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Electric Vehicles

Presented by

**Smitanjali Rout
CUTM, BBSR**



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Course Outline

- 1. Introduction to Electric Vehicles**
- 2. Electric Vehicle Drive Trains**
- 3. Energy Sources**
- 4. Electric Motors**
- 5. Design Concept of Electric Vehicle**



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Introduction to Electric Vehicles



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Lesson - 1

Introduction to Electric Vehicles

Introduction

The fundamentals of vehicle design involve the basic principles of physics, specially the Newton's second law of motion. According to Newton's second law the acceleration of an object is proportional to the net force exerted on it. Hence, an object accelerates when the net force acting on it is not zero. In a vehicle several forces act on it and the net or resultant force governs the motion according to the Newton's second law. The propulsion unit of the vehicle delivers the force necessary to move the vehicle forward. This force of the propulsion unit helps the vehicle to overcome the resisting forces due to gravity, air and tire resistance.



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Introduction (Contd..)

The acceleration of the vehicle depends on:

- ❖ the power delivered by the propulsion unit
- ❖ the road conditions
- ❖ the aerodynamics of the vehicle
- ❖ the composite mass of the vehicle

An Electric Vehicle, technically is an Electric Drive Vehicle.

- uses one or more traction motors for propulsion.
- An electric vehicle is powered by electricity.
- Electric Vehicles are used as Electric Trains, Electric Cars and Electric Bikes.



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History of Electric Vehicle

The history of Electric Vehicle began in Mid 19th century.

- 1832: Robert Anderson invents a non-rechargeable electric carriage.
- 1835: Thomas Davenport builds the first practical electric vehicle.
- 1976: General Electricity was chosen to construct a parallel-hybrid sedan, and Toyota built its first hybrid car.



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Features of Electric Vehicles

Gas is a scarce, natural resource, Electricity is cheaper than gas. Electricity can come from renewable resources such as solar and wind power.

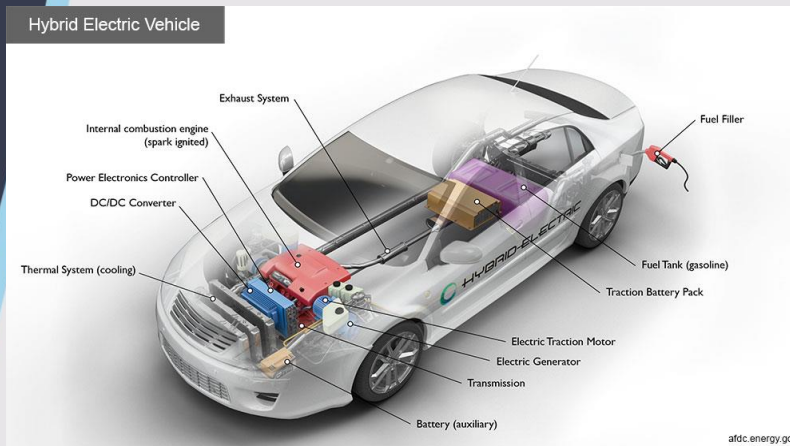
- Electric cars pollute less than gas-powered cars,
- Electric cars are much more reliable and require less maintenance than gas-powered cars.
- Produce 27 per cent less CO₂ than petrol cars and help to reduce greenhouse gas emissions.



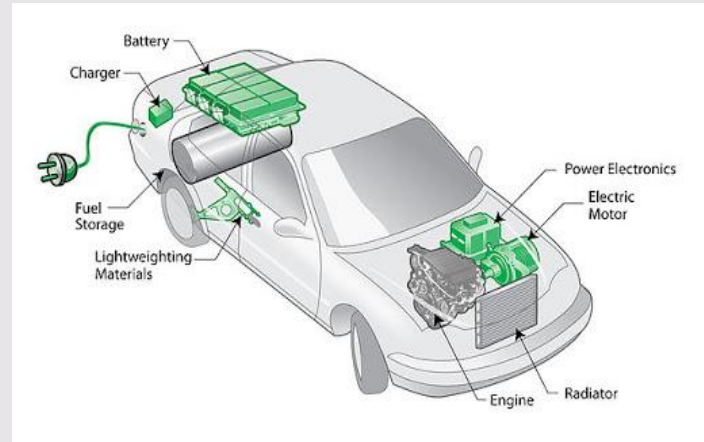
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Basic Concept of electric vehicle

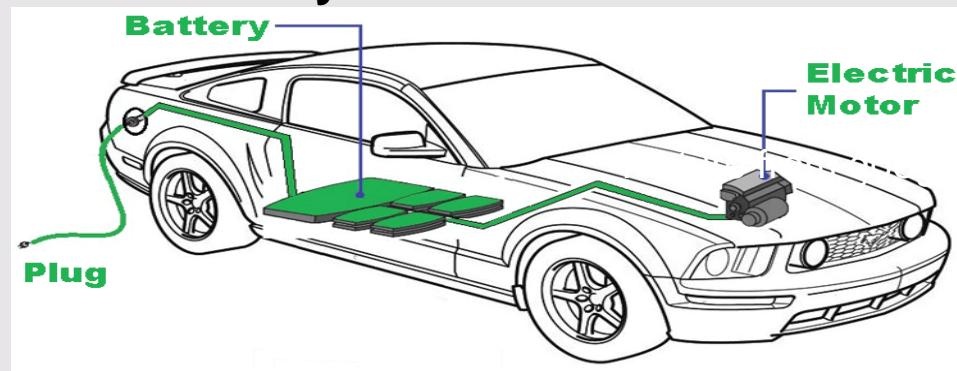
Hybrid Electric Vehicles



Plug-in Hybrids Vehicles



Battery Electric Vehicles



com



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Advantages of Electric Vehicle

1. They're easier on the environment.

For many motorists, simply knowing that electric vehicles are [better for the environment](#) is reason enough to make the investment. EVs don't even have an exhaust system, meaning they have zero emissions. And since gas-powered vehicles are large contributors to greenhouse-gas buildup in the earth's atmosphere, making the switch to an electric car can help contribute to cleaner air and a healthier planet.

2. Electricity is cheaper than gasoline.

Americans pay an average of 15 cents per mile driving gas-powered cars, which really doesn't seem like much — until you compare it to the fact that many EVs run at one-third of that cost, given that electricity is significantly less expensive than gasoline. And since you'll likely charge your electric car in your garage most of the time, installing solar panels on your home can save you even more money on powering both your residence and your EV.

3. Maintenance is less frequent and less expensive.

Since electric cars are, well, electric, they don't run on oil and therefore [don't necessitate oil changes](#) (or any other maintenance related to combustion engines, for that matter). Another upside? The brakes on an EV typically don't wear as quickly as those on a conventional car, which means even more savings for you.

4. They're very quiet.

If you live next to a busy road or have simply driven in rush-hour traffic, you know how noisy conventional cars can be, even if it's just the hum of smaller engines. EVs, on the other hand, are practically silent. They're so quiet, in fact, that many legislators in the U.S. have proposed the installation of noise-making devices to alert pedestrians that they're nearby.



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Advantages of Electric Vehicle

5. You'll get tax credits.

If you're the original owner of an electric vehicle, you'll likely receive a tax credit just for helping to lessen your impact on the environment by driving a zero-emissions car. That tax credit can be as high as \$7,500, depending on the make and model. There is, predictably, fine print when it comes to EV tax credits, so be sure to ask a tax specialist any questions you may have. (**Note:** The U.S. federal EV credit [starts to phase out](#) for a manufacturer's vehicles when at least 200,000 qualifying vehicles from that manufacturer have been sold for use in the U.S.)

6. They can shorten your commute time.

Driving an EV means you have the privilege of using the HOV lane (aka the "carpool" lane) any time of day — even if you're riding solo. If you live in a high-traffic area, this not only saves you so much time, but also a decent amount of sanity. Talk about a win-win.

7. Pollution: According to DOE (USA) • Transportation accounts for one third of all energy usage. • Use of 10% of ZEV cuts 1 million tons/year of air pollutants • With 100% EV - CO₂ emission would be cut by half

8. Capital Cost and Maintenance Cost: • EV has a more capital cost • But life cycle cost of EV is lesser than ICEV 6/6/2017 Dept of Power Engg & Mgmt.,

9. Availability of Fuel: Fast depletion of fossil fuel and dependence on middle east countries for fuel.

10. Well to Wheel Efficiency: The EV is found to have a better WTW efficiency than ICEV



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Advantages of Electric Vehicle

- 11.** Cheaper to operate EVs is cheaper to operate since they have high efficiencies and fuel economies thereby reduce cost for the owner. The electricity to charge an EV is about one third as much per kilometer to purchase fuel for vehicle
- 12.** Cheaper to maintain BEVs have less moving parts than those had by conventional combustion engine vehicles. There is less servicing and no expensive systems such as fuel injection and exhaust systems, which are not needed in an EV. PHEVs have petrol engine and need servicing hence costing more than BEVs but they also have an electric propulsion system, which requires less moving parts leading to less depletion of petrol engine parts .
- 13.** Environment Friendly EVs are less polluting, as they have zero exhaust emissions .If you opt to use renewable energy to charge your EV, you can reduce green house gas emissions even more. Some EVs are made of eco-friendly materials such as the Ford Focus Electric, which is made of recycled and bio based materials and the Nissan Leaf, which is partly made of recycled plastic bottles, old car parts and second hand appliances
- 14.** Health Benefits The reduced harmful emissions will lead to better air quality, which is good for our health. EVs are also produce much less noise compared to petrol/diesel-based vehicles From the first electric car developed in 1837 till the present times, we have witnessed massive advancements, notably in terms of technology but also in the people's attitude towards the environmental impact of cars and other mobility solutions.



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Disadvantages of Electric Vehicle

1. Most EVs have pretty short ranges.

Although EV range is constantly improving, it's still one of the main pain points for consumers deciding between electric and conventional. On a full charge, most electric models are limited to a range of 60 to 100 miles, but a small minority of models can go between 200 and 300 miles per charge. (2020 update: EV range continues to improve, with figures spanning [110 miles for the 2020 Mini Cooper Electric](#) to as high as [520 miles for the 2021 Tesla Model S.](#))

2. Recharging can take a while.

Compared to the few minutes it takes to fill up a conventional car at the gas station, recharging your EV is a much more significant time investment. While most electric car engines take about four hours to reach a full charge, some take a whopping 15 to 20 hours. However, there are kits available that reportedly cut charging time in half.

3. They're a large initial investment.

If you've never shopped for an EV before, you might experience a bit of sticker shock upon beginning your research. Even the more affordable electric car models start in the \$30,000 to \$40,000 range, while luxury models creep into the \$80,000s and upward. Until technology advances and becomes less expensive to produce, consumers can expect to pay between \$10,000 and \$50,000 more for an EV.



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Disadvantages of Electric Vehicle

4. Charging station availability is inconsistent.

Perhaps you live in an area where electric vehicles are relatively common, and so there's a wide availability of EV charging stations for your convenience. But say you're on a road trip or visiting family in a more suburban or remote area — [what happens if you need to charge up?](#) Luckily, as the popularity of electric cars grows, so, too, do the charging stations they require. But for now, the lack of availability is another major grievance for consumers.

5. There are fewer choices.

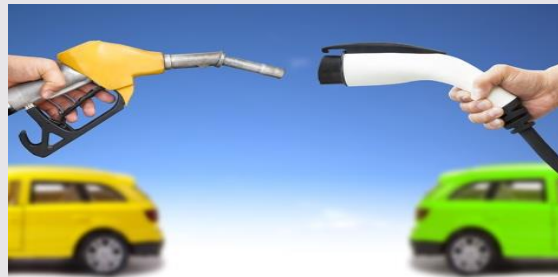
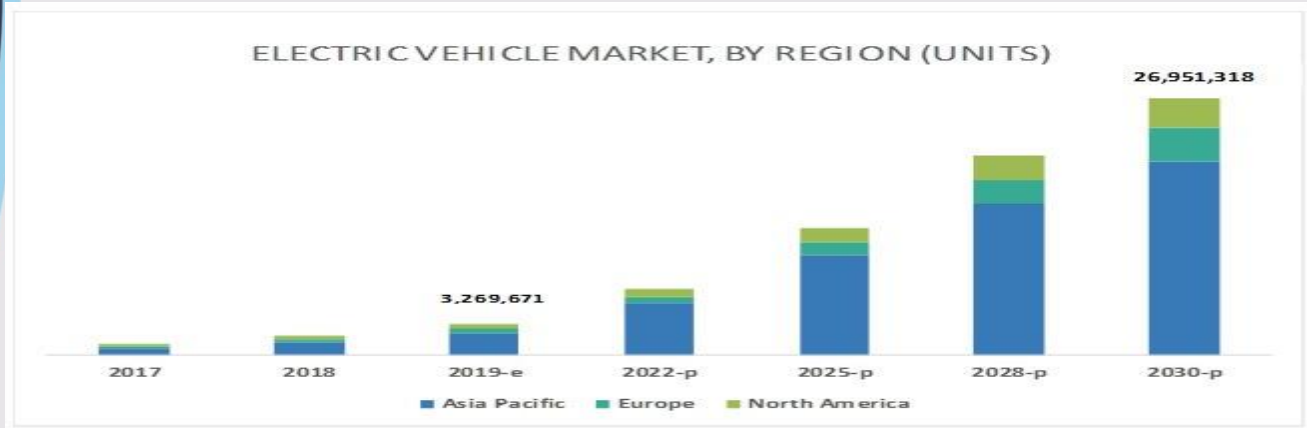
There's no denying that there's a greater variety of electric cars than ever before, and there's no sign it's going to stop growing, either. But the fact remains — there's just not as much to choose from when it comes to the aesthetics of your EV, especially when compared to how much you can customize conventional vehicles. On the upside, this will definitely change as EV prevalence continues to grow



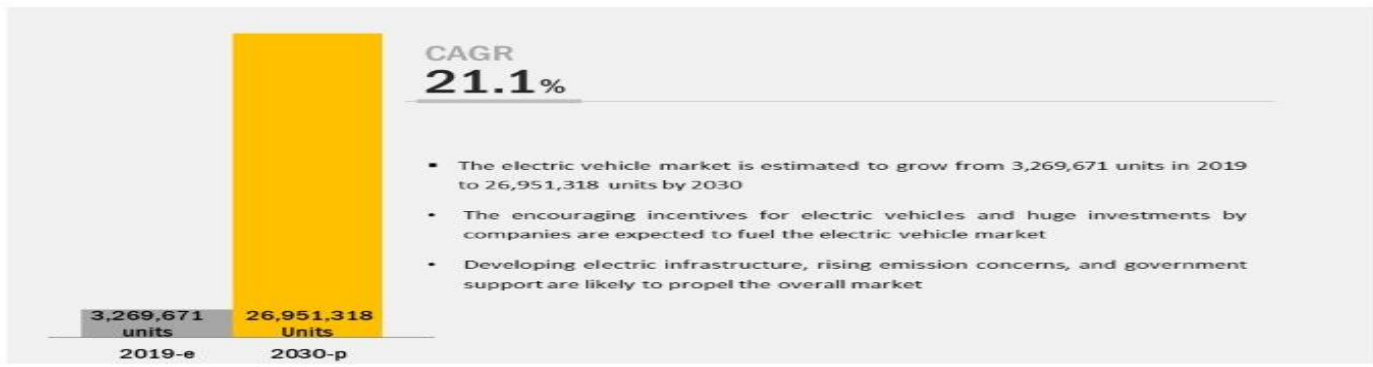
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EV Market and Promotion



Technological Advancements and Greater Intervention From Government are Anticipated to Fuel the Growth of Electric Vehicle Market From 2019 to 2030





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- ❑ Launched into Indian market in June 2001
- ❑ Reva was brain child of Chetan Ravi, MD of RECC (Reva Electric Car Company) and is based in Bangalore
- ❑ Reva is the first electric car to be conceptualized in India
- ❑ The marketing strategy of Reva when first launched mainly concentrated on the car being green and the first of its type in the electric car segment.
- ❑ With a small size, easy to drive (no clutch or gear) and top speed (50 km/hr), Reva was targeted at small families, old couples, female drivers and college going youngsters
- ❑ It was targeted to cover 80 kms on full charge (i.e. approximately 8 hrs full charging- considering an average Indian travels 40 kms/day at an average speed of 40 kms/hr)
- ❑ Company estimated to sell 1500 cars in the very first year of its launch. Even after 3 years of its launch it has sold only about 300 cars in India.
- ❑ Reva was priced at 2.49 – 2.74 lakh
- ❑ On May 26th 2010 Mahindra and Mahindra acquired 55.2% majority stake in Reva and is planning to re-launching EV in Indian market



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Running Cost: Petrol Vs. CNG Vs. Diesel Vs. EV

Vehicle Type	Petrol car			CNG	Diesel car	EV (REVA)
Cost of the Vehicle	Maruti 800 - Rs 2,46,628	Nano -Rs. 1,85,410	Maruti Alto LX - Rs. 2,90,222	Hyundai Santro Xing GL CNG Rs. 379,950	Tata Indica V2 - Rs. 372696	Reva i (AC Car) - Rs. 4,72,500
Average cost for 1000 kms (12kmpl)	Rs. 6370	Rs. 6370	Rs. 6370	Rs. 1742	Rs. 3773	Rs 833*
Average Cost post usage of 4 years @ 10000 kms per year (12kmpl)	255,562	255,562	255,562	69,684	165,912	1,15,083 <i>(incl. battery change cost)</i>
Average Cost after usage of 3 years @ 20000 kms per year(12kmpl) (heavy users)	377,134	377,134	377,134	104,526	242,717	1,32,3333 <i>(incl. battery change cost)</i>
Total cost along with the vehicle after 3 years @ 20000 kms per year	623,762	562,544	667,356	484,476	615,413	604,833



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Cost analysis details

Month / year	Diesel Petrol		CNG	Usage value for 10000 kms per year				Usage value for 20000 kms per year for 3 years			
	Prices	Prices	Prices	petrol 12km/pl	diesel 12km/pl	cng 19 km/kg	EV	petrol 12km/pl	diesel 12km/pl	CNG 19 km/kg	EV
june 4 2012	45.28	76.45	33.10	63708	37733	17421	8333	127417	75467	34842	16667
june 4 2013	49.08	73.09	33.10	60908	40899	17421	8917	121815	81798	34842	17833
june 4 2014	51.27	76.74	33.10	63951	42726	17421	8917	127902	85452	34842	17833
june 4 2015	53.46	80.39	33.10	66994	44553	17421	8917				
Total after 4 years				255562	165912	69684	35083	377134	242717	104526	52333

*Reva cost analysis

Battery cost 80000 (upto 3 years or 36,000 km, whichever is earlier)

100% Charging time 8 hrs

Electricity Consumpt 10 units * 5

Kilometers 80 (non AC) & 60 (AC)



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Consumer buying patterns

Based on initial Reva EV and Resent TATA Nano)

- ☞ What an average consumer expected from a Car (Private/Non chauffeur drivers)
 - Capable of commuting easily (to and from home to office or any other location)
 - Family car (approx. 4 members average family), comfortable seating arrangement
 - Reliable engines, low on maintenance (service cost)
 - Refueling station, Service centers/access to personal who can attend to problems in car
 - Low running cost (Fuel Consumption & maintenance)
 - Boot space (for keeping stuff)
 - Payment Options(At time of purchase)
 - Safe and easy to drive and manure
 - Feel good factor (this is attributed to a persons emotional self)
 - Value for money (What a car offers apart from basic features sets based on cost. This is not a direct factor but suggest why a consumer chooses a competitor brands)
 - Since fuel cost are increasing substantially, consumer are willing to switch to alternatives (Eg: CNG & LPG Kits)



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Reason for Failure

- Over Priced: Reva seems completely overpriced, compared to a small segment cars (eg. Nano/Alto)
- Product not well designed: the insides are cramped. The driving position is elevated but your head disappears into the roof. It lacks basics like comfort and space
- Development cost higher than expected: The exorbitant cost of vehicles entail due to complexity of its design
- friendly in the long run) will find difficulties in getting sanctions from Technology Development Board.
- Future Costs: The replacement cost of the battery is high being pegged as an



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Reason for Failure

- Government Regulations: the government has a five per cent duty for CNG/LPG kits as well as catalytic converters but the materials for electric vehicles attract a 20 per cent duty.
- Aesthetically, it did not appeal to the youth. It was not fast, did not have a high range, had high maintenance problems (100 % charging needed 8 hours) and was not meant for long drives.
- Lead Acid Batteries an old technology is utilized hence the frequency of charges necessitated by low battery storage capacity and long duration of charging times. The power pack needs 8 hours for a complete recharge, i the new technology (lithium ion batteries are not environment friendly in the long run) will find difficulties in getting sanctions from Technology Development Board.
- Future Costs: The replacement cost of the battery is high being pegged as an



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Market Learning(Tata Nano)

∞ TATA Nano & Indica Learning

- TATA Nano (which is a combustion driven small car) captured the market sentiments of being the cheapest car but in the same manner could not be attributed to sales during initial launch
- With the sole agenda being to launch a cheapest car in Market, TATA Nano base model was launched skipping the basic comforts of a car. This created a irk factor towards the car initially
- This outlook changed with subsequent models being launched with reasonable marketing and better attention to customer buying patters
- Tata Indica targeted the Taxi segment, targeted successful business line (BPO) and offered support to the segment
- Indian & State Government
 - The Indian government key agenda is to improve Public transportation, so there was no potential favor/benefits provided to manufacturer/consumer for cars
 - Maharashtra state government were initially against launching Nano in Mumbai because of excessive traffic
 - Technology Development Board initially offered 465 Lacs aid to 1800 lacs project however backed out.
 - The government has a five per cent duty for CNG/LPG kits as well as catalytic converters but the materials for electric vehicles attract a 20 per cent duty



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What Reva should look at (Customer/End user dynamics)

- REVA EV is not a low cost vehicle; vehicle cost puts in the bracket of Hyundai Santro, Maruti Alto, Wagon R, Nano, and all small to medium segment cars
- Due to small size, it cannot be used as a family car, as it has capacity for 2 people, with a small laptop bags only
- Being slow and small it is not meant for fun driving
- Its sole purpose is commuting within City limits
- Since Reva EV is a new segment following queries would require answering
 - What if the battery runs out, are there any charging centers
 - EV breakdown; are there any service guys who can handle problems
 - Re-charging the battery takes hrs, so am I supposed to wait that long always
 - Does India have infrastructure to support EV entry
 - Would I get formidable resale value for the car in case I want to sell it
- An average Indian customer looks at best value car based on cost factor



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What should be Reva's approach to current Market

- Reva being a city car/second car; could primarily target below mentioned market segment
 - Private sector
 - Office commuters
 - Students
 - Public sector
 - Corporate shuttle services (Inter location transport/golf carts etc.)
 - Bus/Cabs/Special Zone transport
 - Large Residential complex
- Invest in recharge service centers
- Introduce possible rental schemes for fuel cell [so that people do not have to wait long in case batteries runs out]
- Most apartments do not have charging points [so tie ups with certain agency so that certain areas in cities/towns are made available for EV charging]
- Consider possibility of excluding fuel cell cost and promoting fuel cell rental
- Understand the city infrastructure as whether it could handle an electric fuel car
- Possible investment in building public infrastructure and public electric transport so that a city could be made ready to accept electric cars
- Create awareness among consumers about EV's

How to create awareness in market



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➤ Internet

- Design Reva website which is easy to navigate and also provides information in layman terms which an end user could understand
- Forums leads to open discussion & feedback, such channels could be promoted within the Reva website
- Possible introduction of games, to capture youth imagination

➤ Television/ Bulletin/ Bill boards

- Television/ Bulletin/ Bill boards are the key points where Reva needs to advertise it self as a second car for executives and a peppy car for youngsters
- Innovative advertisement through television are best medium to spread knowledge about car

➤ BTL (Below the line) (Public areas, Malls, Parking lots, etc.)

- Electric Vehicle is by means a new market segment, so public demonstration is a must to educate about EV benefits
- Possible games/race tracks are many such events could be organized as a medium to get consumer views and interest about Reva EV.
- Nation wide event on world environment day

➤ I care [not a medium but through this consumer gets emotionally attached]

- Reva should look an allowing field trips to there factory outlets
- Run campaigns stressing on environment conservation
- Possible introduction of programs related to electric car and its benefits to environment



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Electric Vehicles Business Ideas & Opportunities for Indian Entrepreneurs

- Production of Electric Cars, Scooters, Bikes, Cycles etc ***
- Electric Vehicle Charging Station, Ports, Spares *****
- Production of Spare Parts for Electric Cars, Scooters, Bikes,
- Electric Car Repair and Servicing Garage
- Electric Car Sales Garage/Electric Car Dealership Shop
- Electric Car Tracker Installation
- Sale of Electric Car Customized Insurance Policy Cover
- Sale of Electric Car Spare Parts***
- Production of Batteries for Electric Cars****
- Electric Car Battery Sales/Service Shop
- Run a Fast Charging Center for Electric Vehicles ***
- Conversion of ICE Vehicles to BEV *****

Cont.....



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- Refurbishing and Recycling of Electric Car Batteries
- Online Electric Car Sale Business
- Online Electric Car Spare Parts Shop ****
- Production of Diagnostic Equipment for Electric Cars
- Run an Electric Car Diagnostic Center(Mobile or Stationary)
- Developing Software Apps for Electric Cars***
- Mfg./Installing Home Solar Systems with EV Chargers*****
- Start Blogging on Electric Cars Related Topics
- Start an Electric Car Related Television /Radio Program
- Become an Electric Vehicle Consultant/Trainer*****
- Start an Electric Car Magazine Business
- Organize Electric Car Expos
- Organize Electric Car Racing Competition
- Mfg./Supply of Portable Electric Car Power Banks*****



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Main Components of an EV

- **Battery:** It powers the electric motor. Its capacity is defined in Ah. The design of battery includes complex calculations which determines various battery parameters
- **Power convertor:** The electrical energy stored in battery is fixed DC which should be converted to either variable DC or Variable AC which depends on the type of electric motor used for power the wheels
- **Electric Motor:** DC series, Induction motors were used at the earlier stage. Now the scope has shifted towards special electrical machines



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Components of an EV Contd.,

- ***Clutch***: The engine must be decoupled from the wheels to shift from low speed to high speed gears or vice versa, this is done by the clutch.
- ***Transmission*** :The gearbox is also called as transmission which allows transfer of power from engine to wheels.
- ***Drivetrain***: The combination of Electric motor, Clutch, Gearbox is referred to as drivetrain