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Merits and Challenges of E-Rickshaw as An Alternative form of Public Road Transport System: A Case Study in the State of West Bengal in India

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Abstract

Battery operated electric three-wheelers or e-rickshaws have recently emerged in the public road transport sector in India. These vehicles have gained much popularity owing to the comfortable and economic mode of transport they provide to the fellow commuters. The present work is based on a case study in West Bengal state where the travel pattern of these vehicles has been studied. The average specific energy consumption of the e-rickshaws has been found to be 53.76 kJ/passenger-km, which is the most efficient among other forms of motorized three-wheeled passenger vehicles. This study also delineates the challenges that stand in the way of proper implementation of these e-rickshaws in the public transport sector.

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Keywords: Electric Vehicles, Public Road Transport, Specific Energy Consumption, Specific Energy Cost, CO_2 Emission

1. Introduction

Road transport in India plays a defining role in the country's economic progress. In case of total passenger transportation, almost 80% of the load is shared by road transport sector [1]. Economic growth is marked by an inevitable increase in transportation activities of any region. In India, the road share of passenger mobility increased from 35% in 1950-1951 to 87% in 2000-2001 [2]. Road transport sector has been a major consumer of fossil fuel in the form of liquid petroleum and gas and the majority of this energy demand needs to be imported. The economic growth in India has been marked by the preference of privatized and para-transit mode of transport by the passengers, the mobility share of which increased

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from 16.2% in 1990-1991 to 21.2% in 2000-2001, respectively, whereas the share of both buses and railways declined during this period [2]. The major increase in the per capita mobility in road transportation has been observed in case of auto-rickshaws by 130%.

Among the private and para-transit mode of passenger transportation, the three-wheeled vehicles play the most important role in ferrying passengers. This sector consists of both motorized and non-motorized modes. The motorized forms consist of vehicles that are either powered by IC (internal combustion) engines or by electric motors. The NMT (non-motorized transport) are those modes of transport which do not consume commercial energy and consist of cycle-rickshaws and van-rickshaws. This transport mode has been an important sub-sector in the transport scenario, but has not been receiving adequate attention.

In India, majority of the passenger transport activities occur in the urban areas, suburbs, and townships. In this transport mechanism, three-wheeled vehicles play the most important role as public, private and para-transit modes of transportation. Recently three-wheeled battery operated electric rickshaw or e-rickshaw has emerged in the public road transportation in West Bengal state in India, like many other parts of the country. Along with the merits of such vehicles, there remain some technical, legal, and social challenges that hinder the pathway of proper implementation of such vehicles. This study has been conducted in major urban and suburban areas of West Bengal state in India, where e-rickshaws have become operational during the last two years. The objectives of the present study were to investigate the advantages and merits of e-rickshaws over the other forms of three-wheeled vehicles, their economic and environmental impact, and also the challenges faced by the vehicles.

2. Scenario of Three-wheeled Vehicles in West Bengal

The three-wheeled vehicles for passenger road transportation in West Bengal may be segregated into two major forms; motorized transport vehicles and non-motorized transport vehicles.

2.1. Motorized Transport Vehicles

a. Auto-rickshaws (LPG based)-

Auto-rickshaws are the most widely used three-wheeled mode of public transportation. In West Bengal, these vehicles run on auto-LPG (liquefied petroleum gas), and are an integral part of the society of major urban areas, townships and suburbs. But unlike other parts in India, auto-rickshaws in West Bengal ferry passengers in a sharing mode. These auto-rickshaws have specific routes of operation recognized by the union bodies and the Regional Transport Authority (RTA) of the region. This auto-rickshaw has a capacity of carrying four passengers at a time. These vehicles are provided with proper registration from the RTAs and are required to pay road taxes. The drivers of these vehicles require proper license for driving. These vehicles have a maximum speed of 60 km/h and the fuel tank capacity varies from 15 litres to 20 litres depending on the vehicle model.

b. Auto-rickshaws (Diesel based)-

These vehicles run on high speed diesel and normally operate in the suburban areas. These vehicles have a capacity of carrying six passengers.

c. Mechanized Van Rickshaws-

Mechanized Van rickshaws are locally assembled vehicles, running mostly in suburban and rural areas. These vehicles have been reported to use water pump engines meant for irrigation or other diesel engines meant for electricity generation purpose for vehicle propulsion

mechanism. Mechanized van rickshaws have an average speed of 12 km/h and the passenger carrying capacity varied from 8 to 18. The specific energy consumption of these vehicles varied between 59.306 and 151.241 kJ/passenger-km [3].

d. Battery operated electric rickshaws or E-rickshaws-

E-rickshaws have become operational in the public transport sector in West Bengal during the last two years. These vehicles are equipped with brushless DC motors for vehicle propulsion, powered by conventional lead-acid batteries. E-rickshaws are environment friendly and have the potential to reduce the carbon foot-print due to passenger transport activities. E-rickshaws have become one of the preferred modes of transport between short distances and are operating in major urban and suburban areas and townships.

The major problem of these e-rickshaws was that they were not legalized as a public mode of transport. There remained technical problems like the manufacturing and designing of the vehicles maintaining safety standards, as these were assembled in local workshops. Thus even the safety of the passengers remained at stake. E-rickshaws were not even included in the Motor Vehicles Act 1988, hence barring the vehicles from being legalized as a public mode of transport. During the last parliamentary session, in December 2014, Government of India has passed new amendments to ensure the legalization of these vehicles [4]. The regulation directed the local authorities to register the vehicles, issue the permits, and to provide the drivers with a separate driving license. But from the technical aspect, the amendment regularized the maximum speed of the vehicle at 25 km/h and the motor size up to a maximum of 2 kW. This limit of 25 km/h speed will likely affect the environment directly due to the low speed emission of the petroleum based vehicles present in the traffic. Thus, if these vehicles are allowed to ply on thoroughfares like that of the auto-rickshaws, the traffic condition will be severely hampered. The following table shows the specifications of an e-rickshaw as available from the dealers.

Table 1. E-rickshaw specifications

Motor type	DC series excitation brushless
Power (Watt)	850 W
Charge voltage	220 V (50 Hz)
Charging time	6-10 hours
Transmission mode	Gear
Top speed	25 km/h
Continued trip mileage	80-90 km
Climb ability	$\leq$ 20 degree
Front wheel size	300-12 mm
Rear wheel size	350-12 mm
Brake type	Double rear drum brake
Ground clearance	250 mm
Dimension	2850*1050*1800 mm
Net weight	190 kg
Max load capacity	$\leq$ 400 kg

Courtesy: Zeniak Innovation India Ltd.

2.2. Non-Motorized Transport Vehicles

a. Van-rickshaw –

Van-rickshaws are three wheeled manual driven vehicles meant for both passenger and freight transport. In many townships, suburban and rural areas these vehicles are utilized at large as a public transportation mode for short distance commute. The motorized form of such vehicles has been the mechanized van-rickshaw as mentioned earlier. The passenger carrying capacity of these vehicles varies from eight to ten. The speed completely depends on the vehicle driver, although a fully loaded van-rickshaw may have an average speed of around 8 km/h [3].

b. Cycle-rickshaw-

These vehicles are the most common form of three-wheeled manual drive vehicles, found in each and every part of the state, from urban to rural areas. Cycle-rickshaws are completely meant for short distance commuting. In majority of the areas where these rickshaws operate, they operate on all types of roads, apart from the ones where they are restricted. These three-wheelers have the speed variation similar to that of the van-rickshaws and can carry two passengers at a time.

The two forms of non-motorized three –wheelers consume no commercial form of energy and thus the aspect of environmental pollution is not applicable in these cases. These are one of the major forms of passenger road transport, but are denied the adequate recognition, and lacks overall database for any of its mode [5]. The operation of these vehicles is mainly regulated by local union bodies. They have no fixed routes of operation, but have specific starting points suggested by the union bodies.

3. Methodology

The three-wheeled vehicles, as mentioned earlier, have an important role in public transport sector in West Bengal. In this study the performance of e-rickshaws were studied and compared to other forms of three-wheeled public transport vehicles to check the merits. Data regarding the operating condition of the vehicles have been collected by conducting primary surveys with formatted questionnaires among the operators, union members, drivers, and commuters at major urban and suburban areas where e-rickshaws have started operating. The energy consumption data has been measured with energy meters that were supplied to the vehicle owners. The distance transverse for a day was measured from the vehicle odometers, corresponding to the intervals of battery charging. Each set of data were collected over a week for checking the travel pattern of energy consumption of such vehicles. Again, this study took into account the energy consumption for other types of three-wheeled vehicles, and was compared to that of the e-rickshaw for a comparative analysis. The specific energy consumption was calculated for the collected data. The cost of energy consumption for the e-rickshaws has been calculated based on the electricity tariff of the respective household electric utilities of the region. This is because the sole charging point for the vehicles has been the household sockets. In the survey conducted the electric utilities involved were CESC Ltd. and WBSEDCL (West Bengal State Electricity Distribution Company Ltd.), and for both the utilities the tariff was around INR 6.40/kWh, taking into account the usage of electricity for e-rickshaw battery charging.

Due to the use of petroleum based fuels in the other form of vehicles, there remained the issue of environmental impact due to public transportation. In West Bengal, majority of the power supplied to the grid has been based on coal fired thermal power plants. Thus the charging of the battery for e-rickshaws

involves the emission of pollutants at the power plants. The survey has been extended for different types of public road transport vehicles like auto-rickshaws, buses, and AC (air conditioned) buses, for comparison of energy consumption pattern.

4. Results and Discussion

In passenger transportation, the auto-rickshaws have been the mostly utilized form that operates for both medium and short distance commute. Taking into account the driving pattern and technical characteristics, auto-rickshaws have been a good option for vehicle electrification [6]. The average fuel consumption of the auto-rickshaws was found to be around 6.04 litres/day of auto LPG for the scenario of Kolkata [7]. Again parallel running of both auto-rickshaws and e-rickshaws by replacing a certain percentage of the former by e-rickshaws showed the economic and environmental benefits [7].

But e-rickshaws have already emerged in the road transport sector in West Bengal. The data collected from the various surveys, revealed that the specific energy consumption of the present e-rickshaws have been the least among the other forms of public road transport vehicles. The average specific energy consumption of the e-rickshaws have been calculated to be around 53.76 kJ/passenger-km. Fig. 1 shows the comparison of the specific energy consumption for different types of public road transport vehicles in West Bengal.

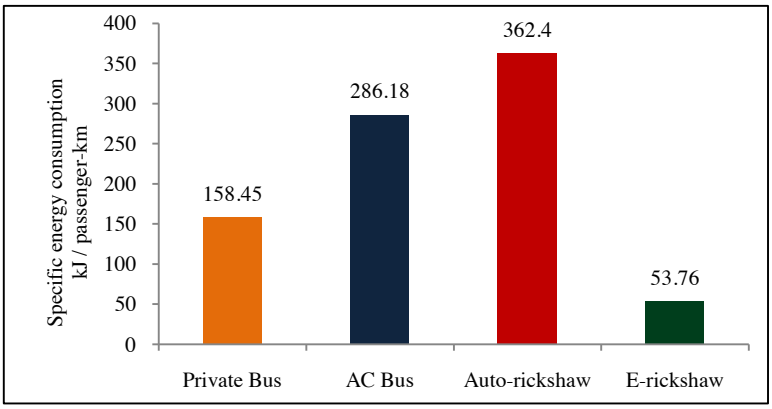

Fig. 1. Comparison of specific energy consumption of public transport in West Bengal

Taking into account the passenger carrying capacity of the e-rickshaws and the corresponding vehicle dimensions, these could have been considered as the major counterpart of the conventional three-wheeled auto-rickshaws. The average specific energy consumption for the auto-rickshaws based on propane based LPG, at INR 40.75 per litre, was calculated to be 362.4 kJ/passenger-km. The energy cost of transportation for the vehicles were calculated based on the present price of auto LPG and the rate of utility tariff as mentioned earlier. Table 2 shows the comparison between the different parameters for the e-rickshaw and the auto-rickshaw.

But the travelling pattern of the auto-rickshaws which shows the maximum speed and acceleration [6], discards the e-rickshaw as the exact counter part of the auto-rickshaws. The maximum speed condition of the e-rickshaws hinders the pathway of their implementation as a replacement for the auto-rickshaws. Compared to all the forms of motorized three-wheeled vehicles, the e-rickshaws were found to be the most energy efficient among the clan, and can be considered for exact replacement of the mechanized

van-rickshaws from which the e-rickshaws were technically superior. Table 3 shows the comparison of the specific energy consumption, passenger capacity, and specific cost of transportation among all the motorized three-wheelers.

Table 2. Comparison between auto-rickshaw and e-rickshaw

Vehicle	Propulsion Technology	Maximum speed (km/h)	Maximum distance per refuel/recharge (km)	Specific Energy Consumption (kJ/passenger-km)	Specific Energy cost (INR/ passenger-km)	Specific CO_2 emission (gm/passenger-km)
Auto-rickshaw	SI* engine	60	230–280	362.4	0.62	23.556
E-rickshaw	BLDC** motor	25	80–100	53.76	0.096	19.129

*Spark Ignition **Brushless DC

Table 3. Comparison of motorized three-wheeled vehicles

Sl No	Vehicles	Specific energy consumption (kJ/passenger-km)	Passenger capacity	Specific cost (INR/ passenger-km)
1.	Auto-rickshaw (LPG)	362.4	4	0.62
2.	Auto-rickshaw (Diesel)	285.71	6	0.41
3.	Mechanized Van-rickshaw* (Diesel)	59.306 – 151.241	8 – 18	0.086 – 0.22
4.	E-rickshaw	53.76	5	0.096

*Dutta et al.[3]

4.1. Environmental Impact

The data collected regarding the e-rickshaw travelling and charging patterns revealed that the sole battery charging option for the vehicle owners remained the household sockets. Thus the e-rickshaws could not be considered as a zero emission vehicle as the charging relates to the CO_2 emission at the thermal power stations. Coal-fired thermal power stations in India have been reported to emit 1.281 kg of CO_2 per unit of electricity generated [8]. Again CO_2 emission considering full combustion of LPG (propane base) has been 1.53 kg/litre [9]. Considering combustion of diesel for the two types of three-wheelers the CO_2 emission rate has been considered at 2.71 kg/litre [10]. Thus the specific CO_2 emission of the motorized three-wheelers for the passenger transportation has been calculated and shown in the Table 4. The results show that the e-rickshaw has been efficient than that of the other motorized versions of three-wheelers, whereas the specific CO_2 emission is higher than that of the mechanized van-rickshaws.

Table 4. Specific CO_2 emission of motorized three-wheeled vehicles

Sl. No.	Vehicles	Specific CO_2 emission (gm/passenger-km)
1.	Auto-rickshaw (LPG)	23.556
2.	Auto-rickshaw (Diesel)	21.51
3.	Mechanized Van-rickshaw (Diesel)	4.46 – 11.38
4.	E-rickshaw	19.129

4.2. Major challenges

Due to the regularization of the maximum vehicle speed and the maximum motor capacity, the major challenge of the e-rickshaws would be to meet the present day traffic conditions. If these vehicles are allowed to travel with the main stream traffic, the speed of the rest of the traffic will be restricted, as for the conventional vehicles the energy efficient speed has been much higher. But there has been no proper rule to regularize the operation of e-rickshaws. In most of the places in West Bengal no restrictions on the operating zones and even the number of vehicles has been implemented. Till date the RTAs have not taken into account the case of e-rickshaws as no rule has been included in the Motor Vehicles Act in the State unlike that of Tripura Motor Vehicles Act. Thus the local governing bodies are regularizing the e-rickshaws by charging monthly toll tax depending on the municipalities where these vehicles have been operating.

But the problem remains as the number of these e-rickshaws is still not controlled by the unions, resulting in an increasing fleet of e-rickshaws. The major reason of this out-break is unemployment in the state. Due to very less number of industrial activities the opening in the job sector has been very limited. Hence, the e-rickshaw has become the source of income for many. The low investment for buying an e-rickshaw and the less number of official formalities has led most of the youths to find this very way of income source. Table 5 shows the average age of the drivers, average daily income, and the average price of the e-rickshaw.

Table 5. E-rickshaw drivers, income and capital investment

Average age of e-rickshaw drivers (year)	Average daily income (INR)	Average price of e-rickshaw (INR)
34	572.73	1,15000

Since no proper regularization has been maintained for the e-rickshaw operating zones, these vehicles have been operating on all types of roads, from by-lanes to thoroughfares. These vehicles have no fixed routes, but the starting points are fixed by the operators and union bodies. In case of passengers, they tend to prefer the e-rickshaws as the ride has been considered comfortable by most of them and even the cost of ride has been cheaper than the NMT cycle-rickshaws or van-rickshaws. Thus two types of major conflicts have been observed regarding the operation of e-rickshaws: 1) Inter – Vehicle Conflict and 2) Intra – Vehicle Conflict.

1) Inter – Vehicle conflict

This type conflict has been observed in case of e-rickshaw operation with that of the other types of three-wheeled vehicles. In many parts of the state where e-rickshaws have come up, the stronger unions of the other vehicles have not been allowing the e-rickshaws to ply of most of the routes. Even petitions were filed against the e-rickshaws by auto-rickshaw unions stating the fact that those were not permitted to carry passengers. The stronger cycle-rickshaw and van-rickshaw unions in many places do not let the e-rickshaws to carry passengers. So, the e-rickshaws often choose to operate during the time of the day when other vehicles population is smaller. These challenges remain due to the sharing of passenger load and thus the income from transportation. Though the e-rickshaws lag behind the auto-rickshaws from the technical frontier, but are more

energy efficient and less polluting. In case of the cycle and van rickshaws, though being environment friendly, the technical aspect of e-rickshaws is superior.

2) Intra – Vehicle conflict

The increasing number of e-rickshaws has also caused a reason of concern among the e-rickshaw owners. Less initial investment and moderate income has led many to arrive at this profession as the job creation has decreased due low industrial activities in the state. So the income of the drivers from the transportation sector has been gradually decreasing due to the division of the passenger load.

5. Conclusions

The study revealed that the e-rickshaws are energy efficient than other forms of motorized public road transport vehicles in the state. Proper implementation of the e-rickshaws has the potential to address the issues of environmental pollution due to transportation as the specific CO_2 emission for the e-rickshaws was found to be 19.129 gm/passenger-km. But the major challenges are required to be addressed for the proper implementation of these e-rickshaws. The present technology of the e-rickshaw needs enhancement for the compatibility with the present day traffic. The designing of the vehicles requires maintaining safety standards for the passengers thus requiring proper inspection of these vehicles by the right authorities. The number of these e-rickshaws operating in the different regions needs proper regularization and thus the eradication of vehicular conflicts by proper route management between the passenger vehicles. E-rickshaws have the potential to reduce the fuel oil consumption for passenger transportation which may lead to both economic and environmental benefits.

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