

Understanding the EV Elephant

with a focus on Storage

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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

- EVs happen today with 30 to 40% subsidy: India does not have enough money for subsidy
 - So how do we does one **get EV to Scale** and that too early without subsidy?
- GDP of auto-sector: **7.1% + 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

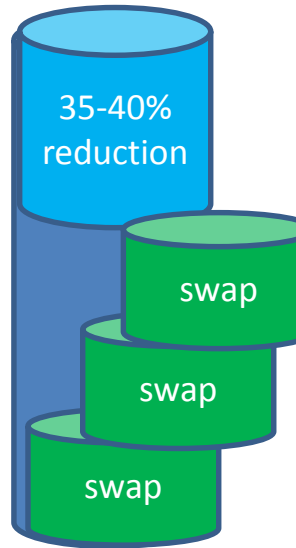
Some Unique aspects impacting EVs in India

- 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: without subsidy

- 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
- 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

Battery size
without range
anxiety



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**

Storage Options

Li-Ion Cell Chemistry	LCO/Graphite or NCA/Graphite	NMC/Graphite	LFP/Graphite	NMC/LTO	LFP/LTO (Nb doped)
Operating V	3.6-3.7	3.6-3.7	2.5-3.6	1.8-2.8	1.5-2.3
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	\$140	\$225	\$500 plus	High???

*difficult to Fast Charge when ambient temperature exceeds 40°C

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

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

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)
- Suppose a car has a **small** low-cost battery with limited range (range-anxiety): example 100 km range
 - **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 find a public fast charger (**1 hour waiting time**) giving another 100 kms
 - Another hour wait for a fast charge if one drives longer than 200 kms
 - Fast Charger at 4C in 15 minutes will hurt battery-life; LTO battery costs are high
 - 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**)