International Journal of Electrical Engineering and Technology.
ISSN 2249-3085 Volume 9, Number 2 (2019), pp. 91-104

http://www.ripublication.com

Challenges for India for Achieving Target of Electric Buses and Cars by 2030

Dr. S N Saxena

Ex-General Manager, R&D Division, BHEL, Hyderabad
2001, OL-1, ELDECO UTOPIA, Sector-93A, NOIDA-201304 (UP), India.

Abstract

Indian Government has formulated policies related to having 30 per cent of electrical vehicles on Indian roads by 2030 and also provided supports to State Governments and manufacturers for this. However, with weak financial positions of State Governments and more than 90 per cent of the buses presently being with private operators, having 30 per cent of electrical buses on Indian roads by 2030 is really a challenge. As public transport has not being able to cope up with growth of population of office going and students, the number of cars and cabs has grown over the last few years. So, reaching the targeted per cent of cars and cabs on road in the next 11 years appears to be more challenging. Presenting these situations, the author proposes a number of recommendations for the Governments, manufacturers and people, so as to achieve the targets for environment preservation.

Keywords: Road Transport, Climate Change Mitigation, Electric Buses, Electric Private Cars, Electric Cabs

1. INTRODUCTION

For climate change mitigation, efforts are being made by all the countries to reduce the consumption of fossil fuels in the two major sectors of electric power generation and transportation. In the area of electric power generation, the two main steps being taken are to avoid the setting up of new coal-based power stations and increase the power generation using renewable energy sources. For transportation sector, efforts are being made to develop and introduce the electric vehicles on roads. At the central level, several ministries and departments of the Government of India (GoI) have been involved in supporting the electric mobility transition. Additionally, several states have formulated or are in the process of formulating their policies for the electric vehicles (EVs).

Apart from growing concern for environment, the other reasons for GoI to introduce EVs on Indian roads have been to have lower pollution in cities, so as to improve the public health and to reduce the import bill of liquid petroleum and gas as the production of these fuels in India is a very small per cent of the consumption. For discussion here, the latest report on EVs, prepared by Rocky Mountain Institute and NITI Aaayog [1], has been considered. For buses and cars, it is being taken here that 30 per cent of the total vehicles will be electric by 2030. The report has mentioned that: a large number of electric buses will be sold through Government support over the next few years; the office cars with all the departments of the Central and State Governments must be converted to EVs as early as possible; and the vehicles registered after 2030 will be only electric. A point requiring clarification is that, although electric buses, cars and cabs will be introduced gradually in different Indian States as per the availability of funds with the Governments, the internal combustion engine (ICE)-based buses and cars will continue to be sold till 2029 [2]. That means, with the present policy of 15 years of valid registration for these vehicles, the ICE-based vehicles sold in 2029 will continue to exist up to 2044. Thus, the challenge with GoI will be how to ensure that the bus and car manufacturers gradually start reducing the production of ICE-based vehicles and gradually start increasing the production of EVs and how to mobilize large funds to provide the subsidies to gradually introduce EVs, so that the number of EVs attains the target by 2030.

In the present study, attention is being concentrated only on electrification of buses, private cars and cabs. The paper tries to analyze the present scenario of these vehicles in India and what are the challenges for the Central and State Governments to implement the plans of gradually getting more and more EVs on roads, both for the intra-city and inter-city travel of people, along with getting the charging infrastructure ready within the cities and on the highways.

2. STATUS OF FOUR-WHEELER ROAD VEHICLES IN INDIA

2.1 Status of Bus Services in India

In India, transport services are under control of the State Governments. A few decades ago, the passenger road transport in every Indian State was managed only by the Public Sector Undertaking (PSU) under control of the State Government. This PSU was called as “State Road Transport Corporation” (SRTC). For example, the intra-city and inter-city bus services in the Indian State of Andhra Pradesh were being organized by “Andhra Pradesh State Road Transport Corporation” (APSRTC). But, gradually, because of the financial limitations of State Governments and SRTCs, the private operators were allowed to enter in transportation of people, in both intra-city and inter-city services. Therefore, most of the addition of number of buses in Indian cities in the last two decades has been only by the private operators, with not much addition by the SRTCs due to their weak financial conditions. As given in Table 1 based on the report by the Indian Government [3], the total number of buses in India increased from 633,900 in 2001 to nearly three times to 1,907,500 in 2015.

Table 1: Growth in number of buses in India

	Total No (x1000)	No with SRTCs (x1000)		No with Private Operators (x1000)	
As on	Total No of Buses	No of Buses	% of Total	No of Buses	% of Total
Mar-01	633.9	115.0	18.14	518.9	81.86
Mar-06	992.0	112.1	11.30	879.9	88.70
Mar-11	1604.4	130.6	8.14	1473.8	91.86
Mar-15	1907.5	140.5	7.13	1767.0	92.87

Thus, with increase in the number of passengers travelled, there was a requirement of increase in the number of buses; and this opportunity was grasped by the private operators. Due to the bad financial position of SRTCs, there was only a marginal increase in their number of buses, resulting in continuous decrease in their per cent share. Assuming a linear growth rate of 10 per cent in number of buses, it can be said that, as on March 2019, the total number of buses in India could be more than 2.793 million. Most of these buses would be with the private operators.

2.2 Status of Personnel Cars and Cabs in India

Although there is a double-digit growth of buses in India, the growth is not able to match the increased requirements of public transport in all the major cities. In many major cities, the Governments have also introduced "Metro Train" services; but even then, those have not been sufficient to cater to the increasing needs of working people and students. With a large number of cars from the reputed Indian and international players readily available in India during the last 10 – 15 years and with easy availability of car loans from banks for the working group, the people have gone to purchase cars if they could afford it. That has resulted in explosive growth in the number of private vehicles on road, giving the problems of traffic congestion on roads (particularly during the peak periods of 0.8.30 to 10.30 hrs and 17.00 to 21.00 hrs) and air pollution due to the tail-pipe emission of gases from these petrol / diesel-driven cars, leading to several diseases in the people of all age groups.

Table 2 shows the number of cars [4] in 10 major cities of India in 2016. One striking observation is that the number of cars in Delhi is more than the total number of cars put together in the three major cities of Bengaluru, Chennai and Mumbai; clearly bringing out the reason for regular congestion on Delhi roads and also why Delhi has become one of the most polluted cities of the world. With about 6 million cars in 10 major cities, the total number of cars in India was about 10 million in 2016; and with linear growth rate of 10 per cent per year, the number of cars in March 2019 would be more than 13 million.

Table 2. Number of cars in 10 major Indian cities

Rank	City	No of Cars
1	Delhi	2,172,069
2	Bengaluru	800,866
3	Chennai	653,270
4	Mumbai	617,556
5	Hyderabad	558,081
6	Pune	332,293
7	Chandigarh	286,584
8	Ahmedabad	239,558
9	Jaipur	235,310
10	Kolkata	222,069
As on March 16, 2016		

Table 3. Number of cabs in Indian States

S No	State	No of Cabs
1	Tamil Nadu	370,000
2	Karnataka	250,000
3	Maharashtra	240,000
4	Rajasthan	130,000
5	West Bengal	130,000
6	Gujarat	120,000
7	Kerala	110,000
8	Uttar Pradesh	100,000
9	Odisa	100,000
10	Telangana	100,000
11	Bihar	90,000
12	Delhi	90,000
13	Andhra Pradesh	80,000
As on March 2016		

Although India still has a very low number of vehicles per capita, the vehicles are crowded in a few large and medium cities, creating problems there. According to a 2016 World Health Organization study [5]: India is home to 10 of the world's 20 most polluted cities; in 2015, India imported more than 80 per cent of its oil; and traffic accidents caused around 150,000 deaths per year on Indian roads.

Table 3 gives the number of cabs in 13 major States of India [6]. (Note: The numbers have been taken from a graph and, therefore, rounded off for the sake of explanation.) With about 2 million cabs in 13 Indian States, the total number in 2016 in all the Indian States would be about 2.5 million. Assuming a linear growth rate of 10 per cent per year, the total number of cabs in March 2019 would be about 3.3 million in India. Some of the reasons for this rapid growth of cabs in Indian cities during the past few years could be as given below.

(a) A number of "App-based" cab operators are available in all major cities, each offering many discounts and schemes to compete with each other. Also, with a large number of cabs with each operator, a user can get the cab at the desired location in a few minutes. Therefore, most of the young people working in information technology (IT) or service industries with disposable income are using these cabs every day for point-to-point travel. Thus, it has become a chain reaction. As number of users is increasing, more cab operators are appearing in the market, resulting in further decrease in fare and the availability in a shorter time, and so more people start travelling by cabs.

(b) There are many "Travel Agents", who are regularly providing vehicles to many public sector and private organizations. These vehicles are being used for bringing the senior people from residences, dropping them back after office hours and for their travel required for meeting clients or attending meetings etc at the other locations.

3. ELECTRIFICATION OF BUSES, PRIVATE CARS AND CABS IN INDIA

India already has a strong base for the production of internal combustion engine (ICE)-based vehicles. As per the "Automotive Mission Plan 2016-2026" [7], Indian auto industry needs to consider an innovative and pragmatic approach in the present transformation phase of electrification of automobiles to be among the top three in world in automobile manufacturing by 2026. In Section 1, the policy of GoI has indicated that only electric vehicles will be registered after 2030. But, as a large number of people are employed in the auto sector in India, GoI and the manufacturers have to think of proper strategy for changing to EVs, so that there is minimum disruption in industrial growth, employment and livelihood of families dependent upon the auto sector.

Indian Government has made favourable policies, so that a large number of manufacturers have started producing most of the components and the complete EVs in India. This would result in decrease in the prices of EVs, so that there would be increased purchase by the people, may be initially with incentives by the Central and State Governments. Fortunately, apart from the efforts of the State and Central Governments, even the private organizations are coming forward in increasing the EVs on the Indian roads. For example, leading cab operator "OLA" has started pilot project in Nagpur city of Maharashtra State [8].

4. CHALLENGE OF GETTING 30 PER CENT E-BUSES BY 2030 ON INDIAN ROADS

With more than 3.34 million buses on Indian roads in 2019 and assuming a linear growth of 10 per cent per year for the next 11 years, the total number of buses in India can be more than 8 million by 2030. With very small growth in buses with SRTCs, it can be taken that the number of buses with them would be about 200,000 and the remaining 7.8 million buses will be with the private operators. With a target of having 30 per cent buses, GoI has to ensure that 2.4 million e-buses are introduced in India by 2030.

4.1 Indian Government Support through FAME

After the announcement of "Faster Adoption and Manufacturing of Hybrid and Electric Vehicles" (FAME-I) by the Ministry of Heavy Industries and Public Enterprises of GoI in 2016, there was opportunities for the State Governments for the introduction of electric buses in the respective States [9]. The FAME-I scheme was initially for a period of two years, but was extended in 2018 for one more year. Then,

from April 2019, GoI announced FAME-II, under which, there were subsidies for the purchase of EVs.

Making use of the subsidies under FAME-I and II, a good number of electric buses of reputed manufacturers were procured and introduced by the different Indian States on trial runs [10]. The buses were from reputed Indian or international bus manufacturers. Each bus was a pure electric zero-emission vehicle and offered the "State-of-the-Art" technologies, such as, low-floor, air-conditioned, CCTV camera, GPS navigation, panic button and many passenger / driver friendly facilities (like mobile charging etc). Each supplier has installed the AC "Fast Charging" facility for the lithium-ion battery bank, by which the bus can be charged in about 1½ to 2 hours at the bus depot. A few cities where e-buses have begun operation are given below.

Presently, trials runs are going on in Delhi of Olectra-BYD "eBuzz K9" and JBM Solaris's "Eco-Life". In Lucknow, 40 numbers of "Ultra" buses of Tata Motors have started running since 2019 beginning. The pilgrims of Sabarimala can now travel in "eBuzz K7" buses from Olectra-BYD. Goldstone Infratech's has officially started running "eBuzz K7" bus in Himachal Pradesh between the Kullu-Manali-Rohtang Pass. This bus had the distinction of successfully completing trial runs at a steep gradient and over 4,000 m altitude for the first time in India. The need for the e-buses was forced by the High Court in order to prevent the melting of glacier during summer at Rohtang. Olectra-BYD has begun commercial operations of 40 number of "eBuzz K9" at Hyderabad.

4.2 Recent Initiative by Indian Government

Apart from the above, GoI has issued tender for purchase of 5,595 e-buses [11], which will be sold at 40 per cent of cost to the interested State Governments, who must submit their proposals to GoI. The State Government must take delivery of e-buses from GoI within 12 months after payment of amount. Under this scheme, GoI sanctioned these e-buses for 64 cities. The States getting the major share out of the above are: Maharashtra 725 buses for 6 cities; Uttar Pradesh 600 buses for 11 cities; Gujarat 550 buses for 5 cities. Also 300 buses will be given to each of the 4 cities (Ahmedabad, Delhi, Bengaluru and Hyderabad).

The cities have to buy the buses at the subsidized rates from GoI. The cities can choose the type of buses depending upon their needs. The buses are in 3 categories: "Standard" (10 – 12 m length); "Midi" (8 – 10 m length); and "Mini" (6 – 8 m length). Out of the above, electric buses are already running in a number of cities, who have made payments to GoI. For example, 40 e-buses (manufactured by Ashok Leyland) are running in the different cities of Gujarat, and for the first time in India, the supplier has provided facilities of "Battery Swapping" at each of the concerned bus depots [12].

4.3 Charging Infrastructure for Buses

4.3.1 Charging at bus depot

In all the cases so far, the bus suppliers are installing the charging infrastructure at the bus depots suiting to their buses. Therefore, whether SRTCs or private operators, when they decide to purchase e-buses, they would have the charging infrastructures at their bus depots installed by the bus suppliers before the arrival of buses. For the fleet of intra-city buses, the slow charging of buses at the depots during night hours will be adequate to run the buses almost the whole next day. In addition, battery charge top-up by fast chargers during day time may also be done, if necessary. But, since the bus depot has a large fleet of electric buses which might require simultaneous charging of a good number of battery banks, the power required would be quite substantial and requires proper planning by the depot management along with the power distribution company (DISCOM), as brought out in Appendix-A.

4.3.2 Battery swapping at the bus depots

The bus suppliers so far have mentioned installation of charging points at the depot for e-buses to be supplied (except for one example given above of Gujarat). But, if the e-buses do not have enough time during day for charging and the buses are required to return immediately for the next trips, then the bus depot may have to consider the option of "Battery Swapping". The bus depot has to keep a sufficient number of charged battery bank ready. When a bus comes to the depot after a trip, electrical staff of the depot must quickly take out the partially discharged battery bank from the e-bus and replace it by a fully-charged battery bank. The discharged battery bank can be charged by the electrical staff during night time. Of course, this system requires a number of extra battery banks to be purchased initially along with the e-buses, necessitating additional expenditure for the bus owners.

4.3.3 Battery charging at bus stops along the route in city

In large Indian cities (such as, Mumbai, Delhi, Kolkata, Bengaluru, Chennai, etc), a city bus on most of the routes runs for many km and for long hours, particularly in the peak traffic hours (08.30 to 10.30 hrs or 17.00 to 21.00 hrs). Therefore, in such cases, top-up of battery charge may be required by fast charging of the battery bank along the bus route. This can be done by having pantograph-type charger at each bus stop [13]. The top-up can be done in 3 to 6 minutes during the period when passengers get down and new passengers board the bus at the bus stop.

4.3.4 Charging infrastructure along highways

It is the inter-city travel of buses covering a few hundred km, which certainly requires charging infrastructures along the highways. These charging stations on highways must have facilities of a number of charging points and for fast charging of EVs.

Fortunately, as per plan of Central Government, one charging station will be set up at every 25 km on both sides of highways [14]. Therefore, by the time SRTCs or private operators decide to increase their fleet and start inter-city operations using electric buses, the charging infrastructures are expected to be ready on highways.

Based on the discussions in 4.3, it can be said that the Government, bus operators and bus suppliers will be able to install charging infrastructure for e-buses as per the requirement in depots or on highways. Therefore, for having 30 per cent of e-buses by 2030, the charging infrastructures will not be bottlenecks. Only challenge will be in terms of funds for bus owners to purchase the required number of e-buses.

4.4 Electric Buses with SRTCs and Private Operators

Regarding e-buses with SRTCs, this is the sector which is directly under the control of Central / State Government, where the Government has to plan to provide substantial funds for gradually increasing the number of e-buses, so as to achieve the target of 30 per cent by 2030. As mentioned above, the Central / State Governments have to concentrate on having electrification of 30 per cent of the fleet (of 200,000); that is 60,000 only. With various steps being taken so far, getting 60,000 electric buses in the next 11 years does not appear to be difficult. The State or Central Governments are already working to gradually introduce electric buses in different SRTCs.

Regarding e-buses with private operators, this seems to be the most challenging sector for GoI. This is because GoI has no control on private operators; and the number of buses by 2030 would be 7.8 million; of which 30 per cent would require 2.34 million electric buses in the fleet. This demands massive investments by private operators over the next 11 years.

5. CHALLENGE OF GETTING 30 PER CENT PERSONNEL E-CARS AND E-CABS BY 2030

5.1 Number of Personnel e-Cars and e-Cabs Required by 2030

Regarding cars on Indian roads, the number of cars in 2019 has been given above as 13 million. Assuming linear growth rate of 10 per cent per year for the next 11 years, it can be said that the number of cars on Indian roads would be about 37 million by 2030. In order to have 30 per cent cars on Indian roads by 2030, total number of e-cars is required to be more than 11.1 million. But, with high cost of electric cars in India compared to the mass-produced petrol / diesel-engine cars, the number of electric cars sold in India [15] has been just 1,200 in 2017-18 and 3,600 in 2018-19. With such low volume sales of electric cars, reaching a target of 11.1 million cars in the next 11 years looks really challenging for GoI. Under FAME-II, there is subsidy for purchase of electric cars also. In August 2019, Finance Minister has announced a number of measures, which would boost the production and sale of cars.

A report by Reuter has brought out the policy of GoI asking all cab operators to plan to go to electric vehicles in a gradual manner: 2.5 per cent by 2021; five per cent by 2022; ten per cent by 2023, before hiking it to forty per cent by April 2026 [16]. GoI also recommended that all new cars sold for commercial use should only be electric from April 2026. With estimated value of totals cabs of 6.43 million in 2026, the number of e-cabs (40 per cent of 6.43 million) would be 2.572 million. Assuming a linear growth rate of 10 per cent, the number of e-cabs would be 3.77 million by 2030. Taking this in true spirit, a new operator (BLU-SMART) has launched 400 e-cabs during the first-half of 2019 in the Delhi National Capital Region (Delhi NCR, which includes parts of Uttar Pradesh and Haryana) [17]. All the cabs are "e-Verito Sedan" of Mahindra & Mahindra. The company is also setting-up 65 charging stations in Delhi NCR (with a spacing of about 5 km), with each charging station having 20 charging points.

5.2 Charging of Personnel e-Cars and e-Cabs

5.2.1 Charging of personal cars

The daily running distance of a large per cent of private cars can be covered by the battery bank fully charged at night hours at residences by slow charging. For independent houses, the charging can be done at parking place in the house. For the cars parked in basement or in open space in ground floor for the multi-storey apartments, presently, there are no charging points available. The "Resident Associations" of such multi-storey complexes have to start planning to provide charging points for e-cars at some suitable locations in the complex. If the distance covered per day is not much, the battery bank charging of personal cars can be done even after one or two days. With this, the battery replacement time will be longer.

The management of medium and large "Public / Private Sector" organizations must provide charging points in the office complexes, so that the employees can purchase e-cars and get these charged during working hours in the offices. Most of these "Public / Private Sector" organizations have sufficient funds for welfare of employees and can provide free-charging points in the offices and also give loans at zero or low interest rates to employees for the purchase of electric cars.

5.2.2 Commercial charging infrastructure in cities

GoI has planned that in all large cities "at least one charging station should be available in a grid of 3 km x 3 km" [14]. Each of these charging stations will provide fast charging for the EVs. As detailed in the notice, even the existing "Petrol Pumps" can also plan to provide charging points for EVs in their existing complex or can set-up charging infrastructure in new locations. One point must be stressed here with regard to the advantage for e-cabs. As is well known, the running and maintenance cost of EV is about 20 to 25 per cent of that for the ICE vehicle. Since e-cab will be running a large distance every day, the higher initial cost of e-cab can be recovered by saving in running cost over a period of a few months. Of course, they would need fast

charging of battery bank one or two times during the day apart from the slow charging during night hours at their houses or at garage. But, with frequent charging and many times battery charge going down to low levels, the battery bank replacement time would be shorter, for which the cab operators must be prepared.

5.2.3 Charging points at public places

In the shopping malls: These days in India, it has become a common habit for young couples to frequently visit shopping malls and purchase most of their requirements from there, particularly during evening hours on week-ends or on holidays. Almost a large per cent of them also have their dinners there. Many other young people visit cinema houses. Thus, with a visit of a few hours by these people, it would be good if the management of shopping malls or cinema houses can provide fast charging of visitors' e-cars in the parking places (reserved for EVs).

At railway stations: In India, it is a common practice in most of the families to receive guests at railway stations when they arrive and also to see them off at the time of their departure. Therefore, the railway authorities must plan to have separate parking places for e-cars and provide facility of fast charging there.

Cab operators: The large cab operators in India (such as, OLA or UBER) must also plan to provide charging stations for their fleet at many convenient locations across the city, as has already been done at Nagpur by OLA. This would enable the cab drivers to run the cabs over longer distance, whenever there are requirements.

Charging stations by private organization: Tata Power presently has 65 EV charging stations spread in 15 cities across 9 states; and they have plans to set-up 500 charging stations in all major cities by the end of 2020, excluding 100 charging stations to be ready in Maharashtra State within a few months [18].

From the above discussions, it can be said that there will be sufficient number of charging stations in all large cities, which can be used by the e-car owners or e-cab drivers. Thus, for e-cars and e-cabs, the charging infrastructures will be available for convenient charging by 2030, when the number of cars attains the desired target.

6. DISCUSSION

For the climate change mitigation, GoI has come out with clear policies in the area of transportation, regarding the number of e-buses, personnel e-cars and e-cabs to be introduced on the roads; and also related to the charging infrastructure within city and on highways. However now, concerted action at the Central and State Government levels and collaboration with the private sector will be required for India to realize the full potential of a mobility transformation. For this, the following are a few recommendations by the author, which would help India in realizing its goals of having the targeted per cent by 2030 for e-buses, personnel e-cars and e-cabs.

6.1 Recommendations Related to Government Policies

Presently, the prices of both e-buses and e-cars are higher than the ICE-driven vehicles. This is mainly due to the cost of the lithium-ion battery bank (which is about 30 to 40 per cent of the cost of EV). The main goal of GoI should be towards reducing the purchase price of EVs, either by increasing the subsidy and / or reducing the custom duty on the main components of EVs. Also, some other favourable policies can be formulated by the State Governments, such as, full exemption of road tax, reduced rates for insurance, concession in power tariff for battery charging, etc. Then only, there will be increase in sales of EVs, particularly e-cars by the common people and e-cabs by the travel organizations. GoI must develop favourable policies also for manufacture of EVs in India, so that many Indian and international producers start the large scale production of the electric buses and cars (along with most of the components, especially the lithium-ion batteries) and offer competitive prices for EVs. These suppliers must also set-up large network of service stations in all the major cities, so that the people can get annual maintenance or replacement of battery bank done at these authorized service stations in their city.

With effect from August 01, 2019, the GST (Goods & Service Tax) Council of GoI has reduced the GST to 5 per cent on EVs and also on chargers [19]. This would certainly result in reduction in the initial cost of EVs. However, the manufacturers must look carefully and bring to the notice of Central Government in case there are still any items remaining related to EVs, where the GST still remains more than 5 per cent. GoI should be aggressive to introduce EVs in SRTCs. For this, GoI should ensure that each SRTC makes purchase of electric buses of more than 10 per cent of its fleet per year for the next 11 years. As, there would be high initial investments by SRTCs to procure EVs in bulk, SRTCs should get long-term funding from the Government (Central and State) and the banks at low interest rate. As there are a large number of ICE-operated buses by the private operators, the Central and State Governments have to think seriously regarding how to make these private operators purchase e-buses of 30 per cent of their fleet in the next 11 years.

6.2 Recommendations Related to Charging Infrastructure

As already announced in the policy, GoI must encourage the large petroleum manufacturers (Bharat Petroleum Corporation Ltd, Hindustan Petroleum Corporation Ltd, Indian Oil Corporation Ltd etc) to set-up charging stations in the grid of 3 km x 3 km inside the major cities at easily accessible locations on main roads, so that the private and commercial car owners can get EV battery bank charged in case of any requirement when driving in city. These corporations must also be encouraged to install EV charging stations on the highways at strategic locations (at every 25 km distance), so that electric buses and cars can have inter-city travel without any problem. The bus owners must plan along with the DISCOM the installation of charging infrastructure in the depot complex before placing orders for the electric buses.

GoI has set a target of 175 GW [19] of renewable power generation by 2022. Therefore, each bus depot and charging station within the city or on highways must have solar photovoltaic (PV) panels installed of the maximum capacity (at rooftop or in open space), so as to generate a part of its required power by solar PV, which would reduce the electricity bill for owner and also reduce load on the distribution system.

6.3 Recommendations Related to Increased Use of Public Transport System

The Central / State Government must think seriously regarding how to increase the utilization of public transport system, so that people avoid the use of own transport (cars) or cabs for movements in city. For this, attempt must be made to increase the number of e-buses to be more than the target of 30 per cent by 2030. As SRTCs are financially weak, the Central Government has to increase their fleet by active support, as already discussed above. Also, as existing in a few cities in India, dedicated e-bus corridors must be set up for the fast movement of e-buses, so that more people will start using these fast buses rather than travelling by their own cars. Further, the number of metro train routes must be increased in the cities which already have these and the metro trains must be introduced in the cities which so far do not have this.

Government and respective employers can encourage their employees by incentivizing them for using public transport services. The print and digital media, manufacturers and the NGOs must do aggressive campaign to educate common people regarding the climate change, why it is necessary to make extensive use of public transport system and why people must go for electric vehicles if they have to use the private car. The people must be informed regarding the reduced maintenance and running costs of EVs, giving lower total cost of operation over the useful life of vehicles.

REFERENCES

[1] RMI-NITI (April 2019): India's electric mobility: Transformation progress to date and future opportunities, https://rmi.org (last accessed on Aug 12, 2019).

[2] Raghunandan D (2017). India needs to think hard whether to put all its eggs in the electric basket, https://www.newsclick.in (last accessed on Sept 01, 2019).

[3] OGD PMU Team (2017). Buses owned by the public sector in India from 2001 to 2015, https://community.data.gov.in (last accessed on July 17, 2019).

[4] Maps of India (2016). Top ten towns with highest numbers of car ownership, https://www.mapsofindia.com (last accessed on Sept 13, 2019).

[5] RMI-NITI (May 2017). India leaps ahead – Transformative mobility solution for all.

[6] Statista (2016). Number of registered taxis by States, https://www.statista.com (last accessed on Sept 18, 2019).

[7] SIAM (2017). Adopting pure electric vehicle, key policy enablers, www.siam.in (last accessed on July 23, 2019).

[8] OLA Electric (2019). OLA launched India's first multimodal electric vehicle project in Nagpur, https://www.mission-electric.in (last accessed on Aug 19, 2019).

[9] PIB (2016). FAME India Scheme, https://pib.gov.in (last accessed on Sept 07, 2019).

[10] News18 (Feb 2019). All the cities in India with electric bus service – Lucknow, Hyderabad, Sabarimala, Delhi and more, https://www.news18.com (last accessed on Sept 18, 2019).

[11] Siva Kumar, Revanthi (2019). Report card: how charged up are electric buses in Indian cities? www.citizenmatters.in (last accessed on Aug 07, 2019).

[12] Sen, Somit (2019). Gujarat on e-bus fast track, https://timesofindia.indiatimes.com (last accessed on Aug 21, 2019).

[13] ABB (2019). Opportunity charging for electric buses, https://new.abb.com (last accessed on Sept 07, 2019).

[14] MOP (2018). Charging infrastructure for electric vehicles, https://powermin.nic.in (last accessed on Aug 16, 2019).

[15] Auto Car (2019). EV sales in India cross 750,000 mark in 2018-19, https://www.autocarindia.com (last accessed on Sept 11, 2019).

[16] Reuter (2019). India set to order UBER, OLA, other taxi aggregators to go electric, https://www.livemint.com (last accessed on Sept 02, 2019).

[17] Reddy, Krishna (2019). India's first smart electric cab service Blu-Smart launched in Delhi-NCR, https://yourstory.com (last accessed on Aug 12, 2019).

[18] News18 (Aug 2019): Tata Power to set up 500 EV charging stations in India by 2020, https://www.news18.com (last accessed on Sept 12, 2019).

[19] ET (2019). Tax boosts for EVs, GST slashed to 5 % from 12 %, https://economictimes.indiatimes.com (last accessed on Sept 01, 2019).

[20] Business Standard (2019). India set to exceed target of 175 GW renewable energy capacities by 2022, https://www.business-standard.com (last accessed on Sept 09, 2019).

APPENDIX

-A: Electric Power Required at Bus Depot

It is assumed that the bus depot has a fleet of 500 buses; of which, 30 per cent are electric buses. Thus, the number of electric buses in depot = 150. Also, the capacity of lithium-ion battery bank has been taken as 300 kWh. Further, if each bus returns after one trip in city with the battery discharged up to 40 per cent and has to be re-charged in the bus depot up to 90 per cent, then the battery bank requires re-charging of the remaining 50 per cent; that is:

= (300 kWh) x 0.5 = 150 kWh. Presently most of the fast charging of battery bank is done in one hour 30 minutes (1.5 hours).

Thus the power will be: = (150 kWh) ÷ (1.5 hrs) = 100 kW.

If 20 per cent of 150 EVs (that is 30 buses) are charged simultaneously, then the power required would be

= 100 kW x 30 = 3,000 kW or 3 MW.

There would be the other lighting, air-conditioning and pumping loads (of say 1 MW) in the bus depot campus. Therefore, the bus depot would need a receiving electric substation of about 4 MW. The substation may be designed for 5 MVA with 2 power transformers, each of about 2.5 MVA, with suitable circuit breakers, isolators, protection circuits, metering, power factor improvement capacitor bank etc. The bus depot management and the power distribution company (DISCOM) must take care of this aspect before ordering the electric buses.