

Scaling Electric Vehicles in India

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Why is Electric Vehicle (EV) the future transport?


Better efficiency with less number of moving parts

Area	Petrol / Diesel	EV
Energy efficiency	17 – 21%	90 – 95%
Moving parts (reliability)	2000+	20+

- In **five years**, EV capital costs will be less than that of petrol vehicles
 - with acceptable range and **operational costs at a fraction** of that of petrol vehicles
- But if we wait, India will **import most EV sub-systems** and batteries instead of oil

Falling battery costs

Year	Li battery costs per kWh
2012	USD 600
2015	USD 450
2017	USD 250
2020	USD 150
2024	< USD 100



But before we begin: Nay-sayers

- But Does India have enough electricity?
- Full conversion of transport to EV will utilise **15% to 20%** of total electricity generation
 - No shortage of electricity: **thermal plant load factor today is 59.6%**
 - Will help power-usage during off-peak hours
- Alternatively, **rooftop solar** may provide all required electricity using ***0.07% of India's geographical area***

Nay-sayers: Pollution

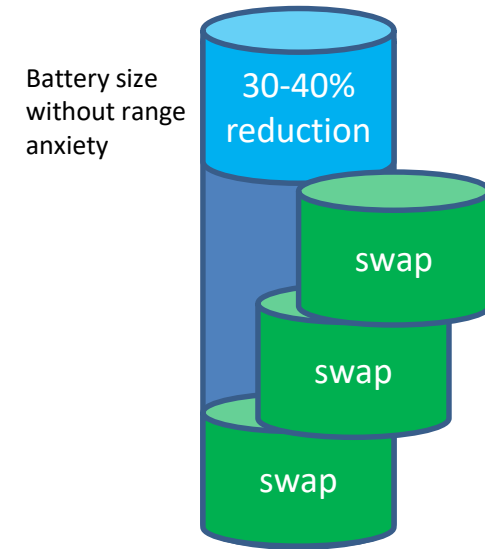
- But does electricity not cause pollution?
- **Zero** pollution levels if **renewables** used
 - Renewable prices have fallen below that of coal-plant: future capacity will mostly come from solar / wind
- If electricity is produced with current thermal plants
 - No **tail-pipe** emission
 - CO₂ pollution **down by 50%**

So how do we enable Electric Vehicle today

- World-over EVs happen today with 30 to 40% subsidy
- India does not have enough money for subsidy
 - So how do we do it without subsidy?
 - must make economic sense
- At the same time scale early
 - And take leadership in the world at least in some segments
 - As far as possible, **Make in India** and develop the complete eco-system from end to end

Approach

- Focus on higher efficiency: **Wh/km** (equivalent to kms/litre of petrol)
 - Lower Wh/km brings down **battery size, weight and cost**
 - For e-autos in last six months: from 70 to 80 Wh/km to 45/50 Wh/km
 - E-buses: from 1600 Wh/km to 900 Wh/km
- **Split battery** into smaller size (one third) and **swap**
 - No waiting time to charge battery; **no public infrastructure** required
- Battery-life severely affected by Fast Charging at 45 deg C: **one-third** as compared to charging in two hours below 25 deg C
 - **Possible** with swapping



Approach (contd)

- Separate **vehicle business** (without battery) & **energy business** (battery)
 - Capital cost similar to that for petrol / diesel vehicle
 - Operation cost today same as petrol / diesel vehicle
 - WITH **no SUBSIDY**; but **zero-rated GST** for strictly **three years**
 - Drive Volumes using public vehicles
 - Get companies to buy vehicles in bulk (100,000 plus) and lease
 - Get companies to buy batteries in bulk and set up energy business
 - Private vehicles to leverage the eco-system
- No subsidy needed as with these 5 steps, capital cost of vehicle similar to that for petrol vehicles, and ₹/km operation costs same as petrol / diesel / CNG
 - Manufacture motors and drives, chargers, batteries, cells and battery-chemicals in India

High Quality Three wheelers: e-rickshaw, e-auto

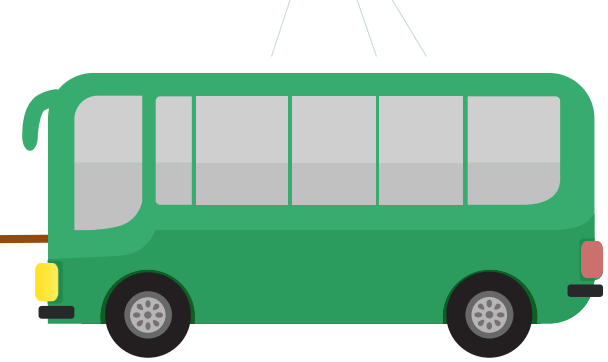
- Use **swapping**: 50 km range Li-Ion **Locked battery**
 - swap in 2 minutes at some 200 locations in a city
 - **Quality** electric vehicles at **similar price as petrol/CNG vehicles**
 - Charged Li-ion **hire price** per km less than that petrol/CNG vehicles
- **50** vehicle, battery & subsystem manufacturers, aggregators, energy business enable
 - Common and **modular Locked battery pack** specs driven with industry
 - Vehicles efficiency (35 Wh/km for e-rick, 45 Wh/km for e-auto), safety and easy battery-swapping
- **Launch in November 2017**
 - 50K early order: can target 1 million 3-wheelers in 18 months

Everything other than battery cells made in India

Large e-auto and e-cargo rickshaw and autos to follow



For City-Buses



- Most city-buses travel less than 30 kms per trip
 - Some 8 to 10 trips per day: Ten minutes break between trips
- **Batteries with 50 kms** range: **Swap batteries** (using robots) at trip-terminal point
 - Operation costs per km is no more than for diesel vehicle
- High performance (**low Wh/km**) buses without battery
 - Capital Costs **similar to** that of today's buses
- 30 bus, battery and subsystem manufacturers/ swappers define
 - **Common Locked battery pack specs**
 - Specs for vehicles: efficiency, safety, easy battery-swapping (with robotics)
- Could launch in **January 2018**: can target 10000 buses in 15 months

Four-wheelers

- Initially focus on taxis, which **ply over 200 kms per day**
 - Total Cost per Km (capital + operational costs) comparable to today's petrol vehicle costs
 - May use a combination of **fixed plus swappable battery tomorrow**
 - Have a range of 110 kms: going up to **160 kms** by July 2018
 - Overnight **slow AC charging** at homes
 - two hour AC charging while parked at office can **extend range** to 150 kms
 - DC **fast charger** for one to one and half hour charging

Public Chargers

- Public chargers for small vehicles standardised
 - Bharat Chargers AC-001 (slow) and DC-001 (fast) [less than 100V, 15 kW]
 - Affordable so that they can make business sense
 - DC chargers may cost ₹1 lakh to ₹1.5 lakhs
 - Make Charger business viable like STD-PCO
- Public fast chargers for larger vehicles to be standardised
 - Working on specifications & financial model for AC-002 and DC-002 [100V to 800V, 30 to 100 kW]
 - Industry needs to get back with what they need
 - Business case needs to be figured out: current costs ₹10 to 20 lakhs

Get going at Speed

- Build Volumes
 - Prices depend much on volumes
 - Focus on **Make in India**
 - Everything other than battery cells are manufactured in India
- Will enable **personal vehicles** to take off
 - Two-wheelers can use the **same battery module** as used in 3-wheelers
 - Four-wheeler need more work
- Other **vehicles** in future
 - Long-distance buses, Tempos, Trucks, Agricultural Equipment and vehicles
 - May require tailoring of approach: not limited to swapping

Cell to Pack Manufacturing
2017 – some 15 companies



Cell Manufacturing: 2019 -20



India has little Li, Mn, Co
Battery Recycling to recover 95% of
Li, Mn and Co

To Conclude

- EVs will give us huge benefit
 - All EV power can be **generated by Renewables** (sun, wind and water) in due course and give us ZERO pollution
 - Would result into huge boost for auto-components
- while Swapping is making EVs possible **today without subsidy***
- **Other financially-viable** approaches being explored for tomorrow
 - Incremental charging at stops: fast charging at 4C
 - Fast-charging at 1 to 2C by DC-002
 - Would need to somehow overcome the impact on battery-life due to fast-charging (over 2C) at high temperatures