

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%**

EVs: Hamare yahan hota to hai,
dikhta nahee hai, dikhna chahiye

World-over EV is scaling driven
by subsidies – some 30 to 40%

Subsidies is possible,
but not at scale

How does one get EV to Scale and that too in 2017?

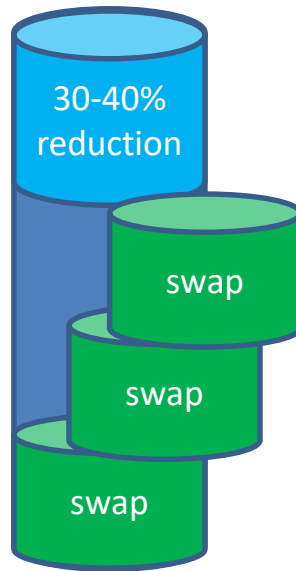
So how do we enable Electric Vehicle today

- 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 about 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) and **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

Three wheelers: e-rickshaw, e-auto

- Current e-rickshaws of poor quality: use Lead-acid batteries
- Use **swapping**: 50 km range 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



Electric Three-wheelers

3W Operators may use vehicles with larger batteries and charge at home / public chargers. But NO subsidy.

- **50** manufacturers, battery manufacturers, potential battery swappers and vehicle aggregators working towards
 - Common and **modular battery pack** specs driven with industry
 - 1.5 kWh, 13 kg, 3000 cycles: two packs for 3-wheelers
 - Additional specs for vehicles: efficiency (35 Wh/km for e-rick, 45 Wh/km for e-auto), safety and easy battery-swapping
 - Inter-operability tests + certification
- ***Launch in November 2017***
 - 200K order: can target 1 million 3-wheelers in 18 months

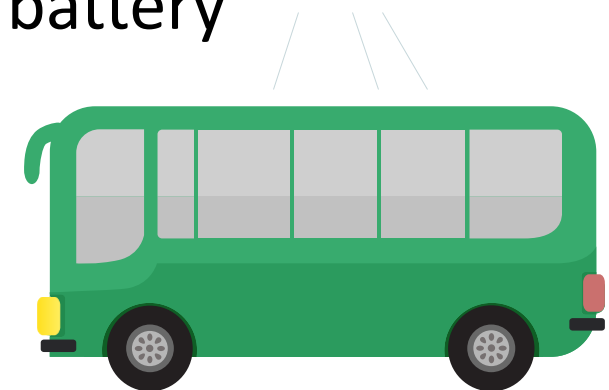
Large e-auto and e-cargo rickshaw and autos to follow

Everything other than battery cells made in India

For City-Buses

E-Bus Operators may use vehicles with larger batteries. But NO subsidy

- Most city-buses travel less than 30 kms per trip
 - Some 8 to 10 trips per day: Ten minutes break between trips
- Choose **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



Electric buses

- Some 30 manufacturers, battery manufacturers, potential battery swappers working towards
 - Definition of **Common battery pack specs**
 - 50 kWh, 450 kg, 3000 cycles
 - Specs for vehicles: efficiency, safety, easy battery-swapping (with robotics)
 - Inter-operability tests + certification
- Could launch in **January 2018**: can target 10000 buses in 15 months

4-Wheelers: need Fast Chargers

- Focus on **Taxis and Government Vehicles**
 - Economics work out as Cost per km comparable to that for petrol vehicles
 - 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
 - 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
- Other **vehicles** in future
 - Long-distance buses, Tempos, Trucks, Agricultural Equipment and vehicles

Cell to Pack Manufacturing
2017 – some 15 companies



Cell Manufacturing: 2019 -20



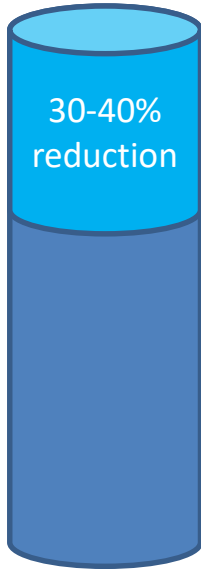
India has little Li, Mn, Co
Battery Recycling to recover 95% of
Li, Mn and Co



ADDITIONAL SLIDES

Challenges and Approach I: Efficiency

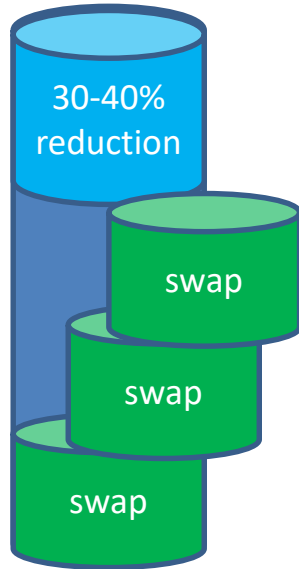
Battery size
without range
anxiety



- Battery most expensive component of EV
- Focus on higher efficiency: **Wh/km** (equivalent to kms/litre of petrol) at low vehicle speed
 - Lower Wh/km brings down battery size and cost
 - higher **motor efficiency**, better tyres, aero-dynamics and light-weight materials: **30 to 40% improvement** in many cases
 - For e-autos in last six months: from 70 to 80 Wh/km to under 45 Wh/km
- Still costs are too high

Challenges and Approach II: Swapping

Battery size
without range
anxiety



- **Introduce Swapping**
 - Split battery into smaller size (one third) and swap
 - No **waiting time** to charge battery; **no public infrastructure required**
 - 50 kms battery for auto: swap in 2 minutes at some 200 locations in a city
- For Fast Charging at 45 deg C, battery life is **one-third** as compared to charging in **two hours below 25 deg C**
 - Swapping enables this

Approach III: Energy Business

- Separate **vehicle business** (without battery) and **energy business** (battery)
 - Purchase enhanced efficiency vehicles without batteries
 - **Capital costs** similar to that of equivalent ICE vehicle costs
 - **Energy Business**: battery ownership (depreciation and interest), swapping & charging
 - **operation costs** (cost per km) no more than that for petrol / diesel / CNG vehicles

Approach IV: Aggregate Demand

- 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
- Manufacture motors and drives, chargers, batteries, cells and battery-chemicals in India