

# Comparative Exhaust Emission Study of North East Karnataka Road Transport Corporation Buses by the use of Alternative fuel-CNG

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**Abstract**—The study is concerned with the development, encouragement and use of more environment-friendly forms of alternative fuels for transport. These innovative solutions encompass new more environment-friendly transport technologies (and also innovative transport concepts with potential for lowering environmental impacts, such as minimizing exhaust emissions)

This study mainly deals with the comparative exhaust emissions North East Karnataka Road Transport Corporation busses by the use of Alternative fuel-CNG. Particularly it focuses on the suggestion to curb the vehicular pollution by the use of CNG. In this study the pollution loads have been calculated and compared by considering usage of the CNG in place of conventional diesel fuel in buses.

For the purpose of this study, the NE-Karnataka Road Transport Corporation was considered. The daily total kilometre operated by NEKRTC is collected with various other information. These buses run on diesel fuel and are responsible for largest amount of lead emissions and various other pollutants. The pollution loads were calculated on the basis of information collected from the Central Pollution Control Board (CPCB), Environment Protection Agency and previous studies carried out in this regard by various important agencies. The use of CNG shows tremendous reduction in various pollutants. By the use of CNG, CO can be reduced to 84%, NO<sub>x</sub> can be reduced to 58% and PM can be reduced to almost 97% in Kalaburagi City.

**Keywords:** Air pollution, Biodiesel, Vehicular Pollution, Central Pollution Control Board.

## 1. INTRODUCTION

- NEKRTC was established on 1.10.2000 having been separated from KSRTC for providing “adequate, efficient, economic and properly coordinated road transport services” in the North eastern part of the state of Karnataka.
- Availability of adequate, safe and comfortable passenger transport facility is a very important index of economic development of any country. Public transport provides the vital connectivity in a developing society.

- NEKRTC is operating 2710 schedules covering 9.78 lakh kms carrying 10.00 lakh passengers every day.
- NEKRTC is serving 92% of the villages in its area (3859 out of 4203) with transport facility.
- NEKRTC’s Infrastructure - one corporate office, 08-Divisional offices, 41 Depots, 108 bus stands and 2745 buses.

## OTHER FACILITIES PROVIDED TO COMMUTERS

- Reservation of seats for lady passengers: Two seats have been reserved in Rajahamsa and higher classes of services for lady passengers travelling single. In Mofussil buses, nine seats and fourteen seats in City/Suburban services are reserved for lady passengers.
- Reservation of seats for physically handicapped persons: Two seats have been reserved in Mofussil and City/Suburban services.
- Free / Concessional Passes: NEKRTC is extending free / concessional travel facility to students, physically handicapped persons, blind, Freedom fighters, Journalists.
- Free Travel in City limits: One day pass holders are permitted to travel free within the city limits wherever City and Suburban services operated.
- Concession for senior citizens: NEKRTC provides Concession in passengers fare for senior citizens about 25% of the Bus fare, having the age 65 and above.
- Discount on Return Journey Tickets: A discount of 10% is offered on return journey tickets, if both onward and return journey tickets are booked simultaneously.
- Discount on Group bookings: A discount of 5% on the fare, if four or more passengers book a single ticket. Further, discount of 8% is given for a group of 10 or more passengers.

- Special promotional fares (less than regular fares) are charged to selected long distance destinations in A/c Sleeper, Rajhansa and other express services.
  - Special services: Additional services to pilgrimage / tourist places are operated during festivals, summer vacation, other fairs/festivals, weekends and holidays.
  - Casual Contract services: For special occasions like weddings, excursions, pilgrimage or study tour etc, NEKRTC is providing dedicated buses on hire basis at competitive rates.
  - Chartered contract services: NEKRTC is also providing buses on chartered contract basis to industries, institutions, schools, colleges, and parent-teacher associations etc to meet the daily travel needs of the employees / students of these organizations.
  - Freedom Tickets or Weekly Passes are available to the passengers for travelling seven days within the state or outside the state irrespective of the distance of travel by using the class of service he prefers. Most suited to Marketing executives, businessmen and tourists.
  - Monthly Season Tickets are available to the passengers travelling between two selected destinations daily. These passes are most suited for office / industry employees, teachers, businessmen etc.
  - Pass Issue counters are working at all bus stands for the convenience of the travelling public in obtaining student passes, Monthly Season Tickets and Freedom Tickets.
  - Insurance Fee has been introduced entitling the dependents of the passengers for compensation of Rs. Two lacks Fifty Thousand in case of accidental death of any NEKRTC passenger. This relief is in addition to the regular compensation awarded by the Motor Accidents Claims Tribunal.
  - Advance reservation booking network (AWATAR): NEKRTC has implemented on-line advance reservation network called AWATAR (Any Where Any Time Advance Reservation), wherein tickets can be booked through Internet. Presently, 9 NEKRTC counters and 20 Franchisees are working on this system. There are 5 on-line booking counters in Hyderabad City, 04 on-line booking counters in Gulbarga, 04 counters in Raichur, 01 counter in Gangavati (Koppal), 04 counters in Bijapur, 07 counters in Bellary. Tickets can be booked 15 days in advance including return journey tickets from selected destinations.
  - Electronic Ticketing Machines: To enhance the usage of IT in day-to-day operations ETMs have been deployed in all 41 Depots. ETMs are convenient, user-friendly, light in weight apart from other benefits like speedy issue of tickets, reduction in manual entry of waybills, generation of MIS reports on the no. of passengers travelled, distance of travel, integration with DCS etc.
  - Passenger Amenities at bus stands: Refreshment rooms, drinking water facility, sitting arrangements, display of timetables, enquiry counters, pass issue counters, advance booking counters, luggage booking counters, separate toilets / urinals for gents / ladies, cycle/ scooter/ car parking stands, CCTV, book stall, fruit stall. STD/local telephone booths etc are provided at bus stands. All the bus stands in NEKRTC jurisdiction are taken up for up gradation.
  - Advertisement media: NEKRTC has an extensive media for advertisement like bus panels, hoardings, on the backside of bus tickets, advance reservation tickets, various types of passes which can be utilized for display of commercial advertisements.
  - Environment friendly initiatives: NEKRTC has undertaken massive afforestation programmes in its premises in Depots, Divisions, and Workshop etc. Modern vehicle testing equipment are procured to adhere to vehicular emission norms. Diesel particulate filters have been fitted to reduce particulate emission on trial basis. Afforestation is taken up in large scale.
- Controlling air pollution is turning out to be an enormous challenge not only because of the rising numbers of total vehicles but also due to the increased toxic risk from the growing numbers of diesel cars and buses. In 1999 CSE had advocated the ban on diesel Vehicles. We need cleaner alternatives to Gulbarga. Serious efforts are needed to create awareness among the consumers to make their vehicles eco-friendly to reduce emissions. In this study we are urging NE-Karnataka Road Transport Corporation to consider CNG as an alternative fuel because of its many Benefits and are as given below.

### Benefits of CNG

Benefits of CNG are mentioned below.

- No visible tail pipe emissions.
- Eliminates sulphur and lead from the exhaust emissions.
- Reduction in CO, NOx and Particulate emissions.
- Significant reduction in benzene and other toxic emissions.
- Higher octane value of CNG reduces knocking problems of a vehicle.
- Reduces noise from running vehicles.
- CNG cannot be adulterated
- Reduce noise in operation.

## 2. EMISSIONS FROM DIESEL VEHICLES

Due to low volatility, evaporative emissions are non-significant. Though the concentration of CO and unburnt HC in the diesel exhaust are rather low, they are compensated by high concentration of NO<sub>x</sub>. There are smoke particles and oxygenated HC, including aldehydes and odour-producing compounds. Fuelled vehicles are CO, HC, NO<sub>x</sub> and Pb while pollutants from diesel-fuelled vehicles are particulate matter (including smoke), NO<sub>x</sub>, SO<sub>2</sub>, PAH. Residence time and turbulence in the combustion chamber, flame temperature and excess O<sub>2</sub> affect CO formation. NO<sub>x</sub> includes nitric oxide (NO), nitrous oxide (N<sub>2</sub>O), nitrogen dioxide (NO<sub>2</sub>), dinitrogen trioxide (N<sub>2</sub>O<sub>3</sub>) and nitrogen pent oxide (N<sub>2</sub>O<sub>5</sub>). NO and NO<sub>2</sub> collectively represented as NO<sub>x</sub>, are the main nitrogen oxides emitted by vehicles. About 90% of these emissions are in the form of NO which is produced in the vehicle engine by combustion of nitrogen at high temperatures. NO<sub>2</sub> is formed by oxidation of NO, and has a reddish brown colour and pungent odour. In developing countries, the transport sector accounts for 49% of NO<sub>x</sub> emissions and the power sector, 25%; the industrial sector, 11%; the residential and commercial sectors, 10% and other sources 5%. Another important gas emitted is carbon-di-oxide which is a greenhouse gas associated with global warming resulting mainly from increased combustion of fossil fuels including motor vehicle fuels.

## 3. MOTIVATION FOR PRESENT STUDY

In Karnataka state, North East Karnataka State Road Transport Corporation comes under Hyderabad-Karnataka Region. This region is having very hot climatical condition. The Gulbarga is also in the same region and stands 2<sup>nd</sup> highly polluted city. Air pollution is particularly alarming because of its harmful effects on human health. Gulbarga is mainly suffering from Air Pollution related problems. The fastest growing infrastructure facilities in the HK (Hyderabad-Karnataka) cities, various construction activities and cement industries made the air pollution level very high. The increasing number of vehicles and buses of NE-Karnataka Road Transport Corporation made situation too worst. In HK region cities the commuters are primarily dependent on the road transport system. This has led to an enormous increase in the number of vehicles with the associated problems of traffic-congestion and an alarming increase in air pollution. Therefore, there is an urgent need for vehicles in NEKRTC to switch over to various alternative fuels such as CNG, Auto-LPG and LNG, to minimize air pollution in NEKRTC

The major pollutants emitted by motor vehicles include CO, NO<sub>x</sub>, sulphur oxides, (SO), HC, lead (Pb) and suspended particulate matter (SPM). These pollutants have damaging effects on both human health and ecology. The human health effects of air pollution vary in the degree of severity, covering a range of minor effects to serious illness, as well as premature death in certain cases. Most of the conventional air pollutants

are believed to directly affect the respiratory and cardiovascular systems. In particular, high levels of SO<sub>2</sub> and SPM are associated with increased mortality, morbidity and impaired pulmonary function, Lead prevents haemoglobin synthesis in red blood cells in bone marrow, impairs liver and kidney function and causes neurological damage. Therefore, it is important to reduce pollution from vehicular emissions

Euro III diesel cars emit 7.5 times more toxic particulate matter (PM) than comparable petrol cars. This means, one diesel car is equivalent to adding 7.5 petrol cars to the car fleet in terms of the particulate matter. Diesel Vehicles are legally allowed to emit nearly three times more NO<sub>x</sub> as Bharat Stage III (Euro III equivalent) norms. Euro III diesel cars emit 7.5 times more toxic particulate matter (PM) than comparable petrol cars

## 4. OBJECTIVES OF STUDY

The principal objective of the present research is to carry out a comparison of vehicle pollution for diesel and CNG fuelled buses. The intent is to suggest strategies for minimizing vehicular pollution in NEKRTC. The objectives of the present research are achieved through

1. Collection of data related to various alternative fuels, particularly diesel and CNG
2. Collection of data pertaining to emission factors
3. Collection of data pertaining to NE-Karnataka Road Transport Corporation's total number of buses in all the depots.
4. The average running kilometre per day of various buses of NE-KRTC.
5. Buses flying in city and other areas and Comparison of emission level for Diesel fuelled and CNG buses in Gulbarga.

## 5. METHODOLOGY

The following methodology has been adopted for conducting the present study.

- The details of number buses in NEKRTC has been collected.
- The average daily running kilometre of various buses were collected from NE-Karnataka Road Transport Corporation..
- The emission levels of various class vehicles have been collected from Central Pollution Control Board, New Delhi and from other reliable sources.
- Available data has been analysed with the objective of minimizing vehicular pollution with Bio-diesel fuels/categories of vehicles

**6. COLLECTION OF DATA**

Now by using the Data given in Table 1, 2 and 3 we can calculate the emission levels in NE-KRTC Gulbarga and reduction by the use of Bio –Diesel Blends.

**Table I: Number of Buses in Various Depots of NE-Karnataka Road Transport Corporation. Gulbarga**

NEKRTC	Number of buses
All Depots	2745 buses.

From Table 1, it is seen that the number of buses in all the three depots of NE-KSRTC consists of 2745 buses. All the buses are using diesel fuel.

**Table II: The Average Running Kilometre Per Day of Various Buses in Various Depots**

Number of Depots	Number of Buses in all the Depots	Operated kms/day
41	2745	9.78 lakh kms

Table 2 shows various depot buses running kilometre per day. About 2745 buses run 9.78 lakh kilometres/day.

From Table 1 and 2 it is seen that the total number of Depots in NEKRTC is about 41, the total number buses in all the depots of NE-KRTC is about 2745 buses. All the buses are using diesel fuel. Every day NEKRTC operates about 978000 km/day.

**Table-III: Comparative Emissions from Diesel and CNG for Buses**

Fuel	Pollution Parameter		
	CO	NOx	PM
Diesel	2.4 g/km	21 g/km	0.38 g/km
CNG	0.4 g/km	8.9 g/km	0.012 g/km
<b>% Reduction</b>	<b>84</b>	<b>58</b>	<b>97</b>

Source: Frailey *et al.* (2000) as referred in World Bank (2001b: 2).

**7. CALCULATION OF POLLUTION LOADS**

This section describes the procedure for calculations of pollution loads. With the help of available data firstly the pollution load of CNG buses and diesel buses can be calculated for the NE-Karnataka Road Transport Corporations. Now the calculation of pollution loads will be done on the basis of buses running km/day. All the calculated loads are shown in the following tables.

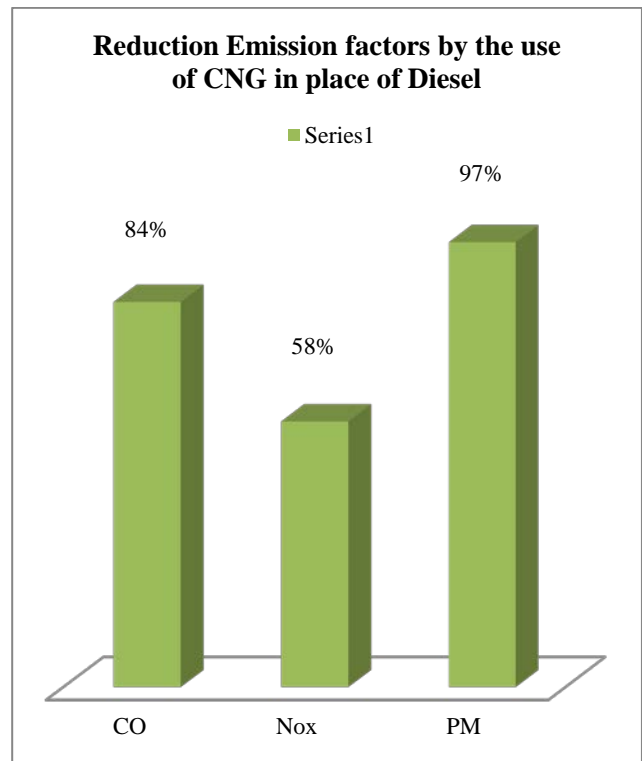
**Table IV: Calculation Emission factors in gm/978000km/day of NEKRTC buses**

Fuel	Pollutant	Pollutant	Pollutant
	CO g/km	NOx g/km	PM g/km
Diesel	978000*2.4 =2347200	978000*21 =20538000	978000*0.38 =371640

CNG	978000*0.4=391200	978000*8.9 =8704200	978000*0.012 =11736
<b>% Reduction</b>	<b>84</b>	<b>58</b>	<b>97</b>

**Table V: Emission factors in Kg/Day of NEKRTC Buses**

Type of Vehicle	Emission Factors in kg/day		
	CO	NOx	PM
Diesel	2347.2	20538	371.64
CNG	391.2	8704.2	11.37
Reduction of Emission factors in Ton/Day	1.956	11.83	0.3602
Reduction in Emission factors in Ton/Year	713.94	4317.95	131.47



**Fig. 1: Reduction in Emission factors by the use of CNG in place of Diesel fuel in NEKRTC Buses**

**8. CONCLUSION**

Based on the present study following are the major conclusions

1. By the use of alternative fuel CNG in Gulbarga City, gross reduction in various emission factors in Ton/Day of NEKRTC are: CO – 1.956 NOX – 11.83, PM – 0.3602
2. By the use of alternative fuel CNG in Gulbarga City, gross reduction in various emission factors in Ton/Year of NEKRTC are: CO – 713.94, NOX – 4317.95, and PM- 131.47

## 9. RECOMMENDATIONS

In addition to minimization of emissions by using alternative fuel CNG there is need for implementation of various other majors in order to save environment on a sustainable bases.

In fact, the containment of vehicular pollution requires an integrated approach, with following components: (i) improvement of public transport system; (ii) optimization of traffic and improvement in traffic management (e.g., area traffic control system, timers at intersection, no-traffic zone, green corridors, removal of encroachment on roads, regulation for digging of roads (iii) comprehensive inspection and certification system for on-road vehicles; (iv) phasing out of grossly polluting vehicles (v) fuel quality improvement (e.g., use of benzene and aromatics in petrol, reduction of sulphur in diesel); (vi) tightening of emission norms (e.g., EURO-IV); (vii) improvement in vehicle technology; (viii) checking fuel adulteration; and (ix) checking evaporative emissions from storage tanks and fuel distribution system.

## REFERENCES

- [1] Agarwal, A. K. (2007). Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. *Progress in energy and combustion science*, 33(3), 233-271.
- [2] Rawat, A, (2004). Joint Secretary, Dept. of Road Transport and Highways, Govt. of India, "UNEP workshop on Fuel Efficiency Improvement and Automotive CO<sub>2</sub> Reduction Policies" of Indian Perspective.
- [3] Anjum, R. H. G., & Hameed, R. (2013). Improving the Environmental Performance of Bus-based Public Transport System in Lahore-Pakistan. *Pak. J. Engg. & Appl. Sci.* Vol, 111-126.
- [4] ARAI (2007), Draft report on "Emission Factor development for Indian Vehicles " as a part of Ambient Air Quality Monitoring and Emission Source Apportionment Studies, Pune
- [5] Badami, M. G. (2005). Transport and urban air pollution in India. *Environmental Management*, 36(2), 195-204.
- [6] Basic Statistics of Indian Petroleum and Natural Gas 2008-09, Ministry of Petroleum and Natural Gas
- [7] Bhandarkar, S. Bio-Diesel for Sustainable Development of Belgaum City Transport
- [8] Bhawan, P., & Nagar, E. A. (2008). Development of National Emission Standards for Petrochemical Plants. .
- [9] Bhawan, P., & Nagar, E. A. (2008). Central Pollution Control Board.
- [10] Bielaczyc, P., Szczotka, A., & Brodzinski, H. (2001). Analysis of the exhaust emissions from vehicles fuelled with petrol or LPG and CNG alternatively. *Journal of KONES*, 8(1-2), 363-370.
- [11] Biswas, D. (2002). Parivesh, biodiesel as automobile fuel. *Central Pollution Control Board, Ministry of Environment and Forests*.
- [12] Biswas, D. (2000). Parivesh Newsletter: June. *Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi*.
- [13] Biswas, D. (1999). Parivesh newsletter: June 1999. *Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi*.
- [14] Brevitt, B. (2002). *Alternative vehicle fuels*. Great Britain, Parliament, House of Commons, Library.
- [15] Carter, A. (2005). Breath of fresh air. *Respiratory Medicine: COPD Update*, 1(2), 73-73.
- [16] Calais, P., & Sims, R. (2000). A comparison of life-cycle emissions of liquid biofuels and liquid and gaseous fossil fuels in the transport sector.
- [17] Catherine, I. A., & Mohideen, K. S. S. (2014). Economic impact of air pollution and legal measures in India. *ZENITH International Journal of Business Economics & Management Research*, 4(12), 160-164.
- [18] Chandini, T. (1998). Control of Vehicular Pollution in India: Some Recent Initiatives. In *Workshop on Integrated Approach to Vehicular Pollution in Delhi, New Delhi*.
- [19] Coroller, P., & Plassat, G. (2003, August). Comparative Study on Exhaust Emissions from Diesel and CNG-Powered Urban Buses. In *Proceedings of the Diesel Engine Emissions Reduction Conference (DEER)*.
- [20] CPCB (Central Pollution Control Board), (2000). Transport fuel quality for year 2005. PROBES/78/2000-01, CPCB, Delhi.
- [21] Das, A. (1997). The Automotive Air Pollution Perspective and Potential Abatement Measures. *Indian Journal of Transport Management*.