Where is EV going in India?

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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; only other 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

Storage Options

Li-Ion Cell Chemistry	LCO/Graphite or NCA/Graphite	NMC/Graphite	LFP/Graphite	NMC/LTO	LFP/LTO (Nb doped)
Spec. Energy (Wh/kg)	150 -300	150-300	90-120 (150 with Silica in anode)	60 -100	50 -80
Charge/disc rate	0.5C/1C	1C/1C (2C with Silica in anode)	1C/2C (4C with Silica in anode)	4C/4C	5C/10C
Life-cycles	1000	2000 (8000 with Silica)	3000 (4000 with Silica)	10000	20000
safety	Cell* < 55°C	Cell* < 55°C	safer	safest	safest
Cell costs / kWh	$120	$145	$225	$500 plus	High???

* Cell costs falling rapidly last few years (NMC-Graphite battery : $200 per kWh). Unlikely to fall over 10% this year

China has set a target for all EVs to have 350 Wh/kg by 2020, 400 Wh/kg by 2025 and 500 Wh/kg by 2030
Most of the world uses NMC/ Graphite except some uses NMC/ LTO for buses with top-up charging

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

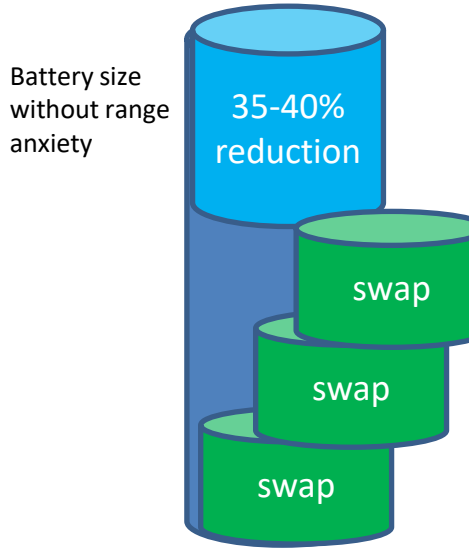
Can Indian EVs do something else?

- 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)

India's alternate strategy for affordable vehicles

- 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

Strategy (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 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

Tasks I: Technology- Power train and Infra

- Build vehicles with higher efficiency (low Wh/km)
  - Some excellent progress by industry; more needed; competition helps
  - much more needed in developing high-efficiency motors and controllers
- Develop Low-cost Swapping infrastructure
  - Ready to launch and scale
- Develop 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 volume
  - Fast Chargers with higher powers for larger cars and buses: standards being defined; product to be developed and made affordable over next one year (useful for higher end vehicles)
- Develop communication protocols to get highest performance: good progress

from 80Wh/km to 52 Wh/km

Driven by Industry and Start-ups

Tasks I: Technology - 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]

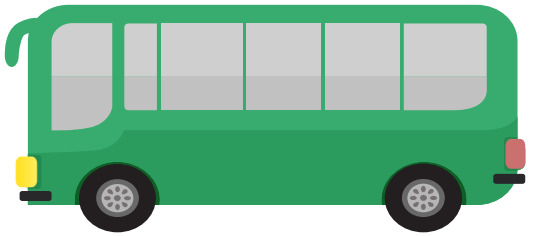
Cell to Pack Manufacturing
2017 – some 15 companies

Cell Manufacturing: 2019 -20

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

Task II: Industry

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



- Creating charger service industry: to be done over next year
- Creating charging and swapping industry: over next year

- Demand generation
  - Volume Buying and leasing 4-wheelers: started with EESL tender
  - Volume Buying and leasing 3-wheelers (e-rick and e-auto): within two months
  - Volume buying and leasing buses: by June- July 2018
  - Volume buying and leasing of small cargo vehicles: to be started over nine months
  - 4-wheeler personal vehicle strategy: propose to use Range-Extension Batteries
  - 2-wheeler personal vehicle strategy: a propose to use Range-Extension Batteries

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: 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: https://electric-vehicles-in-india.blogspot.in/2017/12/