EV in India: Technology and Policy

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Why is Electric Vehicle (EV) the future transport?

Better efficiency with less number of moving parts

<table>
<thead>
<tr>
<th>Area</th>
<th>Petrol / Diesel</th>
<th>EV</th>
</tr>
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<tbody>
<tr>
<td>Energy efficiency</td>
<td>17 – 21%</td>
<td>90 – 95%</td>
</tr>
<tr>
<td>Moving parts (reliability)</td>
<td>2000+</td>
<td>20+</td>
</tr>
</tbody>
</table>

Falling battery costs

<table>
<thead>
<tr>
<th>Year</th>
<th>Li battery costs per kWh</th>
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<tbody>
<tr>
<td>2012</td>
<td>USD 600</td>
</tr>
<tr>
<td>2015</td>
<td>USD 450</td>
</tr>
<tr>
<td>2017</td>
<td>USD 250</td>
</tr>
<tr>
<td>2020</td>
<td>USD 150</td>
</tr>
<tr>
<td>2024</td>
<td>&lt; USD 100</td>
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• In four 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
A year back

• Will not happen in India soon; will take the hybrid route; requires 30 to 40% subsidy; Charging infrastructure not ready
  – Industry was largely disinterested

• Today: some **50 Indian companies** going hammer and tongs on EV. Believe that India will charter its own path
  – **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
  – **Chargers & Motors**: Delta, ACME, Exicom, TVS Motors, Consulneowatt, Valeo Compageautomation
  – **Most State Governments, STUs**
How did this happen?

- Recognition that EVs are the future and will threaten India’s GDP (auto-sector 7.1% + transport fuel processing & distribution is 5%) and large number of jobs

- Recognition: India has low affordability -- EV must make business sense
  - How do we make business sense? Battery contributes 50% of costs

- So India has to do its EV with
  - Limited / no subsidy
  - Low affordability

- Our driving patterns are different (average city-speed is 25 kmph as compared to 40 to 60 kmph elsewhere)
  - Will require different motors and controllers

- Our temperature crosses 40 deg C and even 45 deg C quite often
  - FAST Charging full low-cost battery (in 10 minutes to 30 minutes) would severely impact battery life-time

- Need to scale rapidly: evolve new approaches jointly with industry, Start-ups, R&D community and Government
CAN INDIA DRIVE ITS EV PROGRAM INNOVATIVELY AND DIFFERENTLY?

Copying the EV program of USA, China, Europe will take us nowhere
A new approach: EV Batteries, costs and range-anxiety

- Batteries dominate the cost of an EV
  - Larger battery increase costs (Tesla uses battery for 600 kms)
    - 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
- Fast Charger with 1C charge: takes about an hour to charge the battery
- 4C Fast Charger -- 15 to 20 minutes: but reduces battery life for low-cost Graphite-NMC batteries (worse as temperature crosses 40°C)
- Alternatively LTO batteries: Charge Fast even at high temp: but three times costlier
India’s Alternative: personal vehicle

• Suppose EVs have a small low-cost battery with limited range built-in (example 100 km range for car)
  – Enough to drive within cities for 90% of days
  – Use only night-time Slow Charging: maximising battery life
  – Affordable

• 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), enabling another 100 kms range
    • Swap the swappable battery again for still longer range (300 kms or 400 kms)
  – Swapping by Energy Operators
India’s Alternative: public vehicles (Autos and Buses)

• 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
  • Low temperature and slower charging Possible with swapping
Auto and Bus (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 lower 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
Summing up: India’s Strategy and Tasks

1. Most **Energy Efficient** Vehicles: low Wh/km will reduce the size of the **battery**, the most expensive component
   – Better motor and drive (power-train), better tyres, lower weight and better aerodynamics

2. Battery ecosystem: **Pack manufacturing** (30%), **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 and Demand generation

- E-rickshaw & e-auto / cargo-auto: being deployed with Li-Ion battery swapping – will scale
- 2-wheelers with RE battery swap: will launch next month
- 4-wheelers: 100 km range with fast chargers – volume buying by EESL
  - 4-wheelers with RE battery swap: to be ready in six months
- 9m / 12 m city buses: being deployed with fast charger
  - With battery swapping at end of each trip: to be deployed in four months
- Develop Low-cost Swapping infrastructure -- Ready to launch and scale
- Develop communication protocols to get highest performance: good progress
- Chargers at affordable costs: slow AC chargers: standards defined; product ready and affordable
  - DC Fast chargers under 15 kW (DC-001): product ready and affordable -- costs ₹1.25 lakhs in volumes
  - Fast Chargers with higher powers for larger cars and buses: standards being defined
- Creating charging and swapping industry (energy operators): done

from 80Wh/km to 52 Wh/km
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 moving [30% value add]

- Battery Cell Development: strategy to be worked out
  - external tie-ups -- evolve as demand grows over one year [30% value add]

- Battery Material Development: great progress with battery recycling (urban mining); scaling on way [40% value add]
Industry and Technology

• Waking up auto industry and large auto-companies: done
• Waking up large battery industries: done
• Transforming small and medium sub-system and auto-component industries: not begun
• Developing new Electrical (power-electronics) industries: more needed in developing high-efficiency motors and controllers -- to be done over next two years
• Develop strong R&D to commercialisation in EV subsystems
• Watch out for new approaches and technologies
  – like fuel-cells, distributed motors, batteries withstanding higher temperatures, motors without permanent magnets, heavy trucks
To Conclude

• More needs to be worked out
  – SAARC needs to cooperate

• Time is of essence
  – More focus on Make locally and start-ups

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