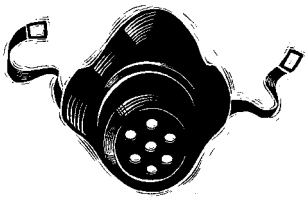

Status of implementation of CNG as a fuel for urban buses in Delhi

FINDINGS – CONCLUSIONS – RECOMMENDATIONS

by
Frank Dursbeck, International Consultant, Germany
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for
CENTRE FOR SCIENCE AND ENVIRONMENT, NEW DELHI

May 23, 2001

Right to clean air campaign

CSE blew the lid on smog and smogmakers in 1996 in its book *Slow murder: The deadly story of vehicular pollution in India*. The study found that the problem of vehicular pollution in India was the result of a combination of outdated engine technology, poor fuel quality, defective transportation planning and bad maintenance of vehicles on road.

CSE exposed that the government was indulging in the game of blaming the victims of air pollution by forcing on them a system of pollution under control certificates. The hype over this periodic drive to test tailpipe emissions of cars in the absence of strong action in other areas, was cosmetic and diverted public attention from more serious issues of technology and transportation planning. But the connection between poor urban air quality and multiple factors such as these eluded most Indian citizens. To help citizens see through the smokescreen of pollution, to understand this vital **CONNECTION,** and protect public health the *Right To Clean Air Campaign* was launched in November 1996. Since then we are consistently campaigning to:

- **improve the decision-making processes related to air quality planning**
- **build up pressure on the government for more transparent policy mechanism**
- **raise public awareness about poor urban air quality and risks to public health**

If you agree with us, remember to give us your support.

Cover photo: Ananda Banerjee

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WHY THIS STUDY?

On April 1, 2001, there was mayhem in Delhi. Not many buses were plying on the roads as the Supreme Court ruling on moving the entire public transport fleet to CNG, came into effect. Unfortunately this had not been complied with. Without diluting the original order the Supreme Court only allowed a conditional extension of the deadline till September 30, 2001.

What reigned supreme was confusion and doubts about CNG technology. Only half-baked information was thrown around, sensational stories were carried, false claims made to create fear about CNG's safety and its health effects. No effort was made to build up confidence in CNG technology. It was never communicated effectively that to protect public health it was important that CNG be used to reduce the dangerously high level of particulate pollution in the city.

The main worry at that stage was whether the right systems and regulations were in place to ensure that nothing would go wrong with the process of moving towards CNG. It almost appeared that for any administrative lapse the blame would be put on the CNG technology. Lack of information made premeditated rumour-mongering so easy, making a normal technical snag look like a disaster. There was also an additional concern for lack of competition in the market given the few players — just two bus manufacturers and one conversion agency. Weak regulations and monopoly could result in price manipulation, compromises in quality, and choice of inappropriate technology.

Centre for Science and Environment (CSE) was concerned as it believed that the CNG strategy was one of the most important decisions taken so far to control particulate pollution that kills one person per hour in Delhi. If there were doubts about safety of CNG, suspicion of high emissions of some pollutants from converted buses, distrust of it on-road performance, it needed to be investigated and proper regulations put in

place to get the maximum benefit from this process. Yet at no point did the government think it fit to investigate and assess the new technology, evaluate the infrastructure facilities and monitor enforcement of safety rules to allay fears.

Sensing that one of the most important strategies to control air pollution was at risk of getting derailed, CSE decided to look into the matter on its own. But such an assessment would need very good technical expertise with wide experience in CNG technology. In view of the fact that very little expertise was available in the country to take up a technical evaluation of this nature we scouted for international experts with long and diverse experience who would understand both CNG and diesel heavy-duty vehicle technologies. We immediately contacted Michael P Walsh, international consultant on vehicular technology, for guidance to select experts who would be able to undertake an assessment of the available CNG technology and prevalent emissions and safety regulations for us. With his help we identified some of the best experts with long years of experience in alternative fuel technology. The team comprised the following:

Christopher S. Weaver, President, Engine, Fuel, and Emissions Engineering, Inc., Sacramento, California

Lennart Erlandsson, Motor Test Centre AB, Sweden

Frank Dursbeck, Independent international consultant in the field of traffic and environment. He has spent many years with TÜV Rheinland Sicherheit Und Umweltschutz GMBH (see box: *Experts' profile*).

They agreed to undertake this study for us and spent about 10 days in the month of May, 2001 in India to do an evaluation of CNG technology. They visited a number of agencies to see for themselves the available CNG technology and the regulations in force.

They visited the following agencies:
Conversion agencies:
- Rare Fuel & Automobile Technologies Private Limited, New Delhi
- VIP Buildcon Pvt. Ltd., New Delhi

Bus manufacturers
- TELCO plant, Pune
- Ashok Leyland plant, Alwar

Certification agencies
- Indian Institute of Petroleum, Dehradun
- Automotive Research Association of India – ARAI, Pune

State-owned public transport operator
- Delhi Transport Corporation

Retrofitment agency
- Power Systems India Limited (Cummins India, engine manufacturer), Pune

Gas supplier
- Indraprastha Gas Limited (gas supplier and CNG fueling station operator), New Delhi

Only one conversion agency, Nugas Technology in New Delhi, refused to meet the experts.

EXPERTS' PROFILE

Christopher S. Weaver
President, Engine, Fuel, and Emissions Engineering, Inc.,
Sacramento, California

Christopher S. Weaver has evaluated different technological options for running heavy-duty vehicle engines on CNG. He has assessed emissions and other characteristics of engines using all three fundamental technology types — spark ignition with a stoichiometric or slightly rich mixture, spark ignition with a lean mixture, and dual-fuel, for application in countries including Chile, Mexico, Thailand, and the US. He is familiar with the technology, emissions, and in-use service experience of heavy-duty natural gas engines produced in the US and Europe. He has also studied fuel supply issues, including the costs and technical issues involved in supplying compressed and liquified natural gas. He has further assessed issues in storing and using natural gas on-board the vehicle. He has helped to develop technical specifications for CNG buses to be purchased for Cairo, Egypt.

Lennart Erlandsson
Motor Test Centre AB,
Sweden

As a member of the one of the largest Motor Testing Centre's (MTC Sweden) in Europe he is involved in a lot of activities related to CNG buses. He has worked in projects in Santiago — Chile, to support the introduction of CNG buses for urban transport. He has been studying different technical solutions and has also carried out tests of the buses intended for Santiago using different test cycles. He has also been involved in a CNG project in Bangkok, Thailand, to evaluate CNG buses running in Bangkok. He has looked into the issues of dedicated CNG engines and conversion of old diesel engines to CNG. In Tehran, Iran, he has been working to introduce CNG buses, both new CNG buses and old bus chassis retrofitted with new gas engines. He has also assessed the conversion possibilities. He has been advising the authorities in Tehran on their CNG programme. He has looked closely into the possibility of developing different systems used for CNG engines.

Frank Dursbeck
Independent international consultant in the field of traffic and environment

He has spent many years with TÜV Rheinland Sicherheit Und Umweltschutz GMBH. He has been deeply involved with a large-scale demonstration programme in Germany under contract of the Mweltbundesamt, where the durability of urban CNG-buses has been proven. He was a part of the project management team dealing with matters especially concerning techniques to control emissions.

In Chile, under contract with GTZ (German Association for Technical Cooperation), he assisted the Chilean Ministry of Transport and the National Commission for the Environment in setting up a programme for the introduction of CNG for urban buses with respect to technical and legal (homologation) aspects. In the first demonstration phase of this programme old buses converted to CNG were included.

He has researched and done reports on the possibility of using to use CNG and LPG in transport in Central America under contract with the GTZ-CEPAL (UN Economic Commission for Latin America and the Caribbean).

This study has addressed some of the key concerns with respect to the status of technology, durability of emission control systems and safety of CNG. Some of the key issues that they investigated are as follow:

- Assessment of the new CNG bus technology: What kind of new CNG technology are we getting and where do we stand with the world's best practice? What do we need to improve it further?
- Assessment of the conversion technology: Is conversion being done the correct way? Recommendations on scope for improvement.
- Assessment of retrofitment of new CNG engine in old buses as an option.
- Ideally what kind of emission standards should be set for CNG conversion and new CNG vehicles to phase in better CNG technology?
- What kind of institutional and regulatory set up do we need to enforce proper safety regulations?
- Suggestions for infrastructure facilities for CNG storage for back up gas supply.

The experts have put together this report based on their assessment and findings. They have concluded categorically that Delhi should take pride in such a big CNG programme that is an outstanding example for other cities in the world. But at the same time they have suggested some modifications in technology and regulations, which if implemented, will help us to get the best out of the CNG strategy and eliminate fears about safety. They have made detailed recommendations on scope for further improvement to get the best emission results.

We would like to express our gratitude to all the agencies that have cooperated with our experts to enable them to do their study.

This study would not have been possible without the financial support from Swedish International Development Agency (SIDA) and German Association for Technical Cooperation (GTZ Germany). We would like to convey our sincere gratitude to them.

We hope that this independent technical evaluation will provide a clear policy direction to the CNG conversion process, improve emissions regulations for CNG buses, dispel fears about CNG conversion and establish consumer confidence in the CNG market.

Right to Clean Air Campaign **May 23, 2001**
Centre for Science and Environment
New Delhi

"POISED FOR OUTSTANDING SUCCESS"

1. Introduction

On July 28, 1998, the Supreme Court of India published a time-frame for measures to be taken against air pollution from road traffic in the National Capital Region (NCR), which includes Delhi[1]. With respect to our scope of work the following directions to the Government of the NCR are of importance:

1. Replacement of all pre-1990 autos and taxis with new vehicles using clean fuels by March 31, 2000.
2. Financial incentives for replacement of all post-1990 autos and taxis with new vehicles on clean fuels by March 31, 2001.
3. No buses more than eight years old to ply except on CNG or other clean fuels, by March 31, 2000.
4. Entire city bus fleet (DTC and private) to be steadily converted to single fuel mode on CNG by March 31, 2001.
5. New interstate bus terminals (ISBT) to be built at entry points in the north and southwest to avoid pollution due to entry of inter-state buses by March 31, 2000.
6. Gas Authority of India Ltd. to expand its CNG dispensing capacity from nine stations to 80 by March 31, 2001.
7. Two independent fuel testing labs to be established by 1.6.1999.
8. Automatic inspection and maintenance facilities to be set up for commercial vehicles in the first phase, immediately.
9. Comprehensive I/M programme to be started by transport department and private sector by March 31, 2001.

The three experts carried out numerous visits to relevant organisations between May 14-23, 2001

The first set of orders on replacement of pre-1990 autos and taxis and eight years old buses with CNG vehicles have already been enforced. This effectively means that vehicles more than eight years old cannot operate in the NCR unless powered by CNG. So, after April 1, 2000, all diesel buses more than eight years old were taken off the road in Delhi.

The order to move the entire bus fleet to CNG by March 31, 2001 has not been implemented. The Supreme Court has given a conditional extension till September 30, 2001. According to its order of March 26, 2001, diesel buses will only be allowed to operate if their owners can demonstrate that they have placed a firm order either for the same number of new CNG buses or for conversion/retrofitment of their old buses to CNG. These diesel buses must carry a sticker from the Delhi Transport Authority stating that this diesel bus has been allowed to ply against a firm order for a CNG bus that will replace it from September 30, 2001.

The total number of public transport vehicles using CNG on the road in Delhi as of March, 2001 were as follows, according to data provided by Indraprastha Gas Limited (IGL).

Type of vehicle	Number as on March, 2001
CNG bus	275
CNG taxis and cars	12,200
CNG three-wheelers	13,500

The number of CNG buses has been increasing rapidly, and we are given to understand that as of this writing more than 900 CNG buses are operating.

In order to assess the present status of the CNG conversion programme of the bus fleet in Delhi we were contracted by the Centre of Science and Environment for a mission to Delhi from May 14-24, 2001. The scope of work for our study is described in the following section.

2. Scope of work

1. Assessment of the new CNG bus technology: What kind of new CNG technology are we getting and where do we stand with the world's best practice? What do we need to improve it further?
2. Assessment of the conversion technology: Is conversion being done the correct way? Recommend scope for improvement.
3. Assessment of retrofiting new CNG engine in old buses as an option.
4. Ideally what kind of emission standards should be set for CNG conversion and new CNG vehicles to phase in better CNG technology?
5. What kind of institutional and regulatory set up do we need to enforce proper safety regulations?
6. Suggestions for infrastructure facilities to store CNG and for back up gas supply?

Additional related questions and issues were identified during the course of the study, and these are also addressed in this report.

3. Activities and organisations contacted

Between May 14th and 23rd we carried out numerous visits to relevant organisations in order to assess the CNG programme. These visits dealt with issues ranging from gas supply to the operation of urban buses in Delhi. The following institutions have been visited:

- Rare Fuel & Automobile Technologies Private Limited (conversion agency)
- VIP Buildcon Pvt. Ltd. (conversion agency)
- Delhi Transport Corporation (state-owned public transport operator)
- Indian Institute of Petroleum - IIP (certification agency)
- The Automotive Research Association of India — ARAI (certification agency)
- Indraprastha Gas Limited (gas supplier and CNG fueling station operator)
- Power Systems India Limited (Cummins India, engine manufacturer)
- TELCO (bus chassis manufacturer)
- Ashok Leyland (bus chassis manufacturer)

The scope of work included assessment of the new kind of new CNG technology and where we stand with the world's best practice?

The visits were excellently prepared and organised by CSE staff. We wish to express our appreciation and gratitude for the time spent and courtesies shown to us by these institutions.

The results of our study were presented to the Environment Protection (Prevention and Control) Authority on May 23, 2001. This report incorporates the results of our discussions with the members of the Authority, and includes additional information requested by them during our meeting.

4. Findings and recommendations

Having visited and interviewed the main actors involved and having reviewed the applicable documentation, **we are unanimous in our view that the principal programme elements required to implement the CNG bus programme in Delhi appear to be in place, and that this programme appears poised for outstanding success**. This is an accomplishment of which the world will take notice, and in which the principal agencies and persons involved can rightly take great pride. **This programme can serve as an outstanding example for other cities and nations of a successful transition to CNG.**

In cities facing severe air pollution problems, the use of heavy-duty natural gas engines in place of diesel offer numerous environmental benefits. Diesel particulate matter has been identified as a serious respiratory hazard and a likely carcinogen. Because of the clean-burning nature of the fuel, natural gas engines have inherently low PM emissions, and these emissions (unlike diesel emissions) show little tendency to increase over a period of time. Natural gas engines can also be designed to achieve very low oxides of nitrogen (NOx) emissions as well. This has led cities from Tehran to Los Angeles to substitute natural gas for diesel engines in buses, garbage trucks, and other urban vehicles. Los Angeles, California, has more than 900 natural gas buses in service, and is in the process of adopting regulations requiring natural gas or other clean fuels in garbage trucks, and school buses as well. Mexico City has purchased more than 500 natural gas garbage trucks. Sacramento, California, has replaced more than two-thirds of its bus fleet with natural gas buses, and has a declared policy never to buy another diesel bus. Bangkok, Santiago, Cairo, Beijing, and many other major cities have also established natural gas bus programmes.

"The principal programme elements required to implement the CNG programme appear to be in place"

Responding to the dire air quality situation in Delhi, the order issued by the Honourable Supreme Court in 1998 required the Delhi public transit system to shift from diesel to CNG buses on a scale and on a schedule that are unequalled in history. Already as of this writing, the fleet of approximately 900 CNG buses plying in Delhi is among the largest in the world, rivaling programmes that have been in operation for a decade longer. By September, Delhi's CNG bus fleet will be by far the largest in the world. Delhi is thus a leader in what is likely to be an increasing trend among major cities in the developing world — the great majority of which are also facing severe air quality problems due to pollution by diesel vehicles.

On the basis of the information we have gathered, we find that:

- **The production capacity of new CNG buses appears to be adequate to meet the bulk of CNG bus demand**. The two principal bus suppliers, Tata Engineering Locomotive Company (TELCO) and Ashok-Leyland, have informed us that they have orders in hand for roughly 7,500 of the estimated 12,000 CNG bus chassis required, and that they expect to be able to fulfil these by September, 2001. Because of bottlenecks in the fitting of bus bodies, not all of these vehicles will be able to enter service as finished buses by September, but the rest should be completed within a few months of that date.
- **The engine and CNG storage technologies used in the new CNG buses now being produced appear to be adequate and appropriate for the needs and abilities of present bus-operators**. The use of dedicated CNG engines guarantees low particulate emissions. The engines produced both by TELCO and by Ashok-Leyland are also designed to reduce gaseous emissions such as oxides of nitrogen (NOx) and carbon monoxide (CO), achieving gaseous emission levels well below Euro II[2] emission standards. In both case, this is achieved through closed-loop, stoichiometric control of the air-fuel mixture in combination with three-way catalytic converters designed for natural gas use. In our view, this technology is

appropriate, and probably the best possible choice given the circumstances and capabilities of the bus industry. If an in-use inspection programme is implemented as we recommend, these buses should be capable of providing safe transportation with greatly reduced levels of emissions for many years to come.

- **Approaches proposed to conversion of existing buses to CNG vary greatly in quality**. The technology and approach proposed by some would-be conversion companies appear adequate and appropriate; while others were grossly inadequate and would pose a clear danger to public safety. To ensure effective emissions control, we recommend that converted bus engines be required to meet Euro II emission standards for gaseous pollutants, and that type approval be required for conversion of each separate diesel engine model. To assure public safety, we further recommend that *each and every* converted bus undergo an inspection of the engine and high-pressure fuel storage system before being allowed to enter service. This inspection programme should subsequently be extended to comprise periodic inspection (at least annually) of all buses for emissions and safety compliance.

"The technology used by some conversion agencies appear adequate; while of others grossly inadequate. Converted engines should meet EURO II emission standards"

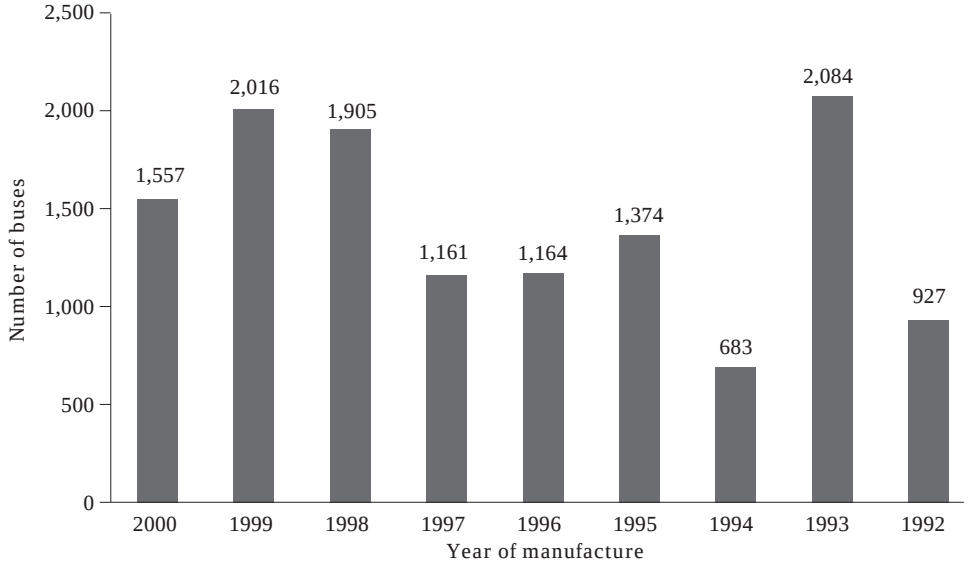
- The CNG compression and refuelling capacity now in place amounts to approximately 250,000 kilogramme per day (kg/day). This exceeds present CNG demand, but will not be adequate to support the number of CNG buses that are expected to come into service by or shortly after September, this year. The projected number of 10,000 CNG buses will require approximately 600,000 to 700,000 kg/day of CNG, to which must be added the further demands of taxis, three-wheelers, and private autos operating on CNG. **Indraprastha Gas Ltd. has presented to us their plans to expand CNG supply capacity to 550,000 kg/day by September, 2001 and to 1.4 million kg/day by March 2002. It is of the utmost importance that these plans be implemented without delay.** Given the crucial role of buses in the city's transport system, measures should be taken in the event of any shortfall to assure CNG buses priority of access to gas supplies over other vehicles and other uses of gas.
- **Indraprastha Gas Ltd. has deployed CNG refuelling systems capable of refuelling a bus in less than five minutes**, and the new buses now in the market are designed to accept refuelling at that rate. We have observed such refuelling taking place. Thus, the concerns expressed by some parties that buses might take up to 45 minutes to refuel appear to be inapplicable at least to new buses. It will be important to assure that buses converted to CNG are also provided with on-board fuel piping adequate to allow this refuelling rate. Not all the converted buses that we observed were so provided.
- The potential exists for further reduction in emissions — especially of oxides of nitrogen (NOx) — through technological improvement that could be implemented over the next few years. **We suggest that government and the honourable court consider the adoption of more stringent emission regulations taking advantage of the special emission characteristics of natural gas.** These regulations could be based on Euro IV emission standards for gas engines, or the recently-adopted European standards for Environmentally Enhanced Vehicles (EEV). To allow time for development and demonstration, we suggest that these regulations be made mandatory for buses subject to the court's order at the beginning of 2005, and that incentives be offered for purchase of compliant vehicles before that time.
- Despite the impressive efforts of many of the parties involved, it is clear that the complete replacement or conversion of all operating diesel buses to CNG cannot be achieved by September 2001, but will likely take several months beyond that date. To assure that this transition takes place as rapidly as possible, but without creating unnecessary disruption to public transport operations, **we recommend that the honourable court consider the establishment of monetary penalties for non-compliance with the court's order, and that diesel buses — for a limited**

time — be allowed to continue in operation upon payment of these penalties. The fine should be set at a level sufficient to encourage speedy conversion to CNG, that is it should be much less expensive in the long run to buy a CNG bus than to continue paying the penalty to operate on diesel. The proceeds could then be applied as incentives for bus operators to shift to CNG in a timely manner.

4.1 Actual status of Delhi's urban bus fleet

According to the Supreme Court's order, all buses older than eight years have been taken off the road by April 2000. The composition of the bus fleet, according to year of manufacture with a total number of 12,871 buses is presented in Fig. 4.1.

Fig. 4.1: Composition of Delhi's bus fleet by year of manufacture as on April 2000



Source: State Transport Authority, Government of Delhi

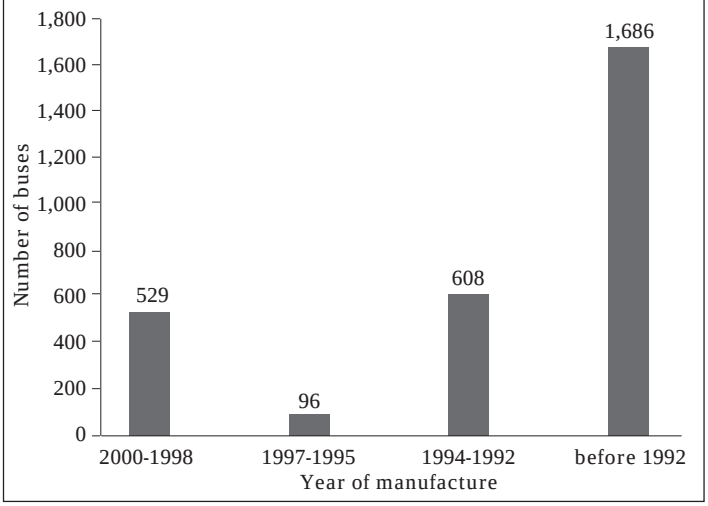
As of April 2000 Euro I standards have been made mandatory for new buses. So, for the first time particulate matter emission standards are now effective for heavy-duty engines in India

Around 48 per cent of this fleet is from model year of 1996 onward and younger and are therefore homologated according to the applicable Indian emission standards, which correspond to Euro 0[3] (CO: 11.2 gramme per kilo watt-hour (g/kWh), HC: 2.4 g/kWh, NOx: 14.4 g/kWh). Additionally, smoke opacity standards of 3.25 m-1 at full load at 60-70 per cent of maximum rated engine revolutions per minute (rpm) and 2.45 m-1 in free acceleration have been implemented. Particulate emissions from these buses are not regulated. As of April 2000, the Euro I[4] standards have been made mandatory for new buses. So, for the first time particulate matter emission limits and standards are now effective for heavy-duty engines in India.

The rest of the bus fleet (model years 1992-1995) had to meet the mass emission standards according to the regulation ECER R49.00 (CO: 14 g/kWh, HC: 3.5 kWh, NOx: 18 g/kWh). But these values are to be considered only as a description of the emission behaviour of heavy-duty engines rather than limit values. Therefore, they did not have any influence on the technical development of heavy-duty diesel engines at the time of manufacture.

The most important operator of urban buses is the Delhi Transport Corporation (DTC), owned by the Delhi government with a total fleet of 2,919 buses. The composition of this fleet according to year of manufacture is given in Fig. 4.2

Fig. 4.2: Composition of DTC bus fleet by year of manufacture as on January 2001



Source: DTC tender document for the conversion of diesel buses to CNG, January 2001

Adequate legislative and regulatory framework has not been set up. Loopholes give possibilities for a lot of interpretations

As can be seen from Fig. 4.2, DTC has a stock of nearly 1,700 buses actually not in operation due to the age restrictions given by the Supreme Court. So, DTC today is operating around 1,200 buses in Delhi.

Generally, the existing buses seem to be poorly maintained as far as the outer appearance and several safety aspects (tyres, headlamps, rear lights etc.) are concerned. The maintenance of the engines also seemed to be rather poor.

Furthermore, we have been informed by various sources that it is quite common to adulterate diesel fuel by blending it with kerosene, which is not subject to road fuel taxes and is sold at a low price for domestic use.

4.2 LEGISLATION

Generally, we must state that the requisite legislative and regulatory framework has not been set up in an optimal way. Bugs and loopholes give a lot of possibilities for interpretations leading to less-than-optimal solutions with respect to the conversion of the Delhi urban bus fleet to CNG. We give the most important examples in the following sections:

4.2.1 EMISSION STANDARDS FOR CNG VEHICLES

On February 9, 2000 the ministry of road transport and highways (MRTH) issued the emission regulations for new vehicles (OEM) using CNG and in-use vehicles converted to CNG[5]. According to this amendment to the Central Motor Vehicle Rules the CNG vehicle fleet is to be divided in two different categories "New CNG vehicles (OEM)" and "Converted in-use CNG vehicles"

New vehicles (OEM)

For the first group the applicable emission standards for gasoline or diesel vehicles are to be fulfilled. Which specific standard to be taken into account depends on which type of engine the CNG engine is derived from (diesel or gasoline).

In the first place, this definition is to be seen as a contradiction to the so far applicable Indian regulations, where — as in Europe — the emission standards are

set according to the gross vehicle weight only, defining the emission standards according to the vehicle categories "passenger cars" and "engines for heavy-duty trucks and buses" respectively. We recommend changing the amendment to be consistent with the system of emission standards now in force.

Secondly, according to this amendment, all new CNG engines for urban buses have only to comply with the Euro I (Bharat stage I) standards. However, with the notification of the MRTH from April 24, 2001[6] all engines for heavy-duty vehicles manufactured after September 2001 have to fulfil the Euro II standards. Fortunately, the CNG engines now being produced by both TELCO and Ashok-Leyland — in addition to their inherently low particulate emissions — also meet Euro II standards for gaseous emissions by a considerable margin, even though this is not legally mandatory until October, 2001. In fact, oxides of nitrogen (NOx) and carbon monoxide (CO) emissions from both engines are well under the Euro II limits.

In-use vehicles

According to the information received, around 7,500 new CNG buses already have been ordered. So, the remaining 2,500 buses may be subject to conversion in the sense of repowering (replacement of the old diesel engine by a new CNG engine) or retrofitment (converting the old diesel engine to CNG).

As laid down in the MRTH notification, these converted vehicles have to comply with the emission standards that were in effect at the time of manufacture of the engine / vehicle. This means that converted in-use buses between model year 1992 and 1996 IMP have to meet the ECE R49.00 mass emission standards, while the buses of model year 1996 through 1999 have to fulfil the Euro 0 limits and the buses of model year 2000 the Euro 1 emission limits. Again it has to be pointed out that the ECE R49.00 standards cannot be seen as limit values enforcing special development.

Existing regulations make it possible to use very poorly developed conversion systems without the use of closed loop mixture control and catalytic converters

By failing to control gaseous emissions, the existing regulations would make it possible to produce and sell very basic, poorly-developed retrofit or conversion systems without the use of closed loop mixture control and catalytic converters. The only advantage of these systems would be that they have low particulate emissions. On the other hand, the carbon monoxide (CO) and oxides of nitrogen (NOx) emissions from these primitive conversion systems can be significantly higher than those of a diesel engine. So, with this regulation Delhi will possibly not get the best solutions for converting in-use buses to CNG. For this reason, and also because it is technically possible (by development of optimised conversion systems with catalytic converter fulfilling Euro II emission standards), we recommend to set the same emission standards for converted vehicles as for new OEM vehicles — that is, Euro II.

Even this will not mean that the real emission behaviour of retrofitted buses on the road will automatically be the same as for new OEM engines. It has to be taken into account that the type approval will certainly be carried out on an engine that has been prepared specially for this purpose. On the other hand, retrofitting is made on old used engines which show a certain degree of wear and tear, and it is doubtful that the conversion agencies will repair the used engine according to the manufacturer's specification. So, from this standpoint, retrofitted in-use engines (unless produced to a very high standard of quality) are likely to have higher emissions than OEM engines. Furthermore, new OEM engines in the type approval test are likely to have lower emissions overall than retrofitted engines. Therefore, to achieve the best possible results from the conversion of existing buses to CNG, we recommend repowering (that is, exchange of the old diesel engine for a new or remanufactured OEM CNG-engine) rather than retrofitting.

4.2.2 TYPE APPROVAL FOR CNG BUSES

The cited MRTH notification allows the extension of the type approval certificate to other engine/CNG-kit combination than the one originally submitted for type approval. This is allowed as long as the engine displacement of the other engine is lower than that of the type-approved system, and within a certain range. This provision is reasonable for conversion of low-technology (that is, carbureted) gasoline engines, but not for retrofitting of diesel engines to CNG. As the current regulation has been interpreted, a conversion system developed and type approved for a specified diesel engine could be used on any other engine of equal or less engine displacement from any other manufacturer without any further type approval or inspection.

Technically the conversion kit and the engine have to be considered as a unique and optimised system. The application of a certified kit to any other than the type approved engine could result in unacceptable exhaust emission levels, poor driveability and performance. So, we strongly recommend not to allow an extension of the type approval certificate to other engine/kit-combinations. Instead, engine converters should be required to obtain a new type approval for each separate diesel engine model they seek to retrofit. As a practical matter, the number of diesel engine models used in Delhi buses is rather small, with three models accounting for the great majority of buses in use. Thus, our proposal would not pose an unreasonable burden for engine converters.

There are no provisions for the inspection of in-use buses after conversion to CNG

4.2.3 INSPECTION OF CONVERTED IN-USE BUSES

No provisions have been defined in the existing regulations for the inspection of in-use buses after conversion to CNG. Some conversions evaluated by us showed seriously deficient installations. In order to guarantee compliance of the converted buses with the specifications of the type approved vehicle, we highly recommend that each and every bus be inspected before allowing them to enter service. This inspection can be seen as equivalent to the foreseen conformity of production (COP) inspections for OEM CNG buses.

Furthermore, this complies with the respective regulations in numerous other countries.

4.2.4 AUTHORISATION OF CONVERSION WORKSHOPS

According to the MRTH notification the kit installation on in-use vehicles can only be carried out by workshops authorised by the kit manufacturer/kit supplier. But no requirements for these workshops have been defined, neither legal nor technical. There should be a specific national regulation for authorisation or accreditation of these workshops. It will be worthwhile to carry out periodic audit at these workshops, checking documents and files and examining the personnel to ensure that they know what they are doing. If the workshop fails to fulfill these requirements its accreditation to convert engines should be withdrawn. This again is a reason for the recommendation made earlier to inspect each and every bus after conversion.

4.2.5 PERIODIC INSPECTION OF CNG BUSES

The actual periodic inspection system in India consists of a road-worthiness inspection and a control of carbon monoxide (CO) exhaust gas concentration (maximum three per cent by volume at idle conditions). From experience in other

countries, this prescription is not sufficient to guarantee a correct functioning of the emission control system of CNG buses equipped with catalytic converters and close loop mixture control. In a German demonstration project[7], the following periodic inspection procedure for CNG vehicles has been proven to be very effective:

a) Visual check of components relevant to emission including the exhaust emission system, lambda sensor, electrical connections, shut off valve for the filling, gauges and random check of tightness of piping, hoses for ventilation of gas and gas cylinders. The engine should be checked for abnormal leakage (lubrication oil), installation of gas mixer.
b) Measurements of carbon monoxide (CO), hydrocarbon (HC), carbon dioxide (CO_2) and oxygen (O_2) levels with the engine idling
c) Closed loop control check
d) Determination of the oxides of nitrogen (NOx) and carbon monoxide (CO) level under full engine load (as specified in rule 115, sub-rule 2 of the Central Motor Vehicle Rules) on a simple chassis dynamometer (costing less than US $20,000 that is, Rs 9.6 lakh).

We recommend to introduce this system immediately as already a significant number of CNG buses have been operating for more than one year in Delhi. The inspection frequency for new OEM buses should be set to one year, and combined with the annual road-worthiness check. For in-use converted buses, inspection should be required every six months. Furthermore, all new and converted buses should undergo the same procedure before coming into operation in order to establish the reference values for the oxides of nitrogen (NOx) standard and to verify that the closed-loop air-fuel ratio control is functioning properly.

As standards to be fulfilled when the engine is idle we recommend the following: for carbon monoxides (CO): 0.5 Vol-% at idle and 0,3 Vol-% at high idle (1700 ± 150 rpm for buses and HDT, 2,650 ± 150 rpm for LDV and LDT). For oxides of nitrogen (NOx) we recommend that type-specific standards be defined based on reference values derived from the initial exhaust concentration inspection.

Gas pipes are covered with a layer of plastic or rubber. This will make it very difficult to visually inspect the pipes

Vehicles with electronic mixer control by a lambda sensor must pass a check of the functioning of the electric circuit for response time of the lambda control system that is whether and in how much time the air fuel ratio, once artifically disturbed, is readjusted to become equal to its initial value. The air fuel ratio has to change from its initial value and has to be restored to the initial value within less than 60 seconds. Longer response times would imply that the control of oxygen sensor is degraded, while no response (that is no restoration of the initial lambda value) would mean that the lambda control system is out of operation.

4.2.6 FUTURE EMISSION STANDARDS FOR CNG BUSES IN DELHI

It is obvious that the use of CNG as fuel in buses will reduce the amount of particulate matter emitted compared to the case if the buses are running on diesel. Recent studies carried out by the Swedish Motor Test Center show that the emissions of “ultrafine” particles less than 50 nanometres in diameter are also reduced using CNG, in proportion to the overall reduction in particulate matter emissions. However, it is also obvious that gaseous pollutants may possibly increase using CNG if the engine technology is not good enough, or if specified requirements are not given for the manufacturer of CNG engines to fulfil. It is therefore recommended to introduce internationally accepted emission regulations for CNG engines. In the case of India and Delhi, emission regulations have historically been based on European or ECE vehicle emission regulations.

The technical development of an engine must go hand in hand with the improvement of fuel quality available in the market. This goes for all kinds of fuels such as diesel, gasoline, CNG and LPG. Presently, there is no proper specification for CNG used as automotive fuel in India — it is only stipulated in the regulations that the gas used for emission testing should contain not less than 70 per cent methane. On the other hand, there are analyses of gas showing that the amount of methane is about 85 per cent in the gas delivered to Delhi via the pipeline. Information given to us indicates that the gas composition — as indicated by methane content and the Wobbe-index is the best indicator of the effect of changes in gas composition on air-fuel ratio and engine combustion — have been stable over time. This quality will make it possible to specify emission standards for CNG engines fully in line with Europe and with the use of latest technology. In case of big changes in the wobbe index due to change in natural gas sources, the air/fuel mixture programming has to be readjusted. However, the "technical infrastructure" in Delhi such as trained workshop personnel, availability of spare parts and test resources will not make it possible to introduce strict emission standards to be implemented by September 2001. The next generation of emission requirements proposed to be implemented around 2005 should take this into consideration.

Starting from year 2000, it is possible for the first time to have CNG engines approved according to EU regulations. It is important to point out that the approval requirements for gaseous fuel engines comprise not only emission limit values, but also requirements for durability testing, emission warranty and other commitments to be made by the manufacturer of the engine. In addition, the test procedure for engines using gaseous fuels such as CNG is changed from a "steady state" to a "transient" test. This type of test is more representative of actual driving on the road under various conditions.

Because of differences in engine technology, test cycle, and test procedures a new set of emission limits is applicable for CNG buses in Europe

Because of the differences in engine technology, test cycle, and test procedures, a new set of emission limits is applicable for CNG engines. These limits take into account the differences in composition of the exhaust from CNG engines. The relevant emission standards for gas-fuelled engines and diesel engines with advanced exhaust emission control devices (deNOx catalyst and/or particulate filter) are given in table 4.1. Since natural gas is considered a fuel without particulate emission, the particulate emission limits shown in the table are not applicable for gas-fuelled vehicles for levels A, B1, and B2. As Table 4.1 shows, the regulation of today specifies the emission limits and other criteria to fulfil for the years 2000, 2005 and 2008. In addition, a further specified emission level is specified for "EEV vehicles" (Environmentally enhanced vehicles)

Table 4.1: Actual and future European emission standards for gas-fuelled engines for heavy duty vehicles[8]

CO	NMHC	CH4	NOx	PM	Level	"Euro"	Date of Implementation in EU
5.45	0.78	1.6	5.0	0.16	A	III	2000
4.0	0.55	1.1	3.5	0.03	B1	IV	2005
4.0	0.55	1.1	2.0	0.03	B2	V	2008
3.0	0.40	0.65	2.0	0.02	C	EEV	2000

NOTE:1. Please observe that the above specified limit values should be fulfilled by the use of the new European driving cycle (ETC, European transient cycle).
2. All units are in g/kwh.

Based upon the above, we recommend the implementation of the European regulation 1999/96/EEC levels A, B1, B2 and C with the corresponding emission values (Euro IV, Euro V, and EEV, respectively). In order for Delhi to catch up with technology, we further recommend compliance with Euro IV standards in the year 2005 (same as for Europe), and to introduce EEV with the help of economic incentives.

4.3 ENGINE TECHNOLOGY

4.3.1 AIR-FUEL METERING

In their interviews with us, representatives of TELCO and Ashok-Leyland indicated that they are producing CNG engines based on a stoichiometric air-fuel mixture and are using three-way catalytic converters designed for natural gas to control emissions of oxides of nitrogen (NOx), carbon monoxide (CO), and non-methane hydrocarbons. These engines use mechanical air-fuel proportioning and mixing systems with electronic "trim" of the air-fuel ratio by means of feedback from an exhaust lambda sensor. One of the prospective engine converters also stated its intention to use this technology. In our view, this is an appropriate technology choice for CNG buses in Delhi, given the present technological level of the bus industry. Emissions of particulate matter using this system is expected to be as low as those with the most sophisticated natural gas engine systems available (that is, nearly zero, in all cases), while levels of oxides of nitrogen (NOx) will be well within Euro II emission limits, and well below those of contemporary diesel engines. carbon monoxide (CO) emissions will also be limited to moderate levels comparable to those of current passenger cars. While the use of sophisticated, digital electronic natural gas injection systems would make possible even lower oxides of nitrogen (NOx) and carbon monoxide (CO) levels, the additional development delays, service issues, and costs that would result from these systems mean that it would be better to consider their deployment at a later date.

Generally, existing buses seem to be poorly maintained as far as several safety aspects are concerned

In our discussions, we found that some persons were confused concerning the relative merits of stoichiometric and lean-burn engines. Heavy-duty lean-burn CNG engines are the dominant type used in the US, and Europe and generally exhibit greater power output and fuel efficiency than the stoichiometric engines planned for Indian buses. To do this, they require advanced (and costly) turbocharging and intercooling systems, as well as closed-loop digital electronic control of the air-fuel ratio using universal exhaust gas oxygen (UEGO) sensors. Few Indian bus operators would be capable of maintaining these systems at the present time. Even more importantly, a stoichiometric engine with a good three-way catalyst can readily achieve exhaust oxides of nitrogen (NOx) emission levels well below those achieved by the best lean-burn engines to date. **Thus, from the standpoints both of feasibility and long-term air quality considerations, we consider the stoichiometric engine *with three-way catalyst* to be the preferable technology for Indian buses.**

4.3.2 IGNITION SYSTEMS

The CNG engines now being produced by both TELCO and Ashok-Leyland use conventional ignition systems with mechanical distributors. In our view, these are not likely to give satisfactory service in the long term. If an ignition problem develops, it is likely to lead to misfire in one or more cylinders, which in turn is likely to damage the catalytic converter. Distributor ignition systems have long been trouble points even for light-duty automobiles, and the high-voltage ignition wires have been particular trouble spots for heavy-duty CNG engines in other countries. We strongly recommend that CNG bus engines be equipped with all-electronic, distributorless ignition systems, preferably of the coil-on-plug design to eliminate

the high-voltage wires. The added cost of these systems is small and will be repaid many times over in greater reliability and reduced maintenance requirements for the engine, and for longer life for the catalytic converter.

To reduce the chance that ignition problems lead to permanent and costly damage to the catalytic converter, we also recommend that bus manufacturers and converters consider installing an interlock mechanism whereby the occurrence of excessive temperatures in the catalytic converter would shut off the fuel supply to the engine.

4.3.3 FUTURE TECHNOLOGIES

Once bus manufacturers and operators have accommodated to the use of CNG, the next step would be to adopt fully-electronic fuel injection and ignition control systems similar to those used on present-day gasoline and natural gas passenger cars and light-duty trucks. Emission levels of oxides of nitrogen (NOx) well below Euro IV norms can readily be achieved using these technologies, with correspondingly low emissions of other pollutants. As discussed in Section 4.2, we recommend that the Indian authorities and or the honourable court consider establishing a second tier of CNG emission standards to take effect at the beginning of 2005. These could be based on Euro IV emission limits, with a view to encourage the development and deployment of advanced fuel and emission control systems. Incentives could also be established with immediate effect, for the acquisition and use of even more advanced emission control systems meeting the European EEV emission standards.

Even though the safety aspects have been well taken care of there is scope for further improvement

4.4 SAFETY ASPECTS

The overall safety for CNG buses is considered to be good. What we have seen during our visits to different organisations supports the impression that the safety aspects have been well taken care of — both in the manufacturing of the chassis as well as when the bus is in operation. In an international perspective, we consider the safety level of the buses to be acceptable. However, there are still items or manufacturing operations that could be further improved in order to minimise the risk of unwanted incidents.

In the production of the chassis, we have noticed some room for improvement in areas such as material of the high-pressure piping, fixing of pipes to the chassis, tightening of the couplings, venting of the pressure relief valve, and inspection of gas pipes. In our opinion, it should be avoided to mix brass fittings with pipes made of steel. Under moist conditions this combination could cause electro-galvanic corrosion. To avoid future problems with corrosion, we recommend the use of stainless steel fittings and tubing for high-pressure gas components. Gas pipes should be mounted in such a way that movement and vibrations in the chassis are not transferred to the gas pipes, thereby causing a risk that the pipe could be broken or damaged by scraping after some time of use. It is common to use rubber wall tube insulators when bridging parts of the chassis and to attach the pipes to the chassis by the use of rubber pads. In addition, when vibrations cannot be avoided there should be enough room and length of the pipe to allow minor movements.

During our visits, we observed that a leakage test is carried out after installation of the gas piping. This is necessary to identify whether there is leakage in the system. The leakage test was carried out by the use of soap-water brushed on each connection. It was further noticed that leakage was detected in many cases. To reduce the chance of leakage, it would be useful to use Teflon sealing tape in threaded fittings. Furthermore, it is suggested to use compression fittings, where possible, or fittings with a tapered thread instead of cylindrical thread.

Each gas cylinder has a pressure relief valve to vent the gas if the cylinder is exposed to high temperatures and/or high internal pressure. The venting of the valve is not directed at present, thereby releasing the gas close to the cylinder. Since the cylinders are installed beneath the body of the bus, there is a risk that the vented gas will reach an area close to people or, in unlucky cases, may enter the passenger compartment. One solution would be to direct the venting of the pressure relief valve via a hose or piping to the roof of the bus. This would allow the gas to dissipate harmlessly upward, with little chance of contacting persons or ignition sources.

When a CNG vehicle has been in use for some time a visual inspection of the gas pipes is recommended. However we have noticed that the gas pipes used in some case are covered with a protecting layer of plastic or rubber. This will make it very difficult to inspect the pipes. If — as we recommend — stainless-steel tubing is used instead of ordinary steel, then it will not be necessary to cover the tubes to protect them from corrosion, and this will facilitate in use visual inspections.

When CNG buses are filled with gas at gas filling stations, normal precautionary measures are implemented according to Indian and also international standards. During our visits we noticed that those requirements were obeyed, and that there were clear signs explaining the rules when filling the gas tanks of a bus. The gas filling stations operated by DTC were constructed to make it as easy as possible for buses to approach the filling pump.

When visiting a number of gas filling stations catering to non-DTC vehicles in Delhi, we could observe a minor risk of damaging the gas pump. This was because there was too tight a radius for a bus to approach the pump easily. Special concern must be given to the lay-out of filling stations, especially to give the privately operated buses plenty of room for safe approach. If there is not enough room the “island” where the pump is located, could either be made larger or a steel barrier could be anchored in a suitable way for protection of the pump.

4.5 Certification

From meetings with ARAI and IIP as type approval authorities we get the impression that the present status of the testing laboratories and equipment is adequate to carry out the prescribed tests for type approval of CNG bus engines. With respect to the Euro III procedures (ETC test = transient test) the IIP laboratory is not capable of carrying out the test at present because of lack of a transient engine test bench. Alternatively, the type approval test according to Euro III could be carried out in the manufacturer’s laboratories in the presence of an authorised inspector of the type approval agency. In this way, which is common in Europe, the current type approval situation could be improved.

The capabilities and capacities of the type approval institutions should be improved in order to reduce the duration of the whole type approval procedure to reasonable, internationally common time-frames. The type approval procedure including the “Information on Technical Specification to be Submitted by Manufacturer” submitted to us by ARAI need to be thoroughly reviewed in order to delete unnecessary test items and administrative procedures, and to make the system more cost-effective and less time consuming. As one example, a complete engine test should not take more than three weeks, and for minor modifications — specified by the competent authority — the vehicle should not need to undergo the complete new type approval procedure. Rather, only those parts affected by the changes should require testing.

The capacities of the type approval institutions should be improved to reduce the duration of the type approval procedure to reasonable, internationally common time-frames

4.6 Compressed Natural Gas Supply and Dispensing

4.6.1 COMPRESSION AND DISPENSING CAPACITY

We met representatives of Indraprastha Gas Ltd. (IGL) to discuss their expansion plans and visited a number of CNG refuelling stations to observe them in operation. According to IGL, the CNG compression and refuelling capacity now in place amounts to approximately 250,000 kg/day. This exceeds present CNG demand, but will not be adequate to support the number of CNG buses that are expected to come into service by or shortly after September this year. We estimate that the 10,000 CNG buses projected to be in operation by early 2002 will require approximately 600,000 to 700,000 kg/day of CNG. To this must be added the further demands of taxis, three-wheelers, and private autos operating on CNG, IGL has presented to us their plans to expand the CNG supply capacity to 550,000 kg/day by September, and to 1.4 million kg/day by March 2002. It is of the utmost importance that these plans be implemented without delay. If necessary, measures should be implemented in the meantime to assure buses priority of access to the existing CNG supply stations, given their crucial role in Delhi's transport system.

4.6.2 REFUELLING NOZZLES AND FILLING TIME

IGL has deployed CNG refuelling systems capable of refuelling a bus in less than five minutes, and the new buses now in the market are designed to accept refuelling at that rate. We have observed such refuelling taking place. Thus, the concerns expressed by some parties that buses might take up to 45 minutes to refuel appear to be inapplicable — at least to new buses. It will be important to assure that buses converted to CNG are also provided with on-board fuel piping adequate to allow this refuelling rate. Not all the converted buses that we observed were so provided.

NGV-1 standard nozzles have advantages regarding refilling speed and the absence of vulnerable o-rings which have been a major problem with NZS standard nozzles

Two designs of refuelling nozzle are in use in Delhi. One, based on New Zealand standards, is used by three-wheelers and most passenger cars. The other nozzle type conforms to the NGV-1 standard — an international standard first developed in North America, but now accepted world-wide. In addition to the advantages of standardisation, this nozzle has important technical advantages — specifically, refilling speed and the absence of vulnerable o-rings, which have been a major maintenance item on the New Zealand Standard nozzles.

In order for buses to refuel quickly, buses should be equipped with NGV-1 nozzles. The NGV-1 nozzles are required because of their higher flow capacity. Use of these nozzles would also help to speed up refuelling of other vehicle types, thus helping to shorten the present refuelling queues. Refuelling of vehicles with New Zealand Standard nozzles is also slowed by the frequent o-ring failures that these nozzles experience. Such failures occurred twice during the limited period that we were at the refuelling stations, and we are informed that they occur on average about every 20 fills. This failure not only interrupts fuelling and requires replacement of the o-ring, it also creates a fire hazard due to the release of a significant amount of high-pressure gas.

Standardising all vehicle refuelling receptacles on the NGV-1 standard would reduce fuelling time requirements and queues, and make possible more efficient use of existing compression capacity. It would also help to open other international markets to Indian CNG vehicles, as this fitting is by far the most common one in use internationally.

4.6.3 SECURITY OF GAS SUPPLY

Some interested persons and organisations have expressed concern that exclusive reliance on CNG buses might be imprudent, as any disruption of natural gas supply to Delhi could disable the public transport fleet. The fact that Delhi is presently served by only a single gas pipeline has contributed to this concern.

In our view, the chances of a disruption of gas supply that could shut down the public transport fleet are remote. Gas pipelines are highly reliable, and are designed to be able to continue in operation at reduced capacity even if there are failures, for instance, in a pumping station. Further, the pipeline and distribution systems themselves store a considerable quantity of gas, as would the CNG tanks of the buses themselves. Appropriate contingency plans should be put in place to assure that buses would have first priority in access to this gas in the event of a supply disruption.

Although the chance of a prolonged disruption in gas supply is remote, such an event would have serious consequences for public transport. To guard against this possibility, we suggest that the concerned authorities consider establishing gas storage facilities. For example, many gas utilities in the northern US have set up gas liquefaction and vaporisation facilities to help them meet peak wintertime gas demands. During off-peak periods, these facilities convert part of the incoming pipeline gas to LNG, which is stored in large, insulated tanks. The LNG is then revaporized and injected into the gas distribution system to meet peak demand. A similar facility could be used to assure continuity of essential gas supplies to Delhi in the event of a prolonged disruption in pipeline activity.

Financial incentives and penalties will facilitate transition from diesel to CNG

The presence of an LNG backup system could also help in other ways. LNG can be used as an alternative to CNG for storing gas on-board vehicles, and has many advantages over CNG for heavy-duty trucks and long-haul buses (in particular, more fuel can be stored with less penalty in increased weight). Systems for converting LNG to CNG have also been developed. These have the advantage that the LNG can be pumped up to the dispensing pressure of 200 bar as a liquid, and then vaporised under pressure to produce CNG. This eliminates the need for a compressor at the dispensing station. Transporting gas to off-pipeline stations as LNG and then dispensing it as CNG would have many advantages over the present arrangement of mother and daughter stations — specifically, more gas could be transported over much longer distances, making it practical to provide CNG over a wider geographic range, and even in surrounding cities not served by the gas pipeline.

4.7 INCENTIVES AND PENALTIES

The use of financial incentives and penalties are suggested to facilitate the transition from diesel to CNG buses in the immediate future. The further use of incentives is also suggested to speed the introduction of advanced and still lower-emitting CNG bus technologies over the next four years.

4.7.1 NON-COMPLIANCE PENALTIES

It is clear from our discussions with bus manufacturers and converters that — despite the impressive efforts of many of the parties involved — the complete replacement or safe conversion of all operating diesel buses to CNG is not feasible by September 2001. Because of bottlenecks in bus body manufacture, many of the new CNG buses now on order are not likely to be ready to enter service until several months after the September 30 deadline given by the Court. Similarly, the

completion of type approval for engine conversion systems meeting Euro 2 standards, setting ups workshops and the accomplishment of these conversions, and the establishment of the necessary inspection mechanisms to assure the safety of converted buses will all take time. Therefore, the process of converting existing buses is not likely to be complete for at least nine months beyond September 30.

To avoid creating unnecessary disruption to public transport operations, we recommend that the honourable court consider allowing diesel buses to continue to operate during this transitional period. If this were allowed to happen without penalty, however, it would be perceived as rewarding procrastinators and those who have chosen to defy the court's order, at the expense of those who have diligently sought to comply. Further, it would likely motivate the operators of buses now plying on the basis of having ordered a new CNG bus or conversion to seek to delay receipt of the ordered vehicles or even to default on their purchase contracts in order to extend the period of operation of their diesel buses.

For these reasons, we recommend that continued operation of diesel buses beyond the September 30 deadline be permitted only upon payment of a financial penalty. Legally, such a penalty might be structured as a fine for contempt of court. The fine should be set at a level sufficient to encourage speedy conversion to CNG, that is, it should be much less expensive in the long run to buy a CNG bus than to continue paying the penalty to operate on diesel. We suggest that the amount of the fine be roughly double the monthly carrying costs of a new CNG bus. We are informed that the cost of a new CNG bus is approximately 16,00,000 rupees, and that the annual interest rate available to finance buses is 16 per cent. The monthly carrying cost would thus be about Rs. 21,300, and the suggested penalty would be about Rs. 42,600 per month.

Diesel buses should be permitted beyond September 30, 2001 but only upon payment of a financial penalty

4.7.2 TOURIST AND INTERSTATE BUSES

Since CNG will not be available in most of India, some accommodation needs to be made for buses using other fuels to transport passengers to and from Delhi. At the same time, it is important that this does not become an incentive to avoid changing to clean fuels where feasible, and that it does not create loopholes for local buses to continue plying on diesel. A system of interstate bus terminals has been proposed, whereby passengers could transfer from diesel to CNG buses at the border, but these will not be available for some time.

As a stop-gap and potential long-term supplement to the proposed interstate bus terminals, we recommend that the Court consider extending the non-compliance penalty scheme outlined above to cover tourist and interstate buses. Diesel buses which need to enter Delhi could pay a stiff daily fee of the order of Rs 2,500 for non-compliance. Buses that enter Delhi only occasionally — for which CNG is not a practical alternative — would find it most economical to pay the fee. On the other hand, buses that enter Delhi on a routine basis would find it in their interest to shift to CNG or other clean fuel (for instance, LNG) as soon as possible, and to collaborate if necessary to arrange for CNG to be provided along their main routes. Once developed and proven for buses, a similar scheme might also be applied to diesel trucks.

4.7.3 NEAR-TERM INCENTIVES

We understand from discussion with chassis manufacturers that financing is available for buyers of new CNG buses, but that many face substantial difficulty in meeting the required down payment of 20 to 25 per cent of the purchase cost (Rs. 3,20,000 to 5,00,000). We suggest that the funds collected as non-compliance penalties be used to fund a system of grants to assist bus operators in meeting this

requirement — thus balancing the "stick" of penalties with the "carrot" of financial assistance. This will help to ensure that bus operators work hard to shift to CNG as soon as possible. Financial assistance for vehicle conversions should be restricted to those conversions that meet defined quality norms and at least Euro 2 emission standards, thus eliminating the cost advantages that might otherwise drive a "race to the bottom" in the quality of bus conversions.

4.7.4 SALES AND EXCISE TAXES

The large-scale purchase of new CNG buses will result in a tax windfall to government. The Central government charges an excise tax of 16 per cent on the CNG chassis, while the Delhi government charges sales tax of 8 per cent on both the chassis and the body. Since the buses provide a public service, and are being replaced in the interest of public health, we recommend that the respective governments facilitate the transition to CNG by rebating to the incentive fund the sales and excise taxes that they collect on CNG bus sales. The combined amounts would come to roughly Rs 3,00,000 per bus, or more than one-half of the required down-payment amount.

4.7.5 INCENTIVES FOR FUTURE-CLEANER TECHNOLOGIES

As discussed elsewhere in this report, the potential exists for CNG buses in India to achieve even lower emissions in the future through straightforward improvements in engine and catalyst technology. CNG bus manufacturers are already meeting or very close to meeting Euro IV emission levels for PM, and could fairly readily meet Euro IV or EEV limits for oxides of nitrogen (NOx), carbon monoxide (CO), and non-methane HC as well. Buses meeting these standards will likely use electronic fuel injection systems, and will display improved reliability and emissions durability as well as lower emissions.

To encourage the future technological improvements required to meet Euro IV or comparable standards, we recommend that buses with engines certified to these standards be eligible for a higher level of incentive payments than those that merely meet the currently-effective emission norms. We further suggest that purchase incentives be limited only to such buses beginning in 2003.

Buses meeting Euro IV or comparable standards, should be eligible for a higher incentive than those that merely meet current emission norms

5 Acknowledgement

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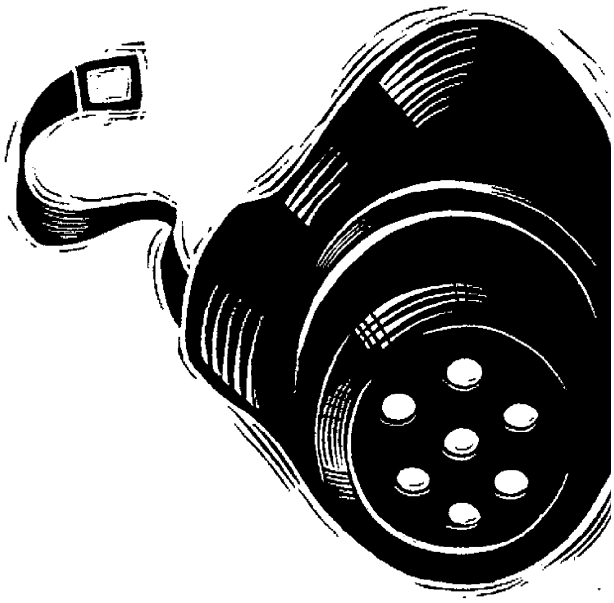
1 The Hon'ble Supreme Court Order Dated July 28, 1998 on Control of Vehicular Pollution in National Capital Region including Delhi
2 Regulation 91/542/EEC
3 Regulation 88/77/EEC
4 Regulation 91/542/EEC
5 Ministry of Road Transport and Highways (Transport Wing), Notification from 9th February 2000: Central Motor Vehicles (4th Amendment) Rules, 2000
6 Ministry of Road Transport and Highways from 24th April,2001: Central Motor Vehicles (2nd Amendment) Rules, 2001
7 BMU Demonstrationsvorhaben Emissionsarme gasbetriebene Nutzfahrzeuge, Final Report 1999 (not published)
8 Regulation 1999/96/EC

XYLENE
POLYCYCLIC AROMATIC HYDROCARBONS
BENZO[A]PYRENE
AMMONIUM SULPHATE
AROMATICS
BENZENE
TOLUENE
PHOTO-IONISATION DETECTOR
BTX ANALYSER
NUCLEATION

and you still insist it's the tailpipe

NANOPARTICLES
AIR QUALITY GUIDELINES
MORTALITY
EMISSION WARRANTY
CONTINUOUS REGENERATING PARTICULATE TRAP
MPFI
COMMON-RAIL INJECTION
EXHAUST GAS RECIRCULATION
BIO-FUEL
ETHYL TERTIARY BUTYL ETHER
ETHANOL
EMISSION TAX
FUEL-DUTY ESCALATOR
ENVIRONMENTAL EXCISE DUTY
FUEL CELL
CARBURETTOR
LEV I LEV II ZEV SULEV
EURO



Join the Right To Clean Air Campaign

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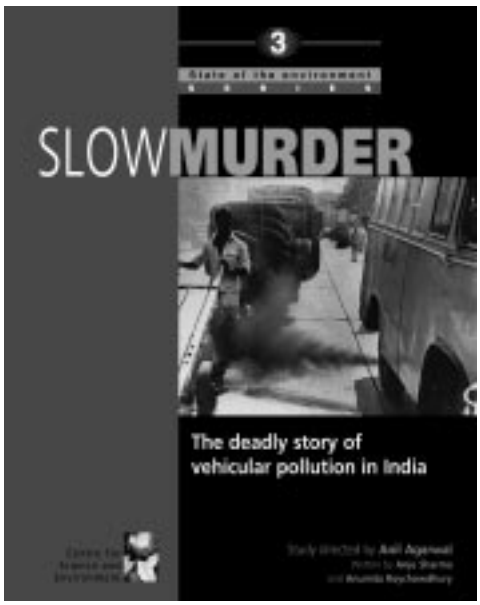
The Centre for Science and Environment is a public interest research and advocacy organisation, which promotes environmentally-sound and equitable development strategies. The Centre's work over the past 20 years has led it to believe and argue, both nationally and internationally, that participation, equity and community-based natural resource management systems alone will lead the nations of the world towards a durable peace and development.

As a public interest organisation, the Centre supports and organises information flow in a way that the better organised sections of the world get to hear the problems and perspectives of the less organised. Environmental issues are seen in an anthropocentric perspective that seeks to bring about changes in the behaviour of human societies through appropriate governance systems, human-nature interactions, and the use of science and technology.

Though the public awareness programmes of the Centre have been its key strength and focus of work, it has endeavoured to move into associated areas of work like policy research and advocacy in the past years. Learning from the people and from the innovations of the committed has helped the Centre to spread the message regarding environment without its normal association with doom and gloom. Rather, the effort of the Centre is to constantly search for people-based solutions and create a climate of hope.

The Centre has always been, and will continue to be, editorially independent of interest groups, governments, political parties, international agencies and funding sources. CSE never accepts funding to push a donor's viewpoint. All its outputs are available for public dissemination.



Published in 1996,
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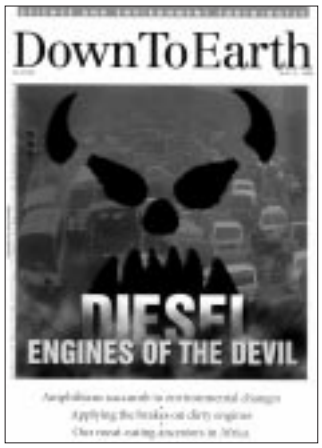

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