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Towards an Emissions Trading Scheme for Air Pollutants in India*

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MoEF Discussion Paper

Towards an Emissions Trading Scheme for Air Pollutants in India

A Concept Note

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From the Minister's Desk

I am pleased to introduce the Discussion Paper: "*Towards an Emissions Trading Scheme for Air Pollutants in India*", prepared by a team from Massachusetts Institute of Technology (MIT), Harvard University and J-PAL at my request.

The idea for this paper originated at a recent workshop organised by our Ministry on innovative instruments for environmental regulation, where we had the Central Pollution Control Board (CPCB), the State Pollution Control Boards/ Committees (SPCBs), outside experts and a team from MIT and J-PAL present. Several recent innovative practices in environmental regulation were discussed, which brought out clearly the point that while **we need robust regulations, we need lesser regulators**. In other words, we need to think of new innovative regulatory systems that go beyond the traditional command-and-control "inspector-raj" systems, which have their own inherent limitations that we know. **These innovative systems include those that leverage technology and harness markets to ensure better compliance with our environmental laws and regulations.**

In the context of environmental pollution, I believe **one such major innovation is real-time online monitoring of pollution loads at the industrial unit level.** I am delighted to see that Tamil Nadu is taking the lead on this, having started a programme for generating real-time air quality information reports in one of their large industrial clusters. I am told that this programme is being scaled up and rolled out across the State. I am confident and hopeful that other States will follow suit.

Availability of accurate real-time data of the type being generated in Tamil Nadu also allows for the possibility of implementing market based instruments, such as Emissions Trading Schemes (ETS) of the type that are discussed in this paper. **An ETS for Air Pollution would have the benefit of enabling lower pollution levels at lower overall costs of compliance. It would allow the regulator to set a cap on the aggregate level of pollution permitted, and then allow a self-regulating system to ensure that pollution does not exceed this cap**. (Caps may also be set for individual units, so that excessive pollution by any one unit is discouraged).

Of course the practical issues associated with such a system will need to be addressed. These include reliability in data monitoring, estimation of accurate baselines, and a strong regulatory frameworks. A clear "benefits case" for such a emissions trading scheme versus the status quo will also need to be established. This is why a pilot programme with a robust design, which allows for such comparisons in a rigorous manner, may well be the way forward.

Our recent experience with market based regulatory instruments has been positive. A Perform, Achieve and Trade (PAT) Mechanism for energy efficiency, which will cover facilities that account for more than 50% of the fossil fuel used in India, and help reduce CO_2 emissions by 25 million tons per year by 2014-15, is being implemented.

I want to congratulate our SPCBs that are responding enthusiastically to the regulatory challenges of the 21st century, by considering such innovative approaches. I am personally committed to supporting our SPCBs build capacity to succeed in the new regulatory era. I also thank the team from MIT and J-PAL for preparing this paper in a short period of time. I look forward to the views of various stakeholders on this paper.

(Jairam Ramesh)
Minister of State (I/C)
Environment & Forests
India
24th August, 2010

1 Introduction to Emissions Trading

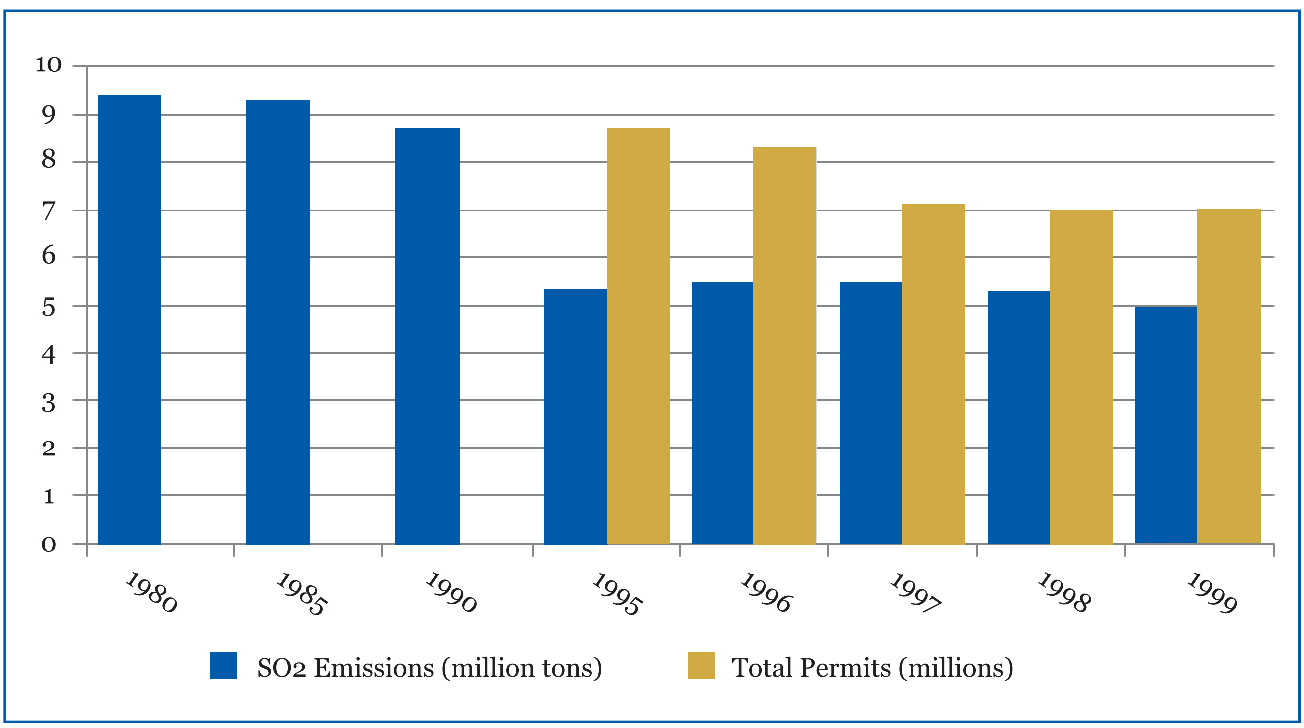
A. Why emissions trading?

An emissions trading scheme is a regulatory tool used to reduce pollution emissions at a low overall cost. In such a scheme, the regulator sets the overall amount of emissions but does not decide what any particular source will emit. Industrial plants and other polluters, rather than being told a fixed emissions limit, face a price for their emissions and choose how much to emit, within reasonable limits, taking this price into account. The price of emissions makes pollution costly and gives polluters an incentive to cut back.

Emissions trading schemes have great potential to lower pollution while minimizing costs for industries. The benefits of such schemes come from two sources. On the industry side, units are able to choose for themselves the cheapest way to reduce pollution. In comparison, traditional command-and-control regulations do not allow for differences across industries. Mandating the same standard everywhere will generally miss the best opportunities for abatement. On the regulatory side, an emissions trading scheme, once established, will provide a self-regulating system that that makes pollution control more efficient. In the longer run, the reduced costs of compliance can also make it easier to introduce new regulations that increase environmental quality.

Past experience with emissions trading, discussed in more detail in Section 3, has shown that cap-and-trade is a robust way to achieve targeted reductions in emissions at a low cost. Figure 1 shows total emissions of sulfur dioxide under the U.S. Acid Rain program. Total emissions, shown by the black bars, fell sharply in 1995, the first year the emissions cap was introduced, and remained beneath the emissions cap, shown by the gray bars, thereafter. Units in fact over-complied at the start, which has been attributed to cautious market participants achieving emissions reductions more easily than anticipated through the

Figure 1: Total Emissions in the U.S. Acid Rain Program, 1980—1999
The cap-and-trade emissions trading scheme sharply reduced emissions from its first year, 1995, onwards



Source: EPA (2009c)

adoption of cleaner fuels. (Schmalansee, 1998)

This paper connects experience with emissions trading, from programs like the U.S. Rain program, to lessons for implementation of a Trading Pilot Scheme in India. This experience suggests that four areas are especially important for successful implementation of an emissions trading scheme.

- ***Setting the Cap.*** The target for aggregate emissions from the sector where trading is introduced must be set to produce reasonable prices and emissions reductions.
- ***Allocating Permits.*** The permits to emit must be distributed in an equitable way to build support for the scheme. In many successful cases this allocation has been made for free relative to baseline emissions, greatly reducing the cost of compliance for industries.
- ***Monitoring.*** The quantity of emissions from each industrial plant must be reliably and continuously monitored with high integrity recognized by all sides.
- ***Compliance.*** The regulatory framework must make industries confident that buying permits is the only reliable way to meet environmental obligations.

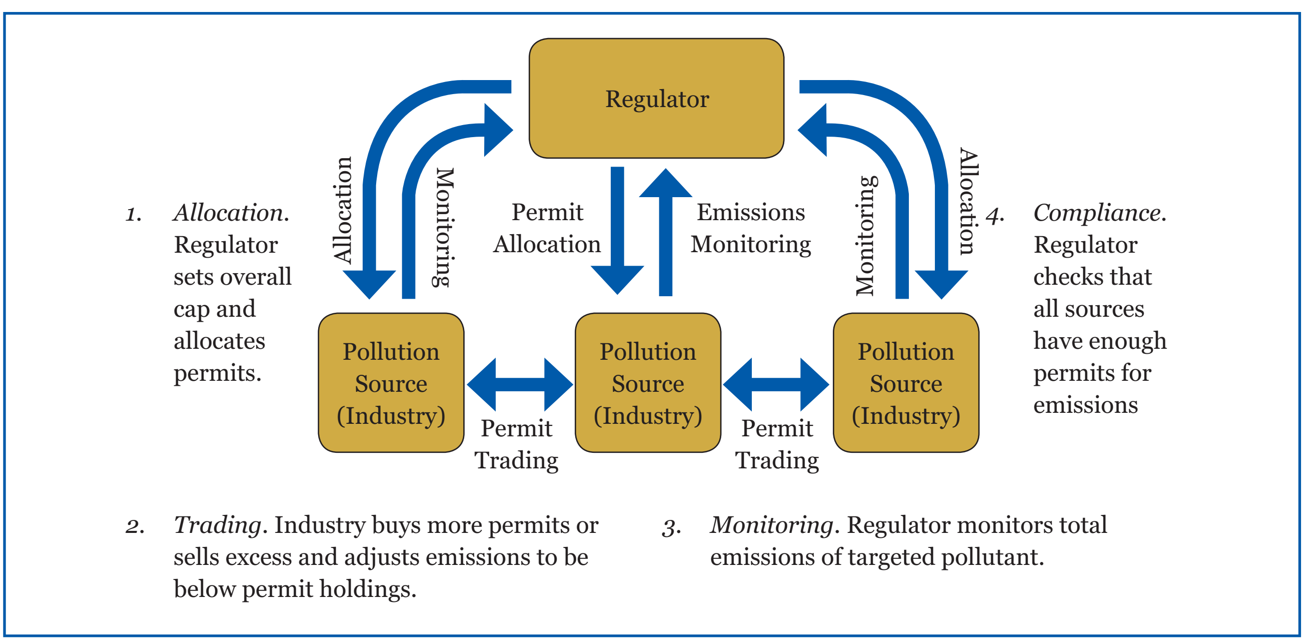
Figure 2 shows the place of these key components within the overall structure of an emissions trading scheme. The figure shows how emissions trading changes the role of the regulator. Rather than fixing emissions at the level of the individual polluting unit, the regulator sets an amount of overall emissions, which are what matter for environmental quality, and allocates these emissions amongst units in the form of permits. Units can then trade this right to emit. Trading does not change the overall cap but allows the required emissions reductions to be achieved by those units that can cut emissions at the lowest cost. At the end of each permit period the regulator checks emissions against permit holdings to verify compliance.

B. Greater benefits from emissions trading

The introduction of emissions trading would position India as a clear leader in environmental regulation amongst emerging economies. The benefits of a trading scheme will extend beyond the immediate goal of achieving compliance at a lower cost to society. Having a trading scheme in place will make it easier to adjust regulation as environmental goals change. Tighter environmental standards can be achieved with a drop in the level of the cap, which would raise the price of emissions permits and give incentives to pollute less, rather than abruptly throwing certain areas or sources out of compliance.

India may also benefit by tying the system for local emissions trading to global emissions trading schemes for carbon dioxide. A successful cap-and-trade system

Figure 2: Mechanics of an Emissions Trading Scheme
Regulator ensures compliance but does not fix emissions for each source



will establish the infrastructure needed for putting a price on carbon dioxide as well as local pollutants, positioning the country to easily receive payments for the contribution of its innovative regulations to reducing greenhouse-gas emissions. The European Union Emissions Trading Scheme, Kyoto protocol and future carbon mitigation policies outlined under the Copenhagen Accord will generate demand for such reductions. An emissions trading system to meet this demand would generate a net flow of foreign investment and reward the Indian economy for growing along a green path.

The next section, Section 2, on the Key Components of an Emissions Trading Scheme, discusses the areas introduced in Figure 2 in greater detail, to show what decisions affect the design of a trading scheme and to guide these decisions in the Indian context. Section 3 presents the next steps needed to move from a concept note to a workable plan for implementation of emissions trading. Section 4 presents some relevant cross-country experience with emissions trading to place the discussion and recommendations from prior sections in the rich context of lessons from existing schemes.

2 Key Components of an Emissions Trading Scheme

This section relates past emissions trading-programs, which are reviewed in section IV, to the pre-requisites for implementing local trading for air pollutants in Indian states. In each subsection, indicated by capital letters, bold-faced headings indicate a point of action where MoEF and participating SPCBs need to set a priority or make a decision. The background information regarding each decision is provided below these points.

A. Purpose.

Targeted pollutants. *Select air pollutant(s) that require reduction in participating areas, have adequate monitoring technology and are emitted by a group of large point sources.*

The purpose of the ETS is assumed to be the reduction of emissions of some conventional air pollutant, such as SO_2, NOX or SPM, for the betterment of human health and the reduction of compliance costs. The pollutants to be regulated will best be determined by a consideration of the goals and problems of the SPCB, as well as market design considerations such as the number of large sources and the ease of monitoring. Markets with many large sources and better monitoring will generally function more smoothly

B. Emissions Cap.

Setting the emissions cap is a key decision in establishing a cap-and-trade system. The cap must be neither so high that the system does not achieve reductions nor so low as to be prohibitively costly to firms. We present two primary options: using baseline emissions to set the cap or using a targeted or desired level of level of ambient pollution. Both ways require data on baseline emissions from the included units. The second way additionally requires information on the local sources of air pollution and the relation between emissions and ambient concentrations. Note that setting the overall emissions cap is a distinct question from how to allocate emissions permits under that cap, which is considered later.

Baseline emissions. *Set emissions cap at the level of historical baseline emissions or at some arbitrary reduction (e.g. 25%) below this level.*

Most every market-based system to date has, to differing degrees, based total emissions on a historical baseline. The monitoring system needed for trading can be used prior to the creation of the permit market to set baseline emissions.

The primary difficulties with this method are making sure that baselines are accurate and that the process of determining baselines does not itself create any incentive to pollute. Caps set on historic baselines must not relate to decisions by units today about how much to emit. For example, it would introduce distortions to announce, prior to baseline monitoring, that this monitoring was to be used to set emissions levels in the future. In that case, units would have an incentive to emit more today in order to increase their allocation.

Ambient targets. *Set emissions cap at the level projected to achieve a desired reduction in ambient pollutant concentrations.*

As an example of this method, suppose that industry is responsible for 50% of particulate emissions and transport the other 50%. The current total level of emissions is 100 tonnes and it is estimated that emissions of 60 tonnes would yield the desired ambient level of air quality. Then the cap introduced for industry would be 30, a reduction of 20 from the baseline level.

The benefit of setting ambient concentrations with this method is that it has sound public policy support. The goal of pollution regulation is to benefit the public at large and it is therefore fitting to set broad targets based on ambient standards. Moreover, the NAAQS are well established and a clear way to measure progress towards the end goal of market schemes.

The main problem with this method is that it can be difficult to link emissions to various sources and to ambient pollution concentrations. The Central Pollution Control Board (CPCB), however, will have most of the information needed to enable this linkage, such as ambient pollution data and source apportionment studies, that measure what share of air pollution is due to various sources, such as transport, industry, power generation, cooking fires or dust. The Central Pollution Control Board initiated such source apportionment studies for particulate matter less than then ten nanometers in diameter (PM10) in the cities of Delhi, Bangalore, Pune, Mumbai, Chennai and Kanpur in 2007-08.

Safeguards. *Set additional parameters, such as hard caps or other limits on high-frequency emissions, that prevent local accumulation of pollutants.*

The overall emissions cap is not the only regulatory parameter to be set. In addition, most market-based systems overlap with hard limits meant to prevent the accumulation of pollutants in one location. Experience with emissions trading has not shown any tendency for this to occur, but this hard cap may be an important safeguard for pollutants like SO2 or particulates where local hot spots will be associated with adverse health effects.

Price ceiling. *Commit to the government selling permits if the price rises too high.*

In addition to providing safeguards against the concentration of pollutants, the market system can also be designed to ensure industry that compliance will not be overly costly. The regulator accomplishes this goal by committing to sell additional permits, raising the overall cap, if the price of a permit rises above a fixed ceiling. This ceiling can be raised over time when it becomes clear that the cap has set a reasonable overall pollution target and the market is functioning well.

C. Implementation.

Free Allocation of Permits. *Supply permits for free to units based on some fixed formula, usually in proportion to baseline emissions.*

In most permit markets to date emission permits have initially been distributed free. This free distribution has been the case in all of the markets considered in detail below. The primary benefits to this method are that it allows for industry buy-in and is therefore easy to implement. As plants will have invested in their capacity prior to the new regulation it may also be fair to compensate them for the regulatory change.

The cost of this method is direct, in denying revenues to SPCBs that could otherwise sell permits to raise money for continuous monitoring or other operations, and indirect, in somewhat compromising the polluter pays principle honored by Indian environmental law.

Auctioning permits. *SPCB or other authority conducts an auction of the total volume of permits decided under the cap.*

The advantages to this method are the exact converse of the costs noted above. Auctioning permits raises revenue for the implementation of regulations or other purposes and ensures that firms responsible for emissions bear the full cost of these emissions.

Several other points are important for the allocation decision. Auctions and give-aways are not mutually exclusive. The EPA used both in the Acid Rain program, wanting auctions not for reasons of fairness but to ensure liquidity in the permit market.

Setting the overall cap and distributing permits to realize this cap are distinct decisions. The cap could be based on an ambient target but unit-level allocations may still made in proportion to baseline emissions. Alternatively, the overall cap could be set based on the sum of unit baseline emissions but the permits auctioned off.

In the broadest economic terms the efficiency of the emissions market does not depend on the initial allocation of permits. This idea, founded on the theoretical work of Ronald Coase that was recognized with a Nobel Prize in Economics, is supported by evidence from the United States. (Fowlie and Perloff, 2008) The initial allocation, however, matters greatly for acceptance of the program by both industry and concerned citizens.

D. Trading.

The main considerations to design a trading system will be what the nature of the permit itself will be and how the permit holdings of participants will be tracked.

Permit quantity and duration. *Decide the unit of pollution that permits represent and the period of their validity.*

The nature of the permit itself can be very important. The permit should be a commodity with a value that industry can easily measure to encourage trading. The U.S. example of a permit being equivalent to 1 tonne of SO_2 is a good benchmark. Permits are based on the total quantity of emissions, rather than their concentration.

Permits also have a time duration. Allowing a longer duration, such as a whole year, may reduce uncertainly by letting units adjust to their emissions. Emissions markets must have periodic true-up points, say for example every year or half-year. At these points, plants are required to hand over to the regulator permits for every unit of pollution emitted since the last true-up point. The duration of the permit can also be matched to pollution goals. The U.S. NO_X budget program only operates in the summer when ozone pollution is worst. The equivalent in the Indian context might be separate pollution permits for the winter and non-winter seasons to adjust to different damages caused by urban pollution at those times.

Some markets, such as that for SO_2 in the United States, allow permits to be used over periods as long as several years. Allowing permits to be used over longer periods generally lowers the total costs of compliance, because firms can choose to emit more in periods when the costs of abatement are low and less when they are higher (e.g., during an economic boom). On the other hand, the greater the time duration of a permit, the greater the chance that firms will lobby to be granted extra permits that ultimately break the cap. At the beginning of a trading scheme, when the right level of the emissions cap is uncertain, permits should have limited validity so that a cap that is too high does not allow high emissions to spill-over into the future.

Set up a permit market. Create an exchange system that sets clear prices and enables easy trading.

The liquidity of the market refers to how easy permits are to buy and sell. Units looking to buy or sell permits should be able to easily and inexpensively determine the market price and be able to conduct transactions at that price at a low cost. The design of the permit itself, as discussed, will affect the liquidity of the market, as will the size of the market itself. If a greater number of units is participating it is more likely that buyers and sellers can promptly find one another so that each may hold permits in accordance with their needs. In a small market, the pollution authority may want to guarantee some measure of liquidity by offering to sell permits at a high price. With this offer units can know that their costs for emissions will never exceed a certain limit.

E. Monitoring.

Monitoring is the foundation for any trading system. The accurate, comprehensive monitoring of total emissions in the U.S. Sulfur Dioxide program helped ensure the transparency and success of the permit market

Monitoring. *Establish a monitoring protocol that accurately and continuously monitors total pollutant emissions and provides clear procedures in case of data gaps.*

With current technology continuous monitoring is costly but generally accurate for a range of pollutants, including SO_2, NO_X and to a somewhat lesser extent, particulate matter. Continuous monitoring of all affected units, along the lines of the Tamil Nadu Pollution Control Board's CARE Air Centre, must be in place to support trading. This monitoring should cover not only pollutant concentrations but also the volume of gas flow, so that trading can be based on aggregate pollutant emissions rather than concentrations.

Monitoring is not only a technology but also a system for filling gaps in that technology and recording emissions levels. The monitoring protocol should specify how frequently continuous emissions monitoring equipment will be inspected and what the consequences are in case of tampering or incomplete data. Following the sulfur dioxide market in the U.S., good practice will be to assume the worst, or near to it, when emissions data is incomplete.

F. Outcomes.

Evaluation. *Track the progress of the emissions trading system through emissions, permit market functioning, and the reduction in costs to firms themselves.*

The obvious and immediate outcome of emissions has been discussed throughout. An important additional outcome will be the cost of compliance for participating firms. By conducting industry surveys during a monitoring-only stage and after the introduction of the permit market, which may be phased in over time, one can measure the cost of compliance and the total benefits to emissions trading more completely than has been done for any of the above schemes. These measurements will help to find Indian sectors where emissions trading will have the greatest bang for the regulatory buck in the future.

3 Next Steps : Pilot Projects in Select States

A. State Level.

To provide specific guidance on how the considerations above can be put into practice to reduce pollution emissions in Gujarat and Tamil Nadu, we will shortly begin dialogue with the Gujarat Pollution Control Board and Tamil Nadu Pollution Control Board to understand their goals, past data and capabilities with respect to local air pollution. These states contain critically polluted areas with many large industries that would be suitable for an emissions trading pilot. TNPCB, moreover, has already begun a continuous emissions monitoring program, one of the prerequisites for emissions trading. The outcome of this dialogue will be a clear working plan to implement emissions trading.

A Trading Pilot Scheme evaluation can be conducted in one or two states to demonstrate a workable model that addresses all of the areas discussed in this note. A robust evaluation design will allow direct comparison of the levels of pollution emissions achieved under command-and-control and trading systems, to answer to environmental concerns, and of the cost of compliance, to answer to industry. Experience with market trading has suggested that costs under the permit scheme will be lower than under traditional regulation. An evaluation can convincingly show this to be the case and thereby build support and a knowledge base for the wider application of emissions trading schemes.

A. At the Centre.

The Ministry of Environment and Forests, on its side, must investigate the changes required for the existing legal system of pollution regulation to enable emissions trading. A supportive regulatory framework will establish the legal connection between emissions trading and existing law. Industries must know that permits do indeed meet compliance obligations to accept the trading scheme.

The important questions that the Ministry will need to address to provide a framework for emissions trading are:

- What legal changes are necessary in order for units to be subject to pollution permits, rather than existing emissions norms?
- How will the permits be allocated and what will be the legal rights and obligations of permit holders?
- Who will bear the costs for monitoring equipment and of central resources, such as software for tracking emissions and trades? This expense could be funded from the auctioning of some share of permits.
- What are the national goals of this program? How will city- or state-level programs be integrated in the future to create more robust markets?

The introduction of this Trading Pilot Scheme can serve as a model for future environmental regulation in India and also position industry to benefit from potential tie-ups to global emissions trading schemes, as for carbon dioxide. Introducing emissions trading would make India a clear leader in environmental regulation amongst emerging economies. Market-based schemes lower compliance cost and provide a powerful, flexible tool to respond to a wide range of pollution problems. A successful cap-and-trade system will have the additional benefit of allowing India to easily receive payments for the contribution of its environmental regulations to reducing greenhouse-gas emissions.

4 Experience with Emissions Trading to Date

The rationale for emissions trading is always the same—reducing the cost of reaching some targeted level of pollution. Societies usually care not who emits pollutants but only about the total of their emissions. By fixing this total and allowing trade between different firms for the right to pollute a certain share, cap-and-trade schemes allow firms with cheaper ways to reduce emissions to achieve more of the overall reductions. This trade therefore lowers the overall cost of meeting the pollution target. Put bluntly, it streamlines regulation and saves firms money while also protecting the environment.

The application of cap-and-trade pollution markets has been very successful in practice, achieving the desired reductions in emissions reliably and at lower-than-expected cost. This section briefly considers three different emissions trading schemes for three different air pollutants that have been implemented in different countries. The purpose of the discussion is to bring out the important aspects of the design and implementation of each scheme to provide some background for the issues discussed in section II.

A. Sulfur Dioxide, United States

An extremely successful trading scheme that reduced sulfur dioxide emissions and the related acid rain problem at a surprisingly low cost to firms.

Purpose. The 1990 Clean Air Act Amendments established the first large-scale system to reduce pollution through tradable emissions permits. (Schmalensee et al., 1998) The purpose of the program was to reduce emissions of SO2 from power plants to stop acid rain and for this reason it is also sometimes known as the Acid Rain program. The overall goal of the program was a reduction in annual SO2 emissions by 10 million tons below 1980 levels.

Emissions Cap. The emissions cap in this program was set at about half of the level of emissions from the same set of power plants in 1980, beginning in 1995. Phase I subjected only the 263 dirtiest power plants in 21 states to the cap and Phase II, beginning in the year 2000, applied to over 2,000 fossil-fuel burning electric generating units, virtually all such units in the United States. Each participating unit is required to hold an amount of permits, or allowances, at least equal to its annual emissions. If a plant emits 5,000 tons of SO_2, it must hold 5,000 permits to do so. Regardless of the number of permits a plant holds, it may not exceed upper limits set by the same act to protect public health. (Environment Protection Agency, 2009a)

The overall level of emissions was set on a per-unit basis based on baseline heat input of the electricity-generating units. Permits were allocated for each year beginning in 1995. The EPA allocated allowances at an emission rate of 2.5 pounds of SO2/mmBtu (million British thermal units) of heat input, multiplied by the unit's baseline mmBtu (the average fossil fuel consumed from 1985 through 1987).

Implementation. Existing generating units were given, free, a number of permits based on the formula above at the beginning of the program. Note that the determination of the cap and the allocation of the units are in principle separate; the EPA could have set the overall cap using the formula above but then allocated permits using an auction.

Trading. After the initial allocation, new units or units needing additional permits could obtain them from two sources: purchasing from other or at auctions run by the EPA. The purpose of the auctions was to provide clear information about prices, but in practice most trading occurred privately.

Trading enables units to achieve emissions reductions at low cost without changing the overall level of pollution set by the cap. Figure 2 compares the sulfur dioxide emissions rates for each polluting source under the trading scheme, as shown by the vertical gray bars, to the emissions rates likely for each unit without trading, as shown by the heavy black line. Many units have actual emissions rates higher or lower than they would have been under a fixed emissions standard, indicating that units used the flexibility of emissions trading to achieve compliance at a low cost. For some units, the best way to comply is to reduce emissions directly, for others it is to pay for the right to emit more by buying credits from units that were able to abate emissions at a lower cost. The price of emissions urged each unit to seek out low-cost means of abatement while the cap ensured that overall emissions fell, as Figure 1 showed above.

Monitoring. Emissions are monitored continuously at affected units, at an average annual cost of $124,000. Continuous emissions monitoring is an essential foundation for trading, which requires that every ton of unit emissions be recorded. Units required to monitor SO_2 emissions in pounds per hour must use both an SO_2 pollutant concentration monitor and a volumetric flow monitor. Both concentration and flow are required because the permit applies to the total mass of the pollutant emitted. In addition to this basic equipment the unit must have a data acquisition and handling system (DAHS) to process and record readings. The monitoring protocol includes conservative formulas for filling-in missing data that penalize units for monitoring downtime. The EPA also has monitoring protocols for NO_X and CO_2 emissions.

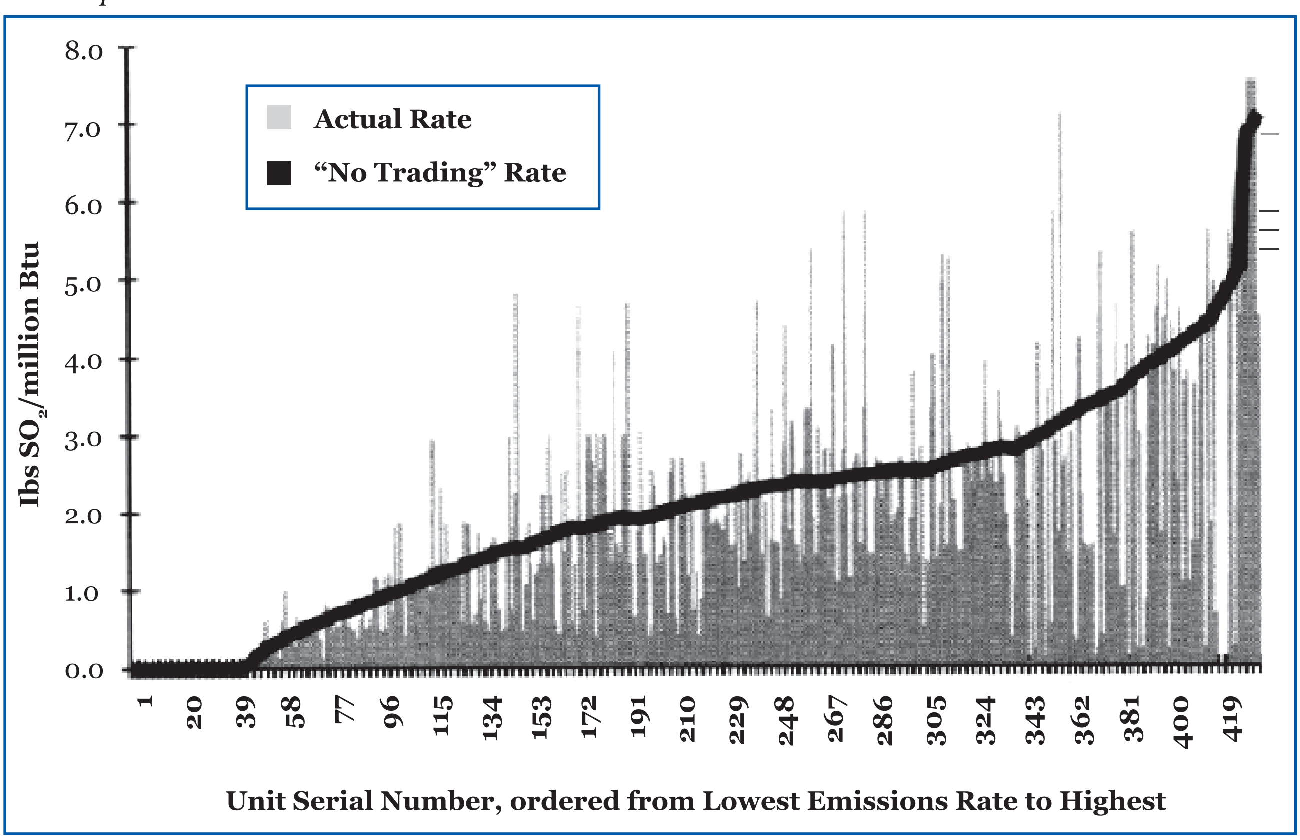
The number of permits held by each unit is tracked in an Allowance Management System (AMS). Parties may trade permits privately but must notify the EPA when permits acquired through these trades are going to be used to cover emissions. Affected units must deliver to the EPA valid permits sufficient to cover a year's emissions by 1 March of the year following.

If a unit does not have enough permits it must surrender any permits for the following year as excess emission offsets and pay a penalty for the present year's excess. (Federal Register, 1997) The penalty is the number of excess tons emitted times a base fine of $2,000 per ton, an excess charge that is adjusted annually for inflation. The excess charge for 1997 was $2,525 per ton. As permit prices in this year were little above $100 per ton the excess charge is enormous and in practice all units complied by holding sufficient permits.

Outcomes. The effect of the program was a large reduction in emissions at a lower cost than anticipated. In 1995, the first year of the program, total emissions fell from 8 million tons to less than 5 million tons. Generating units achieved these reductions by using lower-sulfur coal and by using scrubbers to remove SO_2 from stack gases. The estimated savings to firms from

Figure 3: Emissions Trading in the U.S. Acid Rain Program, 1996

Trading allows emissions abatement at lower cost while total emissions remain limited by the cap on total permits



Source: Schmalansee et al. (1998), derived from Pechan (1995), EPA's EMS and EPA (1996) using a trading scheme instead of fixed regulations was around $225 million to $374 million per year. (Ellerman et al., 1997)

B. Total Suspended Particulates, Chile

An inconsistently implemented trading scheme that nonetheless may have helped push firms to use cleaner fuels.

Purpose. The Emissions Offsets Trading Program was introduced in 1992 to reduce airborne particulate emissions from stationary industrial sources in Santiago, Chile. (Montero and Sanchez, 2002) Standards for particulate matter less than 10 nanometers in diameter (PM10) had been consistently exceeded in Santiago since the 1970s and these high levels have been related to mortality and respiratory disease. (Ostro et al., 1999)

Emissions Cap. At the time the regulation was issued existing sources received daily emissions rights in proportion to a pre-determined baseline emissions rate that was uniform across existing sources. The Program aimed to reduce emissions by 80%, a figure chosen to achieve daily ambient air-quality standards 95% of the time. The cap applied to sources with a flow rate greater than 1,000 m3 per hour, of which there were a total of 680 in 1993.

Both existing and new sources are subject to a maximum cap that cannot be exceeded regardless of the number of permits held by that source. This overall cap was usually about twice the level of emissions permits granted a source. In addition, large stationary sources were liable to be shut down during episodes of severe ambient air quality, again regardless of the number of permits held.

Implementation. Existing sources were granted emissions permits free and in perpetuity, or "grandfathered" in. Any new sources arising after the program began were obligated to purchase rights from existing sources. This difference made the introduction of the program very successful in getting existing but unknown point sources to identify themselves in order to secure emissions rights. Because unknown sources emerged to secure rights, however, and rights were based on a per-unit emissions capacity formula, the overall cap ended up less stringent than expected.

Trading. Rights to emit are based on annual reviews of capacity. Therefore the only requirement is that at the time of this annual monitoring the unit holds enough capacity rights to cover its current capacity. In practice, trading was relatively thin—not many emissions capacity rights changed hands. This low trading is an indication that the market did not realize its full potential for cost savings, as capacity rights have stayed with their initial holders, which may not be the firms to which these rights are most valuable. Low trading appears to have been a reaction to uncertainty about future regulations and transactions costs in the permit market.

Monitoring. The authorities monitored not aggregate emissions but emissions capacity, which was estimated based on field visits to measure source size and fuel type. This is a rough estimate of the potential to produce emissions, which may serve better for particulate matter than for other pollutants, but does not allow for the ability to reduce emissions via better combustion control or other channels that do not change capacity but may reduce emissions. Another limitation of this monitoring method is that it excludes process sources that produce emissions but are not comparable in terms of capacity to boilers. That is, the emissions capacity of each unit is based on estimated flow volume and a uniform emissions concentration quota, but no such quota could be applied to diverse industrial process sources, limiting the scope of the system. For these reasons it is preferable, with modern technology, to monitor aggregate pollutant emissions directly.

Outcomes. Total TSP capacity (not emissions per se) was below the number of capacity rights by 1997. Industry switched to cleaner fuels, such as natural gas, during this period, which appears responsible for most of the decline. There are not good estimates of the cost of these changes but it seems that the establishment of the permit system accelerated this switch and created a response from gas supply.

C. Carbon Dioxide, European Union

A well-functioning scheme that established thriving markets for carbon and reduced emissions but may have set initial emissions too high.

Purpose. The European Union introduced a CO2 emissions trading scheme, the EU ETS, starting in 2005 in order to limit emissions of carbon dioxide that contribute to global climate change. The scheme applies to all EU member states and, within these states, to companies that generate electricity or are in energy-intensive industrial sectors.

Emissions Cap. As the EU ETS is an international program the allocation process was conducted at the level of each country. Each member country was responsible for developing a National Action Plan (NAP), subject to review by the European Commission, that details the quantity of emissions each state expects and how it will allocate its permits to individual emitting units. Unit-level allocations were typically based on historical emissions and covered a total of about 12,000 units emitting 46% of the EU total CO2 emissions. (Robinson and Watanabe, 2005)

EU member states collected emissions data on years up to 2004 to establish NAPs that set expectations for what emissions would be over 2005-2007 and were used for allocating permits to the units included in the scheme. This data was largely supplied voluntarily by facilities that would be receiving allocations and therefore had an incentive to distort emissions upwards. (Buchner and Ellerman, 2009) There was no single, Europe-wide allocation target and member states tended to allocate to their own units generously relative to both historical emissions and Kyoto protocol targets. (Azar et al., 2005)

Implementation. The scheme was implemented in two phases with the expectation that additional phases would follow. The first phase ran from 2005-2007 and the second from 2009-2012. Member states were required to give away 95% of the permit allocations during the first phase and 90% during the second phase to units free of charge.

Trading. The market for permits to emit carbon dioxide has been open and active since its inception. Carbon prices have generally ranged from about €10-30 with considerable movement in that range. Not only units but also many third-parties participate in the carbon market, and permits from the Kyoto protocol, which represent reductions in carbon emissions from outside the EU, are to some extent tradeable with the EU ETS as well.

Monitoring. Units registering for permits are required to have a system to monitor and record emissions in place. During the scheme, units are then required to surrender enough permits by 30 April of each year to cover emissions from the previous year. Units that do not have enough permits have to pay an excess emissions penalty of €40 per tonne of CO2 during the first phase of the scheme and €100 per tonne in the second phase. These penalties constituted big premiums over prevailing prices during the first years of the scheme.

Outcomes. The EU ETS lowered carbon emissions about 3.4% below the business-as-usual case. (Buchner and Ellerman, 2008) Emissions trading within and across countries did a good job in matching units with excess allocations to those with deficits. (Ellerman and Trotignon, 2008) Initial allocation targets were generous, but the positive emissions price indicates the system did have bite and will work to achieve further reductions in the future.

Emissions Trading Schemes: Cross Country Experience

Country	Program	Commodity	Period	Outcomes
Canada	ODS Allowance Trading	CFCs and Methyl Chloroform	1993-1996	Low trading volume except among large methyl bromide allowance holders
	ODS Allowance Trading	HCFCs	1996-	
	ODS Allowance Trading	Methly bromide	1995-	
	PERT	NO_X, VOCs, CO, CO_2, SO_2	1996-	Pilot program
	GERT	CO_2	1997-	Pilot program
Chile	Santiago Air Emissions Trading	TSP emissions rights	1995-	Low trading volume; decrease in emissions since 1997 not definitively tied to system
European Union	ODS Quota System	ODS Production Quotas under Montreal Protocol	1991-1994	More rapid phaseout of ODS
	EU Emissions Trading System	CO_2	2005-	Large, active market and some reduction in emissions
Singapore	ODS Permit Trading	Permits for use and distribution of ODS	1991-	Increase in permit prices; benefits unknown
United States	Emissions Trading Program	Criteria air pollutants under the Clean Air Act	1974- present	Same environmental performance with $5-12 billion savings
	Leaded Gasoline Phasedown	Rights for lead in gasoline among refineries	1982-87	Rapid phaseout of leaded gasoline and large savings
	Water Quality Trading	Point and non-point sources of nitrogen and phosphorous	1984-86	No trading necessary because standards were not binding
	CFC Trades for Ozone Protection	Production rights for some CFCs	1987-	Environmental targets achieved ahead of schedule
	Heavy Duty Engine Trading	Credits for NO_X and particulates	1992-	Standards achieved; cost savings unknown
	Acid Rain Program	SO_2 emissions reduction credits	1995-	SO_2 reductions ahead of schedule at savings of $1 billion per year
	RECLAIM Program	SO_2 and NOX emissions	1994-	Over 50% reduction in pollution emissions at $60 million annual savings
	NO_X Budget Program	NO_X amongst large point sources	1999-	Targets met at 40-50% cost savings

Source: Stavins (2003) and Stavins (2007).

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