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# Electric and Enhanced Cycle Rickshaw as Sustainable Transport System for India

**S. Devaneyan[1], Dr. V. Kirubakaran[2]**

Research Scholar [Energy Engineering], Rural Energy Centre, Gandhigram Rural Institute, Deemed University, Dindigul, Tamilnadu, India[1]

Head, Department of Mechatronics, PPGIT, Coimbatore, Tamilnadu, India[1]

Asst. Professor, Rural Energy Centre, Gandhigram Rural Institute, Deemed University, Dindigul, Tamilnadu, India[2]

**Abstract:** Most cities in India have high air and noise pollution caused by transport vehicles, especially petrol/diesel-powered three-wheelers. An improved and electric cycle rickshaw can provide a nonpolluting and silent transport system for urban and rural areas of India. It can also provide large scale employment to millions of urban and rural poor. These rickshaws can provide a safe, environment-friendly, energy-efficient and cost-effective transport system in cities and towns of India. Commercialization, technology, social and policy issues are discussed for large scale introduction of these rickshaws.

**Keywords:** Electric rickshaw, Enhanced rickshaw, Three-wheeler.

## I. INTRODUCTION

Most of the cities and towns in India are highly polluted. The main reason is the air and noise pollution caused by transport vehicles, especially petrol and diesel-powered two- and three-wheelers. In India, there are presently close to 18 million petrol-powered two-wheelers and about 1.5 million petrol- and diesel-powered three-wheelers and their population is growing at a rate of about 15% per annum1. Besides being a major hazard to people's health, these machines are guzzling huge amounts of petrol and diesel for which the country has to pay dearly in foreign exchange outflow.

It is a common sight in India and in other developing countries that during traffic jams in congested areas of the cities, these vehicles produce tremendous air pollution1. For example, three-wheeler diesel tempos in Lucknow city (capital of Uttar Pradesh) produce close to 70–80 decibel noise at a distance of 1–2 m, besides belching out huge amounts of particulates into the air. These diesel tempos have been recently banned in certain parts of Lucknow, and have been replaced by the equally polluting Tata Sumos.

Similar data exist for almost all major towns where diesel/petrol three-wheelers are being introduced. Even in rural areas the spread of diesel/ petrol three-wheelers has started affecting air quality. There is therefore an urgent need to introduce an environmentally sound transport system in cities and towns of India which is cost-effective and also provides large-scale employment for urban and rural poor. An electric cycle rickshaw can provide a non-polluting, point-to point and a silent transport system for urban and rural areas of India. Besides, it is an energy-efficient and cost-effective vehicle.

## II. EXISTING CYCLE-RICKSHAW SCENE

It is estimated that close to 2 million cycle rickshaws ply on Indian roads, carrying about 6–8 billion passenger km/ year1. The exact number could be even greater, since there are no reliable records available. In some cities and small towns, they are the major means of transport. They provide employment to more than two million rickshaw pullers, are maneuverable, completely non-polluting and hence an environment-friendly means of transport. In the narrow lanes of towns and cities, probably they are the only transport system to provide point-to-point travel. It is, however, unfortunate that deliberate policies in most of the urban towns of developing countries have been made by the concerned authorities to phase out these rickshaws. These non-polluting vehicles are being replaced by polluting (both air- and noise wise) petrol and diesel-powered three-wheelers. However, the existing rickshaws are so poorly designed that running them takes a heavy toll on the health of a rickshaw puller.

A common sight is that of the rickshaw puller getting down and pulling on foot the rickshaw with passengers. The braking system is also poor, with only front brakes on the rickshaw. Thus, when going downhill at high speeds, sudden braking produces a catapult effect which results in overturning of the rickshaw. Similarly, the seating arrangement is uncomfortable, and the aerodynamic drag of the system is high. It is therefore humanly degrading to pull the existing inefficient cycle rickshaw. Yet because of poverty and no other source of income, migrant laborers do become rickshaw pullers and suffer adverse health consequences. There are estimates that rickshaw pulling is far more stressful than even hard labor. The rickshaw manufacturing presently is an unorganized footpath industry with no quality control, and there are as many

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rickshaw designs as the cities in which they ply. These rickshaws are so poorly made that they have to be replaced completely in about two years. Thus there is a need to improve the design of the existing rickshaw to make it user-friendly and bring quality control in its manufacture.

## III.NEW DESIGN OF RICKSHAWS

Two types of cycle rickshaw has been designed and developed: (i) Enhanced pedal cycle rickshaw and (ii) Electric powered pedal cycle rickshaw.

(i) Improved pedal cycle rickshaw
The existing cycle rickshaw has been completely re engineered for the safety and comfort of passengers, and to reduce the workload on the rickshaw puller. It has three-speed gears, reduced length of long chain drives, back-wheel shaft braking, better suspension and less aerodynamic drag than the existing ones. Figure 1 shows the Enhanced pedal cycle rickshaw. This rickshaw is made of mild steel angles, is light in weight, sturdy, and has ample luggage and leg space. The weight of IMPRA is 85 kg compared to 90– 95 kg of the existing rickshaws. Its life is estimated to be between 7 and 10 years.
Our data (based on interviews with more than 300 rickshaw pullers and owners) from urban towns have also shown that a large number of rickshaw pullers are migrant laborers from villages and sometimes have the rickshaw as their sole possession1. Hence, when they sleep at night, they sometimes do so on the cramped seat of the rickshaw for the fear of it being stolen. Our design allows the seats to be arranged in such a way that a long bed results, which allows a rickshaw puller to sleep properly, without the fear of his rickshaw being stolen at night. The cost of this rickshaw is estimated to be Rs 7000 in mass production and compares well with Rs 4000–6000, which is the cost of existing cycle rickshaws.

**Fig. 1.** Enhanced pedal cycle rickshaw

(ii) Electric Powered pedal cycle rickshaw
Discussions with a large number of rickshaw pullers also revealed that their drudgery will be reduced drastically if a small motor is attached to the rickshaw, so that it can assist their pedaling whenever they experienced load, or while going uphill. The extra power may also allow the rickshaw pullers to ply the rickshaw for longer distances and thus increase their earnings per day. Consequently, the Motor has been designed, built and tested (Figure 2). It has the following components:

(a) A chassis with seating arrangement and an extended hood for both passenger and driver.

**Fig. 2.** Motor-assisted pedal cycle rickshaw

(b) A 375 W, four-pole permanent magnet DC (PMDC) motor attached to a planetary gearbox.
(c) Gear drive train so that both pedal and motor power work in tandem.
(d) Two 40 Ah, deep discharge lead acid batteries to drive the PMDC motor.
(e) A stand-alone battery charger to charge the batteries overnight.
(f) High current switches.

All these components, except batteries, were specially designed and developed. The weight (with batteries) is 150 kg. Test results have shown that this motor assisted rickshaw can easily take two passengers at a speed of 10–15 km/h to 40–45 km in continuous running and 50–60 km in stop/start mode, as experienced in congested city-traffic conditions4. Presently, the cycle rickshaws ply a distance of about 20–25 km/day, since plying longer distances is taxing on the rickshaw puller. Hence motorized rickshaw can double the distance that a rickshaw puller can cover in one shift. A simple strategy has been applied in motorized rickshaw, where the motor can be switched on by the rickshaw puller by a high current switch whenever he experiences increased loading conditions. On level roads or while going downhill, he needs to only pedal the rickshaw. Another strategy could have been to use an IC electronic sensor/controller, so that the motor would have come on automatically when the load increased. However that would have increased the cost of motorized rickshaw by about Rs 10,000–15,000. Besides, these controllers have to be imported.

Test data have also shown that when a rickshaw puller has no stake in the motorized rickshaw, he has the tendency to mostly run it on the motor. However, with a stake of either ownership or of earning maximum amount of money, the rickshaw pullers normally pedal (in motor assist mode)

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and drive the motorized rickshaw to cover maximum distances before the batteries get discharged. Thus data show that some rickshaw pullers cover up to 50–60 km on one battery charge.

The retail price of a motorized rickshaw has been estimated to be Rs 27,000. Economic analysis of running a motorized rickshaw shows that an owner can make a net profit of Rs 25,000 per year4. This assumes that loan for the motorized rickshaw will be available at 12% p.a., repayable in ten years. Such loans are available from Indian Renewable Energy Development Agency for non-conventional energy projects. Other assumptions are that the motorized rickshaw will run for 300 days per year, the fare is Rs 3/km, and it will ply for 40 km/day. Presently, the cycle rickshaws charge anywhere between Rs 3 and 5/km and hence the assumption of Rs 3/km for the motorized rickshaw is reasonable. With higher tariff, a motorized rickshaw owner will make even better profit. Our data on existing cycle rickshaw pullers' income show that they make an average profit of Rs 12,000 to 18,000/year. With the motorized rickshaw they can double this profit, since they can cover twice the distance compared to existing cycle rickshaws.

Besides being economically viable, the motorized rickshaw is also energy efficient. Thus it is instructive to look at the energy efficiency of motorized rickshaw vis-à-vis petrol- or diesel powered auto rickshaws. From power-plant to traction energy point of view, the motorized rickshaw consumes 86.5 Wh/ passenger-km compared to 175 Wh/passenger-km consumed by petrol auto rickshaws. Thus the motorized rickshaw consumes half the energy that is required by a petrol powered auto rickshaw. The following assumptions were used in the calculations:

Motorized rickshaw:
The efficiency of electric power plant, including transmission and distribution losses is 0.255 (ref. 1). Charging/discharging efficiency of batteries is 0.64. Motorized rickshaw takes two passengers to a distance of 40 km per battery charge. motorized rickshaw puller consumes 8.3 MJ of energy in food per day. Since he will pedal continuously, this energy input has also been taken into account.

Petrol auto rickshaws:
Average mileage is 25 km/l of petrol6. Calorific value of petrol is 31.5 MJ/l6.

Technological issues

1. There is need to develop a low cost sensor/controller for sensing the load of the motorized rickshaw and to switch on and off the motor accordingly.

2. There is need to develop a low cost battery charger based on switch-mode power supply (SMPS) technology, which should be rugged and could be mounted on the motorized rickshaw, so that the batteries could be charged anywhere. Presently, such rugged and low-cost battery chargers are not available.

3. The issue of battery charging has to be solved before large-scale deployment can take place. It can be addressed in two ways: (a) The motorized rickshaw puller/owner can take the rickshaw home for overnight charging, if he has an electric connection. (b) The rickshaw pullers' cooperative society can also set up a battery charging station where the rickshaw batteries can be charged. The charging can either be done by regular electricity supply or from a suitably sized solar photovoltaic (PV) unit. With PV charging, two sets of batteries will be required so that one set could be charged during daytime.

4. In the long run, there is need to develop high performance capacitors as battery substitutes. These types of capacitors are being introduced in the US and Europe for electric vehicles8 (EVs). EVs are presently limited by the battery technology. An excellent and cheap energy storage system can make EVs the transport vehicles of tomorrow.

Policy issues
1. There is need to permit only environmentally sound vehicles to operate in the congested areas of the cities. Automobiles and buses can be parked at suitable locations from where these types of rickshaws can ferry the passengers. A cluster of such rickshaw stands even in big cities, will help reduce the pollution and congestion in the cities. Similarly, in zoos, university campuses and areas of tourist attraction like heritage sites, these rickshaws should be encouraged.

2. Since both motorized rickshaw and manual pedal rickshaw are environmentally sound and user-friendly vehicles, they should get all the financial benefits available to renewable energy projects. Besides, all the Government of India schemes for providing employment to weaker sections of society should be used to give loans to rickshaw pullers who want to drive these rickshaws.

3. There is a need for the concerned authorities in India to exempt motorized rickshaw from the purview of Motor Vehicle Act since it is essentially a pedal rickshaw with a small motor.

## IV. CONCLUSION

Finally, it should be pointed out that the evolution of cities and towns has been driven by the transport system. The sprawling cities of the US developed because of automobiles. However, most European cities have integrated the public transport systems like rail, subway, bus and tram with private cars, taxis and cycles to cover the 'last mile'. This could also be possible in India where rickshaws can provide transportation to cover the last mile or kilometer. If we consciously promote vehicles which are human propelled, then we can help reduce the growth of cities and at the same time drastically reduce the energy

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used in transportation. This can show us a way towards a sustainable transport system of the future. I also hope that this article will generate interest in the large S&T community of the country to work for producing better cycle and electric rickshaws, which will help the environment and the lives of the poorest of poor of our country.

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