



EVs in India: The Current State

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India Recognises

Business needs to depend upon itself. Some help from state governments (local manufacturing + promotion)

- India imports most of its oil impacting its economy badly
 - It has 14 of 20 most polluted cities in the world
 - EV is the future: four times higher **energy efficiency** and 50% less moving parts
- India's vehicles different from that in most of the world
 - 79% two-wheelers, 5% Autos and e-rickshaw, 3% Buses and large goods vehicle
 - 12% Economy Cars (< \$13000) and 2% Premium Cars (> \$13000)
 - **98% of public and affordable vehicles:** not the focus of the rest of the world; India could attempt to get leadership here
- India has **low affordability** and can afford minimal subsidy
 - EV must make **business sense: How?**
 - Battery contributes to **50% of costs**
 - falling rapidly over last five years but still expensive

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

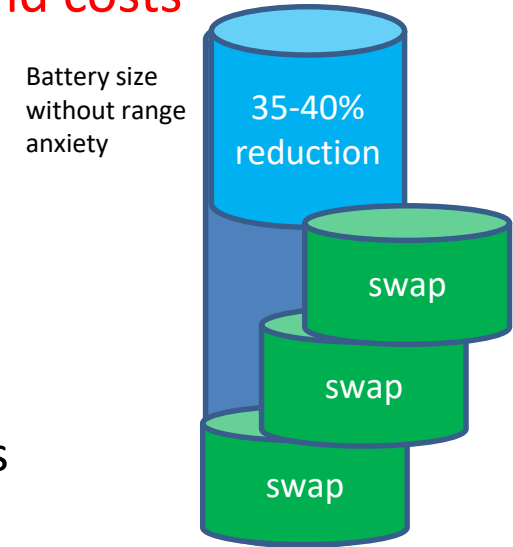


Scaling: Main mantra maximum utilisation of battery resource

- Electric three-wheelers with battery swapping will scale
- Electric two-wheelers (78% of vehicles) would make maximum impact in short run and would require innovation to scale
- Buses would still take time to scale: battery-swapping will emerge in 2019 and would compete with fixed-battery buses
- End of 2019: first signs of scaling of 4-wheelers
 - Battery pack manufacturing will start-scaling
 - Battery recycling would bring-up urban mining
- Industry and local governments would push EV forward

Strategy for EVs for Public Transport

- Higher efficiency **Wh/km** (kms/litre of petrol) reduces **battery size, weight and costs**
 - For e-autos in last one year: 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
 - **Swapped battery** can be charged in conditioned environment and in two hours to maximise its life
- 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 **lower GST** for strictly **three years**
- **Drive volumes** aided by Public procurement



EV Strategy for Private Transport (2/4-wheelers)

- Batteries **dominate** the cost of an EV: Tesla uses battery with 540 kms range
 - and also **vehicle weight** (reducing the **energy efficiency or kms/kWh**)
 - Smaller battery creates **range anxiety**
 - Use Public Fast Charger: **waiting time** + **public charging infrastructure**: takes an hour to charge battery
 - Fast Charge in **15 to 20 minutes**: needs expensive batteries (life impacted as temperature crosses 40°C)
- Suppose EVs have a **small** low-cost battery with limited range built-in: Affordable
 - Example: 100/ 50 km range for e-car / e-scooter: **Enough** within cities for **90% of days**
 - Use only night-time **Slow** Charging: **maximising** battery life
- When one needs to drive longer distances (10% of days)
 - use a **RANGE EXTENDER battery** to overcome range anxiety
 - **Swap-in** a second (swappable) battery **doubling the range** at a petrol pump (**3 to 5 minutes**)
 - **Swap** the swappable battery again for **still longer range (300 kms or 400 kms)**

Strategy for EV Batteries

- Battery pack development: **thermal** design, **mechanical** design and **Battery Management System** to get the best out of low-cost cell: **largely ready**
 - established and start-ups **[30-35% value add]**
- Battery Cell Development
 - **JV with external tie-ups** **[30% value add]**
- Battery Material Development: **great progress** with battery recycling (**urban mining**) **[40% value add]**
 - scaling on way **|**

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 and Co, and 93% of Ni and Mn
and 90% Graphite

Materials for Batteries (40% costs)

- Li-Ion batteries today use **Lithium, Cobalt, Manganese, Nickel and Graphite**
 - India does not have much of the mines for any these
 - **Import bill could sky-rocket** if we import all the materials
 - India may need up to **25 GWh per year** by 2025
- Focus on recycling of used batteries (**urban mining**)
 - A start-up is recovering **95% of Li and Co**, and 93% of Ni and Mn and 90% Graphite: being scaled today
 - Need R&D to set-up large number of recycling plants with **ZERO EFFLUENT**
- India could import used batteries and become the **urban-mining capital of the world** for Li-Ion battery-materials

Summing up: India's Tasks

1. Most **Energy Efficient** Vehicles: low Wh/km will reduce the size of the **battery**
 - Better motor and drive (**power-train**), better tyres, lower weight and better aerodynamics
2. Battery ecosystem: **Pack manufacturing** (30-35%), **cell-making** (30%), **materials and chemicals** (40%)
3. Charging and **swapping** Infrastructure for range-extension
 - Slow-charging, fast charging and battery swapping
4. **Demand Generation** and **Policies**

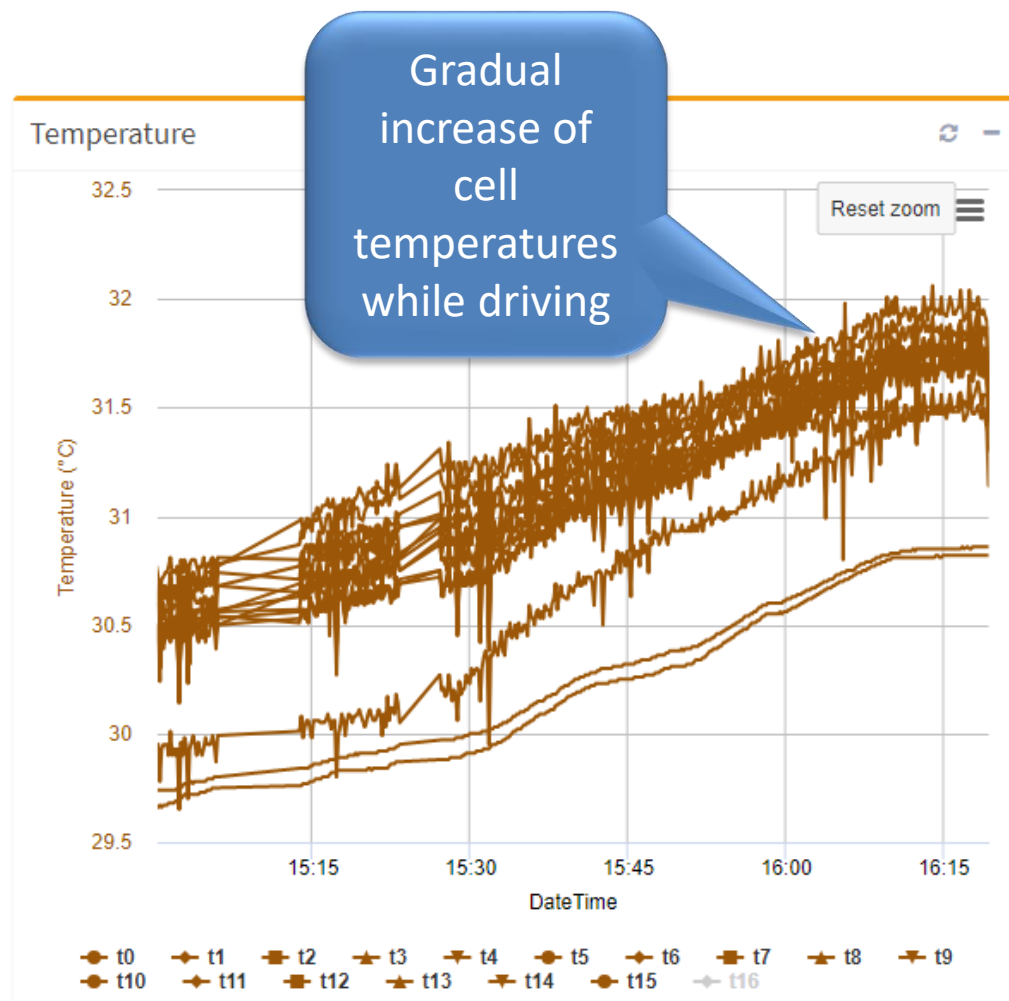
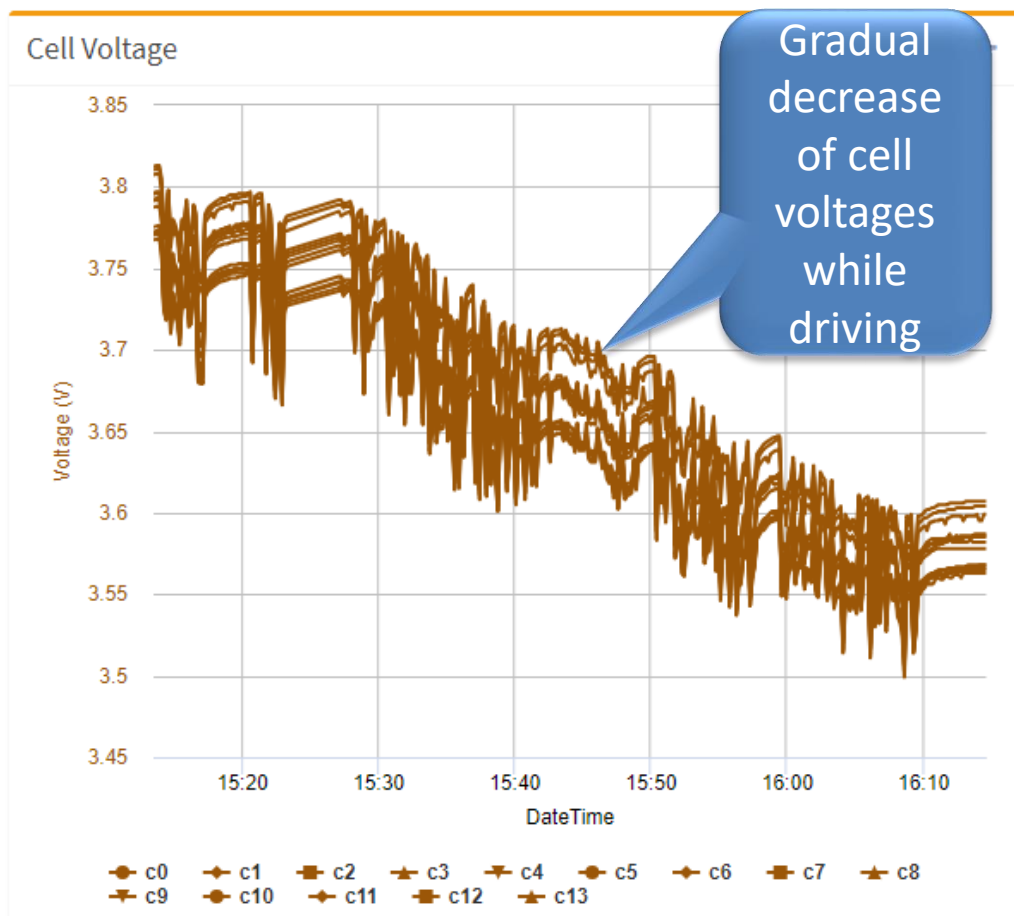
Vehicles on Drive

Pilot with Battery swapping at CBEEV, IITM Campus



Test vehicle with school kids, residents and staff in IITM campus

Cell voltage and temperature monitoring during driving



To

- India needs innovative approach to go
– Or will be flooded by imports in four

- **Time is of essence**

- Several industries and start-ups have
 - They need to be encouraged and see a continuous forward movement
- More focus on Make in India and start-ups and R&D institutions
 - With attempts to preserve India's GDP and grow jobs

- Can we do it by 2030: **Certainly**

- EV article in latest IEEE Electrification Magazine: <https://ieeexplore.ieee.org/document/8546812>

For deeper understanding, look at the blog “understanding the EV Elephant”: <https://electric-vehicles-in-india.blogspot.in/2017/12/>

- **Vehicles**: Ashok Leyland, Tata Motors, Mahindra, Eicher, Bajaj, Kinetic, Lohia, Electrotherm, Goenka, Hero-Eco, Okinawa, Ather, Avon Cycles, TVS Motors
- **Li Ion Battery and recycling**: Exide, Amar Raja, Exicom, ACME, Grintech, Greenfuel, Ion Batteries, Attero, Sun-mobility
- **Energy Operators**: Essel Infra, Sun-mobility, BPCL, NTPC, PGCIL, Kerala DISCOM, Goldstone
- **Chargers, Motors and Monitoring**: Delta, ACME, Exicom, TVS Motors, Esmito
- Most State Governments, STUs