Emissions Trading as an Environmental Policy Tool: A Focus on the Design Issues

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Table of Contents

Abstract

This paper reviews the design of emissions trading and provides an overview of the theory and practice with respect to this environmental management instrument. The paper analyses the experience and insights gained from emissions trading programs in Canada, the U.S. and internationally. The strengths and weaknesses of the programs are highlighted in order to gain a better understanding of the importance of design issues on the final outcome of emission trading programs.

1. Introduction

At the present time a growing body of evidence continues to confirm that human activities are changing the earth's atmosphere at an unprecedented rate (Heggelund, 1991). Our concerns about climate change and air pollution such as smog have increased in recent years as environmental damage became more evident. Up to date, various policies have been introduced with the intention of cost-effectively reducing various pollutants such as greenhouse gases (GHG)[1] and air contaminants. Amongst them, emissions trading plays a significant role.

Experiences with air pollution control models show that designing policies to control air emissions is a complex and many-sided problem. It is suggested that the benefit of environmental policies must be weighted against the total economic costs including the consequences for regional disparities and a potential loss of international competitiveness (Barbier, 1990). In light of the inherent uncertainty and the economic costs involved, it is important that policy tools be chosen carefully with a view to minimizing their economic impact while insuring that the desired level of emission control is attained.

Emissions trading can be efficient in achieving emission reduction goals, but at a fraction of the cost of traditional policy measures of command and control (Randall, 1987; Jorgenson, 1993; Pearce et al., 1990). Emissions trading, as a mean of combating the high cost and rigidity of traditional legal approaches (UNCTAD, 1995), has attracted wide interest among policy makers, industry and others, especially in the context of addressing the acid rain challenge in the U.S., and more recently, for meeting

[1] Greenhouse gases (GHGs) are constituents of the atmosphere that absorb and re-emit infra-red radiation, trapping the heat in the atmosphere. These gases are carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), and sulfur hexafluoride (SF_6).

commitments under the Kyoto Protocol[2]. It is seen as a valuable instrument which offers the advantages of flexibility, cost-effective pollution abatement, direct control of total emission levels, a mechanism for trading reductions in different gases, and incentives for research and adoption of pollution abatement technology (IPCC, 1990).

The purpose of this paper is to provide an overview of the emissions trading programs that have been developed internationally, with particular reference to the U.S. and Canadian experiences, the design issues, and their weaknesses and strengths. This was done through a review of the literature on the theory and practice of emissions trading.

The paper begins with a brief history of environmental policy and emissions trading in particular. Then, the theoretical underpinnings of emissions trading are outlined, followed by a description of the various types of trading schemes and different program features. The requirements for a successful emissions trading program are also analysed and a number of practical experiences are described. Lastly, a comparison between theory and actual implementation is done and concluding comments are offered.

2. Overview of Emissions Trading

Air pollution existed even in pre-industrial times (Randall, 1987). Back then, it usually resulted from the combustion of some biological materials. Smoke from the burning of wood, mostly used for heating, frequently polluted the air above urban centers.

[2] The Kyoto Protocol is an international agreement reached in 1997 in Kyoto, Japan, which stipulates that industrialized countries and countries with economies in transition shall reduce their overall emissions of greenhouse gases by at least 5% as compared to their 1990 levels. In particular, it sets targets for future emissions by each developed country. The Kyoto Protocol was signed by about 180 countries and commits 38 industrialised countries (Environment Canada, 2002).

Accidental and non-accidental forest fires made air pollution a transitory phenomenon in even the most rural environments. Following the Industrial Revolution, the combustion of fossil fuels and the by-products from the manufacture and use of chemicals added greatly to the quantity and multiplied the variety of pollutants in the air.[3]

Air pollution has a number of negative effects, including human morbidity and mortality and decreased productivity of biological resources (Lester, Lave and Eugene, 1977; Environment Canada, 2002). For these reasons it is most definitely a discommodity. Randall (1987), among many others, argued that air pollution occurs because it is an inexpensive way for the producer of waste materials to dispose of them. Because the ambient air is a public good that is both non-rival[4] and non-exclusive, it is unlikely that anyone disposing of wastes into the air would personally suffer all the costs of the resulting air pollution damage. The market failure resulting from non-exclusiveness or non-rivalry permits the acting party to impose some of the costs of the activity on the general public.

Economic theory offers three basic approaches to the problem of air pollution due to residuals from production or consumption activities: tax-subsidies, regulations and emissions trading. However, early environmental policies were not as flexible as what economists recommend.

The late 1960's were a time of heightened interest in environmental issues and an important period for both debate about clean air issues and for the creation of new legislation in the U.S. A significant event was the four-day smog episode the City of New

[3] "*Encyclopedia of the Atmospheric Environment*" available at: www.doc.mmu.ac.uk/aric/eae/Air_Quality
[4] A non-rival good means that if one individual consumes the good, this does not reduce the utility other individuals can derive from it. A non-exclusive good means that any individual can freely consume it without denying others the ability to benefit from it. In other words, the rate of consumption is independent of the number of consumers and how the good is utilized (Oakerson, 1980).

York faced in 1966. This pollution episode caused an estimated eighty deaths. Following this event, President Johnson proposed national emission standards for industrial sources and the establishment of regional air quality commissions. This gave way to the 1967 Air Quality Act, which was in turn a prelude to the legislation of the 1970's. Hard-line regulations and strict enforcement were the norm in the 1970's with the 1970 *Clean Air Act Amendments* expanding the role of the federal government in air quality control (Kneese et al., 1975).

The emission control policies of the 1970s were not cost-effective in that they did not stipulate that most of the abating be done by the least-cost abaters. The command-and-control approach was very prescriptive, usually imposing specific technology to agents regardless of their cost-effectiveness. They led to interregional distortions and were not well adapted to a dynamic economy, precluding continuous improvement and innovation in abatement technology (Randall, 1987). For example, the 1977 *Clean Air Act Amendments* required utilities to install expensive abatement technology regardless of their overall facility emissions (Randall, 1983).

Tradable emission permits were first introduced in the United States during the mid-1970 by the *Environmental Protection Agency* (EPA). Their main purpose was to combat the high cost and rigidity of traditional legal approaches. The new approach brought innovative actions such as limits set on emissions, court procedures for non-observance and fines for infringement. By doing that, EPA's *Emissions Trading Program* allowed polluters to reduce their emissions below a set standard and then apply for a credit (UNCTAD/GID/11, 1995).

The first emissions trading program element under the U.S. *Clean Air Act*, namely "netting", was introduced in 1974. This allowed firms that create a new source of emissions in a plant to "net-out" by reducing emissions from another source in the same plant. This is also referred to as "internal trading." In the late 1970s, emissions trading was improved by adding three key policy innovations, namely "offsets", "bubbles" and "banking". Offsets, which came into effect in 1975, allowed new sources to come online in a region where the maximum allowable pollution level is attained, as long as they can get other polluting sources to reduce their emissions by an amount that exceeds the emissions from the proposed new installation. This is also referred to as "external trading." Bubbles[5], introduced in 1979, are arrangements whereby several neighboring emissions sources are allowed to be combined and treated jointly for regulatory purposes. This flexibility mechanism applies to existing sources and allows for internal and external trades (Hahn, 1979). Banking, also allowed since 1979, is an arrangement by which emissions credits can be "stored" or "stockpiled" for use in trading in the future, as opposed to expiring after a year (Randall, 1987; Hahn, 1989).

These flexibility mechanisms have saved industry an estimated $960 million to $12.7 billion (1989 USD). Most of the savings were achieved through netting/internal trading[6], as firms saw this program element as a lower transaction cost opportunity, as compared to external trading (Hahn, 1989). In that respect, many of the potential gains from trade were not realized. Furthermore, Rose (2000) found that public utility commissions in the U.S. have adopted policies that encourage sub-optimal choices by individual utilities, such as to scrub local high-sulphur coal in order to protect in-state

[5] The term "bubble" stems from the image of an imaginary bubble that would be put over a plant with all emissions exiting the plant at a single point from the bubble.
[6] $525 million to $12.3 billion in savings were realized by using the netting program element.

jobs. This brings us further away from realizing the theoretical efficiency gains from emissions trading.

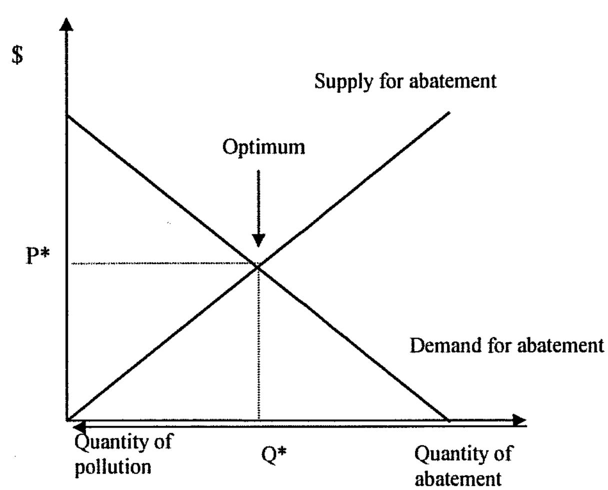
3. Theory of Emissions Trading

The source of the problem of environmental abuse, or overuse of environmental resources, is commonly viewed in economic theory as a failure of the market economy to recognize and internalize the costs imposed on the environment by human activities. In the case of environmental emissions, negative externalities arise whenever the production or consumption activities of some agents reduce the quality and quantity of environmental resources available to others. Using air pollution as an example, pollution of the air from one factory's production activity affects the consumption of clean air for other consumers and producers. The polluter is not required to pay for these costs imposed on others as long as clean air is considered to be a free good (Baumol and Oates, 1988).

A recommended solution to control such externalities from the point of view of economic theory was the idea of using market mechanisms. In his pioneering work, The Economics of Welfare, Pigou (1920) suggested a tax on the output of an activity which generates the negative externality. According to him externalities stem from differences between private and social costs of an activity. These differences should be corrected by taxes or subsidies in such a manner that they alter the private cost until it equals the social cost. He showed that, by choice of an appropriate tax rate, the behavior of the polluter can be altered in such a way that his production decisions conform to that of a social welfare maximizer.

Coase (1960) later reinforced the concept of the market mechanisms' ability to overcome externalities with the introduction of the Coase Theorem. The Coase Theorem states that when property rights are well-defined and parties can participate in unfettered negotiations, externalities can be addressed through trading, that is, the polluter can compensate the pollutee or the pollutee can "bribe" the polluter to reduce pollution. This effectively creates a market for the externality by assigning property rights to the over-used commodity, in order to force compensation to the commodity owner and/or reduce consumption of that commodity. Note that transaction costs have an important role to play in this context. Coase (1960) contends that many potentially beneficial trades will not take place in the market because of the corresponding transaction costs (i.e. search and information costs, bargaining and decision costs, policing and enforcement costs). The works of Pigou and Coase form the first best solutions to the externality problem and provide theoretical foundations for designing economic instruments for pollution control.

Figure 1: Optimal level of abatement[7]



Source: *Adapted from Randall (1987), and Baumol and Oates (1988)*

The affected party has a demand for abatement, whereas the polluter has a supply curve for abatement. The demand curve reflects the value of marginal damages avoided through the polluter's abatement efforts, and the supply curve reflects the incremental production cost required to provide abatement.
Q is the optimum level of pollution, at which point the polluter pays the affected party [Q* x P*], or the affected party could pay the same amount to the polluter, depending on who holds the property rights. (See Randall, 1987 p. 186-189 for more on Coasian analysis)*

[7] Abatement means reducing the degree of intensity of, or eliminating, pollution.

In a similar way, abatement efficiency is achieved when the marginal cost of control (represented by the demand for abatement) is equal to the marginal damage (supply for abatement) caused by the pollution of each emitter. Randal (1987) proposed a way to achieve the equilibrium point by imposing a legal limit on the amount of pollution allowed by each emitter. If the limit was chosen precisely at the level of pollution where marginal costs equal marginal damage (Q* in figure 1[8]), abatement efficiency would be achieved.

In response to this problem, economic theory has devised a set of market-based policy tools to control the excessive use of environmental resources and internalize the external costs to society. Emissions trading is a practical policy tool that allows agents such as firms, individuals or governments to trade pollution units, with the aim of reducing environmental damage, minimize costs and improve the environment. It lowers the cost of achieving a specified environmental objective, such as reducing emissions of a specified pollutant, relative to command-and-control regulations.[9] The environmental authority can directly limit waste discharges to their targeted level by restricting the quantity of permits. As a market for these permits develops, a market-clearing price would emerge that will indicate to polluters the opportunity cost of abatement. Since all sources would face the same price for a permit, cost-minimizing behavior would result because marginal abatement costs would be equalized among these sources. This is the first-order condition for the least–cost allocation of "pollution quotas" among sources (Baumol and Oates, 1988).

[8] Figure 1 ignores transaction costs.

[9] Other possible objectives of emissions trading programs are: to enable a more stringent objective to be achieved because the cost is lower; to enable an environmental objective to be achieved more quickly; or to enable economic growth to occur without adversely affecting the environment.

In its simplest form, a limit on total emissions of a pollutant by a specified set of sources is established; allowable emissions within this total are then defined for each source, forcing agents to limit their actual emissions to this specified environmental target. A source whose actual emissions are below its allowable target can sell this "excess abatement" to agents who are not able to reach their environmental target in the form of a credit or allowance.[10] Conversely, a source whose actual emissions are higher than its allowable target must buy credits or allowances from other sources to cover its excess emissions.

Participants are not obligated to trade, but they have a financial incentive to do so if it reduces compliance costs. Sources able to control their emissions at a low cost can sell surplus credits or allowances at a profit. Sources facing high abatement costs can save money by purchasing credits or allowances from other sources. Trading practically continues as long as there are benefits to agents involved in the process, that is, as long as there is someone in the market willing to pay for allowances or credits.

4. Types of Emissions Trading Schemes

Emissions trading schemes can take various forms; from an "open market" or "credit trading" system to "allowance trading" or "cap and trade" schemes (Dewees, 2001). Both credit and allowance trading can be used to manage the environment and each type of emission trading scheme has differing strengths and weaknesses. The following is a brief description of the different types of trading systems:

[10] The differences between credits and allowances are discussed in the following chapter.

4.1 Allowance trading systems

Allowance trading is a mandatory scheme that requires the establishment of an overall cap on total emissions of a given pollutant, which is then divided up amongst participants. In an allowance trading scheme, the responsible authority creates allowances that are equal to the overall cap and then distributes them to participants according to an allocation scheme. Participants are required to monitor emissions and report them to the program authority according to a specified protocol. At the end of the year participants must provide the program authority with allowances equal to their actual emissions (Environmental Law Institute, 1997).

One of the key issues in such a program is the initial allocation of allowances. The theoretically preferable allocation method is through auctioning because it is simple and efficient (Tietenberg, 1980, 1985). However, experience shows that most existing trading programs have allocated allowances through "grandfathering," that is, the allowances are initially allocated to participants free of charge according to a specified allocation rule (Hahn, 1989; Clean Air Corporation, 2002). Since the allowances are valuable commodities, devising an allocation rule that is accepted and considered equitable by all participants is a contentious issue. Allocation rules can be based on historical emissions, either from a chosen base year or an averaged level from a number of years (Clean Air Corporation, 2002).

Once the allowances are allocated, participants can choose to either reduce their actual emissions below the quantity of allowances received and sell the unused allowances, or buy allowances on the market if their business operation generates more pollution than what is allowed. Participants have an economic incentive to trade as long as the marginal cost of control differs between polluting firms.

4.2 Credit trading systems

In a credit trading system a baseline of acceptable emissions is established for each participating facility with the limit on total emissions being the sum of the baselines of all sources. The baseline is typically set at an arbitrary point in time, for example, 1990 level emissions in the case of the Kyoto Protocol. The level of allowable emissions is determined by the regulations, or negotiated agreement, governing emissions of the pollutant by the given facility. The regulations may establish an allowable emissions rate (e.g., X kg. of emissions per unit of output) or an absolute limit on emissions for a given period of time (e.g., Y tones per year).

Participants can create credits by documenting that their actual emissions are below their baseline emissions. Credit creation is voluntary, and the credits created can be used either to meet voluntary commitments or regulatory obligations. If credits are to be used to satisfy regulatory compliance, the regulation must specify the conditions under which this option can be pursued. Conversely, participants whose projected emissions are higher than their baseline may choose to buy credits if doing so is less costly than alternative compliance options, such as purchasing abatement technology, and if purchasing credits is allowed by the program authority.

4.3 Hybrid Trading Systems

It is also possible to combine elements of credit and allowance systems to create a hybrid trading system. Under a hybrid system participants are assigned an absolute emissions target and are allocated an equivalent number of allowances. In addition, these entities are allowed to purchase emission reduction credits generated by participants that are not subject to absolute emission targets. There are several ways that such credits can be generated. For example, non-covered entities could reduce emissions (relative to a baseline) and then sell the credits; covered entities could invest in off-site emission abatement or sequestration projects; or a third party could invest in emission reduction or sequestration projects and then sell the credits to covered entities. The Ontario *Cap, Credit and Trade* program for NOx and SO_2 is an example of a hybrid system. The program caps emissions of NOx and SO_2 in the province's power sector, but allows power generating units to purchase credits from uncapped sources (Ontario Ministry of the Environment, 2001; Basak, 2003).

Each type of emission trading schemes described above has its advantages and disadvantages. Allowance systems tend to be the most environmentally effective since the establishment of an absolute pollution limit ensures that the desired environmental results are realized. On the other hand, credit creation schemes do provide incentives for uncapped sources to reduce their emissions, potentially leading to lower overall compliance costs.

However, due to the additional flexibility of the credit and hybrid schemes, the absolute effectiveness of neither system is assured, and thus there is no guarantee that the program authority's environmental target will be met. Lastly, the transaction costs associated with the verification and certification of emission reductions tend to be significantly higher in credit and hybrid schemes than they are under a cap and trade program (ICF Consulting, 2002).

5. Emissions Trading System Features

Within each of the three schemes described above, a number of provisions can be included to increase the flexibility that participants have in achieving their targets and/or to extend system coverage by encouraging emission reduction activities from entities that are not assigned targets.

5.1 Banking and Borrowing

Banking provisions allow participants to hold tradable emission unit (allowance or credit) for various time periods, and to use or trade it in the future. In the majority of trading programs, limits are placed on the length of time that allowances and other traded instruments can be banked. Conversely, borrowing allows participants to use allowances that are not yet issued and are in fact scheduled to be released in later periods, for compliance in the current period (Zhang, 1998). Most trading programs do not allow borrowing, as there is an inherent risk that borrowing entities may not be able to repay the borrowed instrument through future emission reductions (ICF, 2002).

5.2 Opt-in provisions

In certain trading programs, entities are allowed to voluntarily opt in. Once they have opted in, these entities are treated as any other regulated participant, that is, they are assigned an emissions target or cap, receive allowances, can generate emission reductions credits, and otherwise act as any other regulated entity covered by the trading system. Once an entity has elected to opt in, it cannot withdraw from the regime (U.S. EPA, 2002).

5.3 Bubbles

Bubbles allow two or more emission points, such as facilities, to be treated as if they were a single source (Hahn, 1989). Bubbles can be extended to include not only emission points within the same plant, but emission points in plants owned by different firms in various locations (Zhang, 1998).

5.4 Netting

Netting is a provision that allows emission reduction credits accumulated elsewhere by a source (facility) to be used to offset increases expected from the expanded or modified portions of a facility (Clean Air Action Corporation, 2002).

6. Requirements for a Successful Trading System

A number of basic requirements must be satisfied for any emissions trading program to achieve cost savings, innovations and to meet the environmental target set by the program authorities. This section briefly describes the key elements for a successful trading scheme.

6.1. Environmental Effectiveness

The environmental performance of an emissions trading system is in most cases determined by its fundamental regulatory requirements. However, there are certain circumstances under which the interaction of a trading system and an existing regulatory structure could work to the harm of the environment. These circumstances are most likely to occur when the trading system allows for inter-gas trading, cross-season or cross-region trading.

6.1.1. Inter-pollutant trading

If the system allows emissions permits for a given pollutant (e.g. NO_x) to be used to satisfy the regulatory requirements of another pollutant (e.g. VOC) in some measure, then the environmental integrity of the system may be compromised. This may be problematic in cases where the scientific proof on the interaction between two pollutants is vague or when their correlation changes in response to other conditions (UNCTAD, 1998). For instance, ground level ozone formation hinges upon the chemical correlation between NO_x and VOCs in the presence of sunbeams. Unconstrained inter-pollutant trading between NO_x and VOCs could result in a reduction in one pollutant in circumstances where reducing the other is of greater importance. Furthermore, as Devlin and Grafton (1994) have found, when the "optimal" number of permits is set, the substitution between pollutants leads to an inefficient outcome.

6.1.2. Cross-season or Cross-region Trading

The effects of some air pollutants on the environment are frequently seasonal and/or regional. Air pollutants such as NO_x, SO_x, and VOCs are all cases in point. If emissions permits in any one of these pollutants can be promptly traded for another on a one-for-one basis (or any other unacceptable ratio, according to atmospheric science), regardless of the season or region in which the permits or emission reduction credits were created, it is conceivable that trading could contribute to the formation of "environmental hot spots"—i.e., regions where the intensity of a given pollutant is extremely high (ICF Consulting, 2002).

6.1.3. Activity Shifting

Leakage associated with activity shifting is another potential source of conflict between a trading system and the underlying regulations that were established to achieve a particular environmental objective. Awarding emission reduction credits for forest conservation activities that can be used as offsets against carbon or other GHG emission reduction requirements is a practice that is particularly vulnerable to this type of problem. Preserving forests on one plot of land might mean that harvesting activities simply shift to another adjacent or near-by area. Activity shifting can also include the contracting out/outsourcing of a company's activities. For example, if a company oxidizes asphalt as part of its manufacturing process and then decides to outsource this activity to another company, the emissions will not have been reduced, but simply shifted (ICF Consulting, 2002).

6.2. Monitoring, Verification, and Record Keeping

In order to ensure that companies actually abide by a given regulatory system, some sort of monitoring and enforcement mechanisms must be in place. This sort of enforcement is not easy. This is particularly true of monitoring and verification systems for air emission regulations, since the output of pollutants can often only be monitored through sophisticated and expensive monitoring techniques. Several different methods of such monitoring exist, and include: self-certification; on-site inspections; and direct monitoring of pollutant flows.[11]

[11] "Regulatory Arrangements for Trading in Greenhouse Gas Emissions" – Report to the Speaker of the House of Representatives on August 25, 1998, Australia.

6.2.1. Self Certification

The first method of monitoring the output of pollutants is to require that participating firms self-report on their output. Obviously, however, firms will have an incentive to underreport their output of the given pollutant. Therefore, this method of monitoring works best in situations where the output of the pollutant is closely related with the use of a given fuel, or with the output of the firm's output of its own product. For example, the burning of traditional fuels like oil and gas emits a known amount of carbon dioxide. Therefore, if the amount of fuel used can easily be verified, the amount of carbon dioxide emitted can be estimated with a fair degree of accuracy. Even under these circumstances, it is likely that self-certification will be a highly reliable enforcement tool. Furthermore, under an emissions trading regime, firms will be unwilling to purchase credits unless there is a third party that can certify that the credits are indeed available (ICF Consulting, 2002).

6.2.2. On-site Inspections

The second possible method of monitoring is the direct inspection of the premises of the firm. This method is good in terms of its ability to force firms to comply, especially if the possibility of a random spot-check is high enough to be credible. This also allows the inspection agency to ensure that measurement and control equipment is functioning properly.

The drawback of such monitoring, however, is that it is more expensive and time consuming for the inspection agency. These inspection costs will, of course, increase with the number of participating firms and with their geographic dispersion (U.S. EPA, 2001; Clean Air Corporation, 2002).

6.2.3. Direct Monitoring of Pollutant Flows

Monitoring of pollutants utilizing direct monitoring technologies can be another reliable method of determining compliance. Continuous Emissions Monitoring Systems (CEMS) are one example of monitoring technologies used to determine the contents of emissions containing several gases from large stationary sources such as electric power generators. Contrary to these benefits, CEMS and related monitoring systems are expensive to purchase and maintenance often requires specialized personnel to ensure the systems are functioning correctly. Additionally, smaller stationary sources and mobile emissions for the most part are not measurable with the CEMS and related technologies.

In addition to direct monitoring technologies to ensure regulatory compliance, allowing firms to use reduction credits to satisfy their emission targets is another option that may ensure that compliance and enforcement issues are satisfied. When dealing with reduction credits, the legitimacy of the reductions must be validated thus showing the declines are real, quantifiable and permanent. Particular emphasis must be placed on the resources needed to determine the quality and suitability of the emission credits. Measures of abatement quality and suitability often involve diverse, detailed knowledge of industry information and related sources.

As part of the effective compliance monitoring process, records need to be maintained to track progress and report on compliance at the end of each compliance period. An area of particular concern involves changes in the ownership of emission allowances and purchases and sales of emission credits. It is recommended that firms should be required to demonstrate their legal claim to all emission instruments at the end of a compliance period. Where the program authority has an inadequate record keeping, the tracking of the transfer of credits and allowances could pose problems. When problems exist, the program authority could be placed in the position of dispute settlement between two or more parties claiming the right to use the same emission credit or allowance (ICF Consulting, 2002).

6.3 Basic commodity market requirements[12]

The creation of an emissions trading scheme is in effect the creation of a market for a new commodity, that is, pollution, or pollution permits. In that respect, the same requirements apply than that of commodity markets. The pollution permit market (or allowance market), like any other market, has a number of basic requirements such as the need for competition in the market, commodity value, liquidity, transparency, confidence and stability, and a forward price curve.

6.3.1. Competition for traded instruments amongst program participants

Trading systems only function well if they are "thick," that is, if there is a sufficiently large number of participants to ensure that no one party (or group of parties) has the ability to significantly influence the price of pollution permits.

For example, if a firm or groups of firms are net sellers of permits, they might withhold/hoard permits from the market in an effort to extract rent from firms needing to purchase permits to meet regulatory requirements. This fear of hoarding is felt in many policy circles in the case of Russia and Kyoto. Many suspect that Russia could exercise

[12] This section draws heavily from CENTRE FOR EUROPEAN POLICY STUDIES , 2002. "EU emissions trading: Environmental credibility, economic efficiency and the international climate regime." Presented at the European Parliament Workshop, "Climate change policy of the EU: The role of emissions trading" Brussels, Thursday, 18 April 2002.

market power by restricting supply and artificially holding the price of credits higher thanks to the large excess of GHG credits that it potentially holds.

Another reason for warranting competition in emissions trading markets is to avoid firms or groups of firms from using their dominant position in the emissions trading market to gain a competitive advantage in their product market. For example, a dominant firm might purchase and hoard permits in order to deny its competitors access to emission instruments they need in order to produce their products. Further, if there are too few participants in the program, prices may become unstable.

In thin markets, price volatility can be a serious problem—discouraging participants from relying on purchases of tradable emissions permits for their compliance needs. However, empirical evidence and model simulations suggest that as few as eight to ten active participants might be all that are needed to ensure reasonably stable markets (Tietenberg, 1985).

6.3.2. Commodity with value

Pollution permits are property rights and in many respects are like currency. They need to be verifiable and fraud-proof to ensure market players assign them value. Independent information on the commodity traded allows market players to make informed trading decisions.

6.3.3 Liquidity

Efficient markets require liquidity. In order for a market to be liquid, it needs to have many players and differing willingness to pay for the commodity being traded (due in part to heterogeneous abatement costs among players). To facilitate transactions, a broad range of participants is required, including buyers and sellers, brokers, speculators or arbitrageurs. The various market players buy risk, allow for long-term planning such as investment in abatement technology and can smooth market volatility.

6.3.4. Certainty

Confidence and stability are also key for the proper functioning of an emissions trading market. Market participants dislike frequent rule changes and prefer a predictable and constant regulatory regime.

6.3.5. Forward price curve

In order to enable market participants to manage risk there is a mechanism that allows the trade in future allowances at a predetermined price. This allows industry to make the best investment decisions, such as choosing between investing in new abatement technology and buying allowances.

7. Experiences with Emissions Trading

While the theoretical literature on the subject of emissions trading continues to accumulate (Kneese and Schultze, 1975; Lester and Seskin, 1977; Tietenberg, 1980, 1985; del Calvo y Gonzales, 1981; Crandall, 1983; Devlin and Grafton, 1994, 1996; Kling, 1994; Klaassen and Nentjes, 1997; Ben-David and Brookshire, 1999; Centre for European Policy Studies, 2002), the actual implementation of such programs remains limited. There is much to be learned from these practical experiences with emission permit markets. Specifically, problems associated with high transactions costs, insufficient competition, restrictions on trade, and uncertainties regarding emission property rights have limited the ability of market systems to achieve cost effective allocations of control. The characteristics and the relative success of several emissions trading programs are examined below.

The U.S. first experimented with emissions trading in the mid-1970s. The program, administrated by the U.S. *Environmental Protection Agency* (EPA), compelled new sources or existing sources that wished to expand their operations to purchase credits, which represented emissions reduction (offsets) achieved by existing sources. For "offsets" to be certified as credits, emissions reductions had to be additional (beyond requirements), quantifiable, and permanent.[13]

As part of an effort to greatly reduce lead in gasoline, the U.S. EPA established a lead credit market in 1982 and expanded it in 1985. The lead phase-down program, which ended in 1987, was designed to facilitate the transition to lead-free gasoline. The program was a typical credit market: a refinery that used less lead in gasoline (grams/gallon) than required by the standard would earn credits; these credits could be traded with any other refinery. The program was successful in meeting its environmental goals.

In 1993, a market for nitrogen oxides (NO_x) and sulphur dioxide (SO_2) was established in California under the *Regional Clean Air Incentives Market*, or RECLAIM.[14] RECLAIM, a cap and trade program with caps designed for NO_x and SO_2 emissions, has achieved significant success in reducing the price of compliance, with annual savings relative to command and control regulation projected at $58 million (USD) annually or 42%. The RECLAIM program is designed to meet its target emission reductions by 2003.

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[13] http://yosemite1.epa.gov/ee/epa/eermfile.nsf/vwAN/EE-0216B-07.pdf/$File/EE-0216B-07.pdf

[14] http://www.aqmd.gov/reclaim/reclaim.html

In 1990, the U.S. Congress announced the creation of a cap and trade program for SO_2, as part of an overall review of the Clean Air Act. The Acid Rain Program[15], which began in 1995, had two key features: it set ambitious SO_2 emission caps for fossil fuel–fired power plants and gave plant operators flexibility to reduce emissions by either switching to less polluting fuels, installing devices to deal with end-of-pipe emissions, or trading allowances. Other key features embodied in the Acid Rain Program included strict monitoring procedures, stiff penalties for noncompliance, and the ability to 'bank' or save surplus allowances towards future compliance periods, which acted as an incentive to cut emissions beyond the requirements. The Program has achieved a strict environmental goal to reduce sulphur dioxide SO_2 emissions. Results from the first years of operation since 1995 show compliance costs were less than half those predicted by the EPA, and many times lower than those predicted by industry (U.S. EPA, 2001; Clean Air Corporation, 2002).

The success of the SO_2 program depended on the emergence of an efficient private market for emissions rights. Empirical analysis of the evolution of this market (Joskow et al., 1998) indicates that a relatively efficient market evolved in the early years of the program's inception. Also, third-party intermediaries developed standardized, transparent trading procedures, after which commission fees fell dramatically. As the transaction costs decreased, active intertemporal futures markets emerged (Joskow et al., 1998).

Other important lessons have been learned from the U.S. experience with emissions trading. For example, emissions trading programs appear to have more success

[15] http://www.epa.gov/AIRMARKET/arp/index.html

if they are developed as a new initiative, as opposed to an "add-on" to an existing regulatory requirement. One of the reasons for this appears to be that environmental groups are more likely to support a trading scheme if it will address a previously uncontrolled environmental problem. Initial allocation is always a contentious issue, but one that is resolved more easily if most parties under the trading scheme stand to gain from the program when compared to a command-and-control approach. Allowing the banking of emissions provides polluting sources with increased flexibility and drives down overall compliance costs. The creation of a market for pollution brings about private institutions that facilitate market transactions and increase information flows to the benefit of all agents involved in trading (OECD, 1999).

Already, the SO2 program's *Allowance Tracking System* has allowed 89% of transactions to be processed within 24 hours. The information revolution could decrease transaction costs and improve information flows even further (Kruger et al., 2000). The U.S. experience also suggests that "cap and trade" systems are easier to negotiate with stakeholders than credit based systems, and are therefore more likely to be politically acceptable (Hahn, 1989; OECD, 1999).

Canadian experience with emissions credit trading programs began in Ontario with the introduction of the *Pilot Emission Reduction Trading* (PERT)[16] project in 1996. PERT was a voluntary, industry-led, multi-stakeholder initiative with the objective of evaluating the feasibility of "open market" emissions trading as a mechanism to assist in the reduction of GHGs, smog and other air pollutants in the heavily industrialized corridor spanning Windsor, Ontario to Quebec City. PERT provided a skeleton of rules,

[16] http://www.pert.org/pert.html

which evolved with experience over time. The program was transformed to *Clean Air Canada Inc*., which seeks to act as an advisory group to governments on SOx, NOx, and also greenhouse gases. Over 60 projects have been reviewed to date.

Another Canadian joint pilot program, the Greenhouse Gas Emission Reduction Trading (GERT)[17] Pilot, was launched in 1998. GERT represents a partnership between the Canadian government, a number of provinces, industry, labor, and environmental groups and is designed to test the effectiveness of a GHG emissions credit trading program in Canada and look at ways to develop rules for the project cycle. Four projects have been evaluated to date. Since GERT's objective was setting rules, from the beginning there was a lot more consultation and analysis involved and less experience compared to the PERT program.

In 2001, the government of Ontario has announced the establishment of a NO_x and SO_2 cap, credit and trade emissions trading system targeting large emitters in Ontario's electricity sector.[18] The system allows for credits to be created outside of Ontario, including international jurisdictions. As well, the use of allowances from other Canadian and foreign environmental regulatory programs would be permitted. The Ontario Emissions Trading System took effect on 1 January 2002.[19] When fully implemented in 2007, the limits would cut smog and acid-rain-causing emissions from fossil fuel plants by 53% for nitrogen oxides (NOx) and 25% for SO_2. These reductions are equivalent to taking more than one million passenger cars off Ontario's roads (Ontario Ministry of the Environment, 2001).

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[17] http://www.gert.org
[18] http:// www.ene.gov.on.ca/envision/news/102401mb.htm
[19] http://www.ene.gov.on.ca/envision/env_reg/er/documents/2001/RA01E0020-B.pdf

In November 2002, the Government of Canada released its "Climate Change Plan for Canada" (Government of Canada, 2002), where it outlined its plans for achieving the country's Kyoto targets. The plan includes a "Large Industrial Emitters" domestic emissions trading scheme that would allow for the creation of credits (offsets) and access to the international greenhouse gas market. Credits from the forestry, agriculture and possibly landfill sectors would be permitted to be created and sold into the emissions trading system. This emissions trading scheme is at an early stage of development, as no final targets have not yet been set for the sectors that fall under the "Large Industrial Emitters.[20]" The permit allocation method proposed is still not fully determined; they are proposing to allocate permits free of charge and based on emissions intensity. Under an emissions intensity approach, also known as "rate-based emissions trading," permits allocated to a firm would grow or shrink based on its annual production. Firms with low emissions per unit of production would not need to purchase as many permits as firms with high emissions intensity. The emissions intensity factor is yet to be determined and will be subject to negotiations with individual Large Industrial Emitters sectors.

A private consortium of 14 U.S. and Canadian companies recently launched the Chicago Climate Exchange (CCX), a voluntary cap and trade program for reducing and trading GHG emissions. The CCX members have agreed to reduce their overall GHG emissions including CO2 and methane by 4% over the next four years. Under the pilot program, CCX members will receive credit for emissions reductions above 4% and will be able to sell or trade those credits to other members having difficulty meeting this goal.

[20] The sectors covered under the "Large Industrial Emitters" include oil and gas (upstream extraction, oil and gas pipelines, gas utilities, petroleum refining), mining (both metal and non-metal), pulp and paper production, chemical production (industrial inorganic chemicals, industrial organic chemicals, and chemical fertilizers and fertilizer materials, iron and steel production, smelting and refining, cement and lime production, glass and glass container production (Government of Canada, 2002).

The emissions trading system is scheduled to begin in the spring of 2003. CCX will administer the program and verify emission sources, carbon sinks, offset projects and liquidity providers in North America. To foster international emissions trading, projects in Brazil that generate emissions offsets may also participate. Projects that may be eligible for offsets include landfill and agricultural methane recovery, and carbon sequestration through reforestation and agricultural soil projects.[21]

Emissions trading systems based on emissions intensity have not been widely used. One example is the U.S. Corporate Average Fleet Emissions (CAFÉ) standards (U.S. EPA, 2001). The main problem with this type of system is that it fails to limit the aggregate amount of allowed emissions, that is, it fails to establish an overall emissions cap on the program participants. For example, while US auto manufacturers met their CAFÉ improvements overall emissions increased due to an increase in miles driven (CO2e.com, 2002).

Early lessons will emerge from greenhouse gas emissions trading schemes beginning to operate in Europe. The UK[22] and Denmark[23] are implementing GHG emissions trading systems. In November 2001, the European Union released a draft legal framework for an EU-wide GHG trading system scheduled for piloting in 2005. All three systems—the UK, Danish and EU—are markedly different. This fragmentation of rules (different sectors, different compliance regimes, different gases) is likely to complicate cross-border transactions.

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[21] Source: Schnapf Environmental Report, published by Law Professor Lawrence P. Schnapf, 55 E.87th Street, #8B, New York, New York 10128.

[22] For further information on United Kingdom's Greenhouse Gas Emissions Trading Scheme, see: <http://www.defra.gov.uk/environment/climatechange/trading/pdf/trading-summary.pdf>.

[23] Denmark's emissions trading system and legal texts: <http://www.ens.dk/uk/energy_reform/emissions_trading/index.htm>.

For more examples of emissions trading programs see Appendix I, where past experiences in Canada, the U.S. and internationally are summarized. These include voluntary pilot programs as means to test design elements of the trading system, voluntary credit purchasing as a way to test the market and gain trading experience, and fully mature and developed emissions trading schemes exemplified by the U.S. *Acid Rain Program.*

8. Comparing theory and practice

Many authors have analysed emissions trading systems that have been put in place in various jurisdictions, including Hahn (1989), who examined the implementation of taxes and tradable permits in three European countries (France, Germany, and the Netherlands) and the United States and concluded that they were rarely introduced in their textbook form. He found that tradable permits had primarily been used to promote cost savings and that little auctioning has been used for allocating allowances. Burthraw (1996) analysed the SO_2 allowance trading system stemming from the 1990 amendments to the U.S. Clean Air Act and found that the costs of compliance were much less than what was initially anticipated by the U.S. EPA, even though at the time of the study, very few trades had taken place. However, Schmalensee et al. (1998) have found that although the U.S. SO_2 allowance trading system surpassed its environmental targets in a timely fashion and resulted in permit prices lower than what had been estimated in ex ante studies, they have also found that investment in abatement technology by market participants was excessive (due to expectation errors) and therefore permit prices understate industry abatement costs.

Many academics and policy-makers have been concerned that certain firms in an emissions trading program could exert market power by hoarding allowances and theory suggests that exploitation of market power could reduce or even eliminate the gains from emission trading (Hahn, 1984; Tietenberg, 1985; Misiolek and Elder, 1989; Godby et al., 1998; Godby, 2000).

Economic theory favours auctioning as the most efficient method of allocation as companies would only buy as many allowances as they need. Further, auctioning leads to a price for allowances, and thereby facilitates the initial functioning of the market. Auctioning would also benefit those that emit few greenhouse gas emissions, such as electricity from renewable energy sources or nuclear power, or that have done best in the past to reduce emissions, since early movers would have to buy fewer allowances. Auctioning has also the advantage of providing equal access to allowances and transparency in the granting of allowances and therefore avoids the risk of distortions to competition in the internal market, by avoiding delicate negotiations of how many allowances are allocated to each firm.

As opposed to grandfathering, where allowances are allocated for free, auctioning inevitably adds costs (in absolute terms) to industry. Auctioning is perceived as a tax by industry, as they are required to pay a price to continue emitting as they have in the past. For industries exposed to international competition with firms that are not subject to a similar pollution constraints, this makes for an uneven playing field and can lead to a competitive disadvantage. One possible solution to reduce the cost burden imposed by an auction would be to recycle auction revenues to firms. That way, auctioning would in principle be made revenue-neutral by equivalent reductions in other taxes. This requires the "earmarking" of government revenues, which in not possible in many jurisdictions[24], including the Canadian government.

The main barriers to the implementation of successful emissions trading schemes are not limited to those outlined by academics. Although issues such as grandfathering and preferential treatment are the main dissonance points between theory and practice, other obstacles are noteworthy. An important hindrance to emission trading implementation in Europe has been stakeholder resistance due to lack of familiarity with the concept. Many perceive this system as a possibility to "evade" pollution control, especially if permits are allocated free of charge. Another important point is that Europeans have preferred the use of green taxes, which generate State revenue. If an emissions trading scheme replaces green taxes, concerns about loss in government revenue will arise (OECD, 1999).

The business community has been broadly involved in developing and promoting tradable permit systems. Therefore, business is not expected to present a significant obstacle to the introduction of a system of tradable permits, even if it is an unfamiliar and untested system. The general experience is that hesitation of business people is linked to lack of knowledge of a new instrument, and to uncertainty about the implications for their own company.

For a trading system to function properly, participants must thrust that the rules of the game will remain stable over along period of time. Cost efficiency is achieved when companies can choose between investing in abatement and selling/buying permits. If buyers do not trust that permits will be accepted in the future, the price of permits will not

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[24] Directing the revenue from a specific tax to a specific purpose can increase the political acceptability of a new tax. However, earmarking is neither effective nor efficient (Glover, 1997).

correspond to marginal abatement costs, and the system will not serve its function. Tietenberg (1980) found that when firms underestimate future allowance prices, they tend to underinvest in abatement technology. Converse was also found to be true.

9. Conclusions

Experience with market-based programs has demonstrated that they have had a positive role in environmental policy and can continue to play this role in the future. The issue is no longer whether they have a role to play but rather what kind of role they should play.[25] The term "Emissions trading" covers a range of policies from voluntary credit purchasing as a way to test the market and gain trading experience, or voluntary pilot programs as means to test design elements of a trading system, to a fully mature and developed emissions trading scheme exemplified by the U.S. *Acid Rain Program.*

The North American experience with emissions trading suggests that allowance trading proves more effective than strictly open market (credit) trading, in terms of both economic and environmental results.[26] In particular, the U.S. history of emissions trading showed the cap and trade approach under the *Acid Rain Program* and *RECLAIM* has resulted in significant program-wide cost reductions, whereas emissions credit trading has not been as successful. The U.S. experience also suggests that "cap and trade" systems are easier to negotiate with stakeholders than credit based systems, and are therefore more likely to be politically acceptable.

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[25] Tom Tietenberg, "Combating Global Warming", United Nations 1992.

[26] While Mexico has not undertaken emission trading schemes, it should be noted that through other non-trading initiatives, the country has experienced some success in reducing the same key environmental pollutants targeted by emission trading schemes in other North American countries.

Since credits are project-specific or activity-specific, they generally must be approved before they can be traded. An allowance might be comparable to a currency unit; a credit might be better compared to a specific good whose value must be determined each time through a regulatory process. Relative to allowance trading, a credit-based-only system reduces the commodity nature of the credit, increases transaction costs and uncertainty, and potentially inhibits trading. Ensuring that a credit represents actual emissions reductions can be complex. Creating credits that do not reflect emissions reductions could compromise the environmental objectives of the system.

In concrete terms, the results of the U.S. SO_2 cap and trade program have been positive. Power plants that participated in the first phase of the program not only reached full compliance (i.e., met all of their reductions) but they also cut an additional 30 percent beyond the original limits. Furthermore, reports indicate that the costs of achieving these reductions, initially estimated to be in the range of \$4–\$8 billion per year, were actually closer to \$1 billion.

Independently of the choice of instrument, experience has also shown that the initial allocation of permits to individual emitters tends to be a critical task. Despite a theoretical preference for an auction approach, grandfathering of the initial permits has been applied in virtually all applications that have been observed in practice (Hahn, 1989; OECD, 1999). The common concern that rises with the grandfathering approach is how to accommodate newcomers into an emissions trading system. In most cases this problem is resolved either by requiring newcomers to buy permits from other emitters, or by leaving a small initial allocation of permits in public hands, to be eventually channeled through an auction to the newcomers when the need arose. In none of these cases was there ever a rule adopted that would have the effect of guaranteeing newcomers access to a sufficient supply of permits with which to launch their business. "Environmental carrying capacity" is apparently at least as scarce as land itself, and there is no tradition of guaranteeing newcomers that the public sector will provide land for the commencement of a new business – in all cases, the land must be purchased from existing owners. All practical experiences with emissions trading systems therefore point to the conclusion that there is no need to give special access privileges to newcomers (OECD, 1999).

Pilot trading programs have also resulted in emissions reductions. For example, emissions reduction credits generated under the Ontario program PERT represent approximately fifteen million tones of carbon dioxide reduced from 1996 to 2000. As well, the private sector's eagerness to participate in the design phases of emissions trading schemes and undertake bilateral trades points to emissions trading as a practical means to encourage emissions reductions. Canadian and U.S. experiences in trading have demonstrated that for firms (entities) to engage in trading they need certainty or rules, experience from learning-by-doing (through PERT, GERT, bilateral trades, etc.), and some sense of assurance that early actions will be recognized.

Early lessons will emerge from greenhouse gas emissions trading schemes beginning to operate in Europe. The UK and Denmark are implementing their own GHG emissions trading systems. In November 2001, the European Union released a draft legal framework for an EU-wide GHG trading system scheduled for piloting in 2005. All three systems—the UK, Danish and EU—are markedly different. This fragmentation of rules (different sectors, different compliance regimes, different gases) is likely to complicate cross-border transactions.

In the final analysis, there is no single policy solution that dominates in all situations. Each instrument has its own strengths and weaknesses, making it particularly advantageous or disadvantageous depending on the specific situation. Summary tables in Appendix I provide a brief description of design elements for the emissions trading systems mentioned in this paper. Lessons learned from the theoretical work and the various experiences with emissions trading will help inform policy-makers on the inevitable creation of other pollution permit markets in Canada, North America, and the world.

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Appendix I

Summary Table 1 (U.S. Programs):

Program	*Geographic Coverage*	*Nature*	*Start*	*Targets*	*Coverage*	*Participation*	*Banking*
U.S. Acid Rain	21 eastern and Midwestern U.S. states in Phase I. Covers 48 states in Phase II	Market-based, cap and trade approaches for controlling air pollution	1995	reductions of 10 million tons of SO2 and 2 million tons of NOx by 2010	SO2 and NOx	Mandatory	Allowed
California Climate Action Registry	California	private, non-profit registry for GHGs	2002	Encouraged but not required	CO2	Voluntary	N/A
RECLAIM	Los Angeles, Orange, Riverside and parts of San Bernardino counties	*Cap and trade, market-based*	1994	75% reduction in NOx and 61% reduction in SO2 by 2003	NOx and SO2	Mandatory	Not allowed
Michigan ET Program	Michigan	State-wide, market based ERC trading	1996	to provide economic means for facilities to come in into compliance with other regulations	VOCs, NO_x, CO, SO_2, PM_{10}, and Pb	Voluntary	Allowed for limited time
Texas ET Program	Beaumont/Port Arthur, Houston/Galveston, Dallas/Fort Worth, and El Paso	Regional, market based, cap and trade program	1993	N/A	NOx, VOCs, SO2 and PM_{10}	Voluntary	Allowed for up to one year
New Jersey ET Program	New Jersey	Open market credit trading system	1995	3.5% GHGs reductions below 1990 levels by 2005, equaling 20.4 Mton CO2e	All GHGs expressed as units of CO2e	Voluntary	Allowed

Source: Gardner Pinfold Consulting Economists Limited, December 2002

Summary Table 2 (Canadian Programs):

Program	*Geographic Coverage*	*Nature*	*Start*	*Targets*	*Coverage*	*Participation*	*Banking*
CleanAir Canada (PERT)	Credit users must be based in Ontario; credits can be created anywhere	open market system for reduction, offset and management of emissions	1996 as PERT	Currently 50 projects totaling 16.4 Mton Co2e in the registry, with another 22 applications under review, totaling 26.9 Mton Co2e	Multi-pollutant approach: CO2, CO, VOC, SO2, Ozone NOx, and Non-Ozone NOx	Voluntary	Allowed with no restrictions in terms of time or quality
GERT	Inter-national	Open trading ERCs program with no restrictions on sector coverage	1998	4 projects reductions of approximately 325,000 tonnes CO2e	All GHGs converted to CO2e	Voluntary	Allowed
Ontario ET Program	Caps apply to Ontario emitters, credits may be created outside of Ontario	Open market cap and trade ERCs trading system	2002	NOx reduced from 35Kt to 27Kt SO2 reduced from 156.5Kt to 130Kt by 2010	Presently NOx and SO2	Mandatory	Allowed ERCs valid for 7 years

Source: Gardner Pinfold Consulting Economists Limited, December 2002

Summary Table 3 (U.K. Program):

Program	*Geographic Coverage*	*Nature*	*Start*	*Targets*	*Coverage*	*Participation*	*Banking*
Emission Trading Scheme	National U.K.	Cap and trade	2002	4,028,176 tonnes CO2e reduction from baseline in 2006	choice between a cap on CO2 only and cap on all six GHGs	Voluntary	Allowed

Source: Gardner Pinfold Consulting Economists Limited, December 2002