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Alternative Fuel CNG For Bengaluru Municipal Transport Corporation Buses

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Abstract : *This paper deals with the exhaust emissions emitted by the Diesel buses of Bengaluru Municipal Transport Corporation buses in Bengaluru and suggestions to reduce the emission levels by the use of an alternative clean fuel CNG. The pollution loads have been calculated and compared by considering usage of the Compressed Natural Gas (CNG) in place of conventional diesel buses. In this study, the Bengaluru Municipal Transport Corporation was considered and collected the required information such as the total number of buses, daily kilometres operated by the BMTC buses. These buses run on diesel fuel and are responsible for largest amount of lead emissions and various other pollutants. The pollution loads 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 in gm/km. By the use of CNG we can find 84% reduction in CO, 58% reduction in NOx and 97% reduction in PM.*

Keywords: *Emissions. Air Pollution, I.C Engines; Mitigation, Compressed Natural Gas (CNG), Alternative Fuels*.

1. INTRODUCTION

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 to far flung areas in a developing society. The Bengaluru Municipal Transport Corporation was established in 1997 under the provisions of Road Transport Corporation Act 1950 with the objective of providing "adequate, efficient, economic and properly coordinated road transport services". BMTC is a government agency that operates the public transport bus service in Bangalore, India. It has the highest number of Volvo buses operated by a public transport company in India. The following are the special services apart from ordinary services run by BMTC:

- Suvarna: Similar fare to ordinary buses serving important feeder routes, painted in red or green/white scheme
- Pushpak: Single door buses with coffee coloring scheme (no service now)
- BIG 10: Suvarna class buses with special green and bottle green livery plying on 12 major corridors towards the central commercial district. These buses are numbered with a G prefix.
- BIG Circle: Suvarna class buses with special white colored BIG Circle livery. These buses ply on inner and outer ring roads . Buses are numbered with a C prefix or a K prefix.
- Atal Sarige: Low fare buses painted with Indian tri-colour livery.
- Vajra: Air conditioned Volvo buses painted in red livery running on important routes serving the IT companies and major residential areas.
- Vayu Vajra: Green coloured Volvo buses operated in 12 routes connecting to Kempegowda International Airport. Free Wi-Fi access is provided to the commuters in these buses.
- Marcopolo AC and Corona AC: Air conditioned buses with lower fare than Vajra services plying on select routes.(Marcopolo AC no service now & Corona AC same fare as Volvo).
- Metro Feeder: Special buses running on 18 routes as feeder network to the Metro stations.
- Hop On Hop Off: This service was introduced for sightseeing in Bangalore. It covers a route connecting about twenty landmarks of great historic, religious and scientific significance.(no service now)

BMTC has also introduced Mercedes Benz buses on a trial basis. BMTC has also introduced buses powered by solar energy on trial basis in Bangalore. The table shows that the BMTC is having 44 depots, and 53 Bus Stations. Total of 6728 buses are running for almost about 1145000 kilometres/day. All these buses use Diesel fuel. Emissions coming out from diesel fuel are legally allowed to emit nearly three times more NOx as per the Bharat Stage III (Euro III equivalent) norms. This clearly reflects the flawed emission standards that allow diesel vehicles to emit more NOx and

PM compared to petrol vehicles. Therefore it is very much essential to guide the BMTC management to switch over to alternative fuel C.N.G, because of its following benefits.

(Source: BMTC website: http://mybmtc.com/mobile/)

2. BENEFITS OF CNG

A. Urban smog reduction
B. It's safe and lighter-than-air; CNG is non-toxic and disperses quickly. It has a higher ignition temperature than gasoline and diesel fuel, which reduces the chances of accidental ignition.
C. Cost effective. Natural gas as a vehicle fuel actually costs less today than conventional gasoline
D. CNG burns cleaner and produces lower levels of harmful pollutants than gasoline or diesel vehicles
E. CNG vehicles reduce emissions of carbon monoxide and reactive hydrocarbons
F. CNG contains no particulates such as those associated with diesel fuel, and also reduces emissions of carbon dioxide - the principal "greenhouse" gas
G. Vehicle emissions are lower with natural gas than with gasoline because ignition temperatures are higher and combustion is more efficient
H. Engine maintenance cost can be reduced by extending time between oil changes because the particulate materials that are produced during the combustion cycle of gasoline engines and cause the engine oil to get dirty are not present in the CNG engine
I. Fewer environmental hazards compared to other fuels
J. It's the most practical. Natural gas is the most efficient feedstock for the production of hydrogen. It's part of an infrastructure that's convertible to hydrogen. CNG stations can easily be converted to hydrogen delivery due to their common properties.
K. It's possible to produce hydrogen-natural gas-blended fuel. A hydrogen/CNG blend makes good economic and environmental sense.
L. Natural gas is also piped directly to the fuelling station, reducing the need to transport the fuel, as well as, eliminating the need of ordering and delivery schedules Motivation for present study

3. OBJECTIVES OF STUDY

The principal objective of this thesis is to compare exhaust emissions emitted by Diesel and CNG buses.

A. To carry out relevant literature review
B. Collection of information related to various alternative fuels and their emission factors.
C. Collection of various data from BMTC such as number of buses, average daily running kilometre of the buses.
D. Comparison of emission level of diesel fuelled buses with the alternative clean fuel CNG.

4. METHODOLOGY

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

- The details of number of buses in BMTC have been collected.
- The average daily running kilometre of various buses was collected from BMTC.
- The emission levels of various class vehicles have been collected from Central Pollution Control Board, New Delhi and from other reliable sources.

5. COLLECTION OF DATA

The following data has been collected from Bengaluru Municipal Transport Corporation.

Table 1: Key Statistics of BMTC (Source: BMTC website)

Depots	44
Bus stations	53
Vehicles	6726
Effective Kms per day	11.45 lakhs
Schedules	6157
Average traffic revenue per day	4.83 Crores

Table: 2 Numbers of Buses in Various Depots of BMTC

BMTC	Number of buses
44 Depots	6726 buses.

From Table 2, it is seen that the number of buses in all the depots of BMTC consists of 6726 buses. All the buses are using diesel fuel.

Table 3 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
44	6726	11.45 lakhs kms

Table 3 shows various depot buses running kilometre per day. About 6726 buses run 11.45 lakhs lakh kilometres/day. From Table 2 and 3 it is seen that the total number of Depots in BMTC is about 44, the total number buses in all the depots of KSRTC is about 6726 buses. All the buses are using diesel fuel. Every day BMTC operates about 1145000 km/day.

Table 4 Comparative Emissions From Diesel and CNG For Buses

Pollution Parameter Fuel	CO gm/km	NO_X gm/km	PM gm/km
Diesel	2.4	21	0.38
CNG	0.4	8.9	0.012
% Reduction	84	58	97

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

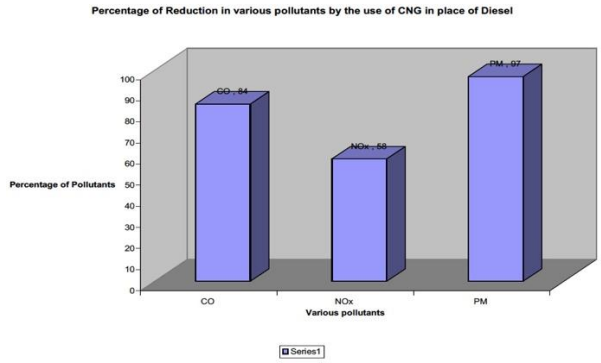

Fig 1. Percentage of reduction in pollutants by the use of CNG in place of Diesel.

6. 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 Karnataka State Road Transport Corporation. Now the calculation of pollution loads will be done on the basis of buses running km/day. All the calculated loads are as shown in the following tables:

Table 5 Comparative Exhaust Emissions of Diesel and CNG Buses Per Day

Pollution Parameter Fuel	CO gm/11.45lakhs km/day	NO_X gm/11.45lakhs km/day	PM gm/11.45lakhs km/day
Diesel	2.4*1145000 =2748000 =2748 kg/day	21*1145000 =24045000 =240451kg/day	0.38*1145000 =435100 =435.1kg/day
CNG	0.4*1145000 =458000 =458.4kg/day	8.9*10190500 =22169900 =10190.5kg/day	0.012*1145000 =13740 =13.74kg/day

Table 5 shows Comparative Pollution load in kg/km of Diesel and CNG fuelled buses running 145000 km/day. By referring table 5 by the use of CNG in place of diesel fuel in BMTC buses we can say that we can reduce CO from 2748 kg/day to 458.4kg/day, NOx can be reduced from 240451kg/day to 10190.5kg/day and PM can be reduced from 435.1kg/day to as minimum as 13.74kg/day.

Table: 6 Comparative Pollution Loads in Ton/Day of Diesel Fuel and CNG Fuelled Buses Of BMTC.

Pollution Parameter Fuel	CO ton/day	NO_X ton/day	PM ton/day
Diesel	2784 kg/day =27.84ton/day	240451kg/day =240.4.1ton/day	435.1 kg/day =4.35 ton/day
CNG	458.4kg/day =4.58 ton/day	10190 kg/day =10.19.6ton/day	13.74 kg/day =0.1374 ton/day

By referring table 6 we can conclude that we can reduce CO from 27.84ton/day to 4.58 tons/day, NOx 240.4to 10.19 tons/day and PM from 4.35 to 0.1374 tons/day.

Table: 7 Comparative Pollution Loads in Tons/Year of Diesel Fuel and CNG Fuelled Buses of BMTC.

Pollution Parameter Fuel	CO ton/year	NO_X ton/year	PM ton/year
Diesel	27.84*365ton/year =10161.6ton/year	240.4.1*365ton/year =87746.5ton/year	4.35*365ton/year =1587.75ton/year
CNG	4.58*365ton/year =1671.7ton/year	10.19.6*365ton/year =3719.35ton/year	0.1374*365ton/year =50.15ton/year

By referring table 7 we can conclude that we can reduce CO from 10161.6 to 1671.7 tons/year, NOx from 87746.5 to 3719.35 tons/year and PM from 1587.7 to 50.15 tons/year.

7. CONCLUSION

1. By referring table 5 by the use of CNG in place of diesel fuel in BMTC buses we can say that we can reduce CO from 2748 kg/day to 458.4kg/day, NOx can be reduced from 240451kg/day to 10190.5kg/day and PM can be reduced from 435.1kg/day to as minimum as 13.74kg/day.
2. By referring table 6 we can conclude that we can reduce CO from 27.84ton/day to 4.58 tons/day, NOx 240.4to 10.19 tons/day and PM from 4.35 to 0.1374 tons/day
3. By referring table 7 we can conclude that we can reduce CO from 10161.6 to 1671.7 tons/year, NOx from 87746.5 to 3719.35 tons/year and PM from 1587.7 to 50.15 tons/year.

8. RECOMMENDATIONS

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., EUROIV); (vii) improvement in vehicle technology (e.g., restriction on manufacturing of 2-stroke engines, emission warranty, on-board diagnostic system); (viii) checking fuel adulteration; and (ix) checking evaporative emissions from storage tanks and fuel distribution system.

An integrated transport policy should be implemented in a planned manner and projects to be fast tracked. As many as parents use car pools to drop their children at school, neighbours and office colleagues could do the same. People should walk to the neighbourhood market rather than driving elsewhere. Use pedal power-Cycle or a rickshaw- for short distances. Cars should be parked wherever one can hop on to the metro. Try to restrict the number of cars per household.

Significant number of old vehicles of Pre-Emission era are still on road, they are polluting more due to poor and improper maintenance. They should be replaced. We have to take care about In-Use Vehicle Emission Management. Presently only Transport vehicles need to undergo an annual Fitness check carried out by Road Transport Authorities (R.T.O) for Emissions, Safety and Roadworthiness. But all the vehicles need to undergo a periodic emission check (3 months/6 months). Pollution under Control (PUC) Centres at fuel Stations and Private garages should be authorised to check the vehicles. Presently Inspection and Certification (I and C) enforced only for commercial Vehicles (Buses, Trucks, Taxis and Auto rickshaws) and RTO is the only authorised agencies. This I and C need to extend for all categories of Vehicles domestic as well as commercial, and the authorisation should be given to Private agencies or Public-Private Partnership agencies.

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