LEEP EDRIVE PRIVATE LIMITED

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- **Li Battery Overview and Li availability**
- **LeeP eDrive present**
  - **3-W auto in Bangalore – Retrofitted prototype in Field trial prototype**
  - **Networked battery & "Pay-On-Charge" model.**
- **EV power train extension to 4 wheeler**
  - **Aggregation model of E-mLCV commercial fleet**

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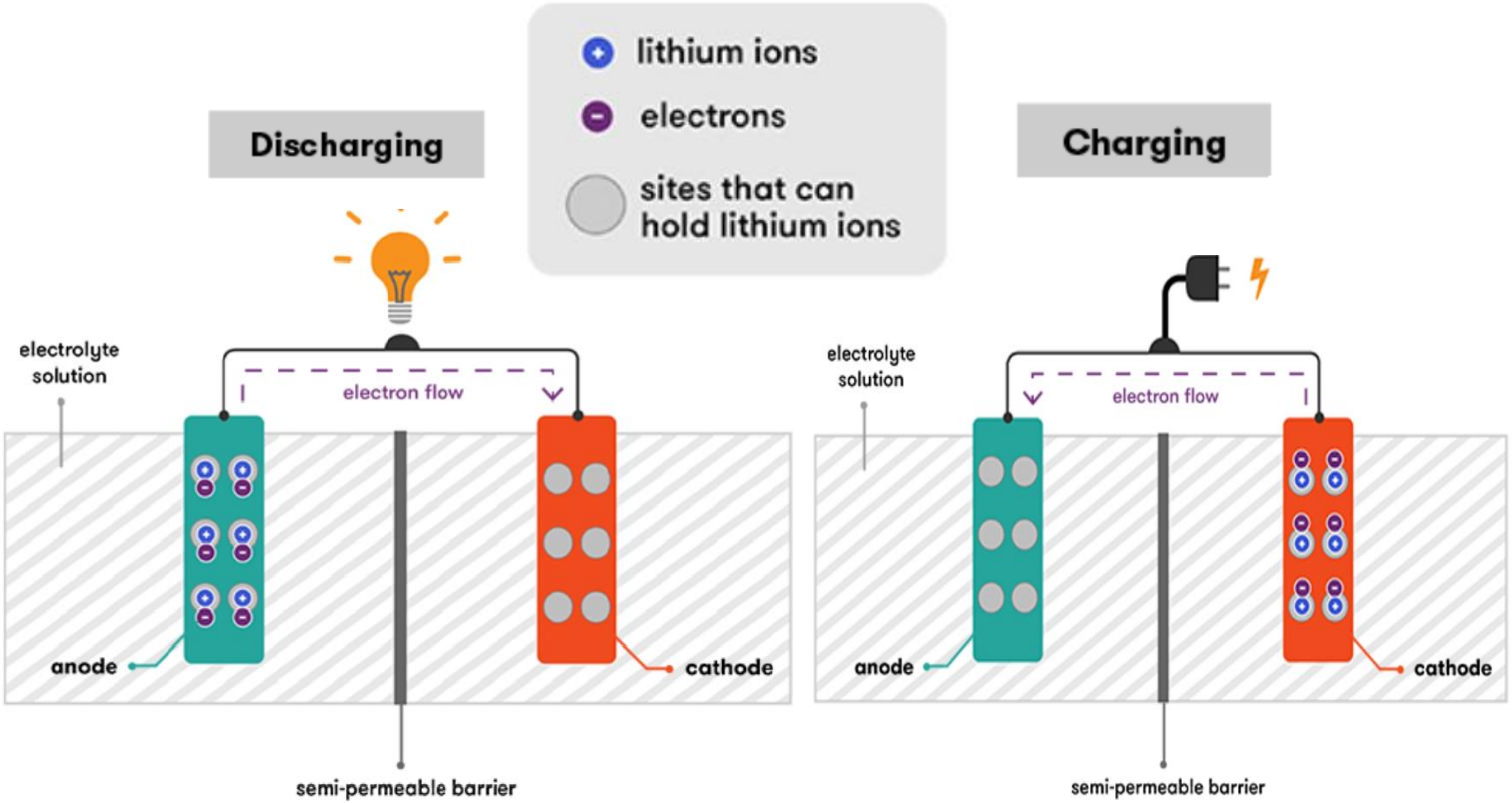
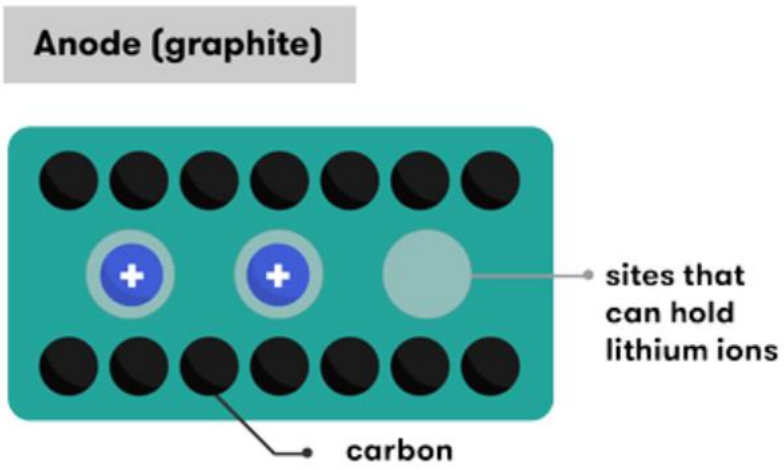
Li battery Overview

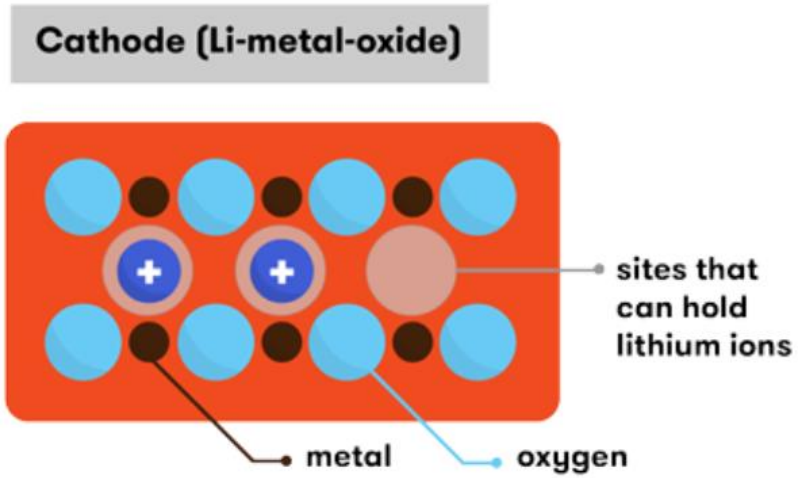


- See notes page for explanation and link below for animation

https://www.science.org.au/curious/technology-future/lithium-ion-batteries

A look inside the anode / cathode





Lithium manganese oxide ($LiMn_2O_4$)

Higher energy density and less internal resistance & better thermal stability

Lithium cobalt oxide ($LiCoO_2$)

Higher energy density but less thermal stability

Lithium nickel manganese cobalt oxide ($LiNiMnCoO_2$ or NMC)

low internal resistance, high charging rate, good stability and safety

Lithium iron phosphate ($LiFePO_4$)

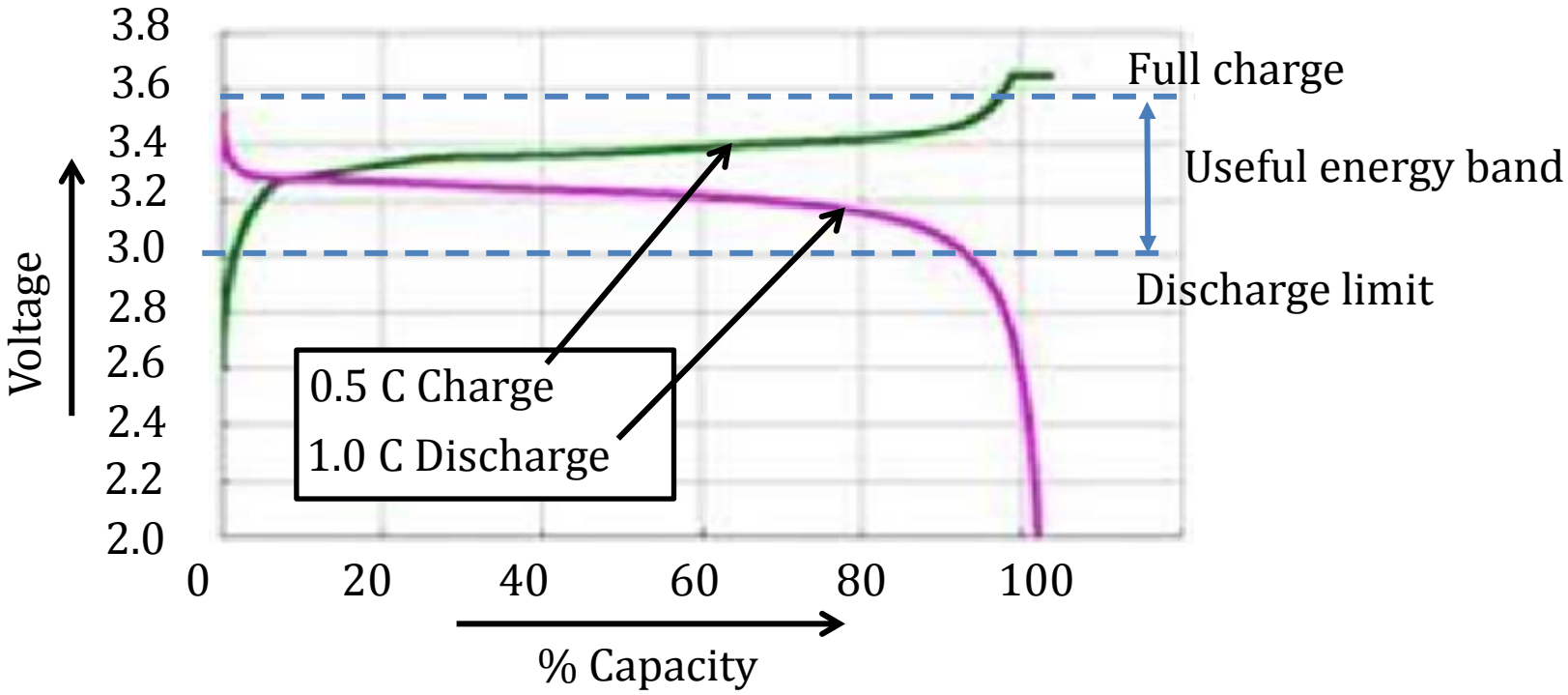
Lower energy density but higher thermal stability

Lithium polymer

Replacing the liquid electrolyte in a lithium-ion battery with a solid electrolyte

Battery management nuances

- ❑ Large Energy storage
- ❑ Safe charge discharge cycles.
- ❑ High current use (upwards of 250 A)
- ❑ Discharge rating can rise to 150 % to 200 %.

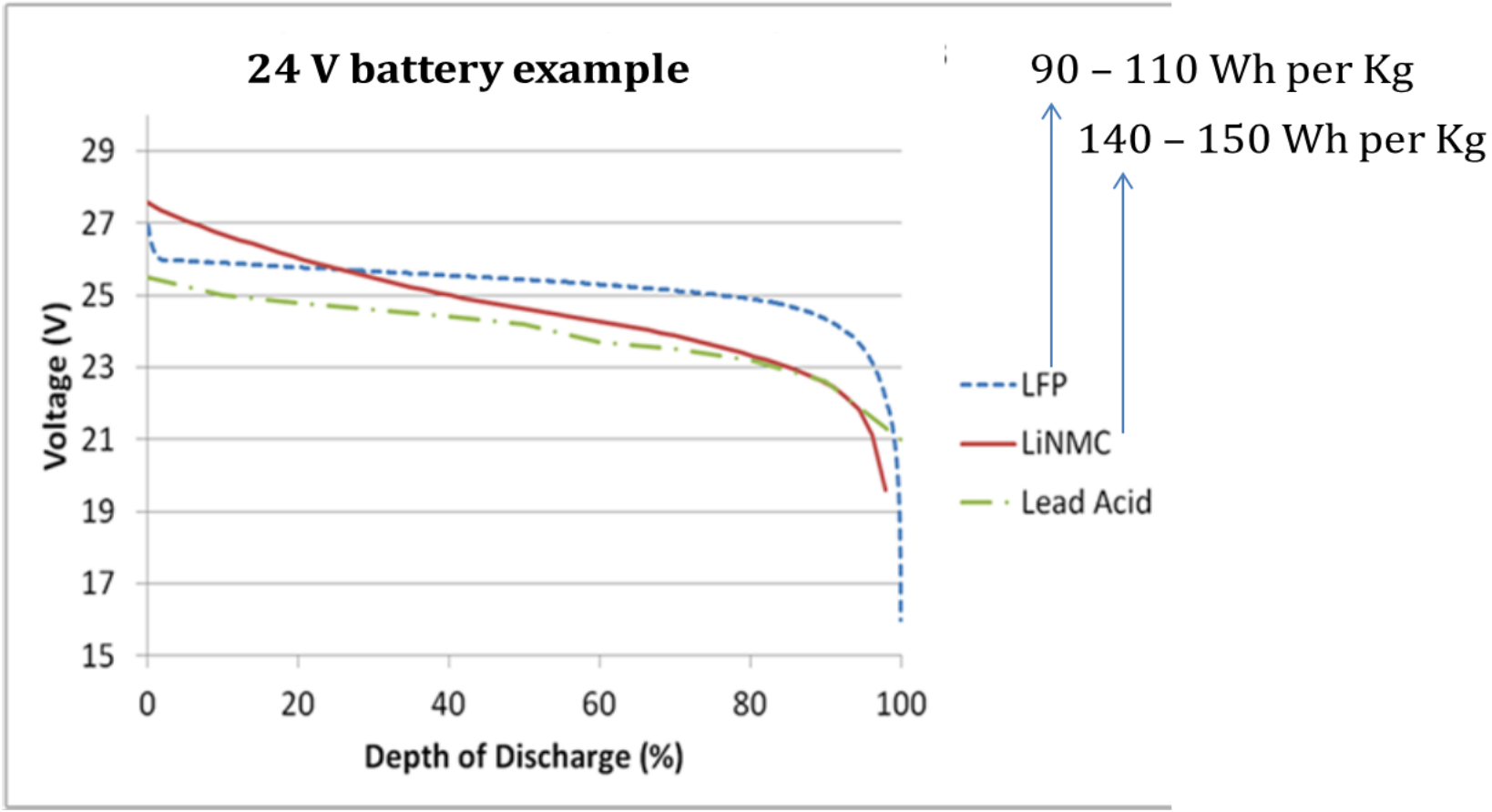


Example : LFP (Lithium Ferrous Phosphate Cell)

Voltage Vs energy storage

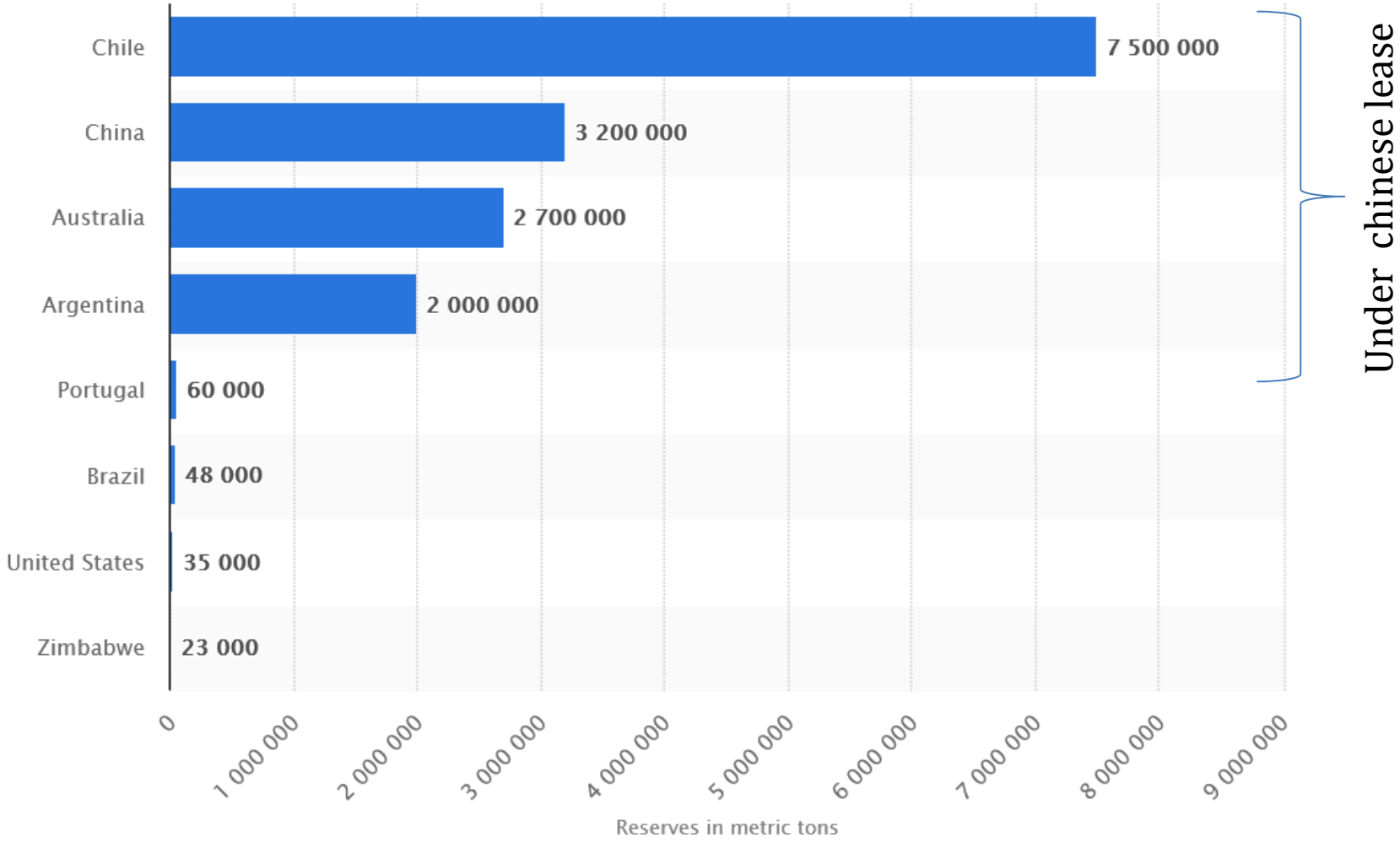
❑ Electro Chemistry differences

- ❑ Lithium Iron Phosphate (LFP)
- ❑ Lithium Nickel Manganese Cobalt Oxide (NMC) **(Preferred for EV)**
- ❑ **Specific energy rating Wh/Kg continues to improve**



Lithium availability – an overview

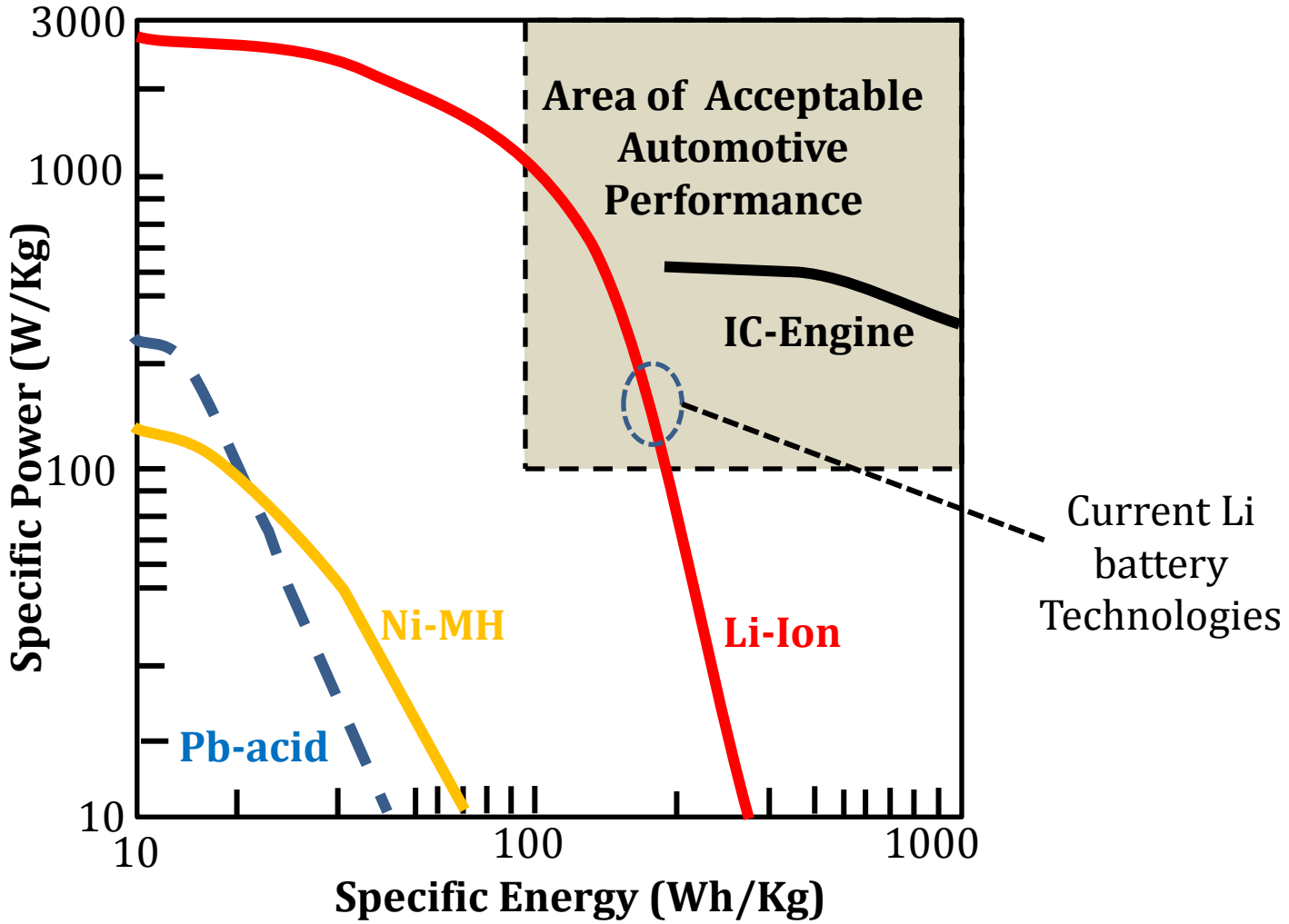
❑ World Lithium reserves by country - 2017



https://www.statista.com/statistics/268790/countries-with-the-largest-lithium-reserves-worldwide/

Why Li – ion batteries for Road Vehicles

- Ragone Plot of Specific Power versus Specific energy



Reproduced from "Battery Systems Engineering" – Rahn & Wang

Pb-acid → Ni-MH → Li-ion compared

	Pb-Acid	Ni-MH	Li-ion
Theoretical			
Voltage per cell (V)	1.93	1.35	4.1
Specific Energy (Wh/Kg)	166	240	410
Practical values - Manufactured			
Specific Energy (Wh/Kg)	35	75	150
Energy Density (Wh/L)	70	240	400
Coulometric efficiency	0.8	0.67	> 0.8
Energy Efficiency	0.67	0.6	~ 0.8
Specific Power, 80% DOD (W/Kg)	220	150	350
Power Density (W/L)	450	> 300	> 800

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Present status of the initiative

- **Main aim of the initiative and prototype building**
  - EV vehicle industry is basically disruptive business for existing vehicle companies but needs to proliferation push in India
  - Technology far different from the existing manufacturing expertise with vehicle manufacturers of all class of vehicles.
  - Need to bridge the cost bias due to the battery being 60 % of the vehicle cost.
  - The industry have to evolve from bottom up and so needs to start at the "start-up" structure.
  - Cost push viability in favor of commercial vehicles .
    - Example: Auto-rickshaws & commercial LCV
    - Maximum km coverage per day use for viability
  - Two autos operational in Bangalore and connected to a pilot network
  - LeeP eDrive Private Limited company registered as startup.
- **Large energy storage battery technology built and in use**
  - 6 to 25 KWH capacity reached
  - 48 – 96 V voltage
  - Battery built with networking capability to be part of "Pay-On-Charge" business modeling.
  - Bicycle / two wheeler / three wheeler prototypes retrofitted and operational.
  - Four wheeler prototype (miniLCV) in prototype assembly.

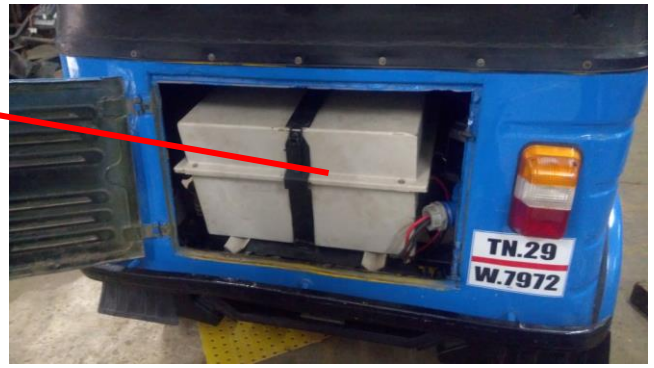
Operational 3 wheeler prototype

❑ Retrofitted three wheeler with electric propulsion

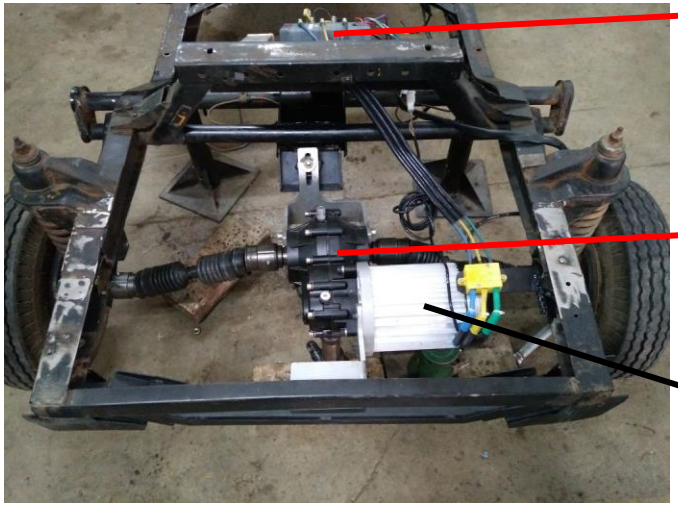
- ❑ Direct drive electric
- ❑ 6.5 to 7.5 Kwh energy storage Li battery
- ❑ 90 to 100 kms range

Rear view of mounting of motor

Battery



Motor controller



8:1 split axle differential

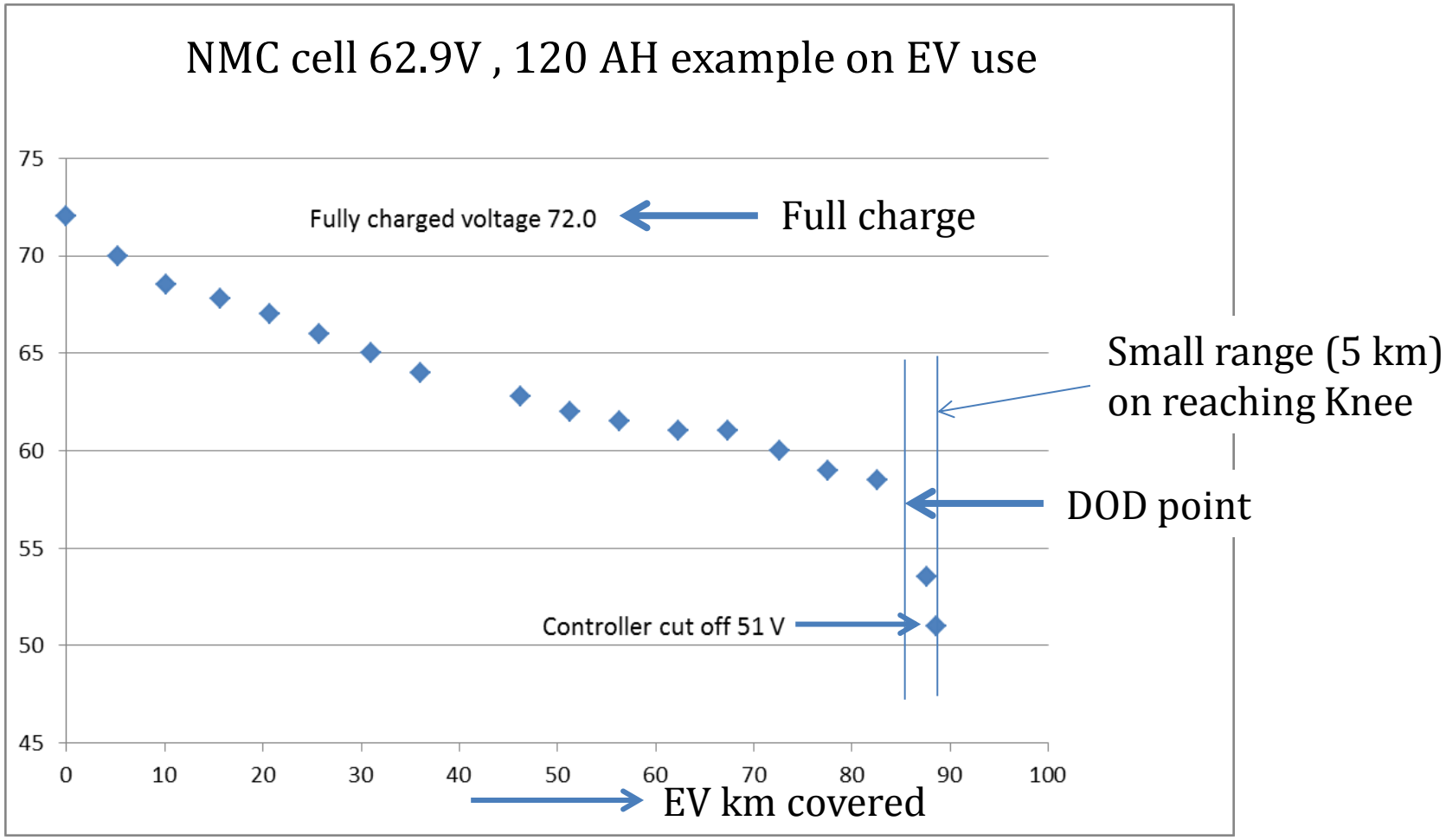
2.5 KW motor with 150 % overdrive provision

Vehicle on road trials in Bangalore

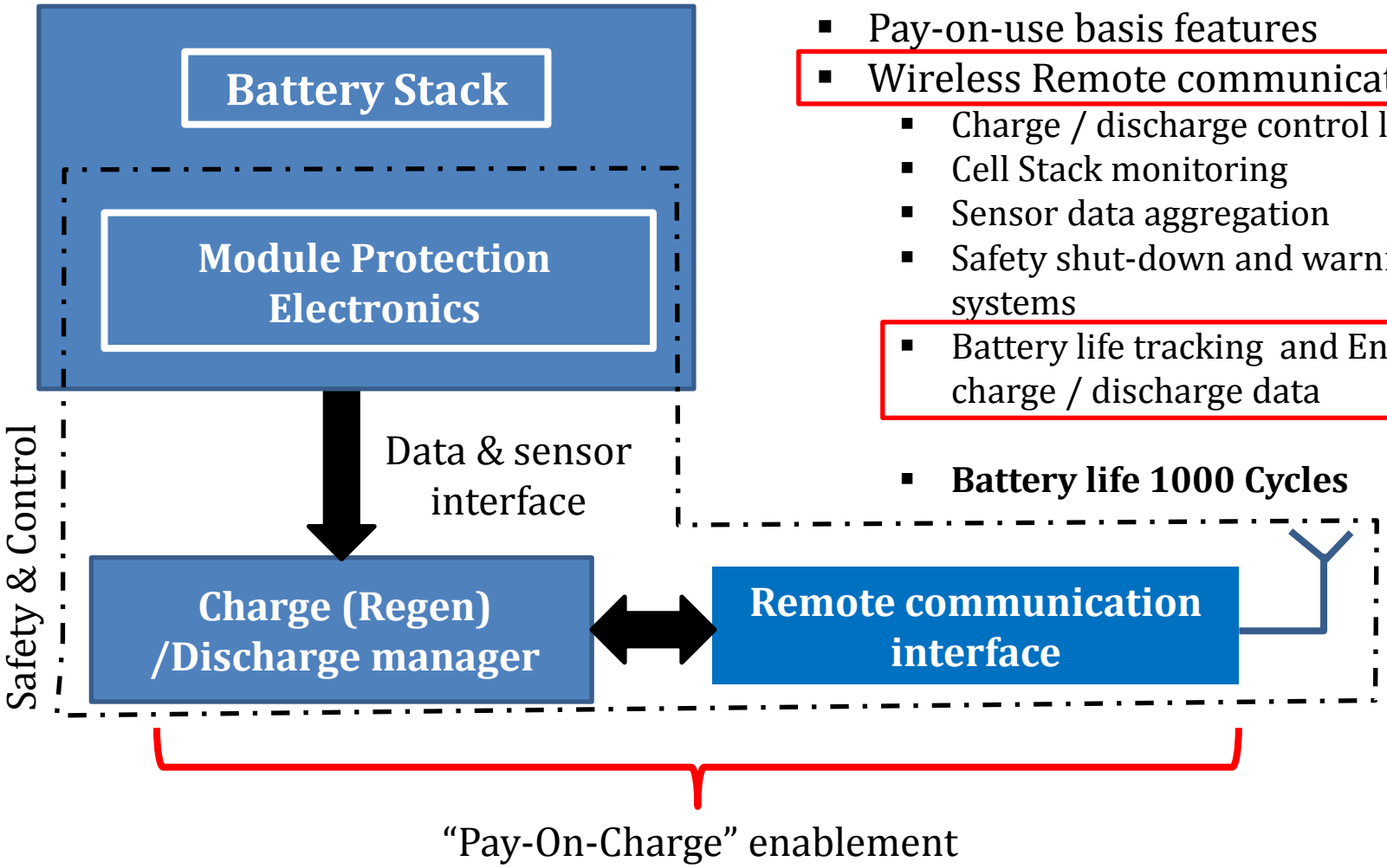
- **Retrofitted three wheeler with electric propulsion**
  - First has clocked > 3000 kms
  - Second has crossed 1500 kms.

On road trials and range

- **Battery performance on three wheeler**
  - NMC cell 62.9V , 120 AH example on EV use
  - Battery voltage swing from Full → DOD point



Dynamic Battery & "Pay-On-Charge" capability

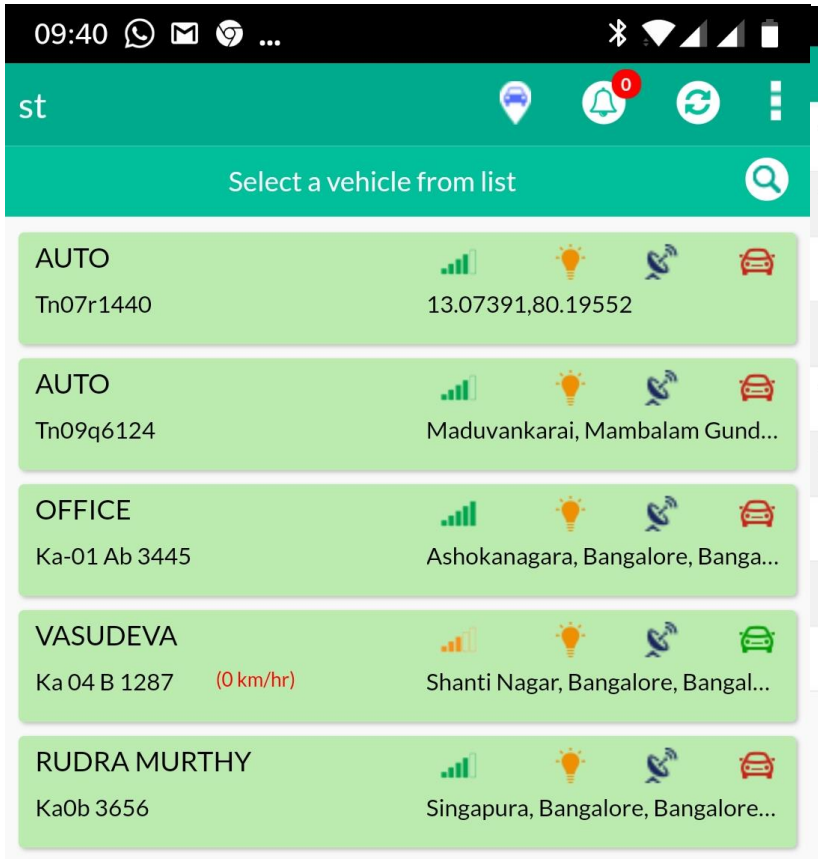


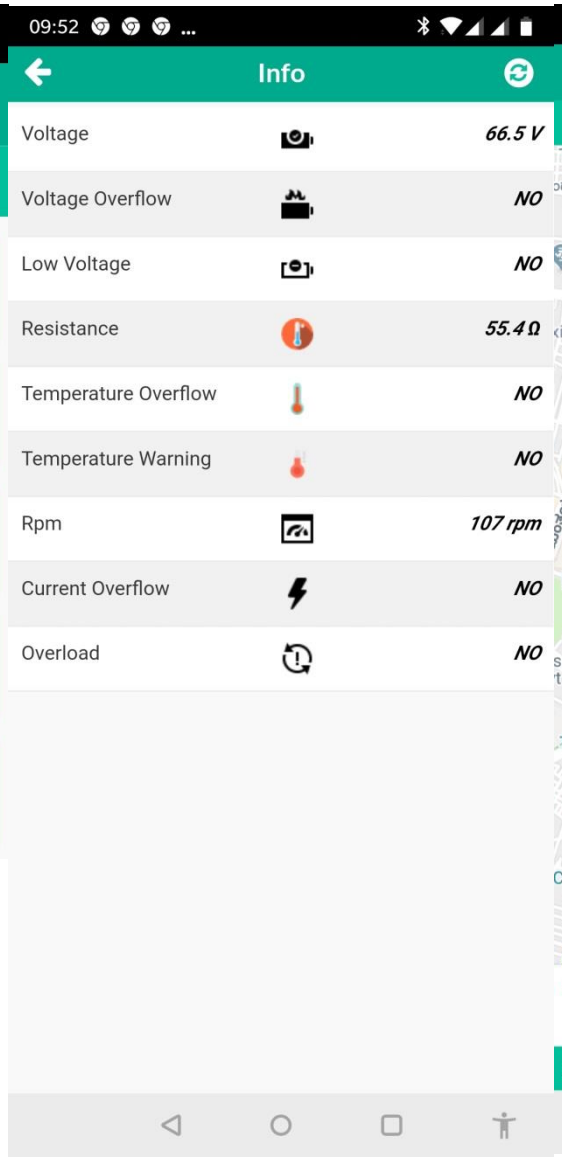
Remote manager functions

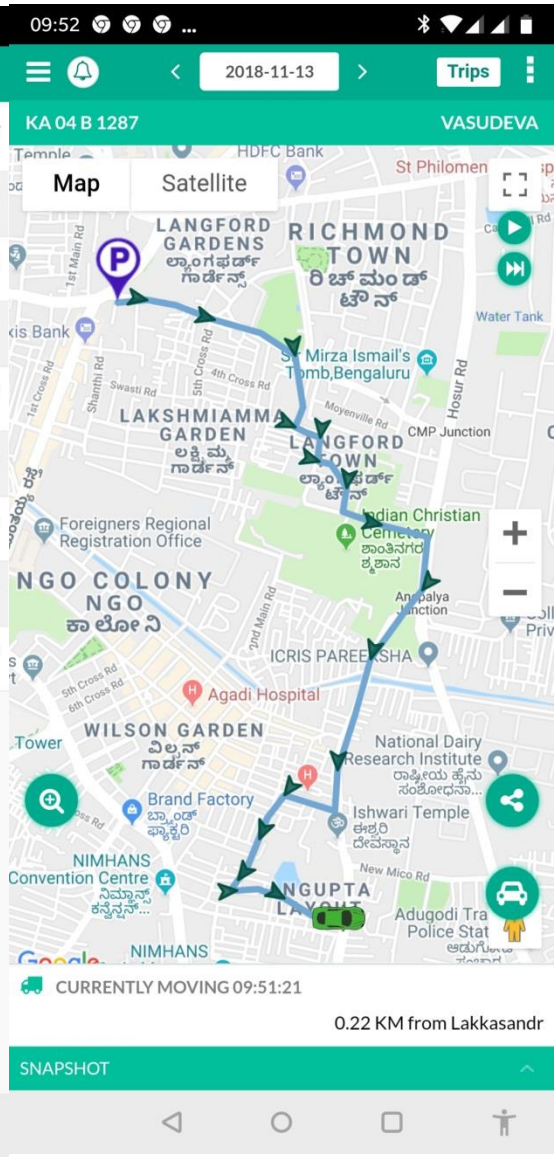
- Pay-on-use basis features
- Wireless Remote communications
  - Charge / discharge control limits
  - Cell Stack monitoring
  - Sensor data aggregation
  - Safety shut-down and warning systems
- Battery life tracking and Energy charge / discharge data
- **Battery life 1000 Cycles**

❑ Capable of fast and slow charge – 15A (6 hours) / 25 A (4.5 hours) / 50 A (2 hours)

Android app tracking the LeeP 3-W







Provisional Patent filed

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GOVERNMENT OF INDIA

INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

CHALLAN : TR-5
DOCKET NO:2096

Date/Time : 10/01/2018

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Agent Number:

Sr. No.	CBR No.	Reference Number /Application Type	Application Number	Title/Remarks	Amount Paid
1	841	ORDINARY APPLICATION	201841001088	NETWORKED BATTERY FOR HIGH ENERGY APPLICATIONS	1750
2		E-101/975/2018-CHE	201841001088	Correspondence	0
3		E-2/93/2018-CHE	201841001088	Form2	0
4		E-3/903/2018-CHE	201841001088	Form3	0
				Total :	1750

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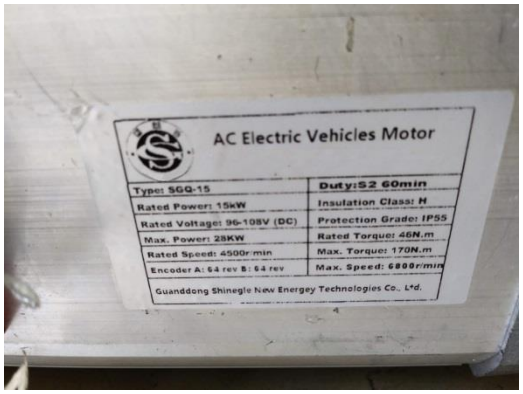
The EV power train – 15 KW drive & control

AC motor

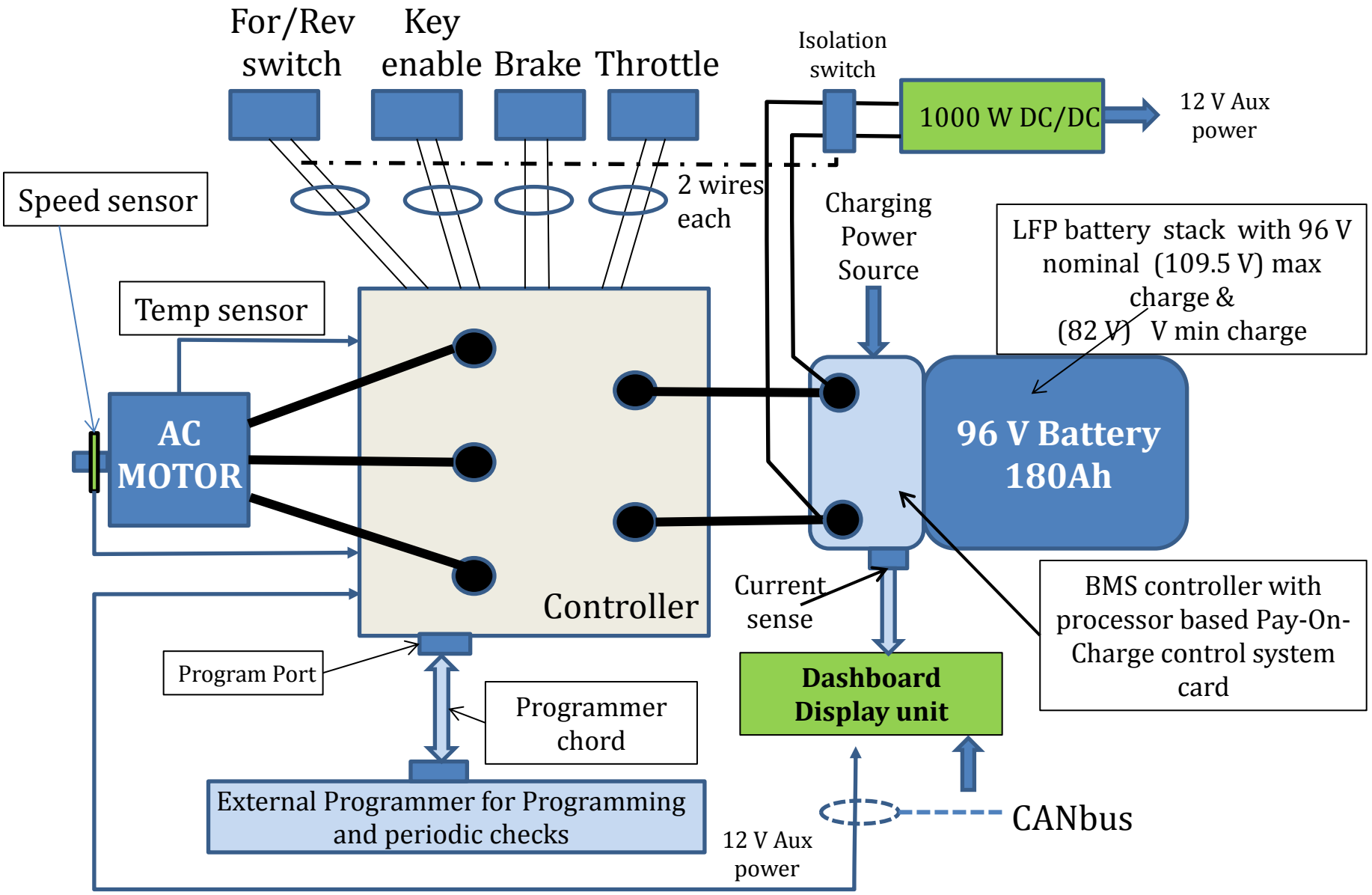


Controller & programmer

Rated power	**15kw**
Battery voltage	96
Rated frequency	152
Rated speed(rpm)	4500
Max. speed(rpm)	7000RPM
Speed sensor	64 Pulse
Protection grade	IP55
Insulation class	H
Max.torque	150 N.m
Size(mm)	Φ230×304
Net weight	60kg

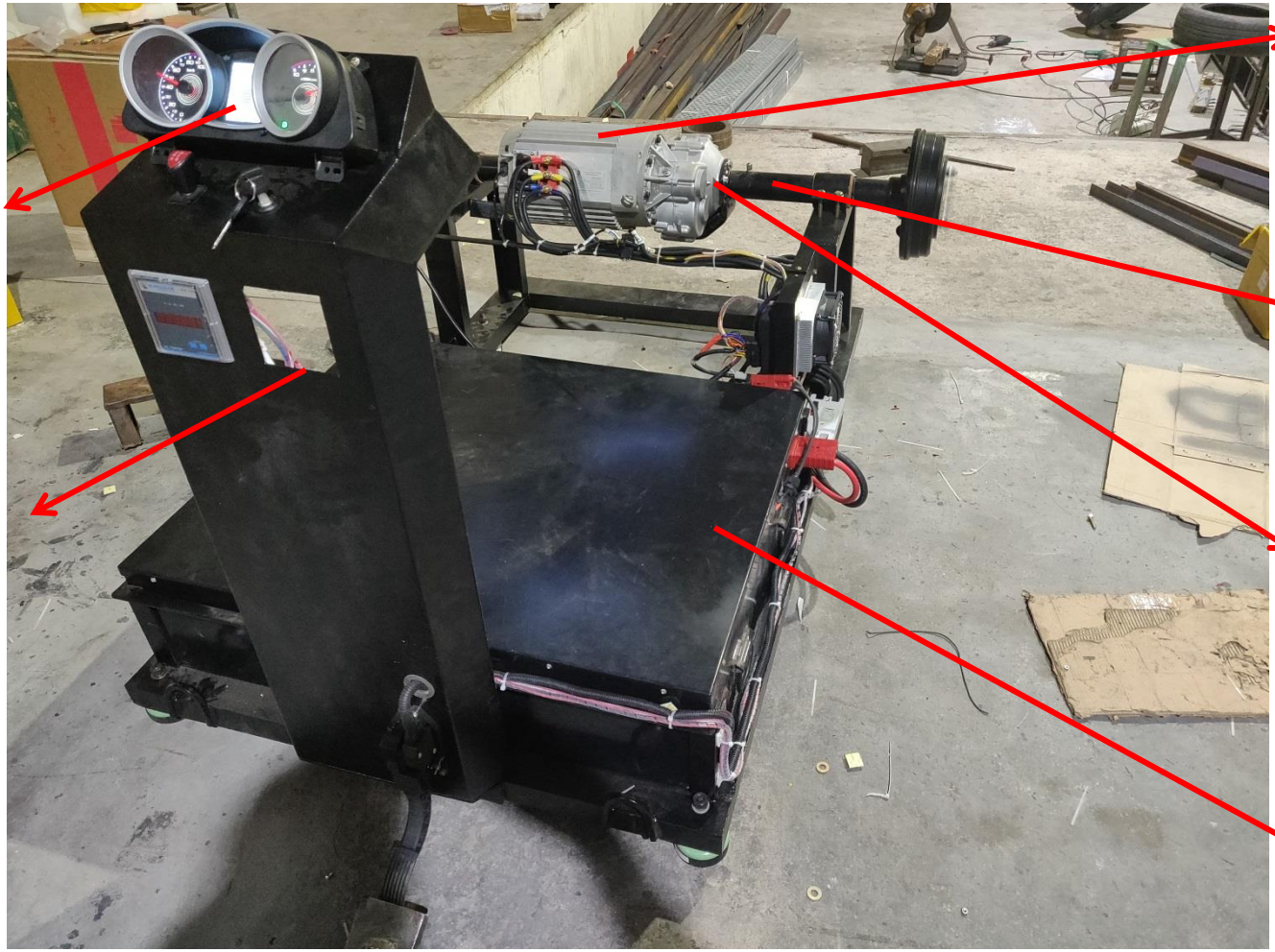
Rated voltage	96
Working voltage range	65%~135% of rated
Rated output current	140A
Max output current	550A
Digital input	8
Analog input	2
Protection grade	IP66
Ambient temperature	-40 ~ 50℃
Control mode	Vector control
Communication mode	CAN
Size（L*W*H)mm	270x238x180
Net weight	9.5kg

The EV power train – Energy connection scheme



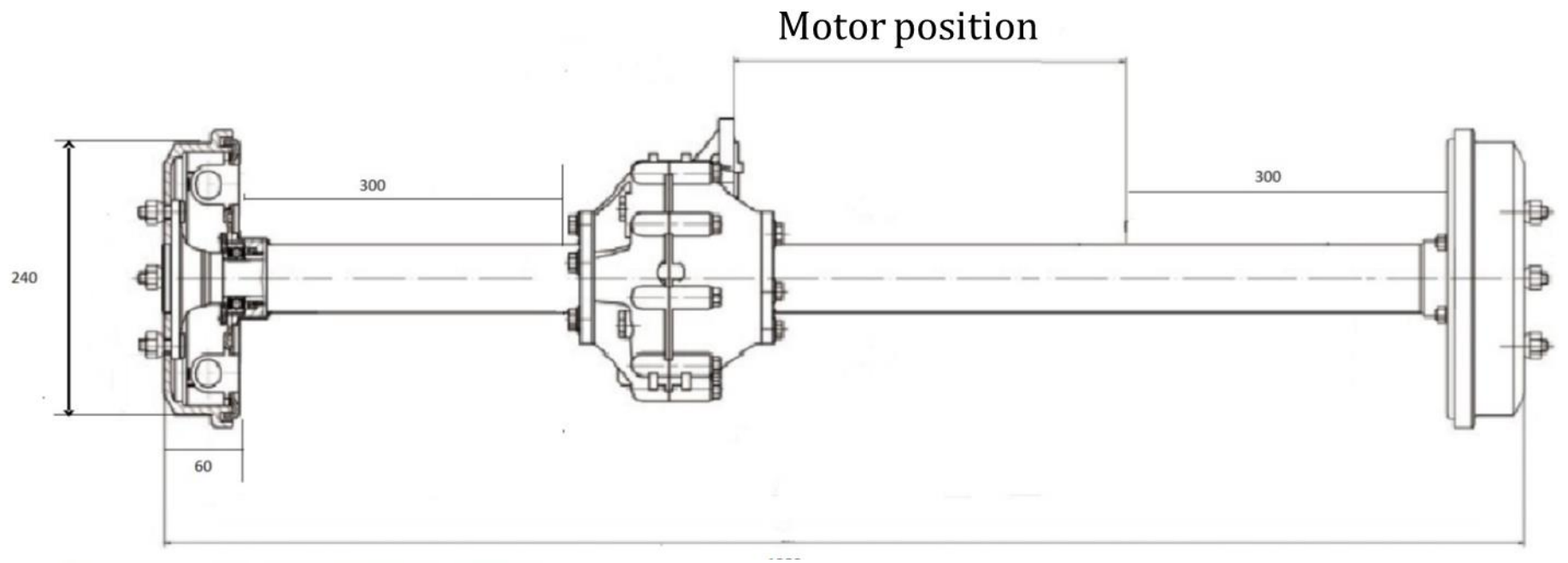
15 KW drive train for dynamometer testing

❑ 15 KW eDrive for dynamometer testing



The EV power train – Geared differential

REAR AXLE WITH GEAR BOX DIMENSIONS :



REAR AXLE SPECIFICATIONS:
GEAR REDUCTION RATIO : 6.5:1
SPEED CAPACITY : 8000RPM
TORQUE CAPACITY : 300Nm
BRAKES : HYDRAULIC DRUM BRAKES WITH PARKING LEVER
WHEEL USED -
13 INCH DIAMETER WITH 5-BOLT PATTERN ASSEMBLY,
TIRE USED 155/70 R13

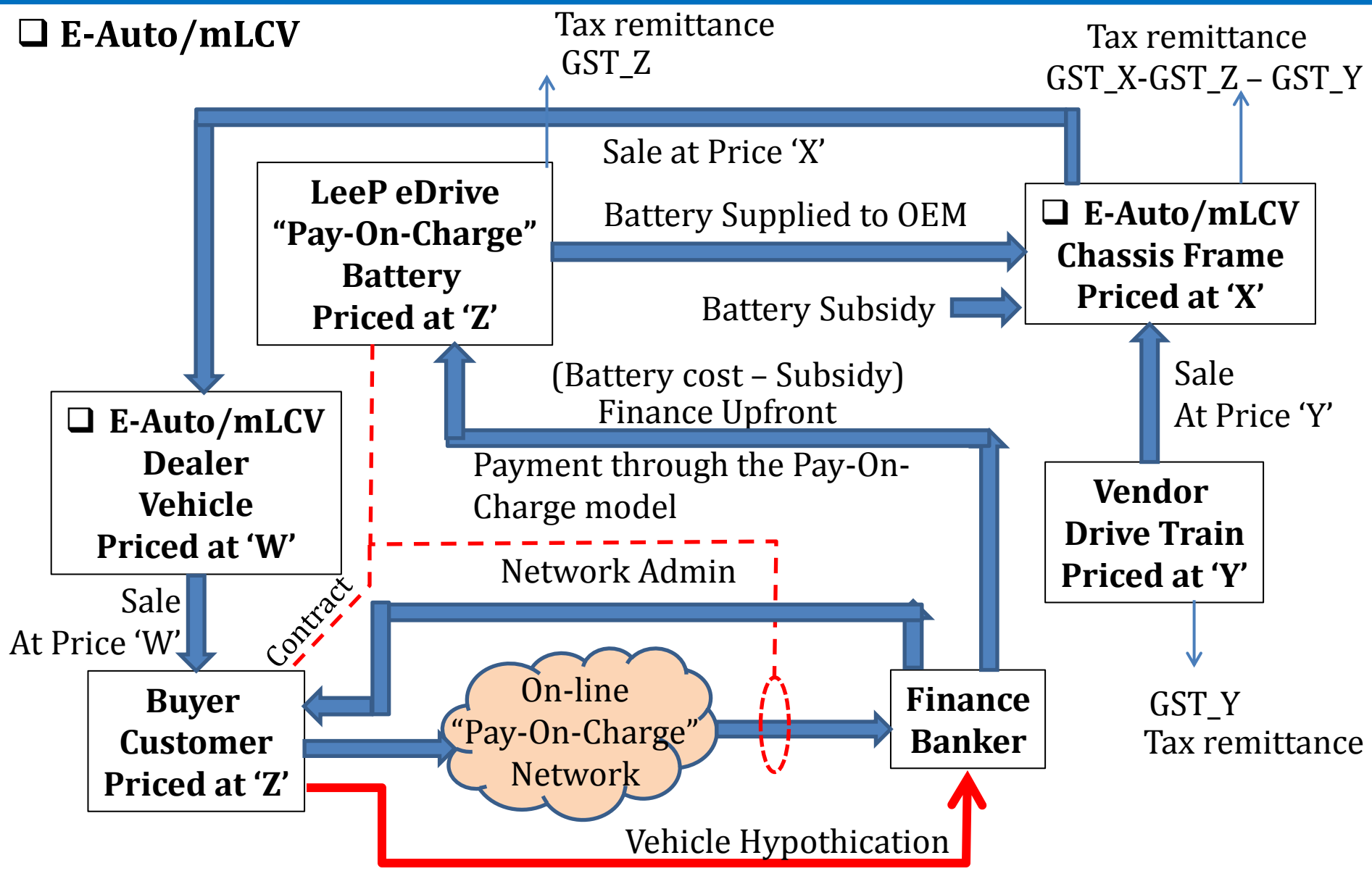
Business Idea from Economics.

- Build and Own "End to End" battery and Charging stations with the networked battery.
  - Battery cost dis-engaged from Vehicle cost
  - Four autos Plus one demo version on road in Bangalore

- Production scale Pilot project –
  - Proliferate in the available 3 wheeler retrofit model in Bangalore
    - Over 5000 Autos available in Bangalore for this retro-fitment.
    - Planning for 300 in three years as POC
  - Possible extend to all Indian cities
    - Proliferation business through OEM : once POC is established
    - "Pay on Charge" battery model extended to OEM operations

- Build technology over the next three years to meet EV proliferation in India as possible extension.
    - Build the 4 wheeler prototype – work in progress
    - Establish supply chain and build engineering in India
    - Use an aggregation model for E-mLCV Commercial fleet

"Pay-On-Charge" model when extended to OEM



Key take Home Points – Pros & Cons

- EV Industry in India
  - Need policy level corrections
    - Policy decisions at Gov't levels to catch up with technology.
      - Rationalize duty structure Li battery
        - EV energy storage and use need to be segregated as a special category and not pooled into other Li battery for imports .
  - OEM level is still in its infancy in India
    - Need EV proliferation at all levels as % of fleet OEM manufactured.
    - Domestic engineering industry should catch up with all engineered items for the power train
      - None in the Horizon.
  - Basic Lithium cell to construct batteries can come only from China
    - Need to have micro level vendor links in China for supply chain
    - Technology gap in Components & modules to be "Made in India"
  - Knowledge gap in Industry for handling power electronics and needs to be augmented over a three year period to support OEM and EV proliferation
  - First mover advantage at Start up level in adopting technology and modifying to meet Indian need.

END