

# Prioritization of Strategies to Overcome Barriers for Cleaner and Energy Efficient Alternatives in Urban Transportation – Multi-criteria Approach

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## *Abstract*

*Adoption of cleaner and energy efficient technologies (CEETs) in urban transport experiences certain barriers and deriving a set of policies to remove/reduce barrier in the case of Delhi and Mumbai transport systems was attempted in this study. A set of policy alternatives and measures (PAMs) were identified for each barrier and a pool of barriers PAMs for all barriers were identified which were finally analysed for their potential based on 4 important criteria namely administrative costs, financial burden, human resource benefits, administrative backup and political acceptability.*

*Based on aggregated multi-criteria assessment, the policy of distinct colouring scheme for alternate fuel vehicles (AFVs) stood first followed by awareness campaigns to the drivers, training programs to the workers, single window/priority check points, financial incentives and task force to carry out check.*

*To realize the completeness, potential of PAMs in handling barriers was analysed considering not only a set of criteria but also their potential in handling more than one barrier. In overall ranking, policy to develop partnerships among major stakeholders and awareness campaigns to the drivers showed highest potential in removing barriers for the adoption of CEETs.*

*Based on the ranking under both approaches a set of seven policy measures and alternatives were selected to remove barriers to CEETS and they are partnership between the Government, public sector undertakings and private actors in proving better infrastructure; Financial incentives like free or priority parking, separate lanes for alternative fuel vehicles and free inspection and maintenance; Task force to carry our checks; Heavy fines on defaulters; Distinct colour coding for AFVs; Demonstration of AFVs and their advantages; and Awareness campaigns to drivers. This set of PAMs would be able to control all seven pre-identified barriers to the adoption of CEETs in Delhi and Mumbai urban transportation systems.*

**Key words:** Barriers, CEETs, multi-criteria, policy analysis, urban transport

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# Prioritization of Strategies to Overcome Barriers for Cleaner and Energy Efficient Alternatives in Urban Transportation – Multi-criteria Approach

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## 1. Introduction

Development of urban transportation has been an essential ingredient of economic development of any country. Many Developing Countries (DC) in Asia have been putting more emphasis on the development of urban transportation systems. However, due to various circumstantial factors, differential priorities, lack of long term planning and poor financial status for Urban Environmental Infrastructure (UEI), development in urban transportation is not following sustainable pathways. This results in both transportation problems like congestion, increased incidence of accidents and environmental problems like increased air pollution, poor fuel efficiency and also contribution to climate change in terms of green house gas emissions. Around 18-25% CO<sub>2</sub> emissions are coming from urban transportation in many developing countries (World Bank, 1997, Imura et al., 2005).

As the pollution levels reach their threshold limits in different cities making the life of public miserable, various mitigation measures were considered viz. court interventions, command and control tools, economic and innovative financial mechanisms. Though transportation needs an integrated approach drawing good balance among various domains like traffic management, congestion control measures, improved operating conditions and auto fuel policies, measures like adoption of alternative technological options and improved fuel quality are predominant. Attempts to induce improved technological alternatives and cleaner fuels are prominent in various Asian countries (UNESCAP, 2001). These measures clearly explain that transportation management in these growing urban centers of Asia has been “reactive”.

Technological alternatives and cleaner fuel alternatives experience various barriers and removal of these barriers is essential to achieve their penetration in urban transportation (May et al., 2003; Yedla, 2005). Various policy measures addressing the implementation of cleaner transportation alternatives and removal of barriers for the adoption of these alternatives result in externalities on various complementing sectors. Thus it is essential to analyze such impacts of various policies and their costs and benefits before attempting their implementation. To add robustness to the analysis it is important to carryout this impact

assessment based on multiple criteria. Further, implementation of alternative options may require more than one policy. Hence, it is important for the policy maker to know which policies have better potential so that they can choose among the bigger lot of policy alternatives.

Application of multi-criteria analysis for decision making in Environmental Management is gaining importance (Yedla and Shrestha, 2003). Thus, ranking of policy alternatives based on their impacts and potential in removing barriers to the alternative transportation options by employing multi-criteria approach would give most convincing answer to the policy makers. In the present paper such assessment and ranking of policy alternatives was carried out for two mega cities of India, namely Delhi and Mumbai.

### **Objective of the study**

To identify, assess and prioritize various policy measures to overcome barriers for the adaptation of selected alternative transportation options in Delhi and Mumbai transportation systems.

## **2. Methodology for the Analysis of Various Policy Alternatives**

Four necessary steps for any policy analysis are - defining the problem; identification of the policy alternatives; establishing evaluation criteria; evaluating alternative policies.

### **2.1 Defining the Problem**

The objective of this study is to suggest potential policy alternatives to overcome major barriers for the adaptation of selected alternative transportation options in Delhi and Mumbai transportation systems.

### **2.2 Identification of Barriers and Suitable Policy Measures**

In a study carried out by the authors at the Indira Gandhi Institute of Development Research (IGIDR), various important barriers for cleaner, energy efficient and environmental friendly technologies (CEETs) in Delhi and Mumbai transport systems were identified and ranked by adopting Analytic Hierarchy Process approach<sup>2</sup> (IGIDR, 2002). Those identified barriers are used in the present study and accordingly policy alternatives are identified for further analysis.

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<sup>2</sup> CEETs considered were CNG cars, CNG buses, CNG 3-wheelers, battery operated 3-wheelers, 4-stroke 2-wheelers. These CEETs were selected based on detailed techno-economic analysis. Further details on this study can be obtained from the authors or IGIDR (2002).

Policy alternatives and measures (PAMs) are identified for the removal of each identified barrier by reviewing the policies and measures tried by different countries for the removal of barriers to CEETs and also by means of personal interviews/brainstorming session among actors involved in transport sector. As certain policy alternatives would be common across barriers and show potential in removing more than one barrier, a policy-barrier matrix was developed with a set of common PAMs which have potential to remove one or more barriers. Depending on the potential to remove number of barriers, policy alternatives are given weights by adopting “maximum point normalization”. In this process, heavier weights are assigned to policies that have potential to remove more than one barrier and are preferred over the others.

### **2.3 Establishing Evaluation Criteria**

Criteria are an important platform to compare various policies for their merits and demerits in the process of selecting the most promising alternative policy options. In order to compare merits and demerits of the selected policy alternatives for the removal of barriers to the CEETs, a set of criteria was identified. Each of these criteria was given weights depending on their importance in assessing the alternative policy options. This was done based on the personal interviews and brainstorming session among various actors<sup>3</sup> involved in transport sector.

### **2.4 Evaluating Alternative Policies – Multi-criteria Approach**

Each policy alternative was assessed based on each of the criteria identified. Performance of each policy alternative based on each criteria was assessed on 1- 4 scale, with 1 representing “poor” and 4 representing “excellent”. This was carried out by personal interview (questionnaire survey)/brainstorming among actors. Average of responses from all the respondents against each question is used as the final rating for the analysis.

The alternative policy options are finally assessed by aggregating their assessment based on individual criteria to arrive at final ranking. Table 1 presents the framework of multi-criteria analysis. The total weighted average score of each policy alternative was used in ranking PAMs.

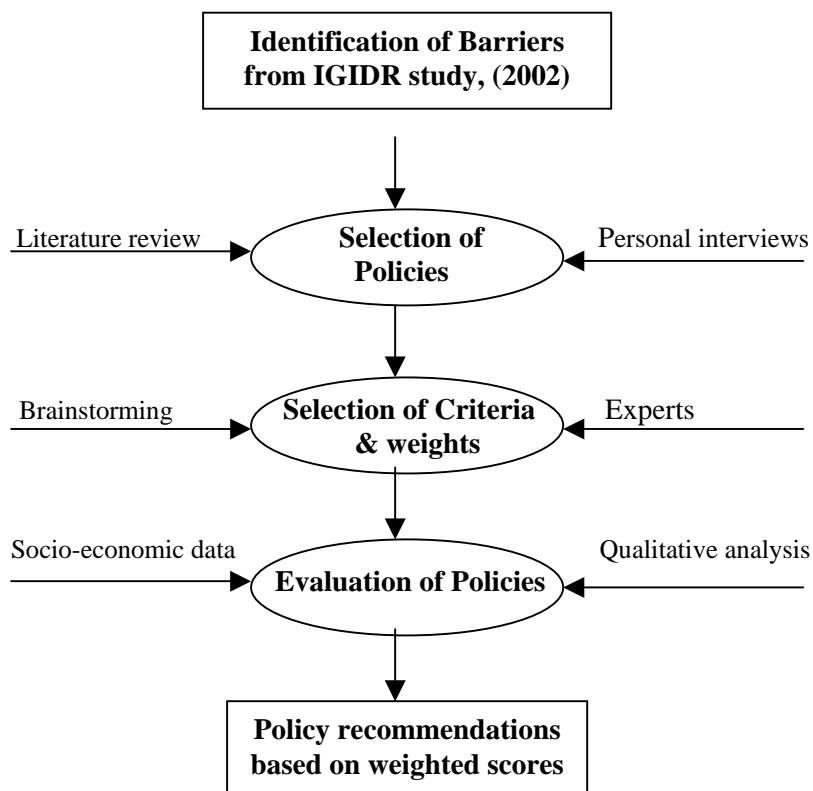
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<sup>3</sup> List of actors considered in such brainstorming sessions and personal interviews is given in appendix A

**Table 1: Simple structure of a criteria/policy alternative matrix (4 x 4)**

Criteria	Weight	Policy Alternatives			
		I	II	III	IV
Criteria 1					
Criteria 2					
Criteria 3					
Criteria 4					
Total weighted average score					
Percentage total weighted average score					

As different policy alternatives have different capacity to remove number of barriers, the above derived total weighted average scores are further subjected to the normalized weights derived for the policy alternatives based on their capacity to handle number of barriers. This final weighted score gives the overall ranking of these alternative policy options. Figure 1 presents the comprehensive view of the multi-criteria model for the policy analysis.



**Figure 1: Flowchart of the policy analysis**

### **3. Barriers to CEETs and Identification of Suitable Policy Measures**

#### **3.1 Barriers for the Clean, Energy Efficient and Environmental friendly Technologies**

Indira Gandhi Institute of Development Research had analyzed several technical and management options for greenhouse gas (GHG) mitigation in Delhi and Mumbai<sup>4</sup>. Based on the techno-economic analysis, economically viable and energy efficient and environmentally friendly alternatives were selected for individual cases of Delhi and Mumbai. Compressed natural gas (CNG) options, battery operated vehicles and 4 stroke engines were the major alternative options qualified based on techno-economic analysis. Important barriers for their adoption in Delhi and Mumbai were identified and ranked using multiple criteria. As the barriers are common across various alternatives both for Delhi and Mumbai, these barriers are clustered into a group and are further consolidated by means of a brainstorming among actors involved in transport sector. Following is the comprehensive list of barrier considered in the present study:

- Lack of Resources and Infrastructure (**B1**)
- Additional Cost (**B2**)
- Lack of Enforcing Mechanism (**B3**)
- Lack of Awareness (**B4**)
- Lack of Availability of Efficient Technology/Conversion Kits (**B5**)
- Unwillingness to Participate (**B6**)
- Lack of Training and Implementation Programs for Smooth Transition (**B7**)

#### **3.2 Review of Various Policy Initiatives in Different Cities/Countries**

There are variety of policies and measures discussed in the literature for the removal of barriers to achieve wider adoption of CEETs. These policies and measures can be summarized into the following categories

1. Market Approach (economic instruments viz. taxes, subsidies)
2. Innovative Financial Mechanisms
3. Information, Education and Technical Assistance Programs
4. Command and Control Measures

Though each of the above categories of policies is capable of handling various problems effectively, it is widely accepted that a combination of the above measures is

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<sup>4</sup> Details can be found at IGIDR (2002)

required to remove various barrier to CEETs. The following section presents various policies tried in different cities or countries to remove/overcome different barriers to CEETs.

### **3.2.1 Market Approach**

Economic instruments like taxes, subsidy and user fee play an important role in transport sector (Pandey, 2004; Krupnick et al., 2003; Yedla, 2005). They have been used in many countries to control the travel patterns and the associated emissions. Fuel taxation in particular plays an important role in all the policy issues related to the transport sector. For instance, higher prices at the pump provide incentives to choose more efficient cars. Differentiated fuel taxes are also widely used to support or limit the use of specific fuels. However, the response to fuel tax increase is very limited in short term although somewhat greater in the longer run. In many countries fuel taxes are already at levels that are not politically popular and the additional increase will create problem in the future (IEA, 2000). Following table (Table 2) presents various cases of taxes, subsidies and fees exercised in different countries.

Success of these tools depends highly on the kind of benefits they render in longer run. In a most structured and long term policy to support natural gas vehicles, Thailand Government, after its decision in October 1999 to promote natural gas utilization in transport sector, has invested hugely on transport sector leading to much better long term implementation<sup>5</sup>.

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<sup>5</sup> More details on this can be found at UNESCAP (2001)



**Table 2: Review of market based policy measures**

Country	Policy Measure
Argentina	<ul style="list-style-type: none"> <li>Increased tax on gasoline as a replacement policy measure for subsidy on Natural gas</li> </ul>
Canada	<ul style="list-style-type: none"> <li>Relaxation on excise tax to introduce cleaner fuel – elimination of federal excise tax at the rate of 8.5 cent per liter on the alcohol proportion of petrol-ethanol</li> </ul>
Denmark	<ul style="list-style-type: none"> <li>Fuel consumption tax waivers on electric vehicles (EVs) that is imposed on gasoline</li> <li>Exemption of import fee on EVs</li> <li>Free parking and charging (at specific parking places) for EVs</li> </ul>
Finland	<ul style="list-style-type: none"> <li>Carbon tax is levied per ton of CO<sub>2</sub> emitted</li> <li>Reduced Value Added Tax on public transport tickets</li> </ul>
France	<ul style="list-style-type: none"> <li>Government has provided a subsidy of \$8000 for the purchase of EVs and French private company provided a subsidy of \$4000 for charging of EVs.</li> </ul>
India	<ul style="list-style-type: none"> <li>Exemption of customs duty on the import of CNG conversion kits in New Delhi; exemption of 12% sales tax on CNG vehicles</li> </ul>
Japan	<ul style="list-style-type: none"> <li>Low automotive sales tax, annual automobile ownership tax and acquisition tax on low emission vehicles are charged</li> <li>Government subsidies to local public organizations or private companies that introduce low-emissions vehicles and system that supply fuel to these vehicles.</li> </ul>
Korea	<ul style="list-style-type: none"> <li>Exemption of VAT and environment improvement charges on CNG buses</li> <li>Subsidies to companies to introduce CNG buses and low interest loans for the gas station owners.</li> </ul>
UK	<ul style="list-style-type: none"> <li>Development of new Vehicle excise duty (VED) system which varies according to the CO<sub>2</sub> emissions from the car.</li> </ul>
US	<ul style="list-style-type: none"> <li>Tax credit for EVs</li> <li>Federal income tax deductions for alternative-fuelled vehicles</li> <li>Zero emission vehicle incentive program of California State</li> <li>Los Angeles Department of Water and Powers' discount on electricity used for recharging of EVs during off peak periods</li> <li>Reform of federal tax subsidy for employer parking</li> <li>License plate fee reduction (from \$25 to %8) and vehicle license tax reduction for alternative fuel vehicles</li> </ul>

Source: IGIDR, 2002; IGIDR, 2004; Imura et al., 2005; Ramanathan, 2000; UNESCAP, 2001; Yedla, 2005

### 3.2.2 Innovative financial mechanisms

Financial mechanisms and incentives are among the important and popular policy measures in transport sector. However, improper fiscal policies would lead to huge financial loss to the state. In Argentina, CNG was introduced and the government failed to create the fiscal driver to promote by keeping the difference between diesel price and CNG price very low. As a result, there was a little conversion from diesel to CNG because of the price difference between diesel and CNG leading to longer recovery period of the incremental costs. As a result, there are no CNG buses in regular operation today, and in fact diesel is actively competing with CNG to capture the taxi market away from CNG.

Federal Government of Canada, with an objective of encouraging the market for natural gas vehicles, had provided financial incentives - \$500 is for vehicle conversion, \$1,000 towards the purchase of a new NGV and \$50,000 for each new vehicle refueling station. This, along with relaxed excise tax on cleaner fuel has resulted in increased share of NGVs in the market. Low-interest loans on alternative fuel vehicles are exercised as an effective instrument to promote cleaner fuels in various countries like Thailand, Bangladesh, India. In India, CNG is available at a price (in gasoline- equivalent terms) of Rs. 8.1- 9.2/ liter, which compares favorably with gasoline prices of Rs. 22-26/ Liter in 2001. It is estimated that the costs of converting a vehicle to CNG in India can be recovered after 30,000km (IGIDR, 2004; Yedla, 2005).

### **3.2.3 Command and Control Measures**

Command and control has been a conventional approach in environmental management with numerous set of examples. It is particularly effective in breaking initial resistance in implantation of alternative policy measures. Following are few such cases –

- Argentine has adapted a command and control approach by developing standards for a successful national private industry of compressors and dispensers, cylinders, conversion kits to promote natural gas usage in transport sector.
- Mandatory vehicle inspections with minimum emissions requirements and zero lead standards were implemented in Finland.
- Finland Government had adopted the privatization of railways to improve efficiency and development of high-speed passenger train connections.
- In order to reduce pollution in the city of Milan, Italian Government permits electric vehicles, bicycles and motorcycles fitted with catalytic converter in the streets only between 8.00 AM to 8.00 PM.
- In a landmark decision, the Supreme Court of India ruling went into effect in New Delhi on March 31, 2001, mandating the conversion of the entire bus fleet to compressed natural gas (CNG). In addition, the honourable court has order the replacement of taxis and auto rickshaws with engines running on clean fuels. Though created friction in the system on short run, it has resulted in rich dividends on a longer run (Yedla, 2005).

### **3.3 Review on Policy Initiative and Measures in Indian Transport Sector**

Standards for controlling emission levels of new vehicles were incorporated into the Motor Vehicles Act (1989) only as late as 1991, enforcing some quality control on the automobile industry. The existing Bureau of Indian Standards (BIS) for fuels started incorporating emission parameters during the same period. In 1996, government came up with stricter mass emissions standards for vehicles. Other policy measures initiated during 1994-96 are – the use of unleaded petrol and fitting of catalytic converters in the car. Now, EURO II and EURO III norms also have been enforced.

The role of maintenance in combating vehicular pollution was reflected in government policy for the first time in 1989, which made the certificate of fitness as mandatory for registration of public vehicles, commercial vehicles and personal vehicles older than 15 years. The 1990 vehicular emission rules required all motor vehicles to comply with the laid down exhaust emission standards. Vehicle owners are required to check the emission levels of their vehicles every three months and obtain a PUC (Pollution under control) certificate. Vehicles failing to meet the standards are required to fix it and obtain the certificate. The State Transport Authority fines those vehicles not possessing a PUC certificate. This, apart from cutting down the emissions, actually created a lot of awareness among citizens for the environmental pollution.

Failure of the administration to enforce environmental regulations, has led to judicial interventions. The Supreme Court has come up with several guidelines in the last few years. The Court has urged the government to accept the emissions standards EURO I, II, III etc. for the vehicles as adopted by European Commissions. In last few years, The Supreme Court issued number of directives aiming at environmental emission control, if which some are specific to Delhi and some are nation wide (CPCB, 1999; GoNCT, 2003)<sup>6</sup>.

Two of the major initiatives towards emission control in India are enforcement of unleaded petrol first in mega cities and then in the entire country and low sulphur diesel. Details of these two programs are given in Box 1. The specification of lead in Indian petrol used to be a maximum of 0.56 gm/L until 1994. As a result of the lead phase out program, India achieved lead free-gasoline within the next 6 years (by February 1, 200). This is a significant achievement when compared with the fact that in the developed countries, lead phasing out was spread over a period of 10 to 20 years. Further, China and many other

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<sup>6</sup> Details can be obtained from Yedla (2005) and IGIDR (2004)

countries in Asia and the Pacific region, South America and Africa are yet to achieve complete phasing out of lead.

**Box 1: Lead and Sulphur phase out programs in India**

<b>Gasoline lead phase out program</b>			
Phase I	June 1994	Low leaded (0.15 g/l)	Delhi, Mumbai, Calcutta and Chennai
Phase II	1.4.1995	Unleaded (0.013g/l)	
Phase III	1.1.1997	Low leaded (0.15g/l)	Entire country
Phase IV	1.9.1998	Ban on leaded fuel	NCT of Delhi
Phase V	31.12.1998	Unleaded (0.013g/l)	All other capitals of States/UT & other major cities
Phase VI	1.1.1999	Unleaded only	NCR
Phase VII	1.4.2000	Unleaded	Entire country
<b>Diesel Sulphur phase out program</b>			
Phase I	April 1996	Low sulphur (0.5%)	Four metros and “Taj Trapezium”
Phase II	August 1997	Low sulphur (0.25%)	Delhi and “Taj Trapezium”
Phase III	April 1998	Low sulphur (0.25%)	Metro cities
Phase IV	April 1999	Low Sulphur (0.25%)	Entire country

Source: CPCB (1999)

**3.4 Barriers and Alternative Policies Matrix**

Based on the description of barriers and review of policies presented in the previous sections, suitable policy alternatives and measures (PAMs) are identified for the removal of each barrier, which are presented in Table 3. Identification of PAMs was done based on personal interviews and brainstorming among various actors involved in transport sector. Policies required for the removal each barrier are explained in detail.

**Table 3: Policy alternatives for each barrier to the adaptation of CEETs in Delhi and Mumbai**

<b>Barrier</b>	<b>Policy Alternatives and Measures (PAMs)</b>
Lack of Resources and Infrastructure ( <b>B1</b> )	<ul style="list-style-type: none"> <li>• Formulation of an implementing agency to provide the necessary infrastructure (<b>P<sub>11</sub></b>)</li> <li>• Partnership between the Government, Public Sector Undertakings and Private actors in providing the infrastructure (<b>P<sub>12</sub></b>)</li> </ul>
Additional Cost ( <b>B2</b> )	<ul style="list-style-type: none"> <li>• Subsidize the additional expenditure (<b>P<sub>21</sub></b>)</li> <li>• Interest subsidies on loan to convert vehicles (<b>P<sub>22</sub></b>)</li> <li>• Financial incentives like free or priority parking and separate lanes for alternative fuel vehicles (AFVs) (<b>P<sub>23</sub></b>)</li> <li>• Free Inspection and Maintenance (<b>P<sub>24</sub></b>)</li> <li>• Access to the otherwise restricted areas (<b>P<sub>25</sub></b>)</li> <li>• Tax on polluting vehicles and earmarking such revenue to provide subsidies for AFVs (<b>P<sub>26</sub></b>)</li> </ul>
Lack of Enforcing Mechanism ( <b>B3</b> )	<ul style="list-style-type: none"> <li>• Single window/priority check points (<b>P<sub>31</sub></b>)</li> <li>• Task force to carry out checks (<b>P<sub>32</sub></b>)</li> <li>• Heavier fines on defaulters (<b>P<sub>33</sub></b>)</li> <li>• Colouring scheme for easy tracking of vehicles (<b>P<sub>34</sub></b>)</li> </ul>
Lack of Awareness ( <b>B4</b> )	<ul style="list-style-type: none"> <li>• Awareness campaigns (<b>P<sub>41</sub></b>)</li> <li>• Demonstration of AFVs and their advantages (<b>P<sub>42</sub></b>)</li> </ul>
Lack of Availability of Efficient Technology/ Conversion Kits ( <b>B5</b> )	<ul style="list-style-type: none"> <li>• Development of indigenous technologies (<b>P<sub>51</sub></b>)</li> <li>• Creation of market by command and control measures (<b>P<sub>52</sub></b>)</li> <li>• Time bound waivers on import duty (<b>P<sub>53</sub></b>)</li> </ul>
Unwillingness to participate ( <b>B6</b> )	<ul style="list-style-type: none"> <li>• Command and Control Measures (<b>P<sub>61</sub></b>)</li> <li>• Judicial interventions (<b>P<sub>62</sub></b>)</li> <li>• Demonstration of AFVs and their advantages (<b>P<sub>63</sub></b>)</li> </ul>
Lack of Proper Training and Implementation Program in case of CNG Technology ( <b>B7</b> )	<ul style="list-style-type: none"> <li>• Training programs to the workers (<b>P<sub>71</sub></b>)</li> <li>• Awareness campaigns to the drivers (<b>P<sub>72</sub></b>)</li> <li>• Demonstration of AFVs and their advantages (<b>P<sub>73</sub></b>)</li> </ul>

Following is the detailed analysis of PAMs against each barrier.

Lack of resources and infrastructure: Infrastructure required for the supply of cleaner fuels is filling stations and pipe network in the case of CNG; desulphurization units in refineries for the supply of low sulphur diesel; and network of charging stations for battery operated vehicles (IGIDR, 2002). In order to remove this barrier, efforts of the Government need to be complemented by market. Thus, partnership between the City Government, public sector undertakings and the private actors is a necessity.

There is a need for dedicated and exclusive body to build the infrastructure and services so as to remove the infrastructure bottlenecks for better penetration of CEETs. Indraprastha Gas Limited is one such example in Delhi. This body mobilizes its own resources from various

stakeholders and by going for public issue it can sustain the financial burden and also clear it in a relatively shorter span of time (DoNCT, 2003). This barrier can be handled effectively by the above two measures. Just by providing subsidy to the service provider it may not be possible to create the momentum for its spread and longevity.

Additional cost: Conversion of existing vehicles to CNG needs substantial investments. The cost of a diesel-CNG kit is about Rs. 85000 (Indian Rupees) and that of a petrol-CNG kit is about Rs. 30000, exclusive of customs duty (DoNCT, 2003). This investment requirement has become a major barrier for its adoption. A new CNG bus costs around 1.6 million Indian rupees where as the diesel version costs only 0.8 million India Rupees. This additional expenditure overshadows the fact that the CNG is cheaper. It is estimated that the costs of converting a vehicle to CNG can be recovered after 30,000km (DoNCT, 2003). However, the feeder services like 3-wheelers (auto rikshaw) face severe problem in meeting this huge initial cost of conversion kits. Hence, it is essential to provide some sort of financial incentives to overcome this barrier and allow the user to capture the low operating cost of AFVs.

In case of major manufacturers, demand driven markets take care of the additional investments required. In India, the CNG market was limited to a total of around 7,000 vehicles in Mumbai and Delhi, with total demand of around 0.03MMcm/ day in 2001. This number has gone up substantially to reach as high as 70,249 motor vehicles in Delhi alone by 2004 creating good market for Natural Gas Vehicles (NGVs) (DoNCT, 2003; Yedla, 2005). However, the small scale user needs incentives to over come this important barrier.

A subsidy in the range of 50% on the additional cost for NGVs would encourage conversions to a great extent. However, such subsidy puts heavy burden on the Government. An alternative measure could be interest subsidies on loans to convert the existing vehicles to NGVs or other alternative fuels. Command and control measures are required to break the initial stigma before the financial incentives add to the momentum. In such an attempt in Delhi, to increase the penetration of CNG vehicles, the Government of India (GoI) had provided an exemption of customs duty on CNG converter kits imports. Other financial incentives attempted include exemption from the 12% state sales tax and a 3% low-cost loan option for weaker sections of the society (DoNCT, 2003). Customs duty on imported CNG kits was waived. These incentives helped reducing the cost of CNG conversion kit by about 15%. However, these subsidies were given only for the initial few months. Similar

mechanisms can be tried in Mumbai to improve the penetration of NGVs and other cleaner options like electric and battery operated vehicles.

Apart from these direct financial incentives to provide the initial drive for conversion, indirect incentives like free or priority parking for AFVs, special lanes would help speed up the adoption. These mechanisms have been attempted successfully in many developed countries and found giving good results.

Other incentives that can be offered are free inspection and maintenance, access to areas like CBD where other gasoline and diesel vehicles are prohibited would be a major driver, in spite of the additional costs involved in fuel switching. Another effective financial mechanism could be a tax on polluting vehicles and earmarking such revenue to provide subsidies for AFVs. Such measure help reduce the financial burden on the state.

Lack of enforcing mechanism: Among various barriers to the adoption of AFVs, lack of enforcing mechanism is important because this directly influences the enforcement of the alternative. In spite of providing infrastructure and financial incentives, the alternative options may fail due to the absence of enforcing mechanisms.

Once the regulation for conversion of vehicles is made, a single window/priority checking points would enhance the effectiveness of enforcement. A mobile task force to carry out random checks on vehicles would remove this barrier of weak enforcement. As an indirect approach, levying heavier fines on defaulter could be an effective enforcement tool. This would work well in the case of 3-wheelers and cars. For buses the enforcement will not be a barrier as the number is limited and are easy to trace and monitor. A scheme of distinct colouring for AFVs would help in easy tracking of vehicles. This would enhance the enforcement and fining defaulters would be that much easier.

Lack of awareness: In the case of semi public transport encompassing taxis and 3-wheelers (auto rikshaw) lack of awareness also poses a major barrier. Operating costs of the three wheelers driven on natural gas is almost half that of conventional fueled three wheelers. However, the initial capital cost requirements overshadows the other benefits because of the poor awareness. Hence, removing this barrier could help better adaptation of AFVs. It is required to design and execute strong awareness campaigns like bill boards, advertisements in news papers and other media like TV and Radio. NGOs have a particularly important role in this. Another measure to remove this barrier is the field-demonstration of these AFVs.

Lack of availability of efficient technology/conversion kits: In the initial phase of the AFVs, lack of availability of efficient technology/conversion kits poses a severe constraint on their penetration. However, this barrier disappears over a period of time as the market itself takes care of such demand. But, it is essential to reduce its intensity to achieve a better penetration rate in the beginning. This barrier can be controlled in a three pronged approach. During the initial period, incentives like import duty waivers on CNG conversion kits need to be implemented to encourage the conversion of vehicles. However, it needs to be a time bound process, slowly reducing the waivers so that it initiates the development of indigenous kits. However, leaving it exclusively to the market might make it unsuccessful as it takes longer to create a market. Thus, it is necessary to make a regulation for this conversion so that market is created with a specific time frame. Therefore, there is a need for regulation making the conversions mandatory. Alongside, to meet the demand, indigenous technology and conversion kits need to be developed. These three measures put together can remove this barrier of non-availability of efficient technology/conversion kits.

Unwillingness to participate: One of the difficult barriers to remove is peoples' unwillingness to participate. In spite of the financial incentives and other measures people resist these changes. Two possible ways to handle this problem both in Delhi and Mumbai are command and control with judicial intervention and demonstration of AFVs and their advantages to individuals and the public in general. As in the case of Delhi, a strict regulation to adopt AFs with a strict time frame is necessary to force the conversions in spite of peoples' unwillingness to participate. Demonstration runs of AFVs and showcasing their benefits would reduce the initial friction resulting from the enforcement of regulation.

Lack of proper training and implementation programs: Lack of proper training and implementation programs for smooth transition is a functional barrier affecting the efficiency of conversion/penetration. As these alternatives like natural gas, battery operated vehicles are technology intensive, the workers handling them need to be trained specially for the task. Lack of such training would fail to provide a smooth transition to AFVs. No proper training results in various operational problems and improper conversions lead to mishaps creating havoc in the public (DoNCT, 2003). This barrier is prominent during the initial phases. Drivers need to be made aware of the changes/adjustments in the technology in absence of which there is every possibility of mishandling of the vehicle. Hence, awareness campaigns for drivers (for taxis and auto rikshaws in particular) are necessary to provide a smooth



transition to these AFVs. Demonstration of AFVs and their advantages would reduce the gap between introduction and implementation of these efficient alternatives in urban transportation.

### 3.5 Selection of Alternative Policies and their Weights

From the above description it is observed that certain policy alternatives and measures (PAMs) are common to remove the set of identified barriers. Thus, a pool of common policy alternative and measures are selected against the set of barriers. Table 4 presents this matrix of barriers and PAMs.

**Table 4: Barrier-PAM matrix**

Barriers	Policy Alternatives and Measures
<ul style="list-style-type: none"> <li>• Lack of Resources and Infrastructure (B1)</li> <li>• Additional Cost (B2)</li> <li>• Lack of Enforcing Mechanism (B3)</li> <li>• Lack of Awareness (B4)</li> <li>• Lack of Availability of Efficient Technology/Conversion Kits (B5)</li> <li>• Unwillingness to Participate (B6)</li> <li>• Lack of Proper Training and Implementation Programs for Smooth Transition (B7)</li> </ul>	<ul style="list-style-type: none"> <li>• Formulation of an implementing agency to provide the necessary infrastructure</li> <li>• Partnership between the Government, Public Sector Undertakings and Private actors in providing the infrastructure</li> <li>• Subsidies on the additional expenditure</li> <li>• Financial incentives like free or priority parking, separate lanes for alternative fuel vehicles and Free Inspection and Maintenance</li> <li>• Tax on polluting vehicles and earmarking such revenue to provide subsidies for AFVs</li> <li>• Single window/priority check points</li> <li>• Task force to carry out checks</li> <li>• Heavier fines on defaulters</li> <li>• Colouring scheme for easy tracking of vehicles</li> <li>• Awareness campaigns</li> <li>• Demonstration of AFVs and their advantages</li> <li>• Time bound waivers on import duty</li> <li>• Regulations</li> <li>• Training programs to the workers</li> <li>• Awareness campaigns to the drivers</li> </ul>

Some PAMs have potential to handle more than one barrier. Any such measure potential in removing more than one barrier should be given priority over the other which handles only one barrier. Thus, in an attempt to provide weights to different PAMs based on their potential in removing number of barriers, various barriers that can be removed are listed against each PAMs and weights are given to each PAM by normalizing (maximum point normalization) their capacity to remove number of barriers. These weights are applied later in the process of deriving final performance of these PAMs in removing barriers. Table 5 presents the normalized scores of each PAM. Consultations with experts/actors (from the list given at the end) helped in arriving at these weights. Normalized score of one indicates highest potential of PAM in removing barriers.

**Table 5: Scores for Policy Alternatives and Measures**

<b>PAMs</b>	<b>Affected Barriers</b>	<b>Normalized Score</b>
Formulation of an implementing agency to provide the necessary infrastructure (P1)	B1, B5, B7	0.75
Partnership between the Government, Public Sector Undertakings and Private actors in providing the infrastructure (P2)	B1, B2, B5, B7	1
Subsidies on the additional expenditure (P3)	B2, B3	0.5
Financial incentives like free or priority parking, separate lanes for alternative fuel vehicles and Free Inspection and Maintenance (P4)	B2, B3, B4	0.75
Tax on polluting vehicles and earmarking such revenue to provide subsidies for AFVs (P5)	B2, B3, B5	0.75
Single window/priority check points (P6)	B3, B7	0.5
Task force to carry out checks (P7)	B3, B4, B5	0.75
Heavier fines on defaulters (P8)	B3, B2, B5	0.75
Colouring scheme for easy tracking of vehicles (P9)	B3, B4	0.5
Awareness campaigns (P10)	B4, B2	0.5
Demonstration of AFVs and their advantages (P11)	B4, B6, B7	0.75
Time bound waivers on import duty (P12)	B5	0.25
Regulation (P13)	B2, B3, B6	0.75
Training programs to the workers (P14)	B7	0.25
Awareness campaigns to the drivers (P15)	B7, B3, B2	0.75

## **4. Selection of Criteria for Policy Analysis**

### **4.1 Criteria for Policy Analysis**

Set of criteria is required to make comparison among various policy alternatives and measures and to assess their potential in removing as many barriers for the better penetration of CEETs. Based on careful examination of the set of policy alternatives and measures (PAMs) considered the following criteria are selected for further assessment. Each PAM is assessed based on each one of these criteria.

- Administrative cost
- Financial burden
- Human resource benefits
- Administrative backup
- Political acceptability

#### *Economic considerations*

Direct cost of any barrier removal policy may include administrative cost, cost of financial incentives, and cost of advertising the program. Impacts of these policy measures on the transport sector and economy in general should be identified to assess the indirect policy costs and benefits. Successful implementation of barrier removal policies includes the following costs:

- Administrative costs – this includes physical infrastructure cost, cost of changing existing rules and regulations, capacity building of implementers and stakeholders, cost of hiring the consultants, cost of collecting required information, cost of program monitoring, etc.
- Cost of financial incentives – Financial incentives are one of the most commonly used barrier removal policies to increase the wider adoption of CEETs. In case if the policies and measures include any financial incentive program, the cost of this incentive will have to be considered in addition to other administrative costs.

*Financiability:* Financing barrier removal policies can be a major challenge for the developing countries. Hence, financiability was selected as another criterion to choose appropriate policy options.

*Administrative Feasibility:* Policies should be practical and feasible to actually produce intended benefits. Implementation of barrier removal policies requires a good organizational set-up with appropriate infrastructure, manpower and technical support.

*Political Acceptability:* It may be difficult to get political support for most of the GHG reduction policies and measures because the policy makers are more likely to have their priority on economic and social needs, as mentioned earlier, rather than giving attention to environmental issues of global concern. The passing of GHG mitigation policies through political and bureaucratic process can be a challenge for developing countries. Hence, political acceptability could be one of the evaluation criteria.

*Equity:* Equity can be considered as an evaluation criterion because the equitable distribution of policy cost and benefits among stakeholders could be of great importance.

#### **4.2 Assigning weights for Criteria**

Method of subjective comparison is applied in choosing the appropriate criteria to evaluate policy alternatives. A weightage matrix for the criteria was constructed based on the brainstorming session held at IGIDR and also consultations with experts. A group construction approach with a supra user was adopted in constructing this matrix. Weights derived for each criteria are given in Table 6.

Financial burden is the cost involved in meeting costs arising from the policy to remove barriers by means of financial incentives. Human resources benefits include employment generation, training of workers and development of skilled labour etc.

**Table 6: Derived weights for criteria**

<b>Criteria</b>	<b>Weight</b>
Administrative Cost	0.1
Financial Burden	0.2
Human Resource Benefits	0.1
Administrative Capability	0.3
Political Acceptability	0.3

## **5. Analysis of Alternative Policy Options to Reduce Barriers to the Adoption of CEETs**

### **5.1 Prioritization of Policies based on Criteria**

Any alternative policy option has strengths and weaknesses and it is important to make a consolidated assessment accounting for all its strengths and weaknesses. Hence, the effectiveness of each PAM against each criteria is assessed on a four point scale - Low – 1, Medium – 2, High – 3, Very High - 4. On this scale low value represents the least priority of a policy based on the criteria under consideration. For instance, a score of 1 for P1 (formulation of an implementing agency to provide the necessary infrastructure) on the criteria of “Administrative cost” implies that P1 is less preferred as its implementation would involve high administrative costs. Group responses for each alternative against each criteria are developed based on brainstorming among experts. Merits and demerits of all PAMs are explained under each criteria as presented below:

#### Criteria: Administrative cost

Any policy to be implemented essentially involves various efforts like changing the existing rules and regulations, and organizational set up. If the policy cannot be implemented with the existing organizational setup, it takes quite an effort to make it work. It involves costs like infrastructure, hiring consultants and staff, training and education of the staff, etc.

Formulation of an implementing agency to provide necessary infrastructure essentially involves huge administrative costs. Construction of 23.8 km CNG pipeline in Delhi by IGL needed 250 million Indian Rupees. Establishment of 110 CNG stations and the other necessary infrastructure needed 5220 million Rupees (DoNCT, 2003). It essentially involves other huge costs like training personnel and providing support in execution. Policies to promote partnership between major stakeholders also demands huge administrative costs. At times it would be a necessity to go for amendment of rules to accommodate such new bodies.

However, providing subsidies and financial incentives would not involve much administrative cost as it can be implemented with the existing organizational setup. Taxing pollution vehicles needs legislation in support and such changes demand huge administrative costs. Similar costs would be observed in the case of fines on defaulters. Priority checks with single window and constitution of task force doesn't demand too much of administrative costs as they can be handled with the existing organizational set up and man power.

Colour coding schemes, training and awareness programs can be successfully implemented with the existing system without having many changes. Delhi presents an interesting illustration of achieving such without any significant additional costs. Time bound waiver on import duty and regulation to promote AFVs doesn't involve substantial administrative costs. The group rating of policies under this criteria is presented below. For instance, P4 shows better potential to remove barriers compared to P1 when compared on the basis of "administrative costs" involve in implementing policies as P1 involves high administrative costs while P4 involves less administrative costs.

<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	Criteria - <b>Administrative costs</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>	<b>P8</b>
1.0	2.0	3.0	3.0		2.0	3.0	3.0	2.0
<b>P9</b>	<b>P10</b>	<b>P11</b>	<b>P12</b>		<b>P13</b>	<b>P14</b>	<b>P15</b>	
4.0	2.0	2.0	2.0		2.0	3.0	3.0	

Criteria: Financial burden

Financing the partnership among key stakeholders is not difficult because of the fact that market takes care of the capital demand. Financiability would not be a problem with such partnerships in place. Though formulation of implementation body involves substantial administrative costs, its financiability should be taken care by the shares held by individual actor.

Subsidies on the conversion present a serious case of financiability problem. Price difference between diesel driven bus and CNG bus is 0.8 million rupees with diesel bus costing 0.8 million rupees and CNG bus 1.6 million rupees. Cost of diesel-CNG conversion kit is 85000 rupees and petrol-CNG conversion kit is 30000 rupees (DoNCT, 2003; IGIDR, 2004). Table 7 explains the level of burden that comes on to the state at various levels of subsidy given.

Subsidy essentially creates more penetration of the option. However, it places a heavy burden on the State as heavy as billions of rupees. Hence, this policy of providing heavy subsidy on conversions may not be strong compared to other policy measures in spite of its potential in handing the barrier of "additional cost". Providing financial incentives would also lead to similar consequences and hence rated low on this criteria.

**Table 7: Estimates of financial burden on the state as a result of subsidies**

Vehicle type	Number	100% subsidy on conversion	50% subsidy on conversion	25% subsidy on conversion
Old Buses Conversion	7231	614.6 million rupees	307.3 million rupees	153.6 million rupees
New CNG Buses	2539	2031.2 million rupees	1015.6 million rupees	507.8 million rupees
3-wheelers	50,830	1524.9 million rupees	762.45 million rupees	381.22 million rupees
Mini buses	4468	134.04 million rupees	67.02 million rupees	33.51 million rupees

Tax on polluting vehicles, providing single window check point facility, constituting task force for checking and implementation, heavier fines on defaulters and distinct colour scheme would not pose considerable finance crunch on the State. In the Delhi CNG implementation for the public transport, many such activities were handled with the existing organization and the manpower, without incurring significant additional resources. In the year 2002-03 the daily fines on defaulter in Delhi has amounted to 24 million rupees (Yedla, 2005).

Awareness campaigns and demonstrations need to be financed by the State and its requirements depend on the level of activity. In a city where the pollution levels are extremely high and needs an intensive campaign would demand considerable resources and hence financiability could be a problem. Time bound waivers would face financiability problem as they involve huge loss in income for the State. Follow are the group ratings given to various policies under this criteria of financial burden on the State.

P1	P2	P3	P4	Criteria - Financial Burden	P5	P6	P7	P8
3.0	3.0	1.0	2.0		4.0	4.0	4.0	4.0
P9	P10	P11	P12		P13	P14	P15	
4.0	3.0	3.0	2.0		3.0	3.0	3.0	

Criteria: Human resource benefits

Certain policy measures like establishment of implementing agency and partnership between the Government, Public Sector Undertakings and Private actors have very high potential to generate employment at various levels starting from labour, technicians to managerial executives. However, partnership among various stakeholders like government owned agencies responsible for public transport, publicly owned transport corporations and the company (s) responsible for providing clean fuel, implementing body (s) and the local government has more potential in employment generation.

Policy measures like free inspection and maintenance will have a moderate level of employment generation, which at times may be insignificant. In the case of Delhi CNG program, the additional responsibility of increased checks was managed by the existing staff of the transport department of Delhi. However, a city with a heavy vehicular population essentially shows potential employment generation. In Delhi CNG program 2.4 million vehicles were checked for pollution during the year 2002-03 (DoNCT, 2003, IGIDR, 2004). Taxing the polluting vehicles and single window scheme for pollution checks would have least impact on employment generation or training of manpower.

Policy of establishing a task force may have a slight impact on the human resources, as it may need some additional manpower and expertise in the alternate fuels and related environmental impacts. Distinct colouring scheme may have slight impact on the human resources. Awareness campaigns, training programs and demonstrations may slightly have scope to generate additional employment opportunities. Therefore, under this criteria all the policies can be rated as shown below

<b>P1</b> 3.0	<b>P2</b> 4.0	<b>P3</b> 1.0	<b>P4</b> 3.0	Criteria - <b>Human Resources Benefits</b>	<b>P5</b> 1.0	<b>P6</b> 1.0	<b>P7</b> 2.0	<b>P8</b> 1.0
<b>P9</b> 2.0	<b>P10</b> 2.0	<b>P11</b> 2.5	<b>P12</b> 1.0		<b>P13</b> 2.0	<b>P14</b> 1.5	<b>P15</b> 2.0	

Criteria: Administrative Capability/Feasibility

Successful implementation of policy measures requires a well-designed system supported by appropriate infrastructure and trained personnel. In assessing the administrative feasibility of any policy, it is worthwhile to understand organizational and legal implications. It should be made known whether the current organization has the capacity and system to implement the policy. If not, would it be practical to set up a new organization or is it only necessary to improve the capacity of the current personnel through training and formal education? Do the existing legislations, programs, bills, and laws, promote or hinder implementation of a newly crafted policy?

Policy measures like the formulation of implementing agency would take much for administrative capability. Any such drive needs extensive administrative efforts in creating and earmarking human and financial resources. Establishing partnership among various key stakeholders and providing required infrastructure essentially need additional efforts on administrative grounds. Establishment of Indraprastha Gal Limited (IGL) for the



implementation of CNG for public transport in Delhi is such an example where substantial administrative efforts went in at a level of head of the state.

Incentive based policies like subsidies and other incentives would essentially need administrative backup. To bring CNG commercial vehicles under permit and tariff jurisdiction of the city/state Government, it was essential to amend the Motor Vehicles Act in India. This kind of administrative bottlenecks make these policies difficult ones to implement. Taxing vehicles would essentially face a similar limitation, if attempted. Providing single window/priority checks for AFVs should be relatively less intensive. Policies like distinct colour scheme, awareness rising, demonstrations and trainings should be relatively easing as far as administrative feasibility is concerned. However, policies like time bound waivers on import duty and regulation to bring in change of fuel usage essentially need substantial efforts. Following chart shows the group rating of various policies on the basis of administrative capability to bring in these policies.

<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	Criteria - <b>Administrative Capability/ Feasibility</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>	<b>P8</b>
2.0	2.0	3.0	3.0		2.0	3.0	2.0	3.0
<b>P9</b>	<b>P10</b>	<b>P11</b>	<b>P12</b>		<b>P13</b>	<b>P14</b>	<b>P15</b>	
3.0	3.0	1.0	3.0		1.0	3.0	3.0	

Criteria: Political acceptability

Though transport department is a state department it has links with environmental issues, which have links at national and international level. Hence, these policies, though local in nature have been greatly influenced by political agendas of the country and the leaders. In a city like Delhi and Mumbai, urban transport and the related environmental issues have become big issues in the election campaign and leaders have started counting on these policies to improve their chances of winning election. Thus it is essential for any successful policy to be accepted politically. It may be difficult to get political support for most of the GHG reduction policies and measures because the policy makers are more likely to have their priority on local pollution control rather than giving attention to environmental issues of global concern. Hence, certain policies, which may not fit into the agenda of the set of policy makers may be difficult to be implemented even if they are potential in controlling certain transport and environmental related problems. Hence, political acceptability is one of the important criteria to evaluate alternative policy measures.

<b>P1</b> 3.0	<b>P2</b> 2.0	<b>P3</b> 2.0	<b>P4</b> 3.0	Criteria - <b>Political</b> <b>Acceptability</b>	<b>P5</b> 2.0	<b>P6</b> 3.0	<b>P7</b> 3.0	<b>P8</b> 2.0
<b>P9</b> 4.0	<b>P10</b> 4.0	<b>P11</b> 4.0	<b>P12</b> 3.0		<b>P13</b> 2.0	<b>P14</b> 4.0	<b>P15</b> 4.0	

### *Equity Considerations*

The impacts of policies and measures on income distribution are equally important and therefore need careful evaluation. These alternative fuels target mostly the public transport. This essentially reaches the lower strata of people who rely on public transport for their daily commuting. Subsidy on buses will control the possible hike in fares. This directly reaches the urban poor as a benefit.

Auto rikshaws (3-wheelers) caters major share of travel needs, especially acts as feeders to the bus and train networks. Auto-drivers are typically urban poor. Policies to convert their conventional fueled vehicles to clean fuels would hit them badly. But a policy to subsidize the additional expenditure on the conversion would add to their benefits. Without subsidy the additional expenditure can be retrieved within 30000 kilometers of service. With say 50% subsidy on the additional expenditure it could be recovered in 15000 kilometers, which on an average is covered in a year.

Employment generation due to policies such as formulation of an implementing body, partnership between various stakeholders would meet the urban poor to an extent of 60-75% as the remaining 25% would be executives.

Fuel cost difference between petrol and CNG is almost 100% with Petrol costing about 31.49 rupees a liter and CNG 16.83 per kg of gas. Hence, a regulation to convert the conventional vehicles to cleaner fuels would give the urban poor good returns and also it would add to the States income due to increased share of CNG in the market. Such conversions would result in substantial improvements in ambient air quality which is a huge benefit both for the State and urban poor who suffer from severe air pollution in the city. It is possible to control particulates, CO and SO<sub>x</sub> to an extent of 30-40%.

Table 8 summarizes rating of various policies under different criteria and calculation of total weighted average scores and percentage average scores.

**Table 8: Criteria-policy matrix**

Criteria	Score	Policy Alternatives							
		P1	P2	P3	P4	P5	P6	P7	P8
Administrative Cost	0.1	1.0	2.0	3.0	3.0	2.0	3.0	3.0	2.0
Financial Burden	0.2	3.0	3.0	1.0	2.0	4.0	4.0	4.0	4.0
Human Resource Benefits	0.1	3.0	4.0	1.0	3.0	1.0	1.0	2.0	1.0
Administrative Capability	0.3	2.0	2.0	3.0	3.0	2.0	3.0	2.0	3.0
Political Acceptability	0.3	3.0	2.0	2.0	3.0	2.0	3.0	3.0	2.0
Total weighted Average score	1	<b>2.5</b>	<b>2.4</b>	<b>2.1</b>	<b>2.8</b>	<b>2.3</b>	<b>3</b>	<b>2.8</b>	<b>2.6</b>
Percentage total weighted average score		<b>62.50</b>	<b>60</b>	<b>52.50</b>	<b>70.00</b>	<b>57.50</b>	<b>75.00</b>	<b>70.00</b>	<b>65.00</b>

Criteria	Score	Policy Alternatives							
		P9	P10	P11	P12	P13	P14	P15	
Administrative Cost	0.1	4.0	2.0	2.0	2.0	2.0	3.0	3.0	
Financial Burden	0.2	4.0	3.0	3.0	2.0	3.0	3.0	3.0	
Human Resource Benefits	0.1	2.0	2.0	2.5	1.0	2.0	1.5	2.0	
Administrative Capability	0.3	3.0	3.0	1.0	3.0	1.0	3.0	3.0	
Political Acceptability	0.3	4.0	4.0	4.0	3.0	2.0	4.0	4.0	
Total weighted Average score	1	<b>3.5</b>	<b>3.1</b>	<b>2.55</b>	<b>2.5</b>	<b>1.9</b>	<b>3.15</b>	<b>3.2</b>	
Percentage total weighted average score		<b>87.50</b>	<b>77.50</b>	<b>63.75</b>	<b>62.50</b>	<b>47.50</b>	<b>78.75</b>	<b>80.00</b>	

Any policy will have its effects on various domains. Hence, it is possible that one particular policy can influence/remove more than one barrier (barrier to the adoption of AFVs). Therefore, the potential of policies in removing barrier needs to be assessed based on not only certain criteria but also their potential to remove more than one barrier. Table 5 presents the set of barriers that each policy alternative and measure (PAM) can affect. The scores derived based on normalization are applied to the percentage total weighted average score to determine the final ratings of these PAMs in controlling barriers. Table 9 presents the final (aggregated) ranking of PAMs against a set of criteria alone and also the overall ranking with due consideration to their multiple barrier removal capabilities.

**Table 9: Weighted scores and final rating for policy alternatives and measures**

Policy	Total weighted average score	%total weighted average score *	Normalized weights of policies**	Final Rating ***	Percentage final scores
Formulation of an implementing agency to provide the necessary infrastructure (P1)	2.5	62.5 (IX)	0.75 (3)	1.87 (V)	46.87
Partnership between the Government, Public Sector Undertakings and Private actors in providing the infrastructure (P2)	2.4	60 (X)	1 (4)	2.4 (I)	60
Subsidies on the additional expenditure (P3)	2.1	52.5 (XII)	0.5 (2)	1.05 (XI)	26.25
Financial incentives like free or priority parking, separate lanes for alternative fuel vehicles and Free Inspection and Maintenance (P4)	2.8	70 (VI)	0.75 (3)	2.1 (II)	52.5
Tax on polluting vehicles and earmarking such revenue to provide subsidies for AFVs (P5)	2.3	57.5 (XI)	0.75 (3)	1.72 (VII)	43.12
Single window/priority check points (P6)	3	75 (V)	0.5 (2)	1.5 (IX)	37.5
Task force to carry out checks (P7)	2.8	70 (VI)	0.75 (3)	2.1 (II)	52.5
Heavier fines on defaulters (P8)	2.6	65 (VII)	0.75 (3)	1.95 (III)	48.75
Colouring scheme for easy tracking of vehicles (P9)	3.5	87.5 (I)	0.5 (2)	1.75 (VI)	43.75
Awareness campaigns (P10)	3.1	77.5 (IV)	0.5 (2)	1.55 (VIII)	38.75
Demonstration of AFVs and their advantages (P11)	2.55	63.75 (VIII)	0.75 (3)	1.91 (IV)	47.81
Time bound waivers on import duty (P12)	2.5	62.5 (IX)	0.25 (1)	0.62 (XIII)	15.62
Regulation (P13)	1.9	47.5 (XIII)	0.75 (3)	1.42 (X)	35.62
Training programs to the workers (P14)	3.15	78.75 (III)	0.25 (1)	0.78 (XII)	19.68
Awareness campaigns to the drivers (P15)	3.2	80 (II)	0.75 (3)	2.4 (I)	60

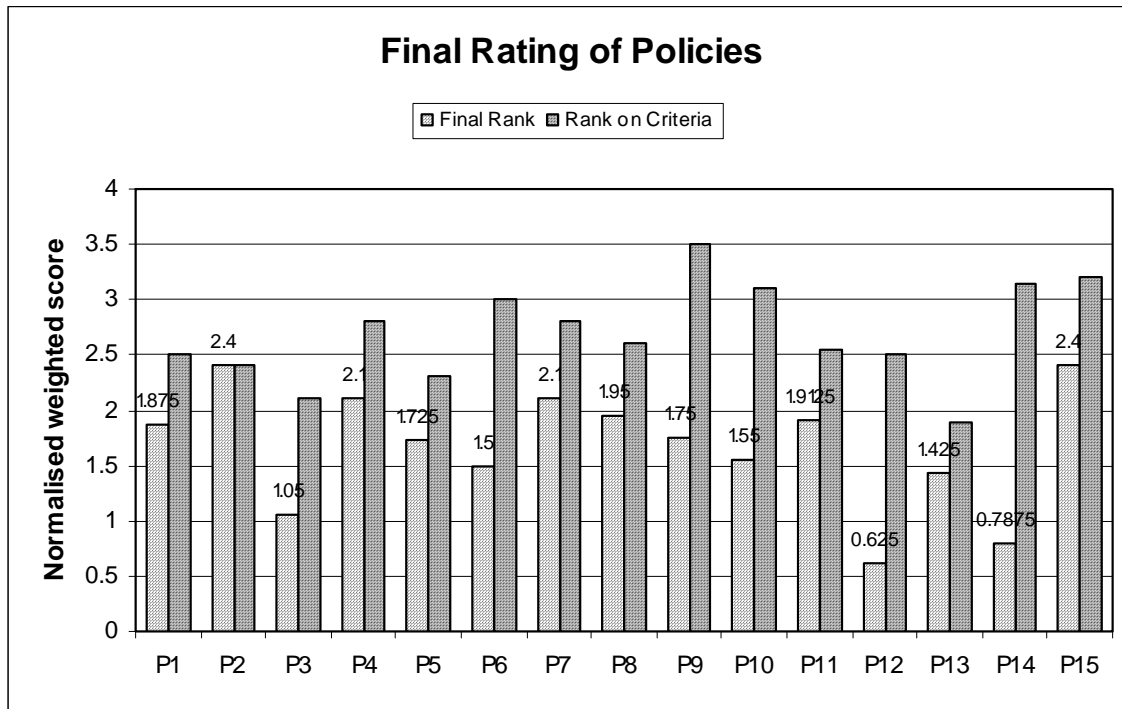
\* figures in parenthesis indicates the final (aggregated) rank of policies according to the set criteria

\*\* figures in parenthesis indicates number of barrier removed/reduced by that particular policy

\*\*\*figures in parenthesis indicates overall ranking

Partnership among major stakeholders (P2) and awareness campaigns to the drivers (P15) showed highest potential in removing barriers for the adoption of CEETs and came first

in overall ranking. Financial incentives (P4), Task force to carry out checks (P7), Heavy fines on defaulters (P8), demonstration of AFVs and their advantages (P11) and formulation of an implementing agency to provide the necessary infrastructure (P1), distinct coloring scheme (P9) showed better potential and are ranked among top SIX. Ranking of various policy measures based on only a set of criteria (aggregated ranking) and the overall ranking considering the potential of PAMs in handling multiple barriers is presented in Figure 2.



**Figure 2: Ranking of various policies on a set of criteria and their potential to remove number of barriers**

## 6. Discussion and Conclusions

According to the set of criteria and the respective analysis and assessment, distinct colouring scheme for AFVs (P9) stood first followed by awareness campaigns to the drivers (P15), training programs to the workers (P14), awareness campaigns (P10), Single window/priority check points (P6), financial incentives (P4) and task force to carry out check (P7) in the top SIX ranks. Policy measures like partnership among various stakeholders to provide infrastructure (P2), heavy fines on defaulters (P8), demonstration of AFVs (P8), and formulation of an implementing agency fall short compared to the other PAMs and occupy lower ranks.

To realize the completeness, potential of PAMs in handling barriers was analysed considering not only a set of criteria but also their potential in handling more than one barrier.

Ranking on this criteria has substantial changes. Partnership among major stakeholders (P2) and awareness campaigns to the drivers (P15) showed highest potential in removing barriers for the adoption of CEETs and ranked first in the final ranking. Financial incentives (P4), Task force to carry out checks (P7), Heavy fines on defaulters (P8), demonstration of AFVs and their advantages (P11) and formulation of an implementing agency to provide the necessary infrastructure (P1), distinct colouring scheme (P9) showed better potential and ranking among top SIX.

It is interesting to see that the policy to have partnership among stakeholders to provide better infrastructure could get only 10<sup>th</sup> rank based on a set of criteria but with its potential to handle many barriers it could TOP the overall rankings. The top ranked PAM based on a set of criteria, colour coding (P9) slipped to P6 when it's potential to handling more than one barrier. Policy of imposing heavy fines on defaulters also has its rank shifted based on the criteria. However, financial incentives (P4), task force to carry out checks (P7), colour coding (P9) and awareness campaigns to the drivers (P15) were ranked high under both the criteria, which testimonies their potential in removing barriers. Hence the following PAMs can be considered, based on both patterns of ranking, as potential PAMs for the removal of barriers to CEETs (seven out of fifteen PAMs):

- Partnership between the Government, Public Sector Undertakings and Private actors in providing better infrastructure (P2)
- Financial incentives like free or priority parking, separate lanes for alternative fuel vehicles and free inspection and maintenance (P4)
- Task force to carry out checks (P7)
- Heavy fines on defaulters (P8)
- Distinct colour coding for AFVs (P9)
- Demonstration of AFVs and their advantages (P11)
- Awareness campaigns to drivers (P15)

Choosing one or combination of PAMs would only help in reducing certain barriers. However, the above set of PAMs would be able to control all seven pre-identified barriers to the adoption of CEETs in Delhi and Mumbai urban transportation systems.

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## **Appendix A**

Actors groups from transport sector participated in personal interview and brain storming sessions

- Environmental and Economics Experts from Various Institutions/Universities
- National and International Policy Research Experts
- Development Research Experts
- Transportation Experts and Planners
- Local policy makers and implementers (Transport Commissioner)
- Pollution Control Boards
- Researchers from Urban Transport and Environmental Linkages
- Central Road and Transport Research Institute Representatives
- Automobile Research Institute Representatives
- Air Pollution Experts from National Laboratories (NEERI)
- Executive Bodies for Implementing CNG Initiatives in India
- CNG Providers
- Users of different modes of transport under consideration for the present study