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INCENTIVE SYSTEM FOR REPLACING OLD VEHICLES: ITS FEASIBILITY AND ADEQUACY OF INCENTIVES

I. Policy Instruments for Pollution Control from Vehicles in Use

It is being increasingly realised that despite rapid improvement in emission standards for "new vehicles", emissions from automobiles will continue to be a major source of urban air pollution in the large cities in India. The reasons for this are complex and numerous, but two important factors are the deterioration in performance of emissions control equipment and other systems on the vehicle that affect emissions as vehicles age, and the number of older vehicles with less effective pollution controls which are still in use.

In addressing the pollution problems from in-use vehicles the following policy instruments have been discussed in the literature.

*i) **Regulatory Programmes:*** Regulatory programmes involve compulsory periodic inspection and testing of motor vehicles and require owners to repair failing vehicles, to enforce compliance with applicable emission standards. These programmes put the onus of bringing the vehicle in for testing, as well as the cost of any repairs that might be necessary, on the motorists. Fixing the responsibility of testing and repairing on owners seems to make sense for at least two reasons. First, some repairs that reduce emissions might also result in better driveability and better fuel economy that vehicle owners should care about. Second, making motorists responsible is consistent with the "polluters pay" principle. Periodic inspection and Maintenance programme (I/M) has been implemented in a number of countries (see Annexure 1), however, in USA I/M programme is not only in operation for three decades but has also been examined to understand the costs and effectiveness of this programme. For a review of studies, which examined I/M performance, see Harrington et. al. (1999).

I/M programmes were first introduced in the U.S. in the late 1970. It has been reported that these programmes were not very effective as actual pollution reductions were very small and total costs of I/M programme were very high[1]..According to Harrington, et.al. (1999) I/M has been a disappointment. The study states that "our review of the existing in-use emission reduction programmes persuades us that I/M will continue to disappoint as long as motorists are held responsible for the emissions of their own vehicles". The paper claims that this conclusion is shared to a considerable degree by the regulators, who have responded by forcing manufacturers to extend warranty provisions on new vehicles, in effect pressuring manufacturers to reduce emission rates in new vehicles and make emission systems in new vehicles more durable and impervious to poor maintenance by the owners. It further states that this approach is not likely to be efficient, at least in the short run, because it does not do anything about the emissions of existing vehicles and thus it will take a very long time to have an appreciable effect on fleet emission. Harrington et.al. (1999) explores alternative liability assignments for in-use vehicle emissions and examines the kind of policies that would be necessary to change those assignments and compares how they affect the transaction costs associated with existing I/M programmes (see Table 1).

As shown in Table 1, each of the discussed instruments ~~address~~ addresses some of the transaction cost categories characteristic of I/M. In particular, by shifting responsibility from motorists, all remove the motorists' incentive to avoid emission repair. However, they only remove a positive incentive; they do not put any incentive for good maintenance of vehicles for motorists in its place. This issue is taken up later in this paper.

Ande et.al. (1998) which examines I/M programme in Arizona shows that only 29 to 36 per cent of the total costs of the programme is devoted to the repair of the vehicle while the rest is used for vehicle emission testing. Transaction costs also arise because motorists have ample opportunities for evading the responsibilities. Motorists can fail to take the emission tests; they may opt for incomplete repair; they may register their vehicles outside the I/M jurisdiction while continuing to use it there; or they may fail to register their vehicles at all.

Table 1

Alternative Approaches to Sharing Emission Liability: Summary of Characteristics

Policy	Transaction Cost Category			Manufacturer Incentives to produce durable vehicles
	Motorist Avoidance Incentives	Monitoring Costs	Transferability of emission reductions	
Extended warranties[a]	Depends on length of warranty. Some effort required to ensure motorists bring in vehicles to be repaired.	No effect on existing vehicles; new vehicles could be identified with OBD	Some within-manufacturer transferability possible if emission averaging is allowed. But potential savings are low.	Strong
Motorist subsidies or emission repair insurance[b]	Depends on subsidy levels. If high and broad, there will be little incentive to avoid repair.	Substantial cost reduction if gross emitters can be identified by remote sensing or OBD.	Difficult to overcome. agency problems if private mechanic are given discretion over repair decisions	Weak
Centralised repair liability[c]	Minimal incentive to avoid repair	Public costs could be low, since average subfleet-specific emissions can be estimated by RSD. Private costs are uncertain and depend on the case of winning motorists' co-operation	Emission reductions are quite transferable. Well-adopted to emission fee or tradable permit regimes.	Weak, unless manufacturers are parties responsible for repair
Mandatory leasing	Minimal incentive to avoid repair	.Lowest costs	Emission reductions are quite transferable. Well-adopted to emission fee or tradable permit regimes.	.Strong

Note: The baseline for the implied comparisons in the table is the Enhanced I/M programme as promulgated by EPA in 1992.
Other Comments:
A Only applies to new vehicles; therefore no immediate effect on emissions.
B Public funding source required.
C Political problems if liability for groups of vehicles is assigned by fiat. High administrative start up costs if liability is auctioned off.
D Possibly serious political opposition.
OBD: On-board devices that continuously check emissions systems and signal motorists if controls are not working properly.
RSD Remote sensing devices

Source: Harrington et. al., 1999

(ii) Emissions Fee: Emission fee on vehicles has been suggested by many economists [White (1982); Kessler and Schroeer (1993); Harrington et.al. (1996); Eskeland and Devarajan (1996); and Smith (1995). A pollution fee programme involves charging a fee from vehicles based on their emission rate (grams per km) times total kms driven. According to Harrington (1996) such an approach (with an I/M programme used only for determining the emissions rate) has the potential to substantially increase economic welfare over regulatory I/M policy (as currently in force in the US) for reducing vehicle emissions for at least two reasons. First, under the regulatory I/M policy motorists must repair a vehicle if it does not pass the inspection, regardless of the benefits of doing so whereas with an emissions fee motorists have a choice about whether to repair the vehicle and costly repairs can be avoided if they are unlikely to produce significant emissions reductions. Second, an emissions fee can especially target vehicles that contribute the most emissions, i.e., that have a high emissions rate and high mileage, whereas I/M programmes treat all dirty vehicles equally.

Besides the difficulties in determining the rate of emissions fee and in its implementation, the fee system is criticised for being unfair to low income earners (because they are likely to disproportionately own dirty vehicles). To partly address this and to raise the general political viability of a emissions fee system, it has been suggested that the revenues be recycled to citizens of the affected area in such a way as not to interfere with the incentives to reduce polluting behaviour. Harrington (1996) using a simulation model based on empirical evidence about vehicle emissions and repair effectiveness compares I/M programmes in US with various emissions fee policies. The difference between economic incentive policies and regulatory I/M policies would depend on how well the incentive polices are targetted and on their ability to influence polluter behaviour. The vehicle emissions tax considered in Harrington (1996) is a tax rate on grams of pollutants per mile. A vehicle owner can respond to an emissions fee by repairing the vehicle, by driving it less, or by scrapping it[2]. The paper finds that fees have higher net benefits than the regulatory I/M policy. It also finds that the extent of uncertainty in measuring and

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[2] The paper focuses on vehicle repair.

repairing vehicle emissions can have important impact on emission reduction potential of both regulatory as well as emissions fee policy. The regulatory policy is particularly affected by uncertainty, as there is limit to the amount of possible emissions reductions. Under uncertainty, a fee which only has to be paid after emissions reach some limit, are found to be as efficient as pure fees[3] and have the advantage of mitigating the high costs of fees to motorists.

(iii) ***Vehicle Replacement Programme***: As new vehicles are cleaner than older vehicles (present in large numbers in vehicular fleet in many countries), policies that encourage early scrappage of older vehicles hold the promise of significant emission reductions. Thus both road safety and air pollution concerns warrant implementation of measures that would encourage early scrappage of old vehicles. Different policy instruments to encourage replacement of old vehicles have been used in various countries[4]. However, few systematic studies have been made to evaluate the effectiveness of alternative policies designed to encourage fleet turnover in order to reduce emissions. One such study is Alberini, et.al. (1998) which using a simulation model of rational scrappage evaluates policies designed in the U.S. to encourage early scrappage, and simulates the effects of various policies on the decision to repair or scrap old vehicles. The model simulates the decisions of motorists under three policies: (a) Accelerated Vehicle Retirement[5], (b) Regulatory Programme (with and without scrap programme)[6], and (c) Emissions Fee Policy (with or without scrap programme).[7]

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3 Two types of fee are considered. The first type has no exempt emissions, i.e., a fee to be paid on all emissions or baseline = 0. In the second type, baseline = I, owners must pay fee only on emissions exceeding the base line. Pure fee refers to the former.

4 See Annexure 1.

5 In which old cars are purchased at a specified offer price. In the model the price is allowed to vary from $100 to $1000.

6 This represents the current enhanced I/M programme. This programme requires that owners must test vehicles on a regular basis, and failing vehicles must be repaired up to some cost limit (In most I/M programme vehicles can get a waiver after they have spent some amount on repairs and the vehicle still does not pass. The waiver rate specified in the 1990 Clean Air Act for ozone non-attainment areas is $450). As part of the programme, there can be a standing offer to buy old vehicles at a specified offer price e.g. $ 500 per car.

7 Emissions fees are based on emissions per mile of a vehicle and are of two types: a fee to be paid on all emissions and a fee to be paid on emissions above a base line. A scrap programme can be added to the fee programme giving owners an alternative to repairing the car or paying the fee.

The simulation model represents emissions from a fleet of vehicles, and includes stochastic and behavioural elements of emissions measurement and repair. The study finds that old car scrap programme may increase net welfare under a current regulatory programme like I/M in USA, but that a stand alone scrap programme is unlikely to provide very much in the way of emission reductions. *Simulation results of the study show that emissions fees are a cost-effective way to reduce emissions, and that their technical and political feasibility should be explored.* Their cost-effectiveness is highest in the absence of an overlapping scrappage programme. Cost effectiveness worsens – while remaining still comparatively better than that of the regulatory I/M approach – as a scrappage subsidy is introduced, which considerably lessens motorists costs.

II. Incentive Systems for Replacing the Old Vehicles

Owners decisions to keep, repair or scrap their in-use old vehicles depends critically on the owner's perceived value of the vehicle and the disincentives of running a vehicle (emissions fee or I/M programme) when it is not in compliance with the specified emission standards. Of these possible options a rational owner would choose the one with the least costs. Since objective of this paper is to examine incentive systems for replacing the old vehicles we focus our attention on policies that would encourage early replacement by scrapping the vehicle or selling it outside their present jurisdiction

Subsidies to encourage scrappage: Decision to scrap or sell the old vehicle would depend on the subsidy offered to scrap and the selling price. If subsidy paid to scrap the vehicle is less than the selling price of vehicle, the owner would choose to sell the vehicle. The success of scrappage programme both in terms of its cost-effectiveness and actual emissions reductions critically depends on the amount of subsidy. The amount of subsidy would ideally be set equal to the marginal damages of emissions in the region. Scrappage programmes, however, suffer from at least three limitations: (I) if subsidy offered is less than the selling price of old vehicle, it may not have much impact on emissions reductions; (ii) raising the level of subsidy would not only reduce the cost effectiveness of this programme (Alberini, et. al., 1966; and Hahn,1995) but it might also have large price effects in used vehicle markets, raising the cost of purchasing older vehicles and thus reducing the cost-effectiveness of the programme; and (iii) a long-term scrappage programme might also accompany perverse incentives to avoid regular maintenance of vehicles. *Therefore a scrap subsidy should be backed with policies which would ensure that the incentive for proper maintenance of vehicle is not diluted and scrap subsidy does not lead to creating a premium on in-use vehicles.*

Indirect economic instruments have been used in some countries to encourage scrappage of old vehicles. Singapore provides a rebate on additional registration charge of a new car (which is at 150 per cent of the cost of the cars) if an old vehicle is scrapped. In Brazil an exemption from the road surtax and initial lump sum tax for a period of five years for new cars fitted with CAT is provided to the buyer of new car if the old car is scrapped. In USA old vehicle scrappage programmes paid a subsidy (usually $ 500 to $ 1000) to owners of older vehicles who give their vehicles to be scrapped, thus removing the vehicles emissions equivalent to what would have been during their remaining life time[8]. Most scrap programme in the US have been private financed, usually by companies seeking emissions offsets or relief from other regulations. All have been of short duration, primarily designed to demonstrate the feasibility of the idea (Alberini, et.al. 1994). *Raising funding for large scale scrapp~~ed~~age programme is another serious limitation in implementation of the programme[9] (Alberini, 1998).*

[8] Alberini, et.al. (1996) shows that the extent of emissions reductions depends on how much longer those all vehicles would have been kept in use in the absence of scrappage programme, their age and miles driven.

[9] In 1994, California included as part of its state implementation plan a provision to allow for the scrappage of 75,000 older vehicles per year for ten years, using as a scrappage inducement bounty of up to $ 1000 per vehicle. However, the state has yet to come up with the funding to implement the programme.

III. Combining the Emission Fee, Scrappage and I/M Programme

Given the shortcomings of a scrappage programme on the one hand and the I/M on the other, combining the two has been suggested. However, little is known about the properties of such hybrid programmes. "There is not much empirical data on motorist scrap decisions in the first place, let alone how these decisions might operate in an environment containing both I/M and scrappage inducements" (Alberini, et.al., 1998). Combining the scrappage programme with the vehicle emissions fee policy has also been suggested[10]. Alberini, et.ai. (1998) using a simulation model examines the role of scrap programmes alone and combined with other policies for reducing emissions such as I/M programmes and emissions fees. The model assumes that of all possible options (repairing the vehicle, scrapping the vehicle or taking up the scrap offer, paying the emission fee without repairing the vehicle) the owners will choose the one with the least cost. *The study finds that the cost effectiveness of a emissions fee policy (with exempt emissions) is better than that of the I/M programme.* Its cost effectiveness is about $ 1100 per weighted ton with no scrap offer, and worsens to about $ 3700 when the scrap offer is $ 1000. Adding a scrap programme with successively higher scrap offers raises cost more quickly. This is because the low-valued high emitting vehicles would have already been scrapped under an emissions fee policy, so scrapping additional vehicles will bring in higher valued vehicles.

IV. Proposals to reduce Emissions from in-use Vehicles

The following policy instruments are proposed to replace old vehicles and reduce emissions from in-use vehicles:

1. Annual emissions fee on all vehicles
2. Emissions warranty programme.

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10 Emissions fee or environmental tax policy has been used in some countries. Austria introduced environmental tax on car registration in 1992. In Belgium an annual tax on new vehicles was introduced in 1992. It has now been extended to in-use cars. Finland levies an annual tax on diesel vehicles and passenger cars. Emissions linked annual taxes have been levied in Germany and Korea also (See Annexure 1).

3. Clean alternatives for in-use vehicles to be specified and certified for use by the regulator.

These proposals are discussed in detail below:

A. **Annual Emissions Fee:** Ideally emissions fee should be set equal to the difference between the marginal private cost and marginal social cost of emissions. This would make the motorists aware of their social costs and induce them to treat emissions fee as a relevant decision making parameter. Polluters exposed to such a fee would self-select the most effective measures of emissions control, such as modified travel plans, technical modifications of vehicles. However, to levy such a fee, the policy makers would need to know how much pollution each vehicle is causing during a day/year. That is, information would be required on emission rate (grams per km) and total km driven by each vehicle. This information is, however, not available to the policy makers. While it is possible to obtain information on emissions rate and distance travelled in the case of new vehicles – yet to hit the road – by bringing in regulations such as compulsory fixing of tamper proof odometers in vehicles and Emissions Warranty Programme, obtaining this information for in-use vehicles which are characterised by poorly functioning odometers, substantial variation in average emissions rate by make, age, class, and owner behaviour towards maintenance of vehicle is not practically feasible.

Owing to practical difficulties in continuous monitoring of emissions from this mobile source of pollution, emissions fee/tax in many countries are lump sum levies based on proxies of emissions rate. For purposes of emissions fee, vehicles can be categorised by model-year/age which would reflect the gradual tightening of emissions standards, i.e., the basic environmental characteristics of a vehicle (whether it uses carburettors or electronic fuel injection) and lowered efficiency of various parts of vehicle from normal use. A great deal of emissions variation thus appears systematic which can be explained by observable vehicle characteristics (Harrington and McConnell, 1997). Our hunch is that unobserved causes of difference in emissions (such as good maintenance) of the existing vehicular fleet are likely to be small in the absence of any incentive for motorists, in

India, to care for emissions rate of vehicles. Given this, age of the vehicles in a given class[11] appears to be a reasonable proxy to be used as a base for levying emissions fee. *The next step in designing an emissions fee would be determining the average emissions rate of a given age and class of vehicles.* Some studies have been carried out in India in the recent past which have compiled information on emissions rate for motor vehicles by actually measuring the emissions from a sample of vehicles (Xie, Jian, et.al., 1998). More studies of similar nature would be required for different age and class of vehicles. *Another important aspect in designing emissions fee programme is defining the base line emissions.* That is, the level or threshold up to which emissions are not charged a fee, motorists only pay fees when emissions exceed the base line. Emissions baseline are generally vintage–dependent These baselines may be more equitable but likely to be less efficient than a constant baseline for all vehicles. *Finally, the policymaker would need to know the value of damages due to emissions.*

As pollutant gases and particles settle to earth, they come in contact with human and animal populations, terrestrial ecosystems, and man-made materials. Human health effects are likely to dominate an economic valuation of pollution effects, although the physical association is difficult to measure. At the ecological level, knowledge of pollutant impacts remains incomplete and largely qualitative. In documenting the effect of the air pollution exposure, a three-step approach is used. It begins by characterising exposures, comprising an inventory of the susceptible population and its baseline status; uses a concentration – response function to calculate aggregate population risk or physical outcomes at given concentrations; and then assesses damages using appropriate measures of willingness to pay. Such comprehensive studies are rare especially in the context of developing countries. Alternative approaches such as human capital approach and cost of treatment approach have been used in valuation of health impacts of emissions. One such study is World Bank (1995) which provides estimates of health costs due to air emissions in India. Using the health cost estimates in World Bank (1995) and available estimates of emission intensities of various types of vehicles,

11 Vehicles can be categorised by class – whether commercial or private. Within commercial bus, truck, taxi or 3-wheeler. Similarly, private vehicles can be distinguished between four wheelers and two wheelers.

Pandey and Bhardwaj (2000) proposes annual emissions fee rates for various types of private and commercial vehicles in Delhi (see Table 2). The study recommends that cars, taxies, buses and three wheelers running on CNG be exempt from the annual emission tax which is consistent with the results of a recent study by CRRI (Times of India, February 15, 2002). The study also proposes a progressively increasing annual emissions surcharge on more than 10 years old vehicles. This is likely to encourage changes at the margin both in the repair of older vehicles (retrofittment/engine replacement, etc.) and in scrapping of older vehicles. It must be pointed out that once emissions rate by age and class of vehicles, and emissions by

Table 2

Annual Emissions Fee

S.No.	Vehicle Type*	Rate of Fee (Rs)
1.	Cars	
	(i) With CAT	200
	(ii) Without CAT	400
2.	Taxies	
	(i) Petrol	1700
	(ii) Diesel	2200
3.	Three Wheelers	
	(i) Petrol	1500
	(ii) Diesel	1800
4.	2-Stroke Two-wheelers	
	(i) With CAT	-
	(ii) Without CAT	200
5.	4-Stroke Two-wheelers	-
6.	Buses	2700
7.	Diesel Cars	800

* Cars, taxies, buses and three wheelers running on CNG are proposed to be exempt from the annual emission tax.

Source: Pandey and Bhardwaj (2000)

vintage become available this exercise would need to be done again to compute annual emissions fee for different groups of vehicles.

B. Emissions Warranty Programme: Because of the high costs and modest success of the current I/M system in the US that assigns liability to the motorist, there is a movement already underway to shift the liability of maintaining emissions control throughout the life of the vehicle more towards manufacturers. To some extent, there has always been a shared responsibility between motorists and manufacturers because of the warranty coverage requirements on emissions control equipment. Both the state of California and the EPA are currently considering extension of these warranty requirements as a way of increasing manufacturer liability. In addition, motorist liability itself creates incentives for manufacturers to improve the lifetime performance of emissions control equipment. Manufacturers do not want to be revamped with warranty-covered repairs or with complaints by motorists whose vehicles have failed I/M test. As a result of shift of liability of emissions towards manufacturers, vehicles produced after 1991 in the manufacturers, vehicles produced after 1991 in the U.S appear to have much lower emissions at 50,000 miles than did vehicles of earlier vintages (Harrington and McConnell, 1999). This can be attributed to the following three factors.

(i) Emissions Equipment Warranties: Warranties on emission control systems and parts place liability with the manufacturer through the period of warranty. Table 3 shows the past and current warranty provisions by the EPA for U.S. vehicles. Warranties cover defective parts and the performance of the equipment to meet I/M requirements. The performance requirement means that if a vehicle fails on I/M test and is under the warranty period, the manufacturer is liable for the repair even if there is no defect in the equipment.

Table 3 History of Emission Component Warranties for Light Duty Vehicles and Light Duty Trucks		
Vehicle Model Year	Section 207 (a) of the Clean Air (Defects)	Section 207(b) of the Clean Air Act (Performance)
1994 and Earlier	5 years/50,000 mils	1) 2 years/24,000 miles on components 2) 5 years/50,000 miles on emission control devices or systems
1995 and Later	2 years/24,000 miles	2 years/24,000 miles
	Certain specified components (Catalyst, ECU, OBD) 8 years/80,000 miles	Certain specified components (Catalyst, ECU, OBD) 8 years/80,000 miles

Until the 1990 Amendments to the Clean Air Act, manufacturers were responsible for defects in all emission control equipment and for the performance in use of major emission control devices or systems for 5 years or 50,000 miles, whichever came first. Minor component problems had only a 2 year or 24,000 mile warranty. These warranty requirements continued through the 1994 model year, but the Amendments actually reduced the warranty period for most components and systems for 1995 and later model years. As Table 3 shows, the 1995 and more recent model year vehicles only have to meet the 2 years, 24,000 mile standards for almost all parts and components. It is only the major components such as the catalyst, the Electronic Control Unit and the OBD system that have the longer 8 years or 80,000-mile requirement.

It is unclear what impact warranty requirements have had on manufacturers (Harrington and McConnell, 1999). The presence of the 5-year/50,000 mile warranty through the early 1990s may have pushed manufacturers to build cleaner cars. The change in warranty requirements after 1994 provides a mixed message – some components face stricter warranty requirements, others more lenient. It is clear, however, that the EPA is moving in the direction of requiring stricter warranty requirements for federal "Tier 2" vehicles (those which have to meet the next round of stricter federal new car standards). It is likely that the warranty period on these cars will be 120,000 miles for major parts – California has already made this requirement and is extending this warranty to trucks as well. Longer warranty period mean higher costs for manufacturers in repair and replacement costs and given them a clear incentive to improve the emissions performance of vehicles, at least through the warranty period.

(ii) *Concern about customer satisfaction*: Even after the warranty period is over, manufacturers do not want to deal with motorist complaints about I/M failures. There are reputation effects associated with vehicles makes that are known to have high failure rates. This provides some incentive to improve emissions control technology so that it is longer lasting. For example, the fuel injection technology implemented in the 1980s allowed controls to last longer. Currently, some manufacturers are trying to develop an air-fuel sensor instead of 02 sensor to improve the life time performance of vehicle emissions.

(iii) *New Car Certification also Extends Liability to the Manufacturer*: Recent changes in the new car certification process have also begun to shift the responsibility for in-use emissions more to the manufacturer. In the past, new car emissions certification had to be completed before cars were sold. Prototypes were driven for 100,000 simulated miles in the laboratory in order to certify an engine family. Under the new rules, manufacturers with a good track record on emissions compliance can sell cars and certify that they meet the emissions standards by testing samples of in-use vehicles. This regulatory change is likely to give manufacturers even more incentive to maintain performance of vehicles in use.

We recommend that an Emissions Warranty Programme be designed in consultation with automobile manufacturers and other specialists, for implementation. Vehicles under emissions warranty may be exempt from annual emissions fee.

C. Clean Alternatives for in-use Vehicles:

Since Emissions Warranty Programme as discussed above would affect only new vehicles, a policy which would impact the current stocks of in-use vehicles as well as those which would eventually go out of warranty will be required.

A policy instrument – annual emissions fee – differentiated by the age and type of vehicles as a means of internalising the social cost of emissions was discussed and proposed for implementation in section IV. It may be recalled that this annual emissions fee is not proposed to be levied on the actual emissions (emission rate x km driver) due to practical difficulties in accurately measuring the emissions of each vehicle and also the high costs of such monitoring exercise but on close proxies of vehicle emissions derived from available technical knowledge and behavioural information about motorists. While such an emissions fee system provides the motorists an option between whether to pay the fee and run the vehicle or scrap/sell the vehicle, it does not provide repair option to motorists as emissions fee is fixed for a given age and type of vehicle. *Therefore, emissions fee programme should be backed by policies which would encourage motorists to repair their vehicles and claim rebate in annual emissions fee.*

In an emissions fee programme which does not require continuous monitoring of vehicle emissions, motorists would not be provided full flexibility in choice of which repairs to undertake as it would require testing and certification of the extent of emission reduction due to repairs. An alternative would be to examine the characteristics of the current vehicular fleet and specify the clean alternatives for in-use vehicles along with the credits/rebates such clean alternatives would qualify for.

A number of technological options can be considered for controlling emissions from vehicles. Some of these options include conversion of petrol and diesel driven vehicles to CNG or switching to new CNG vehicles; switching to four stroke 2 and 3 wheelers; vehicle retrofitting (electronic ignition system, CAT and CRT). These technological options have been analysed and ranked according to their net cost of emission reduction for Delhi in Pandey and Bhardwaj (2000) (see Table 4). It may be mentioned that cost computations in Table 4 use fuel prices as were prevailing in the year 2000. Fuel prices are likely to change from April 2002 when administered prices mechanism is dismantled. Costs of abatement will change depending on the direction and the magnitude of change in fuel prices. Further, these computations were done for Delhi where CNG has been made available. CNG conversion options may not be relevant for cities where CNG is not available currently as a vehicular fuel. Other clean options in addition to those listed in Table 4 for in-use vehicles should be identified and certified for use by the regulator.

Table 4.

Technical Options and Emission Reduction in Delhi

S.No	*Technical Options*[i]	*Cost: Thousand Rs. Per Weighted ton of abatement*[ii]	*Cumulative Emission reduction (weighted tons)*	*Cumulative Emissions reduced as % of total vehicular emissions*
1.	Convert taxies to CNG vehicles[iii]	-27.7	27348.4	2.5
2.	Convert cars to CNG vehicles[iv]	-22.3	148356.0	13.6
3.	Convert buses to CNG vehicles (50% of the fleet)[v]	-20.3	163699.0	15.0
4.	Convert 3-wheelers to CNG vehicle (40% of 3-wheeler fleet)[vi]	-20.1	212828.6	19.5
5.	Modern carburetor (20% of 3-wheeler fleet)[vii]	-10.6	215360.3	19.7
6.	Fuel/oil premix (10% of 3-wheeler fleet)[viii]	-6.5	216638.8	19.8
7.	Electronic ignition (10% of 3-wheeler fleet)[ix]	-2.5	219642.9	20.1
8.	Catalytic converter (10% of 3-wheeler fleet)[x]	5.9	231862.6	21.2
9.	Catalytic converter retrofitment (10% of 2-wheeler fleet)[xi]	9.6	246517.4	22.5
10.	CRT retrofitment in buses (50% of fleet)[xii]	32.3	281834.8	25.7
11.	4-stroke 2-wheelers (30% of fleet)[xiii]	55.2	327804.8	29.9

Notes:

(i) Computations are based on vehicular population as on 31st December, 1998.

(ii) The cost of technical changes is paid up-front. It is also assumed that this is financed by a loan obtained at 10 per cent interest to be repaid in equal instalments over a period of five years.

(iii) Reduction in emissions of CO and HC is 98 and 82 per cent respectively from the base line emissions from a petrol driven Ambassador car. Cost of CNG conversion is taken to be Rs. 30,000. Source: Gas Authority of India Limited (GAIL, 1999).

(iv) Emission reduction of CO and HC is 97 and 11 per cent from the base line emissions from a Maruti 800 model car. Source: GAIL, 1999.

(v) Reduction in emissions of CO, HC, nitrogen oxide (NO_x) and particulate matter (PM_{10}) is 19, 17, 42 and 83 per cent respectively. Source: GAIL, 1999. The operating cost is taken to be Rs. 3.37/km, on CNG and Rs. 5.08/km on diesel mode. Source: Sharma, 1999. The cost difference between a new CNG bus or CNG retrofitment in a diesel bus and diesel bus is Rs. 3.5 lakh. Source: Chima, 1999.

(vi) Emission reduction of CO, HC, NO_x and PM_{10} is 71, 63, 20 and 80 per cent respectively. Source: GAIL, 1999 and Xie et. al, 1998. The cost of conversion to CNG fuel is taken to be Rs. 18,000. Source: AIAM, 1998a.

(vii)-(x) Source: Xie, et. al, 1998.

(xi) Emission reduction of CO and HC is 45 and 40 per cent respectively. Cost of CAT retrofitment is taken to be Rs. 1000 and refuel cost of catalyst is Rs. 500 once in two years. Source: AIAM, 1998b.

(xii) Emission reduction of CO, HC, NO_x and PM_{10} is 76, 96, 34 and 90 per cent respectively from the base line emissions from a diesel bus. The cost of CRT is taken to be Rs. 2.5 lakh and it requires ultra low sulphur diesel (50 parts per million). Source: Adie, 1999.

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Annexure 1

Application of Economic Instruments in Various Countries

	VEHICLE	
	Direct	***Indirect***
Australia		• Tax on sale or initial registration of vehicles. Rate of tax varies on the basis of value of vehicles. • Higher annual registration fee on commercial vehicles compared to private vehicles.
Austria		• Environmental tax on car registration was introduced in 1992. While the base is the selling price of cars the tax rate depends on the standard petrol consumption. • Since May 1, 1993, the annual vehicle tax on passenger cars is assessed on the basis of engine power and no longer on cylinder volume. From January 1, 1995, cars without catalytic converters are imposed a surtax of 20 percent. • At the same time VAT on new vehicles was reduced from 32 percent to 20 percent and the VAT rate on electric cars was cut by half to 10 percent. • Tax is based on net weight for buses and on loading capacity for trucks.
Belgium		• An annual tax on registration was introduced for new motor cars on June 1, 1992, and it has been extended to in-use cars since June 1, 1993. This tax is based on the engine power of the car.
Brazil		• Penalty system for violation of air pollution standards since 1981. Fines are arbitrary as the level of emission from trucks is generally visually assessed. Fines are related to frequency of violation rather than intensity or toxicity of pollution.

	VEHICLE	
	Direct	***Indirect***
Britain		• Sales tax on new cars (17.5 percent) and annual vehicle excise duty. • Higher taxes on commercial vehicle sales, ownership (excise duty based on axles and weight) and use than on private cars.
Canada	British Columbia introduced permit fees on pollutant emissions in 1992. The fees are reduced if the actual emissions are less than the permitted emissions.	• A tax on purchase of fuel inefficient passenger and sport utility vehicles. A subsidy of $100 is provided to cars with a highway fuel efficiency rating of less than 6 litres per 100 km.
Finland		• Annual tax on diesel vehicles and passenger cars of 150 FIM/100 kg of weight, and on delivery vans of 27 FIM/1000 kg of weight. • Environmental taxes on cars, differentiated on the basis of whether or not these are equipped with catalytic converters.
France		• Accelerated depreciations allowed for electrical vehicles.
Germany	Emissions fee	• Annual tax on motor vehicle not meeting the EU emission standards to accelerate the introduction of cleaner vehicles. Rates are differentiated by age of the car. • A higher tax has been imposed on diesel cars as compared to petrol cars since 1994.
Greece		• Since 1990 exemption from the road surtax and initial lumpsum tax for a period of 5 years for new cars fitted with a catalytic convertor, subject to scrapping of old car by the buyers of new car. About 3 lakh old cars were scrapped.
Hungary		• New cars with catalytic convertors get a discount of Forint 50000 from consumption tax.
Iceland	Excise duty based on cylinder capacity of vehicles.	• IKr 330 is charged for a mandatory annual emission test. Inspection fee charged for annual inspection of vehicles over 2 years old. Rate of charge is on the basis of weight of vehicles.

	VEHICLE	
	Direct	*Indirect*
Ireland		• Sales tax on retail price of private vehicles based on cylinder capacity.
Italy		• One-off Registration tax on purchase of new and used vehicles depending on type and size of vehicles.
Japan		• Tax deductions for cars with low emissions, electric cars and cars on alternative fuels. • One-off consumption tax on new or old car registration at 3 percent. • Annual tax in relation to power and load of vehicles.
Korea		• Introduced environmental quality improvement charges, in 1991. Besides other economic activities it covered vehicles (buses and trucks using diesel). The charge is computed by the price of catalytic converter.
Netherlands		• Lower sales tax on cars that complied with future EU standards. Consequently, share of future EU standard cars rose from 37% to 70%, faster than expected by the government.
Norway		• Differentiated taxes on car prices, with a tax advantage given to cars fitted with catalytic converters and cars powered by electricity or gas.
Singapore		• Additional registration charge at 150 percent, since 1983, of the cost of the car to discourage ownership. A rebate on tax is given if an old vehicle is scrapped simultaneously.
Sweden		• Vehicle taxes based on weight and environmental characteristics. • Subsidy on cars with catalytic converters, special tax on cars without catalytic converters.

	VEHICLE	
	Direct	***Indirect***
United States		• Higher excise tax (12 percent) on trucks, annual use tax on "heavy vehicles", excise tax on tyres weighing over 40 pounds, a "Gas Guzzler" tax on automobiles with unsatisfactory fuel economy ratings. • The Gas Guzzler excise tax is imposed on the sale of autos whose fuel efficiency is less than 22.5 miles per gallon. The tax varies from $ 1000 to $ 7700 depending on the fuel efficiency. • Non-conformance charge on heavy vehicles and engines are based on the degree of non-compliance.
Country	*FUEL*	
	Direct	***Indirect***
Australia		• Petrol taxes were increased. Differential pricing for leaded and unleaded petrol was introduced in favour of the latter.
Belgium		• Higher excise duty on leaded petrol.
Britain		• Tax Differential has been gradually increased and now stands at 4.8 pence per litre. The proportion of unleaded in total petrol sales rose to 50% in 1993 from a negligible share in 1986.
Denmark		• Fuel tax based on CO_2 content at combustion was introduced in 1992. • Since the mid-1980s, differential tax on leaded and unleaded gasoline. In 1994 the market share of unleaded petrol rose to nearly 100%.
Finland		• Lower tax on lead free petrol than on leaded petrol since 1986. • Lower excise duty on sulphur free diesel since 1993. • Carbon tax on fuel since 1994.
Germany		• Duty differential between leaded and unleaded petrol at the rate of DM 0.10 per litre.

	VEHICLE	
	Direct	***Indirect***
Hungary		• In 1992, at tax at the rate of 0.7% of the price was introduced on motor vehicle fuels. The revenue is earmarked for environmental expenditure relating to vehicular traffic.
Ireland		• Higher excise duty on leaded petrol than on the unleaded petrol.
Luxembourg		• Higher excise duty and VAT rates on leaded petrol by 2-3% than on unleaded petrol.
Mexico		• Higher excise tax on leaded petrol than on unleaded variety.
Netherlands		• Environmental charges on fuel since 1988. These charges were revised in 1990 to include CO_2 emissions. Unleaded petrol was cheaper than leaded petrol.
New Zealand		• Tax treatment in favour of unleaded petrol vis-a-vis leaded petrol. A fee of NZ$ 0.068 i.e. US$ 0.039 per gram was levied on lead added to gasoline.
Norway	Since 1995 gasoline tax difference was introduced for leaded petrol based on emissions of lead per litre.	• Fuel tax based on sulphur, carbon and lead content. • CO_2 tax since 1991.
Sweden		• High gasoline taxes. Differential tax in favour of unleaded petrol. • A carbon tax was imposed on motor and other fossil fuels since 1991. The part of the tax levied on motor fuels amounted to SKr 0.58 per litre for petrol and 0.92 for diesel. • System of tax rebate for producers of cleaner diesel fuel since 1991.
Switzerland		• The market share of unleaded petrol increased to 655 in 1992 due to a tax differentiation of ECU 0.04/l in favour of unleaded petrol.
Taiwan		• Differential price in favour of unleaded petrol. This led to an increase in the market share of unleaded petrol from 18.7 per cent in 1990 to 51.84 per cent in 1993.

	VEHICLE	
	Direct	***Indirect***
Thailand		• Differential price in favour of unleaded petrol.
Thailand		• A surtax on leaded gasoline to finance the subsidy on unleaded gasoline.
US		• Trade in lead credits, to phase out lead in gasoline in 1982-87.
Country	*TRAFFIC*	
	Direct	***Indirect***
Chile		• In 1990 the city allocated bus transit rights and auctioned routes based on fares and types of buses.
Norway		• In 1986 to control congestion the city of Bergen introduced toll for motorists entering the city between 6 a.m. to 10 p.m. on weekdays. The rate is differentiated on the basis of loading capacity of vehicles. The revenue so collected is used to finance the construction of by-passes.
Singapore		• Implemented a licence ticket scheme for entering some identified zones during peak hours. Fine for non-compliance was 10 times the licence price. It helped reduce the traffic flow and thus pollution. These zones also have higher parking fee.

Sources: Pandey and Bhardwaj (2000)