CapaCITIES

E-Rickshaw Pilot Assessment for Udaipur, Rajasthan

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LOW CARBON • CLIMATE RESILIENT • CITY DEVELOPMENT

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1 Introduction

Udaipur is the sixth largest city in Rajasthan. As per the Census of India, the population of Udaipur in 2011 was 4.51 lakhs. The city has an area of 64 sq km under municipal jurisdiction, and is divided into 55 election and revenue wards. The city acts as an industrial, administrative, and educational centre of the region. It is also an important tourist destination for local as well as foreign travellers. The city is relatively compact with a dense road network, but is gradually growing in all directions through lower-density development. The city has a mixed-use development, especially in the city core surrounding the city palace. The city core is the hub of commercial activities, whereas the eastern part of the city is well known for industrial establishments.

In the recent decades, the city has witnessed rapid growth and development.The city is struggling with various infrastructure issues especially sustainable mobility for its citizens. In absence of a robust public transport system in Udaipur, intermediate public transport (IPT) caters to the need for mobility of citizens. IPT in Udaipur consists of auto rickshaws running on internal combustion engines (diesel and petrol), which leads to higher emissions and vehicular pollution[1]. Vehicular pollution increases the risks for various respiratory diseases and other health risks, which is a major public health concern across India's cities.

As per the RTO(Regional Transport Office)data, Udaipur had more than 6313 auto rickshaws and 2600 tempos in 2012, catering to the local mobility needs.As a result of the rising number of conventionalauto rickshaws,Udaipur has to address numerous challenges including deteriorating air quality, rising greenhouse gas emissions, and energy security risks. The number of IPT vehicles in the city is gradually increasing and over 40 per cent of auto rickshaws are more than10 years old[2],contributing substantially to the city's pollution. There is increasing consensus among planners that a range of additional measures will be required, beyond the existing policies, to mitigate the adverse impacts of transportation on these sustainability indicators.

In the above context, Udaipur Municipal Corporation plans to transform its IPT fleet by introducing e-rickshaws in the city and restrict growth of diesel/petrol based autos. The city is unique becauseof its terrain and user base and is keen to implement an initial pilot to develop a city-wide deployment plan. The Capacities project is offering to assist the city in developing and implementing a pilot to evaluate the technical capacity and workability of e-rickshaws in context of Udaipur. The results from this initial pilot will assist the city to develop a city-wide deployment plan fore-rickshaws.

[1] Low carbonmobility plan for Udaipur

[2]http://www.unep.org/transport/lowcarbon/PDFs/LCMP_Udaipur.pdf

2 Background

The Capacities project conducted an initial assessment in the city in order to obtain the bigger picture on transport and Greenhouse Gas (GHG) emissions in the city, identify problem areas and potential mitigation options. The assessment includes a Greenhouse Gas (GHG) transport inventory for the city of Udaipur for the year 2013 (refer table below), a GHG projection to 2030 and a quantification of potential GHG mitigation measures for the city.

Table 1: GHG Emissions for Transport sector in Udaipur-2013

Mode	GHG TTW	GHG WTW	BC	GHG WTW incl. BC
Passenger cars	4,658	5,822	276	6,098
Motorcycles	33,770	42,213	0	42,213
IPT (all motorized rickshaws)	11,264	14,080	2,292	16,372
Bus	2,620	3,275	293	3,567
Total passenger transport	*52,312*	*65,390*	*2,860*	*68,250*
Freight	*34,328*	*42,910*	*11,219*	*54,129*
Total transport GHG emissions	86,640	108,300	14,079	122,379
Share passenger transport	60%	60%	20%	56%
GHG per annum per inhabitant for passenger transport	0.09	0.11	0.00	0.11
GHG per annum per inhabitant total transport	0.18	0.23	0.03	0.26

Table 2: GHG Transport Emissions 2013 and Projected Baseline Emissions 2030[3]

Mode	2013 TTW	2030 TTW	2013 WTW incl. BC	2030 WTW incl. BC	% increase (TTW)
Passenger cars	4,700	13,900	5,800	17,600	300%
Motorcycles	33,800	101,100	42,200	126,400	300%
Motorized rickshaws (IPT)	11,300	45,600	14,100	66,200	400%
Bus	2,600	3,800	3,300	5,100	150%
Total passenger transport	52,300	164,300	65,400	215,400	310%
Freight	34,300	104,200	42,900	162,900	300%
Total transport GHG emissions	86,600	268,500	108,300	378,300	310%
GHG per annum per inhabitant total transport	0.18	0.38	0.26	0.53	210%

As per the projections for 2030, in the Business As Usual (BAU) scenario, the total transport GHG emissions will increase by 3 times.As part of the mitigation measures, the study established that e-rickshaws have one of the largest reduction potentials of all the measures identified. They also have a significant replication potential across other Indian cities. Based on the assessment and discussion with city officials, it was proposed to promote e-Rickshaws in the city. The expected impact is around 70,000 tCO_2 or 27% lower GHG emissions than under the BAU scenario.

2.1 Capacities Project

In the above context, the Capacities project is assisting the city to develop and implement a pilot to evaluate the technical capacity and workability of e-rickshaws in the context of Udaipur. The results from this initial pilot will assist the city in developing its city-wide deployment plan for e-rickshaws. The goal of the Capacities project is 'lower greenhouse gas emissions growth path

[3]See Annex 2 for details of all parameters and calculations performed

achieved and resilience to climate change increased in selected Indian cities'. The project aims to strengthen the capacities of Indian cities to identify, plan and implement measures for reducing GHG emissions and for enhancing resilience to climate change in an integrated manner. This first phase shall focus on mainstreaming climate change mitigation and adaption into development policies at the city level, support the city authorities in the formulation and implementation of integrated action plans and measures across priority sectors and share experiences with other cities in developing and emerging countries.

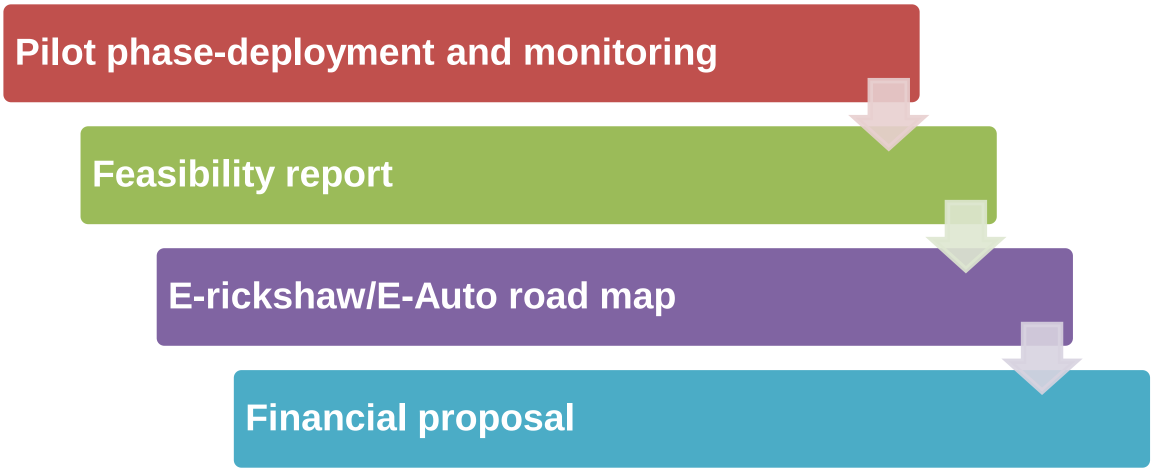
2.2 Need of E-rickshaw pilot for Udaipur

The mitigation measure to promote e-rickshaws/e-autos is of interest for further exploration,for the following reasons:

- The city of Udaipur has expressed explicit interest in this measure and would like to implement it on a large scale. The Government of India is also promoting electric vehicles and has a vision of complete electric mobility by the year 2030. The strategy is therefore in line with local as well as national policies.
- The measure has the potential to have a significant GHG, environmental and social impact (noise, air pollution) as well as improving the image of the city, specially among the tourists which are an important source of revenue for the city.
- The measure has a high visibility impact and can create a positive impulse in order to implement politically sensitive measures such as Transport Demand Management or re-organization of the public transport.
- Electric rickshaws are already plying in some cities of India. However, e-rickshaws deployed on a commercial scale are low-cost, low-power units which have a limited applicability scope due to the range and power issues. Also, there exists a risk that they will not last for long in the market due to power and quality problems. Therefore, it is essential to have a technically sound strategy if such vehicles shall be promoted.
- Rickshaws are a very common means of transport in multiple Indian cities. A successful deployment strategy could therefore be replicated widely.

3 E-rickshaw operationalization Pilot

The long-term strategy of a successful large-scale intervention includes following core steps:



1. **Pilot phase**: This includes deployment of eighteen e-rickshaws of different types (passenger and freight) and technology in the city, with close monitoring (see Annex for monitoring framework). Data is collected on conventional rickshaws as well as e-rickshaws, including data on technologies and batteries available as well as financial information. This is further complemented with stakeholder assessments. The pilot phase had duration of around 3 months. The data from this stage will be useful to develop technical, economic and financial feasibility report.

2. **Feasibility Report:** A detailed technical, financial and economic feasibility report is developed which assesses the viability of promoting e-rickshaws and proposes a potential financial structuring. This also includes the assessment of available national and international finance sources.

3. **E-Rickshaw roadmap**: This stage draws a roadmap for the implementation of e-rickshaws in Udaipur. It includes the medium and long-term perspective and the instruments to be used to achieve the goals and forms the base for the financial structuring. Stakeholder involvement in the roadmap establishment is important. At the end of this phase, a roadmap for the deployment of e-rickshaws is available for Udaipur.

4. **Financial proposal**: A financial structuring and concept will be developed, which forms the base for a financial proposal. Based on the information collected in Phase II, the identified financial institutions are targeted. At the end of this phase a financial proposal is available to be submitted to national and/or international entities.

3.1 Pilot phase to operationalize E-rickshaws

The pilot project consists of operationalizing electric rickshaws to demonstrate the benefits. ICLEI South Asia under the Capacities Project in collaboration with Udaipur Municipal Corporation, deployed 18 E-rickshaws of different categories as part of pilot initiative. An online tender was floated on the web portal southasia.iclei.org and www.udaipurmc.org on 30th Jan 2017. Based on the assessment of various e-rickshaws of different capacity, technology and power, the mix of vehicles listed below were procured.

Table 3: Details of E-Rickshaw deployed in Udaipur

Manufacturer	Model	Type	Battery Type	Load/ passenger Capacity	Number of Rickshaws
Goenka Motors	Prince	Passenger	4 Lead acid + 2 Lithium ion	4+1	6
Goenka Motors	Samrat	School Van	Lithium-ion	6+1	2
Goenka Motors	Samrat	Loading E- cart	2 Lead acid + 2 Lithium-ion	500 kg	4
Lohia Auto	Hamrahi	Passenger	Lead Acid	4+1	3
Electrotherm	ET Uvraj	Passenger	Lead Acid	4+1	3

Figure 1: Images of E-Rickshaw operationalized in Udaipur as part of pilot project

3.2 E-rickshaw operations

The E-rickshaws procured under the project are deployed on three routes decided with consultation of Udaipur Municipal Corporation and traffic police. The UMC has also provided charging points at three locations. Currently the rickshaws are owned by UMC and given to selected beneficiary from vulnerable user group at nominal charge of INR 500 per months. The fees also include cost of electricity usage at charging points.

3.3 Selection of Beneficiary /drivers

Apart from environmental sustainability, the focus of project was to promote inclusiveness and create economic opportunities/livelihood for marginalized sections of the city. Therefore, the Udaipur Municipal Corporation invited applications from Below Poverty line and handicapped categories. Beneficiaries were selected through an open lottery in the presence of the Honourable Home Minister of Rajasthan, the Mayor of Udaipur and the Municipal Commissioner. 21 candidates were selected (18 in priority and 3 in waiting list) out of which 4 were handicapped, 6 under food security and 11 from the BPL category. Among the 21 beneficiaries, 7 women candidates were selected as a way to promote social upliftment of women. Therefore the E-rickshaw pilot was also clubbed with the National Urban livelihood Mission, to provide economic opportunity.

3.4 E-Rickshaw Infrastructure

The infrastructure provided by UMC consists of parking facilities and charging points. Three places were selected by the UMC with the consultation of the CapaCITIES project team. These parking spaces are at Chetak Circle in the North, Meera Kala Mandir in the South and PWD parking near the old city as shown in Figure 5.

3.5 Routes

The routes were decided upon by the CapaCITIES implementing team in consultation with the Udaipur municipal Corporation Municipal Corporation, traffic police and RTO. The routes were prioritised so as to cover the educational, public and semi-public, medical and major commercial locations of the city. As the UMC intends to replace the IPT fleet, which requires validation of the E-rickshaws on different typologies, three different routes covering a total of around 20 kms distance were selected as shown in image below:

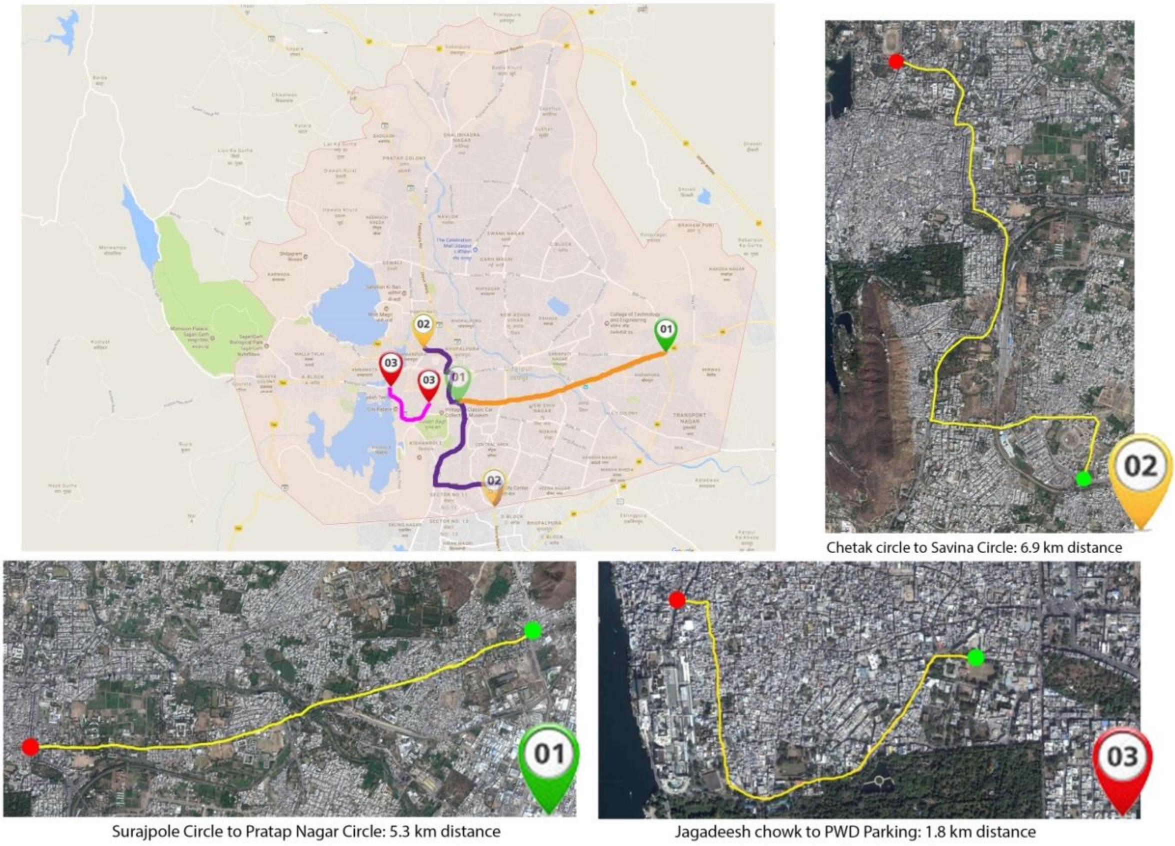


Figure 2 : Prioritized routes for e-rickshaw operations in Udaipur

Table 4 : Details of identified routes for e-rickshaw operations in Udaipur

S.no	Route	Maximum Slope
1	Surajpole Circle to Pratap Nagar Circle (East –West) -8 kms Hanuman Temple, Regional Rickshaw Stop, MB College, BN College, Pratap Nagar Railway Station, Sundarvas, Transport Nagar	8% at 3 km
2	Chetak Circle to Savina Circle Regional Rickshaw Stop Chetak, Chetak Circle, MB Hospital, Delhi Gate, UMC/ Town Hall, Surajpole, Udaipole Rickshaw stop, City railway station, Paras Circle, SavinaMandi.	5% at 5.5 km
3	Jagadeesh Chowk to PWD Parking	7% at 1.1 km

Figure 3: E-rickshaw Routes, Parking and charging facilities

4 E-Rickshaw Operations Monitoring

After the completion of background work which includes provision of infrastructure, a fleet of eighteen e-rickshaws was launched in March 2017. The pilot was inaugurated in the presence of the Swiss Ambassador, the Udaipur Mayor, the District Collector, the Municipal Commissioner and the National Director of the Smart Cities Mission.

Post the completion of the formalities, the e-rickshaws were handed over to UMC and an 11-month contract was signed between the selected beneficiaries and the UMC. Based on the discussion with the UMC and the RTO the tariff structure was finalised. The E-rickshaw drivers are supposed to charge between Rs 5 to 15 based on distance , however the maximum fare is capped at Rs 15.

As part of pilot, the operation of all e-rickshaws was monitored by ICLEI-SA. In order to collect the data, a structured questionnaire was prepared and real time data was collected on a daily basis for a period of three months. The user survey with the passengers as well as drivers provided an insight to the problems and the facilities associated with operating these vehicles. Apart from the e-rickshaws procured under project, privately operated e-rickshaws of Kinetic and conventional autos were included as part of monitoring process. Three kinds of conventional rickshaws were selected for the study, as a comparison was needed in between 6 seater vikrams , Auto rickshaws and freight vehicles which are seen in the figure.

Figure5 :six seater -Vikram

Figure4 :Auto autorickshaw

Figure6-Freight rickshaw

Figure7 Fix route passenger autorickshaw

4.1 Operations Monitoring:

Listed below are the main parameters/aspects monitored during the pilot

Technical aspects

- Power/Grade ability
- Range
- Battery durability
- Risks
- Max Speed

Economical and Financial aspects

- Capital expenditure
- Operational Expenditure
- Ecomomical return
- Financial Return

Organisational aspects

- Local Government
- Rickshaw operators
- Financial Intermediaries

4.2 Technical Aspects

Important technical aspects monitored are:

- **Power/Gradeability**: Most of the currently operational e-rickshaw versions in Indian cities tend to be low-powered due to cost considerations. Higher powered versions have a higher electricity demand which, in order to maintain driving range, results in either more batteries (limited however due to space) or a higher quality battery (Lithium-ion instead of lead-acid batteries) with a significantly higher cost. Low powered e-rickshaws have significant disadvantages concerning carrying capacity of passengers and usage in non-flat areas when compared to conventional internal combustion engines counterparts .

- **Battery durability**: The battery capacity should be higher than 80% in order to prevent range loss. The critical point is therefore the number of charging cycles with which the battery still maintains this capacity level. This is relevant for financial structuring as well as for technical optimal solutions as for example, Lithium-ion (Li-ion) batteries have a higher number of charging cycles than low-cost lead-acid batteries.

- **Top Speed**:It is the maximum speed a vehicle can attain. However, a very high speed lowers the battery efficiency (km/kWh), which reduces the ROI. High **power is withdraw**n from a battery to achieve higher speeds, which causes capacity fading in the battery, especially in the context of high slope conditions.

- **Battery Storage Capacity**: It determines the range of the vehicle. The product of capacity and mileage is called range. In the case of electric rickshaws, a higher battery capacity will increase the capital cost of the vehicle. However, fewer charging cycles due to higher battery capacity might improve the economy of the rickshaw. The battery pack design should be optimized over the cycle life of a battery, drive cycle, charging time and depth of discharge.

- **Range:** It is well known that producers of e-vehicles overstate the range of their vehicles. In actual driving conditions, the range tends to be shorter. This is related again to the battery capacity and battery quality as well as the driving conditions.

- **Recharging Time**: In electric rickshaws, the recharging time is very high. In the case of diesel rickshaws, however, the refueling time is small compared with the running time. Therefore, an alternative mechanism for quick charging is an important parameter for scalability of e-rickshaws.

- **Impact of EV charging on Grid infrastructure:** The number of e-rickshaws in the fleet determines the charging requirements, which in turn would determine the energy requirement. A large e-rickshaws fleet charged during peak-load hours,will require the addition of new infrastructure such as transformers etc.

4.3 Economic and Financial Aspects

The economic and financial data which was collected during the pilot phase allows determining incremental financial and economic costs of different e-rickshaw types, the marginal GHG reduction costs and the financial feasibility of promoting e-rickshaws. It also allows to structure a technical and financial proposal as major barriers can be identified, including access and availability of finance, additional incremental cost and higher risks of e-rickshaws.

- **CAPEX and OPEX** of conventional as well as e-rickshaws including investment cost per rickshaw type, commercial life-span and replacement investments, repair and maintenance costs, fuel usage and fuel cost and annual distance driven. A cost calculation on differential FIRRs is thereafter performed to determine the incremental cost of using e-rickshaws versus conventional units.
- The results from the pilot phase will allow determining the profitability of operating electric rickshaws. The main calculation will be a differential cost calculation in which CAPEX and OPEX are determined as well as the differential FIRR and risk rates.
- Economic benefits in terms of air and noise pollution and fuel savings is also quantified to determine EIRR.
- **Risk components** is also identified. This includes perceived or actual risks of operators and investors concerning vehicle range, battery durability, and commercial life-span of the vehicle and operating costs.
- **Finance models deployed** for existing vehicles, including how conventional rickshaws are financed (owner's capital, credit, manufacturer loans etc.).
- **E-Rickshaw Life**: the service-life policies for diesel/petrol and electric rickshaws are different. The service life of electric rickshaws is longer because of less moving components as compared with those in diesel rickshaws. A higher service life will increase the ROI and decrease the TCO.
- **Cost of vehicle**: the price of the rickshaw has a direct correlation with Total Cost of Ownership (TCO) and returns. Currently, the price (and therefore the depreciation component) is the biggest factor of the TCO. In diesel rickshaws, fuel costs are the biggest cost components in the TCO.
- **Maintenance Rate:** maintenance cost is one of the major components in the operating costs. It depends on the maintenance requirements of the moving parts, cleaning of the rickshaw, replacement of components, labour and garage space. This is expressed in "INR/ km".
- **Annual Maintenance Cost**: the annual maintenance cost is a product of maintenance rate and annual distance travelled.
- **Distance Travelled Per Day**: this represents the distance travelled by the rickshaw per day in the drive cycle data. Longer distances travelled might require the battery to be

charged more often. Also, more distances will contribute to more operating costs. Therefore, this value has to be optimal with regards to the battery capacity, to maximize returns.

- **Working Days per Year**: It is the number of days the rickshaw is in operation. For a fewdays, every year, conditions will be too extreme to operate the rickshaw, e.g., heavy rainfall etc. Lower working days per year reduces the revenue.
- **Annual Distance Travelled**: Annual distance travelled is the product of distance travelled per day and working days per year. It impacts the operating cost and return calculations. The total fuel or electricity requirement is also calculated from this value.
- **Electricity Price**: there is a direct relationship between the operating cost and price of diesel or electricity. The fuel cost is more than 50% of the TCO of a diesel rickshaw. Similarly, electricity cost is about 10%–15% of the TCO in the case of electric rickshaws.
- **Annual Fuel/Electricity Demand**: the annual fuel demand is obtained by dividing the distance travelled per year by the mileage.
- **Annual Cost of Electricity**: this value will determine the TCO and operating costs. It can be calculated from the distance travelled per year and the diesel cost or electricity tariff.
- **Fuel Inflation Rate**: inflation rates are different for diesel and electricity. Electricity is seen as a stable-growth commodity and diesel is seen as a volatile commodity; i.e., diesel shows more price fluctuations. Inflation rates will have a direct impact on the TCO and operating costs. Historically, the price of diesel has grown faster than the price of electricity. Over a longer service life period, the TCOs for electric rickshaws can be lower than those of diesel rickshaws. Inflation is one of the most important factors in sensitivity analysis.
- **Discount Rate**: this value can be taken as the general discount rate considered in the vehicle industry investments or it can be taken as the interest rate on the vehicle loan. It is the most important financial parameter to calculate the TCO and the returns, and to perform a sensitivity analysis.

4.4 Organisational Aspects

Organizational aspects include the involvement of the different stakeholders and their roles. The core idea is to providesufficient financial incentives to rickshaw operatorsso that they invest voluntarily in electric units. The pilot phase includes stakeholder mapping and determination of an optimal organizational structure which is effective and of low cost, to promote e-rickshaws.

5 Assessment of E-rickshaw operations

5.1 Technical assessment:

Maximum Power – The observed maximum power was in the range of 1200 W to 1500 W. Maximum power refers to the quantum of power that can be drawn from the diesel engine or battery in the case of electric rickshaws. However, the battery is never operated at maximum power because of safety requirements and the life of the battery.

Rated Power – The rated power was observed to be around 80 percent of maximum power. Rated power is the maximum power at which a battery can be operated. It is less than the maximum power rating of the battery. Manufacturers provide a level of operating power under which the equipment will not be damaged while allowing a certain safety margin.

Top Speed – The observed top speed with full load was between 15 to 20 km/hr compared to 25 km/hr claimed by manufacturer. Variants with lithium ion battery gave consistent speed even on slopes compared to the lead acid variant. High power is withdrawn from a battery to achieve higher speeds, which causes capacity fading in the battery, especially in the context of high slope conditions.

Range – The observed range was in the range of 55 to 65 km on single charge against the 80 km per charge claimed by the manufacturer. The lower range can also be attributed to high gradient in the city.

Battery Storage Capacity – Battery storage capacities determine the range of the vehicle. In the case of electric rickshaws, a higher battery capacity increases the capital cost of the vehicle. However, fewer charging cycles due to higher battery capacity might improve the economy of the rickshaw. During the pilot, the lead acid battery had a capacity of 110 Ah while theLithium ionone hada capacity of 80 Ah.

Based on the monitoring for 90 days, it was concluded that batteries are the most important aspect of e-rickshaws. The comparative assessment of different batteries is presented in the table below.

Table 5: Comparative analysis of Li-ion and Lead acid batteries used in E-rickshaw

Parameters of comparison	Lead acid battery operated E-rickshaw	Li-ion operated E-Rickshaw
Battery company	Amaron, East-man, Firefly	Acme
Battery cost (Rs)	22000-28000	85000
Battery charger cost	3000-4000	10000
Battery scrap cost (Rs)	55 to 70 rupee per kg	3500-4000
Subsidy by GOI[4] (Rs)	20000	45000
Mileage (km)	60-70 based on terrain and slopes.	55-60 constant.
Charging time (Hrs)	8	4
Charging point required	15A	15A
Energy consumption for single charge	5 unit	4 unit
Monthly maintenance (rupees)	80 approx.	Not required
Wear and tear in study period	1 time	7 times
Issue occurred	-	Deep discharge
Frequency of technical issue	Low	Very high
Impact of technical issues on driver's income	Low	Very high
Vehicle pickup	Reduced while driving over slopes	Same on plane or slopes
Weight (kg)	120	35
Warranty	1 year or 6 month	2 year
Battery life	8 to 10 months or 400 cycles	2 years or 1500 cycle
Service requirement	Locally available	Experts needed
Standby time	Low self-discharge	High self-discharge
Recycle	Yes	Yes, but cost will be high
Environmental impact	Sulfuric acid and lead used in batteries which are hazardous to Environment.	Much cleaner technology and are safer for the environment.
Limitation	Standby time is approximately 1 month,	cannot be stored in discharge condition

Source: Survey, observation and drivers feedback.

Table 6: Battery discharging pattern

Description	Battery type		Remarks
	Lead Acid	Li-ion	
Mileage for 100% charged battery	70Km	60km	These figures are purely depended on driving pattern
Mileage for 80% charged battery	60Km	50Km	
Mileage for 50% charged battery	40km	30Km	
Mileage for 30% charged battery	20Km	20Km	Lead acid battery vehicle moves slowly at a speed of 10 to 15 km/hr after battery discharge 25% but Li-ion has a constant speed.

Source: pilot monitoring

Based on comparison of all passenger e-rickshaw models used in the study, it was observed that Electrotherm and Kinetice-rickshaws produced more output power as they have a higher wattage motor with gear. Both the variants of e-rickshaws are able to climb slopes. The lead acid battery variant rickshaws struggle over higher gradients with full capacity. In the case of Li-ion battery operated e-rickshaws, they performed much better than regular lead acid battery operated e-rickshaws over slopes. However the frequent technical faults in Li-ion batteries highlights the fact that the manufacturer was not able to calibrate the batteries with vehicles, which is one of the technical barrier in terms of capacity of indigenous manufactuers to utilize lithium ion batteries.

[4] Gazette ofIndia, Ministryof heavy industriesandpublicenterprises, Notification 4july2017, S.O. 2199(E)
Itis on E-rickshawcostonly in caseofrickshawmanufacturercompanyis registered under FAME Indiascheme.

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Description	Passenger E-rickshaw (4 seater)				Passenger E-rickshaw (6 Seaer)	Load Carrier
	Goenka	Electrotherm	Lohia	Kinetic	Goenka	Goenka
Type ofElectricRickshaw	Prince seater	Et-uvraj 4 seater	Humrahi 4 seater	Safar 4 seater	School van6 seater	Samrat Load Carrier
Reverse Gear	Yes	Yes	Yes	Yes	Yes	Yes
Maximum Speed	25 Km/hr	Lessthan 25 Km/hr	22.13 Km/hr	Lessthan 25 Km/hr	Lessthan 25 Km/hr	Less than 25 Km/hr
CurbWeight(Weightoftheel ectricRickshawincludingBa ttery, in kg)	~460	~415	~438	NA	NA	465
LoadingCapacity(Weightof Passengers, The driverandtheluggageof 40 kg)	~350	~375	~350	~350	378	378
Laden Weight(curbweight + weightoffourpassengers , + driverandluggageof 40 kg)	~810	~790	~788	NA	NA	843
Range (in km, as per manufeturer)	90	80	80	80	80	80
Motor Output Power	900 Watts	1400 Watts	1300 Watts	NA	1500 Watt	1500 Watt
Motor Type	BLDC	BLDC	BLDC Geared Motor	Brushless DC motor	BLDC-32 MOSFET	BLDC-32 MOSFET
Motor Controller	Micro Processorbasdbrusles scontroller	BLDC	Hangzhou Yuyang Tech Co.	NA	Mirco ProcessorBasedBrusless Controller -32 MOSFE	
BatteryVoltage	48 Volt	48V	48 V	48V	48 V	48 V
BatteryCapacity	100 Ah	100 Ah	100 Ah	100Ah	100 Ah	100 Ah
Battery Type	Lead acid/ Lithium Ion	Lead acid	Lead Acid	Lead Acid	Lead acid/ Lithium Ion	Lead acid/ Lithium Ion
Gradeability	6 Degrees	7 degrees	7 Degrees	7 Degree	6 degrees	6 degrees
Groundclearance	155	130	220	130	155	155
Windshield	Yes	Yes withwiper	Yes, IS Mark Laminated, withwiper	Yes, withwiper	Yes	Yes
Brakes	Parkingand Service brakes	NA	Internallyexpanding , type brakes on all wheels	NA	Parkingandservicebrakesafeandeffi cient	Parking and service brake safe and efficient
Instrument Panel	SpeedometerandBatt ery Charge Indicator	SpeedometerandBatt ery Charge Indicator	Speedometer, Odometer, battery Level Indicator, Reverse Indicator , High Beam Indicator	SpeedometerandBatt ery Charge Indicator, High Beam Indicator	Speedometerandbatterychargeindic ator	Speedometer and battery charge indicator

Description	Passenger E-rickshaw (4 seater)				Passenger E-rickshaw (6 Seaer)	Load Carrier
	Goenka	Electrotherm	Lohia	Kinetic	Goenka	Goenka
Controls	Start /Stop ,Indicator , Horn andLights	Start /Stop ,Indicator , Horn andLightstwospeedgearswitch, hazardindicator	Throttle Control, All Lights , Horn	Start /Stop ,Indicator , Horn andLights	Start/stop,indicator,hornandlights	Start/stop,indicator,horn and lights 24 motor controller mirco processor based brusless controller -32 mosfe
Tyres	NA	4.50-10-8 PR	2.75 X 17 .6 PR	NA	3"x12" 4 plyrating	3"x12" 4 ply rating
Indicator	Yes	Yes	Yes	Yes	Yes	Yes
On Road Price Lead AcidBattery(INR)	132,821	169,120	132,000	164,968	-	137,369
On Road Price Lithium Ion Battery (INR)	241,807		-	-	271,978	247,315
ActualMileage(km) In a singlecharging	~60-70 Lead, 55-60 Li-ion	~60	~60-70	~60-70	~70	~60-70 Lead, 55-60 Li-ion
Gradeability	Li-ionmodelismoresuccessfulthenleadbattery on slopes.	seemsunstableoverslopes	Geared E-rickshaw L5 technology, canclimb on slopeseasily	Geared E-rickshaw, canclimb on slopeseasily.	-	Climb but not with full load
Tech issues	More	Less	Less	Less	More	More
Company Service	Poor	Good	Good	Good	Poor	Poor

Table 7 : Technical specifications of e-rickshaws deployed as part of pilot project

5.1 Financial Analysis

E-rickshaw fleet were deployed on different routes. They were also plied for tourist purpose as well as school Van and loading cart to evaluate their applicability in different modes and routes of the city. It was observed that the revenue potential is mostly dependent on seriousness of individual drivers. However based on the monitoring of three months on an average, daily revenue of single E-rickshaw drivers was observed at Rs. 500 to 600.

5.2 Passenger E-rickshaw rickshaw

It was observed that an e-rickshaw is plied for 6-7 hrs a day and covers an average distance of 64 km. Approximately 6 trips were made per day with an average trip length of 11 km .The average for passenger E-rickshaw was observed at around Rs.580. It was also observed that the passenger E-rickshaw covered around 8 kms of dead mileage.

Table 8 Results of passenger E-rickshaws

Particulars	Average Results	Unit
Total days	96	Days
vehicle not running due to a tech issue	15	Days
Vehicle not running driver on leave	10	Days
Total running days	72	Days
Total Running hours	438:17:45	hh:mm
Average running hours per day	6:06:57	hh: mm
Total Distance traveled	4414	Km
Average distance travelled per day	63.68	Km
Maximum run in a single charging	70	km
Average speed of vehicle	18.17	Km/hr
Average number of trips per day	6.07	Trips
Average trip length	10.62	Km
Average number of passenger	31	Passenger
Average Passenger per trip	5.20	Passenger
Maximum weight loaded by driver	Not applicable	Kg
Total Revenue earned in study period	₹ 43825	Rupee
Average revenue earned per day	₹ 579	Rupee
Average revenue earned per trip	₹ 88	Rupee
Average waiting time	16.45	Min
Type of goods	Not applicable	
Average battery charging per day	9:19:05	hh:mm
Average dead kilometers per day	7.85	km

5.3 E-carts

Four e-carts were used for the study. These rickshaws are used for selling vegetables and fruits and short trips are made for transporting grocery items. It has a carrying capacity of 400 kg on plane surfaces. The average earnings of e-carts drivers was observed at 534 rupees per day, however the full potential of these vehicles was not explored. On an average they were not plied for more than 40 km on daily basis against the potential of 60 – 70 kms.

Table 9 Results of E-Loader rickshaw

Particulars	Average Results	Unit
Total days	95	Days
vehicle not running due to a tech issue	16	Days
Vehicle not running driver on leave	17	Days
Total running days	63	Days
Total Running hours	599:40:00	hh:mm
Average running hours per day	9:45:00	hh: mm
Total Distance traveled	1888	Km
Average distance travelled per day	30.49	Km
Maximum run in a single charging	50.00	km
Average speed of vehicle	19.32	Km/hr
Average number of trips per day	1.00	Trips
Average trip length	30.49	Km
Average weight Loaded	109.83	Kg
Maximum weight loaded by driver	250	Kg
Total Revenue earned in study period	₹ 33,480	Rupee
Average revenue earned per day	₹ 534	Rupee
Average revenue earned per trip	₹ 534	Rupee
Average waiting time	65.47	Min
Type of goods	Vegetable and fruits	
Average battery charging per day	4:08:37	hh:mm
Average dead kilometers per day	4.52	km

5.4 E-school van/ shared rickshaw

Two electric school vans were used in the study. This e-school van has a capacity of 6-7 children. The drivers earn an average of 459 rupees.

Table 10 Results of E-school van rickshaw

Particulars	Average Results	Unit
Total days	94	Days
vehicle not running due to a tech issue	8	Days
Vehicle not running driver on leave	18	Days
Total running days	68	Days
Total Running hours	174:25:00	hh:mm
Average running hours per day	2:33:54	hh: mm
Total Distance traveled	2335	Km
Average distance travelled per day	34.34	Km
Maximum run in a single charging	70	Km
Average speed of vehicle	18.00	Km/hr
Average number of trips per day	3.59	Trips
Average trip length	9.57	Km
Average number of passenger	17.49	Passenger
Average Passenger per trip	4.87	Passenger
Maximum weight loaded by driver	not applicable	Kg
Total Revenue earned in study period	₹ 31,200	Rupee
Average revenue earned per day	₹ 459	Rupee
Average revenue earned per trip	₹ 128	Rupee
Average waiting time	39.18	Min
Type of goods	not applicable	
Average battery charging per day	2:36:02	hh:mm
Average dead kilometers per day	2.88	Km

5.5 Passenger share by type:

The E-rickshaw passengers can be categorized here by type as labour, professionals, tourist, student, social trips. As per the data, maximum trips were made by labourers and professionals which is respectively 31% and 27% while the percentage share of social trips is only 8%.

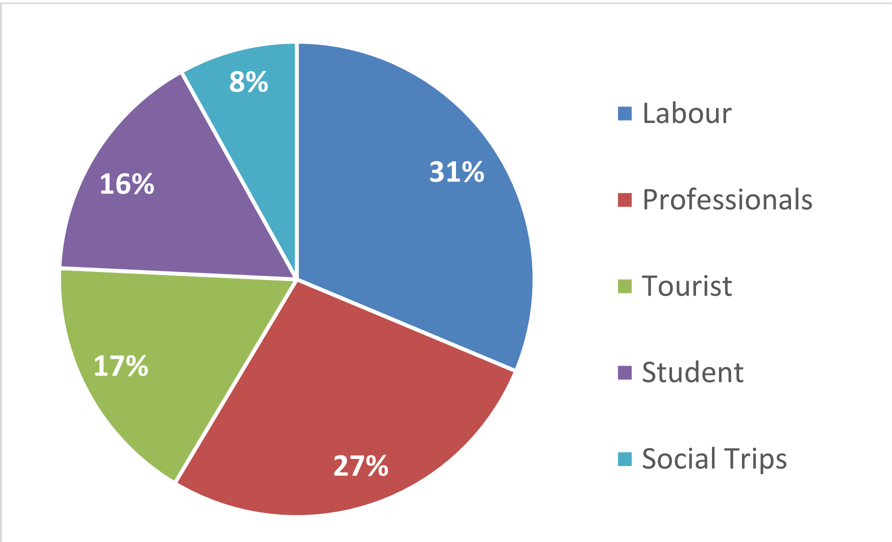

Figure 8 : Passenger share by type

5.6 Earning and expenditure

The table below presents the overall financial summary of E-rickshaw operations.

Table 11: Financial analysis of the vehicles involved in the pilot

Parameters	Passenger E-rickshaw				E- Loader rickshaw		E-School Van	Remarks
	Lohia	Goenka		Kinetic	Goenka		Goenka	
	Lead	Lead	Li-ion	Lead	Lead	Li-ion	Li-ion	
Initial investment	132,000	132,821	241,807	164,968	137,369	247,315	271,978	Vehicle cost including registration and insurance cost
Battery replacement	31429	33143	42500	31429	33143	42500	42500	₹ Per annum
Maintenance costs	9500	10172	8972	9000	10172	8972	8972	₹ Per annum
Electricity consumption	13500	13500	9000	13500	13500	9000	9000	₹ Per annum
Total O&M cost (A)	54,429	56,815	60,472	54,429	56,815	60,472	60,472	₹ Per annum
Revenue earned (B)	173,700	173,700	173,700	173,700	160,200	160,200	138,000	₹ Per annum
Net Profit (B-A)	119,271	116,885	113,228	119,271	103,385	99,728	77,528	₹ Per annum

The operational and maintenance cost and earnings are a variable parameter which increases with vehicle mileage and depends on driving patterns. The O&M cost, which accounts in between 35% of its annual income for lead-acid battery and 30% for Li-ion battery powered passenger E-rickshaw, includes the cost of routine maintenance on the vehicle, battery replacement and electricity consumption cost. The maintenance cost of the lead battery was higher compared to the Lithium ion batteries. The fuel cost for the e-rickshaw was calculated on the actual consumption of electricity. Due to higher efficiency of lithium ion battery , electricity consumption for these e-rickshaws was significant less. Additionally due to less charging time (2-3 hrs) these vehicle were able cover more distance on daily basis and thus increasing the earning potential.

5.7 Comparison between conventional rickshaw and E-rickshaw

The important parameters such as energy source, prime mover and the other accessories involved in the vehicles were studied and compared.

Table 12: Basic comparison of Vehicle feature between E-rickshaw and conventional rickshaws.

Sr. No.	Parameters	Conventional Auto (Petrol/Diesel)	Fix Route Tempo (Diesel)	Passenger E-Rickshaw
1	Energy Source	Petrol/Diesel	Diesel	Grid/ Batteries (Lead Acid/ Li-ion)
2	Energy Storage	Fuel tank	Fuel tank	Batteries
3	Extraction of Energy	Crude Oil/ Fossil fuel	Crude Oil/ Fossil fuel	Both renewable and non-renewable
4	Prime Mover	Internal combustion Engine	Internal combustion Engine	AC/DC motors
5	Speed Control	Variable speed gear box	Variable speed gear box	Motor controller
6	Prime Mover Power	~5.9 kW at 3400 rpm	~7.5 kW at 3000 rpm	~1kW-2kW
7	Breaking system	Disk breaks	Hydraulic brakes	Mechanical Drum brakes
8	Front and Rear Suspension	Front: Helical spring and Rear: Rubber compression hydraulic telescopic shock absorber.	Front: coil spring with hydraulic damper And Rear: leaf spring with hydraulic damper.	Front: coil spring with hydraulic damper And Rear: leaf spring suspension.
9	Emission	NOx, CO, HC and CO2	NOx, CO, HC and CO2	No on site Emission
10	Maximum Speed	50-60 km/hr	50 km/hr	20-25 km/hr
11	Mileage	20-25 km/lt, city	18-20 km/lt, city	60-70 km/complete charging
12	Sitting capacity	2+1	6+1	4+1
13	Gross vehicle weight (kg)	975	1250	780
14	Payload (kg)	496	558	350
15	Maximum Distance travelled per day with a full tank fuel capacity (km)	300	200	60

Table 13: Basic comparison of Loader Vehicle feature

Parameters	Loading Auto (Diesel)	Loading E-Rickshaw
Energy Source	Petrol/Diesel	Grid/ Batteries (Lead Acid/ Li-ion)
Energy Storage	Fuel tank	Batteries
Extraction of Energy	Crude Oil/ Fossil fuel	Both renewable and non-renewable
Prime Mover	Internal Combustion Engine	AC/DC motors
Speed Control	Variable speed gear box	Motor controller
Prime Mover Power	~5.9 kW at 3400 rpm	~1.5 kW
Breaking system	Disk breaks	Mechanical Drum brakes
Front and Rear Suspension	Front: Helical spring and Rear: Rubber compression hydraulic telescopic shock absorber.	Front: coil spring with hydraulic damper And Rear: leaf spring suspension.
Petrol rickshaw	Diesel rickshaw	E-rickshaw
Power source	Diesel	Electricity
Power generator	IC engine	Battery
Costs (INR)	2.7 lakhs	1.3 Lakhs
Fuel efficiency	20-25 Km/L	0.08 Kwh/Km
Fuel tariff	62/L	7 /Kwh
Fuel cost	3/km	0.6/Km
Emissions	Highest (baseline)	Zero (local)
Noise	High	Minimum'
Secondary benefits	Low	High
Major cost share in TCO	Fuel	Depreciation and battery
Maintenance	High	Lowest
ICE propulsion system, transmission, , power accessories, body	ICE propulsion system, transmission, , power accessories, body	EV propulsion system, transmission, battery charging system, power accessories, body

Parameters	Loading Auto (Diesel)	Loading E-Rickshaw
Emission	NOx, CO, HC and CO2	No on site Emission
Maximum Speed	50-60 km/hr	20-25 km/hr
Mileage	20-25 km/lt, city	60-70 km/complete charging
Gross vehicle weight (kg)	975	~380
Payload (kg)	494	~400 (reduced over gradients/ slopes)
Maximum Distance travelled per day with a full tank fuel capacity (km)	300	60 (reduced over gradients/ slopes)

Source: Information extracted from manufacturer's websites, brochures and automobile market.

Limited range is the biggest barrier for E-rickshaws since conventional rickshaws are able to cover much more distance due to zero fuelling time .

Table 14 : User and driver's feedback, issues and general opinions

Positive	Negative
Environment friendly	Poor suspension
Noise and fuel smell free	Unpleasant noise from vehicle's body
Slow in speed so probability of accidents is less	All weather protection is less
Nicely designed, good looking vehicle	slow in speed not preferable for more than 4 km travel
Best for tourist sightseeing	feeling unbalanced over slopes and un even roads
nonpolluting vehicle	Open from all sides so poor in child safety
E-school van is a safe vehicle for children	Small seats
Comfortable ride	No protection from rain
Cheap transportation facility	Rickshaw does not climb up with load after a halt
Free from hustle and rickshaw like big tempos running in city.	Narrow leg and seating space in 6 seater E-rickshaw and bad appearance.
Safe from pickpocketers	Side jalies of E-loader carrier can't open fully
	Carriage need 3-4 feet support both side
	Weather protection
	Rickshaw does not climb up with load after a halt

5.1 Economic Comparison

Table 15 : Comparison between earnings and expenditure of E-rickshaws

Sr. No.	Particulars	E-rickshaw		Auto Rickshaw		Fix route Tempo (Vikram)	E-loader		Small Loader Auto
		Lead Acid	Li-ion	Petrol	Diesel	Diesel	Lead acid	Li-ion	Diesel
1	Cost of vehicle (including RTO, insurance and Permit)	132000-165000	241807	~250000	~270000	~325000	137369	247315	~200000
2	Revenue earned per day (A)	579	579	560	560	1220	534	534	730
3	Average Fuel cost per day (Rs)	45	30	132	210	372	45	30	249
4	Average Maintenance per day	138	171	48	78	133	173	141	66
5	Total O&M cost per day (B)	183	201	180	288	505	218	170	315
6	Profit/ Earning of Driver per day (A-B)	396	378	380	272	715	316	364	415
7	Annual earning of Driver	118800	113400	114000	81600	214500	94800	109200	124500
8	Distance travelled per day (in km)	63	63	27	27	113	34	34	47
9	Profit/ Earning of Driver (Rs per km)	6.28	6.00	14.07	10.07	6.32	9.29	10.70	8.82

6 E-rickshaw Pilot – Outcomes of Pilot

6.1 Financial Impact

Based on detailed financial calculations for the pilot consisting of 18 e-rickshaws, the payback period is observed at 418 working days. Based on project life of 5 years (conservative estimates), FIRR is around 35% and EIRR around 49%.

Table 16 : Detailed financial implications (INR)

	Year 0	Y1	Y2	Y3	Y4	Y5
Income						
Fare		2016000	2217600	2439360	2683296	2951626
Advertisement		0	0	0	0	0
Total Income		**2016000**	**2217600**	**2439360**	**2683296**	**2951626**
						Outflows
Total Capex :	3274646					
Opex : Electricity Charges		151200	155736	160408.1	165220.3	170176.9
Opex : Battery replacement		580000	591600	603432	615500.6	627810.7
Opex : Maintenance		72000	79200	87120	95832	105415.2
Total Expenditure	**3274646**	**803200**	**826536**	**850960**	**876553**	**903403**
Net(Incomes- Outflows)	-3274646	1212800	1391064	1588400	1806743	2048223
Present value		1133457.944	1215009.171	1296607	1378356	1460355
Discount Rate	**7%**					
Financial IRR	**35.5%**					
Economic IRR	**49%**					

6.2 Environmental/Sustainability Impact

Eco-friendly: These vehicles are battery operated so they can be an excellent alternative to petrol/diesel conventional auto rickshaw, which causes severe pollution. These e-rickshaws do not emit smoke so they don't generate on site pollution.

Air quality and GHG reduction

Airquality benefits from electric rickshaws can be attributed to a reduction in local air pollution compared with conventional diesel and petrol e-rickshaws. E-rickshaws contribute to zero emissions (local), a major source of air pollution in urban areas. The table below quantifies the environmental benefits of the pilot.

Table 17 : Quantification of environmental benefits of pilots

Component	Reduction	Benefits in terms of Economic value
Annual emission reduced by pilot project consisting 18 e-rickshaw	45.622 tCO2 e	INR 306591.285
	261 Kg of NOx	
	132 Kg PM	

Reduced Noise

Noise pollution is linked to a number of health issues. Further still, one can also consider the effects of excess noise pollution on economic productivity; it not only causes health problems, but also decreases economic efficiency. Generally, electric rickshaws are quieter than the diesel variants by 17 decibels (dB). Diesel variants produce noise that is as loud as 70 dB, whereas electric variants tend to operate at about 60 db. Since dB is on a logarithmic scale, this means that e-rickshaws are half as loud as their diesel counterparts. Such a significant reduction in noise “at the source” has the potential to have a significant impact on well-being.

6.3 Social and Economic

Livelihood opportunity for unskilled poor community: As e-rickshaws are substantially cheaper as compared with diesel rickshaws, a large investment is not required to buy e-rickshaws and is a cheaper option for employment. The earning is quite good for an e-rickshaw driver and hence it can be an important means of livelihood for many, especially the poor. These vehicles can be large scale employment generators for unskilled and semiskilled people.

7 Key takeaways

Impact of Charging on Grid Infrastructure

When it comes to faster adoption of e-rickshaws, the lack of charging infrastructure is amongst the major barriers. India already has a peak electricity shortage of 3.7% (Press Trust of India 2014), with regular power outage being a concern in many cities. Over next few years, with rapid adoption of e-rickshaws, Udaipur may experience an increase in the load on exiting electric grid by 0.5 MW per thousand e-rickshaws. The total number of e-rickshaws would to a significant extent determines the charging requirements, which in turn would determine the energy requirement.

If a large e-rickshaws fleet is charged during peak-load hours, it will require the additional energy /power generators and will involve considerable infrastructure investment. A detailed grid supply-and-demand analysis will need to be carried out to arrive at the optimum electricity usage policy for a particular city. An analysis of load profile can show if low demand during off-peak hours can cater the need of large e-rickshaw fleet. Some loads like consumer (residential and office) electricity demands are instantaneous and need to be catered in real-time. However, an -rickshaw charging schedule can be controlled (by dynamic tariff) since they can be charged most economically during off-peak times.

Therefore, the city should assess the local distribution network capacity and shortage probability due to recharging needs and patterns. It will assist the city to formulate electricity usage policy and tariff structure for charging of e-rickshaws.

High Charging time

An e-rickshaw can run maximum 65 kms in a single charge after which it needs to be recharged. Conventional lead acid battery takes around 8 hours for charging. Lithium ion battery offers faster charging options; however, its high cost makes them unaffordable.

Battery swapping technology and Standardization of charging infrastructure

There is a need to develop and standardize the charging infrastructure so that use of e-rickshaws can be promoted. Charging, and possibly fast charging, infrastructure must be deployed or retrofitted in public spaces and petrol pumps.

It is also critical to develop standard frameworks for the charging infrastructure (including voltage norms and access). The standardization process will promote the battery swapping technology. “Battery swapping” is a way forward to promote electric rickshaws and also electric vehicles. by bringing down upfront capital cost and reduced operational cost and charging time.

The Indian Government is actively working in this direction; however,it needs the participation of manufacturers as well. Private players should be encouraged to use existing examples from around the world to explore the model (including battery loading and swapping) best suited to the local context.

Ensure reliable Supply chain

Earlier the Ministry of New and Renewable Energy (MNRE) had launched an incentive program in 2010 to promote EVs. It led to a remarkable increase in the sales of two-wheeler EVs. But in a years, many two-wheeler electric vehiclemanufacturers in India have shut down their businesses because of the receding demand. Owners of these electric two-wheelers were left with no replacement parts for their vehicles.

Therefore, scalability of e-rickshaws in Indian cities greatly depends upon the ease of availability of the spare components. Currently Udaipur has very limited availability of authorized service stations and spare parts. Therefore, development of a robust supply chain to sustain continuous demand of e-rickshaws is critical.

One of the proposed solutions for the issue is to have long-term contracts with suppliers to establish authorized service centres and ensure availability of spare parts. In addition, warranty claims and parts for replacement can be seamlessly obtained from the manufacturers. ULB can have such long-term contracts with e-rickshaws manufacturers. Moreover, municipal corporations should facilitate the procurement of vehicles from well-established vendors with proven track records. This might incur some additional efforts (from local governments initially), but might save future expenses by reducing the failure rates of batteries and vehicles, and defaults on warranty claims and services.

Parking space

Parking space is scarce and expensive within the cities. If some parking spaces along with charging facilities could be reserved for e-rickshaws, it might incentivize adoption of E-rickshaws. It would also help to address the barrier of driving range/limit for e-rickshaws.

Low output power and vehicular speed perception

Due to low output power of available models in India, E-rickshaws are comparatively slower, when operated at full capacity (4 passengers), which is around 20 km/hr. It has created a general perception amongst decision makers as well as public that e-rickshaws restrict the speed of traffic and are responsible for traffic congestion. However, it may be noted, during the peak hours on workdays, the average traffic speed of India's cities is 22.7 kmph (Ola annual survey based on data from 5 lakhs moving vehicles). Therefore, the perception about e-rickshaws slowing the traffic needs to be altered.

Embrace New Technology: Make policy to regularize E-Auto

As explained above, low output power and vehicular speed perception of one the barrier for e-rickshaw. Therefore, the government should promote the more powerful version called as e-Auto. The 3-seatere-Auto has speed upto 45 km/h. However, the absence of clarity on the vehicle specification need to be addressed before it can be plied in city. The Government of India has formulated a committee to finalise the specification of E-autos.

Training of drivers - Mechanical exploitation of batteries

It is observed that due to rash driving and lack of training to drivers, the vibrations and shocks sustained during the daily operation of e-rickshaws causes mechanical defectsin the battery. These defects might also lead to short-circuits in the cells. Therefore, a strong chassis to hold the batteries and shock-absorbing materials around the battery packs can ensure vehicle safety. Also, professional training to drivers regarding handling electric rickshaws is also useful.

8 Way Ahead/Next Steps

As explained earlier the number of IPT in the Udaipur city is gradually increasing with time and over 40 per cent of auto rickshaws are more than ten years old, substantially contributing to the city's pollution. Therefore, primary interest of the city is to phase out the old polluting rickshaws with cleaner alternative such as e-rickshaws. However, the shift has to be gradual with a multiyear strategy. Listed below are initial steps for city to move towards cleaner and sustainable IPT systems:

Develop long term, multiyear action plan to phase out existing old and polluting rickshaws:

As highlighted earlier in the report, the e-rickshaw technology is rapidly improving especially vehicle power and battery efficiency. Therefore, the strategy to shift towards electric mobility should be flexible enough to absorb the constructive developments. The initial step is to develop long term multiyear implementation plan with the well-planned phasing of existing old and polluting rickshaws. The strategy should also embrace new developments such as E-autos.E-autos are three-wheelers with a covered cabin, have speed limits below 25 km per hour and can seat four passengers (excluding the driver). They are ideal for last-mile connectivity. The e-auto can cover longer distances at higher speeds and has more stringent criteria on performance, safety and construction.

Table 18:primary specification for E-rickshaws and E-auto

	E-Auto	E-rickshaw
Speed Limit	Upto 45 km/h	Upto 25 Km/h
Energy Usage	45 w/h	35 w/h
Acceleration	42 km in 25 Sec	Not defined
Seating Capacity	3(excluding driver)	4 (Excluding driver)

Develop Electric mobility policy to support action plan

The UMC needs to formulate an electric mobility policy for various modes of public transport including IPT, to put in place the necessary support system towards implementation of electricmobility.The policy should consider various aspects such as :

- Vehicles specification/technology
- Incentives for shift towards electric rickshaw
- Charging infrastructure including load on Grid and electricity tariff

The electric mobility policy will assist city to adopt the upcoming e-Auto. In absence of any mention about e-auto in CMVR 1989, the city electric mobility policy can help to remove grey area over its operation.

Notably the central motor vehicles rules give Municipal corporation the authority to come up with its own guidelines regarding operations of an electric IPT system. Even the Government of India is planning to finalize the vehicular specification for the same.

Create awareness about shift towards electric mobility

The city should engage all key stakeholders including relevant citizen groups, IPT union and other stakeholders to create awareness about benefits of Electric IPT system brainstorm. The city should also discuss the strategy with various officials from industry, state government as well national governments to discuss the critical issues in shift towards electric IPT system.

Avail various national as well as international funding as part offinancial proposal to implement action plan

The UMC needs to develop a financial plan to implement its electric IPT strategy.The plan should also try to avail various subsidesfrom the National Government as well as clean/green climate funds.

Currently the Government of India is providing support to cities/state governments/state undertakings for Pilot Project under FAME India Scheme specifically designed to give a push to multi-modal public transport by way of extending incentives in combination of electric buses & electric 3-wheelers. As part of the pilot, the total financial support of upto Rs.105 crore will be provided to each selected city for electric public transport system. Apart from subsidies for procurement of vehicles, cities can avail funds for providing requisite charging infrastructure as well. The purpose of the scheme is to encourage comprehensive air quality solution of cities and to promote multi-modal public transportation system through shared electric mobility in the cities.

Apart from the national pilot, the city can also avail international funding through clean/green climate funds. However, to avail funding from the above sources, the city needs to submit a well-structured proposal.

Way ahead- Low Carbon Action Plan as part of CapaCITIES project

As a next step to the e-rickshaw pilot project and current feasibility report which validates the viability of Electrification of IPT system in the city, the CapaCITIES project is assisting the Udaipur Municipal Corporation to develop a 5 to 10-year action plan/road for the city to transform its IPT fleet to low carbon based on national and regional context. The action plan will include options to integrate the IPT system with public transport and recommend possible funding options to support it. Based on the learning and key takeaways from pilot phase of e-rickshaw project, the action plan would assist city to overcome various identified barriers such as regulatory, technical as well as infrastructure.

The action plan would outline the need for infrastructural requirements such as parking areas, maintenance facilities, along with institutional structures to check vehicle specifications, performance monitoring schedules, fare structures/ revisions etc. It shall also develop financial plan as well as institutional mechanism for implementation. The action plan will try to capitalize various incentive available from national government to implement its vision of 100 percent electric transport system by the year 2030.