Final Report

Feasibility of Electric Cycle Rickshaw for Rural and Urban Transport in India

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The report is divided into the following 4 sections :

1. **Present situation** : This deals with the present situation of cycle rickshaw in India, its usage and the economic, technological, environment and other issues involved in running them. It also includes the data collected by NARI from various cities.

2. **NARI's work** in improving the existing rickshaw and then converting it into electric rickshaw.

3. **Issues involved** in plying of electric cycle rickshaw on Indian roads.

4. What are the **next steps** in furthering this project.

I. PRESENT SITUATION :

There are guesstimates that close to 1 million cycle rickshaws ply on the Indian roads carrying about 3-4 billion passengers-km/year. In some cities they are the major means of transport. They provide employment to about 700,000 rickshaw pullers, are very maneuverable and are completely non-polluting and hence environmentally friendly means of transport. It is very unfortunate that deliberate policies in most of the urban towns have been made by the concerned authorities to phase out these rickshaws. Hence these non polluting vehicles are being replaced by polluting (both air and noise wise) petrol and diesel powered 3 wheelers. One of the reasons for authorities to phase out these rickshaws is because they are considered humanly degrading. An electric cycle rickshaw can take care of this issue besides providing extra income to a rickshaw puller.

The existing cycle rickshaw has hardly changed since it is introduced in 1930's and 40's in India. The gearing and the mechanical advantage of the pedal is very poor. Hence the rickshaw puller has to work very hard while climbing even a slight slope. The braking system is very poor with only front brakes. Thus when going downhill at high speeds sudden

braking produces a catapult effect. The seating arrangement is very uncomfortable and the aerodynamic drag of the system is very high. It is therefore uncomfortable to ride and humanly degrading to pull the existing inefficient rickshaw. Nevertheless in cities for short distances (4-5 km), these rickshaws provide an effective transport system. The rickshaw manufacturing presently is a footpath industry with no quality control and there are as many rickshaw designs as cities in which they ply. Thus there is a need to improve the existing rickshaw and bring quality control in its manufacture.

During this study detailed survey on cycle rickshaws was conducted in Lucknow, Allahabad and Hyderabad. The following data was therefore collected on various issues :

A. **Economic Issues** :

1. There are about 28,000 registered cycle rickshaws in Lucknow and about 15,000 in Allahabad. In Hyderabad the cycle rickshaws are not registered any more and hence exact data on the numbers cannot be ascertained. Last four years' growth rate (data is from the Lucknow Municipal corporation where they are registered) shows an average increase of 10% per annum. In Allahabad it is about 15% per annum.

2. There are two types of rickshaws. One is called goods rickshaw which can carry between 300-500 kg of load and the other is the passenger rickshaw. Both are powered by a single person. Figure 1 and 2 show these rickshaws.

3. The goods rickshaw costs about Rs. 2,500 whereas passenger rickshaw costs between Rs. 3,500-4000.

4. Most of these rickshaws are rented out to the rickshaw puller by rickshaw owners. Rickshaw pullers are mostly migrant laborers. The rent varies from Rs. 10-15/day.

5. The average rickshaw plying charges are between Rs. 2.5-3/Km, though these vary drastically for small distances.

6. Rickshaw pullers earn wages (net) on an average of Rs. 50-60/day, though some (who are physically fitter) claim of even making Rs. 80-90/day. On an average they go 30-40 Km/day and work for 12 hours/day.

7. The rickshaw puller has to have a license for driving the rickshaw. It costs about Rs. 50/year and the rickshaw registration fee is Rs. 40/year.

8. Most of the rickshaw pullers work for 15-20 days a month and then go to their village for farm work. Thus rickshaw pullers are migrant laborers from rural areas. A single rickshaw therefore rotates through many drivers.

9. Discussions with big rickshaw owners (they own between 50-100 rickshaws each) revealed the following :

   a) The hire charges are between Rs. 12-15/day. All of them complained that their biggest headache was collecting hire charges. Quite a number of times the rickshaws are stolen by the pullers and it takes for ever to get the police to take any action. So some strong arm tactics are used which help keep these pilferage's low. They narrated quite a number of cases where rickshaws were found 200-300 km from Lucknow (in one case the stolen rickshaw was located 700 km from Lucknow !). In such cases the cost of getting police to act and bringing the rickshaw back to Lucknow is greater than the cost of rickshaw and hence any attempt to retrieve it is abandoned by the owners.

   b) They give rickshaw pullers a place to stay (which is mostly a tin shed and a rudimentary bathing/toilet facility).

   c) The biggest problem the owners face is having a suitable rickshaw parking lot. Hence most of these rickshaws are parked in the open on the road. Invariably, police fine the owners for illegal parking. The problem becomes acute when the owner has more than 50 rickshaws.

d) The maintenance cost of a rickshaw varies from Rs. 300-600/year (or 10-20% of the rickshaw cost). Because of poor construction of rickshaws any small impact or collision necessitates major repair job.

e) They think that rickshaw numbers will increase because of population increase.

f) Their estimate is that on an average their rickshaw runs for 6 months/year.

10. The nationalized banks as a part of their social responsibility have been given a mandate to provide loans to the individual rickshaw owners for buying rickshaws. However, because of problems of loan recovery they have stopped giving them. Presently private loans are given by individuals who charge hefty interest rate. They also use strong arm tactics for recovering them.

11. The competition to rickshaws in Lucknow and Allahabad is in the form of a 3-wheel diesel-driven tempo called “Vikram”. It is manufactured in a U.P. Government owned company in Lucknow. The tempo is authorized to take 5 people but normally takes 9 people. They also charge about Rs. 0.5/person-km. In Hyderabad, anecdotal evidence shows that the Bajaj Scooter rickshaws are displacing the cycle rickshaws. Thus these cycle rickshaws ply only in the congested region of old Hyderabad.

12. The tempos operate on the main roads of Lucknow and Allahabad and are the single most important cause of noise and air pollution in the city.

13. The tempos give an average of about 20-25 km/l of diesel and their speed is between 15-20 km/hr. This is because of heavy traffic, traffic lights and need to pick up passengers from different locations.

14. There are about 5100 tempos registered in Lucknow. They cost about Rs. 1,10,000/- each for which the owner can easily get a bank loan.

15. The tempo drivers earn between Rs. 100-150/day (net) and if they take school children on fixed hire basis, then their earnings can go up to Rs. 200/day. If the tempo is taken on hire, then the driver has to give Rs. 200/day as hire charges to the owner.

16. Because of too much noise and air pollution, the Lucknow Regional Transport Office (RTO) has stopped issuing registrations to these tempos. This can be very good news for rickshaws and even better news for electric rickshaws. This was confirmed during discussions with RTO. This decision was taken in 1995. However discussions with new tempo owners revealed that quite a number of new registrations are being given for under-the-table considerations !

B. **Technology Issues** :

1. Almost nothing in the design of cycle rickshaws has changed for last 60-70 years.

2. Two rickshaws kits were purchased from Lucknow and assembled at NARI. Observations were as following :

   a) The workmanship of parts is very shoddy. The manufacturing of these parts takes place in unorganized sector with no quality control.

   b) The rickshaw is generally assembled in the roadside workshops where most of the assembly is done by hand (Figure 3). Hence each rickshaw is “unique”. A similar thing was observed during assembly at NARI.

   c) The load bearing mechanism is very rudimentary and hence there is very low comfort level for rickshaw passengers. Similarly, the driving mechanism is a single chain/sprocket assembly (single gear) with long chain length such that there is a continuous slippage of chain and very poor transfer of human muscle power to rear wheel.

   d) The breaking system (which is only on the front wheel) is very poor and dangerous. The total weight of system which includes 2 passengers, a rickshaw puller and rickshaw weight comes to about 250 kg. This mass traveling sometimes at 15-20 km/hr possesses enough momentum such that sudden front wheel braking can produce a catapult effect thereby throwing the passengers forward. Some serious accidents have resulted form this action.

e) Due to the poor material used for rickshaw fabrication, the life of rickshaws is a maximum of 2-3 years. The seat and the body is made of poor quality wood and deteriorates within 1-2 years.

f) It seems that there can be a lot of improvement made in the design of rickshaw s as to make it comfortable and easy to drive.

3. There are guestimates that in Lucknow about 100 rickshaws are manufactured every day. In Allahabad the number is 1500 rickshaws/year. Most of these rickshaws are for out of town use and about 40-50 roadside manufacturers make these rickshaws. It is like a cottage industry. This high production has come only in last 3-4 years indicating that high cost of diesel/petrol and increased requirement for mobility has fueled the demand for such rickshaws.

C. **Environmental Issues** :

1. Government has collected data (this has been done in 1995 only) on the amount of suspended particulate matter (SPM) on one of the major thoroughfares of Lucknow. The major pollution producers are the tempos followed by cars and petrol powered two wheelers. This road is blocked for heavy trucks and hence the diesel trucks don't contribute to this pollution. The data shows that SPM levels of 610 PPM exist whereas the clean air act norm allows for only 200 PPM. Thus there is 3 times more air particulate matter than permissible, mainly because of diesel smoke of tempos.

2. The tempos produce noise in the range of 80-90 dB (at 1-2 m distance away). However when 10-15 of these tempos are running almost one after another and sometimes almost together during rush hour, the noise is deafening. Talking with tempo drivers revealed that they are getting deaf. They don't wear any protective ear shields and driving this vehicle for 8-10 hours per day puts a tremendous strain on their hearing capabilities.

D. **Other Issues** :

1. One of the major issues that came out during the discussions with the rickshaw pullers was of their dignity. Apparently rickshaw pullers are considered as belonging to the lowest rung of the society. They are harassed by policemen and quite a number of times

beaten up just for parking at any place. Their status is really like that of casual laborers. The rickshaw pullers always stressed the fact that policemen and others give more respect to tempo drivers. Hence they feel that motorized cycle rickshaw will give them some dignity and they will feel proud of driving it.

2. The rickshaw pullers also indicated that especially during hot season (which is generally for 7-8 months) they cannot pedal more than 25-30 km/day. Hence a motorized rickshaw would be a boon for them. When it was pointed out that it might cost about Rs. 25,000 for one rickshaw, they immediately compared this cost with tempo and three wheel petrol rickshaw costs which are about Rs. 1,10,000 & Rs. 55,000 respectively.

3. Once the rickshaw gets motorized it might come under the purview of Transport act. Thus there could be better monitoring of the rickshaw thefts and registration. This will help the large rickshaw owners who might get a better control on the whereabouts of their rickshaws.

II. **NARI's WORK** :

a) **Improvement of existing cycle rickshaws** :

1. The existing cycle rickshaw ha a very inefficient chain-drive mechanism. The mechanism consists of a single speed system with chain length of 119 cm and gear reduction ratio of 2.

   The long chain length results in constant slippage of chain at higher loads and very inefficient transfer of human power to the traction. The low gear reduction ratio puts a heavy burden on the rickshaw puller so that on up-slopes and with higher load he is unable to pedal and hence has to get down to pull the rickshaw on foot.

2. Another serious problem with the existing rickshaw design is the availability of only front wheel braking system. Thus at high speeds with sudden braking of the front wheel the rickshaw becomes a giant catapult system.

3. The existing body is made of low quality wood and hence deteriorates in 2-3 years. Besides it provides a high air drag coefficient.

4. All the above shortcomings were overcome in the new design of rickshaw. The design included the following :

   a) Shortening the chain length drive. The drive mechanism was divided into two pars – the primary and secondary drive each of ½ the length of the original.

   b) A five speed gear mechanism was put on the primary drive. This then drove the secondary drive with 1:1 gear ratio.

   c) A rear axle brake drum mechanism was installed.

   d) The body was fabricated of steel frame and steel mesh. The modifications also required changes in the frame design.

   All these changes were effected at a total cost of about Rs. 800/-. From the outside the changes are not evident at all and the look of the rickshaw remains nearly the same.

5. Trials were then conducted both on the existing and the modified rickshaw in Phaltan. The rickshaw run was done with 2 passengers on level road and on 6% slope. The results are as follows :

   a) In the regular rickshaw the puller had to get down and pull the rickshaw on foot while climbing the slope. However in the modified rickshaw he just had to put the gear on the lowest speed and could easily climb the slope without getting down from his seat.

   b) The rickshaw puller felt that it was much easier to drive the modified rickshaws. He could also go longer distance without getting very tired.

c) The back axle brake drum also worked quite well on the down slope drive with a load of 4 passengers (2 of the passengers stood on a platform at the back of the rickshaw).

d) The speeds of both rickshaws were on par with each other.

6. After the above modifications were done, it was felt that the electric traction system should be put on the improved rickshaw.

b) **Conversion of improved rickshaw into electric cycle rickshaw** :

1. The methodology followed in this development was :

a) Evaluation of load characteristics of the improved cycle rickshaw with 2 passengers and a driver. Initial assumption of the weight of batteries and motor was also made.

b) Use of an iterative methodology to optimize the voltage of motor, battery weight and aerodynamic loading of rickshaw.

c) Once the parameters of motor size, battery numbers and ampere-hour size were set (based upon item (b)) then efforts were mounted for identification of suitable motor and batteries.

d) Procurement of correct size motor was the most difficult part of the project and resulted in the maximum time lost. Initially **BALDOR** (a U.S. company) representative in India was contacted. They supplied one motor after almost 4 months which was found to be inadequate. Then another motor was ordered from them. This was a special motor based upon our design. This motor was lost by the Indian party and so a replacement was ordered. This whole exercise took about 10 months to complete. Thus valuable time was lost during this process. The third BALDOR motor was tested on the rickshaw and seemed to work allright except that the range was only 45-50 km per battery charge. Besides the motor was series wound D.C. motor with high current loss.

e) Subsequently my article on electric rickshaw appeared in one of the leading newspapers (Economic Times) of India. This article elicited response from some motor manufacturers in India. After some trials one local motor was found to be suitable. We tried 2 motors made by this local manufacturer and found one of them useful for our purpose. Consequently tests were conducted with this motor and based upon these results the manufacturer is designing the final motor for us. This motor is a permanent magnet D.C. motor.

f) All the motors procured from this manufacturer were thoroughly tested in a specially designed pony break at NARI. Hence data on load vs. current, speed, torque and efficiency were developed. This data pointed towards the optimum current and voltage on which to operate the rickshaw.

g) A smart control card has also been developed. This PC based card (made according to our design by a Pune party) has smooth start capability, controls the speed of rickshaw and limits the current to motor for high load conditions. This card is designed so that the present system is a pedal assisted electric cycle rickshaw. Figure 4 shows the electric cycle rickshaw which has been christened as NARI ELECSHA and Table 1 gives the data on this rickshaw.

Table 1

Characteristics of electric cycle rickshaw (ELECSHA)

1.	Improved cycle rickshaw weight	82.5 Kg
2.	Electric cycle rickshaw weight	229 Kg (including batteries).
3.	Motor used	1.2 kW PMDC with 1200 rpm at 36 V input.
4.	Batteries used	3 numbers of lead acid with capacity of 100 Ah. each.
5.	Suitable gearing is designed so that rpm of wheel is 250 max.	
6.	Electronic card with ability to switch on the motor when the rickshaw speed reaches 5 km/hr	

h) The rickshaw till todate has logged about 650 passenger-kms in test runs on Phaltan roads and goes at speeds of 20-25 km/hr. It has a range of about 75-80 km/charge of battery (80% battery discharge) and is a great source of attraction anytime it is run on the Phaltan roads. It has the ability to climb a 12% slope at 10-12 km/hr (with two passengers).

3. The main problems still to be solved to close the design are :

a) **Better and sturdier tires and rims** : The present rim/tire of the cycle rickshaws are designed to carry loads upto 200-250 kg. The total weight of electric cycle rickshaw with two passengers is about 400 kg. This results in frequent punctures of the tires. Efforts are on to procure a wider tire and rim.

b) The batteries used are Indian make lead acid ones. They are heavy and bulky and are not meant for deep charge/discharge cycles. We have identified Trojan battery Co of California who make batteries for deep chare/discharge cycles and which are also light in weight. It is proposed to get batteries from this company in the next phase.

c) Accelerated life cycle testing of materials of construction.

d) Improvement in the hub design (together with back wheel braking system) of the wheels so that a spare wheel could be a standard item in electric rickshaws.

e) Long term testing and improvement of the electronic control card.

We feel these problems can be solved by making 2 more rickshaws and running them extensively in Phaltan. We also feel that R&D and improvement in design is an ongoing process but the basic soundness of the design of electric rickshaw has been shown.

4. Some amount of publicity has also been received regarding our work on electric rickshaw. Besides my article in Economic Times, one of the leading Environment Magazines of South (Down to Earth) has carried an editorial which mentions our work. Consequently

some major T.V. producers of India would like to make a program on our rickshaw. I feel that we will do it after our 2 rickshaws have undergone testing in Phaltan.

III. ISSUES INVOLVED IN PLYING THESE RICKSHAWS ON INDIAN ROADS :

1. **Cost of electric rickshaw and its finance** : Presently it is estimated that the rickshaw will cost between Rs. 35,000-40,000 each. Nevertheless the exact costing can only be done after the design closure. Then only the tooling cost can be calculated. It is envisaged that the commercial banks will be approached to finance these rickshaws for owners. Some element of Govt. of India's intervention in making the necessary policy regarding soft financing of these rickshaws will have to be made.

2. **Certificate of road worthiness** : India's premier agency called Automotive Research Association of India (ARAI) in Pune will have to give a certificate of road worthiness to this rickshaw for it to be allowed by Regional Transport Commissioners for plying on Indian roads. Initial discussions with ARAI officials have revealed that they might charge about Rs. 100,000 to test this rickshaw. Talks are on to see if they can reduce these charges.

3. **Market testing in Lucknow and Pune :** It is envisaged that 20 rickshaws will be tested (10 in each city) in these two cities. The choice has been dictated by the fact that Pune has the largest number of petrol and diesel powered 3 wheelers and Lucknow has the largest number of cycle rickshaws in the country. Testing of electric rickshaw will give us all the data on user acceptability, costing, ownership profile and economic viability vis-a vis petrol/diesel powered 3 wheelers. Group (s) still need to be identified who will do the testing in these two cities. Issues regarding selling these 20 rickshaws or giving them on hire/purchase to these groups need still to be addressed.

4. **Freezing of final design :** As discussed above, the final design needs to be developed so that the test marketing of rickshaws and testing them with ARAI can take place. It is envisaged that the complete rickshaw will be shipped in a 2.5' x 2.5' x 5' box to the dealers who will assemble and then sell them. This will reduce the cost of shipment of these rickshaws considerably.

IV. **NEXT STEPS FOR FURTHERING THIS PROJECT** :

We envisage 2 phases in furthering this project. In the first phase (duration of 6 months) two electric rickshaws will be fabricated so that the final design could be frozen. In the second phase (duration of 1 year) 20 rickshaws will be test market in Pune and Lucknow. The details program of the phases are as follows :

Phase I (duration 6 months) :

There is a need to make 2 more rickshaws so that they can be tested and evaluated in Phaltan. This testing and evaluation phase will take 6 months. During this time the following will be achieved :

a) Complete analysis and performance characteristics of rickshaw so that the design could be frozen for the time being (at least for a year or two).

b) Development of complete set of Engineering drawings.

c) Identification of vendors in Pune and around Phaltan who will make various parts of rickshaw.

d) Identification of parties in Pune and Lucknow where we would like to test 10 rickshaws each.

e) Preliminary market survey.

f) Development of business plan and identification of business partners.

g) Testing of final prototype at Automotive Research Association of India (ARAI) in Pune.

Phase II (duration 1 year) :

a) Fabrication of 20 rickshaws from the engineering drawings.

b) Testing of these rickshaws in Lucknow and Pune. These rickshaws will be sold or leased on hire/purchase arrangement to parties in Lucknow and Pune and who will also provide performance and other data on these rickshaws.

c) Identification of dealers in these two towns for business.

d) Arrangements to start limited production of these rickshaws.

V. **CONCLUSIONS** :

1. This study has resulted in the design and development of a pedal assisted electric cycle rickshaw called ELECSHA.

2. This ELECSHA can carry two passengers at speeds between 20-25 km/hr on level roads. It can also climb 12% slope with speeds of 10-12 km/hr.

3. Present estimates are that ELECSHA will cost about Rs. 40,000/each.

4. Preliminary indications are that ELECSHA can serve as an inner city vehicle and can help in reducing pollution in these areas.

5. Some indications also exist that ELECSHA may become a family vehicle for urban and rural middle class and hence can fill an important niche in this segment of the market.

6. This study has also pointed towards steps that need to be taken to commercially introduce ELECSHA for the Indian roads.

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