Where is EV going 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 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

Falling battery costs

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

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 future and will threaten India's GDP (auto-sector 7.1% + transport fuel processing and distribution 5%) and large number of jobs
- Recognition: India has low affordability -- EV must make business sense
  - Options
    - Government subsidies: but subsidies can not scale (treat is at upside)
    - Invest today and earn tomorrow
    - Obtain large loans and default (tax-payer's subsidy)
- How do we make business sense? Battery contributes 50% of costs

India's Specifics

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

- So India has to do its EV with
  - Limited / no subsidy
  - Low affordability
  - So how do we do it without subsidy?
    - must make economic sense

- Our driving patterns are different (average vehicle speed in city 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 and evolve new approaches in partnership with industry, Start-ups, R&D community and Government

Copying the EV program of USA, China, Europe will take us nowhere

CAN INDIA DRIVE ITS EV PROGRAM INNOVATIVELY AND DIFFERENTLY?

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

Can Indian EVs do something else?

- 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

Summing up: India's 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

Task I: Vehicles and Demand generation

- E-rickshaw & e-auto: just started to deployed with battery swapping – will scale
- E-cargo auto: to be developed over next six months with battery swapping
- 2-wheelers with RE battery swap: will launch next month

from 80Wh/km to 52 Wh/km

Driven by Industry and Start-ups

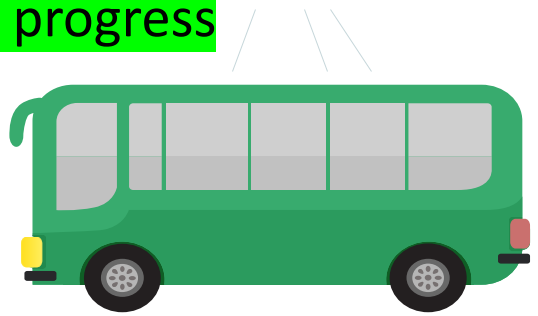
- 4-wheelers: 100 km range being deployed with fast chargers – volume buying by EESL
  - 4-wheeelers with RE battery swap: to be ready in six months

- 9m / 12 m city buses
  - being deployed with fast charger (will require 20 minute charging every 30 km or 1 hour charging every 100 kms)
  - With battery swapping at end of each trip: to be deployed in four months

Task II: Charging & swapping Infrastructure

- Develop Low-cost Swapping infrastructure -- Ready to launch and scale
- Chargers at affordable costs
  - Overnight chargers: standards defined; product ready and affordable
  - DC Fast chargers under 15 kW (DC-001): standards defined; product ready and affordable -- costs about ₹1.25 lakhs in volumes
  - Fast Chargers with higher powers for larger cars and buses: standards being defined; product to be developed and made affordable over next one year
- Creating charger service industry: to be done this year
- Creating charging and swapping industry (energy opeartors): done
- Develop communication protocols to get highest performance: good progress

- Most City buses travel 30 km /trip
- Typical 8 trips per day
  - Swap at each trip



Tasks III: 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]

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

Task II: Industry

- Waking up auto industry: done
- Waking up 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

Other tasks

Biggest Threat: Policy paralysis allowing massive Chinese Imports

- Develop Comprehensive long-term and stable policy for EVs
  - Including policy to incentivise setting up new technology industry in order to attract investment
- Develop strong R&D to commercialisation in EV subsystems
- Encourage electricity production from Renewables
  - Encourage solar-PV modules being manufactured locally
- 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

- Time is of essence
  - Several industries have worked hard over the last few years
    - They need to be encouraged and see a continuous forward movement
  - More focus on Make in India and start-ups

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