

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
 - will threaten India's auto sector (**with 7.1% GDP**) and jobs

Falling battery costs

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



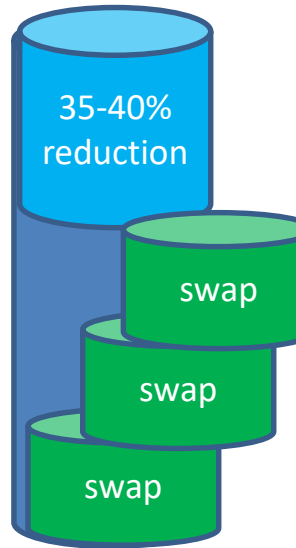
So how do we enable Electric Vehicle today

- 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

Battery size without range anxiety



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

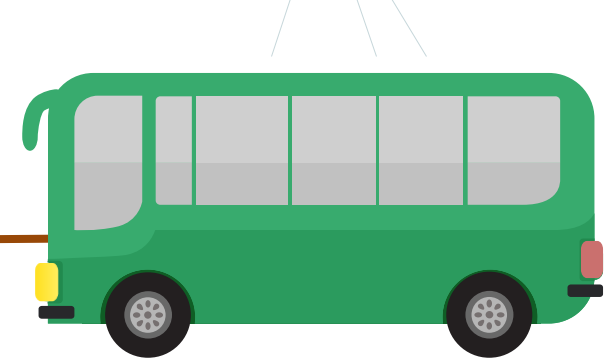
- Use **swapping**: 50 km range Li-Ion **Locked battery**
 - swap in 2 minutes at some 200 locations in a city
 - **Quality** electric vehicles at **similar price as petrol/CNG vehicles**
 - Charged Li-ion **hire price** per km less than that petrol/CNG vehicles
- **50** vehicle, battery & subsystem 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**
- Will need **charging infrastructure**
 - Need to be designed to be economically viable
 - AC001 (slow) and DC001 (fast) [**less than 100V, 15 kW, approx ₹1.5 lakhs**] charger specs defined with this in mind
 - Could be set-up like **STD PCOs**
 - Working on specifications & financial model for DC002 and AC002 chargers
 - 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



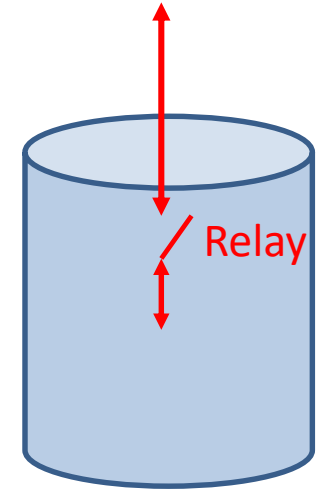
Extra Slides

Key Policy support

1. Have zero import duty and 5% IGST on lithium cells import to be used for EVs. Have 5% GST on Locked Smart Batteries, EVs, Charging Equipment for three years
2. Have 5% GST on Integrated Service provided by the Locked Smart Battery Charge and Swap stations
3. Allow Aggregators and Businesses to own and operate fleet of electric 3-Wheelers
4. Exempt e-Autos from permit requirement for three years
5. Allow Energy-business (Locked Smart Battery Charge & Swap Stations) to procure power at competitive rates through **Open Access without cross-subsidy** and create special tariff category for energy supplied for dedicated charging of Electric Vehicles / Locked Smart Batteries

What is L-Batt?

- Can not be charged except through **authorised Chargers**
- Can not feed power except to **authorised vehicle**
 - Encrypted Key exchange between Charger / vehicle and L-batt
 - Relay turns on only after authentication (each L-batt has an unique ID)
- Important for Energy Business, as they **charge by kWh used**
 - Charge includes depreciation and interest cost of batteries besides costs of charging and swapping
 - Without Locking, a vehicle owner auto can charge – discharge a battery multiple times and not pay the Energy Business
- At swap-point
 - a **mobile phone** will read actual kWh used and transmit to **CMS** for **e-payment**
 - Program the new battery to be usable to specific vehicle and inform **CMS**



L-Batt designed

- To contain all data about usage: at what time
 - what **speed and acceleration** the vehicle had been driven?
 - how much **energy** of battery was used, L-batt State?
- Data read by authorised chargers and send to **CMS** where it analyses
 - The efficiency of the **vehicle**
 - The **driver**-characteristics (does she speed, how often she applies breaks, etc.)
 - The **Battery** characteristics: State of Charge, state of cells and unbalanced cells, cell temperature, state of health
 - Determine how to **pair** multiple modules
- Similarly during charging battery, charger sends all information to the **CMS** for analysis
 - How to **extend life** of each battery module
 - Enable **second use** of battery module (when its capacity deteriorates to below 80% of initial level)

Charging Buildings and Swapping-Outlets

- L-Batt **charged** in special air-conditioned buildings, which are guaranteed 24 x 7 power and have all safety precautions
 - **Large number of swapping outlets** in one-two km radius
- Software designed to **track each module**
 - What are the number of charged and discharged packs at each **outlet**?
 - How much is the rate of L-batt **off-take** at each outlet?
 - Coordinate vehicles (e-rickshaws) to **transport** charged L-batts to outlets and carry back discharged L-batt
 - All **payments**: from vehicle owners to Energy Business, from Energy business to transport operator and to each outlet
 - Charging uses a **combination** of kWh used as well as holding-time of a L-batt

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

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%**