003) and more specifically for climate change by Pizer (2002). Jacoby and Ellerman (2004) argue that banking can play a similar role in the face of unexpected shocks, but do not dispute the importance of such mechanisms.

Stavins (2003) provides a recent summary of experience with and lessons from market-based policies from around the world. He focuses on several lessons relevant for emissions trading that concern flexibility, simplicity, monitoring and enforcement, and the capacity of the private sector. On flexibility, he argues that flexibility over time (banking) and flexibility in technology choice has been particularly important in the past. He suggests that simple rules regarding allocation and trades are important to avoiding contest and manipulation, and to encourage market participation, respectively. Based on his survey of programs, Stavins concludes that without effective monitoring and/or enforcement most programs are ineffective. Finally, he observes that many firms are poorly equipped to take full advantage of market-based policies. Perhaps because they are unsure about the future of such programs, many firms have yet to reorganize from an approach designed to minimize the cost of compliance with command-and-control regulation to an approach designed to make strategic decisions in the marketplace.

One way to summarize these discussions is to group various concerns along the lines of enforcement, equity, and efficiency (which includes issues related to education, flexibility, and liquidity). A successful emissions trading program needs to monitor emissions and enforce the requirement to surrender allowances equal to those emissions; if not, cheating is rewarded and the environmental goals are compromised. A successful program also needs to allocate emissions allowances (more broadly, address the distribution of program costs) in a way that is simple, transparent, and equitable in order to avoid contest and manipulation, as well as to remain politically viable. Finally, in order to reach the goal of lowering compliance costs and achieving efficiency, participants in an emissions trading program need to be educated in its operation and to make strategic decisions to take advantage of flexible program features. These flexibility features, in turn, need to ensure a liquid market both within and across time periods, to moderate volatility, and to promote innovative behavior.

3.2 Summary of U.S. Multistate Emission Trading Programs

The U.S. is currently implementing two major multistate emissions cap-and-trade programs: (1) the SO_2 Trading Program, which began in the early 1990s and (2) a regional NO_x Trading Program, which began in the late 1990s. These programs are described briefly below.[7]

SO_2: The U.S. SO_2 Program caps SO_2 emissions from large electric power units (over 25 megawatt generating capacity) in the continental 48 states in two phases. The first phase, from 1995 to 2000, encompassed about 374 of the largest emitting units (over 100 MW of capacity) at more than 100 power plants. During the second phase, which began in 2000, all covered units over 25 MW capacity are included (involving about 3,000 generating units, of which about 1,800 are responsible for about 99 percent of emissions) at more than 700 power plants. The initial allocation of allowances under the SO_2 cap was based on historic fuel input in the mid-1980s multiplied by an emissions performance standard.[8] All allowances are bankable. The SO_2 program is implemented largely at the federal level by EPA and is national in geographic scope. The U.S. EPA runs electronic allowance and emissions registries and is responsible for verification of emissions data.

NO_x: In many ways, the U.S. NO_x trading program is more analogous to the EU ETS than is the SO_2 program. The NO_x cap-and-trade program is a multi-jurisdictional partnership between federal and state governments. It has evolved in geographic scope over time, first encompassing nine northeastern states in the late 1990s. In 2004, it was expanded to include 19 states and the District of Columbia with two additional states to be added in 2005.[9] Unlike the SO_2 program, the NO_x program includes certain large industrial boilers with over 250 million Btus heat input/hour (such as at petroleum refineries, pulp and paper plants, and steel plants) as

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[7] Descriptions of the SO_2 and NO_x programs are available at http://www.epa.gov/airmarkets. Burtraw and Palmer (2003) and Ellerman (2003) provide recent assessments of the SO_2 program. Farrell (2001) and Burtraw and Evans (2003) provide an assessment of the 9 State NO_x OTC program.

[8] In addition to the basic allocation formula, there were also a variety of special formulas that addressed early reductions, high growth States, and other issues (Kete, 1993, Joskow and Schmalensee, 2001).

[9] The initial program is referred to as the Ozone Transport Commission (OTC) program and the expanded NO_x cap-and-trade program is the sometimes referred to as the NO_x SIP Call Program

well as electric generating units. Under the NO_x Trading Program, states have fixed NO_x budgets and may use varying means of specifying how allowances will be distributed within each state. For the NO_x Trading Program, EPA issued a "model rule" that specified areas for consistency among states (for example, in enforcement) as well as areas of flexibility (for example, allocation of allowances to firms). U.S. EPA runs the allowance and emissions registries, verifies emissions data, and reconciles emissions and allowances at the end of each year.

3.3 Comparison of Size and Scope

Table 2 illustrates several ways in which the scope of the EU program is broader and more complex than past U.S. efforts. For example, the EU has more regulated sources and covers more industrial sectors. Some of the sectors covered, such as cement or iron and steel, have more varied sources of emissions, for which emissions measurement is not as straight forward as the utility and industrial boilers that make up the bulk of the U.S. programs. The EU ETS could also include multiple greenhouse gases in the second phase of the program and is likely to include a mixture of cap-and-trade and offset provisions. Finally, although the EU program doesn't encompass significantly more political jurisdictions than the multijurisdictional U.S. NO_x program, the EU ETS structure is considerably more decentralized than that of U.S. trading programs. This will be discussed in more detail later in the paper.

3.4 Comparison of Allowance Allocation Process in the EU and U.S.

3.4.1 EU National Allocation Plans

Probably the most difficult step in the development of the EU ETS is the preparation and review of National Allocation Plans. By March 31, 2004, Member States were to have submitted a plan to the Commission that contained a list of installations with their proposed allocations and an extensive justification of the decisions and methodologies used to make the allocation. The EU Directive provided Member States with general criteria for allocation, including ensuring that the allocation is "consistent with achieving the overall Kyoto target." In addition, the allocation was to take into account:

- the proportion of emissions in the capped sector compared to total emissions
- actual and projected emissions
- the impact of other policies on emissions
- the technical potential of activities to reduce emissions within the sector

Member States were also to describe an approach in their plans for providing access to allowances for new entrants into the system. For example, Member States may simply require new entrants to purchase allowances on the market, or they may create “set-aside” pools of allowances that will be allocated free of charge to new installations. Member States also have the option to adjust allocations to take into account early actions to reduce emissions and to address potential competition from non-EU countries.

Finally, Member States must include an opportunity for public participation in the review of the National Allocation Plan. According to the Directive, there should be two rounds of public comment. First, the public should have an opportunity to provide input into the proposed NAP before it has been submitted to the Commission. Second, there should be an opportunity for public comment after the proposed NAP is submitted to the Commission, but before the plan is final on October 1, 2004, for the first compliance period (EC, 2004b).

After the Commission receives the plans at the end of March, it has three months to review whether the plans meet the allocation criteria. Of particular concern to the Commission is the evaluation of “State Aid” considerations related to allowance allocation. “State Aid” is a term of art within the EU that refers to public subsidies that give industry within one Member State an unfair competitive advantage over industry within another country. The evaluation of this criterion will be conducted by the Competition Directorate—the department within the Commission that makes determinations on all State Aid issues (*Carbon*, 2004).

For those who are primarily familiar with U.S. cap-and-trade programs, the term “National Allocation Plan” understates the scope of decisions that must be made. In the U.S., the term “allocation process” usually refers to decisions about allocating to firms *after* a cap has already been decided. However, in the National Allocation Plan process, there are three decisions that must be made by each Member State, more or less simultaneously.

The first decision that must be made by Member States is how much of their Kyoto target will be given to the sectors participating in the emissions trading program—that is, the level of the cap for ETS sources within their borders. Each of the 15 original Member States has national targets for Kyoto compliance that have been negotiated under the EU's burden sharing agreement. The EU ETS is essentially a "cap within a cap." Therefore, as they decide how much of this burden the ETS sectors will meet, Member States are deciding (either implicitly or explicitly) how much the non-capped sectors will contribute to meeting the national target (Harrison and Radov, 2002). Note that the Directive already establishes which categories of activities Member States must cover under the program.

Once it is decided how much of a country's overall Kyoto target should be assigned to the trading program, the National Allocation Plan may set targets for each of the sectors involved. This is a particularly difficult decision because a sector's target will determine its net costs (mitigation expense plus net cost of allowance purchases) and may have implications for competitiveness within the EU. In other words, industrial sectors in two different Member States with different allocations would have differing profitability, which could affect their liquidity and ability to raise capital, if not directly affect relative prices.[10]

Put another way, to the extent that sectors included in the ETS must deliver emissions reductions beyond expected levels that encompass existing emissions reduction policies or programs, Member States must decide upon which sectors to impose the economic burden via reduced allowance allocations. To make this decision, Member States must balance a complex array of factors, including relative cost effectiveness, competitiveness issues, and equity. The United Kingdom's Draft National Allocation Plan illustrates this point. During the first compliance period, the draft NAP proposes to allocate to sources at levels that reflect their projected emissions based on existing sectoral climate change agreements negotiated with

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[10] Because there is one market and one price associated with all emission allowances, marginal production costs are unaffected by allocation *unless* allocations are updated based on production. In that case, the updating allocation serves to subsidize production costs. See Burtraw (2001) and Fischer (2001). The EU ETS Directive does not allow for updating of allocation decisions within a trading phase, but updating could occur across phases.

industry. However, the U.K. may decide to reduce allocations by an additional amount in the power sector. In justifying this additional reduction, the U.K. government notes:

> This reflects the fact that power generation faces limited international competition—electricity imports amounted to only 2% of total electricity supplied in 2002; exports were considerably lower than that; and all trade is concentrated in the EU market, all of which is affected by the EU ETS—and has relatively good, low-cost abatement opportunities. (DEFRA, 2004a)[11]

In contrast, in the U.S. SO_2 and NO_x programs, target setting was done before the allocation to firms was begun. For the SO_2 Trading Program, the U.S. Congress decided the sector cap first and then later determined allocation formulas for splitting the cap between firms (Joskow and Schmalensee, 1998), although clearly the cost imposed on the electricity sector was a key factor in setting the cap (Kete, 1993). In the U.S. NO_x trading program, caps for participating states were based on common metrics. In the case of the 9 State OTC program, caps were based on the less stringent of a percent reduction of historic emissions or a performance standard. The cap in the expanded 22 jurisdiction NO_x SIP Call Program was also based on a performance standard. In both cases, once the cap was determined, states then had the flexibility to allocate their allowance budgets to sources according to various formulas. [12]

Although a complete discussion of the options available to Member States for allocation to firms is beyond the scope of this paper, it is worth noting the complexity of the issues involved. Harrison and Radov (2002) outline some of the design variables for allocation, including whether allocations should fixed based on historic measures or updated over time; whether they should be based on emissions, production, or fuel use; and whether they should take into account special issues such as early reductions and other policies. A growing literature is exploring the efficiency and equity implications of these different approaches (Burtraw, 2001, Fisher 2001). However, the point here is that allocation decisions typically affect different firms

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[11] The United Kingdom is reportedly revisiting some of the decisions in its draft NAP. Thus, this statement should be viewed as an illustration of the factors that influence allocation decisions, rather than as indictative of the final allocation decision.

and sectors in very different ways. Because different approaches create winners and losers, allocation is primarily a political, as well as a technical decision. Allocation decisions are certain to be controversial and may be difficult for some Member States to resolve quickly.

3.4.2 Allocation Implementation Challenges

In addition to the political and policy challenges raised by the National Allocation Plans, there are significant practical implementation challenges for the Member States. Depending on the allocation formula, there may be a need to have accurate data for a given base year on emissions, fuel use, and output. In some cases, the necessary data to make the allocation may be unavailable or incomplete (Harrison and Radov, 2002; Mullins, 2003). Incomplete information on sources has led to changing estimates of the number of installations covered by the EU ETS, varying from 10,000 to 17,000.

Though not required, at least some Member States may use third party verification of their baseline data. The U.K. and Germany have stated that they will require third party verification, and it is possible that other Member States may follow their leads (Phillips, 2004). We examine some of the challenges associated with third party verification below in our discussion of compliance.

The U.S. SO_2 program illustrates the time-consuming nature of the allocation process. EPA began to compile the data for its allocation database in 1989 and conducted two separate formal public comment processes on the data. EPA found that allocation methodologies sometimes require steps beyond just quality assurance of emissions and activity data. For example, because SO_2 allocations were based on average heat input during the period from 1985 to 1987, units with significant outages would have received fewer allocations than similar units that were in continuous service. Therefore, EPA collected data on the number of continuous hours a unit was out of service due to a planned or forced outage. Using this data, EPA adjusted

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[12] For example, in the NOx OTC program, some states used a benchmark based on heat input and others used a benchmark based on electricity generation output. States also have used a variety of different provisions to address new entrants, early reductions, and incentives for energy efficiency and renewable energy (Harrison and Radov, 2002).

the data for units as if they were operating during extended outages. If there were individual outages each totaling less than four months during the period 1985–1987, no adjustment was made to the calculations. Ultimately, the national allocation database was finalized in March 1993 when EPA published its final allowance allocations and implementing regulations. Thus, the entire process took almost four years (Harvey et al., 2003). A key challenge facing the EU ETS will be to determine installation-level allowance allocations over a period of nine months (assuming the initial plan is accepted) or less.

3.4.3 Comparison to Literature

Much of the literature on the distribution of tradable allowances describes the benefits of auctioning allowances rather than distributing them at no cost. These benefits include providing a source of revenue that could potentially address inequities brought about by a carbon policy, creation of an equal opportunity for new entrants in the allowance market, avoiding the potential for "windfall profits" that might accrue to emissions sources if allowances are allocated at no charge, and avoiding the politically contentious process of allowance allocation[13] (Crampton and Kerr, 1998). Moreover, the revenues from auctioning allowances may have economy-wide efficiency benefits if they are used for certain purposes such as reducing taxes (Crampton and Kerr, 1998, Goulder et al., 1998, Dinan and Rogers, 2002).

Despite these apparent benefits, there has been little experience with the use of auctions in the distribution of tradable emissions allowances in the United States.[14] This is largely because of the political difficulty in convincing industry groups to support auctions. The EU Directive provides at least the possibility of a modest experiment with auctions by allowing Member States to auction up to 5 percent of their allocation in the first phase and 10 percent in the second phase.

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[13] On the other hand, the subsequent process by legislatures to distribute these revenues could be equally contentious.

[14] The SO_2 trading program contains a small reserve auction and there have been recent reports that the states of Kentucky and Virginia are considering auctioning a portion of their NO_x allowances under the NO_x SIP Call Program.

It remains to be seen, however, how many Member States will take advantage of this provision.[15] The use of this provision by even a few Member States would be a significant innovation and would provide valuable lessons for future trading programs.

Ultimately, however, the vast majority of allowances in the EU ETS will be allocated at no cost as they were in U.S. programs. The literature on the U.S. experience with the free allocation of emission allowances to firms describes the deeply political nature of these processes (Kete, 1993, Joskow and Schmalensee, 1998; Raymond, 2003). For example, the simple initial allocation methodology in the original Acid Rain Program legislative proposal program ultimately became a complicated amalgam of more than 29 formulas by the time it had passed through the entire U.S. legislative process (McLean, 1996). The Regional Clear Air Incentives Market, or RECLAIM, program in Southern California similarly went from a relatively simple formula proposed by the local regulatory agency to a much more complex set of allocation formulas after a lengthy stakeholder process (Ellerman et al. 2003).

What are the implications of this past experience for the EU ETS allocation process? On one hand, there are several unique aspects of the EU ETS that could make allocation more difficult than in past programs. First, the scope of the economic rents at stake are much higher in the EU ETS than in past emissions trading programs. The wealth transfers inherent in the EU system could be 20 times greater (or more) than those of past trading programs (see Table 2). Thus, the distributional consequences are greater and are more likely to make the process even more politically difficult. Second, the three-stage decisionmaking on allocation described above is also complex and difficult to do quickly. This is particularly worrisome because of the tight timeframe for submitting National Allocation Plans. This tight timeframe may also prevent Member States from doing necessary quality assurance on the emissions and other data that are necessary for determining allocations.

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[15] Thus far, two Member States have announced that they will auction portions of their allocations. Denmark will auction 5% of its allocation and use the proceeds for purchase of CDM and JI credits. Ireland will auction .75 % of its allocation and use the proceeds to cover the costs of administering its emissions trading program.

On the other hand, the lesson of the U.S. experience may be that once the allocations are final, it may not matter whether the allocation process or methodologies were messy. To varying degrees, U.S. trading programs have been successful despite complex allocation processes and formulas. In each case there was a political allocation process that finally came to a resolution and allowed the programs to progress. Similarly, by providing multiple opportunities for public comment and by subjecting the National Allocation Plans to a Commission review, including review by the Competition Directorate, the EU ETS appears to place a high value on transparency and equity in its allocation process. Inevitably, not everyone will be happy with the outcome. However, as long as there is not "political gridlock" that prevents the program from going forward or undermines the future use of the cap-and-trade mechanism, it will be difficult to say that the allocation process was unsuccessful.

3.5 Comparison of Enforcement and Compliance Features

Compliance and enforcement provisions give emissions trading programs environmental integrity and provide the incentive for an efficient outcome. These provisions include (1) accurate and complete emissions monitoring and reporting; (2) tracking of tradable permits with an electronic registry; (3) automatic financial penalties for excess emissions; (4) a credible threat of enforcement action if provisions of the compliance regime are violated; and (5) public access to emissions and trading data (U.S. EPA, 2003a). Following is a discussion of these provisions within the EU ETS, and a comparison to provisions within U.S. programs.

3.5.1 Emissions Monitoring, Reporting, and Verification

In the U.S., there are detailed and prescriptive requirements for continuous emissions monitors (CEMs) for both SO_2 and NO_x, programs. (U.S. EPA 2003c). Emissions are reported electronically to the EPA, there are extensive electronic auditing procedures, and there are occasional on-site audits of facilities. Monitoring regulations emphasize complete accounting and consistency among sources.

The EU's emissions monitoring, reporting, and verification system procedures vary from the U.S. example in several ways. First, the proposed guidelines are less prescriptive and give considerably more flexibility to installations and to the Member States to develop specific monitoring procedures. The guidance spells out different "tiers" of methodologies with different degrees of assumed accuracy. For example, for general combustion activities (for example, burning fuel in an industrial boiler), the highest tier method would require measurement of fuel with methods resulting in a maximum permissible uncertainty of + or – 1% and would require an installation specific emissions factor for the batch of fuel used. The lowest tier method would require measurement of fuel with methods resulting in a maximum permissible uncertainty of + or – 7.5% and would allow the use of standardized, general emissions factors listed in the Appendix of the EU guidance (EC, 2004a).

Under the proposed guidance, firms would propose installation-specific methodologies to the relevant authority in each Member State. Installations are assumed to use the top tiers, but they may petition to use lower tiered methods that is, with lower assumed accuracy if they show that a methodology is impractical or cannot be achieved at reasonable cost. Each Member State has the autonomy to grant waivers from use of the top tier methods. No adjustments of emissions measurements or calculations are required to compensate for the greater uncertainty of lower tier methods (EC, 2004a).

One reason for the less prescriptive approach is that there is more variety in the types of sources that must be monitored than in U.S. programs. The SO_2 program in the United States consists entirely of electric power plants. Although the U.S. NO_x program has some industrial sources as well as electric power sources, most of these sources are combustion boilers that are monitored similarly to power plants. In contrast, the EU program also includes process sources, such as cement and iron and steel installations, which may have unique monitoring requirements.

The EU's monitoring, reporting, and verification system is also more decentralized than systems used in past cap-and-trade programs. For example, in addition to the flexibility of choosing monitoring methodologies discussed above, the EU ETS delegates emissions verification to the Member States, who may use either a government authority or a third party. If they elect to use third party verification, a Member State is required to set up a process to certify that third-party verifiers are qualified to verify emission reports. The Directive does not impose uniform, mandatory standards for this certification.

The use of third party verification for a cap-and-trade program raises several questions. First, is this approach more cost-effective and efficient than having a more centralized verification of the data by Member State authorities? Third party verification may reduce government costs while providing valuable technical expertise to some Member State authorities who may not have adequate internal staff resources. However, it will likely increase costs to industry. In the UK Emissions Trading System, verification costs ranged from €5,000–€7,500 ($6,250–$9,375) for a simple site to €10,000–€20,000 ($12,500–$25,000) or more for a more complex site (Phillips, 2003b). Thus, assuming an average cost of €10,000 per installation, annual costs for verification of 12,000 installations could be €120 million ($150 million) or more.[16]

Second, will there be inconsistencies in interpretation of guidelines among different verifiers? Inevitably there are numerous technical issues that come up in the course of emissions measurement. Will all verifiers make the same interpretations? Who will resolve inconsistencies, and will there be a "case law" of decisions shared among verifiers?

Perhaps equally important is ensuring that all verifiers are credible and independent of the firms they are verifying. Phillips (2003) argues that the there is a danger that "different national jurisdictions in the EU will adopt different 'standards' of verification with different guidance resulting in different 'levels of assurance' given in the verification opinions ." There may also be perverse incentives caused by the use of third party verifiers hired by the firms themselves. In theory, firms could shop for verifiers who provide the most lenient treatment of emission accounting. Some have argued that it is important to avoid a "race to the bottom" by verifiers, who may have an incentive to provide lower cost, less stringent verification to compete. (Phillips, 2003).

[16] Roughly 5% of total estimated costs (see economic analysis below). A number of variables could affect costs per installation, including whether management of the installation has prepared adequate monitoring plans and documentation of its annual emissions and whether more than one installation can be grouped together for verification (Phillips, 2003b).

Decentralized verification is a dramatic departure from the U.S. experience in which there is centralized verification of emissions data by the EPA. The U.S. system relies heavily upon electronic reporting and electronic auditing of data.[17] Electronic reporting has both made it possible to process and analyze emissions data and to make this data available to the public in an accessible form on the Internet (Kruger et al. 2000). EPA also makes monitoring policy decisions that apply to sources across all states in the SO_2 and NO_x programs.

3.5.2 Registries

Although the term "registry" is used in several different ways, it generally refers to an allowance tracking system in the EU context. Allowance tracking registries track account information, account holdings, and transfers of allowances among private parties. In many cases, these systems assign serial numbers to allowances that contain identifying information such as information on the facility where the allowance originated and the year ("vintage") in which the allowance was issued. Registries allow program administrators to perform various functions, such as setting up allowance accounts, issuing allowances, and retiring allowances (Schreifels, 2001). Although some registries allow allowance holders to transfer their allowances to others online, registries are not trading platforms. Rather, they are data systems that protect the integrity of trading programs by ensuring that only the fixed number of allowances embodied in an emissions cap are transferred and used for compliance.

The state of the art for registries has advanced considerably since the EPA developed the first allowance and emissions registries for the SO_2 program in the early 1990s. Costs have come down, and functionality has increased significantly. For example, EPA's recently developed Emissions and Allowance Tracking System software (EATS) is an integrated data system (that is it tracks both allowances and emissions) with a variety of features including the ability to be used for multiple pollutants, to communicate with other registry systems, and to provide electronic reports on data to the government or the public (Schreifels, 2003). The United Kingdom and

[17] Although the EU program requires an electronic registry to track allowance data, there is no similar requirement for electronic emissions tracking systems.

France are also building registry systems, which will be used for the EU ETS and for Kyoto compliance (Fremont, 2003).

The EU program will add a layer of complexity to the use of allowance registries because each Member State may have its own registry. Member States may also join together to share common registries, but for a variety of sovereignty and political reasons, they may not choose to do so (Fremont, 2003). Separate Member State registries will communicate through standardized protocols, and the European Commission will run an independent transaction log, which will serve as a communications hub between national registries and conduct various automated checks (EC, 2004c). Although this is technically feasible (and is the same registry approach used in the Kyoto Protocol), it is considerably more complicated than running one, centralized registry. In contrast, multijurisdictional programs in the United States., such as the NO_x OTC and SIP Call, had a centralized registry run by EPA to track allowances in the program.

3.5.3 Public Access to Emissions and Trading Data

In the United States, emissions data from the SO_2 and NO_x trading programs are available to the public and may be accessed through the Internet. There are no confidentiality requirements for this data. The public can also access data on allowance transfers among different accounts in EPA's registry. It is important to note that these transfers represent only a portion of all allowance trades. Trades may be conducted contractually between private parties, and there is no obligation to notify the EPA or transfer allowances in the registry unless these allowances are to be used to meet a compliance obligation.

Similarly, the EU directive requires Member States to makes emissions and allowance data available to the public. The forthcoming registries regulation will include common emissions and allowance data elements that must be reported and made available to the public (Lefevere, 2004). However, the availability of emissions data may still be subject to certain limitations, which include cases in which data is judged to violate national laws designed to ensure business confidentiality (EC, 2003). It is unclear whether Member States will handle these determinations of data confidentiality in a consistent manner.

3.5.4 Penalties and Enforcement

As mentioned above, the EU Directive provides for excess emissions penalties of €40/ton CO_2 in the first period, and €100/ton CO_2 in the second period. There is also a requirement to offset excess emissions in the following year (that is, firms who pay the penalty must still obtain the required allowances in the following year). Although excess emissions penalties are set uniformly for all Member States in the EU, additional civil and criminal penalties (such as, for fraudulent reporting) are left to the Member States, with a requirement that the Commission be notified about the relevant legal provisions (EC, 2003a). The Directive also requires the publication of the names of operators who are not in compliance (the so-called "naming and shaming" provision). Among the 25 different EU Member States, there are significantly different legal systems, enforcement cultures, and administrative capabilities. An uneven approach to enforcement among Member States could create unfair competitive advantages for firms in Member States with weaker enforcement regimes. In a Partial Regulatory Impact Statement in support of the United Kingdom 's draft National Allocation Plan, the authors note: "If monitoring and enforcement is not pursued with equal skill and rigour within and across Member States this could lead to distributive and competitive effects at the installation, sector and country level" (DEFRA, 2004b).

Special concerns have been expressed about the Accession Countries where there historically there have been weak environmental institutions.[18] Of the Accession Countries, Poland has the largest number of installations (approximately 1200) followed by the Czech Republic (500), Slovakia (200), and Hungary (300). Concerns about weak institutions are not limited to Accession Countries, however. For example, Tabara (2003) argues that Spain's environmental administrative capacity has not always been adequate to face complex problems such as climate change.

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[18] For example, Blackman and Harrington (2000) have described some of the difficulties Poland has had with enforcing its emissions fee system. Also, see Bell and Russell (2002) and Kruger et al. (2003) for different views of whether emissions trading is appropriate for economies in transition and developing countries.

3.5.5 Enforcement at the EU Level of Member State Requirements

Thus far, we have discussed features of the EU ETS associated with enforcement and compliance at the firm level. There are parallel issues associated with the enforcement of the responsibilities of Member States. The EU ETS is now binding law, and Member States are required to transpose it into national law and to abide by its mandatory provisions. Failure to implement provisions of the EU ETS can result in enforcement proceedings—initiated by the Commission and followed by the European Court of Justice (ECJ) if necessary. Ultimately, the ECJ has the authority to impose fines on Member States if its rulings are not followed. However, this is considered a last resort that is only taken if a number of other legal steps fail to induce compliance (Borchardt, 1999).[19] In the past, this has proven to be an important incentive for Member States to comply before the actual imposition of a fine (Lefevere, 2004).

Commentators have written of the "implementation gap" in European environmental regulations (Jordan and Jeppesen, 2000). A recent EU survey found that "there is difficulty in the timely and correct implementation as well as proper application of community environmental law by Member States" (EC, 2003d). In some cases, this failure to implement comes from delays in transposing EU laws into national laws. In other cases, laws are not interpreted or applied correctly.

It is too early to tell if there will be significant delays in the implementation of the EU ETS or if there will be misapplication of the EU rules. However, it is worth noting that the first significant deadline of the process, the requirement to incorporate provisions of the EU directive into national law by December 31, 2003, was only met by one of the 15 EU Member States (the United Kingdom; Bloomberg News Service, February 6, 2004). The European Commission has subsequently begun preliminary enforcement actions against Member States who missed the deadline (Hobley, 2004). More recently, additional governments have adopted national laws incorporating the Directive, and additional laws are pending with national parliaments (Zapfel, 2004).

3.5.6 Comparison to Literature

Several critical elements of an effective enforcement regime for emissions trading are described in the literature. First, excess emissions penalties create a necessary incentive to meet the cap. These penalties should be set at levels substantially higher than the prevailing permit price to create the appropriate incentives for compliance (Stranland et al., 2002; Swift, 2001). On the other hand, penalties can be viewed as a "safety" valve on the market, limiting how high prices can go in the face of unexpected events (see more below). In any case, if excess emissions penalties for tradable permit programs are too high, regulatory authorities may be reluctant to impose them (Tietenberg, 2003).

In addition to the level of the penalties, the certainty that a penalty will be imposed is a critical element in providing the correct incentives in an emissions trading program. The automatic nature of excess emissions penalties in U.S. trading programs is in contrast with the traditional regulatory approach where sources in violation may negotiate for a regulatory exemption (Ellerman, 2003a). If these negotiation costs are less than the cost of compliance, then participants in a trading program have little incentive to comply. Conversely, if participants in a trading program know that the costs of a ton of excess emissions will exceed the cost of buying an allowance on the market, they have every financial incentive to comply.

A second necessary component of an enforcement regime is reasonably accurate emissions monitoring (Stranland et al., 2002; Peterson, 2002). San Martin (2003) has demonstrated that incomplete monitoring can undermine the efficiency of trading programs. Moreover, although Ellerman et al. (2000) note that the costs of the monitoring regime in the U.S. SO_2 program are not insignificant, they maintain that rigorous monitoring gives environmental regulators the confidence to dispense with case-by-case reviews of emission reductions.

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[19] Thus far, there are only two instances of fines imposed by the ECJ for Member State noncompliance with EU laws (Hobley, 2004).

Finally, some commentators note that public access to emissions and trading data builds confidence in the environmental results of the program and provides an additional safeguard for compliance. (U.S. EPA 2003a). Information technology has been the key to providing this transparency in the U.S. emissions trading programs, where all emissions and allowance data are available online (Kruger et al., 2000). Tietenberg (2003) argues that public access to this type of information may create a greater incentive for firms to comply.

The EU ETS generally incorporates most of the lessons from the economic literature and from past U.S. experience. Most notably, the uniform excess emissions penalties are well above the projected marginal costs. On the other hand other penalties, such as those for submitting fraudulent data for following monitoring requirements, will be less uniform because they will rely on national laws that may vary considerably. The impact of this lack of harmonization should be examined in the first years of the EU ETS. In particular, there may be special concerns associated with the lack of effective enforcement institutions in the Accession Countries and some of the less economically developed southern tier nations of the European Union.

The EU ETS also emphasizes emissions monitoring through binding guidelines that are considerably more detailed than comparable past guidance put forward for EU environmental directives. The requirement for independent verification may also provide an important resource for Member States with limited internal capability to verify emissions. Similarly, the requirement in forthcoming registry regulations to include standardized, installation-level emissions information could be a valuable feature of the compliance regime. This will both facilitate compliance determinations and public access to emissions data.[20] However, as discussed above, Member State discretion on the interpretation of monitoring guidelines and the certification of third party verifiers may undermine some of the consistency that is necessary for an effective monitoring and compliance regime. Moreover, the lack of standardized electronic auditing procedures may make it difficult to run an efficient and effective compliance determination

[20] The value of this requirement will depend on the type and detail of the data ultimately required by the regulation.

process across 25 diverse Member States. These are areas where the European Union may want to consider further harmonization as it evaluates the results of its pilot phase.

3.6 Does the EU System Strike the Right Balance Between Centralization and Decentralization?

As the previous discussion notes, many of the features that have been centrally decided within the federal U.S. SO_2 trading program and the multijuridictional NO_x programs are decentralized within the EU system (see Table 3). This is not surprising given that EU Member States are sovereign nations while U.S. states are not. Unlike the United .States, the European Union is not yet a true federation and the European Commission's centralized authority is more limited.[21] Moreover, the approach taken in the Emission Trading Directive is consistent with European Community legal tradition, where EC Directives usually set overall standards for Member States. Member States are then responsible for implementing the standards and have a certain amount of discretion in their interpretation (Hargrave and Lefevere, 1999). Still, it is worth noting that with common mandatory excess emissions penalties, mandatory emissions monitoring requirements, and veto power over National Allocation Plans, the EU ETS has broken new ground in its efforts to harmonize the implementation of an environmental requirement across its Member States.

While absolute standardization is not feasible or necessary, it is an open question whether the EU ETS model strikes the right balance between consistency—and simplicity—versus national sovereignty. At the outset, it was noted that added complexity can harm the effectiveness of a market-based policy. Equity and enforcement are also concerns. For example, without the use of common benchmarks, will it be possible to set sectoral targets across Member States that are perceived by a critical mass of participants to be equitable? If firms in different Member States face significantly different compliance and enforcement regimes, will there be

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[21] For a discussion of the issues associated with centralized versus decentralized authority in EU environmental policy, see Jordan and Jeppesen (2000).

different gaming responses that undermine both the environmental credibility and the efficiency of the trading system? These questions suggest potential pitfalls to current implementation.

Aside from variation in design elements, the decentralized nature of the EU ETS also raises questions about whether Member States are using comparable data sources and analytical tools to develop their National Allocation Plans. For example, emissions projections from Member States are done using a variety of techniques and assumptions (EEA, 2003). In contrast, for U.S. multijurisdictional programs, analysis of potential targets are done for all states using one model and a common set of assumptions (U.S. EPA, 2003).

Ultimately, questions of standardization in the design and operation of emissions trading systems are applicable beyond the EU. To the extent that future climate regimes link different domestic trading systems, similar issues are likely to arise. Thus, the balance between centralized versus decentralized features in the EU system should be closely evaluated during the pilot phase of the program, offering the opportunity to build a foundation as well as experience towards future policies.

4. Uncertainties About Costs and Liquidity

So far we have discussed some of the implementation questions and challenges faced by the European Union in implementing the ETS. From the vantage point of participants this creates uncertainty about how the program will operate. This section describes a different concern: uncertainty associated with the cost of the program. In some cases, this revolves around implementation but in many cases it does not. We will review the most recent economic analysis commissioned by the EU for estimating the costs of the ETS and will discuss some of the uncertainties associated with this analysis. In particular, we will review assumptions about the availability of clean development mechanism (CDM) and joint implementation (JI) credits, as well as other factors that will affect liquidity in the EU market.

4.1 Review of EU Economic Analysis

The European Union's most recent economic analysis explores the impacts of different limits on CDM and JI credits on marginal and total annual costs (Criqui and Kitous, 2003). The analysis uses marginal abatement cost curves from the POLES—Prospective Outlook on Long-term Energy Systems—model[22] with simulation software to project allowance prices in the EU. The model reflects global demand for greenhouse gas offsets and makes the following assumptions:

- **Overall Target.** The analysis assumes that the EU's collective Kyoto target is met. Thus, an overall target of 4,664 MtCO_2e (million tons of carbon dioxide equivalents) is assumed for the enlarged union—that is, the 15 existing Member States plus the 10 Accession Countries.
- **Caps on Trading Sectors.** Sectoral caps are set for all scenarios in the analysis by assuming that marginal costs are equalized for trading and nontrading sectors within each country before trading begins. In other words, the national allocation of allowances to ETS sources versus sources outside the ETS is set at efficient levels absent EU trading and JI/CDM.[23]
- **Offsets.** The analysis allows purchase of Kyoto project-level offsets (JI and CDM) from outside of the enlarged European Union. Transaction costs are assumed to be 20%. In addition, the analysis assumes that there are "accessibility factors" for offsets that vary by sector and country. These factors range between 10% and 40%, and they represent the need to discount the technical potential for offsets to reflect the indirect incentives to bring forth actual reductions.
- **Government Buyers.** The model assumes that there is competing demand for offsets from EU governments who must offset emissions in the nontrading sectors to meet their Kyoto targets. This is consistent with current activity in the greenhouse gas market. For example, the Dutch government has already made significant purchases in the

[22] For a detailed description of the POLES model, see Criqui (2001).

[23] Once trading begins, this is no longer efficient because installations outside the trading system cannot respond to higher or lower market prices.

offset market; several other governments have announced plans to do the same (Natsource, 2003).

- **Russian Tons.** Russia is assumed to ratify the Kyoto protocol and make JI credits available. However, the analysis assumes that EU Member States will not purchase the excess assigned amount units (AAUs) available because of the downturn of the Russian economy since the 1990 Kyoto base year. Purchases of these emission reductions, sometimes referred to as "hot air," are controversial in Europe and may not be accepted by the EU for Kyoto compliance unless they are "greened" by being tied to specific greenhouse gas reduction projects (Henkemans, 2003; Newcomb, 2003).

Table 4 shows the results of the EU's analysis for ETS costs in 2010 (note that the full cost of Kyoto compliance that include costs in the nontrading sectors are not presented). The table presents several scenarios, ranging from no offsets to unlimited offsets. Assuming that the 6% limit to offsets is reached, the analysis shows estimated allowance prices of €14/ton CO_2e ($64/ton C) and total annual costs of €2.4 billion ($3 billion). This includes the cost of abating 165 MtCO_2e and purchasing of 91 MtCO_2e from the world offset market.[24] According to the analysis, allowing unlimited offsets would drop the price of EU allowances to €12/ton CO_2e, would only modestly increase the percentage of tons from offsets to 7% and would lower costs to €2.2 billion. Meanwhile, the complete absence of credits would double the price to €26/ton CO_2e and raise costs to €2.9 billion. Note that costs in the 2005 to 2007 period are not estimated in the EU's analysis. However they are expected to be lower and will depend on the targets chosen by Member States in their National Allocation Plans (Criqui, 2003).

4.2 Modeling Uncertainty

The aforementioned analysis represents the work of a single modeling team, subject to a host of assumptions about how consumers, producers, and the economy as a whole respond to

[24] Note that a simple calculation of ½ x €14/tCO2 x 163 mmtCO2 + 91 mmtCO2 x €14/tCO2 equals €2.4B, where the first term approximates the average abatement cost times the amount abated and the second term is precisely the cost of purchasing offsets abroad.

market-based policies. A different modeling team, presented with the same question, could easily come up with a different framework, different assumptions, and different results. Such differences are distinct from uncertainty about future events, discussed below, and represent uncertainty in the modeling exercise itself. This leads us to ask how much impact does model choice have on estimates of allowance price and cost.

A study by the Energy Modeling Forum (Weyant and Hill, 1999) considered the cost of implementing the Kyoto Protocol according to a dozen different global energy-economy models. A useful element of this exercise is Figure 10 in that article, showing marginal cost schedules for various countries and for various *fractional* emissions reductions based on the different models. Because the figure presents results for a range of emission reductions, and because it is scaled to fractional reductions, it provides an interesting study of variation in estimated costs based primarily on model structure—such as, semi-elasticity's of abatement supply. For the European Union, reductions of 13% (comparable to the no offset case) are in the range of $0 to $400/ton C (in $1990). Excluding the extreme cases, the range is about $70-$140/ton C or, converting to Euros/ton CO_2 and adjusting for inflation, €20–35/tCO_2. Compared to Criqui and Kitous (2003), the costs are comparable.

However, the main point is that *each* Criqui and Kitous estimate should itself be viewed as an uncertain guess. Technical modeling assumptions alone appear to introduce an uncertainty spread equal to a factor of two.

4.3 Uncertainties Affecting Liquidity and Prices

In addition to model structure, there are numerous uncertainties surrounding EU implementation and other events beyond EU control that will affect the prices of emission allowances and overall costs in the EU ETS. These uncertainties include:

- How rapidly will EU emissions grow?
- Will the CDM process supply an adequate supply of offsets?
- Will all Member States (including the Accession Countries) be ready to participate at the start of the program?

- Will Russia ratify Kyoto?
- Will the EU systems banking provision work effectively?

Each of these issues is addressed briefly below.

Emissions Growth. A recent report by the European Environmental Agency showed that it will be a challenge for the EU Member States to meet their collective Kyoto target. As Figure 1 shows, in 2001, greenhouse gas emissions were 2.3% below 1990 levels. This is compared to the overall Kyoto burden-sharing target for the EU 15 is 8.0% below 1990 levels. The projection for 2010 is even more daunting (Figure 2). It shows that with existing policies and measures, emissions will be only 0.5% below 1990 levels. Figure 3 shows that much of the shortfall is caused by growth in emissions from the transport sector, which are projected to increase by 34% from 1990 levels by 2010.[25]

Growth in emissions from the transport sector has important implications for the EU trading system. On the one hand, these emissions are not included in the program during the first compliance period. However, regardless of whether or not they are included in the second period, their growth could have an impact on allowances prices, assuming governments meet the Kyoto targets by purchasing offsets to cover growth in the non-trading sector.

Availability of Offsets. The benchmark economic analysis assumes that in the 6% offset scenario, the EU purchases 208 $MtCO_2$ annually (91 in the ETS and 117 by Member States to cover sectors outside the ETS). Demand from other Annex B countries (for example, Japan, Canada) is an additional 220 tons, for a worldwide total of 428 $MtCO_2$. The analysis projects that 55% of CDM credits will come from China and 12% will come from India.

Is it realistic to assume that so many tons will be available? In a study for the World Bank's Prototype Carbon Fund (PCF), Lecocq and Capoor (2003) find that unclear signals about whether Kyoto will be ratified have put a damper on new projects as investors and potential users of credits are waiting to see how things develop. Lead times for greenhouse gas mitigation projects can be from three to seven years, depending on the type of technology and the business environment of the host country. They note that for new projects to deliver significant emission credits by 2012, contracts should be signed by 2006 at the latest and conclude:

> Apart from ratification, lead-time is probably the single most important issue JI and CDM faces in the medium-term. Absent some clarification of the validity of project-based ERs [emissions reductions] beyond 2012, volumes transacted under these mechanisms might diminish sharply before the beginning of the first commitment period.

Moreover, it is not clear that the process to review and approve CDM projects would be capable of handling the necessary number of projects, even if there were enough in the pipeline. Although the CDM Executive Board hopes to further standardize methodologies in the future, the current process is a "bottom up" collection of project specific methodologies. Thus far, 11 methodologies have been approved but no projects have made it through the process. Some analysts have questioned whether this "case law" approach to methodology development will be effective in the long run (Trexler et al. 2003), or whether it will successfully lead to standardized baseline methodologies (Jepma, 2003).

To get a sense of the number of projects that will have to pass through the process, we calculated a rough "typical size" of a project based on the first 11 projects to have approved methodologies by the CDM methodologies panel (see Table 5). At an average sized project of 400,000 tons, there would have to be nearly 520 projects to satisfy EU demand and a total of nearly 1,070 to satisfy worldwide demand.[26]

Banking. There are questions about whether the EU system will have enough liquidity, particularly in the beginning years, to avoid price shocks from unexpected events such as severe weather. U.S. experience has shown that in properly designed programs, a banking provision can

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[25] Figure 3 does not include Germany and three other Member States who did not report their projected transport emissions for the EEA study.

[26] In fact, some greenhouse gas experts believe that the size of a "typical" project will be smaller than 400,000 $MtCO_2e$. A more realistic "typical" project may generate between 250,000 and 300,000 $MtCO_2e$ per year (Youngman, 2004). Using 250,000 $MtCO_2e$ as a lower bound, there would have to be 832 projects to satisfy EU demand and 1,712 to meet worldwide demand for GHG credits.

create a cushion that will prevent spikes in price and can hedge uncertainty in allowance prices (Jacoby and Ellerman, 2004).

Between the first two periods, the EU allows each Member State to decide whether it will allow banking. The Directive states that each Member States must cancel extra allowances at the end of the first period, but may then "reissue" these allowances as banked allowances (EC, 2003c). Because banking is not universally required, it is unclear how Member States will react to this provision. Some Member States may be concerned that use of banked allowances may make it more difficult to meet the Kyoto target. For example, the U.K.'s draft National Allocation Plan would prohibit banking between Phase I and Phase II of the program. On the other hand, if any single Member State allows unlimited banking, then the fungibility of allowances suggests that market participants will attempt to funnel as much banking as possible through that country's program.[27] In any case, banking and some borrowing are allowed within each compliance phase, and a banking provision would be mandatory for Member States between Phase II and any subsequent period (DEFRA, 2004a).

Delays in Entering the Program. A second question about the EU program is whether key participants will delay entering the program. Delayed entry could have both positive and negative effects on prices, depending on whether the Member State entering is a net buyer or seller. For example, a delay by one of the larger Accession Countries might have a short-term impact on prices. According to the POLES analysis, Poland, the Czech Republic, Slovakia, and Hungary would provide 36 $MtCO_2e$ from the trading sectors to the market in 2010. According to the EU's analysis, this represents approximately 70% of the supply of tons from the trading sectors within the 25 EU countries (Criqui and Kitous, 2003).[28]

Conversely, a delay in entry of a net buyer could dampen the price of allowances. For example, some of the fast-growing, southern tier countries such as Spain will need to be heavy

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[27] Thus far, only France has indicated that it might allow banking from the first to the second phase (Zapfel, 2004).

[28] Because of the way countries are grouped in the POLES model 12 $MtCO_2e$ of supply are shown to come from the Annex B countries in the "Rest of Central Europe." Thus, some of these tons may come from countries like Bulgaria, which are not among the 10 Accession Countries joining the EU in May 2004.

buyers of allowances in the EU market. According to the POLES analysis, Spain is estimated to purchase 34 million tons of carbon dioxide for use by their emissions trading sectors. Thus, if there is a delay in participation in the program by Spain or other net buyers, this could have a short-term dampening effect on allowance prices.

Russian tons. Finally, the availability of Russian tons is still a question. Although the POLES analysis does not model Russia separately, it does model collectively countries in Annex B from the former Soviet Union. As stated previously, the analysis only allows for JI credits, not excess Assigned Amount Units (AAUs) resulting from the collapse of the Russian economy and the subsequent reduction in emissions after the 1990 base year. Given this restriction, countries of the former Soviet Union are expected to provide only 45 million tons of carbon dioxide to the market. On the other hand, full inclusion of Russian "hot air" could have a large impact on world prices of allowances and, indirectly, on the costs of compliance with the EU ETS (Bernard, et al., 2003). [29]

4.4 Efficiency Suggestions from Theory

All of the aforementioned uncertainty—program features, technology and behavioral response, and external events—indicates that the market could be quite volatile. Experience in the U.S. NO_x RECLAIM and OTC markets, for example, shows that prices can jump by many orders of magnitude in response to various shocks. Figures 4 and 5 show the path of these prices. In the case of the RECLAIM market, the California energy crisis during the fall of 2000 created a spike in demand for generation in the Los Angeles basin, which unfortunately coincided with already relatively tight NO_x allowance markets. The result was allowance prices jumping from hundreds or perhaps a few thousand dollars per ton to more than *$90,000* per ton. Meanwhile, in the OTC NO_x market, uncertainty about allocation and participation in advance of the program

[29] Although Russian AAUs could not be used directly in the EU ETS, they could affect EU allowance prices in two ways. First, a Member State government could purchase AAUs for Kyoto compliance rather than imposing a lower cap on sources covered by the EU ETS. Second, large quantities of Russian AAUs would expand the overall supply of greenhouse credits and could subsequently depress prices of CDM credits. Under the proposed linking directive, CDM credits would be directly convertible to EU allowances.

start date caused a significant run up in prices from roughly $1,000 per ton to more than $6,000 per ton. Once rules were finalized—less than six months before the season began—and once participation was clear (Maryland's participation, for example, was held up by a legal challenge), pressure eased and prices dropped dramatically to levels below $1,000 per ton (Burtraw and Evans, 2003).

While both the NO_x OTC and RECLAIM markets differ from the proposed EU ETS in many important ways—perhaps most importantly smaller size—the risks are qualitatively if not quantitatively the same. Namely, a shortage can lead to spikes in the price of allowances. The question for a larger market is whether shocks are likely to be idiosyncratic, with one source's higher demand cancelled out by another source's lower demand, or whether shocks are likely to be common, with higher demand occurring across a great number of sources at the same time. Crude data on annual emission fluctuations at the national level suggests that variation of several percentage points is common (Pizer, 2003). Even absent real shocks, shifts in expectations can have large, system-wide effects (as in the OTC market). What remains to be seen is how easily marginal mitigation opportunities can absorb such shocks.

In any case, volatility is costly. On the one hand, firms can choose to insulate themselves from volatility by using derivative markets—options and futures contracts—to hedge or fix their cost. There are premiums involved in such exercises, however, because there is real risk. In response to shocks, someone, somewhere will have to adjust their emissions away from their planned level. It is those adjustments that will drive the market price of allowances and will represent the cost to society, on the margin of adjusting those emissions.

Meanwhile, one can ask the question: does it make sense to spend a large amount of resources—$90,000 per ton in the case of NO_x RECLAIM or $6,000 per ton in the case of NO_x OTC—to meet an emissions target. If emissions targets are designed to avoid a precipitous damage threshold, the answer is undoubtedly yes. But if the emission target is meant to be a down payment on a much longer-term effort, the answer would seem to be no. This intuition, articulated first by Weitzman (1974) and then by others, suggests that strict emission limits are often undesirable—inefficient—when mitigation benefits (or emission damages) fail to be precipitous.

While not envisioned by the Directive in this way, the penalties included in the EU ETS could go a long way toward ameliorating these risks if the EC decided to encourage their use in a noncriminal manner.[30] The initial penalty of €40 / tCO_2—ton of carbon dioxide—is about three times the estimated price of €14 / tCO_2. This could avoid the risk of the enormous price spikes noted in the two NO_x programs by allowing firms to opt out and pay the penalty. At the same time, the penalty is high enough that prices can fluctuate quite a bit before it becomes relevant. Curiously, this factor of three between the expected price and the penalty is nearly identical to the factor used in the U.S. Clear Skies proposal.[31]

The penalty in the second phase jumps to €100 / tCO_2, or perhaps seven times the expected allowance price. Further, sources must pay the additional cost of purchasing offsets in the following year.[32] Coupled with "naming and shaming" consequences associated with failing to hold the requisite emission allowances and the additional penalties that may be levied by Member States, it is questionable whether firms would intentionally choose this option. Still, any kind of cost limiting mechanism is better than none and the framework remains in place should the EU choose to revisit the question in the future.[33]

5. Conclusions

Without a doubt, the rapid launch of the first large-scale greenhouse gas trading program is an impressive political achievement. Many of the design elements of the program are sound, and the program clearly builds upon many of the lessons learned from earlier experience with emissions trading programs. On the other hand, with 25 countries, multiple industrial sectors,

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[30] A similar "decriminalization" of penalties was discussed in the National Academy study of the Corporate Average Fuel Economy program in the U.S. (NRC 2002)

[31] Expected prices under Clear Skies are around $1,000-$1,500 per ton for NOx and SO2 with a safety valve at $4,000 per ton. See S. 1844, 108th Congress. A penalty or safety valve, by cutting off price outcomes above the specified level, will tend to lower the expected price. Therefore, the penalty or safety valve price *must* be above the expected price—it is simply unclear how much above is desirable.

[32] Although the capacity to effectively borrow through a compliance phase means that this additional cost could be delayed until the end of the following phase.

and the mixture of a cap-and-trade structure with project-level offsets, the EU ETS has many new (and some old) issues to address. The timeframe for starting up the program is short, particularly considering the number of installations that will participate in the program and the lack of experience in most European countries with emissions trading. With the exception of emissions trading experiments in the United Kingdom and Denmark (for CO_2) and Slovakia and the Netherlands (for NO_x), most Member States are still coming up to speed on the fundamentals of emissions trading. This is significant because, as discussed in this paper, the EU ETS has a much more decentralized structure than previous multijurisdictional programs in the United States.

Thus, there may be some bumps in the road as the EU goes through its “warm-up” phase starting in 2005. These may include delays by some Member States in meeting various deadlines, controversy over different Member State Allocation schemes, significant inconsistencies in compliance and enforcement provisions across Member States, and volatile allowance markets. EU officials have stated openly that they expect significant “learning by doing” in the initial years of the program (Runge-Metzger, 2003), and the EU Directive explicitly sets up a process that could result in recommendations for changes and fine tuning. In June 2006, the Commission will submit a report assessing key elements of the program and making recommendations for change. To the extent there is a rocky start to the program, this assessment of the first phase will undoubtedly be critical for turning the pilot phase into an effective program.

The EU ETS represents a great opportunity, on the one hand, to set up the architecture and get moving toward a solution to the problem of global climate change. On the other hand, there are many potential pitfalls that could limit its effectiveness and, at worst, hurt future efforts to set up similar programs. We identified three major areas of concern: equity, enforcement, and efficiency. The biggest challenge facing the EU ETS in the first two areas is simply the heterogeneous, multijurisdictional nature of the European Union. Coupled with the particularly tight timetable, it is unclear what will happen as countries with weaker environmental

[33] Pizer (2002) makes this point quantitatively—a safety valve many times higher than the desired price still dramatically raises expected welfare relative to the case where there is no safey valve.

institutions, both to allocate allowances and to enforce compliance, are brought into the program. Lessons from the U.S. programs indicate that even under the best of conditions, these things take time; therefore, the deadlines may need to be delayed for some or all countries. The main challenge regarding efficiency is to avoid the kinds of shortages and price spikes that have characterized some U.S. allowance markets. There is little in the science of climate change to suggest that short-term targets are worth an exorbitant expense when the real challenge is the long-term trend. The existing penalty provisions could be used to take a large step toward alleviating such risks, should Member States choose to do so.

Besides the implementation challenges of the EU ETS, Members States face the daunting political and economic challenges of meeting their Kyoto burden-sharing targets. EU officials continue to express a strong commitment to the Kyoto process, and meeting the Kyoto targets has been a driving force behind the EU ETS. However, it is also clear that several aspects of the structure and process inherent in the Kyoto agreement discussed earlier in this paper will make it more difficult to implement the EU ETS. For example, the CDM Executive Board process could be a bottleneck for the project-level reductions that will help reduce costs in the EU system. The current directive also precludes linking the EU ETS to domestic trading programs of countries (such as the U.S. and Australia) who are not parties to the Kyoto Protocol.[34]

In addition, concerns about meeting the Kyoto commitment could constrain banking from the first to the second compliance phase. This could also undermine longer-term mitigation plans because firms may have little incentive to implement strategies that create extra emissions reductions beyond their allocated levels. Although firms may trade excess allowances to other firms for use within the first compliance period, the inability to bank these "early reductions" could be a significant disincentive if prices are low in the first period and high in the second. Moreover, some firms may fear that reducing emissions beyond the levels of their allocations could lead to lower baselines (and allocations) in the second phase. Although procedures to

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[34] There have been proposals in the European Parliament to allow linking of the EU ETS to potential cap-and-trade programs from regional authorities in developed countries that have still to ratify the Kyoto Protocol. This could include cap-and-trade programs developed by U.S. or Australian states.

provide “baseline protection” to prevent penalization for these extra reductions are possible, their credibility and practicality are unclear. Finally, the lack of a bank of allowances in the first phase forgoes a potentially strong political incentive for European companies to support the continuation of the program into the second phase—namely, the holding of a large and valuable portfolio of banked allowances

A more fundamental difficulty raised by the Kyoto process is uncertainty about the form and level of international commitment beyond 2012. This will constrain EU Member States in planning for the next phase of the EU ETS. It also makes it difficult for European industry to take a long-term approach to investing in climate friendly technologies and to planning a least cost, longer-term strategy for GHG abatement. Moreover, although banking will be available between the second period and subsequent periods, uncertainty over the structure of a future international regime could make Member States and their industries reluctant to make the investment decisions that would enable them to take advantage of a banking provision.

The ultimate challenge raised by Kyoto may be maintaining the political will in Europe to meet the Kyoto target. Concerns about the cost of meeting the target and the potential competitiveness disadvantage for Europe compared to the U.S. and other countries could make EU Member States reluctant to impose the necessary measures on industry. A recent study from the European Environmental Agency shows that even with projected new measures (excluding the EU ETS), the EU will miss its collective target. They highlight the transport sector as a source of emissions growth, suggesting that one of the most difficult decisions to be faced by the EU in the next few years will be how to address these emissions—whether through inclusion in the trading program when it revises the program in 2006, imposing a commensurate carbon tax, or some other sectoral policy. Without such policies, it will be difficult for the EU to meet its overall Kyoto target.[35]

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[35] This assumes that the EU does not allow the widespread use of Russian “hot air” or force all the reduction onto installations participating in the EU ETS. Even if unspecified “additional measures” are included in projections, the EEA (2003) study finds that there will be an increase of emissions in the transportation sector of greater than 20% by 2010 in the 11 Members States where projection data was available (see Figure 3).

Finally, even if EU Member States are unable to meet their targets, or if Kyoto does not come into force, a functioning EU trading system could still be influential in future international efforts to reduce greenhouse gases. Ellerman (1998) notes that one of the biggest obstacles to an international trading system has been the lack of even a single national system that can create demand for emissions reductions. Once such a system is in place, an international system may evolve, more as a matter of trade than as an international agreement. Other observers have predicted that a post-Kyoto climate regime may consist of negotiated linkages among domestic programs, rather than the type of formal multilateral process embodied in the Kyoto Protocol (Purvis, 2003). To the extent that emissions trading plays a role in such evolving schemes, precedents set by the first large greenhouse gas trading program could be critical. Thus, with or without Kyoto, the stakes are high for Europe as it carries out its new, but much more difficult grand policy experiment.

Tables

Table 1: Estimated Number of Installations in the EU ETS

Country	*Installations*
Austria	240
Belgium	295
Cyprus	15
Czech Rep.	500
Denmark	350
Estonia	39
Germany	2,600
Greece	185
Finland	500
France	1,500
Hungary	300
Ireland	97
Italy	1,900–2,100
Latvia	86
Lithuania	NA
Luxembourg	12–19
Malta	NA
Netherlands	250–300
Poland	1,100–1,200
Portugal	200
Slovakia	200
Slovenia	70-100
Spain	NA
Sweden	500
UK	1,500
Total	**12,439–12,826**

Source: European Commission, “National Allocation Plan Progress Table—8 March 2004” http://europa.eu.int/comm/environment/climat/pdf/nap_progress.pdf

Table 2: Comparison of Key Features of the EU ETS and U.S. Programs

Features	*U.S. SO2 Program*	*U.S. NOx Program*	*EU ETS*
Sectors	Electric Power Voluntary opt-in of industrial combustion sources	Electric Power Large Industrial Combustion Sources	Energy (including electric power, oil refineries, coke ovens) Metal ore, iron-and-steel production Minerals (including cement, lime, glass, ceramics) Pulp and paper
Number of Regulated Sources	3,000 units[a]	2,400	12,000–13,000 installations[b]
Number of Political Jurisdictions	1 (U.S. Federal Govt.)	22 (21 states and the District of Columbia)	25 Member States
Emissions Covered	SO_2	NO_x	CO_2, some or all of five other "Kyoto Gases" may be added later
Project-Level Offsets?	No	No	Yes (proposed)
Value of Annual Allocation	$2.25 billion[c]	$1.2 billion[d]	$37 billion[e]

[a] A "unit" is defined in U.S. trading programs as a combustion boiler. Thus, a power plant with five distinct boilers would be considered five units under the U.S. SO_2 and NO_x programs.

[b] The classification of a regulated source of emissions is different in the EU ETS than it is in the U.S. programs. An installation could consist of multiple sources of emissions that have a technical connection with the activities carried out at a site. For example, a power plant would be considered one installation, even though there are multiple boilers.

[c] Assumes an annual allocation of 8.9 million tons and an allowance price of $250/ton.

[d] Assumes an annual allocation of 500,000 tons and an allowance price of $2,400/ton.

[e] Although the size of the EU ETS cap won't be known until the National Allocation Plans for Phase II are final, Harrison and Radov (2002) cite an EU study that estimates an annual value of €30 billion ($37.5 billion) for allowances in the EU ETS.

Table 3: Comparison of Where Provisions are Implemented in U.S. and European Emissions Trading Programs

Design Element	*U.S. SO2*	*U.S. NOx*	*EU ETS*
Sectors Covered	Centralized	Centralized	Centralized
Size Threshold for Sources	Centralized	Centralized	Centralized
Sectoral Target Setting	Centralized	Centralized	Decentralized (with guidance)
Allocation to Firms	Centralized	Decentralized	Decentralized (with guidance)
Banking	Centralized	Centralized	Decentralized (first compliance period); Centralized (second compliance period)
Registry Operation	Centralized	Centralized	Decentralized (based on mandatory standards)
Emissions Measurement Standards	Centralized	Centralized	Centralized
Emissions Reporting Standards	Centralized	Centralized	Centralized
Emissions Verification	Centralized	Centralized	Decentralized (with guidance)
Excess Emissions Penalty	Centralized	Centralized	Centralized
Criminal and Civil Penalties	Centralized	Centralized	Decentralized (with guidance)
Dissemination of Data	Centralized	Centralized	Decentralized (with guidance)

Key:

Centralized=Decided at U.S. Federal/European Commission level

Decentralized=Decided at U.S. State/EU Member State Level

Decentralized with Guidance=Decided by EU Member States with European Commission guidance

Table 4: EU ETS Costs in 2010

Scenario 2008–2012	*No Offsets*	*3% Limit on Offsets*	*6% Limit on Offsets*	*Unlimited Offsets*
Annual Costs	€2.9 billion	€2.8 billion	€2.4 billion	€2.2 billion
Estimated Allowance Price	€26/ton CO_2e	€20/ton CO_2e	€14/ton CO_2e	€13/ton CO_2e
Amount of Offsets in the System	NA	3%	6%	7%
Annual EU Emissions	4,664 $MMTCO_2$e	+171 $MMTCO_2$e	+208 $MMTCO_2$e	+224 $MMTCO_2$e

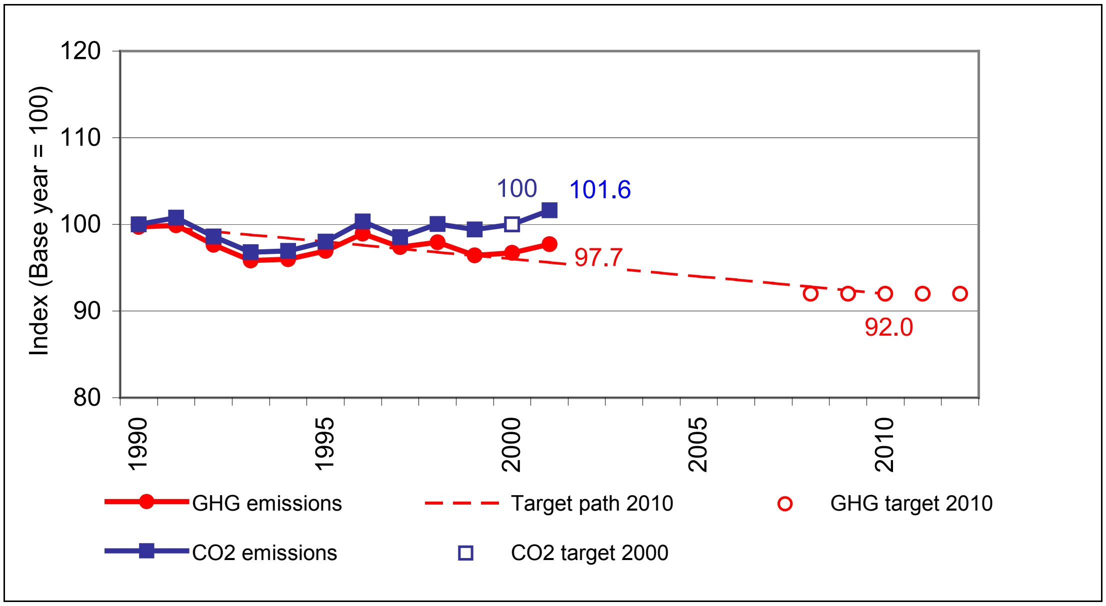
Table 5: Annual Tons from Projects with Approved CDM Methodologies

Name	*Country*	*Project*	*Annual Tons*
El Gallo	Mexico	Hydroelectric	70,484
Onyx	Brazil	Landfill Gas	90,075
A.T. Biopower	Thailand	Biomass	80,450
Graneros	Chile	Fuel Switch	16,063
Durban	S. Africa	Landfill Gas	441,571
Nova Gerar	S. Africa	Landfill Gas	197,213
Vale de Rosario	Brazil	Cogeneration	134,015
Ulsan HFC	S. Korea	HFC Destruction	1,400,000
Salvador de Bahia	Brazil	Landfill Gas	825,139
Lucknow	India	Landfill Gas	88,017
Rang Dong	Viet Nam	Oil Field Methane	1,220,000
AVERAGE			**414,821**

Annual tons reflect estimates for 2010 in the project documents that accompanied these methodologies. In some cases, 2010 estimates were derived from overall emission reduction estimates for the life of the project. Documentation for these projects is available at : http://cdm.unfccc.int/methodologies/process?cases=A

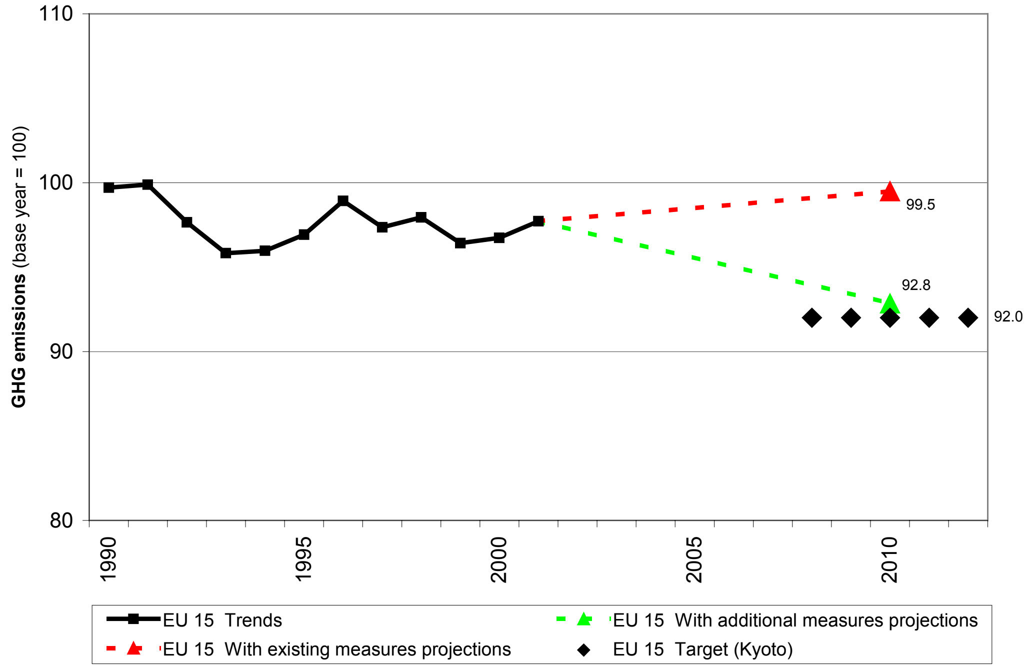
Figures

Figure 1: Emission Trends Since 1990 Versus Kyoto Target



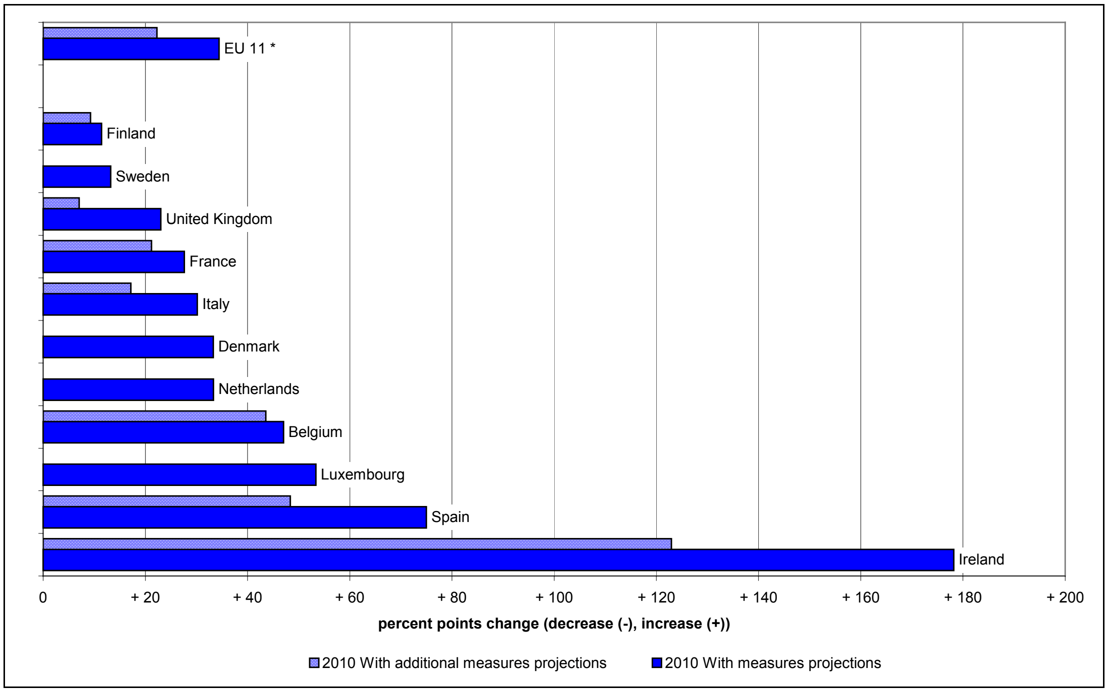
Source: EEA, 2003

Figure 2: Emissions Projections to 2010



Source: EEA, 2003

Figure 3: Transport Sector Projected Emissions Growth 1990–2010



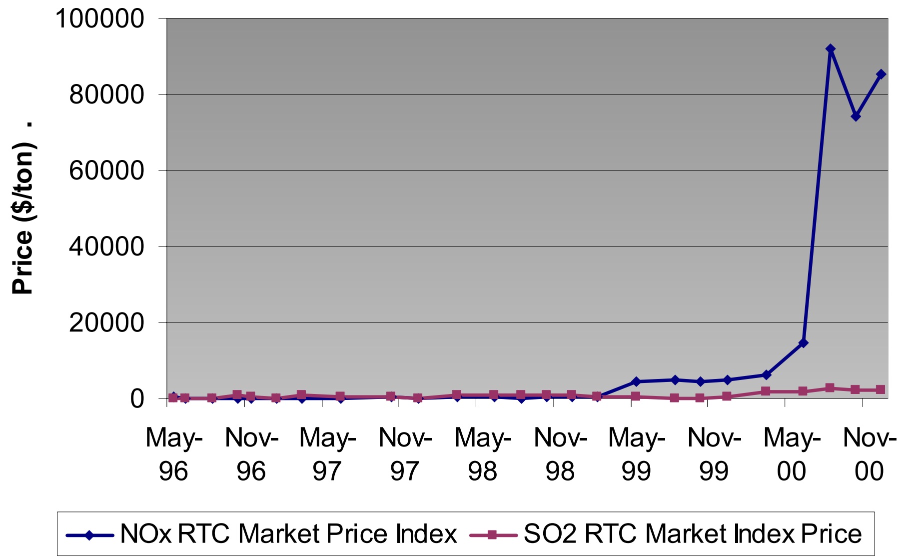
Source: EEA, 2003

Note: EU-11 emission projections are presented only for those Member States that reported projections (B, D, DK, E, FIN, IRL, I, L, NL, S, UK). Emissions exclude international aviation and navigation.

Figure 4: NO_x RECLAIM Market Prices

RECLAIM NOx Prices

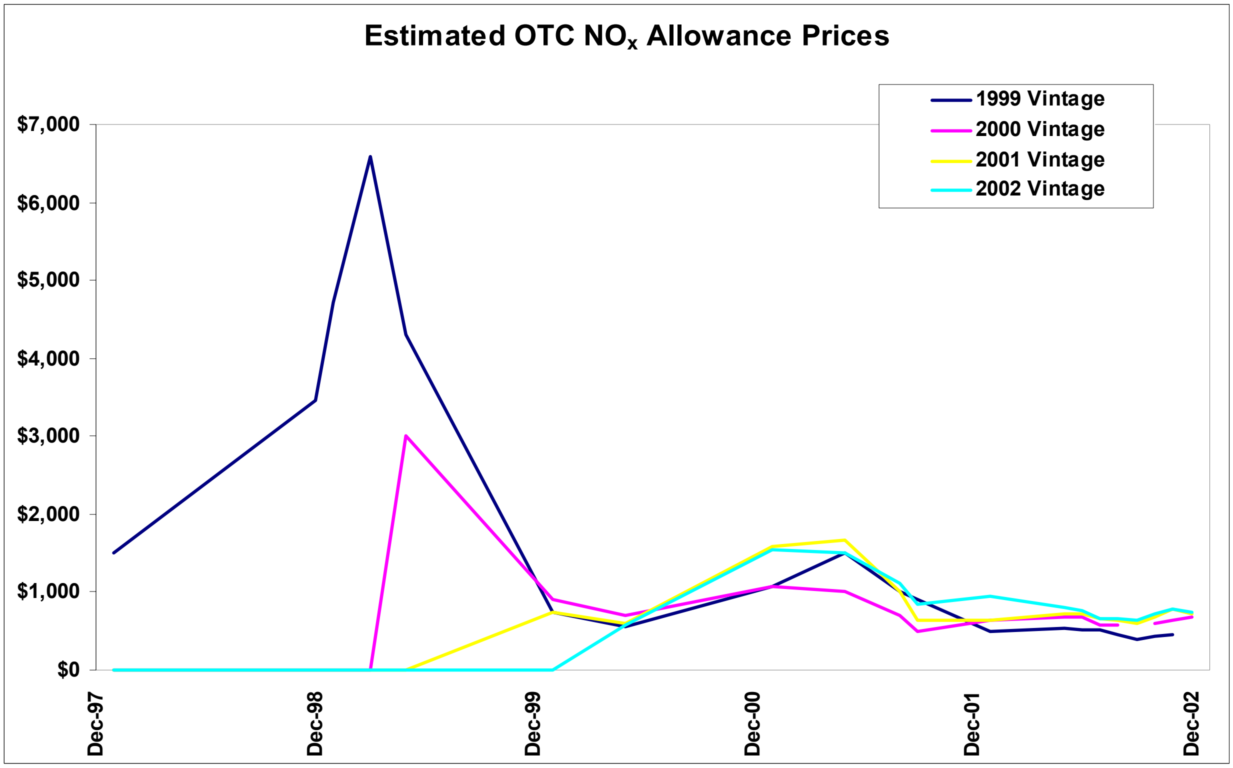
SO_2 and NOx RTC (Compliance Year) Market Price Index



Source: Cantor Fitzgerald, EBS

- **NOx Trading continued throughout 2000 despite high prices**

Figure 5: NO_x OTC Market Prices



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List of Acronyms

AAUs assigned amount units

CDM clean development mechanism

CEM continuous emissions monitor

CO_2 Carbon dioxide

EATS Emissions and Allowance Tracking System software

EC European Commission

EU ETS European Union Emissions Trading System

JI joint implementation

$MtCO_2$ Million metric tons of carbon dioxide

$MtCO_2e$ million tons (metric) of carbon dioxide equivalents

NAP National Allocation Plan

NO_x Nitrous oxide

OTC Ozone Transport Commission

PCF Prototype Carbon Fund

POLES Prospective Outlook on Long-term Energy Systems

RECLAIM Regional Clear Air Incentives Market

SIP State Implementation Plan (SIP)

SO_2 Sulfur dioxide