EPIC INDIA
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USING EMISSIONS MARKETS TO MANAGE THE SOCIAL COSTS OF FOSSIL FUELS

A HANDBOOK

Contents

Introduction

The draft National Energy Policy (NEP), issued by the NITI Aayog in 2017, laid down four fundamental goals that should guide policy going forward. These include: (i) *access at affordable prices*, (ii) *improved security and independence*, (iii) *greater sustainability*, and (iv) *economic growth*. Achieving these objectives requires several changes away from the status quo, including shifting the energy mix away towards cleaner fuels, improving energy efficiency, and reducing the environmental damages associated with energy use.

Given these fundamental objectives, there is a close link between environmental regulation and a successful energy policy. Fossil fuels (especially solid fuels) are highly polluting and therefore successful and well-designed environmental policy should encourage moving to cleaner fuels and improving energy efficiency. The discussion in this document largely applies to existing environmental regulation in India, which targets local pollution. Global pollutants such as carbon can also be regulated using markets but decisions pertaining to the type and extent of climate change policy (including the use of carbon markets) are determined based on a separate international negotiation process.

This handbook begins from this starting point and provides a detailed follow-up to the NITI Aayog Breathe India Action Plan, as well as the National Energy Policy. The handbook describes how efficient environmental regulation may be designed to achieve the complementary goals of energy and environment policy. It also discusses different forms of environmental regulation as they exist in India today, and shows how to design more efficient policy instruments as recommended by the Breathe India Action Plan. This document is implementation oriented and provides a detailed discussion of how to practically implement market-based environmental regulation, particularly cap-and-trade markets.

Markets are being used in India to encourage energy efficiency among very large energy users (the Perform, Achieve, Trade scheme) but surprisingly have never been integrated into environmental regulation. This gap has meant that many of the potential complementarities between environment and energy policy, such as energy efficiency have not been fully realized. In addition, because market-based instruments minimize the costs of environmental regulation, they serve to improve economic growth from energy use. These considerations are discussed in greater detail in the text.

The existence of significant social damages from energy use, due to pollution, is the underlying motivation for all environmental regulation, including market-based instruments. Reducing these costs is also critical to achieving the sustainability goals of the NEP. This handbook draws upon cutting-edge scientific evidence from the last few years to provide preliminary estimates of the social costs associated with energy use from different fuels. Although such estimates are always approximations, it is hoped the handbook will help to introduce a concrete basis for the discussion of these issues.

The structure of the handbook is as follows. Section 1 provides estimates for the social costs due to air pollution of fossil fuels. Section 2 contains a discussion of the strengths and weaknesses of existing environmental regulation which uses primarily command-and-control policies. The focus is on the characteristics of existing policy instruments that relate to the goals of the NEP, namely the ability to encourage economic growth, shifting to cleaner fuels, and improving fuel efficiency. Section 3 provides a discussion of market-based regulation, including a detailed review of the international experience to date. Section 4 discusses two pre-requisites to market-based environmental regulation – data transparency and data quality. In both these areas significant steps forward have been made in recent years. Section 5 provides a detailed outline of how an emissions market should be designed, outlining the key requirements and decisions needed to implement such a policy on ground. Throughout the handbook, we refer to recent scientific evidence where further information may be obtained.

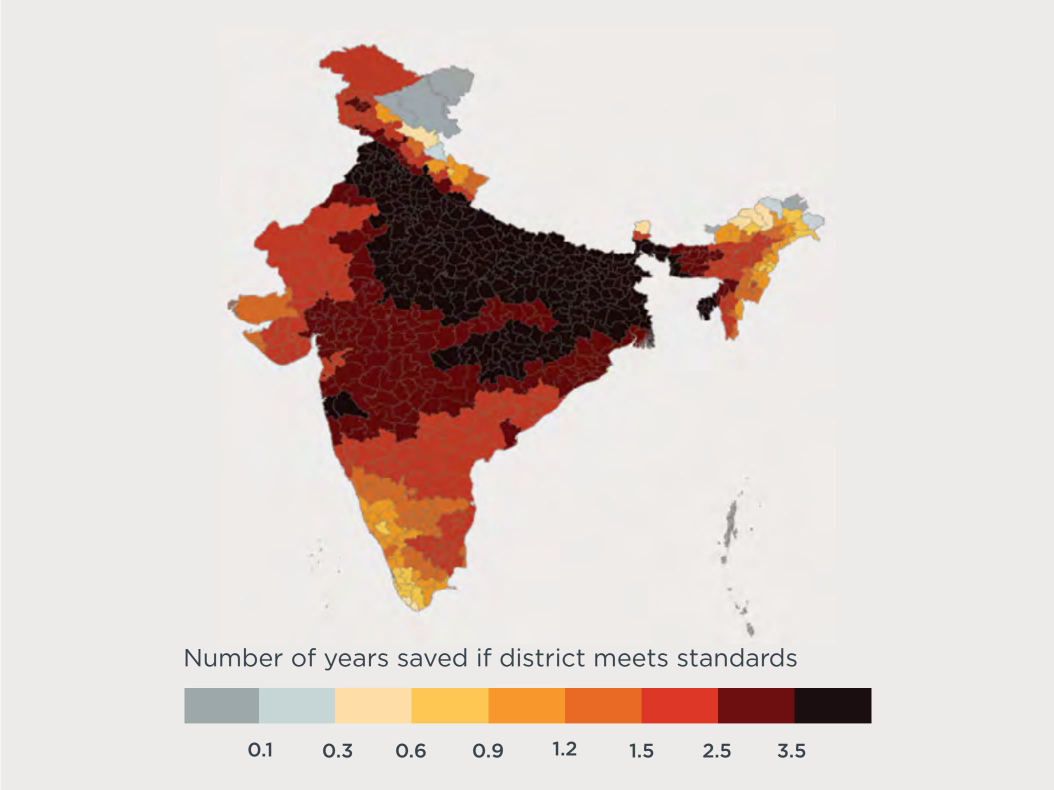
Social Costs of Air Pollution

The health costs arising from air pollution have now been carefully studied for different pollutants, in different parts of the world. Within the last two years alone, a recent study in China showed that the effect of sustained exposure to particulate matter smaller than 10 μm (PM_{10}) on life expectancy and found that a 10-μg/m3 increase in airborne particulate matter reduces life expectancy by 0.64 years (Ebenstein, 2017)[i] . Across the world, the Global Burden of Disease report (Lim et al., 2012)[ii] estimated that ambient particulate matter air pollution accounts for 6 percent of global deaths and that over 10 percent of premature deaths owe to lower respiratory diseases. In addition to increased morbidity and mortality, there is also evidence to indicate that air pollution reduces the productivity of workers in physically demanding occupations (Graff Zivin and Neidell, 2012[iii]; Heyes and Saberian, 2015[iv]; Chang et al., 2016[v]). Most recently the Ministry of Health and Family Welfare, Government of India and the Indian Council of Medical Research have funded and published a study in Lancet showing that life expectancy in India would increase significantly through reducing air pollution.[vi]

Recently, scientists have developed the Air Quality Life Index (AQLI) which provides a means to predict the overall reduction in life expectancy caused by living in places with high levels of air pollution.

These costs to society are significant and may reduce economic growth. Achieving the sustainability goals of the NEP, and the goals of existing environmental regulation, would therefore provide large benefits. Recently, scientists have developed the Air Quality Life Index (AQLI) which provides a means to predict the overall reduction in life expectancy caused by living in places with high levels of air pollution[vii]. Based on this metric, if India were to achieve NAAQS standards, we could increase life expectancy across India by 1 year on average; this number increases to 4.7 if we were to meet the WHO norms. Figure 1 (page 7) maps life expectancy loss in India based on satellite data on air-pollution. Notably, these health costs are not restricted to urban areas.

Figure 1: Increase in life expectancy from meeting WHO norms on $PM_{2.5}$



It is very useful to derive a monetary cost to society occurring due to the environmental damages associated with fossil fuel combustion. Estimating such a number allows us to efficiently balance the costs and benefits of environmental regulation and put in place rules that maximize social welfare. A fundamental motivation of market-based regulation for instance, is that regulation should be undertaken at the least possible costs necessary to balance or account for the environmental externalities associated with fuel use. The use of markets is consistent with the "Polluter Pay" principle. The following sections briefly outline a back of the envelope approach to identifying social costs. The social costs derived here should be treated as indicative of damages due to environmental externalities.

Before reviewing local environmental social costs, it is important to point out that this discussion does not by itself imply that fuels are priced too low. It only motivates the need for environmental regulation of some type, and this document discusses market-based alternatives relative to status quo regulation. Answering the question of whether fuel prices are too low or too high requires a complete accounting of existing taxes, and all other costs.

Pollutant Emissions and Average Ambient Concentrations

A recent report by the Health Effects Institute[viii] assesses the contribution of highly polluting sectors to atmospheric $PM_{2.5}$ levels. These contributions are weighted by population and region. In addition to estimating the impacts of exposure to rising pollutant levels on human health, the study aims to estimate the increase in ambient $PM_{2.5}$ levels that may be contributed by major sources of pollution in India.

According to this report (GBD MAPS Working Group, 2018), total $PM_{2.5}$, SO_2 and NO_x emissions across India in 2015 were 9.1, 8.1 and 9.5 million tonnes respectively. Sector-wise emissions are provided in the report, based on which columns B1, B2, C1 and D1 in Table 1 are reproduced.

Table 1 also shows average ambient pollutant concentrations that can be attributed to different sources. Sector-wise ambient concentrations of SO_2 and NO_x are unavailable from the Health Effects Institute report, which provides these numbers for $PM_{2.5}$ (Column B2). We use 2015 ambient air quality data from the Central Pollution Control Board[ix] to calculate the national population-weighted SO_2 and NO_x levels[x]. These values are provided as All India average ambient SO_2 and NO_x levels in Table 1 (row 12). Table A1 in the Appendix outlines state-wise ambient SO_2 and NO_x levels from 2015 along with population data gathered from the Indian Census[xi].

To calculate values in columns C2 and D2 of Table 1, we refer to the source apportionment study conducted by the Central Pollution Control Board in 2010[xii] across six cities. The report provides an inventory of PM_{10}, SO_2 and NO_x emissions from different sectors in Delhi, Kanpur, Bangalore, Mumbai, Chennai and Pune. We derive population-weighted estimates of the percentage contribution of each sector to national ambient SO_2 and NO_x concentrations. We multiply these proportions with the All India ambient averages calculated earlier to get ambient concentrations attributable to each sector.

Table 1. Source-specific emissions across India in 2015. Annual emissions in million tonnes have been reproduced from GBD MAPS Working Group (2018).

A	B1	B2	C1	C2	D1	D2
	$PM_{2.5}$		SO_2		NO_x	
Sector	*Annual Emissions (Mil Tonnes)*	*Average Ambient (µg/Nm³)*	*Annual Emissions (Mil Tonnes)*	*Average Ambient (µg/Nm³)*	*Annual Emissions (Mil Tonnes)*	*Average Ambient (µg/Nm³)*
Residential Biomass	3.512	20	0.322	0.42	0.324	1.72
Industrial coal	1.173	4.9	3.652	3.08	1.508	3.45
Power plant coal	1.003	5.5	3.595	4.01	3.738	8.68
Open burning	1.030	5	0.075	0.012	0.451	0.11
On-road gasoline	0.053	0.39	0.008	0.250	0.24	3.00
On-road diesel and railway	0.211	1.21	0.044	0.767	1.156	2.26
Brick production	0.386	1.7	0.331	NA	0.399	NA
Distributed diesel	0.133	1.6	0.009	0.35	1.369	1.19
Others	1.600	26.3	0.056	0.61	0.313	0.73
All India	**9.1**	**74.3**	**8.1**	**9.5**	**9.5**	**28.09**

Estimating the Social Cost of Pollutants

$PM_{2.5}$

We estimate benefits associated with reducing overall ambient $PM_{2.5}$ levels of 74.3 µg/Nm³ by 46.16% to meet the National Ambient Air Quality Standard (NAAQS) of 40 µg/Nm³. We assume that this would require a 46.16% reduction uniformly across all sectors (Column A of Table 1). For example, coal-fired powerplants would need to reduce their contribution by 46.16% of 5.5 µg/Nm³ (or 2.54 µg/Nm³).

Social costs of pollutants are determined by assessing health impacts from long-term exposure to pollution. According to Greenstone and others (2015) a reduction of 10 µg/Nm³ in ambient $PM_{2.5}$ levels increases life expectancy by one year on average, which is seen only in cases of prolonged exposure. In order to realize these life expectancy benefits, $PM_{2.5}$ emissions would need to be abated every year, over the average Indian lifetime[xiii]. In the case of coal, a reduction of 2.54 µg/Nm³ in ambient levels would require an annual abatement of 0.463 million tonnes of $PM_{2.5}$ for 69 years.

We estimate the value of this increase by approximating the Value of a Statistical Life using the method proposed by Roy and Braathen (2017)[xiv,xv]. Each Indian life carries a value of 34.33 million rupees or 0.5 million US dollars, which falls in line with other estimates[xvi]. Total benefits are calculated by multiplying per life benefits by the population. We employ the same methodology to calculate benefits from abating $PM_{2.5}$ emissions from road transport. The results are outlined in Table 2. The associated social costs are calculated as unseen benefits per kg of $PM_{2.5}$ that should be abated. The average social cost of $PM_{2.5}$ is Rs. 5,992.33/kg or $86.85/kg.

Emissions of particulates from natural gas are negligible in comparison to these other fuels are correspondingly the social cost from $PM_{2.5}$ can be assumed to be approximately zero.

Table 2. Benefits from lowering ambient $PM_{2.5}$ levels to meet the National Ambient Air Quality Standard.

Fuel	ΔC (µg/Nm³) to be lowered	ΔM (million tonnes to be abated)	Unseen Benefits (Million INR)	Social cost per kg $PM_{2.5}$ (INR/kg)
Coal (power)	2.539	31.95	169,169,209.83	5,295.00
Petrol (transport)	0.181	1.688	12,087,477.13	7,159.87
Diesel (transport)	0.557	6.721	37,125,383.91	5,523.75

The report estimates the social cost of SO_2 from coal power to be 3.8 2007 US cents per kWh. The SO_2 emissions factor from Indian coal power plants is estimated at about 0.0071 kg/kWh

SO_2 and NO_x

University of Chicago researchers calculate the social costs of SO_2 and NO_x emissions from coal-powered electricity using a report by the National Research Council of the National Academies (2010)[xvii]. The report estimates the social cost of SO_2 from coal power to be 3.8 2007 US cents per kWh. The SO_2 emissions factor from Indian coal power plants is estimated at about 0.0071 kg/kWh (Cropper et.al, 2012 and Mittal et.al, 2012[xviii,xix]. In 2017 Indian rupees, the social costs of SO_2 translate to about 7.61 2017 USD/kg[xx]. Cropper and others (2012)[xxi] estimate 10 deaths for every thousand tonnes of SO_2 emitted from coal-fired powerplants in India. Based on our VSL estimates, this translates to a social cost of $5 per kg of SO_2. We apply the higher of these two estimates in our study.

In the NAS report, authors estimate the social cost of NO_x from coal-powered electricity in the United States to be 0.34 2007 cents/kWh, which is approximately 1.52 2017 USD/kg NO_x in India[xxii]. Cropper et. al estimate about 9 deaths per thousand tonnes of NO_x emitted, resulting in a social cost of $4.5 per kg NO_x. As is the case with SO_2, we apply the higher of these two estimates to estimate pollution costs.

Once again natural gas is a much cleaner fuel than coal or liquid fuels, at least when considering these local pollutants.

CO_2

Although carbon is not explicitly regulated through Indian law, it is nevertheless useful to compare local air pollution costs which are felt by the Indian population in the present day, to estimates of climate change related carbon costs. Several sources put the latter value $40 per tonne of CO_2 emitted, which is equivalent to $0.04 per kg CO_2 . Table 3 summarizes the social costs estimated for each pollutant.

The procedure above is used to estimate the environmental social costs associated with an additional kg of pollutant emissions. A more intuitive way of understanding these costs is to use emissions factors for different fuels to calculate the additional environmental charge that would be needed to compensate for these damages. To express this number in rupees of social cost per kg of fuel, we may multiply costs per unit mass of pollutant by emissions factors for each fuel. Table 3 provides estimates for coal, natural gas, petrol and diesel. More detailed calculations are provided in the appendix.

Air pollution alone would suffice to make coal an expensive and undesirable fuel if the full social costs were accounted for.

The most striking conclusion from these figures are the remarkably high social costs of coal. Air pollution alone would suffice to make coal an expensive and undesirable fuel if the full social costs were accounted for. Thus, a shift to natural gas, that is often advocated as a step towards reducing carbon emissions, may also be justified even if India focused on air pollution considerations alone. Note that these estimates are based on a value of statistical life as explained above. Should the VSL be assumed to be low, the implied damages from air pollution, especially from coal would reduce. That said, the degree to which we would want to adjust fuel mix may depend on several factors and the discussion below draws attention only to one.

Table 3: Social costs expressed as an environmental tax on fuels

Fuel	Carbon Social Cost	Air Pollutants	Total
Coal	3.54 INR/kg	10.84 INR/kg	14.38 INR/kg
Natural Gas	141.52 INR/MMBtu	-	141.52 INR/MMBtu
Petrol	4.74 INR/litre	2.28 INR/litre	7.02 INR/litre
Diesel	5.22 INR/litre	2.24 INR/litre	7.46 INR/litre

Note: The density of diesel is assumed to be 0.84kg/litre, petrol 0.74kg/litre, natural gas 0.76 kg/SCM. The calorific value of gas is assumed to be 25.2 MMBtu / SCM.

Command and Control Regulation

Environmental regulation in India largely derives from three fundamental pieces of legislation: The Environment Protection Act (1986), the Air (Prevention and Control of Pollution) Act (1981), and the Water (Prevention and Control of Pollution) Act (1974). Taken together, these three acts provide a significant amount of freedom to the Central and State Pollution Control Boards, in devising policy to control air and water pollution. Judgements by the judiciary including the Green Tribunal have also drawn upon these laws in diverse ways, including industry closures, fines and monetary penalties, establishment of consent conditions, and requirement to introduce more stringent pollution control measures in sensitive areas.

Notwithstanding the wide scope of the underlying legal framework, regulation to date has largely focused on "command and control" instruments, including technology mandates and fixed concentration and/or load standards. Other initiatives have also been introduced in the past, targeting highly polluted regions or specific industry sectors or factories. These conditions may often be defined in the environmental clearance documents.

These instruments have had varying degrees of success, but low compliance and the high costs imposed on industry have become serious concerns in recent years. The use of concentration standards may deter investments in energy efficiency as a means of fulfilling environmental objectives. Partly for these reasons, the NITI Aayog recommended the use of a National Emissions Trading System in the recently issued Breathe India Action Plan.

Both state governments and the union government have important roles to play in the context of environmental policy. The Ministry of Environment, Forests, and Climate Change (MoEFCC) and the Central Pollution Control Board (CPCB), play a leading role in defining policy and setting standards respectively. A significant amount of flexibility is granted to states in the case of water, which is a state subject. In the case of air pollution, which is a concurrent subject, the CPCB sets standards and state governments are obligated to implement pollution standards that are at least as strict as those defined by the CPCB. Of course, this does not prevent state pollution control boards (SPCB) from introducing additional schemes or regulation, within the legal framework. As an example, market-based regimes could be implemented by state governments, provided minimum concentration standards imposed by CPCB were also retained. This is one of several ways for state governments to successfully link environment and energy policy.

Existing command and control regulation of industrial pollution broadly falls into three categories. First, and most common, the CPCB and SPCB establish absolute standards relating to the production of pollutants. These standards primarily define the concentration of pollutants in air emissions or water discharge. Failing to adhere to these standards may result in criminal penalties.

A significant short-coming of command-and-control regulation is that the economic costs associated with these instruments are very high.

Second, environment regulators may explicitly mandate the use of specific technologies, production processes, or fuels. This may include a requirement to install pollution abatement equipment or switching to natural gas as a combustion fuel.

Third, the government may ration or even entirely ban certain types of polluting economic activity. Industry closures in sensitive regions are an example of this type of action. All these approaches seek to reduce pollution emissions from plants, especially particulate matter emissions from solid fuel.

Measurement and Monitoring

Well defined standards have been laid down by the CPCB to measure the concentration of air pollutants. This document will not reproduce the details of these guidelines which are available in the public domain, but an important characteristic of these techniques is that they require manual sampling at the plant site itself. This process imposes significant burden with regards to the availability of trained staff, and this constraint has resulted in very limited and infrequent testing in many states. Because sampling is infrequent, there are concerns about the maintenance, operation and efficacy of pollution reduction technology such as bag filters, even if they are properly installed. In other words, even if plants have the equipment necessary to reduce pollution, it is impossible to monitor ongoing effectiveness.

Subtler concerns have also been noted in the manual sampling regime, as noted in the NITI Aayog Breathe India Action Plan. In cases where industries are asked to pay for pollution audits themselves, there are serious concerns because of conflicts of interest and differing incentives of industries, environmental laboratories (who are paid by industry) and the state pollution control board. For this reason, the Breathe India Action Plan recommends introduction of measures such as random assignment of auditors to industrial plants, payment from a common pool, monitoring for accuracy and accuracy-based bonus payment system that have proven to be effective in enhancing the compliance of industries. These issues have been discussed at length in recent studies including Duflo et al, 2013[xxiv] and Greenstone et al, 2017[xxv].

Continuous Emissions Monitoring

Recently, Continuous Emissions Monitoring Systems (CEMS) have been mandated in 17 Industry sectors. These instruments allow for remote monitoring of emissions but currently cannot be used as the legal basis of action against industries. Building upon this commendable initiative and integrating these instruments into the regulatory system would serve two important purposes. First, it enables government to continuously track pollution and thus dramatically improves the quality of data available to support environment policy goals. Secondly, this type of data assists plants in determining combustion efficiency because real-time emissions provide information on the performance of the boiler. Thirdly, continuous emissions monitoring systems provide data that can be used as the basis for new and innovative regulation, including market based instruments. Using CEMS, it is possible to estimate the total mass of pollutants released into the atmosphere over any period. This quantity, and not the instantaneous concentration, is of direct relevance to health impacts from pollution.

A detailed discussion of the relative benefits of CEMS and traditional command-and-control instruments is provided in Greenstone et al, 2017[xxv], as part of the National Council for Applied Economic Research, "India Policy Forum" report released by the former Chief Economic Advisor, Sh. Arvind Subramaniam in July 2018.

Economics of Command and Control

A significant short-coming of command-and-control regulation is that the economic costs associated with these instruments are very high. In the context of initiatives such as Make In India, and the urgent need for development and growth in India, energy and environment policy must be designed to reduce costs on industry, while simultaneously protecting our environment.

The primary reason that command-and-control regulation is expensive is that it is highly inflexible. As implemented, concentration standards also have only an indirect relationship to the underlying cause of pollution in the ambient air. Pollution in the atmosphere is caused by the total mass of pollutants emitted by any source, including industry. However, the existing command and control standards target concentration of pollutants in water and air discharge, and not the total load (mass). This means that plants are not rewarded for operating fewer hours in the year, and are not necessarily encouraged to improve energy efficiency, even though both actions reduce their environmental impact. A small factory operating for 6 months in peak season must meet the same standards as a large unit operating 24x7 for 12 months, even though the environmental impact of the larger unit is much higher. Similarly, reducing overall fuel use is not rewarded under concentration-based standards. As it stands, the total mass of emissions produced, which are directly related to the total fuel use, is not relevant for assessing compliance.

The outcome of this inflexibility is that small and medium scale enterprise, which are in many cases the engines of growth in India, have high costs of compliance with environmental regulation. Frequently this means that they do not meet standards causing high pollution. Enforcing criminal penalties and closures is not always a feasible response because there are high economic costs and lost jobs. See Dasgupta, 2000[xxvi]; Duflo et al, 2018[xxvii] for data on these problems.

Absolute emission norms also do not provide any incentive for industries to reduce emissions above and beyond the minimum that is required, even if the marginal costs of additional abatement are negligibly small in comparison with the social costs they impose. An additional advantage of economic instruments such as taxes or cap-and-trade is that polluters have dynamic incentives to continue abating their emissions and to innovate using cleaner fuels and processes (Jaffe and Stavins, 1995[xxviii]).

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Market-Based Regulation

The Breathe India Action plan recommends market-based regulation as a solution to these problems. This includes both cap-and-trade regimes and financial incentives or taxes. An important benefit of such policy instruments is that they follow the "polluter pay" principle. In addition, they reduce costs imposed on industry, and provide increased flexibility, *while meeting environmental objectives.* Such instruments also address the direct link between encouraging energy efficiency, clean energy sources, and low carbon intensity, while at the same time providing immediate health benefits by controlling local pollutants (SO_x, NO_x, particulate matter). It should be noted that the importance and requirement of market-based regulation and monetary fines has also been highlighted by the Green Tribunal. Some of these cases are described in Govindarajan, 2017[xxix] and Outlook, 2017[xxx], which has established that these tools may be used under current laws. It is interesting to note that the use of market-based instruments has been used as part of national energy policy, such as the Perform, Achieve, Trade (PAT) scheme. However, by itself the PAT scheme cannot serve the goals of energy efficiency in manufacturing, because it is targeted at large designated consumers. This is one reason why it is important that environmental regulation, which applies to all manufacturing is in line with the same goals.

To quote the Breathe India Action plan:

"Introducing a market-based instruments within a regulatory framework based on the concept of 'polluters pay' should be implemented. It would entail capping the individual pollution levels of all industries to certain emission allowance. The currency of trade would be tonnage of pollutants produce such as 'CO_2, SO_x and NO_X units', which are inter-convertible. Similar trading units for particulate matter can also be introduced.

This cap should be shrunk annually, leading to a faster adoption of cleaner fuel and stringent pollution curbing mechanisms. Similar models exist in the European Union (Emissions Trading System) and in India (Perform Achieve Trade) for combating greenhouse gas emissions (GHGs). The emission allowances should be customized – division of industries into clusters, with respect to factors such as polluting intensity, scale, type etc. The firms operating at a deficit, i.e. emitting more than permitted, can purchase through the open trade exchange from the firms that are operating at a surplus. Additionally, firms that do not use their allowance can monetize their trading units.

To incentivize adoption of renewable energy sources like solar energy, wind energy, and to promote installation of efficient filtration equipment provisions such as accelerated depreciation lower GST rates or import duties should be explored."

The cost reductions from emissions-trading can be calculated directly using engineering-economic models. One example of this exercise for textile plants in the city of Surat in Gujarat is provided in the study by Nilekani and Harish, 2018[xxxi], but similar calculations may be done for any specific context. Building these engineering models requires rich information on emissions levels, existing abatement measures in plants, the capacity of emission sources, the efficiency of abatement equipment, and estimates of the costs of retrofits, repairs, and new capital equipment. These data may be obtained from field surveys.

The cost reductions from emissions-trading can be calculated directly using engineering-economic models. One example of this exercise for textile plants in the city of Surat in Gujarat is provided in the study by Nilekani and Harish, 2018, but similar calculations may be done for any specific context.

An alternative means of assessing actual benefits is the use of pilots designed to evaluate the impact of markets. It is recommended that such pilots be implemented because there may be gaps between engineering models and ground realities. Such pilots would also provide the implementation experience that is necessary to allow SPCBs to successfully implement these schemes at larger scales.

RELATIONSHIP OF MARKETS TO EXISTING AND PROPOSED REGULATION

Ideally, market-based methods and command-and-control regulation should be viewed as substitutes, especially if the cost savings from markets are to be fully realized. There is a clear economic reason for this – if both regulatory instruments are used simultaneously then the command and control standards will constraint the extent of flexibility available to plants. In turn this places limits of the number of permits that can be bought and sold and in an extreme scenario might result in no trades at all. This would occur for instance if the command-and-control regulation were extremely strict.

There are cases where both regulations may co-exist without much loss of efficiency. These are primarily situations where (i) the existing plant-level standards are relatively lax and (ii) the market cap is significantly lower than the amount of pollution that would be produced if all plants adhered to concentration standards. In such a situation the market cap would "bind" and concentration standards would be higher than the maximum emissions seen in any plant, after permits are bought and sold.

Another setting where both regulations could co-exist is where compliance and enforcement of command-and-control is very weak. In such cases factory emissions would be seen to be higher than the concentration standard that is legally defined. One reason for lack of compliance may be high costs associated with meeting command-and-control regulation. Introducing a market in these settings may then be an improvement on two dimensions. First, because overall costs reduce, there is less incentive to not comply with the regulation. Second, markets involve transparent and publicly available data on the permit holdings and trading behavior of all participants. All participants in the market are affected if even one participant chooses not to comply with permit holding requirements. Therefore, there is greater interest from all stakeholders in advocating for universal compliance.

These considerations of dual regulatory frameworks become especially important in cases where command-and-control regulation has been recently tightened, provided compliance with these standards is strongly enforced. Recent notifications by the CPCB issued in December 2015 have meant that for local pollutants, power plants will be expected to comply with much stricter standards by the year 2022. If high compliance with these new norms is also observed, the introduction of markets alongside new concentration standards may not be useful in this setting. For some sectors, other factors may also play a role in setting new policy. For instance, in the power sector, regulation is also set by the CERC and SERC. Environmental regulation must also be in consonance with constraints resulting from this fact.

Having said this, concentration norms for all pollutants are not equally strict, even under the new notifications, and some pollutants, such as carbon dioxide, are not regulated at all. The power sector is critical to development. As such the use of regulatory techniques that minimize costs is important. In the future, if it is felt that gaseous pollutants or carbon should be regulated more strictly, market-based mechanisms may be a good way of meeting these environmental goals while imposing minimum costs on the sector.

International Experience

Although ultimately the success of new regulatory instruments depends on ground-realities within India, it is helpful to review the experience with market-based regulation in other parts of the world, where significant experience has been built up.

The "polluter pay" principle has been adopted as a desirable goal in India. Notwithstanding this, the absence of monetary charges in India lags behind not only the United States but also China, which has relied on financial penalties since the early 1980s. In China, although non-compliance could invite criminal legal sanction, the use of this penalty is extremely rare (Wang and Wheeler, 2005)[xxxii]. Instead, industries are charged a levy for non-compliance, which is proportional to the exceedance; since 1993, Chinese regulators have also been levying charges for air emissions or water discharges within the standards for some pollutants (Wang and Wheeler, 2005)[xxxii]. As a result, pollution levels become an economic choice for industries, as a response to the levies imposed on them. Wang and Wheeler (2005)[xxxii] determine the elasticity of pollution with levy rates and find that a statistically significant, strong marginal deterrence for the pollution levy: for water pollution and SO_2 emissions, estimated elasticities are about -1.0.

In India, criminal penalties are still the norm. The problem with such tools is that they cannot be calibrated to the actual environmental damages caused. Thus, plants that exceed a norm by 5 percent are subject in theory to the same penalties as those that exceed norms by 200 percent. The outcome of inflexible regulation is that regulators choose to target harsh punishments at a small fraction of major violators, while letting many other plants off with no penal action. This phenomenon has been well studied, see for example a legal analysis in Ghosh (2015)[xxxiii].

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The U.S. Clean Air Act Amendments (CAAA) of 1990 initiated the first experiments using market-based regulation to control air particulates: the sulfur dioxide (SO_2) and nitrogen oxide (NO_x) emission trading schemes. These programs, along with California's Regional Clean Air Incentives Market (RECLAIM) in the South Coast Air Basin, stimulated the adoption of environmental markets for greenhouse gas (GHG) emissions in Europe (EU ETS) and California (AB 32).

SO_2 Trading Program

In the late 1980s, before any market mechanisms were in place, SO_2 concentrations in many regions of the United States exceeded the national ambient air quality (NAAQ) standards set under the 1970 Clean Air Act. After two decades of experimenting with command-and-control regulation, the US Environmental Protection Agency (EPA) had eliminated nearly all of the most severe air quality non-attainment "hot spots", by closing high emitting electric generators and mandating many generators build tall stacks, to dissipate the local effects of SO_2 emissions. However, the smokestack remedy for local air quality contributed to the deterioration of regional air quality. Released high in the atmosphere, SO_2 emissions from tall stacks travel hundreds of miles and convert to sulfates that damage human health, degrade air quality and visibility, and ultimately contribute to acidification.

To address the regional pollution problem, the CAAA established the SO_2 emissions permit-trading program for electric generating units. The program was introduced in two phases. Phase I began in 1995 and affected 374 pollution-intensive coal-fired electricity-generating units, covering all of the eastern half of the United States. Phase II started in 2000 and covered all other coal-fired electricity-generating units with a capacity greater than 25 megawatts, plus smaller ones using fuel with a relatively high sulfur content, totaling just over 1,400 generating units. Similarly, the first phase of the India ETS will target the largest point sources within well-defined boundaries of each regional airshed.

The SO_2 permit-trading program produced substantial declines in power plant emissions. Total emissions in 1995, the first year of the program, were 11.87 million tons – more than 35 percent below 1980 levels. During the first year of Phase II in 2000, total SO_2 emissions declined to 11.2 million tons – almost 40 percent below 1980 levels. Phase I units reduced emissions by 57%, while Phase II units reduced emissions by 14%.

Studies estimate the cost savings attributable to SO_2 emissions trading by comparing total costs under the program with a hypothetical counterfactual policy, taking into account changes in fuel markets. These studies consider an emissions rate standard as the alternative to trading. Carlson et al. (2000)[xxxiv] use econometric estimates to calculate savings of 45–55%, compared to a uniform standard that would have regulated the rates of emissions at facilities. Epidemiologic and economic models indicate that dramatic improvements in public health and reduced acidification outweigh the costs of the program by an order of magnitude (Burtraw et al., 1998[xxxv]; Muller and Mendelsohn, 2009[xxxvi]). These measures of benefits and costs suggest the program is cost-effective.

Clear Air Interstate Rule (CAIR), previously the NO_x Budget Program

The CAAA regulate NO_x emissions from coal-fired electric generators and industrial sources, because, along with SO_2, NO_x contributes to the problem of acidification and nonattainment of air quality standards for ozone. As with SO_2 policy, the shift toward market-based solutions for reducing NO_x emissions evolved over time.

In 1997, EPA required states to impose restrictions on electricity generators and industrial sources of NO_x emissions, to help downwind states comply with the federal ozone standard. The rule is known as the NO_x SIP Call, because it called on states to revise their State Implementation Plans (SIP), which outline their strategies for complying with NAAQ standards. The NO_x SIP Call assigns each state a summertime NO_x emissions budget for large point sources. A state has the flexibility to either require its sources to directly comply with the state budget or, as EPA preferred, to participate in the regional cap-and-trade program: the NO_x Budget Program (NBP).

Between 2000 and 2008, the NBP reduced summertime NO_x emissions by 62% within the covered region (U.S. EPA 2009). Concentrations of ozone averaged over eight-hour intervals decreased in all states participating in the NBP by 10% (U.S. EPA 2008). Engineering estimates of compliance costs and econometric estimates of avoided health impacts from reduced NO_x emissions estimates gains from the NBP at $264 million per year (Fowlie and Muller, 2013)[xxxvii].

RECLAIM

In the Los Angeles air basin NO_x is the critical factor in ozone (O_3) formation. Nearby mountains and warm temperatures create an atmospheric inversion layer that traps O_3 and contributes to the basin's consistent failure to meet the NAAQ O_3 standard. In 1994, unable to achieve the ambient O_3 standard via prescriptive measures alone, the South Coast Air Quality Management District started the first regional, urban trading program for NO_x. Replacing 40 pre-existing NO_x standards, RECLAIM called for approximately 400 facilities to reduce aggregate emissions by 8% per year from 1994 through 2003, a remarkable total emissions reduction of 70%.

In 2000, the permit price spiked, as the regular ratcheting down of permit supplies coincided with flawed deregulation in the electric sector. By 2001, NO_x permits traded at over $60 per pound as demand for permits substantially outpaced supply, eventually resulting in some electric generators failing to meet their compliance obligations. This is the only known breach of a binding cap in a permit-trading program. To address future price spikes, RECLAIM was amended to include a price containment mechanism: if the permit price rises above $7.50 per pound, the district can increase annual allocations in the following year. While it is highly unlikely that similar events would unfold in the India ETS, the proposal includes a price ceiling, which would prevent large price spikes.

While estimates of the cost savings achieved under RECLAIM vary widely (in part due to the price volatility experienced during late 2000 and early 2001), the program delivered significant environmental benefits. Matching firms in the Los Angeles basin under RECLAIM to firms subject to command-and-control regulations in nearby areas, Fowlie et al. (2012)[xxxviii] show that emissions from firms complying with RECLAIM were, on average, 24% lower than those outside the program.

EU ETS & CA AB32

The world's leading climate scientists agree that the climate system is warming, and that it is extremely likely that GHGs from human activities are the dominant cause. The latest scientific evidence suggests that, if little or no action is taken to reduce GHGs, by the end of this century global warming is likely to exceed the threshold beyond which there is a significant risk of catastrophic changes in the global environment.

Launched in 2005, the EU ETS is the main component of the European Union's policy to combat climate change and the key tool for reducing industrial GHGs cost-effectively. The EU ETS covers more than 11,000 power stations and industrial plants in 31 countries, and is the first international system for trading GHG permits, The EU ETS covers emissions of carbon dioxide (CO_2) from power plants and a wide range of energy-intensive industrial sectors, nitrous oxide (N_2O) emissions from the production of certain acids, and emissions of perfluorocarbons (PFC) from aluminum production. The target for the EU ETS – now in the third phase – is 20% below 2005 the level by 2020.

The world's leading climate scientists agree that the climate system is warming, and that it is extremely likely that GHGs from human activities are the dominant cause

Toward the end of the first compliance phase of the EU ETS, the permit price collapsed to zero, as it became clear that permits were substantially oversupplied. Had permits from the first phase been bankable into future compliance periods the oversupply would have diminished prices and the future effectiveness of the EU ETS. To guard against the risk of persistent over- or under-supply, the proposed India ETS would not allow banking or borrowing between annual compliance periods.

Launched in 2013, the CA AB32 cap and trade program is the main component of a suite of policies – outlined in the AB32 Scoping Plan – which California is undertaking to curb GHGs. Similar to the EU ETS in scope and design, the cap covers emissions of CO_2, methane (CH_4), N2O, sulfur hexafluoride (SF_6), and PFC from electricity generators and large industrial sources in the first phase (2013-2014), expanding to emissions of CO_2 from the combustion of transportation fuels and residential, commercial, and small industrial natural gas in the second and third phases (2015-2020). The GHG reduction target is 1990 the GHG level by 2020, a 17% reduction from the 2012 GHG levels.

Covering a similar number of sources to each region of the India ETS, CA AB32 has instituted holding limits to ensure that the largest participants in the program, some of which may be responsible for as much as 10% of the total compliance obligation in the first phase, are not able to manipulate the market or exercise market power. To guard against similar concerns of manipulation and market power, the proposed India ETS includes recommendations for a permit holding limit.

Due to the global nature of GHG damages and the relatively recent implementation of the EU ETS and CA AB32, it is difficult to quantify costs and benefits of these GHG permit-trading programs. However, as early permit prices in each program are significantly lower than most estimates of the social cost of GHG emissions – perhaps due in part to the economic impact of the recent global recession – it is likely that the emissions reductions induced by the programs will prove to be highly cost-effective. Table 4 summarizes evidence from a number of cap and trade markets across the world.

Table 4: Summary of emissions trading markets across the world

Country / Region	Name	Year	Pollutant	Effects / Target
Mexico	Pilot ETS	Expected 2017	CO_2	Plans to link with Western Climate Initiative (WCI) market
China	National Emissions Trading Scheme	Expected 2017	CO_2	7 existing regional pilots with high compliance, over 4 million tons of quota trade to date
Beijing	Emissions Trading Pilot	2011-2015	CO_2	In first period, emissions fell 4.5% and the cost of cutting emissions fell by 2.5%
Shanghai	Emissions Trading Pilot	2011-2015	CO_2	Emissions fell 3.5% from 2011 to 2013
Shenzhen	Emissions Trading Pilot	2011-2015	CO_2	Emission fell 11.7% from 2010 to 2013
Tianjin	Emissions Trading Pilot	2011-2015	CO_2	Intensity target of 15% above 2010 levels
Hubei	Emissions Trading Pilot	2011-2015	CO_2	Intensity target of 17% above 2010 levels
Chongqing	Emissions Trading Pilot	2011-2015	CO_2	Intensity target of 20% above 2010 levels

Country / Region	Name	Year	Pollutant	Effects / Target
Guangdong	Emissions Trading Pilot	2011-2015	CO_2	Intensity target of 19% above 2010 levels
South Korea	Korean Emissions Trading Scheme (KETS)	2015-present	All GHGs	Targets 4% reduction below 2005 levels by 2020
Kazakhstan	Kazakhstan Emission Trading System	2013-present	CO_2	targets 15% reductions below 1992 GHG levels by 2020
Switzerland	Swiss ETS	2008-present	CO_2	N/A
New Zealand	New Zealand Emissions Trading Scheme	2008-present	All GHGs	Enabled New Zealand to meet emission target for the first commitment period of the Kyoto Protocol
Japan	Japan Voluntary Emissions Trading Scheme (JVETS)	2005-present	CO_2	25% cut below 1990 levels by 2020
Tokyo	Tokyo Cap-and-Trade Program	2010-present	CO_2	In 2012, emissions were reduced by 22% below base year levels
European Union	EU ETS	2005-present	CO_2	21 % cut below 2005 levels by 2020
Australia	New South Wales Green House Gas Abatement Scheme (NSW GGAS)	2003-2012	All GHGs	Discontinued to avoid duplication with the Commonwealth's carbon price
Chile	Santiago Air Emissions Trading	1995-present	Total suspended particulates	Low trading volume; decrease in emissions since 1997 not definitively tied to TP system
Canada	ODS Allowance Trading	1993-present	CFCs, Methyl Chloroform, HCFCs, Methyl Bromide	Low trading volume, except among large methyl bromide allowance holders
	Pilot Emissions Reduction Trading (PERT)	1996-present	NO_x, VOCs, CO, CO_2, SO_2	N/A
Alberta	Climate Change and Emissions Management Act	2007-present	All GHGs	reduce emissions vis-a-vis GDP to 50% of 1990 levels by 2020
	Regulatory Framework for Air Emissions	2007-present	All GHGs	industrial emission-intensity reduction of 26% by 2015

Country / Region	Name	Year	Pollutant	Effects / Target
British Columbia, California, Manitoba, Ontario, Quebec	Western Climate Initiative (WCI)	2013-present	GHGs	First international cap-and-trade system to consist of subnational territories
United States	Leaded Gasoline Phasedown	1982-1987	lead in gasoline among refineries	More rapid phase out of leaded gasoline; $250 m annual savings
	Water Quality Trading	1984-1986	Point-nonpoint sources of nitrogen & phosphorous	No trading occurred, because ambient standards not binding
	CFC Trades for Ozone	1987-present	Production rights for some CFCs, based on depletion potential	Environmental targets achieved ahead of schedule
	Protection Heavy Duty Engine Trading	1992-present	NO_x and particulate emissions	Standards achieved; cost savings unknown
	RECLAIM Program	1994-present	SO_2; NO_x	NO_x emissions fell by 60%; SO_x emissions by 50 per cent.
	Acid Rain Program	1995-present	SO_2 emission reduction credits	SO_2 reductions achieved ahead of schedule; savings of $1billion/year
9 northeastern states	Regional Greenhouse Gas Initiative (RGGI)	2005-present	CO_2	10% cut below 2009 levels by 2018
27 eastern states	Clear Air Interstate Rule (CAIR) previously known as NO_x Budget Program	2003-present	SO_2; NO_x	61% reduction from 2003 levels; sharp reductions in compliance costs
California	CA AB32	2013-present	CO_2, methane, N_2O, sulfur hexafluoride, PFC	target is 17% reduction from 2012 levels by 2020

Pollution Monitoring: Quality and Transparency

In February 2014 the CPCB passed an order mandating the installation of continuous monitoring systems for air and water pollutants in seventeen categories of highly polluting industries. When successfully implemented, CEMS would transform the quality of regulatory data to the level required to underpin sophisticated markets.

Introducing modern market-based instruments involves two prerequisites. The first is to improve the quality of regulatory information, exploiting the fact that technology now makes this possible. The second change is to make regulatory data transparent. On both dimensions the MoEFCC, Central Pollution Control Board (CPCB), and SPCBs have made important steps. These steps have enhanced preparedness to use modern regulatory instruments.

In the last few years, the CPCB has encouraged continuous emissions monitoring systems (CEMS), which are instruments that attach to the chimney stack of factories and supply real-time data on the emissions being generated. In so doing, they allow for dramatic improvements in the time granularity of data available to regulators. In 2013, CPCB released the first ever specifications for CEMS devices (CPCB, 2013)[xxxix], outlining allowable technology as well as auditing and maintenance procedures. Interestingly these specifications were designed to produce data that could also underpin market based regulatory frameworks such as cap and trade regimes. Following this initial standards document, which focused only on particulate emissions, the CPCB has since released a more general specification. With these regulatory instructions, in February 2014 the CPCB passed an order mandating the installation of continuous monitoring systems for air and water pollutants in seventeen categories of highly polluting industries. When successfully implemented, CEMS would transform the quality of regulatory data to the level required to underpin sophisticated markets.

While CEMS technology improves the quantity of emissions data available to the regulator, the quality of data is vulnerable to similar corruption issues as manual auditing that we have discussed above. CEMS data are only as reliable as the accuracy of their calibration. With particulate matter emissions in particular, calibration involves comparing sensor-measured data with manual measurements. For CEMS data to be useful, regulators need to introduce systematic protocols that consider the incentives of industries, CEMS vendors, and auditors. Mechanisms to reduce corruption in auditing procedures were also discussed in the Breathe India Action Plan and are described in more detail in Duflo et al, 2013[xl], and Greenstone et. al, 2017[xli].

Enhancing the quality of information on emissions is an important step towards modern regulation. However, it is important that this also be accompanied by transparency, wherever possible. In itself improving regulatory transparency requires no leaps in technology but helps increase public faith in regulation and is a necessary element of market-based regimes.

When information available with the regulator is also made transparent to the public, there are reasons to believe that environmental performance may also improve. Although quality and transparency are two distinct concepts, making data visible to the public may also have the indirect benefit of forcing regulators to improve the reliability of disclosed information. In health care for example, Marshall et al (2003)[xlii] argue that disclosure initiatives in the United Kingdom also improved the quality of report cards issued by hospitals.

Transparency and disclosure initiatives have become commonly used in several countries. In the United States, the Toxic Release Inventory and public disclosure programs around safe drinking water are prominent examples. Indonesia initiated a ratings regime for industrial water pollution in 1995 called Program for Pollution Control, Evaluation and Rating (PROPER). Research suggests that PROPER resulted in improved environmental performance of firms (Blackman et al 2004)[xliii] through a mix of improving the information available to firm management, and making data public. Likewise, evidence from a disclosure scheme in China called Green Watch found similar results (Wang et al, 2004)[xliv]. Public ratings may also create competition among plants on environmental performance and there is evidence that when a firm is seen as being better for the environment, it also does better on the stock market (Klassen and McLaughlin 1996)[xlv].

There is also significant evidence suggesting that public pressure and engagement are also important in determining the success of regulation (Greenstone and Hanna, 2014)[xlvi]. Even the release of data on ambient air or water pollution – which is not tied to an individual source – can lead to greater knowledge and participation of the public. Wide public release can both play an important role as a health advisory system and increase pressure on polluters to comply with regulatory standards (Afsah, 2013[xlvii]; Tietenberg 1998[xlviii]; Wang et al. 2004[48]).

In recent years' transparency initiatives have spread beyond Europe and the United States and also been introduced in China. In 2006, the China Institute of Public & Environmental Affairs began collating public information on air and water pollution and environmental violations at plants across the country. This first ground-breaking step came from civil society, not the government. However, since then, the Chinese government has gone further and made available a large amount of real-time data on ambient and plant pollution levels, including the 2014 disclosure of industrial emissions for around 13,000 enterprises.

In India, possibly the first such initiative was launched on the 5th of June 2017 in the state of Maharashtra where hundreds of large industrial plants are now publicly rated on a 1 to 5 star scale based on how much particulate air pollution they emit[xlix]. This initiative has begun as a pilot, designed with the explicit goal of evaluating the effects of disclosure on performance. The emphasis on rigorous evaluation makes this pilot possibly the first of its kind anywhere in the world.

The Maharashtra Star Rating scheme targets large plants with capital investments exceeding 25 crore INR and belonging to the Cement, Chemicals, Metal Works, Paper, Pharmaceuticals, Power, Sugar and Distilleries or Textiles sector. Data from the last four times a plant was tested for particulate emissions is used to generate a star rating, and the median test value is used to assign a rating based on the scale in **Table 5.** The pilot has continued to expand in the year since it was launched.

Table 5. Maharashtra Star Rating Initiative

Rating	RANGE OF PM EMISSIONS (mg/Nm^3)		Rating Key	Representation
	Minimum	Maximum		
1 star	250	-	Very Poor	★☆☆☆☆
2 star	150	250	Poor	★★☆☆☆
3 star	100	150	Moderate	★★★☆☆
4 star	50	100	Good	★★★★☆
5 star	0	50	Very Good	★★★★★

Source: http://mpcb.info

Designing Emissions Markets: Practical Guidelines

Over the last two decades, the Indian government has reviewed environmental regulation through the appointment of multiple task forces, high-level committees, and external consultants (Ministry of Environment Forests & Climate Change, 2014)[l]. Several expert committees have emphasized the need to use market-based regulation and fiscal instruments that align incentives and reduce costs of complying with regulations, following the "polluter pays" principle (Ministry of Environment Forests & Climate Change, 2014)54. Similar recommendations have been made by NITI Aayog (in the National Environment Policy, and Breathe India Action Plan, amongst others).

However, there is still an absence of a practical handbook describing important principles of market design. This document provides these details with the hope that it will be useful in implementation of these recommendations and provide a starting point for further refinement.

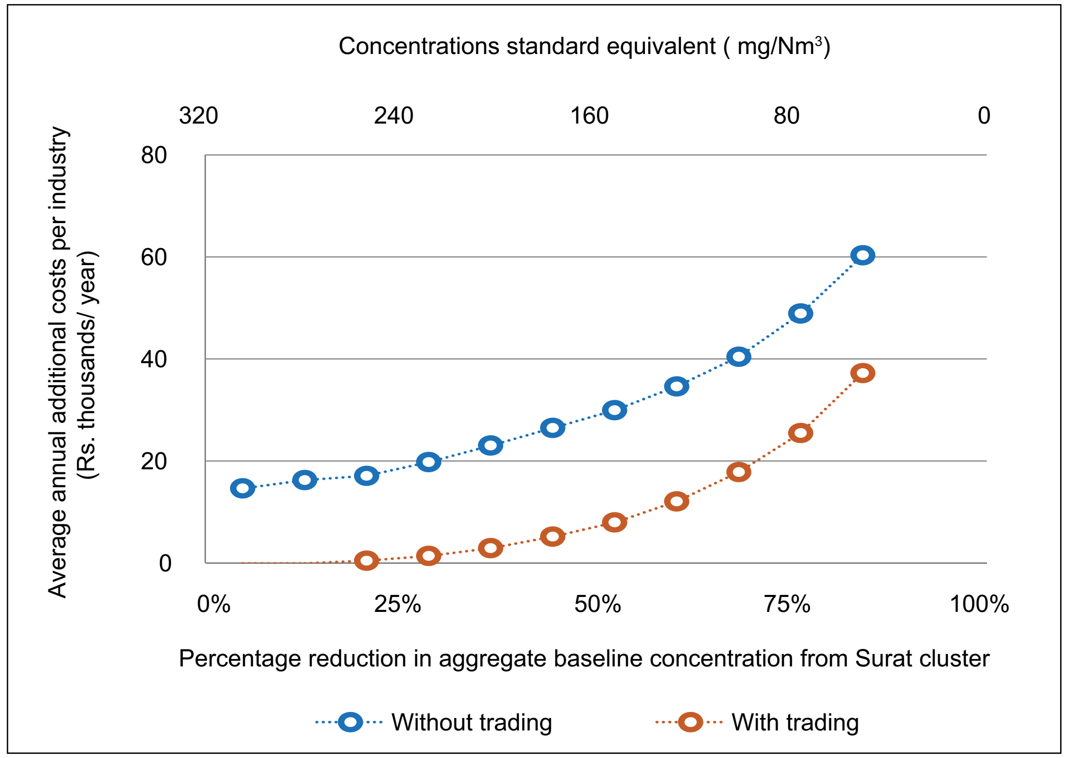
Principles of Cap Setting

The emissions cap determines the total amount of emissions that will be permitted from all sources in the market. Setting an emissions cap balances the environmental target of reducing emissions with the financial target of reducing compliance costs. A higher cap will mean greater emissions but a lower cost of emissions abatement, such as the installation, operation and maintenance of air pollution control devices. While emissions trading will reach any target at the lowest possible cost, setting more aggressive (lower) targets will increase costs. A lower cap will therefore mean lower emissions but correspondingly higher costs. This relationship can be summarized in an abatement cost curve that relates the amount of abatement (emissions reduction, relative to the uncontrolled scenario) to the cost needed to achieve that abatement. Figure 2 provides an example of such an abatement curve from Nilekani and Harish (2018) and based on the proposed design for a pilot emissions trade scheme in Surat, Gujarat jointly envisaged by the Central Pollution Control Board and the Gujarat Pollution Control Board, in collaboration with the Institute for Financial Management and Research.

Economic theory describes an efficient emissions cap as one where the cost of the most expensive emissions reduction undertaken by a source is equal to the damage from the very last unit of pollution emitted. That is, an emissions trading scheme is said to be efficient, when the marginal social damage from emissions is equal to the marginal social cost of abatement. However, in implementation, it is possible that a cap be gradually tightened to reach the marginal social cost, to give regulated sources time to adjust.

If a cap is set too stringently, emitters will have to pay too much for permits and make too many direct emissions reductions. And if the cap is set too loosely, emitters will pay too little for permits and make too few direct emissions reductions.

Figure 2. Engineering Economic Model of Abating PM Emissions in Surat.



Emissions Cap in Individual Industrial Clusters

When working with primarily industrial sources, an abatement cost curve for eligible can be constructed using baseline survey data. To do so, for each industrial unit, we need data on emissions concentration and load, boiler capacity and air pollution control devices installed. In addition, inputs on costs of new abatement equipment and typical operations and maintenance costs in industry are required. Based on this information, a simulated abatement cost curve can be modeled. This may provide a useful guide to design of an emissions market. Such a curve is an engineering model, so the abatement curve *in practice* may look different. Often true costs may be lower than predicted because it is difficult to identify ex-ante all the margins of adjustment available to sources.

If the trading market functions correctly, industries with the lowest marginal costs of abatement will reduce their emissions. Industries with higher marginal costs will choose to buy load permits. An engineering model of abatement functions by estimating the marginal costs for each abatement action (retrofitting and proper maintenance of existing APCD, or purchase of new efficient APCD) for each industry in the cluster. These abatement actions are then sorted in the ascending order of marginal costs. The market price is expected to be equal to the marginal cost of abatement action at the point where total emissions in the cluster equals the cap.

If the trading market functions correctly, industries with the lowest marginal costs of abatement will reduce their emissions. Industries with higher marginal costs will choose to buy load permits.

Although the ideal cap should be set based on the social costs associated with pollutants, this is not an easy task because quantifying the true social costs is difficult. Alternative methods are often used. For instance, baseline survey data may be used to estimate annual load based on the concentration of PM and flow-rate of stack emissions for every industry in the market. If CEMS data is available then this is an even more straightforward and accurate calculation. A cap may then be set to reduce the estimated annual load by a certain percentage every year. Such an approach was also recommended by the NITI Aayog in the Breathe India Action Plan.

Principles of Permit Allocation

The method of allocation of permits in an emissions trading scheme will affect the total costs of compliance for sources, but will not affect the level of emissions, which is fixed by the cap. It should also not affect the abatement actions undertaken, which are driven by the abatement costs of different sources, and not by how many permits they initially received.

In general permits may be allocated for free, or "grandfathered", based on past emission or some characteristic of sources, or may be sold off. This initial allocation does not constrain final emissions since industries may buy or sell permits. However, grandfathering has the advantage of lowering the initial costs of participation for industry and thereby ensuring broad support for the scheme. If all permits are grandfathered, however, it may be difficult to establish the market value of permits. Many schemes, therefore, will auction some share of permits to establish their value and encourage trade from the start of the market.

When permits are initially allocated, a transparent rule needs to be followed. One such rule is that a share of total permits defined by the cap are allocated in proportion to boiler capacity. This form of allocation is transparent and ensures that firms participating in the pilot emissions trading scheme do not need to incur significant up-front cost in purchasing emissions permits and may be able to defray some or all of the costs of making direct emissions reductions.

Using fixed capacity measures to initially allocate permits is preferable to using baseline emissions. Boiler capacity is available from the baseline survey or environmental consents. While boiler capacity is a strong determinant of emissions potential, industrial units may have lower emissions than expected due to fuel mix, combustion control or air pollution control measures. Any allocation based on boiler capacity will therefore benefit industrial units that pollute less per unit of capacity. Conversely allocations based on baseline emissions may discriminate against cleaner plants. A related advantage of using a fixed measure of capacity is that it avoids the incentive for industries to raise baseline emissions in order to capture a greater share of permits.

Grandfathered permits could be allocated to industries at the beginning of each month in twelve equal shares over the compliance period. While industries will receive the full amount over the course of the year, this gradual disbursement encourages attention to permit allocation and the rate of emissions load from the first month of the scheme.

New sources meeting the eligibility criteria for the pilot ETS could be granted permits, along with their environmental consent, following the same rule used to grandfather permits to the existing sources. The granting of permits to new entrants would reduce the cost of industrial units starting up and place them on a level playing field with existing permit holders. However, there is an obvious tension between allocating new permits and eventual levels of pollution in the market. One way of resolving this is that the SPCB may impose a maximum threshold on the size of the new entrant reserve, such as 5% of the level of the cap, beyond which no additional permits would be granted. This still allows new entrants to enter the market but increases their costs because they must purchase enough permits from currently operating units. This is a flexible version of more extreme rules that are currently used, such as outright banning all industrial activities in heavily polluted areas. It retains the objective of fixing total emissions since new permits are not indefinitely granted to new entrants. At the same time, it allows new entrants to pay existing plants to reduce their pollution to “make room” for another source.

When a certain fraction of permits are grandfathered, the rest should be allocated via auction. Auction revenues can be used for various purposes including rebating to eligible industries to offset monitoring and abatement costs. They may also be used by the state pollution control board to offset regulatory costs. Auctioning permits facilitates price discovery, by requiring allowance recipients to reveal their value for allowances via their bids. Having auctions early in the compliance period helps industrial units to form expectations about permit prices and decide whether or not to undertake abatement actions.

At each auction, the SPCB must offer the share of permits mentioned for sale. It is good practice for auctions to be spaced out over the compliance period in order to provide new information about prices and ensure some availability of permits for industrial units that wish to buy. It is also possible to include other sellers in the market, in which case the auction serves the purpose of both an allocation mechanism and a trading opportunity.

Permit Validity

Initially the compliance period should be fixed at one year. Permits may be denominated in units of a fixed mass of pollutant emissions (for example, one kilogram of particulate matter emissions) and valid for the fiscal year period from April to the following March. An annual compliance period allows flexibility for the sources to respond to permit prices and achieve emissions reductions. After a testing period, states may wish to re-evaluate the length of compliance periods using more complete CEMS data on the seasonality of emissions load and ambient pollution levels. Having multiple compliance periods would allow states to control the level of emissions during critical periods, such as by setting lower emissions targets when weather conditions make emissions contribute more strongly to ambient pollution.

For simplicity, a new ETS might begin with no banking (saving) or borrowing permits across years. Although banking and borrowing are part of several cap-and-trade markets they increase complexity and no longer guarantee that the level of emissions will not exceed the cap in any compliance period. On the other hand, they increase flexibility for industry and since the total number of permits released over any period of time does not change, borrowing permits in one year means that fewer permits are available in the next year.

Trading Platform and Trade of Permits

A trading platform serves as the market where load permit transactions are made among the participant industries. An appropriate platform needs to be identified, that is accountable and transparent to SPCB and the industries. The platform will also need to coordinate with a designated registry at SPCB to keep an integrated account of permits initially allocated, all permit transactions (sales and purchase), as well as the total emissions in the compliance period, for each industry.

Different alternatives are possible. First, an existing commodities exchange like Indian Energy Exchange (IEX) or the Power Exchange may be used. The Perform, Achieve, Trade scheme for instance uses this solution. Alternatively, an online trading platform may be housed in a secure server and hosted within the SPCB. With existing exchanges, permits must be included as a tradable commodity at the exchange, and the rules for trading must be adapted to be consistent with the trading rules at the exchange.

The exchange would be required to send regular reports to the designated registry cell within SPCB. The advantages to do so are as follows. One, the platform can be custom designed for the purposes of the ETS. Two, hosting the server at the industry association may give confidence to the participant industries about the programme. Three, the SPCB will only need to supervise the functioning of the exchange, without investment of additional resources to run the same. The disadvantage is that effort must go into building the platform in the first instance, including security and computing infrastructure.

Principles of Permit Trade

Emissions markets reduce compliance costs to the extent that sources with higher costs are able to find and purchase permits from sources with lower costs—that is, costs are reduced to the extent that the market encourages easy trades. It is therefore essential that the system of permit trade be set up to encourage activity and reduce transactions costs to the lowest possible levels. Industrial units should be able to easily find buyers or sellers for permits, according to whether they choose to reduce emissions below their initial allocation or not and should have a clear idea of the going value of permits in order to guide their abatement decisions.

Permit trade, in addition to being low-cost, should also satisfy the principles of transparency and security or robustness, to support an emissions market. Transparency means that the methods of finding trading partners, deciding prices and verifying trades should be clear to all market participants and relevant data on transactions should be available to the market. Security means that transactions should be executed only with the consent and approval of both parties and should be recorded in a central database that tracks permit holdings for compliance purposes. This is why high quality and transparent emissions data are the bedrock of a successful market.

Definition of a Permit and Permit Trade

A permit is the right to emit one kilogram of particulate matter emissions during a specified compliance period. Permits should each have a unique permit identification code (permit ID) and other information may be embedded in this number. For instance, a cluster-based market might have a code consisting of two portions: One indicating the cluster in which that permit may be traded followed by a sufficient number of digits to uniquely designate all the permits in the market.

Permit trade is the transfer of ownership of a permit from one party to another. Trades should be considered provisional until the transaction is cleared by the designated trading platform, with clearance consisting of verification that:

- the seller, or party from which permits are transferred, is in possession of the permits specified in the trade, as determined by the permit record files maintained by the designated trading platform;
- the buyer, or party to whom permits would be transferred, would not exceed any holding limit if the trade were executed.

This type of verification is standard for all trading platforms.

Means of Permit Trade

Permit trade is allowed via two separate channels, auctions and a permit exchange. The two channels are complementary. Auctions are relatively infrequent but provide a more liquid market, with more participants, and create a reference price to guide future trading activity. Auctions also allow for the gradual sale of the share of permits that are not grandfathered in a fair and transparent manner. The permit exchange, by contrast, maintains a limit order book on a continuous basis and allows individual permit transactions in the periods between auctions. Both the auction and exchange functions should be housed on a single trading platform that maintains the registry of permits and submits records of permit holdings to the SPCB for review.

Auctions

Auctioning permits in each month of the scheme promotes transparency and trust in the permit market and price discovery at regular intervals. Participation in the bidding process and receipt of a number of permits corresponding to one's bid reinforces to participating units the market value of permits. A high price signals that market participants expect abatement to the cap level will be costly, and so any industries with abatement options below that price should undertake them and offer to sell permits.

A good option for a designated trading platform is to hold two-sided sealed-bid uniform-price multi-unit auctions, where all market participants may submit piecewise bids to either buy or sell permits at a range of specified prices from zero up to the ceiling price. The market-clearing price will then be discovered by finding the price such that the permit demand equals the fixed total permit supply exactly. This method is analogous to the auction methodology used in the power exchanges and allow for industrial units to express their demand for permits at a range of prices.

Auctions may be conducted on a quarterly basis. In the event that there is insufficient demand for permits sold, even at a price of zero, the permits not sold would be retained by SPCB and offered in the subsequent auction. In the event there is over-demand for permits, even at the ceiling price, the permits offered could be allocated pro rata according to the quantity bid at the ceiling price amongst all bidders.

All payments for permit trades must be intermediated by the exchange or platform—that is, parties must deposit funds with the exchange itself in a designated account and the exchange itself should execute the transfer of funds and permits.

Means of Permit Trade by Exchange

Industrial units may find their emissions load increasing or decreasing in the periods between auctions and wish to trade to true-up their permit holdings with emissions on a continuous basis. Such trade may be facilitated by a designated exchange platform that will register participants, track permit holdings, maintain an order book, match orders and settle permit trades. The exchange must record the unit IDs of the trading parties and permit IDs of the traded permits and submitting information to the SPCBs.

Trading should occur according to the rules outlined in the prospectus for the pollution permits as drafted by the exchange in agreement with principles delineated here. Payments should also occur according to the rules as drafted by the exchange. All payments for permit trades must be intermediated by the exchange or platform—that is, parties must deposit funds with the exchange itself in a designated account and the exchange itself should execute the transfer of funds and permits. This intermediation offers the advantages that the prices of all transactions are recorded and that the matching of orders will be transparent and non-discriminatory across market participants. The designated trading platform should maintain a complete electronic file recoding the permit holdings of each unit ID, inclusive of trading IDs specified by the exchange, at all times. This record should include unit or trading IDs and the complete list of all permit IDs held by the unit or trader as on the close of the trading day. This procedure is outlined in Table 6.

Table 6. Matching of orders for trading.

Principles for Matching of Orders	
Area	**Principle**
Trading Period	Trading will be open from at least 11 a.m. through 3 p.m. each working day.
Order Book	The exchange will maintain a complete and auditable order book of all bids and offers received. Each order will consist of the quantity bid or offered and the price at which a party is willing to buy or sell and will be identified by the unit ID and cluster of the parties submitting the order. In case the party is not a regulated source, they shall be assigned unique unit IDs for the purposes of trading with the prefix "TR" short for trader.
Order Matching	Order matching will be conducted without discriminating as to the party of trade but depending only on the price of the bids or offers and the order in which they are received.
Order Reporting	The exchange will electronically transfer the complete records of proposed permit trades to the concerned SPCB along with cluster wise permit holdings as soon as practical after the end of the day's trade and no later than one hour after the end of trade. The exchange will make every effort to check the two clearance conditions, on seller permit holdings and cluster permit caps, as trades are executed so as to allow the prompt approval of permit trades.
Order Approval	At its discretion the SPCB may depute this order verification function to the exchange provided that the auditable order book is maintained and cleared order data submitted on a daily basis to the concerned SPCB.

Price Ceiling

A price ceiling may be imposed on permit prices to remove the chance that costs of abatement become "too high". A permit price can be limited at the high end by a price ceiling which is a normally a multiple of the originally estimated marginal abatement cost of emissions. The price ceiling would be implemented in a two-pronged manner, during quarterly auctions and as an offer extended by SPCB to sell permits at the ceiling price in the true-up period following the end of the compliance period and prior to the compliance deadline.

At the auction, all bids would be limited to at most the ceiling price. During the true-up period, the SPCB would offer to sell permits to covered industries at the ceiling. It will not be necessary to impose the price ceiling on exchange trades, since no industry would purchase at a price above the ceiling given that permits will later be available at the ceiling price.

The rationale for a price ceiling is to provide an upper limit to industry on how much compliance would cost. Provided that the market price is below this ceiling, then industries would prefer to buy on the market, but if the market price rises, industries could buy from the SPCB itself. This would naturally limit the market price to be no more than the ceiling price.

The benefit of the ceiling price is that industries can be certain that compliance will cost them no more than the ceiling price times their quantum of emissions. This certainty may promote confidence in the scheme from the industry side and protect against uncertainty in the scheme design—for example, if the cap turns out to have been set very low, at a level difficult for industry to achieve, the ceiling price would prevent the market from costing industry too much. A price ceiling also limits any chance of "hoarding" permits to push up prices. The cost of the ceiling price is that when SPCB sell permits to keep the price below the ceiling the cap rises and so do emissions.

The rationale for a price ceiling is to provide an upper limit to industry on how much compliance would cost. Provided that the market price is below this ceiling, then industries would prefer to buy on the market, but if the market price rises, industries could buy from the SPCB itself.

Parties to Permit Trade

Permits may be traded by industrial units regulated as sources under the scheme as well as authorized third-parties such as brokers. All potential traders, whether sources of emissions or otherwise, must comply with holding limits and other trading rules. The involvement of third-parties can help increase the liquidity of the market, making it easier for units to find other permit holders with which to trade, and ensuring that orders to buy and sell will be maintained continuously on the exchange. The trading platform will create rules for the registration of traders and specify holding limits for non-source traders. It is also possible to restrict trades to sources regulated under the market – this may help simplify the market in an early implementation but may also reduce liquidity and increase transaction costs.

Information Release

Daily statistics of aggregate emissions, average permit price, and trading volume, should be made available freely, publicly, and without delay, on the website of the designated trading platform. The foundation of an emissions trading market is the concept that market participants will recognize a price for emissions and will incorporate that price in making decisions about input choices, output quantities, and price setting for their own products. To respond efficiently, firms need to have a credible idea of the cost that is associated with the emissions liability that they incur. Further, market transparency makes attempts at manipulation of prices much more difficult.

Holding Limits

A holding limit should be imposed to prevent hoarding. For instance, sources may begin with a holding limit equal to 150% of their annual permit allocation. The initial holding limit would be updated at quarterly intervals to converge to the industry's compliance obligation over the compliance year. Traders should each be allowed to hold at most 2.5% of the total annual permit pool.

Compliance

The basic compliance obligation under any emissions trading scheme is for each industrial unit to hold and surrender enough permits, at the end of the compliance period, to cover its emissions over the course of the compliance period.

For emissions trading to be successful in lowering compliance costs it is important that there be as few other compliance obligations with respect to the covered pollutant or the control of that pollutant as possible; e.g., industrial units should not be obligation to use specific means of control, to emit at only certain times during the compliance period, or to meet intermediate goals for emissions, provided that they met their basic obligation to emit less than final permit holdings. An important exception to this general rule concerns obligations for reporting of reliable data; because it is not possible to calculate compliance obligations without CEMS data on load on a continuous basis, it is critical that data reporting be continuous and accurate, and that non-reporting is treated as a serious breach in and of itself.

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Another obligation that is sometimes present is to meet pre-existing concentration standards. This can be a significant constraint on the amount of flexibility, and thus cost reduction, created by the market. For this reason, this is not a recommended situation. However, in several instances legal and regulatory requirements make it difficult to remove these command-and-control rules. In practice, whether such legacy standards reduce effectiveness depends heavily on the cap – if the cap is generous, the primary constraint on emissions remains the concentration standard. As the cap becomes stricter, the concentration standards may no longer remain the binding constraint.

Using validated emissions in aggregate over the compliance year, SPCBs should calculate the difference between aggregate emissions and final permit holdings at the end of the period.

- If there is no exceedance of emissions above permit holdings, a unit will be considered in compliance for the purposes of this scheme.

- If there any exceedance of emissions above permit holdings, a unit will be considered out of compliance and the amount of the exceedance, called excess emissions, will be used to determine the course of penalties.

There should be a true-up period of one month after the end of each compliance period during which units may continue to trade permits in order to bring their permit holdings in line with their compliance obligations. The emissions during the true-up period of one month after any given compliance period are regulated under the next compliance period. The true-up period following a compliance period thus overlaps by one month with the next compliance period.

Emissions will be received in real-time and provisionally validated on a quarterly basis throughout the compliance period. After the final validation of emissions in aggregate over the compliance period, and within two weeks from the end of that period, the SPCB shall issue each unit a report with contents as above but based on the actual, validated level of emissions over the compliance period. Note that this report can be automatically generated and electronically sent to the regulated industry to fulfill the obligation of reverting to industry within a two-week period.

Charges for Exceedance of Emissions Beyond Permit Holdings

An exceedance of emissions during the compliance period beyond permit holdings at the end of the true-up period shall result in a financial charge equal to the ceiling (maximum) price for compliance purposes for every denominated unit of emissions in excess of the total denomination of permits held by the unit. As an example, given a ceiling price of Rs.21 per kg and assuming an industrial unit has exceeded by 1000 kg then the charge would be (21 per kg) fine × (1000 kg) exceedance = Rs. 21,000. This charge is motivated by the fact that by not complying the plant has generated additional social costs that are not paid for previously. The SPCB should levy the fine for exceedance in the above amount on the unit within one month of the end of the true-up period. The offending unit shall have two weeks in which to deposit the fine in favor of the SPCB.

The purpose of a financial charge as part of compliance is to incentivize industries to fully participate in the emissions trading scheme by buying permits to cover all of their emissions. The ceiling price as implemented is greater than the average price of permits available in the market, ensuring that industries will always be better off buying permits at any time during the compliance or true-up periods rather than not complying and paying the charge instead.

If a unit does not deposit the amount of the charge for any exceedance within the allowed two weeks, the SPCB may take additional penal action such electricity disconnection or criminal action. Additionally, the SPCB may require the unit to post a bank guarantee for the next compliance period in an amount sufficient to cover the entire permit obligation (not only the amount of the exceedance) of the unit from the prior compliance period.

Intermediate and Final Reporting of Emissions to Industrial Units

The SPCB should ideally run a set of automated reports based on the permit and emissions records to generate unit-wise and cluster-wise sums of permit holdings on a regular basis and once per quarter and at least twice per compliance period. These reports would indicate to regulated units, in a clear manner, their current permit holdings, their current estimated aggregate emissions, the level of emissions that the unit would reach by the end of the compliance period if it maintains the same average daily emissions rate as seen till the date of the report, the excess or shortage of permits the unit would have at the end of the compliance period at that level of emissions, and the amount which the unit would be penalized for exceedance, if any, given the current market price for permits.

Non-reporting or False Reporting of Emissions Data

Non-reporting or false reporting of emissions data can be treated as non-compliance. Action may be directly taken by the SPCB under law, and normally all data that is found falsified or deliberately misreported may be replaced by the highest level of emissions previously observed for that source. This ensures that the market continues to function properly, but no participant is benefited by false reporting.

Market Scope and Selection of Sources

Market Scope refers to the geographic area and the eligibility criteria for the sources in the market. The more sectors and emission sources that an emissions trading scheme covers, the greater are the potential emission reductions and efficiency gains from differences in abatement costs. However, broader scopes may involve trade between distant sources. It is important to verify that emissions between these sources are well-mixed so that trade does not generate concentrations of emissions. For example, a relatively local pollutant such as particulate matter should not be traded over long distances. Conversely gaseous pollutants such as SO_x or CO_2 may even be traded in national markets.

Selection of different sources is also possible provided monitoring is feasible. This is a condition that may be hard to meet for many mobile sources, so transportation is difficult to include within a cap-and-trade market. Other market-based instruments, such as an emissions tax imposed on fuels, could be used for such sectors. Many programs have adopted a gradual process of expanding scope: first incorporating the highest-emitting sources in the highest-emitting sectors and eventually expanding coverage to additional pollutants and emissions sources in a stepwise way.

The European Union Emissions Trading Scheme (EU ETS) provides a good example of a stepwise approach. While the initial scope of the Kyoto Protocol includes six GHGs, in consideration of the limitation of monitoring technology, difficulty in establishing the relative global warming potential of several of the GHGs and the primacy of CO_2 in global GHG emissions, the EU ETS chose to cover only CO_2 in the first compliance phase, subsequently covering N_2O in the second compliance phase. The EU ETS initially covered electric generators, fuel providers, oil refineries, iron and steel manufacturers, cement clinkers, glass and ceramics brick industries, and paper making industries, choosing to add aviation fuel providers, and various minerals industries in later phases.

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Notes

Notes

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