# Policy Issues and Effectiveness Evaluation of Carbon Abatement Strategies: Case Study of Indian Transportation Sector

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**Abstract**

Carbon emissions in developing countries are increasing most rapidly in the transportation sector. Delhi the capital city of India is a rapidly expanding mega-city. The rapid and unplanned growth of the city has given it the dubious distinction of being one of the most polluted cities of the world. The economic growth of the city and its exponentially increasing demand for mobility has led to fouling up of the city's air.

The year 1998 saw major interventions on the part of the government to curb the growing carbon and suspended particulate matter (SPM) emission problem in Delhi. The government faced tremendous opposition from the transporters and the industrialists and the public had to bear a lot of inconveniences during the transition phase of the transportation sector. But all said and done Delhi is now experiencing fresher air and cleaner sky.

This paper shall probe into the policy initiatives of the government, the challenges faced in implementation of the abatement steps and the efficacy of the steps (through a detailed comparative study of the emission loads from various types of automobiles plying on different roads for the year 1998 and 2000) taken in lowering the carbon and SPM emissions. It shall also act as a guide for countries struggling to adopt similar cleaner fuel initiatives for carbon emission reduction.

**Introduction**

The rapid and unplanned growth of Delhi has given it the dubious distinction of being one of the most polluted cities of the world. The economic growth of the city and its exponentially increasing demand for mobility has led to fetid air in the city. Lack of efficient public transportation system and predominance of private vehicles has led to Delhi being India's largest vehicular populated city. The vehicular population in Delhi is more than the sum of the vehicular population in rest of the three metros. This huge population of vehicles contribute to more than 60% of the air pollution in the city that leads to the city's air becoming toxic.

To manage the ever-dwindling quality of Delhi's air the year 1998 saw major interventions on the part of the government. Some of the significant steps taken were:

- Closure of heavily polluting industries,
- Relocation of industries,
- Retiring more than eight year old commercial vehicles,
- Enforcing stricter emission norms,
- Registration of only compressed natural gas (CNG) driven 3-wheelers, buses and taxis,
- Usage of better quality fuel like low ash content coal, unleaded petrol, ultra low sulphur diesel and petrol with octane boosters.

Besides these direct steps other indirect measures like traffic management, building of flyovers and widening of roads so as to reduce the idling time of the vehicles, improving the public transportation system etc were taken.

Due to strict enforcement of the above-mentioned initiatives the air in Delhi is dramatically cleaner now. This development is clearly important for residents of the city. According to a World Bank study conducted in 1992, prior to the clean-up, the annual health cost of ambient air pollution in Delhi was

on the order of Indian Rs. 10 billion (about US $ 200 million). Delhi's experience is also being watched closely by other rapidly growing mega cities in the developing world and by the development banks and donors supporting efforts towards environmental clean up.

This paper elucidates the efficacy of the steps taken and documents the important points to be considered before implementing similar steps. A comparative study of the emission status for two years i.e. 1998 (year before implementation) and 2000 (year after implementation) was done.

**Methodology**

To calculate the emissions from the vehicles:

- A list of 42 roads under study was made with the length of roads and population density of various kinds of vehicles for the year 1990*
- Proper emission factors to be applied were determined
- The vehicular growth factor was calculated and applied to find out the vehicular population for the year 1998 and 2000.

Growth Factor = 1+ (A –B)/ B

Where, A: Total number of vehicles in a particular category in the year 1998/2000

B: Total number of vehicles in that category in the year 1990

The Growth Factor multiplied by the number of vehicles (category wise) in the year 1990 gives the number of vehicles for the year 1998/2000. The vehicles are then categorised age wise. The proportion of age wise distribution of vehicles is obtained by dividing the number of vehicles registered in each year by the number of vehicles registered in the year of minimum registration (considering a twenty year life span for cars, 2-wheelers and taxis and fifteen years for three-wheelers, trucks and buses).

After calculating the total number of vehicles on the roads under study and categorising them according to age the pollution load from them is calculated by multiplying the number of particular kind of vehicle e.g. cars with the emission norm for the particular year in which it was registered, with the length of the road stretch under consideration.

The load of pollutants i.e. Carbon Monoxide (CO), Oxides of Nitrogen (NOx), Particulate Matter (PM) and Hydrocarbon (HC) is calculated for each vehicle type on each road and it is then summed up to give the total pollution load on each road. The road results are then categorized zone wise to give the zonal pollution load from vehicles.

The results of the research indicate an appreciable decrease in pollutant emissions in the year 2000 as compared to 1998. The tables below clearly illustrate the benefits of implementation of pollution abatement steps as seen in Delhi case study.

***Comparative Analysis of Emission Level***

****Table 1: Comparative data of the vehicular emissions for Years 1998 and 2000**

| Mode of Transport | CO (kg/day) | | HC (kg/day) | | $NO_x$ (kg/day) | | PM (kg/day) | |
|---|---|---|---|---|---|---|---|---|
| | 1998 | 2000 | 1998 | 2000 | 1998 | 2000 | 1998 | 2000 |
| 2-Wheelers | 14072.05 | 14562.54 | 14993.79 | 9623.29 | 175.66 | 185.73 | 115.10 | 40.96 |
| 3-Wheelers | 7504.09 | 2486.84 | 4850.61 | 1177.03 | 162.33 | 171.13 | 79.97 | 13.52 |
| Buses | 3013.97 | 2989.06 | 808.99 | 658.11 | 4449.26 | 4083.60 | 97.46 | 94.21 |
| Cars | 31461.89 | 37546.09 | 4695.16 | 4723.81 | 3574.93 | 3109.56 | 31.61 | 32.61 |
| Taxis | 2369.43 | 722.30 | 223.04 | 80.73 | 1219.36 | 222.53 | 300.83 | 89.81 |
| Trucks | 739.54 | 872.28 | 236.79 | 244.42 | 1263.87 | 1301.36 | 63.42 | 65.04 |
| Total | 59160.96 | 59179.10 | 25808.39 | 16507.39 | 10845.41 | 9073.91 | 688.38 | 336.15 |

**Table 2: Increase in vehicular population between 2000 and 1998**

| 2-Wheelers | 3-Wheelers | Buses | Cars | Taxis | Trucks |
|---|---|---|---|---|---|
| 199955 | 59118 | 5177 | 100388 | 927 | 9540 |

**** Table 3: Projected Emission in the business as usual scenario (i.e. the increase in emissions if no proactive interventions would have taken place)**

| Mode of Transport | CO (kg/day) | | HC (kg/day) | | $NO_x$ (kg/day) | | PM (kg/day) | |
|---|---|---|---|---|---|---|---|---|
| | 1998 | 2000 | 1998 | 2000 | 1998 | 2000 | 1998 | 2000 |
| 2-Wheelers | 14072.05 | 15151.81 | 14993.79 | 15841.2 | 175.66 | 192.06 | 115.10 | 119.1 |
| 3-Wheelers | 7504.09 | 7982.946 | 4850.61 | 5221.28 | 162.33 | 174.75 | 79.97 | 87.36 |
| Buses | 3013.97 | 3075.162 | 808.99 | 822.09 | 4449.26 | 4527.95 | 97.46 | 98.88 |
| Cars | 31461.89 | 32507.53 | 4695.16 | 4901.96 | 3574.93 | 3729.53 | 31.61 | 32.61 |
| Taxis | 2369.43 | 2375.038 | 223.04 | 223.27 | 1219.36 | 1221.31 | 300.83 | 301.69 |
| Trucks | 739.54 | 808.1994 | 236.79 | 252.97 | 1263.87 | 1360.97 | 63.42 | 67.7 |
| Total | 59160.96 | 61900.68 | 25808.39 | 27262.77 | 10845.41 | 11206.55 | 688.38 | 707.36 |

*** The results are based on the research done by author 1, the methodology may or may not be acceptable to all.

**Table 4: Reduced vehicular emissions compared to the business as usual scenario:**

| Pollutants | CO | HC | $NO_x$ | PM |
|---|---|---|---|---|
| **Percentage reduction in emissions** | 4.4 | 39.45 | 19.03 | 52.48 |

**Process of reform**

The Indian Supreme Court's order of July 1998 regarding transportation sector reform was the major trigger of the change in Delhi. The Court's ruling was a triumph for the public interest and the environment. Observers worldwide have been impressed by the improvement in air quality, but the changes demanded by the Court were costly and inconvenient, especially for some parts of Indian society without great resources. The Court's decision was opposed by bus, taxi and three-wheeler operators and by numerous special interests including diesel fuel dealers, companies that own and operate diesel buses, parts of the government and competing users of CNG. Initial lack of proper infrastructure led to great discomfort to almost all sectors of society. The three-wheeler and bus drivers had to spend hours away from their livelihood in kilometre long queues waiting for CNG fill-ups. The public had to cough up double fare to travel in three-wheelers and wait for hours to travel in desired buses.

Policy change, however desirable, usually advantages some stakeholders at the expense of others. This, in turn, may cause the realization of these benefits to be delayed by the opposition of stakeholders who perceived their interests to be wronged. In some cases, the policy may be completely derailed. The Supreme Court's decision appears to have created both "winners" and "losers." Among the former are manufacturers of new vehicles purchased to replace obsolete ones, as well as companies that retrofit existing vehicles for CNG; and those branches of government that serve these constituencies. Losers included diesel fuel dealers, companies that own and operate diesel buses, and competing users of CNG.

Lessons from Delhi are being and will further be applied to other countries of the developing world struggling, thus far unsuccessfully, with punishing levels of urban air pollution. The Delhi experience puts forth the following list of points, which should be considered before introduction of cleaner fuel technologies in other parts of the world:

- Political, social, and economic factors that come together to effect policy change

The reform processes like the one that took place in Delhi have direct major impact on the political, social and economic status of the city. According to Delhi Transport Minister, a whopping amount of Rs. 10 billion (US $ 200 million approx) was at stake on the CNG conversion issue. While the process was incomplete and had contributed to a lot of hardships for the people, the Central Government had started wavering. Therefore before implementation of similar cleaner technology drives the issues that can affect its success should be analysed carefully.

- Means of implementation of policy change in difficult, seemingly intractable situations

Despite heavy resistance and lobbying against implementation of CNG as the sole fuel for public vehicles by the government and other organisations the Supreme Court did not deter from its decision. In it's hearing in April 2002, the Supreme Court rejected the idea of other hydrocarbon fuels being clean and insisted on the use of CNG alone. While the Delhi administration was asked to phase out all diesel buses or pay penalties, the Government of India was asked to make arrangements to supply CNG to Delhi as per its need.

- Stakeholders of the change and the role and effect on each

As the deadline of April 2002 approached, transporters' associations were joined by political leaders in opposition to demonstrate against the impending decision on the streets of Delhi. Commuters suffered as the public buses did not ply and the schools were closed because the children could not be transported to school. Delhi roads saw chaos with offices and schools getting disrupted with frequent strikes by transporters associations backed by the political parties in opposition. The Delhi

administration, responsible for the conversion of diesel buses into those of CNG and of acquiring more CNG buses, had done precious little. The Government of India was also against the conversion and argued that extreme hardships were being caused to people of Delhi because of supply bottlenecks. The public was ill informed of the pros and cons of the issue and could not decide whom to back.

- Cost effectiveness of the proposed policy

Every policy has its positive and negative impacts and they vary with their place and mode of implementation. CNG conversion, which proved to be beneficial in case of Delhi, may not serve the same purpose in a city like Chennai, where LPG should be preferred. With a huge number of alternative technology options available, cost-benefit analysis of each option should be carried out and means of accruing resources for implementation of the same should be considered. For example, Delhi has the highest per capita income and the lowest diesel prices compared to other metros. Bringing diesel prices at par with other metros could have funded entire CNG conversion. In 1998-99, diesel sale in Delhi was 1,451 Million litres. An additional sales tax of Re 1 in 1999 and 2000 would have fetched about Rs 300 crore. Increasing the price of diesel to that of Mumbai would have netted the government over Rs. 450 crore in one year. (Source: Centre for Science & Environment, CSE)

- Adequate infrastructure for implementation of the policy and reliable and safe supply of alternative fuels in quantity, quality and at least costs

The CNG crisis in the Capital initially clearly demonstrated that the Ministry of Petroleum was unable to provide the desired infrastructure leading to problems for both the citizens as well as the CNG vehicle operators. Frequent strikes by auto and taxi drivers demanding a streamlined refuelling infrastructure for their vehicles were witnessed. Long queues outside CNG refuelling stations became a common sight and taxi and auto operators had to often wait for 36 hours for refuelling. Their plight was such that they were able to ply their vehicles only two days a week as the rest of the time they spent in long queues without proper water or other facilities. The CNG crisis had actually become a human problem, which in political terms could have led to downfall of the central/ state government. There were cases of CNG leakage at refuelling stations and some plying CNG buses catching fire due to lack of adequate safety measures.

- Better information for policy makers

The Central government kept the Supreme Court in the dark about its inability to meet the CNG demand. This could have been because the CNG lobby had exercised a lot of influence on key operatives in the Central Government or because of sheer incompetence of the government to meet the targets. Also the issue kept taking new directions as representatives from various technical research institutes kept offering research-based arguments for and against the use of multiple fuels like low sulphur diesel or CNG. Hence there was a lot of debate and confusion on the issue of implementing CNG as single fuel for all public vehicles and finally a committee of experts had to be formed to research impartially on the issue.

- Consensus on issues and actions; Political commitment & rigorous enforcement; Institutional cooperation; Public awareness of the emissions, safety; and end-user financial benefits issues; facilitation of open dialogue among government, private sector, civil society and academe to overcome possible confrontations and arrive at the most cost-effective solutions

- Adequate care of the technical concerns like safety, periodic inspection, guidelines for retro-fitting workshops and mechanisms to inspect and certify each converted vehicle, effective mechanisms to control illegal conversions, specifications and safety standards for alternative fuels and vehicles and capacity building to enforce the standards

- Learn from international experience

Worldwide researches are going on, Government is spending billions of dollars on R&D to develop effective means of carbon reduction and sequestration. This Indian case study brings into light the way such pollution abatement policies can be implemented and effective results obtained. Such cases can be effectively replicated in other parts of the world by fine-tuning the issues to country specific situations and lead to a global decrease in carbon and pollutant emission level from transportation sector.

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