

# Revolution in growth of three-wheeler electric vehicles in India:

## Providing job opportunities to semi-skilled and unskilled people

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### Abstract

*The paper proposes to present the silent revolution taking place in India related to battery-powered e-rickshaws. Though many State and Central Governments did come forward with some schemes to promote e-rickshaws, the main reason for this rapid growth has been the opportunity of self-employment (as drivers) for uneducated and poor people, who migrated to cities in search of livelihood. Taking advantage of this, many manufacturers started producing e-rickshaws with low-cost parts imported from China. These manufacturing factories along with their ancillary units and distribution centres also provided jobs to a large number of semi-skilled persons. Some agencies provided further growth by purchasing a large number of e-rickshaws and giving these on rent to the poor people. But still there are possibilities of further growth if Central/State Governments and manufacturers can take some measures, recommended in the paper.*

### Keywords

*three-wheeler electric vehicle, growth in India, employment opportunities, support from government, actions by manufacturers*

### 1. Introduction

Three-wheeler vehicles are popular mostly in the Asian countries. A few decades ago, the version was manually-driven cycle-rickshaw. Then, internal combustion engine (ICE)-driven three-wheeler auto-rickshaws appeared in the Asian countries.

The world oil crisis in 1973 suddenly reminded the people about the diminishing fossil fuels. Then, the concern of climate change, jointly realized by the countries in 1997 from “Kyoto Protocol” onward, made the Governments and manufacturers discuss the subject of reducing the use of fossil fuels. One major sector responsible for consumption of fossil fuel was transportation; for which, efforts were directed all over the world towards development and popularization of electric vehicles (EVs). But, the efforts in America, Europe and in many other countries were concentrated on electrification of four-wheeler vehicles (cars and buses), as these were the vehicles being used by the society in those countries.

The ground reality in the Asian countries, and particularly in India, is different than the western world. There is large section of middle-class people in India, who cannot afford a car or even a two-wheeler vehicle (ICE-driven scooter or motorbike). With public transport not able to cope-up with the rise in population of service-class people and college going students, most of the people have to search for alternative mode of transportation. Another problem in public transport (buses and metro-trains) is that it is not able to provide the “Last-Mile Connectivity”. Taxies (cabs) are being used only by a limited class of Indian people, mostly for long distance travel.

With the above background, the only choice for the people a few years ago was to hire either a manually-driven three-wheeler rickshaw or a three-wheeler auto-rickshaw for travel between residence and the nearest metro station, or between

metro station to the place of work or the institution. In most of the places, each of these vehicles operated as “Shared Service” to offer a low-cost mode of transport.

With the large-scale production of batteries in China and many other countries, resulting in reduction in their costs, the ingenious people of Asian countries thought about the electrification of rickshaw; and suddenly there was a tremendous growth of battery-operated rickshaw (e-rickshaw) during the last 10 years.

This paper proposes to bring out the silent revolution taking place in India regarding e-rickshaws, reasons behind this uncontrolled and unsupported change, and the support required from Indian Central/State Governments and suppliers to sustain the rapid growth of e-rickshaws.

One aspect of this paper requires clarification. All the analysis done in this paper is based mostly on the news reports of the leading English news papers in India, as given in the “References”.

### 2. Three-wheeler vehicles in India

Today, India has a large population of middle-class people, living in medium and large cities. Their main aim in life is to provide a quality education to their children, so that when the children grow up, they would have a better job and more comfortable life than what they had. For this, both the husband and wife try to get employed, so that they can take care of the basic needs of the school/college going children. Most of the people cannot afford a vehicle (car or two-wheeler) and, therefore, depend upon the other available means of hired transport for travel to their place of work. For children up to class 12, most of the standard schools have their some means of transport for travel of children between houses and schools. But, for the students going to institutions for higher education, they have to use the hired transport for reaching the institutions in time.

There has been a good growth of the metro trains and the buses in most of the Indian cities. But, the problem with these

metro trains and buses is the “Last-Mile Connectivity”; that is, the connectivity between residence, office or institution to the nearest metro stations or bus stands if the distance is more than a few hundred meters. In addition, as mentioned above, the resources (even in the field of transportation) are not able to match the rise in Indian population.

Till a decade ago, India had a good number of manually-driven cycle-rickshaws, providing the “Last-Mile Connectivity”. Then, shared three-wheeler ICE-driven auto-rickshaws (Figure 1) appeared on the streets and slowly people preferred these over the slow-moving cycle-rickshaws.

This situation created problem of survival for these cycle-rickshaw drivers; but fortunately, with the arrival of battery-powered rickshaw (e-rickshaw), the cycle-rickshaw drivers immediately shifted to this without any difficulty.



Figure 1: Three-wheeler auto-rickshaw

India is the largest manufacturer of all types of three-wheeler vehicles. The three-wheeler segment (mostly with ICE) has reported a robust 24 per cent growth in overall volume (sales) in 2018-2019, due to 49 per cent growth in exports. Total sales of three-wheelers during 2018-19 stood at 1.269 million units, against 1.017 million units in 2017-2018 [Ravichandran, 2019]. The domestic sales during 2018-2019 saw about 10 per cent growth to 701,011 units as compared to 635,698 units in 2017-18, mainly because of increase in demand of auto-rickshaws in cities necessitated by increase in population there. Exports supported domestic sales heavily with about 49 per cent growth to 567,689 units in 2018-2019, against 381,002 in the year-ago period; this could be possible primarily due to enormous demand for the low-cost Indian three-wheelers in Asian and African regions.

A study in India [Majumdar and Jash, 2015] had shown that during the last decade, whereas there was a double-digit growth in use of auto-rickshaw by people, there were considerable decline in the use of buses and railways. This is a disturbing trend because the pollution by a large number of auto-rickshaws is much higher than that by the public transport.

### 3. Three-wheeler electric vehicles in India

All over the world, there were efforts towards electrification of road vehicles, mainly for reducing the pollution in the cities. Also, in order to reduce the long-term effects of climate change, Indian Government provided supports for increasing the electric vehicles, not only buses and cars, but also two- and three-wheeler vehicles. With the increase in production, the initial cost of batteries and so also the cost of electric vehicles started reducing. Of course, the running and maintenance costs of EVs are also lower, apart from these vehicles being noise-free. For India, another reason for Government going all out to encourage EVs has been to reduce the import bill of liquid petroleum and gas as the production of these fuels in India is very small per cent of the consumption. Supported by all the factors mentioned above, a large number of entrepreneurs took up the production of electric three-wheelers (e-rickshaws), mostly in Northern and Western States of India.

China is having a large number of manufacturers (supported by the Government), producing low-cost parts for all types of electric vehicles. Indian businessmen started importing low-cost parts from China and started assembling three-wheeler electric vehicles (e-rickshaws) in India. Of course, there are a few large manufacturers, who are producing most of the parts in India (and importing only the lithium-ion battery cells) for the large-scale production of e-rickshaws.

Simple explanation of electrical system of e-rickshaw is given in Appendix A. The battery capacity is an important parameter for any EV. After EV covers a certain distance, the depth of battery discharge goes down. When battery charge goes down below a certain level, the battery is required to be re-charged by connecting the battery to the AC supply through a charger (given by the manufacturer along with the EV). The experts on battery normally advice people to see that the charge of battery does not go below about 40 per cent, after which the battery should be re-charged. In emergency, the battery can be used even if the depth of discharge goes below 40 per cent; but if the battery is used quite often up to the low depth of discharge, the life of battery gets reduced. Lower the depth of discharge of a battery, longer will be the time for re-charging the battery up to about 90 per cent.

In case the EV controller is provided with a regenerative braking system, then whenever the vehicle speed is reduced or whenever the vehicle goes down-hill, the kinetic energy of vehicle converted into electrical energy is used to charge the battery. Most of the latest EVs have this regenerative braking system, and this feature extends the range covered by the EV with a single charge.

### 4. Growth of e-rickshaws in India

A typical sight seen in Noida or Ghaziabad cities in Uttar Pradesh State of India is e-rickshaw (Figure 2), near most of the Metro Railway Stations, bus stands or in markets.

The e-rickshaws were introduced in Delhi during the “Commonwealth Games” in India in 2010. But, these have gained



Figure 2: Battery-powered e-rickshaw

popularity in India since 2015. Almost 300,000 battery powered rickshaws have now replaced the cycle rickshaws in key markets of the North-East, Uttar Pradesh, West Bengal, Delhi and Bihar States of India [Philip, 2019]. These battery-powered three-wheeler vehicles have become one of the fastest growing segments in India, with a compounded growth rate of 20 per cent in the past four years. In the year 2014-2015, e-rickshaw sales were 170,000 units. The figure is estimated to grow 25 per cent annually from 350,000 units in 2017-2018 to a million units by 2024-2025.

In 2018-2019, the sale of electric three-wheeler vehicles was 630,000 units, which interestingly was 83 per cent of total EV sales in India [Wadhwa, 2019].

### 5. Why three is silent revolution of e-rickshaws in India?

Based on the reports in the leading English newspapers in India or the reports of the surveys/studies done on the subject of e-rickshaws by some organizations, as given in the “References”, the author has tried to analyze the factors which have been responsible for the rapid growth of e-rickshaws in Indian cities during the last 4-5 years. The three most significant factors are discussed below. (Note: For explaining the rent or the other costs in this paper, the Indian currency of rupees (Rs.) has been used, where approximately 1 US\$ = Rs.70.)

#### 5.1 Preferred mode of travel by users: The common people

E-rickshaw is very popular in India among common people for hire because of its easy availability wherever one requires it, almost at the “door-steps”. Also, it is available at fixed low rates of either Rs.10 or Rs.20 (depending upon the distance) for travel between homes / offices and the nearest Metro Railway Stations or bus stands where there are no other means of travel. Further, for short distance travel from the residence to the nearby market, the e-rickshaw is providing a very convenient low-cost means. A report [Urban Transport India, 2015] by 8th Urban Mobility India, Conference & Expo 2015 based on the survey done in five medium and large Indian cities, has brought out that: (1) the e-rickshaws are being used by the people of all

age groups; (2) nearly two-thirds of the users are office going people and the students; and (3) most of the users are daily users.

The e-rickshaws have already replaced cycle-rickshaws in most areas and are slowly inching out auto-rickshaws (ICE-driven) for short distance travel. [Bhasin, 2014]:

According to the notification issued on June 17, 2019 [Indo Asian News Services, 2019], the minimum charge for auto-rickshaw in Delhi will be Rs.25 for the first 1.5 km, and thereafter, the charge per km will be Rs.9.5; thus, for a travel of about 3.5 km, the people have to pay the hire charges of Rs.44. Therefore, for short distances from residence to market, or from Metro Railway Station, or bus stands to the destination, the e-rickshaw with low rates of Rs.10 or Rs.20 has become the preferred mode of transport, providing the “Last-Mile Connectivity” for a large number of common people. Not only in Delhi, the cost- difference between auto-rickshaw and e-rickshaw is nearly the same in all the major Indian cities.

Of course, as compared to the auto-rickshaw, apart from economical advantage of e-rickshaw for a short distance, smokeless travel (“Green Transport”) is an attractive feature. The maximum speed of 25 kmph for e-rickshaw is not an issue as it is mostly being used for short distance, where people can reach in 10-15 minutes. In fact, due to less speed, the e-rickshaw can be stopped very quickly, preventing any accident.

Even the auto-rickshaws are not affected by the popularity of e-rickshaws because the auto-rickshaws are still being used by common people when travelling out of town with family members to railway stations or “Inter-State” bus-terminals along with luggage, and also within the city for long distance travel.

As per comparison brought out in a news report [Baggonkar, 2019], while the sales of e-rickshaws in 2018-2019 grew about 21 per cent compared to that a year ago, the sales of petrol and gas powered auto-rickshaws grew by about 10 per cent; and based on the number of vehicles sold, for the first time that year, the sales of e-rickshaws exceeded that of auto-rickshaws. Thus, in the opinion of author, though a double-digit growth of e-rickshaws is estimated to continue in India for many coming years, the auto-rickshaws will also continue to co-exist at least for a few years. It must also be pointed out here that, while there is general slow-down of economy all over the world and also in India and there are downward trends in the sales of four-wheeler vehicles in India during the last one year, it is only the three-wheeler segment (both auto-rickshaws and e-rickshaws) which have shown double-digit growth.

As compared to a closed taxi (cab) going at 80 kmph, or a closed auto-rickshaw going at 50 kmph, the ladies (when alone) feel safer to travel in an open-type e-rickshaw going at 25 kmph. This is because if any unsocial person tries to create problems for the ladies travelling in e-rickshaw, then they can shout for help, so that the nearby people can stop the e-rickshaw, catch the unsocial person, and hand him over to the police.

## 5.2 Growth driven by owner or driver of e-rickshaw

Due to preference shown by the common people for the use of e-rickshaws for short distance travel, a large number of e-rickshaws are being purchased every month all over India, either by the drivers (if they can afford to buy), or by the agencies for giving on daily rent to the drivers. Some of the reasons for a large number of people all over India taking up the profession of “e-rickshaw driving” are given below.

- Most of the other jobs would require some skill and its training for a specified period of time by a trainer and after payment of the due fees. But, when taking up the “Driving” of e-rickshaw as a profession, an uneducated and even not so young person can easily do self-learning by driving an e-rickshaw for a few days along with a friend as the controls are very simple in an e-rickshaw. With the battery pack fully charged during night time in the house, the driver need not worry about anything (re-fuelling or re-charging) throughout the day as the e-rickshaw can comfortably cover the distance normally driven in a day. That is the reason that e-rickshaws have provided self-employment all over India to a large number of rural people of all ages (who have migrated to the cities in search of livelihood), even if they are not educated. The report [Urban Transport India, 2015] has brought out that: (1) nearly half of the drivers of e-rickshaws are uneducated; (2) nearly one-fourth have primary education; and (3) 94 per cent are in the age group of 19-50; of which, nearly half of the drivers are in the age group of 19-30.
- The Government jobs for lower-level supporting staff are very less and require minimum education up to class 10. The jobs in public-sector or private organizations are also very less, require minimum education up to class 10, and are also on contract for a period of 11 months, after which there will be a break of one or more months.
- If not as a driver, then the uneducated people in India normally work as daily or casual workers in sectors, in which most of the jobs are on contract or seasonal (such as, agriculture, construction work etc). Therefore, the people working in these sectors have to sit idle (or be job-less) whenever there is no requirement. The other area for these uneducated people has been working as helpers (with very low monthly salaries) in shops, restaurants etc. In contrast, the job as “Drivers” of e-rickshaws gives them satisfaction that they are “standing on their own feet” to support their families, assures them of year-long income, and thus, at least three square meals to their families throughout the year.
- The UTI Report [Urban Transport India, 2015] has shown clearly that, even the e-rickshaw drivers operating the rented vehicle are able to earn monthly income more than the minimum wage level specified by the Government of India; and certainly, the drivers operating their own vehicles are able to earn much more.
- The e-rickshaws operating near large offices and colleges

are able to make many trips per day with four persons (daily users) between these offices/colleges to the nearby metro station or bus stand and, thus, are able to earn a good amount every month. Similarly, the drivers operating in the evenings near temples are able to earn sufficient amount as many family members come together for prayers.

- Of course, being an unorganized sector, the drivers have nothing like retirement age or the post-retirement benefits. So, they can operate e-rickshaws as long their health permits. But for old-age, they must invest some fixed amount (say Rs.500 or more) every month in National Pension Scheme of Government of India or any other pension schemes, so that they would get some amount every month after the age of 60 years [Wikipedia, 2019].
- A study on e-rickshaws in Delhi [Singh, 2014] has analyzed that 37 per cent of the e-rickshaw drivers were either unemployed or cycle-rickshaw pullers before turning to the profession. Another 21 per cent were either factory workers or daily wage laborers involved in jobs such as painting or wood-working, where the job security is low and the physical work is relatively higher. It was also found that about 89 per cent saw an increase in their salary after they started working as e-rickshaw drivers.
- Also, the drivers of e-rickshaws have satisfaction that they are working independently and not under the order of others (as they would have felt when working as daily workers or helpers).
- Drivers of the three-wheeler e-rickshaw discovered that e-rickshaw is quieter and cleaner than a traditional auto-rickshaw. E-rickshaw is also less strenuous than cycle-rickshaw, which requires all-day peddling. Further, while the cycle-rickshaw normally carries two passengers, the e-rickshaw can carry up to four passengers. So with more rides possible in a day and with more number of passengers carried every day, the e-rickshaw is proving more lucrative than the cycle-rickshaw. One more psychological difference the people feel is that, the cycle-rickshaw driver was looked down as a manual labourer, whereas the e-rickshaw driving is recognized as a better job.
- Another favourable aspect of e-rickshaw is its initial cost of about Rs.130,000 (US\$1857, with drive range of about 80-100 km with one charge, and no registration or insurance charges in many States of India) as compared to the initial cost of more than Rs.200,000 (US\$2857) for the auto-rickshaw (plus registration and insurance charges, charges for renewal of insurance every year, and necessity of “Pollution Under Control” certificate every six month).
- The drivers of e-rickshaws have also realized that the maintenance requirement of e-rickshaw is practically negligible. Even the running charges are lower than the auto-rickshaw.

Due to the reasons discussed above, a large number of people are taking the profession of e-rickshaw driving. It is a common observation of economics and sociology that, with a large



number of young people able to earn livelihood, there would be reduction in the unemployed young people being forced to go for petty crimes.

### 5.3 Growth driven by supports from manufacturers, other organizations and government

Along with the growth driven by the preference of users and the large-scale purchase by drivers/agencies, the growth of e-rickshaws is being supported by the manufacturers, other organizations and also by the schemes brought out by many State Governments and Central Government, as given below.

- Many small and medium-scale manufacturers find it convenient and financially lucrative to import only the low cost parts from China and assemble a large number of the e-rickshaw with FRP body in India. Thus, the production of e-rickshaws has seen a large number of entrepreneurs coming up all over India, giving a rapid growth in the production of e-rickshaws in the last few years.
- “This is once-in-a-lifetime, transformational opportunity that we’re looking at,” said Goldie Srivastava, Chief Executive Officer (CEO) and co-Founder of “SmartE”, an “UBER”- style App using 800-plus e-rickshaws around New Delhi [Bloomberg, 2018]. India’s dominant ride-hailing startup, “OLA”, plans to place 10,000 e-rickshaws in its service by April 2020. “SmartE” partnered with Delhi Metro Rail Corporation is providing charging points near 10 Metro Railway stations, with plans to expand throughout the 214-station system by the end of 2020.
- Most of the State Governments in India are encouraging the deployment of e-rickshaws. For example, many cities in the State of Haryana were having small or medium-scale industries for the manufacture of parts of all types of ICE vehicles. But, in the last few years, with favourable policies of Haryana Government, a large number of medium-scale manufacturers have come-up in Haryana for producing or assembling e-rickshaws. A number of e-rickshaw manufacturers have their “Distribution Centres” in all the major cities of Haryana, making it very convenient for the buyers to see and choose the e-rickshaw. This has made e-rickshaws popular throughout the Haryana State. The same is the situation in Noida and Ghaziabad cities of Uttar Pradesh State.
- The report by UTI [Urban Transport India, 2015] has brought out that many Indian States do not allow auto-rickshaws to operate in tourist places, where only e-rickshaws are permitted. This also has given boost to the number of e-rickshaws on the road.
- Also, Gujarat Government [Prasher, 2018] had announced in Oct 2018 that subsidies worth Rs.30,000 (US\$409) for e-rickshaws with lead acid batteries and Rs.40,000 (US\$545) for vehicles with lithium-ion batteries will be provided to manufacturers for the year 2018-19. This would certainly provide incentive to the drivers and the agencies for the purchase of e-rickshaws.

- Delhi Metro Railway Corporation (DMRC) has announced [Delhi Metro Railway Corporation, 2019] that it is planning to start its own e-rickshaw services along with some private operators from its major Metro Stations to nearby places in Delhi National Capital Region (Delhi NCR, which includes Delhi city and also parts of neighbouring States of Uttar Pradesh and Haryana) just like normal e-rickshaws existing now. The passenger can do advance booking of the e-rickshaw on the “DMRC App” and can also make on-line payment or through “Metro Card”. Those Metro Stations would also have charging points and marked parking facility for the DMRC e-rickshaws. With five e-rickshaws already in service, DMRC plans to increase e-rickshaws to about 610 in phase-wise manner. The specially designed e-rickshaws with covered cabin and full front windscreen will provide the “First and Last-Mile Connectivity” within an area of 3-4 km around Metro Stations. The route will not be parallel to the metro rail and will be to the areas where there are no bus services. The e-rickshaws will be enabled with CCTV and GPS availability; and will have first-aid box and fire extinguisher. They will display help-line numbers to register grievance, complaint or suggestion, if any, by a passenger.

By October 2018, there were about 1.5 million battery powered three-wheeler vehicles in India. As many as 11,000 new e-rickshaws hit the Indian streets every month [ET, 2019], and annual sales are expected to increase faster, according to consulting firm A.T. Kearney. Three-wheeler EVs make up a market of more than Rs.100 billion (US\$1.43 billion) in India.

As the e-rickshaws do not require registrations in a number of States in India, it can be said with certainty that the actual number of e-rickshaws will be much more than the officially known figure. Various agencies are just procuring a large number of e-rickshaws directly from manufacturers and offering on daily rent or monthly contract to poor e-rickshaw drivers (who cannot afford to purchase the e-rickshaw but find it a convenient way of earning their livelihood even after paying rent to the agencies). Based on average of data collected from survey done in five cities, the UTI Report [Urban Transport India, 2015] has brought out that, while only one-half of the drivers are able to purchase their e-rickshaws, the other-half are operating the EVs taken by them from agencies on rent. Of course, the situation would be different in different cities.

It is necessary to bring one aspect regarding ownership of e-rickshaws. A driver residing in rented one room accommodation on the first or higher floors would prefer to take e-rickshaw on rent because of the non-availability of parking space and charging point for the batteries near house; for which, the driver would return the e-rickshaw to the owner at night. No driver would like the e-rickshaw to be left unattended at night on street because of chances of theft of the costly battery bank.

### 6. Availability of a large variety of e-rickshaws

With growth in sales of e-rickshaws, a number of manufac-

turers of e-rickshaw have come up in India [Mandela, 2019]. Most of these are manufacturing a range of e-rickshaws catering for various segments of use, as given below.

### 6.1 Passenger carrier

- Passenger carrier for school-going children:, that is, closed-type EV keeping safety of children in mind. Most of the parents of small children going to “Kinder Garden” or “Primary” classes prefer to admit the children in a school which is near their houses. Therefore, many small schools are collecting the children from nearby places using e-rickshaws and dropping them back to their houses after the school hours.
- Passenger carrier” for general public, that is for transport of general public between Metro Railway stations, bus stands or market to their nearby destination (mostly open type).
- Three-Wheeler EV in Airport Terminal: This is a variation of “Passenger Carrier” e-rickshaw, being used for travel inside the airport terminal, of course, made more elegant and comfortable suiting to the “aura” inside the airport terminal. After the passengers get down from the aircraft and pick-up the baggage, there is a great distance from there to the main gate where the passengers have to go to get the private/office cars, taxis (cabs) or the busses, for onward travel to the destinations in the city. Therefore for this purpose, in all big airport terminals, the administration is providing three-wheeler EV “free-of cost”, being used commonly by the old people.
- “Golf Cart”: This is another variation of the “Passenger Carrier”. As the name suggests, the vehicle has been used for the travel of “Golfer” along with the “Clubs” when the game of golf is in progress. However, these days, these ‘Golf Carts’ have found their use in “Gated-Community” type residential complexes (housing hundreds of families). In these residential complexes, there is considerable distance from the main gate to the houses. In these complexes, outside vehicles are not allowed to enter. Therefore, “Golf Cart” (Figure 3) is provided by the “Residential Associa-

tion” for “Free-Travel” of guests between the main gate and the houses. Also, these “Golf Carts” are being used by the residents for free travel between the houses and the shops located outside the main gate for the purchase of daily household items. These “Golf Carts” have low capacity battery and travel at a maximum speed of 10 kmph. When not in use by the residents during any part of the day or night, the batteries are being charged at the parking place near the main gate.

### 6.2 Goods carrier

- Goods Carrier (Figure 4), that is transport of goods (both closed type and open type) in the city. It can carry a load of 500 to 1000 kg, depending upon the power of motor and battery. These “Goods Carriers” are owned by the distribution agencies; and can be charged in their premises when these are not being used.



Figure 4: Electric goods carrier

- Three-Wheeler EV Trolley at Railway Platforms: This is another variation of “Goods Carrier”, being used by railways for transport of “passenger-booked” luggage from the “Luggage Office” to the luggage compartment in the train. These “Goods carriers” (Figure 5) are owned by the railways and can be charged near the luggage office when not in use.



Figure 3: Electric golf cart



Figure 5: Three-wheeler trolley on railway platform

Out of the two types of e-rickshaws described in 6.1 and 6.2 above, passenger carriers dominated the Indian market in 2018, accounting for over 95 per cent revenue share and are expected to continue holding the larger share in the near future as well [Business Wire, 2019]. The reason for their dominance would be: (1) the growing requirement for the rented transportation for short distance, (2) rising demand for the low-cost shared mobility, and (3) the increasing urban population in the country.

Delhi NCR has been the largest market for the e-rickshaws. Surprisingly, the “North-Eastern” States of India have also been leading the revolution of e-rickshaws.

Most of these e-rickshaws have fibre-glass body (giving strength, durability, aesthetic look along with light weight construction and low maintenance). Many of the old suppliers of e-rickshaws use “Lead Acid Battery Pack”; and since there are many reputed manufacturers of lead acid batteries in India, the initial cost of these e-rickshaws has been low. The latest designs of e-rickshaws are all based on “Lithium-ion Battery Pack”, giving driving range of more than 100 km on a single charge; but the cost of these e-rickshaws are higher than that with the lead acid batteries.

The modern e-rickshaws come with various features, like internal LED light for passenger and driver (required during evenings & nights), USB mobile charger for driver, side curtains and inclined back support for passengers.

## 7. Analysis of growth of e-rickshaws

Although there is healthy growth rate for the e-rickshaws, the vehicle manufacturers are not doing much marketing to encourage their use. The information available to the public is either from the websites of manufacturers/suppliers or the news items.

It is only the employment opportunity for the poor e-rickshaw drivers (as discussed above), that is driving the growth. Many drivers are operating their own e-rickshaws making use of some old savings and borrowing the balance amount from friends. Also, many agencies are purchasing the e-rickshaws in large number and giving on daily rent to the drivers.

For four-wheeler EVs (cars and buses), the lack of charging

infrastructure within cities or on highways is being cited as the main reason for their slow growth in India. But, for the battery-powered three-wheeler EVs owned by the driver, the battery charging can be done conveniently during night hours at home, sufficient to run the vehicle the full next day. Further, many drivers, coming home for lunch during day time and for taking rest for 1-2 hours, can do battery charging during this period also. For drivers who do not have charging facilities in houses and those who have taken e-rickshaws on rent from owners, the details are discussed in Appendices A, B and C. So, the lack of public charging infrastructure is not an issue for the e-rickshaws.

With effect from August 1, 2019, the GST (Goods & Service Tax) Council has reduced the GST to 5 per cent on electric vehicles and also on chargers [ET, 2019]. This would certainly result in reduction in the initial cost of the e-rickshaws. However, the manufacturers must look carefully and bring to the notice of Central Government in case there are still any items remaining related to three-wheeler EVs, where the GST still remains more than 5 per cent.

As transport remains under the control of State Governments, the manufacturers must try to persuade all the Indian States and Union Territories to bring uniform legislations to encourage the adoption of three-wheeler EVs. Particularly, the aspects related to driving license and registration of three-wheeler EVs are still not clear in most of the States and Union Territories.

It is well known that there is very little awareness among general public in India about the long-term economic and environmental aspects of electric vehicles. As mentioned earlier, the suppliers of EVs are not spending money on marketing of these products, and therefore, the NGOs or Government/Public Sector organizations must come forward to spread awareness among the society. One such initiative has been started [ANI, 2018] in West Bengal State of India by Eastern Auto and Power Limited (EAPL) to sensitize people about the overall benefits of e-rickshaw, what kinds of batteries are best suited for this vehicle, and what care must be taken for the maintenance of battery pack and the other parts for getting longer life of the e-rickshaw as a whole. EAPL plans to enlarge the similar initia-

tives in phase-wise manner in the other Indian States.

As is being planned by “SmartE” to provide charging points on most of the Metro Railway Station in Delhi, many NGOs can come forward to help the poor e-rickshaw drivers by providing charging stations at some central points, so that these drivers can get the battery re-charged, if necessary and can have longer running hours, if required during some special occasions.

At most of the railway stations, bus stands and many locations in Indian cities, there are parking places marked for private/office cars, taxis (cabs) and auto-rickshaws. The manufacturers and NGOs must take up with the municipal authorities to provide marked parking for the e-rickshaws also.

## 8. Discussion

Presently, the e-rickshaws have created independent identity of their own. They have positioned themselves as an affordable and clean mode of mobility with immense potential of bridging the gap between first and last mile connectivity. It is already on the path of rapid growth in India, mainly because it is able to provide livelihood to a large number of poor, young and uneducated people (as a driver).

However, presently about 50 per cent of the e-rickshaws purchased are by the contractors who give it to the driver on rent. It would be nice if the State Governments or the Public / Private Sector organizations can come forward with some schemes to distribute these e-rickshaws directly to the poor drivers who would like to operate their own vehicles. The poor people cannot get the loan directly from the banks because the e-rickshaws are not registered vehicles in most of the Indian States and these poor people cannot show any “Surety”, which is essential when taking the bank loan.

There are some organizations with vested interest, who are always voicing for prohibiting these e-rickshaws from plying in some areas, or for putting stricter laws for registration and license etc for these e-rickshaws. So far, fortunately, the Central and most of the State Governments have always supported the manufacturers and drivers of e-rickshaws, resulting in the rapid growth of these vehicles. But, the manufacturers must continue to persuade all the Indian States and Union Territories to bring uniform and encouraging legislations related to three-wheeler EVs.

A large number of medium scale manufacturers in north India are using this opportunity to manufacture or assemble the e-rickshaws using imported parts, also providing jobs to thousands of the semi-skilled people in the factories, ancillary units and in the “Distribution Centres” of e-rickshaws all over India. The States and Central Governments must provide more favourable conditions, so that there is incentive for more manufacturers to come forward and increase the production. With a large number of manufacturers and the corresponding competition, there will be competitive prices, which would benefit the poor people who would like to own their e-rickshaws.

With great improvements taking place all over the world in

the technology of lithium-ion batteries, the batteries will become lighter, driving range with a single charge will be more and the life of batteries will also become longer. The motor technology is also improving, giving more powerful motors with lesser weight. Electronics and communications have always been changing fast, resulting in low-cost controllers coming out every year with more features. Therefore, with some efforts by Central / State Governments and manufacturers, these e-rickshaws have the opportunity of improved performance and sustained double-digit growth for many years, which would help India: (1) in reducing the pollution in cities, (2) in lowering the import bill of liquid petroleum and gas, and most importantly (3) in providing the employment to the poor and uneducated people as drivers and also to the semi-skilled people in the manufacturing industry and the associated support activities all over India.

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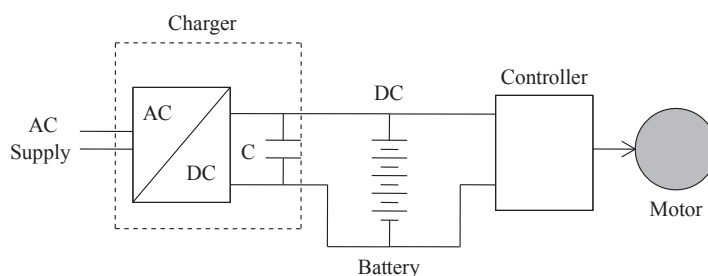


Figure 6: Schematic of battery-powered three-wheeler

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#### Appendix A: Electrical system of e-rickshaw

In simplest explanation, the three-wheeler EV is driven by electric motor, receiving power from battery pack (Figure 6).

A controller changes the power input to the motor to vary the vehicle speed. In a modern EV, the controller also continuously monitors the condition of charge of the battery pack and displays it on the panel. The charge of battery pack gets reduced as the EV keeps on covering distance. Thus, the battery capacity (Ah, ampere hour; or Wh, watt hour) decides the range that can be covered by the EV with a single charge. The driving range of three-wheeler EV can be increased by having a battery pack of higher Wh; but, that increases the size, weight and cost of the EV. Therefore, it is always necessary to select the battery capacity which would give an optimum solution of the driving range versus the weight/cost of EV.

#### Appendix B: Charging Infrastructure for e-Rickshaws

Since the battery bank of e-rickshaw is normally of small capacity, it can be re-charged at night using slow-charging from three-phase, 400 V supply. If the e-rickshaw driver has parking space in his house, then the charging can be done there. Oth-

erwise, there are many garages providing parking space and charging of e-rickshaws as there is a good business there.

For e-rickshaw taken on monthly charges from an owner, the driver will return the vehicle to the owner at night and then the owner can do the charging of many vehicles in his garage.

However, as there will be a large number of e-rickshaws to be charged simultaneously at one location, the owner must contact the power distribution company for the design of substation of adequate power capacity, as discussed in Appendices C and D.

#### Appendix C: Parking Space and Charging Power for 100 e-Rickshaws with Lead Acid Batteries

For explaining the details, "VICTORY DELUX" e-rickshaw of "Victory Electric Vehicle" [Victory, 2019] company has been considered, having Lead Acid Battery bank of 48 V and 110 Ah.

The vehicle length and width are 2,780 mm × 997 mm. Keeping some space of say 300 mm width-wise and 500 mm length-wise between two EVs, each EV needs a parking space of about 3.3 m × 1.3 m. With 20 EVs parked in one row width-wise, the total width comes to about 26 m. Then, arranging 5 such rows to park 100 EVs, the total length comes to about 17 m. Thus, 100 EVs need a parking space of about 442 sq m. If the agency has a total fleet of 1000 e-rickshaws, then it would have 10 such different facilities in the outskirts of a city.

With charging of each EV done in 7 hours at night, say from 11 PM to 6 AM, and assuming that each battery bank was discharged only up to 40 per cent, the charging required for each EV for the remaining 60 per cent (of 110 Ah) would be about 70 Ah in 7 hours, requiring a current of about 10 A. For 100 EVs, the total current will be about 1000 A at 48 V, giving about 48 kW power. Adding lighting and the other loads in the complex of say 12 kW, the total power would be 60 kW at a power factor of about 0.7. Therefore, the facility requires a three-phase 11 kV incoming lines to a pole-mounted three-phase 11 kV/400 V distribution transformer of 100 kVA capacity along with isolators, fuses etc.

#### Appendix D: Parking Space and Charging Power for 100 e-Rickshaws with Lithium-Ion Batteries

For calculation for 100 EVs with lithium-ion battery bank, "TREC YAARI" of "Mahindra and Mahindra" company

[M&M, 2019] has been taken, having 3.69 kWh battery bank of 48 V, which can be re-charged in 2 hours 30 minutes and has a guaranteed life of more than 5 years.

As the dimensions of “TREO YAARI” are nearly the same as those of “VICTORY DELUX”, this complex with 100 EVs would also need the parking area of about 442 sq m.

Assuming that during the day, the battery bank of 3,690 Wh has been discharge up to 40 per cent, it has to be re-charged for the remaining 60 per cent (that is 2,214 Wh) in 2 hours 30 minutes, requiring a power of about 886 W for each EV and about 90 kW (at a power factor of say 0.7) for 100 EVs. With other loads in the complex, the facility would require a three-phase 11 kV incoming lines to a pole-mounted three-phase 11 kV/400 V distribution transformer of about 150 kVA capacity along with isolators, fuses etc.

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