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## PRESENTATION ON RETROFITTING EV KIT ON EXISTING RIKSHAW

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## THE HISTORY OF ELECTRO-MOBILITY

- Electromobility has always been an issue that has helped drive the development of vehicles. It did become less important for a while because the oil fields did not appear to be drying up, but now electromobility is becoming increasingly significant as people became aware of the depletion of oil reserves and the need for global environmental and climate protection.
- For India it is of very high importance as India is second largest importer of oils, and a huge amount of foreign reserve is used for importation of oils.
- In the year of 1821 Thomas Davenport builds the first electric car with non-rechargeable battery with a range of 15 to 30 km.
- In the year 1860 the rechargeable lead –acid battery was invented.
- In the year 1881 the first officially recognized electric vehicle is a tricycle made in Paris, using a rechargeable lead-acid battery. The vehicle achieved the speed of 12 KMPH.
- In the year 1900 Ferdinand Porsche presents a vehicle with in-wheel motors on both wheels of the front axle at the world exhibition in Paris.
- In the year 1985 the world's first race for solar powered cars, the "Tour de Sol" is staged in Switzerland.
- PSA Peugeot Citroen builds 10,000 electric vehicles from 1995 to 2005.
- In the year 2008 The exclusively electric powered "Tesla Roadster" built by Tesla Motors is launched in US market with 6187 laptop batteries connected in series.

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## E- mobility and its impact-India

**Environment –**

- Climate change
- Reduction of global CO 2 Emissions
- Reduction of Noise emission
- Awareness of consumption of raw materials.

**Economy –**

Limited Oil reserve
Rising prices for fossil fuels
Desire for independence from oil exporting countries
Infrastructure -
Comprehensive infrastructure to supply energy for EV

**Technology –**

- Technical advantage of electric motor compared with IC engine.
- Increase in efficiency
- High voltage safety

**Society -**

Growing mobility
Increasing urbanization
Increasing acceptance
Increasing demand

**Policies --**

International specifications for emission limits.
Development plans and subsidies.

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## ADVANTAGES OF ELECTRO MOBILITY

- Electric drive motors run quitter than IC Engines. The noise emission from EV is very low.
- EV produce no harmful emission or green house gases while driving. If battery is charged from renewable energy sources, an EV can be run $CO_2$ free.
- EV motors is very robust requires little maintenance.
- Electric motors have a high efficiency of up to 96% compared with IC Engines that have an efficiency of 35-40%
- Electric drive motors have an excellent torque and output characteristics. They develop maximum torque from standstill. This allows an electric vehicle to accelerate considerably faster than a vehicle with ICE producing the same output.
- The drive train design is simpler because vehicle components like transmission, clutch , starter, alternator, spark plug are not required.
- The electric drive have the regenerative capabilities, that means the batteries can be charged during braking.
- The energy is only supplied when the user need it. Compared with conventional vehicles the electric drive motor never runs when the vehicle stops at red light. The electric drive motor is highly efficient particularly in traffic jams and bumper to bumper traffic.
- Electric drive minimizes the no of moving components compared to ICE and thus the maintenance requirements are drastically low.

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## DISADVANTAGES OF ELECTRIC VEHICLES

- Electric vehicles have limited range due to the battery size and construction.
- Charging high voltage battery can take a long time, depending upon the battery charge and power source.
- The network of  electric charging station is yet to be develop in India.
- If the destination is beyond the range of electric vehicle, there might be necessity to carry range extender or have the battery charging facility on the way.

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## WHY ELECTRIC VEHICLE?

- The Indian auto industry is one of the largest in the world which accounts for 7.1% of the country's Gross Domestic Product (GDP). Production of passenger vehicles, commercial vehicles, three wheelers and two wheelers grew at 5.41% in FY17 to 25 million vehicles from 24 million vehicles in FY16.
- Exhaustion of fossil fuels, environmental concerns and increase in energy costs is compelling India to shift to electric mobility. E-mobility is the future and the most potential solution.
- Committing to the Paris Agreement, India has announced a major transformation to electric vehicles by 2030. The Government has also initiated Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) scheme which provides incentives for purchasing electric vehicles.
- National Electric Mobility Mission Plan (NEMMP) 2020' which was formed in 2013 addresses issues of National energy security, vehicular pollution and growth of domestic manufacturing capabilities.
- Government's vision is to see six million electric and hybrid vehicles by 2020.
- Unlike vehicles with ICE, electric vehicles do not produce exhaust gases during operation. This alone makes electric vehicles more environmentally friendly than vehicles with conventional technology.

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- With pollution levels going high and global warming the vehicles using fuel are being replaced with non polluting all electric vehicles.
- In India also the electric vehicle movement has started, Mahindra has started manufacturing all electric car in Banglore, Honda has brought all electric two wheeler on the road. Government has imported all electric buses for parliament,  in New Delhi,  and in Nagpur, and Delhi, all electric three wheelers are replacing existing three wheelers on road.
- In the near future the market for all electric vehicles and components in India will be huge. If one can go in to this business at this stage, when there is total vacuum, can enjoy benefits of leader.

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## TRANSPORT SECTOR - INDIA'S GREATEST POLLUTER

- Transportation comprises 51% of pollution in India, and in urban area, 75-80%
- Earth has oil sources which can last for about 40 years.
- World wide the movement of Electric vehicles has started long ago and EV's are on the road in developed countries.
- In India, the movement of EV has started recently, and expected to pick up the speed in near future.
- Development of EV in India started by Mr. Chetan Mani. Chetan's petrol free race across Australia inspired him to work on delivering zero emission mobility solutions.
- In 1994 he founded REVA to give sustainable mobility via affordable electric cars. The first Reva was rolled out in 2001 in Bangalore, and 2004 in London.

# EV _ Is it the answer?

- EV solves two major issues – **Climate change and Energy Security**
- Lowers overall energy consumption and emission regardless of source
- Much lower in noise pollution
- Use available power sources
- Initial cost is high however, profitable in long run

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## Barriers to Electric Vehicles.

- Higher cost of EV, every individual cannot afford the high cost of EV. The target in first phase is to convert mass transport system to EV
- Challenges in Battery technology, Battery cost is very high as well battery charging time is considerably high. Fast charging batteries are comparatively costly. Government is giving cash subsidiary of about RS 10,000 per KW on Li-FE batteries to bring down the cost.
- Limited range of EV, Battery required to give considerable range add on weight to vehicle, also the battery cost is directly proportional to battery capacity.
- Lack of infrastructure, Charging infrastructure not yet developed. Soon all HP and BP petrol stations will have charging stations. Also the battery swapping options are available.
- Consumer mindset,
- In-adequate government support, now recently government has declared support in many areas and policies are framed to push the EV in mass transport segment and on passenger vehicle segment also. (FAME II, higher depreciation, income tax rebate and cash incentives to promote EV)

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## WHY RETROFITTING ELECTRIC KIT?

As per the government directives the BS IV emission standard vehicles manufacturing and sales will stop from April 2020.

In due coarse BS IV emission standard and older vehicles will be removed from road.

The amount of such vehicles is very high, and all of a sudden if these vehicles are removed from system, they will not be replaced with new vehicles immediately. This may create a shortage of vehicles on road.

Secondly the investment required for replacement is very high, and all transport operators may not afford such investment.

*Retrofitting the electric kit is a best solution, As the old vehicles can get new life and can be brought back on road by replacing the IC Engine, Gear box, and transmission. By retrofitting we can create an asset out of old vehicle, which probably has no value.*

Retrofitting helps in Cost savings, implementation of re-use concept, best option for individuals, & Reduced load on recycling, and faster roll out,

- Reduce – Use of oil & Emissions –Braking loss, transmission loss, Engine loss, Standby/idle loss.
- Reuse – Existing vehicle, pocket friendly, minimize the resources consumption
- Recycle – Used components from old vehicles.

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## WHY SHOULD WE RETROFIT THREE WHEELER

The electric three-wheeler market in India is estimated at ~$970 Million in 2019 and has the potential to go past $1.7 Billion by 2025.

The market is having very high CAGR of 45% plus.

## FIRST TIME E RIKSHAW SALE EXCEED THE ICE SALE.

India has emerged as the largest three wheeler industry with a large domestic market and export base.

As per data shared by the Society of Manufacturers of Electric Vehicles (SMEV), sales of electric three-wheeler segment grew 21 percent during 2018-19 to 630,000 as against 520,000 sold in 2017-18.

In 2018, sales of petrol, diesel and CNG-powered passenger three wheelers grew by just 10.6 percent to 572,400 units.

However, most of such electric three-wheelers are from the unorganized market and are considered an assembly of cheap parts imported from China.

The rush for the electric three-wheeler is driven not just by the call of the government but from the ownership economics of these vehicles also.

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## SPECIFICATION OF Petrol/Diesel/CNG RICKSHAW

Curb weight – 406 kg

Weight of passenger – 266 kg

Luggage weight – 40 kg

Total weight – 712 kg

Engine 9.11 hp @4800 rpm, 10.05 hp @ 5100 rpm

Fuel tank capacity 3 litre petrol

Max working speed 70 kmph

Max gradeability – 18%

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The main driving force behind this is Total ownership Cost. The petrol powered rikshaw has a operating cost of RS. 4 per km, where as the e- rikshaw is less than RS. 0.4 per km. (considering Power cost @8 RS per KWH, charging cost is about 0.32 RS/KM)

Due to this cost advantage the e-rikshaw is sold at a premium cost of 15-25%.

The major disadvantage in E rikshaw on roads is the range, which is about 120-130 km for full charge where as the petrol rikshaw goes about 200 km for a full tank.

The range can be extended by using higher capacity or high watt density battery, however it attract additional cost.

More than 10 companies are involved in developing E- three wheelers with many of them in advance stages of launching in due course.

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## WHAT IS DRIVING E-RIKSHAW TO A COMPETITIVE MARK?

Country being home to about 1.5 million battery-powered three-wheelers, the e-rickshaw market is expected to be selling 1,00,000 units per month pan India with a major chunk being monopolised by the unorganised players.

Affordability, better value proposition in shared mobility space, and higher take home income are three core unique selling points.

**Easy to maintain, e-rickshaws generate an income of Rs 800-1000 per day for the owner.**

Last mile commercial transportation in India is driven by one factor alone i.e economics. And you cannot beat the total cost of ownership of an electric three-wheeler, even with an expensive battery pack.

The daily rental is about 300 Rs, where as the income is about RS. 800 -1000 per day.

The cost of maintenance is also reduced by more than 80% as there are no moving parts.

Starting from a small amount of Rs. 50,000 as compared to more than 150,000 from the organised players, affordable e-rickshaws are a fast moving segment providing last mile connectivity and definitely grow further in the areas where transportation still poses a challenge. The life of these vehicles is limited.

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## WHY E- RIKSHAW IS EXPENSIVE COMPARED TO IC ENGINE RIKSHAW

Electric three wheeler are more expensive than fossil fuel powered three wheeler, due to the high cost of batteries. The replacement cost of battery is likely to further boost the operating cost.

The battery technology is developing very fast, the battery prices are expected to be half by end of this year. Currently government is giving subsidiary of RS 10,000 per KW of battery power, but only for new vehicles.

In order to make higher penetration of e mobility the battery subsidiary should be extended for the retrofitted vehicles also.

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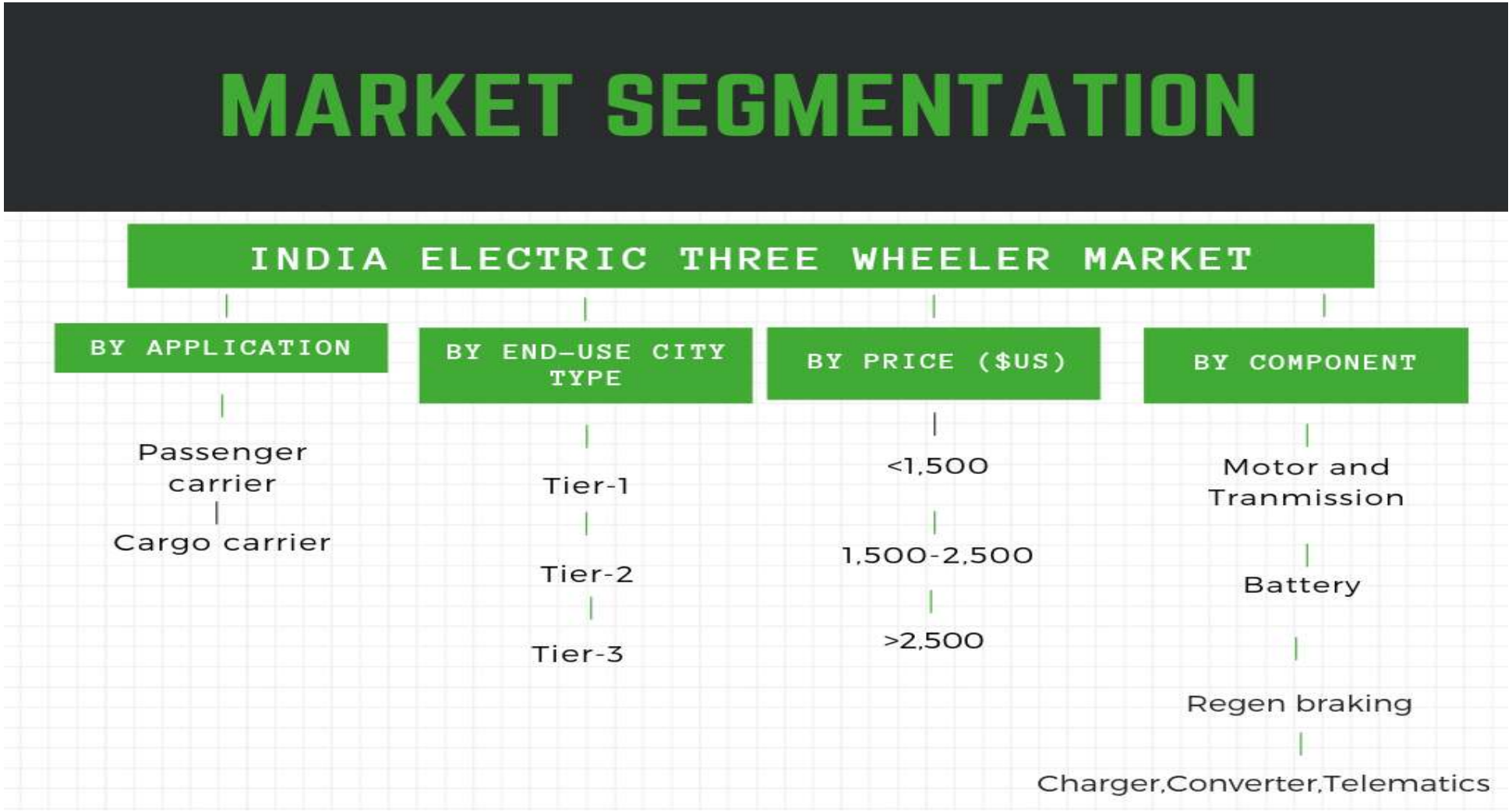

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## MARKET SEGMENTATION

Based on type e-three wheeler market can be bifurcated in to –

- Battery powered
- Hybrid

Based on battery type –

- Lithium –ion
- Nickel Metal hybrid
- Lead acid

Based on end user –

- Passenger carrier
- Utility carrier

Based on seating capacity –

- Three
- Four and above

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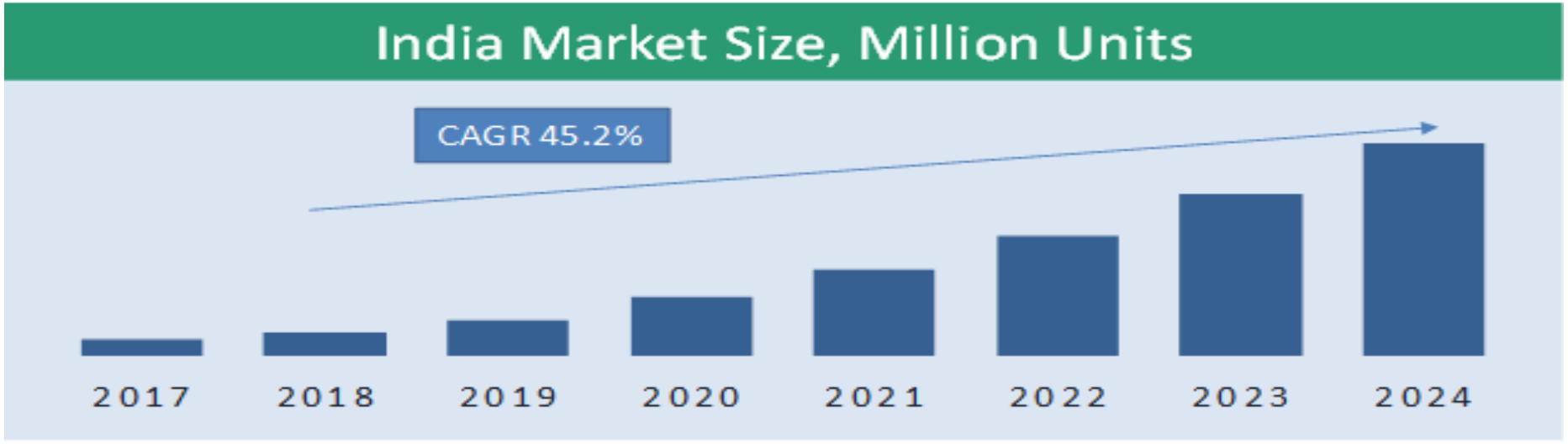
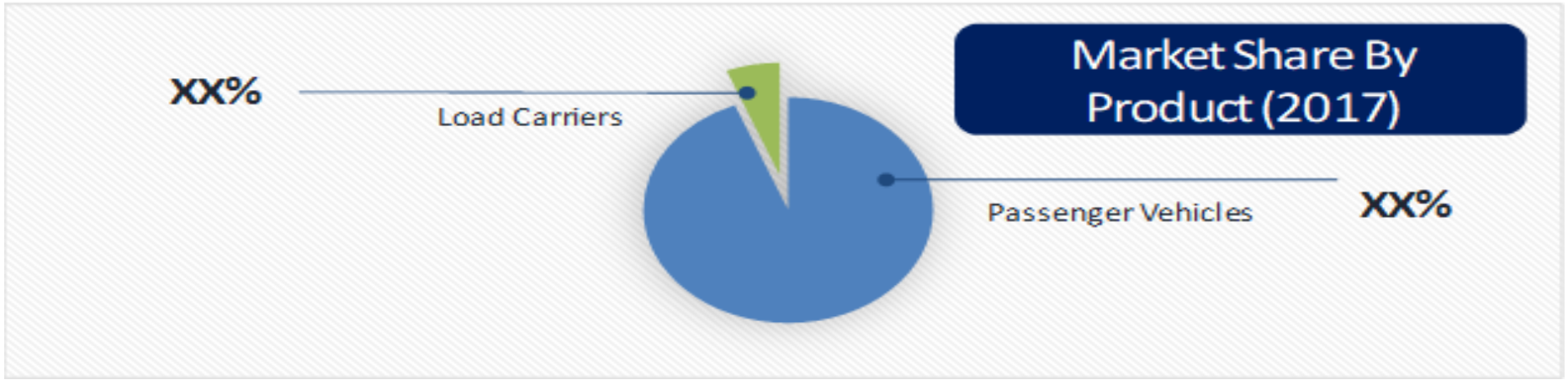
The Indian electric three-wheeler market is predicted to grow at 45.2% CAGR



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## SOME OF THE ELECTRIC THREE WHEELERS AVAILABLE IN INDIA -JULY 2019

| Sl no | OEM | Model | Battery(kWh) | Top speed (Km/hr) | Ideal Range (Kms) | Price range without subsidy(USD) |
|---|---|---|---|---|---|---|
| 1 | Mahindra & Mahindra | Treo | 3.7-7.4 | 25-45 | 85-130 | ~$2,000-$3,200 |
| 2 | Lohia Auto | Comfort | 4.8 | 25 | 100 | ~$1,800-$2.400 |
| 3 | Kinetic Green | DX | 2.1 | 25 | 80 | ~$1,900 |
| 4 | Terra Motors | Y4 Alfa | 4.8 | 25 | 100 | ~$1,900 |
| 5 | Gayam Motor Works | Urban ET | 4.8 | 55 | 110 | ~$4,700 |

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## E RIKSHAW IN INDIA

Majority of the e rikshaw on road are having low powered motor rated from 750 W to 1.5 KW, and about 60 AH battery, mostly at 48 V system.

This low powered drive ultimately give the low torque and the performance cannot be matched with Petrol/Diesel/CNG rikshaw.

Main reason for using low power drive is keeping low cost. These rikshaws are available from Rs 50-60,000 to RS 110,000.

Majority of these are imported from China, fully assembled or partially assembled, where some components like tyres added locally to get the benefit of FAME 2 scheme. This is mostly from the un-organized sector. The maximum speed is about 25 kmph, and range is about 40 km.

The E rikshaw manufactured by organized sector is available with higher power, with speed limited to about 25 to 55 kmph, available at a price of RS 150,000 to RS 350,000. majority of these fails to give the matching performance with petrol engine.

## RETROFITTING EV KIT ON EXISTING ICE RIKSHAW

While retrofitting EV kit the power should be matched with petrol engine so as the same performance can be achieved.

If the performance is not matching with petrol engine, we can not get the volumes. The performance in terms of speed, torque and gradeability should match to get the volumes for retrofitting.

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## RETROFITTING EXISTING ICE RIKSHAW WITH EV KIT –

Retrofitting can be done in two ways –

1) By removing the IC engine,
2) By removing IC engine and gear box together.

Main Components required for retrofitting existing rikshaw with EV kit.

A) Drive motor – Preferably PMSM (BLDC) 48 V 0R 72 V rating.
B) Controller matching to motor rating.
C) Accelerator paddle or twist type (as per end user choice)
D) DC_DC converter.
E) Charging socket with cable.
F) On board charger.
G) Wiring harness. Etc.
H) E axle -optional

Regenerative breaking system, telematics, and other features can be added to get additional benefits.

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## BATTERY SELECTION AND ITS IMPACT ON COSTING.

EV batteries drain out faster than a regular car battery because they are the source of power in the vehicle.

EV batteries are Deep cycle batteries that can be depleted to 80% of their charge before they need to be topped up.

Different types of batteries used for EV Rikshaw –

1) Lead acid battery – These batteries are well developed, tried and tested technology. The advantage of this battery is their reliability, availability and affordability. The main disadvantage of this battery is that they are not energy efficient, because they have lower energy density.
2) Nickel Metal Hydride – this battery have almost double the range however the cost is almost 5 times compared to Lead acid battery.
3) Lithium ion battery – This battery is having better energy density, however the life cycle is limited and they are costly, price may go from 5 times and above depending upon the types, charging and discharging time, and other variables.
4) Lithium Polymer – They are very flexible and have a shorter life compared to Lithium Ion battery.

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Lithium batteries are having different cell chemistry with different specifications as listed here below. The cost of these battery will vary from about 200 USD per KW to 450 USD per KW complete with Battery management system.

| | | | Chemistries | |
|---|---|---|---|---|
| S.no | Parameters | LFP | NMC | LTO |
| 1 | Cell Nominal Voltage (V) | 3.2 | 3.7 | 2.2 |
| 2 | Max Charged Voltage (V) | 3.65 | 4.2 | 2.8 |
| 3 | Min Discharge Voltage (V) | 2.5 | 3 | 1.5 |
| 4 | Cell Energy Density (Wh/kg) | 155 | 196 | 70 |
| 5 | Lifecycles @ 80% DoD @ RT | 3,500 | 8,000 | 20,000 |
| 6 | Lifecycles @ 100% DoD @ RT | 4,000 | 4,500 | 15,000 |
| 7 | Temperature Window | | | |
| a | Charging | 0 to 55 deg C | 0 to 45 deg C | -20 to 55 deg C |
| b | Discharging | -20 to 55 deg C | -20 to 55 deg C | -20 to 55 deg C |

Battery management system controls the charging and discharging pattern of individual battery cell for longer battery life. The cost of NMC battery is about 25% extra compared to LFP battery, where as the cost of LTO battery is about 50% extra compared to LFP battery. The LTO battery can be fast charged and discharged, also it has a very high life compared to other chemistry.
Obviously if one choose to have the longer life and faster charging, an associated high price need to pay.
The battery prices are likely to go down in near future. By end of 2020 it is expected to be at least 30% cheaper, where as by 2121 end it should be less than half.

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## ECONOMICS OF RETROFITTING

Retrofitting option can be well accepted by the end user/industry, subjected

- The performance of the e rikshaw is matching with ICE rikshaw.
- Solution is cost effective, if available at about 50 – 60 % price of new rikshaw (excluding battery cost).

Since there is no change in body or suspension system etc, the comfort level to driver and passenger is improved as there are no vibrations, sound and heating like IC Engine.

Battery with higher charging cycles like 5000, will give piece of mind and cost savings for longer period, by little cost addition. Even with top up charge during lunch break, the battery life will be more than 8 years.

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Since there are no approved kit in the local market, retrofitting kit is sourced from China, or local components mainly manufactured at New Delhi, Faridabad, and Northern parts are used. They lack of efficiency and quality.

A typical kit where the performance can be matched with petrol rikshaw, will cost about 1250 USD (RS. 90000) fob Shanghai, for a minimum order of 50 units. (excluding battery)

The price can come down if the volumes are increased.

If the components like BLDC motor, Controller, peddle accelerator, wiring harness, etc. are manufactured locally the cost can be minimized and should be in the range of 50 – 60% of new rikshaw cost.

Technology for component manufacturing is already available in India, however need out of box thinking. The manufacturing set up requires low capex, start with in short time and can have a payback period of about 2-3 years. Most of the equipment required for manufacturing are available in country, except few soft wares for design of high efficiency motor and simulation. High efficiency motor now give 96 % efficiency and in some cases even up to 98% efficiency is achieved. Liquid cool motors are more preferred in India, mainly due to the ambient temperature in some areas is as high as 48 degree C. Motor and battery performance is lowered at higher temperatures.

We can assist in local development as well arrange for technical know how for local manufacturing from industry leaders mostly from Europe.

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## WHAT WOULD BE THE ESTIMATED COST FOR RETROFITTING E KIT.

| COST OF RETROFITTING | | | | | |
|---|---|---|---|---|---|
| S. No. | Description | Value_RS. | | | |
| 1 | Conversion Kit | 1,10,000 | Av, run per day_km | 200 | |
| 2 | Cost of hard ware etc | 5,000 | Savings in operating cost_RS./KM | 4 | |
| 3 | Cost of labour | 10,000 | Estimated savings per day_RS | 700 | |
| 4 | Cost of batery | 75,000 | Estimated savings per year _ RS | 2,10,000 | |
| 5 | Profit for the agency | 50,000 | Less Interest 10% | 25,000 | |
| | Total | 2,50,000 | Loan repayment_ yearly | 50,000 | |
| | | | Estimated NET savings per year _ RS | 1,35,000 | |
| | | | Payback period in Months | 23 | |
| Battery considered at 100 AH rating. | | | | | |
| Battery life about 8 years. | | | | | |
| Life of Electrical/Electronics components above 10 years. | | | | | |
| Retrofitted vehicle can be in operation for more than 10 years subjected to routine maintenance and up-keep. | | | | | |
| Funds borrowed for a periof of 5 years | | | | | |
| 100% investment is borrowed at 10% interest per annum. | | | | | |