

*Understanding the EV Elephant: Limited subsidy
and Low-affordability imperatives for EVs in India*

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The talk around a year back

- EV will not happen in India soon; will take the hybrid route; requires 30 to 40% subsidy (as in rest of the world); Charging infrastructure not ready
 - Industry was largely disinterested
- Today: some **50 Indian companies** going hammer and tongs on EV, believing 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 EV is the future
 - Four times higher **energy efficiency** and far higher **reliability** (50 times less moving parts)
 - will threaten India's GDP (**auto-sector 7.1%** + **5%** transport fuel processing and distribution) and large number of jobs
- Recognition: India has **low affordability**
 - 30 to 40% subsidy on Electric Vehicles in USA, Europe and China: but subsidies in India will be limited (or none at all)
 - EV must make **business sense even with this!**
- How do we make business sense? Battery contributes to **50% of costs**
 - Falling rapidly over last five years
 - Battery-pack with low-cost NMC-Graphite cells under \$200 per kWh today
 - but still expensive for the desired range

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



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

Can India Drive its EV program Innovatively and Differently?

India's Vehicles dominated by two-wheelers

No of Vehicles sold in India in Millions

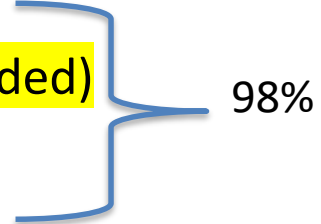
Category	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Passenger Vehicles	2.63	2.67	2.5	2.6	2.79	3.05
Commercial Vehicles	0.81	0.79	0.63	0.61	0.69	0.71
Three Wheelers	0.51	0.54	0.48	0.53	0.54	0.51
Two Wheelers	13.4	13.9	14.8	15.9	16.5	17.6
Grand Total	17.4	17.8	18.4	19.7	20.4	21.9

- Cars no more than **14% of total vehicles**
 - About 15% of this (**less than 2% of total**) costs more than ₹10M (\$15,000)
 - World-efforts focused only on this

- **Three wheelers** have become the main last-mile public transport for 75% Indians
 - Urban as well as Rural (village to town)
 - Rickshaws **not** included in above table

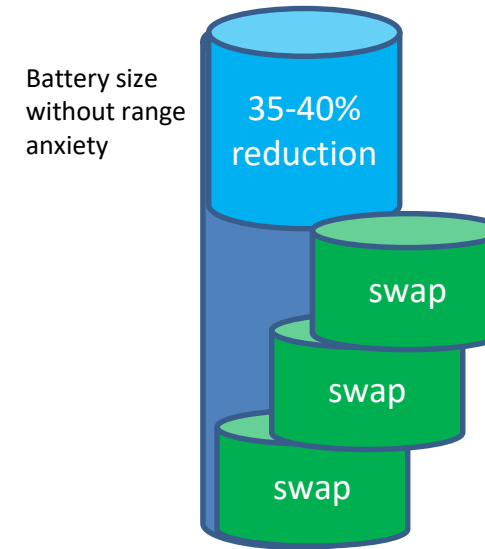
Percentage of Cars sold in India			
Price Range	2015-16	2016-17	2017-18
Below ₹500,000	2.82	28.85	27.43
₹500K to 1 million	55.49	54.96	56.48
₹1 to 1.5 million	15.29	15.23	14.65
Above ₹1.5 million	1.20	0.96	1.43

EV Policy: India's focus on its 98% vehicles

- India's autos different from that in most of the world: **small and affordable vehicles**
 - Domination of 2-wheelers: 79%
 - Autos including small goods vehicle: 4% (rickshaw not included)
 - Buses and large goods vehicle (including trucks): 3%
 - Economy Cars costing below ₹1 million: 12%
 - Premium Cars costing above ₹1 million: 2%
- **98% of public and affordable vehicles:** not the focus of the rest of the world; India would attempt to get leadership here
- **2% vehicles (premium four-wheelers):** similar to that in rest of world; India would learn and adopt; encourage multinationals to manufacture them in India
 - Will help us build a stronger ecosystem for components and subsystems

An Alternate Approach for Public Transport

- 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
 - **Swapped battery** can be charged in conditioned environment and in two hours to maximise its life



Approach towards Business Viability

- 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

Private Vehicles: EV Batteries, costs and range-anxiety

- Batteries **dominate** the cost of an EV
 - Larger battery increase costs (Tesla uses battery for 540 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 (gets worse as temperature crosses 40°C)
 - Alternatively **LTO batteries**: Charge Fast even at high temp: but **three times costlier**

Range-extender Batteries for 4W and 2W

- Suppose EVs have a **small** low-cost battery with limited range built-in (example 100 km range for e-car or 50 km for e-scooter)
 - **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 for a e-car
 - **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**
 - 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

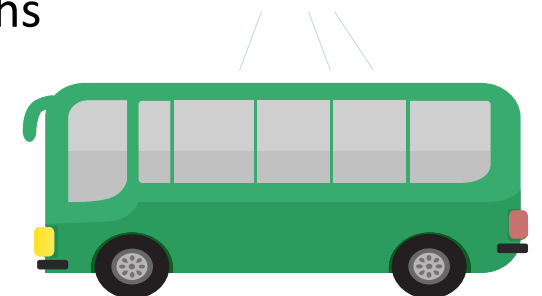
- 4-wheelers: 100 km range being deployed with fast chargers – volume buying by EESL
 - 4-wheelers with RE battery swap: to be ready in six months

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



Driven by Industry and Start-ups

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



Task II: Charging & swapping Infrastructure

- Develop Low-cost Swapping infrastructure -- Ready to launch and scale
- Chargers at affordable costs
 - Overnight AC 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 operators): done
- Develop communication protocols to get highest performance: good progress

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 **[30% value add]**
- Battery Cell Development
 - **JV with external tie-ups** **[30% value add]**
- Battery Material Development: **great progress** with battery recycling (**urban mining**) **[40% value add]**
 - scaling on way

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, and 93% of Ni and
Mn and 90% Graphite

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**

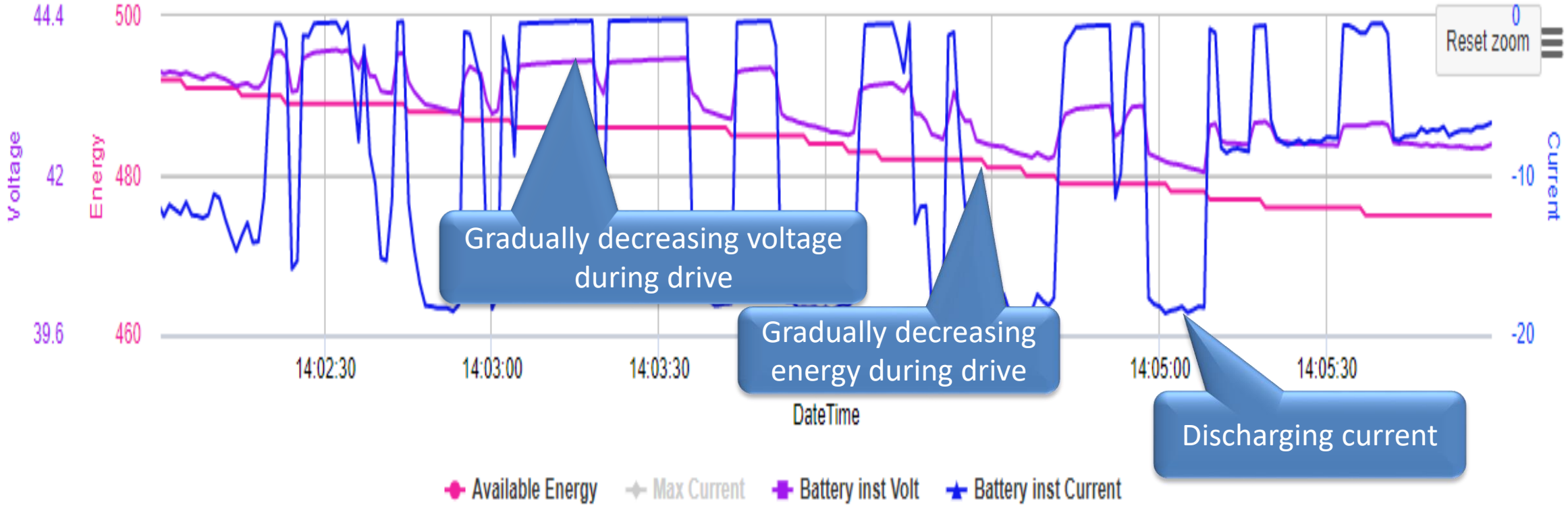
Vehicles on Drive

Pilot of LS Battery swapping at IITM Campus

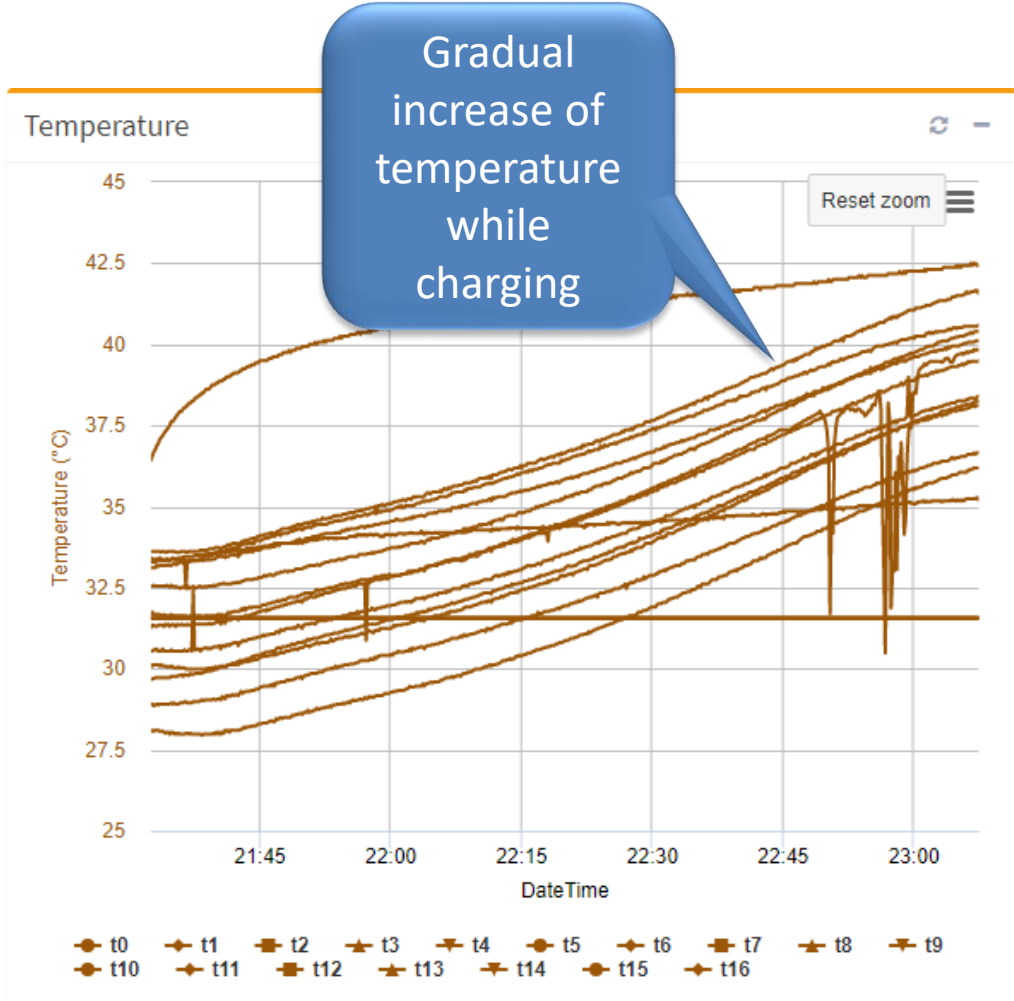
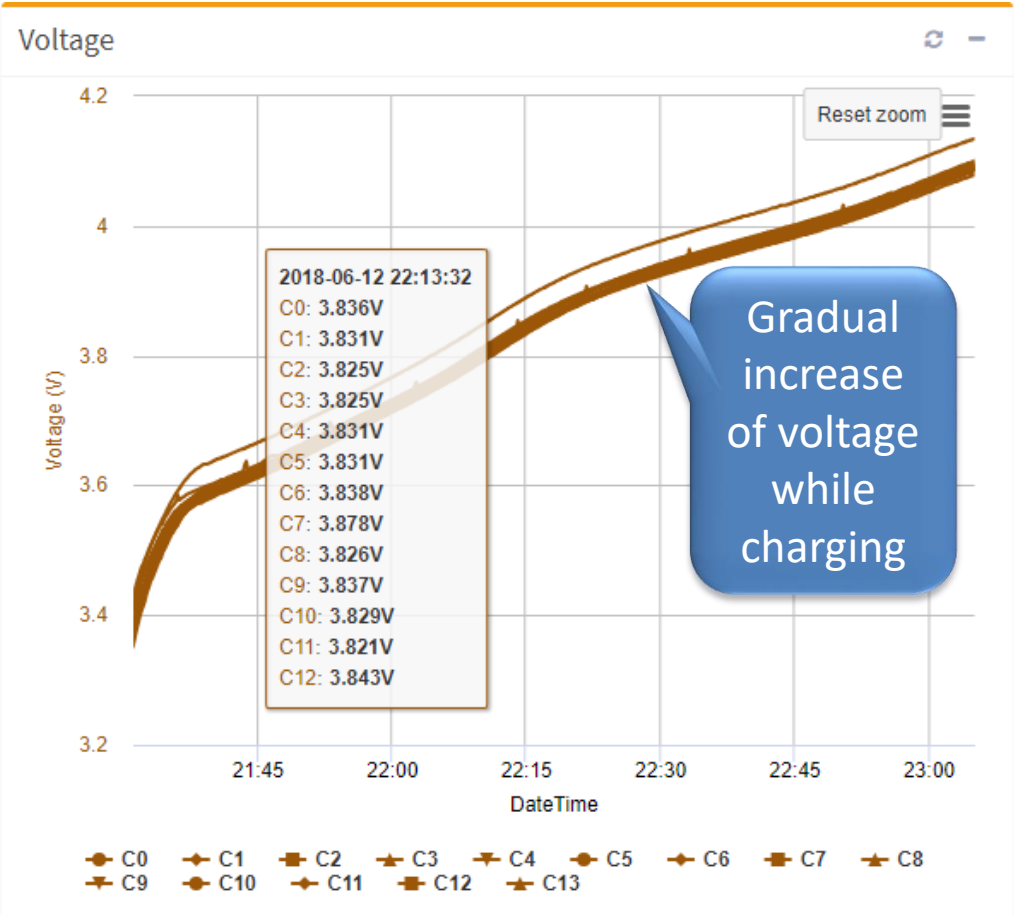


Test vehicle with school kids, residents and staff in IITM campus

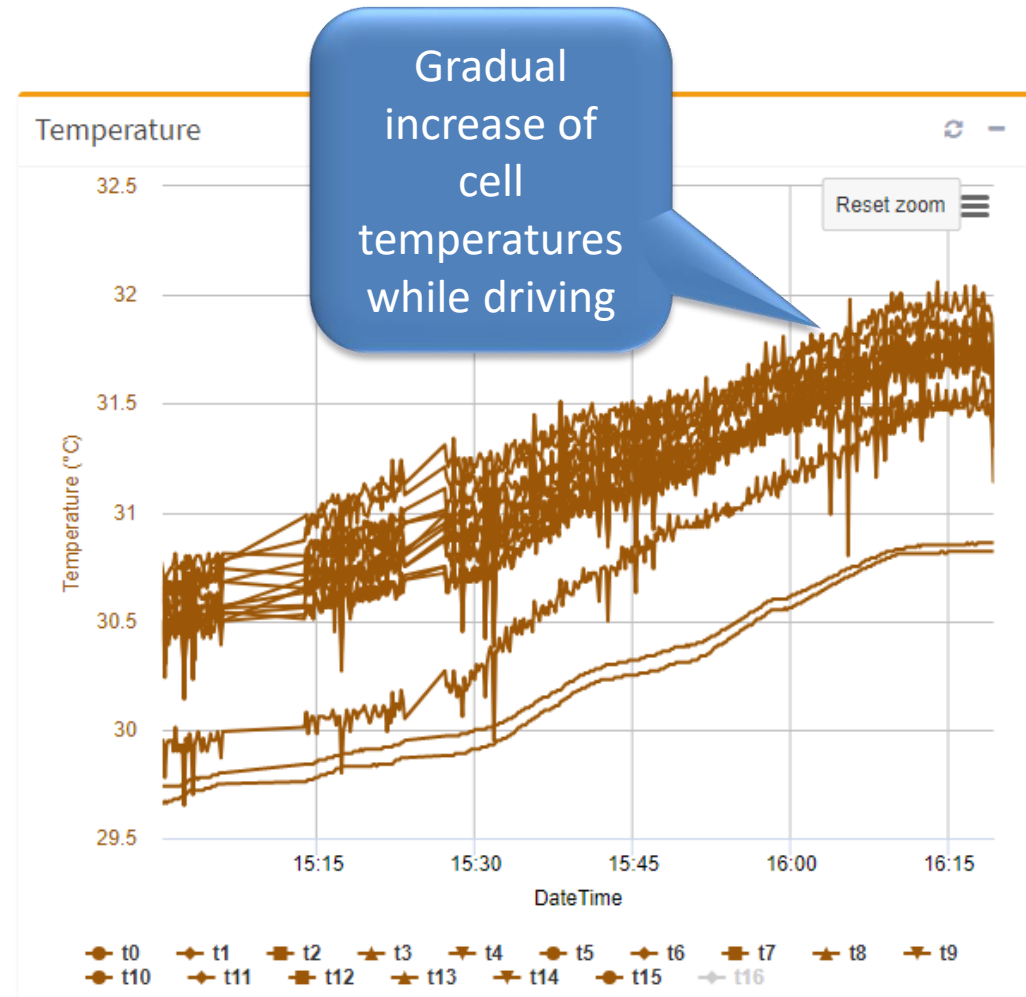
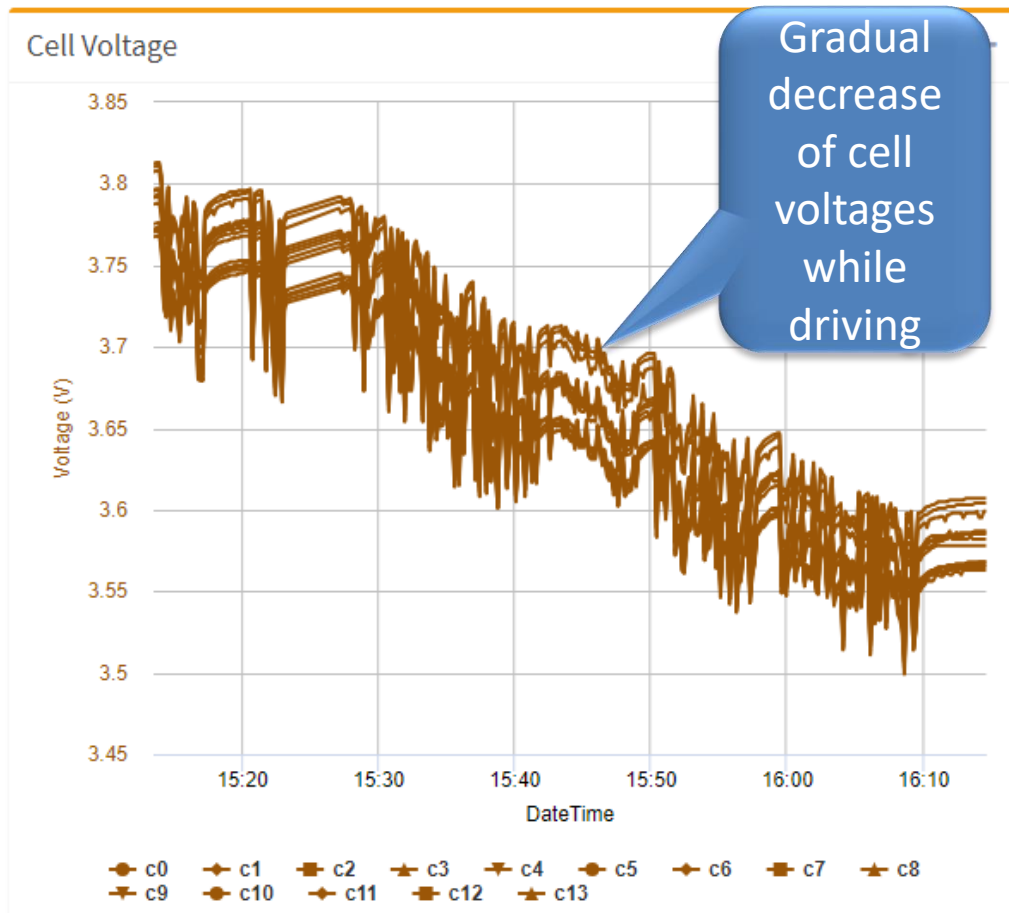
Battery pack energy, voltage and current during driving



Individual Cell Voltage and Temperature while charging



Cell voltage and temperature monitoring during driving



Performance Comparison

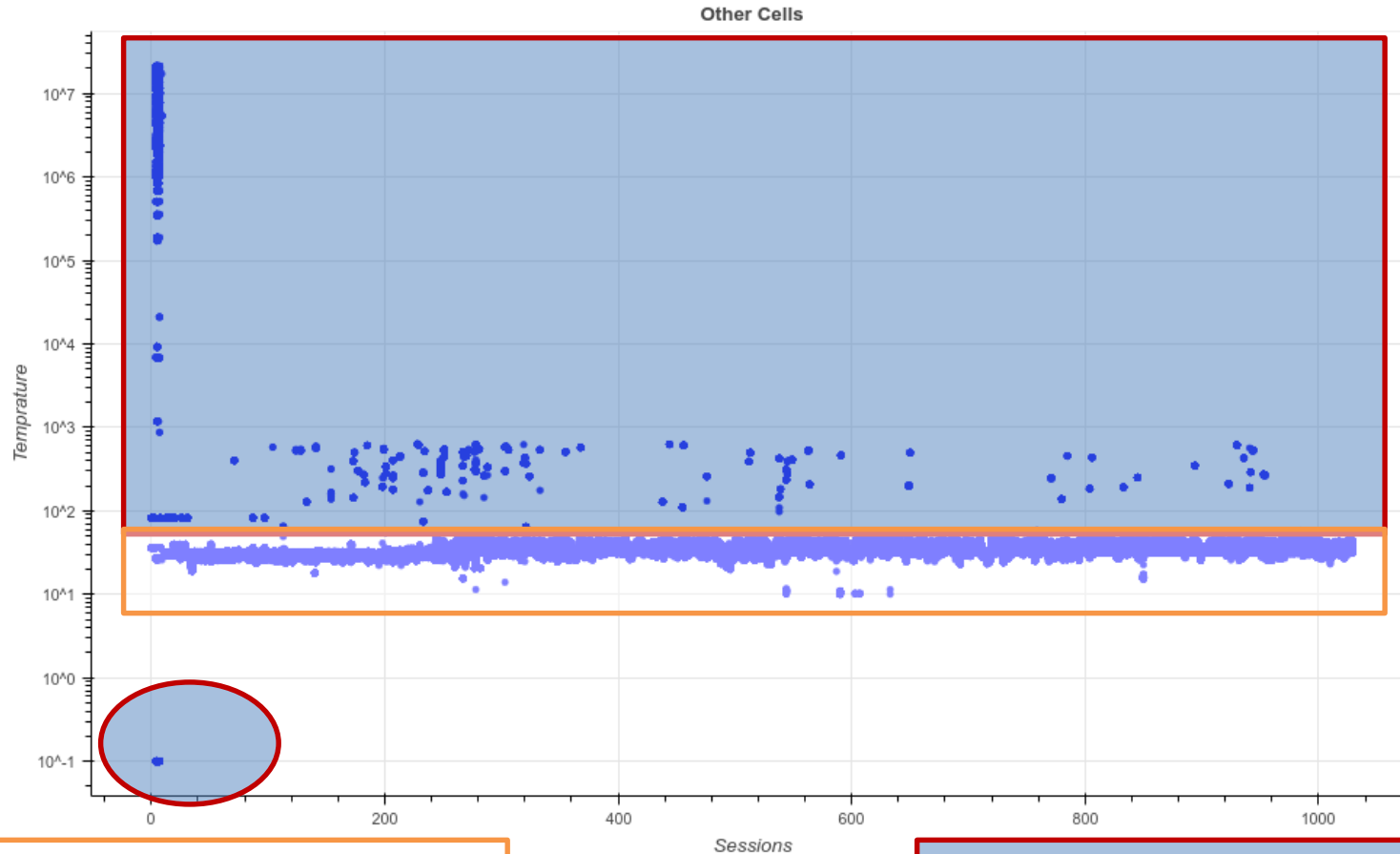
S.No	Make and Model	Wh/Km	Distance travelled (Kms)
1	Make 1, Model A	44	36
3	Make 1, Model C	38	27
4	Make 2, Model A	42	43
5	Make 2, Model B	37	51
6	Make 3	39	46
7	Make 4	58	31
8	Make 5	41	46

Sample Dated: 14th June, 2018

S.No	Vehicle Make	Total Rides	Avg. Wh/Km
1	Make 1/C	164	40.36
2	Make 2	331	44.15
3	Make 3	324	44.28
4	Make 4	419	46.29
5	Make 5	82	52.18
	All	1320	45.45

Cumulative of 4 Months

Charging – All Cell temperatures for all sessions (~ 6 Million data points)



Normal operating range –
25 to 50 deg.C

Wrong values - to be analyzed

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
 - With attempts to preserve India's GDP and grow jobs
- Can we do it by 2030: **Certainly**

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