Understanding the EV Elephant

Path to Green Energy

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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 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

- 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

- 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_2 pollution down by 50%

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

How does one get EV to Scale and that too in 2017?

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

- Today GDP of auto-sector is 7.1% of GDP + 5% of GDP for transport fuel processing and distribution
  - Large number of jobs
- If EV in India crawls, imported EV and accessories will dominate the market in a few years
  - Catching up with technology would become almost impossible
  - Will impact our GDP and jobs

- India needs to act to acquire technology leadership in some EV segments and build upon it
  - As far as possible, Make in India and develop the complete eco-system from end to end

Some Unique aspects impacting EVs in India

- Limited / no subsidy
- Low affordability

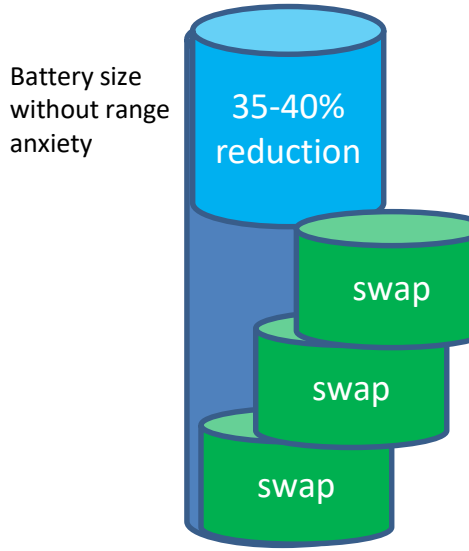
- Our driving patterns are different (average vehicle speed in city is 25 kmph as compared to 40 to 60 kmph elsewhere)
  - Will require different motors and controllers

- 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 evolve new approaches in partnership with industry, R&D community and Government

Approach 1

- 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

Approach I (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

Approach II

- Focus on vehicles with larger drive-distance per day
  - Taxis with 200 kms
  - Buses with 200 plus kms

- Possible to work towards solution where total cost of ownership per km comparable to that of petrol vehicles with
  - Some slow (overnight) charging
  - Some fast charging / or top-up charging (top-up with small batteries possible)
    - need to overcome high temperature barrier: may be higher-cost LTO batteries
  - Some combination of slow-charging and swapping

India's Strategy

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

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
  - Fast chargers under 100V / 15 kW (DC-001): standards defined; product ready and affordable
    - Test set up at ARAI and IITM -- costs about ₹1.25 lakhs in volume
  - Fast Chargers from 100V to 400V: standards to be defined; product to be developed and made affordable over next one year
  - Fast Chargers for buses: standards to be defined; product to be developed and made affordable over next one year
- Develop communication protocols to get highest performance: good progress

from 80Wh/km to 52 Wh/km

Tasks I: Technology - batteries

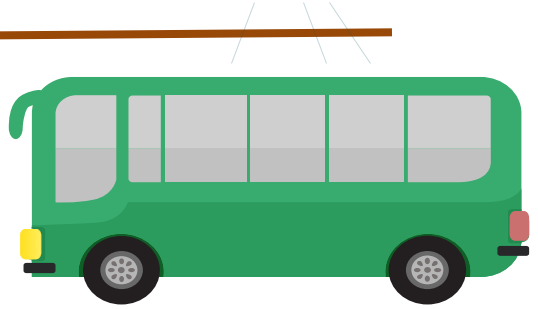
- Battery pack development: thermal design, mechanical design and Battery Management System to get the best out of low-cost cell: largely ready
  - established and start-ups moving [30% value add]
- Battery Cell Development: strategy to be worked out
  - need outside help -- evolve as demand grows
    - Will work out strategy over next 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: to be done 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): ready to be started over next three months
  - Volume buying and leasing buses: ready to be started over next six months
  - Volume buying and leasing of small cargo vehicles: to be started over nine months

  - 4-wheeler personal vehicle strategy: a proposal to use Range-Extension Batteries
  - 2-wheeler personal vehicle strategy: a proposal 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

Task III: Immediate Policy & Regulatory support

- Have zero import duty and 5% IGST on lithium cells for EVs. Have 5% GST on Locked Smart Batteries, EVs, Charging Equipment for three years
- Have 5% GST on Integrated Service provided by the Locked Smart Battery Charge and Swap stations
- Allow Aggregators and Businesses to own and operate fleet of electric 3-Wheelers and exempt e-Autos from permit requirement for three years
- Allow Charging and Energy-business (Charge & Swap Stations) to procure power at competitive rates through Open Access (without cross-subsidy)

Future technology tasks

- Examine Hydrogen-fuelled vehicles
- Distributed Motor architecture for vehicles
- New Motors without or with minimum permanent magnet
  - China has about 90% of rare-earth magnets
- Development of low-cost cell chemistry tolerating higher temperatures
- Develop second use of batteries
- Better understand battery behaviour in different use conditions
- Develop heavy duty EV trucks
- Develop Agricultural Machinery using electric power

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

A new approach: EV Batteries, costs and range-anxiety

- Batteries dominate the cost of an EV
  - Larger battery will increase costs
    - And also vehicle weight (reducing the energy efficiency or kms/kWh of energy)
  - Smaller battery will create range anxiety (what happens when battery runs-out?)
    - Conventional solution uses Public Fast Charger: waiting time + public charging infrastructure
    - Fast Charger with 1C charge will take a little more than an hour to charge the battery
    - Fast Charger with 4C can charge in 15 to 20 minutes
      - But fast charge at this rate reduces battery life, specifically the low-cost Graphite-NMC batteries
      - Problems get worse as temperature crosses 40 degree C, as is common in India
    - Alternatively use LTO batteries which can withstand fast charging as well as higher temperatures
      - But about three to four times as expensive as low-cost Graphite-NMC batteries

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
- When one needs to drive longer distances (10% of days)
  - Option 1: Stop and use a fast charger (1 hour waiting time) giving another 100 kms
    - Another hour wait for a fast charge if one drives longer than 200 kms
  - Option 2: use a RANGE EXTENDER to overcomes complete 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)

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/