

# Scaling Electric Vehicles in India

Ashok Jhunjhunwala, IIT Madras (on sabbatical)  
Principal Advisor, Minister of Power and MNRE

[ashok@tenet.res.in](mailto:ashok@tenet.res.in)

# 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

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- 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

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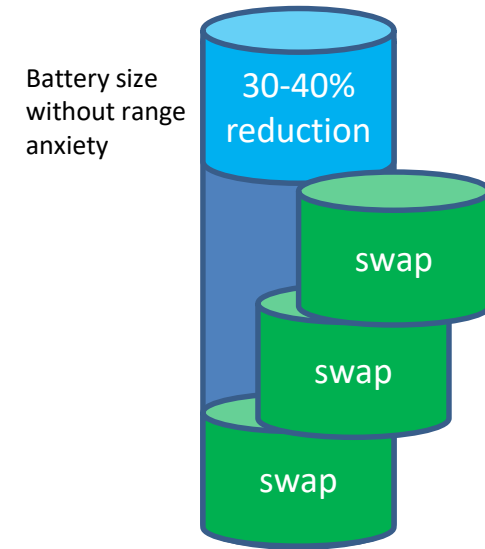
- But does electricity not cause pollution?
- **Zero** pollution levels if **renewables** used
  - Renewable prices have fallen below that of coal-plant: future capacity will mostly come from solar / wind
- If electricity is produced with current thermal plants
  - No **tail-pipe** emission
  - CO<sub>2</sub> 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)

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- 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

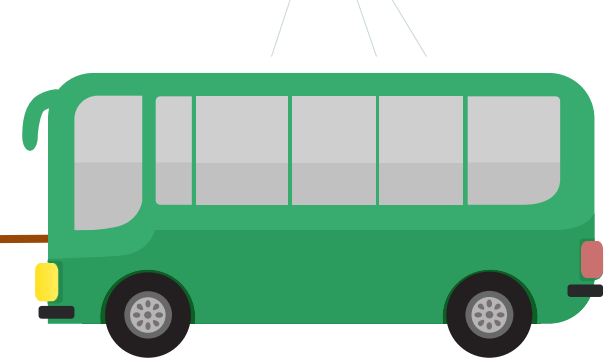
Large e-auto and e-cargo rickshaw and autos to follow





# For City-Buses

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- 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

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- 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

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- 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

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- 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

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- 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