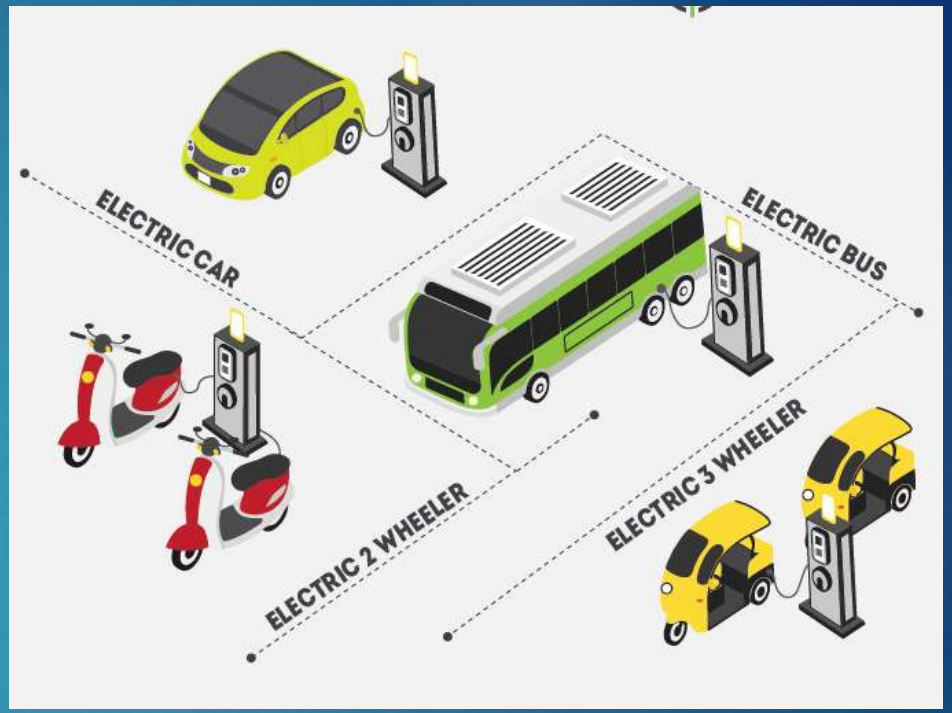
EV Ecosystem



Gourab Paul
Sushmita Panigrahi
Nirvana Laha

THE AUTOMOBILE ECOSYSTEM IS GOING THROUGH A DRAMATIC SHIFT. THE THEMES DRIVING THOSE ARE PERSONALIZED, AUTOMATED, CONNECTED AND ELECTRIFIED (PACE)

ICE to EV transition

1. GLOBAL REGULATION/STANDARD
2. TRANSITIONS IN THE 2W ECOSYSTEM
3. TRANSITIONS IN THE 4W ECOSYSTEM

Global regulations & trends

- EU7 – Emission norms + OBD
- CARB - Emission
- ACC2 - OBD
- AIS 35 – Electrical, performance etc.
- SAE
- ISO 26262

The emission norms are getting stricter across the globe. The regulation is driving massive changes in the automotive space with respect to safety of passengers , carbon footprint etc.

EV adoption - India

Electric vehicle penetration in India currently only around 1%: Moody's report

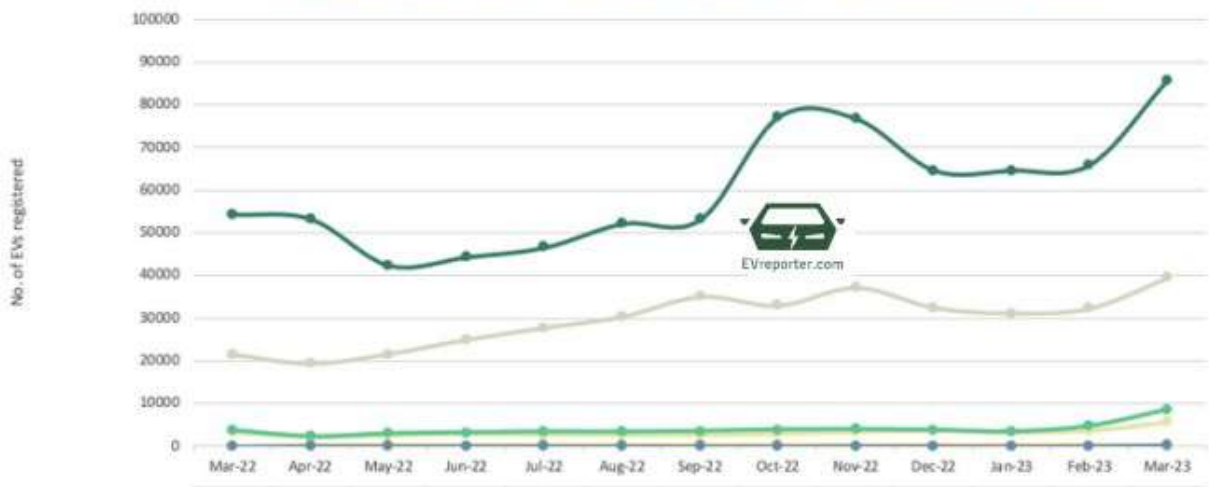
Electric mobility has been one of the main focus points of the government in order to cut the import bills frc petrol and reduce carbon emissions. However, electric vehicle (EV) penetration is still in its development st the country. A recently released report by Moody's Investors Service revealed that though India has the thi largest car market globally, EV penetration is currently only around 1%.

By: **HT Auto Desk** | Updated on: 12 Apr 2023, 12:32 PM

The Indian EV growth story is driven by e-2W and e-3W

Category wise-Sales Trend from Mar 2022 to Mar 2023

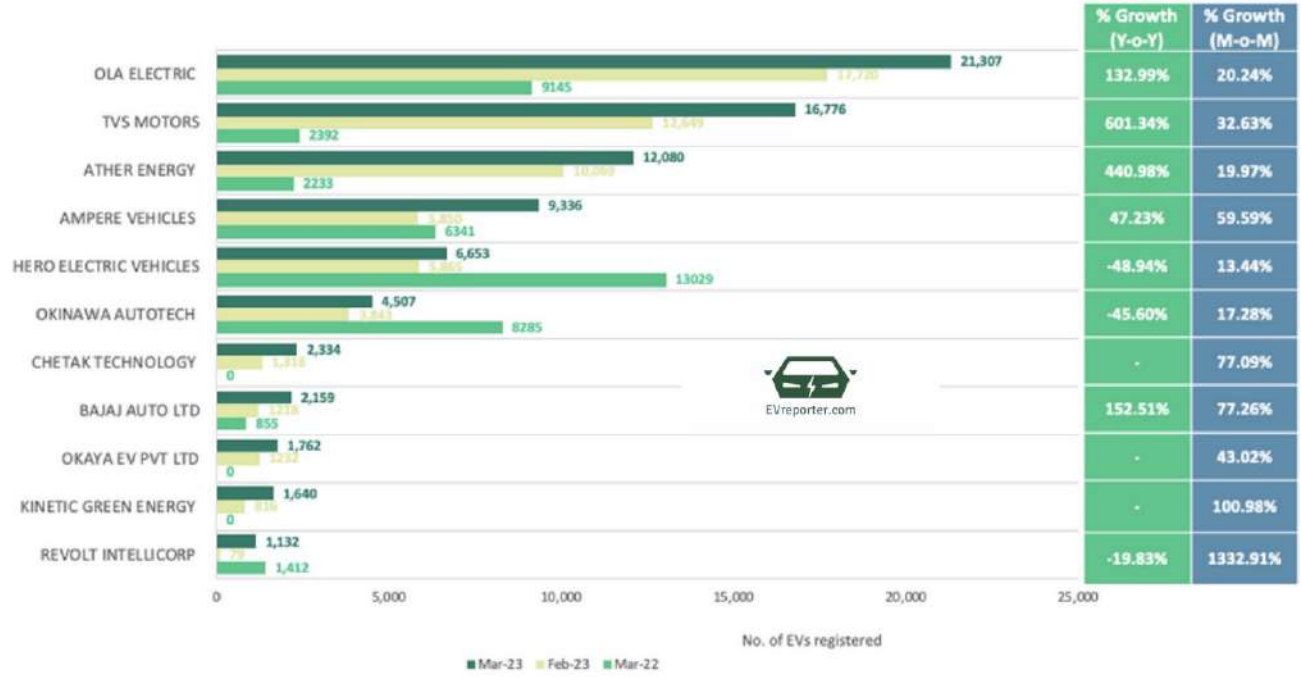
11,80,903 EVs sold in last 12 months from Apr 2022 to Mar 2023



	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23
E- 2Wheeler	54400	53259	42403	44367	46599	52187	53192	77098	76684	64579	64,640	65,979	85,850
E-3Wheeler Passenger	21511	19340	21641	24988	27754	30365	35028	32945	37131	32435	31,140	32,292	39,450
E-3Wheeler Cargo	3312	2419	2673	3041	2842	2757	2757	3045	3457	3770	3,333	3,779	5,780
E-4Wheeler	3718	2249	2959	3210	3404	3351	3529	3898	3960	3820	3,423	4,724	8,591
E-Bus	78	165	165	145	207	227	214	241	117	151	96	98	87
Others	51	63	48	81	50	60	43	41	58	55	3	92	279
TOTAL	**83070**	**77495**	**69889**	**75832**	**80856**	**88947**	**94763**	**117268**	**121407**	**104810**	**102635**	**106964**	**140037**

Source: Vahan Dashboard. Data as per 1350 out of 1436 RTOs across 34 out of 36 state/UTs
Low speed 2Ws not included.

EV adaptation – 2W



	% Growth (Y-o-Y)	% Growth (M-o-M)
OLA ELECTRIC	132.99%	20.24%
TVS MOTORS	601.34%	32.63%
ATHER ENERGY	440.98%	19.97%
AMPERE VEHICLES	47.23%	59.59%
HERO ELECTRIC VEHICLES	-48.94%	13.44%
OKINAWA AUTOTECH	-45.60%	17.28%
CHETAK TECHNOLOGY	-	77.09%
BAJAJ AUTO LTD	152.51%	77.26%
OKAYA EV PVT LTD	-	43.02%
KINETIC GREEN ENERGY	-	100.98%
REVOLT INTELLICORP	-19.83%	1332.91%

The EV penetration can easily be 70-80% but.
Is the sales growth profitable at OEM level ?

Unit economics 2W

- 2W unit economics are poor (battery ~65-70% of vehicle cost)
- New entrants in this space due to low barrier to entry
- Standardization is difficult impacting scale of component manufacturers
- Low cost Chinese retrofit kits are also available
- Okinawa - Hero electric – import from China (Scuttlebutt)
- Newer use-cases,
  - Yulu / Bounce for Gig workers etc.

Battery Cost= 3.97*22k	= 87298
Motor cost	= 12000**
Power electronics	= 10000#
Body plastics + panels	= 9000
Display	= 10500
Tyres	= 1600
Headlights	= 6900
Ola S1 ex showroom*	= 125000

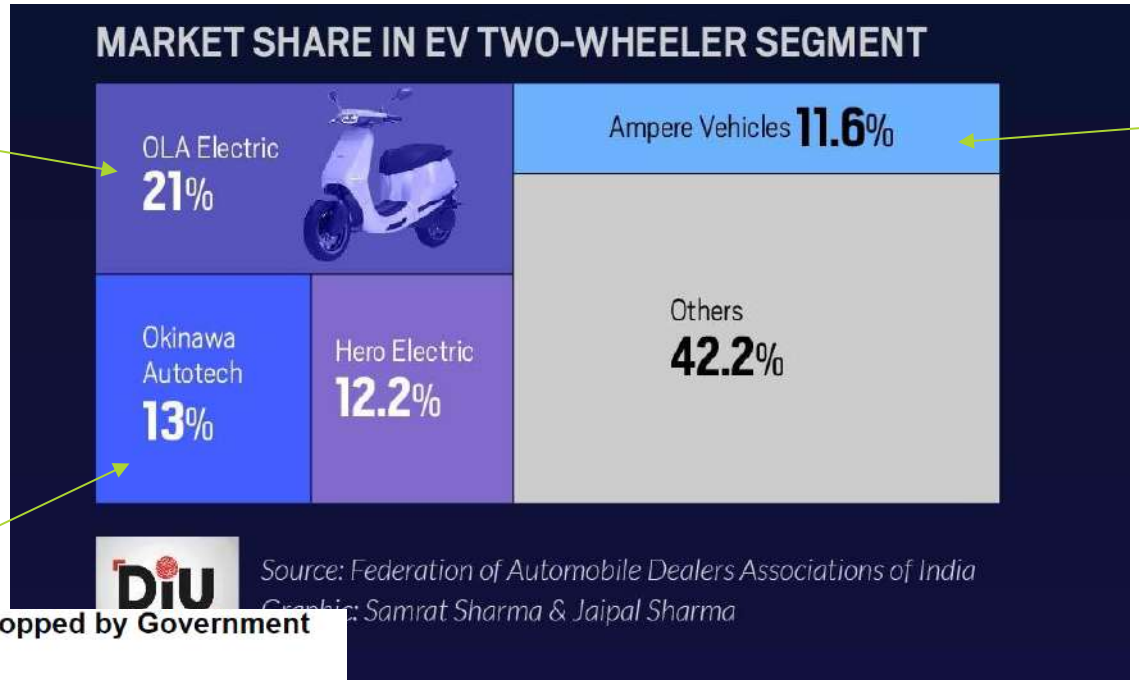
Battery Cost= 3.24*22k	= 71000
Motor cost	= 10000**
Power electronics	= 7000#
Body plastics + panels	= 9000
Display	= 8000
Tyres	= 1600
Headlights	= 6500
Ather 450x gen 3	= 114000

* https://www.cartoq.com/ola-s1-pro-electric-scooters-battery-pack-costs-rs-87298-scooter-costs-rs-1-28-lakh-heres-proof/
** Approximate from scuttle butt, IPM motor,
##Inverter + BMS+ MCU + Other control units.

Denim to EV

Market Share 2023

Selling at a loss*



Selling at a loss*

Okinawa and Hero Electric's FAME-II subsidies stopped by Government of India: Here's why

The Government of India has stopped processing pending FAME-II subsidies of Okinawa and Hero Electric. The Government had earlier served a notice to both companies, last year. As per a PTI report, the manufacturers were under probe for alleged misappropriation of subsidies under the Rs 10,000 crore FAME scheme, which is currently in its second phase.

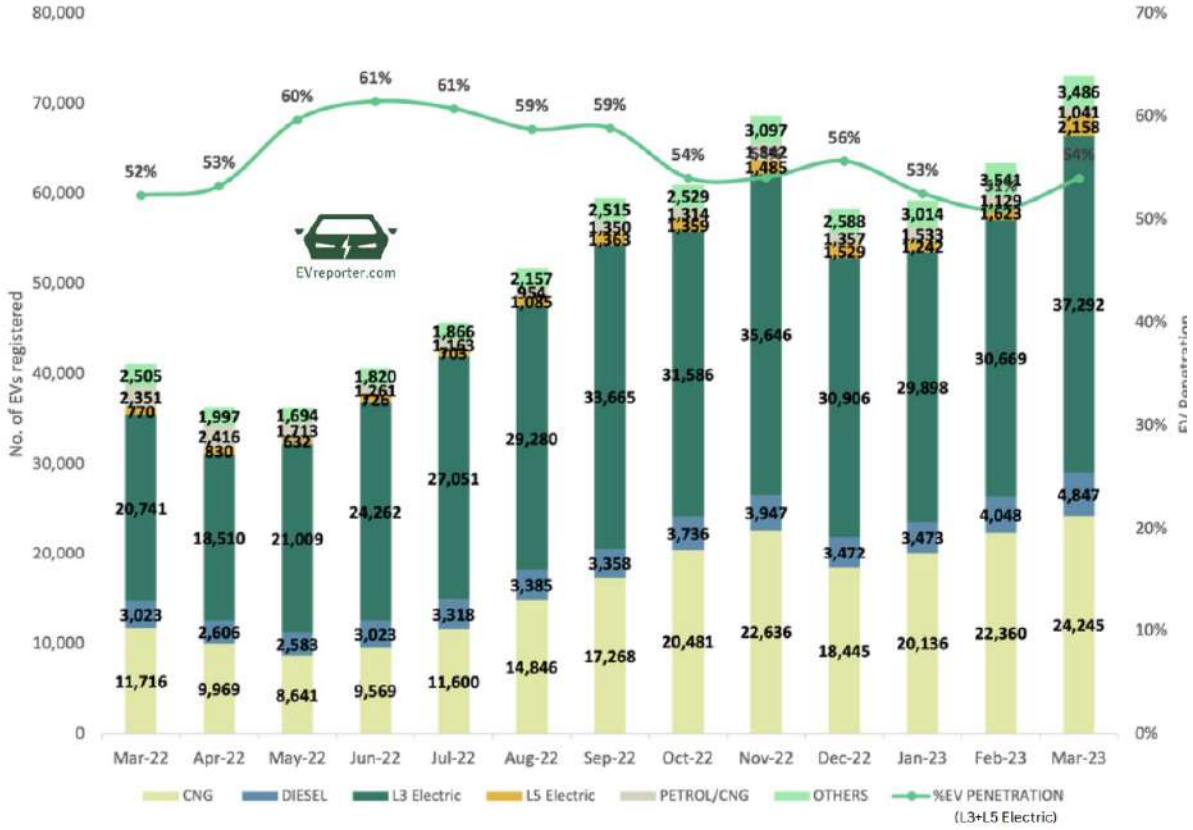
Authored by: Sutanu Guha | Updated Mar 23, 2023 | 02:13 PM IST

Unlike social media, there is no network effect in 2W EVs

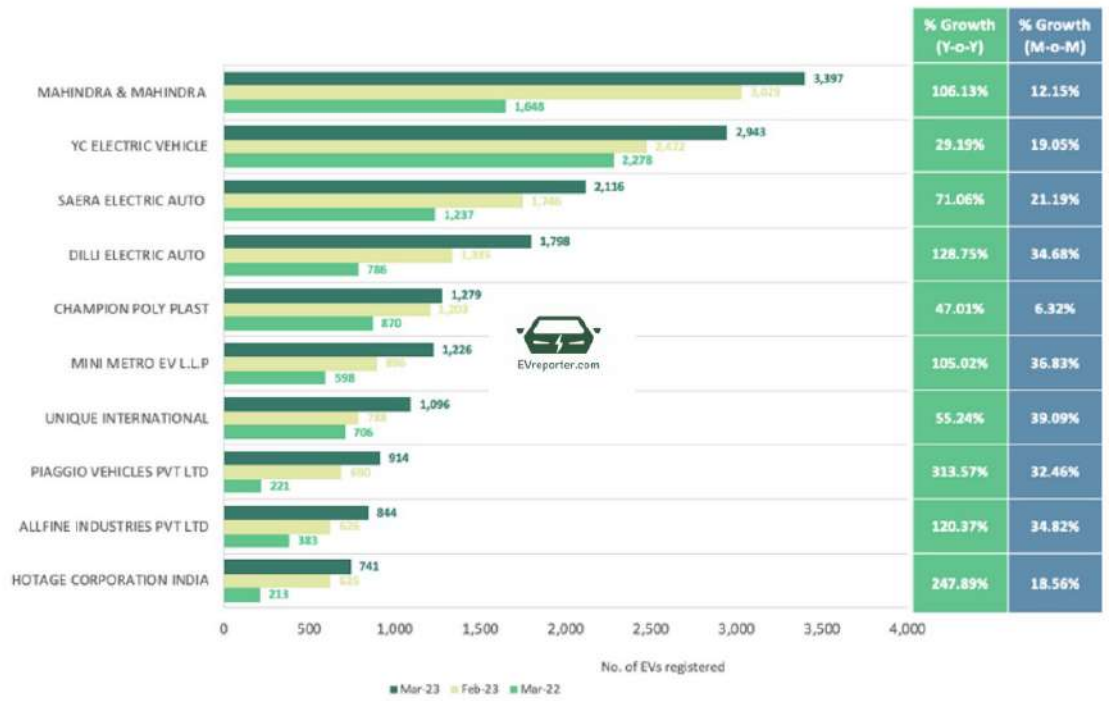
Source: https://www.indiatoday.in/diu/story/tata-motors-ola-electric-lead-electric-vehicle-race-in-india-2358602-2023-04-11
https://www.saurenergy.com/ev-storage/ev-maker-ampere-sells-79000-scooters-in-fy22-revenue-crosses-rs-500-cr
* Based on above calculations

Electric 3 Wheeler - Passenger

3W Passenger Sales Trend by Fuel Type, Mar 2022 - Mar 2023



E-3W Passenger Sales Trend by OEM

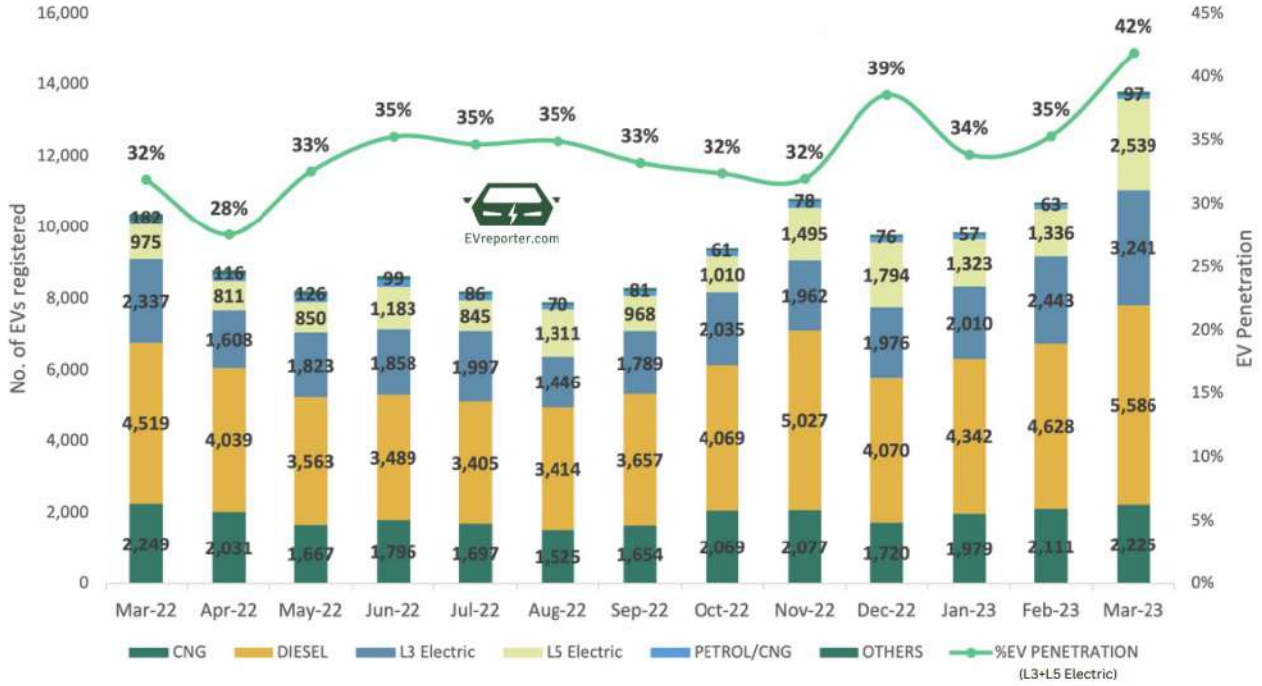


	% Growth (Y-o-Y)	% Growth (M-o-M)
MAHINDRA & MAHINDRA	106.13%	12.15%
YC ELECTRIC VEHICLE	29.19%	19.05%
SAERA ELECTRIC AUTO	71.06%	21.19%
DILLI ELECTRIC AUTO	128.75%	34.68%
CHAMPION POLY PLAST	47.01%	6.32%
MINI METRO EV L.L.P	105.02%	36.83%
UNIQUE INTERNATIONAL	55.24%	39.09%
PIAGGIO VEHICLES PVT LTD	313.57%	32.46%
ALLFINE INDUSTRIES PVT LTD	120.37%	34.82%
HOTAGE CORPORATION INDIA	247.89%	18.56%

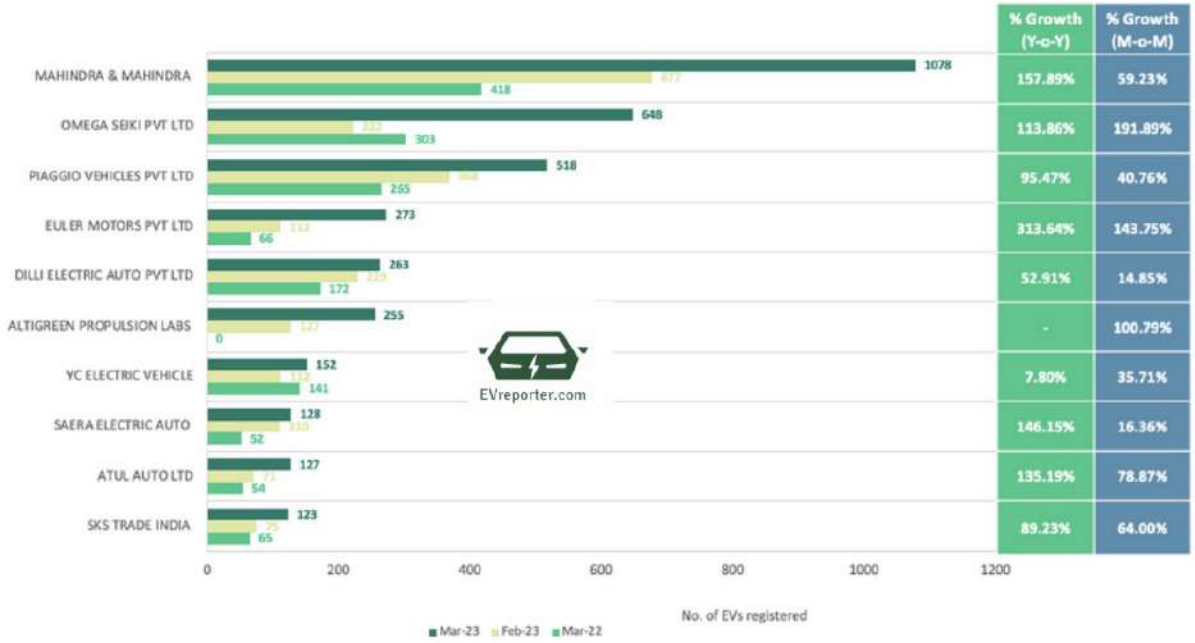
Source: Vahan Dashboard. Data as per 1350 out of 1436 RTOs across 34 out of 36 state/UTs. The aim of these graphs is to represent an overall trend of the new EV registrations in India.

Electric 3 Wheeler - Cargo

3W Cargo Sales Trend by Fuel Type, Mar 2022 - Mar 2023



E-3W Cargo Sales Trend by OEM



	% Growth (Y-o-Y)	% Growth (M-o-M)
MAHINDRA & MAHINDRA	157.89%	59.23%
OMEGA SEIKI PVT LTD	113.86%	191.89%
PIAGGIO VEHICLES PVT LTD	95.47%	40.76%
EULER MOTORS PVT LTD	313.64%	143.75%
DILLI ELECTRIC AUTO PVT LTD	52.91%	14.85%
ALTIGREEN PROPULSION LABS	-	100.79%
YC ELECTRIC VEHICLE	7.80%	35.71%
SAERA ELECTRIC AUTO	146.15%	16.36%
ATUL AUTO LTD	135.19%	78.87%
SKS TRADE INDIA	89.23%	64.00%

Source: Vahan Dashboard. Data as per 1350 out of 1436 RTOs across 34 out of 36 state/UTs. The aim of these graphs is to represent an overall trend of the new EV registrations in India.

Electric 3 Wheeler

3-wheeler electrification is also driven by lead acid battery which is non considered in the database.

	LEAD-ACID AGM	LITHIUM-ION
Installed capacity	100 KWh	50 KWh
Usable capacity	50 KWh	50 KWh
Lifespan	500 cycles at 50% DoD (Depth of Discharge)	3000 cycles at 100% DoD
Number of installations	6 (1 + 5 replacements)	1
Battery cost	60 000€ (100€/KWh x 100 x 6)	20 000€ (400€/KWh x 50 x 1)
Installation cost	12 000 € (2000 € per install x 6)	2000 € (one shot install)
Transportation cost	6 000€ (1 000€ per transport x 6)	1 000€ (one shot install)
TOTAL COST	78 000€	23 000€
Cost per usable KWh per cycle	0.42€ / usable kWh (78 000 / 3000 / 50)	0.15€ / usable kWh (23 000 / 3000 / 50)

10 years of usable life

The 3W Passenger / cargo space has lithium ion battery enabled vehicles.
There are a lot of unlisted startups in this space
The unit economics seems better → Mahindra Treo – 7.37 kWh @ 3.14 Lakhs (battery is 50% of the vehicle cost)

Resources
https://static1.squarespace.com/static/55d039b5e4b061baebe46d36/t/56284a92e4b0629aedbb0874/1445481106401/Fact+sheet_Lead+acid+vs+lithium+ion.pdf
https://www.powertechsystems.eu/home/tech-corner/lithium-ion-vs-lead-acid-cost-analysis/

Way forward 2030 for vehicles < 5 kWh

- Electrification in 2W and 3W space is expected to be 80%+
- OEMS will move towards more standardization of electronics, motors to reduce cost.
- Competitive intensity will increase.
- Indigenous small scale BMS manufacturing companies might come up.
- Large Tier-1 does not have EOS advantage due to high number of SKUs.
- Domestic cell manufacturing seems financially unviable due to unavailability of key raw material
- Few component manufacturers will keep growing and maintain good margins. ☺

EOS – Economies of Scale
SKU – Stock Keeping Unit

FAQ

- Will the profitability of 2W improve with decrease in lithium prices
  - Probably not as all 2W OEM will pass the discount
- What about companies like Bajaj? How are they placed
  - I think that they are smart. They have sold 2.5K e-chetak in march. The ICE demand will not be completely over.
- Impact of AIS
  - The new AIS standard will get stricter with respect to safety and reliability. This is a headache at 2W OEM level and a positive for critical components such as shunts. This could also be positive for PCB manufacturers.
- Fame Subsidy
  - Overhang that the subsidy might not go beyond 2024. This might cause EV OEMs to go towards cost cutting measures.

Transition in 4W

Major 4W OEMS announcing 100% electrification

Jaguar is going all-electric by 2025

Jaguar will become an all-electric car brand by 2025, and t
entirely new vehicle lineup. The current Jaguar internal cor
scrapped. Jaguar has also already killed off an XJ sedan suc
ready for production. The I-Pace EV will likely be the only c
2025.

Mercedes-Benz to go all electric by 2030

Luxury carmaker to go electric-only in some markets; to have a full-EV option for each of its models by 2025.

Published On Jul 22, 2021 07:50:00 PM

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By Autocar India News Desk

Share -

Audi Will End ICE Development In 2026, Become EV-Only In Early 2030s

The final Audi to be powered by an internal combustion engine could be the next-gen Q8

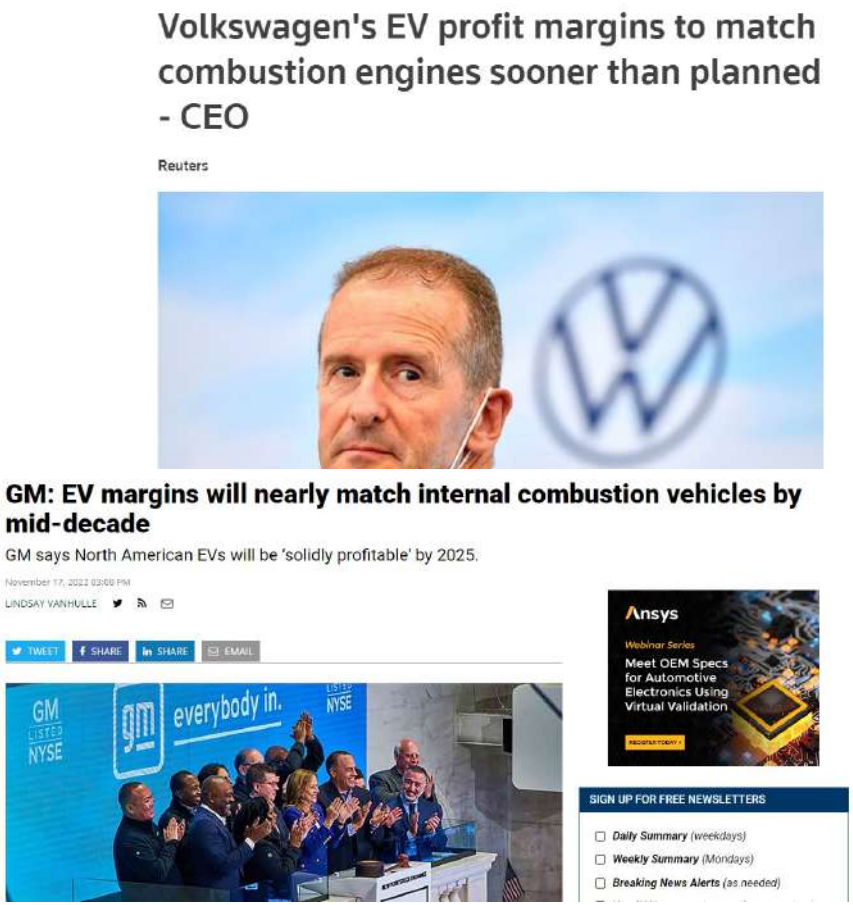
Audi is set to end the production of new internal combustion engine models by the end of 2026.

"No future" for ICE: Volvo will sell only pure electric cars by 2030

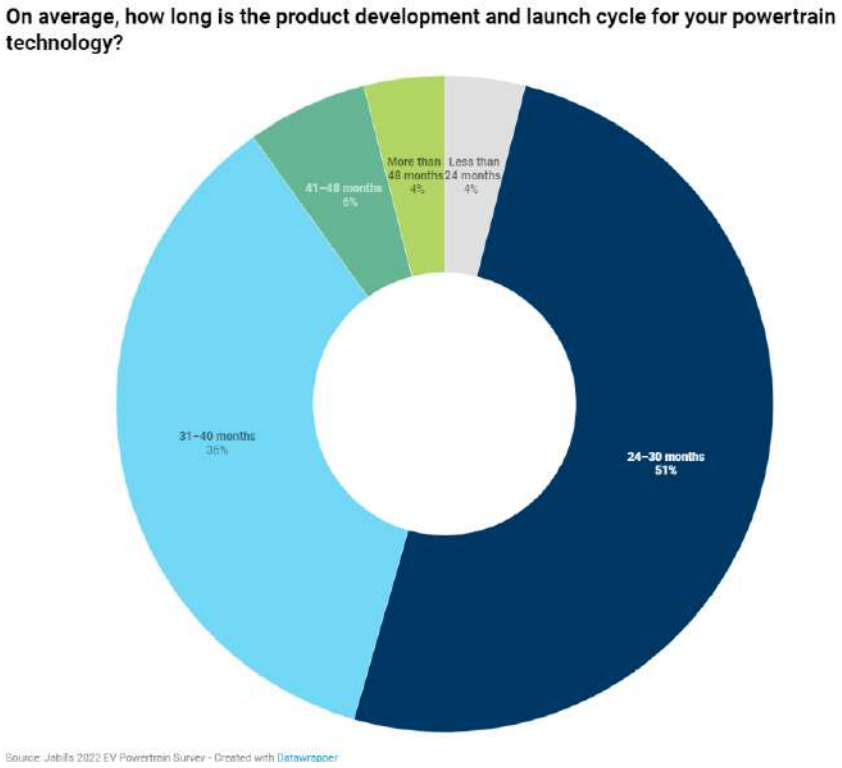
MARCH 3, 2021 · 5 COMMENTS · 2 MINUTE READ · BRIDIE SCHMIDT

Transition to EV is profitable for OEMs

- Reduced components helps improve on cost efficiencies
- OEMs becoming more vertically integrated
- OEMs are sensitive towards Intellectual Property.
- OEMS opening cost centers
- OEMS are licensing electric powertrain platforms.
- OEMS are using data to improve validation, calibration etc.
- Tier 1s such as Bosch losing automotive business
- Tata Nexon prime battery is 48% of vehicle cost.
- Mercedes EQC battery is 29% of vehicle cost.
- Electrification of high end vehicles makes the most sense
  - Tax benefits
  - Cost optimization



High refresh rate



- Life of EV < Life of ICE
  - Ageing of batteries
  - Inefficiencies in charging / discharging
- Product development cycle is smaller
- New features in every facelift

Reference : https://www.jabil.com/blog/automotive-industry-trends-point-to-shorter-product-development-cycles.html

Other Implications

- Electric Vehicles do not require much service.
- Second hand Electric Vehicles market will not be lucrative
- Fleets made up of electric vehicles makes financial sense
- EV chargers infrastructure can create network effect
- Electric vehicles will get replaced sooner

Tata Power to set up 25,000 EV charging points across India

1 min read . Updated: 13 Jan 2023, 03:40 PM IST

Saurav Anand

Tata Power is showcasing its range of hi-tech electric vehicle charging solutions at the ongoing Auto Expo (Mint)

SYNOPSIS

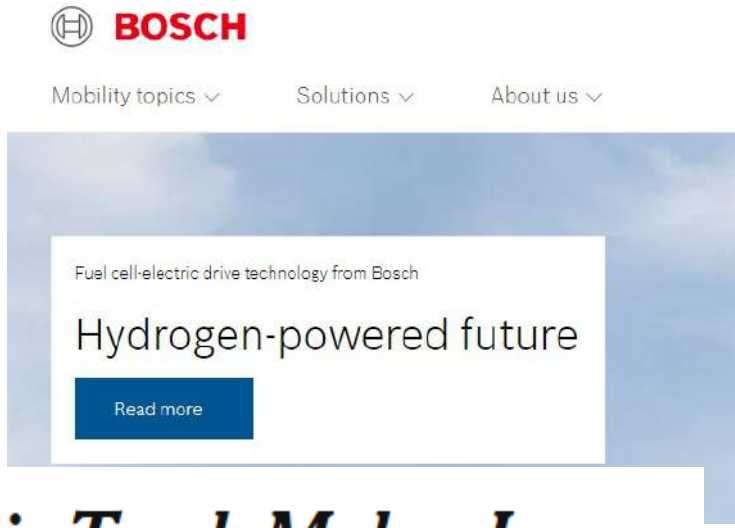
Tata Power said its app Tata Power EZ Charge helps commuters find the nearest charging station, know the real-time availability of charging points, and receive updates on charging status

New Delhi: Tata Power on Friday said it plans to set up 25,000 electric vehicle (EV) charging points across the country to support faster adoption of e-mobility over the next five years.

Reference : https://www.jabil.com/blog/automotive-industry-trends-point-to-shorter-product-development-cycles.html

Tier 1 diversifying out of EV

- Once the largest Tier 1 is silently diversifying to AI services
- Loosing footprint in EV space
- Trying to create narrative in the Hydrogen economy
- Enabling non automotive companies get into EV space



Founder of Electric Truck Maker Is Convicted of Fraud

Trevor Milton was accused of boasting about nonexistent technology to inflate the stock price of Nikola, a maker of electric trucks.

Cell manufacturing → OEM

Nov 24, 2022 - 02:52 pm

BYD to build 20 GWh battery plant in China

BATTERIES | BATTERY PRODUCTION | BYD | CHINA | WENZHOU | ZHEJIANG

BYD is further expanding its battery production capacities in China with a new plant in Wenzhou in Zhejiang province. The new factory will have an annual capacity of 20 gigawatt-hours and is scheduled to start production in 2024.

The only thing is that BYD does not yet specify what kind of batteries will be produced there. The Chinese press release, from which the portal *CN EV Post* quotes, only says that the batteries in the new plant will be "produced with one of the currently available promising battery technologies".

The batteries built by BYD primarily use lithium iron phosphate (LFP) technology – for example in the manufacturer's widely used electric buses or in the blade batteries for electric cars. In addition to solid-state batteries, which are probably what most battery manufacturers are working on, BYD has recently also been linked to sodium-ion batteries. The company denied these rumours, but has now given them new fuel with the wording about batteries from the new Wenzhou plant itself.

Chinese automaker BYD enters India's passenger car market, plans local manufacturing plant

"We intend to sell 15,000 units of BYD-Atto 3 in India over the next year and plan to set up a local manufacturing facility in due course," said Ketsu Zhang, Executive Director of BYD India. The Atto 3 will be assembled at BYD's plant near Chennai.

Legacy OEMs are recognizing this risk and building JVs to manufacture cells

Merce
produc

By: HT Auto Desk

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Mercedes-Benz
production of ne
Debrecen, Hung

Volk
cell f

Volkswage
Canada, w

By David Leggett

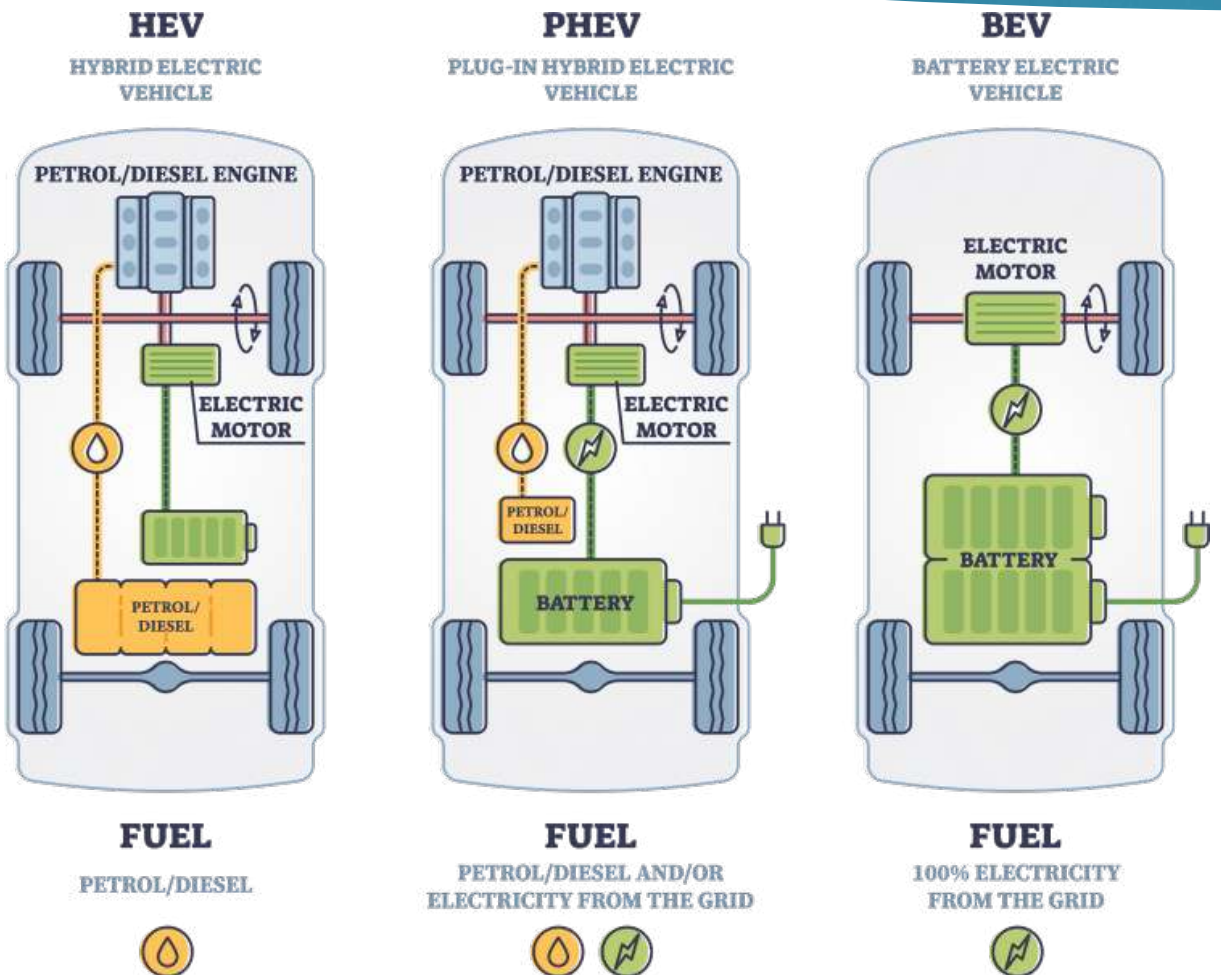
Tata Group planning to set up EV cell-manufacturing operations in Europe

Tata is finalizing plans and will announce details soon, he said, declining to disclose the location of the facility and a time frame

EV Deep-Dive

1. POWERTRAIN
2. HARDWARE AND SOFTWARE
3. TECHNOLOGICAL SHIFT
4. MOTOR
5. BMS
6. DCDC
7. INVERTER
8. CHARGERS

Configuration

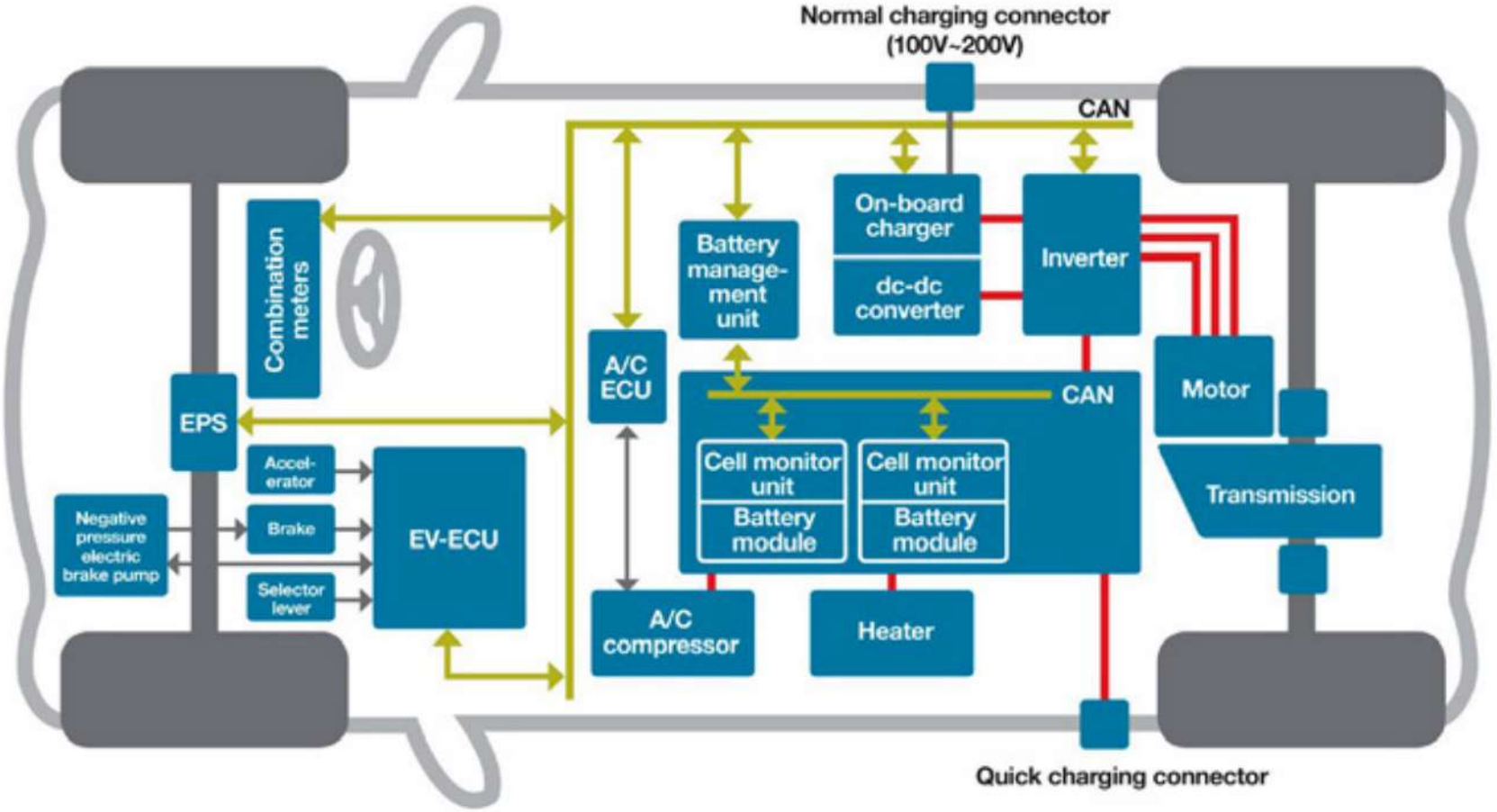


Unlike ICE, with EVs, OEMs can play around with the powertrain configuration which differentiates the product.

Areas where OEMs can create an edge

1. Aerodynamics - Design
2. Data
3. Luxury

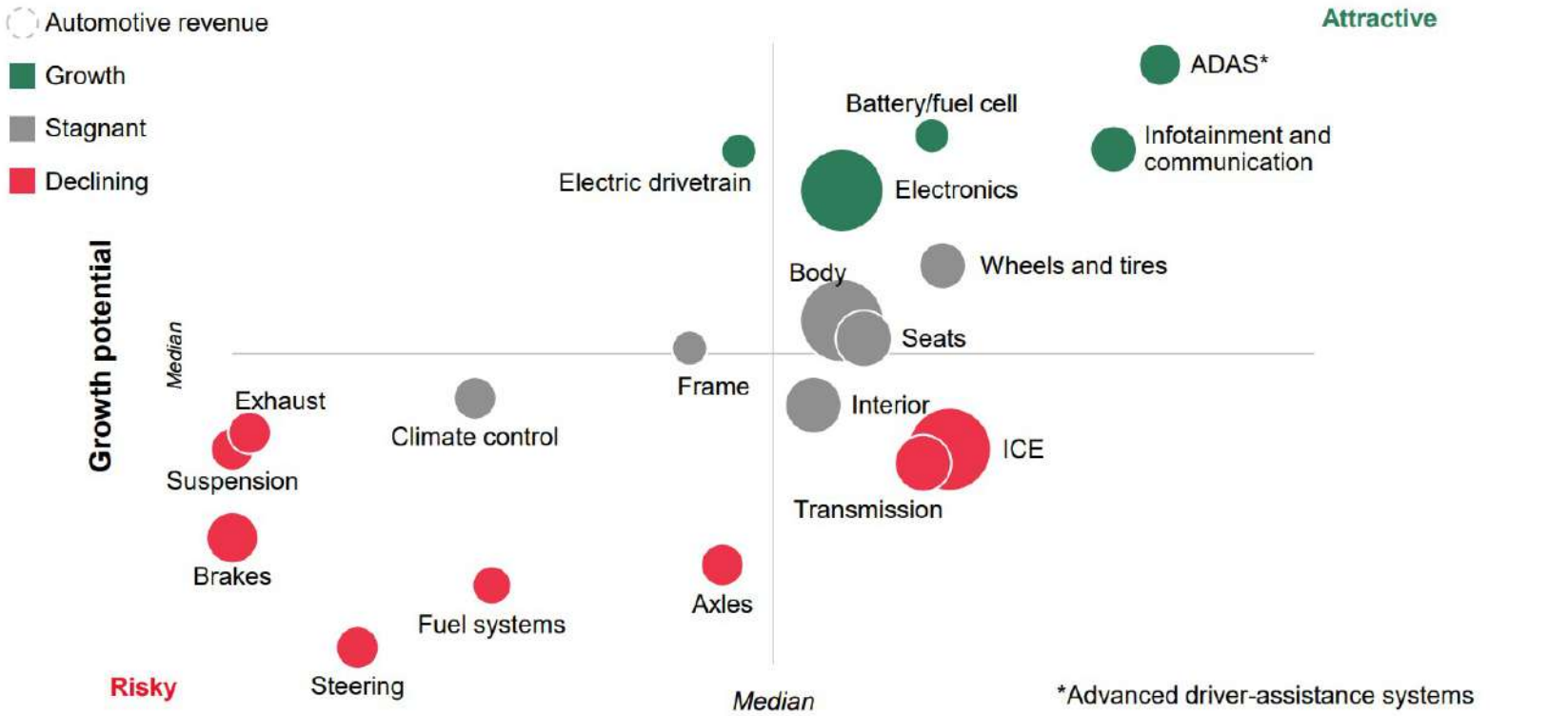
Simplified Picture of BEV



Impact on components

Impact of electric vehicle disruption

Each part of the automotive ecosystem will be impacted differently by the various technology changes, leading to a divergent future based on segment, as some thrive while others struggle

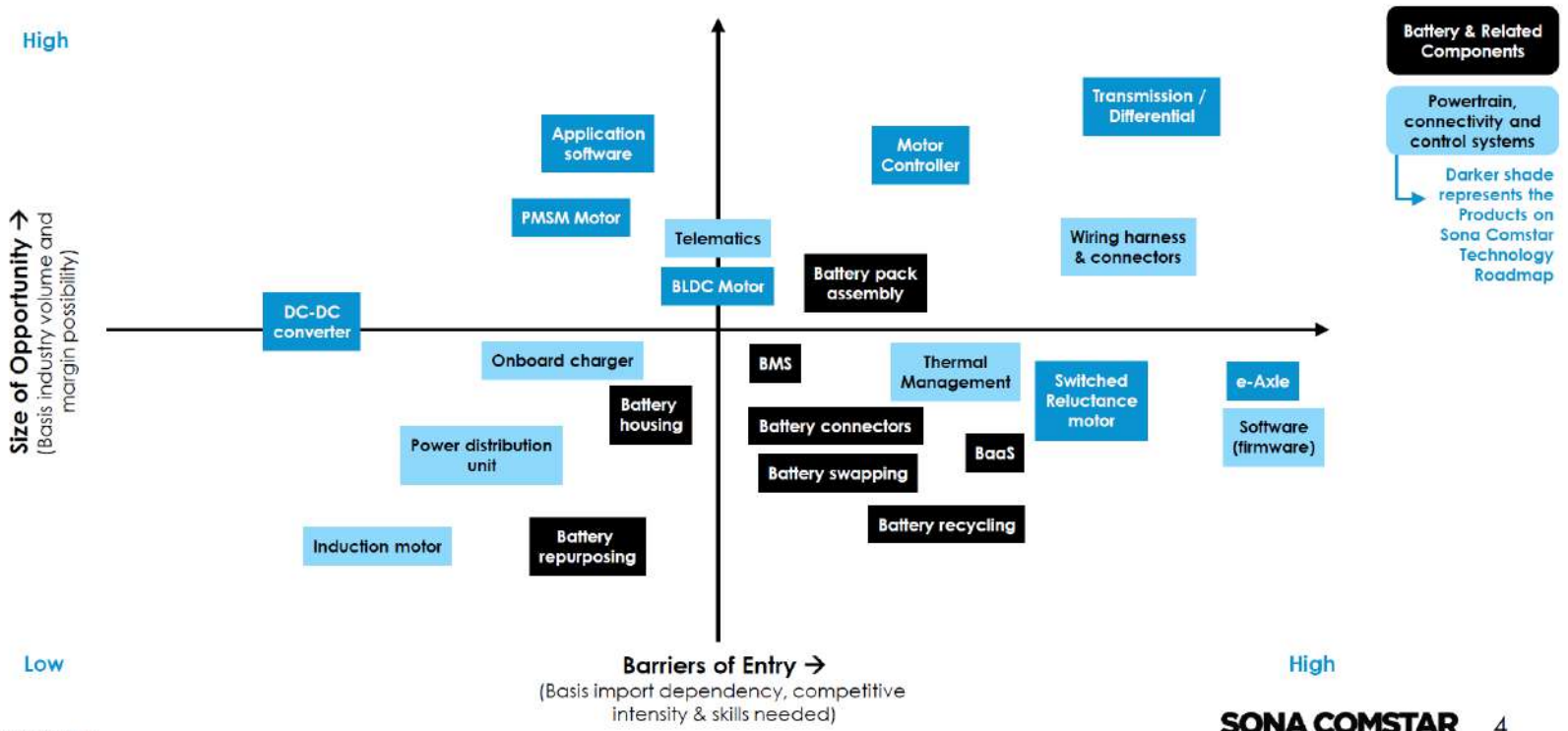


Source: IHS Markit; Deloitte, *Transformation and disruption for automotive suppliers*

APPLIED Insights

Impact on components

Many powertrain & connectivity systems are expected to have high opportunity, but with high barriers of entry



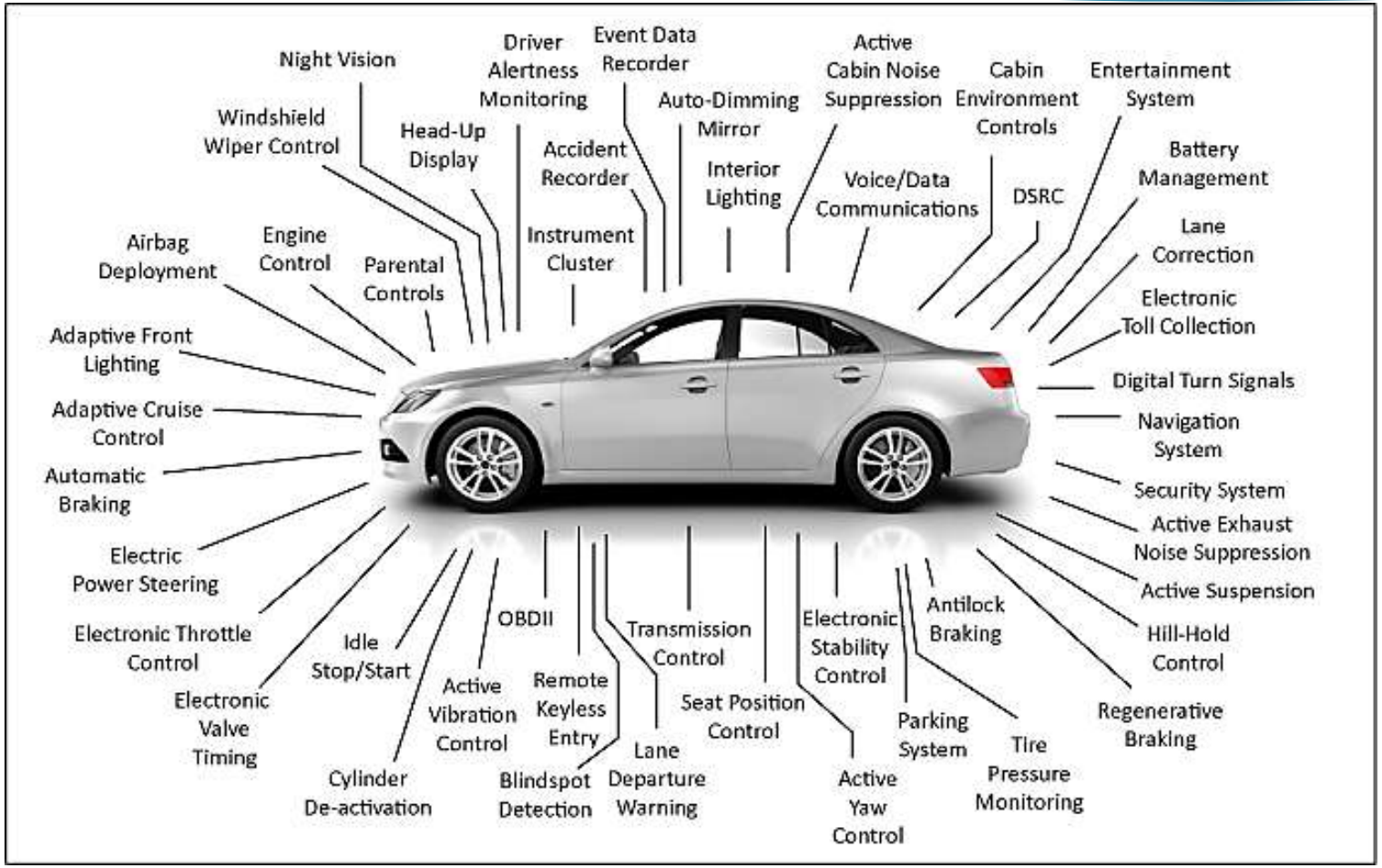
Illustrative Representation

Source: *EV Landscape: Opportunities for India's Auto Component Industry – Yes Bank & ACMA, Company Analysis*

Broad Themes

- Components have decreased.
- ECUs have increased in complexity with more software usage.
- General control system in the car has been simplified.
- Focus on safety due to battery fire.
- Practical usage of AI leading to decrease in engineering effort
- Body and chassis design is different from ICE
- Expiry date of the vehicle
- Short product development cycles
- More electric Power available in the car
- High amount of Data generation. Usage of cloud driven analytics.
- Software standardization led by German OEMs (Autosar)
- Quality standards uniform at OEM level – ASPICE
- Recycling, Scrappage and second life use cases are coming up.

Feature Explosion



Mid segment cars can have 100+ Electronic control units

Each independent function is housed in a specific ECU

The ECUs talk to each other via network protocol – CAN, LIN, Flexray, Ethernet

Software is eating up the car

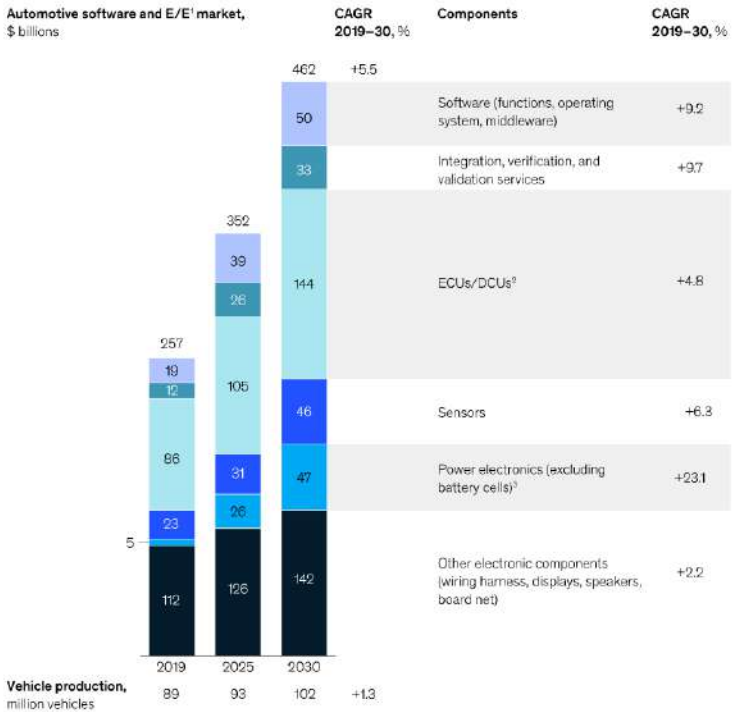
Features are exploding in the
- Driver safety / Autonomous Driving
- Electric powertrain controls
- Infotainment systems

OEMs are targeting shorter functional development cycles with on the air feature download models. (FOTA)

Software and Hardware

While passenger car and LCV sales will increase slightly from 89 million vehicles in 2019 to 102 million in 2030 (just higher than 1 percent CAGR), the automotive software and electronics market is projected to grow at nearly four times that rate during the same period. Making up the largest share of the market, electronic control unit (ECU) and domain control unit (DCU) sales are expected to reach $144 billion by 2030. The second-largest share of the market will be software development (including integration, verification, and validation), with a revenue potential of $83 billion by 2030. Power electronics is by far the fastest-growing component market, with EV adoption fueling an expected CAGR of 23 percent through 2030. Sensors are projected to grow at a compound annual rate of 6 percent, driven by AD/ADAS sensors.

The automotive software and electronics market is expected to grow at 5.5 percent per year through 2030.

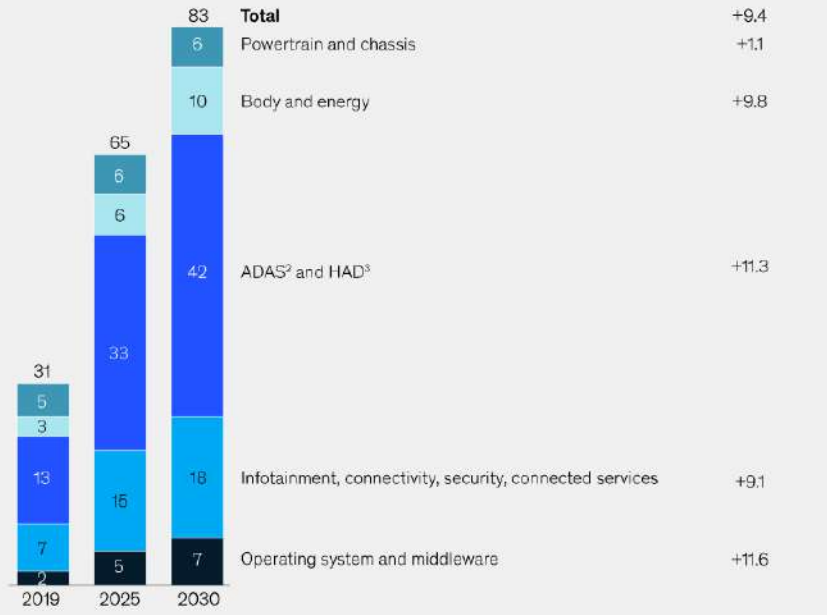


Note: This is a forecast for light vehicles, including passenger cars and light commercial vehicles. Figures may not sum to 100%, because of rounding.
[1]Electrical and electronic components.
[2]Electronic control units and domain control units. Hardware only.
[3]Includes onboard charger, DC/DC converter, and high-voltage inverter.
Source: McKinsey Center for Future Mobility Current Trajectory Scenario

The automotive software market is projected to more than double in size from $31 billion in 2019 to roughly $80 billion in 2030—a CAGR of more than 9 percent. ADAS and AD software will account for much of this growth and make up almost half the software market by 2030. Timing also plays a role: the development of software for higher-level autonomous driving (for example, urban AD) will precede market introduction by several years.

Infotainment, connectivity, security, and connected services will also grow at pace with the overall software market, becoming the second-largest software market by 2030. This growth is driven by a high share of connected vehicles and demand for features such as in-car payments, location-based services, and music streaming. The market for body and energy software will exhibit a CAGR of 10 percent as a result of increasingly stringent energy management requirements for EVs and an increasing number of premium comfort features in lower vehicle segments.

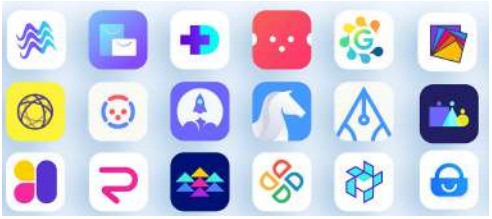
The automotive software market is expected to grow at 9.4 percent per year through 2030.



Note: Figures may not sum, because of rounding.
[1]Software includes function development, integration, and verification or validation.
[2]Advanced driver assistance systems.
[3]Highly autonomous driving.
Source: McKinsey Center for Future Mobility Current Trajectory Scenario

Software Stack

Application Software – Think Apps



Base Software – Think, android OS

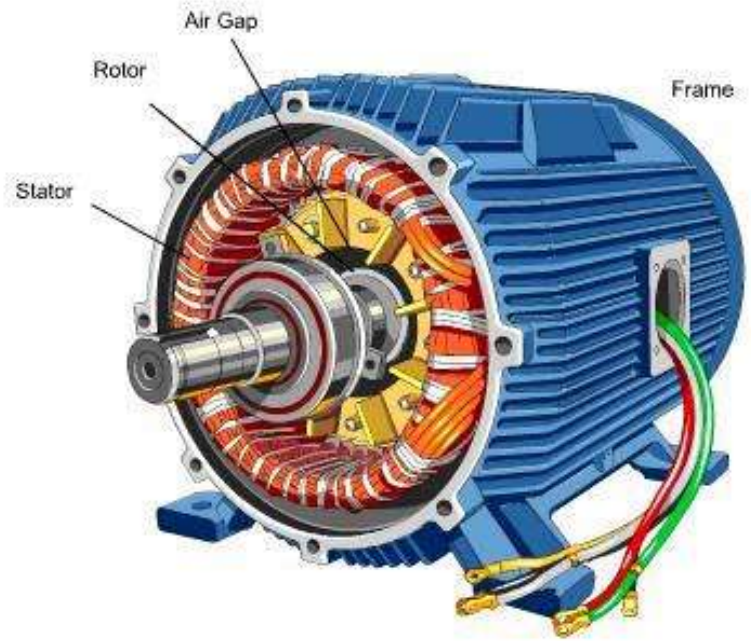
Electronic Component – Think of the chip set in your android phone

Software Stack

Application Software	High Margin, IP	Algorithms, control logic, safety logic	OEMs setting up cost centers.
Base Software	Low margin but high volume, lowest cost, moving towards standardization, Product change relatively faster.	Communication stack, measurement stack	Vector, KPIT, Tata Elxsi, BGSW, etc.
Electronic Component	Low margin but high volume, lowest cost, adhering to strict standards, Product changes slower.	BMS, MCU	Bosch, Continental etc.

Motor Parts

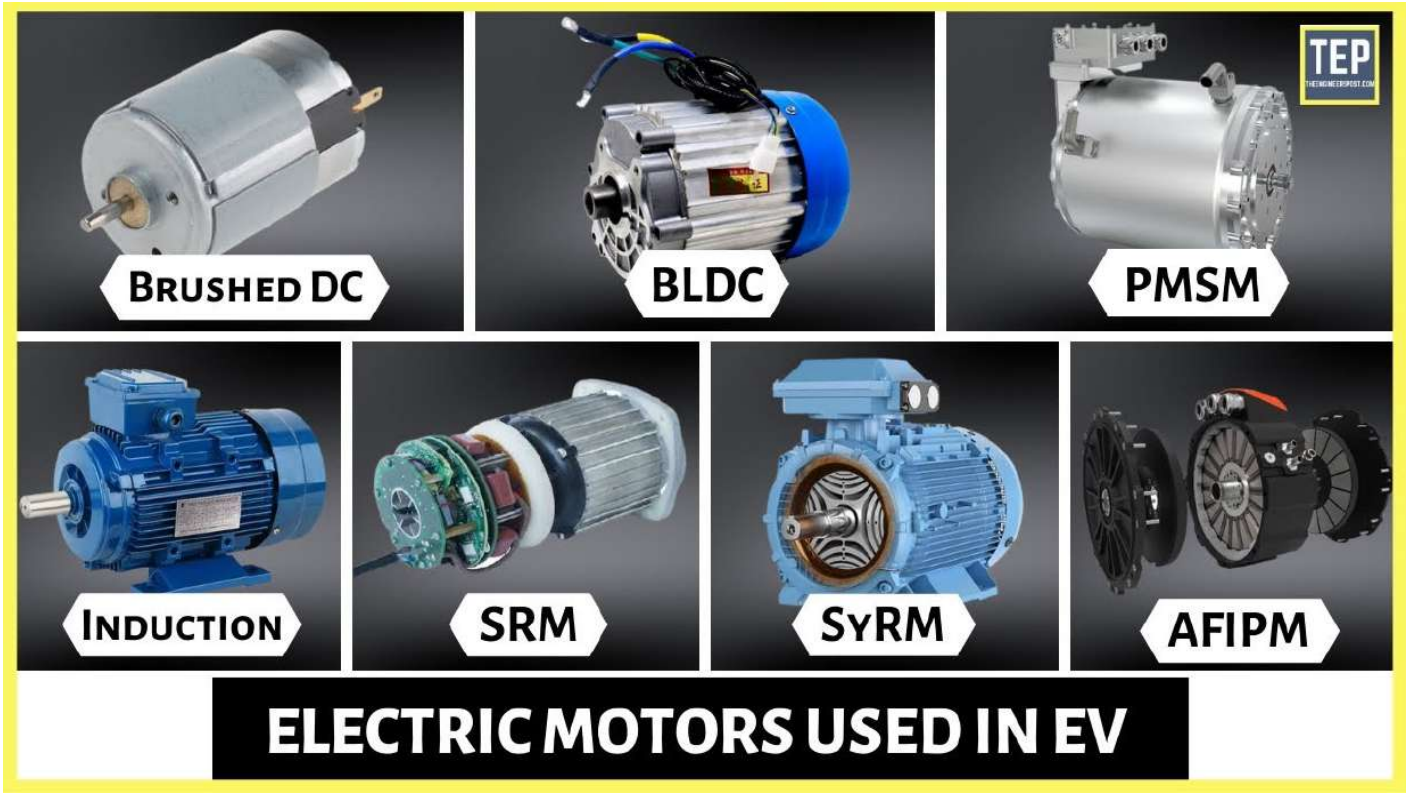
- Rotor
  - Permanent Magnets
- Stator –
  - Windings for ELectromagnet.
- Motor Casing
- ERND for motor control



Partially Assembled Motor

Deep Dive – Motors

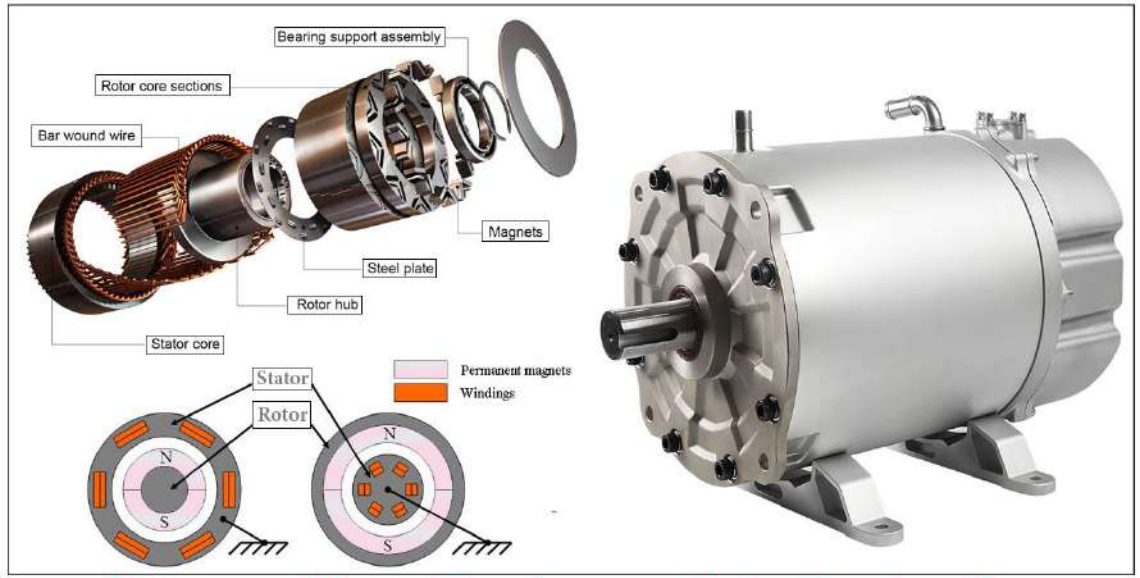
The different types



Deep Dive – DC Motors

Motor	Advantage	Disadvantages	Manufacturing companies	Vehicles
DC Series Motor (AC supply) Not used any more	Simple & No controller required to operate speed Max torque at low speed	Bulky, Low Efficiency, heat by brushing		Fiat Panda Elettra)
Brushless DC Motor	High Starting torque and efficiency 95-98%, High power density, Maintenance free	Short constant power range. Decreased torque with increased speed. High cost due to P.magnet	Sona Comstar	Toyota Prius Ather, E-TransNeo, EPluto 7g Go-karts Preferred for small cars with max 60kw power

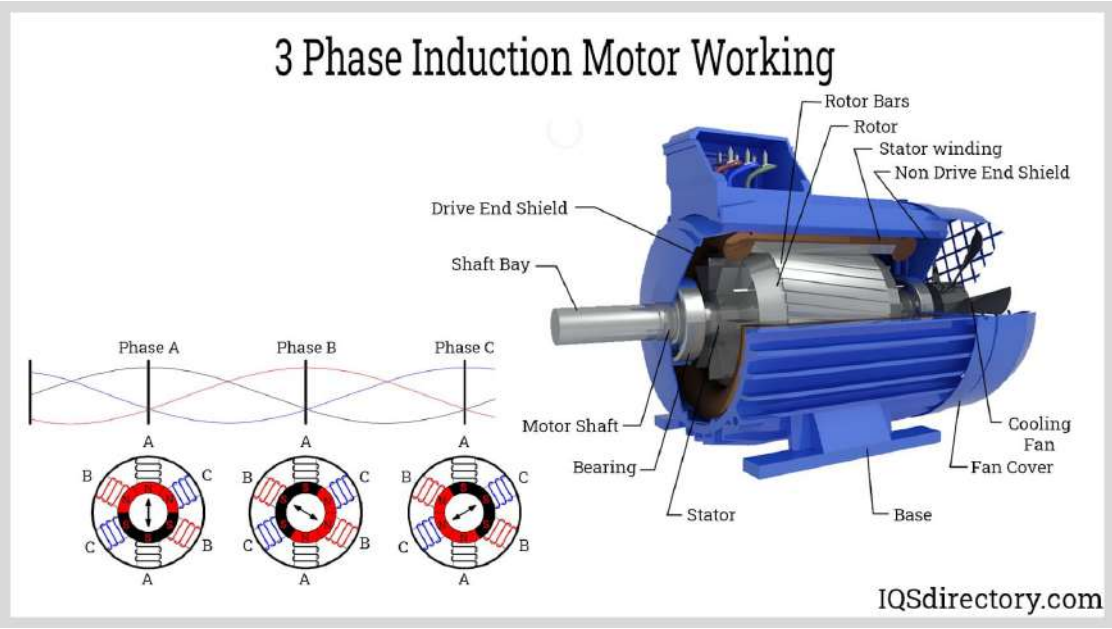
Deep Dive – Motors



Permanent Magnet Synchronous Motor Construction

Motor	Advantage	Disadvantages	Manufacturing companies	Vehicles
Permanent Magnet Synchronous Motor (PMSM) (DC Supply)	High power density, high efficiency High Torque at low speeds	Expensive due to permanent magnets.	Soma Comstar	CHevrolet bolt EV, BMW i3, Ford Focus Electric, Nissan Leaf, Tata Nexon & Tiago, Tata Electric buses

Deep Dive – Motors



Motor	Advantage	Disadvantages	Manufacturing companies	Vehicles
Three Phase AC Induction Motors	Low maintenance Efficiency 92-95%.	No high starting torque (Control systems to be used to attain it) Requires complex inverter circuit		Tesla model S, Tesla Roadster, Toyota RAV 4 GM EV 1, Mahindra E-verito, Mahindra E20

Deep Dive – Motors

Motor	Advantage	Disadvantages	Manufacturing companies	Vehicles
Synchronous Reluctance Motors	No windings or P. Magnets Easy and strong construction High torque, low losses			
Switched Reluctance Motors (SRM)	No windings or Permanent magnets for rotor. High power density Higher range and top speed	Low Torque, Complexity in control Increased switching circuits Noise issues	**Sona Comstar (future plan)**	Latest Tesla model 3

Deep Dive – Motors

Companies into Motor manufacturing

SONA COMSTAR

CG Power Solutions

Companies with future plans

Ramkrishna Forgings Limited

MM Forgings

SHAKTI
PUMPING LIFE

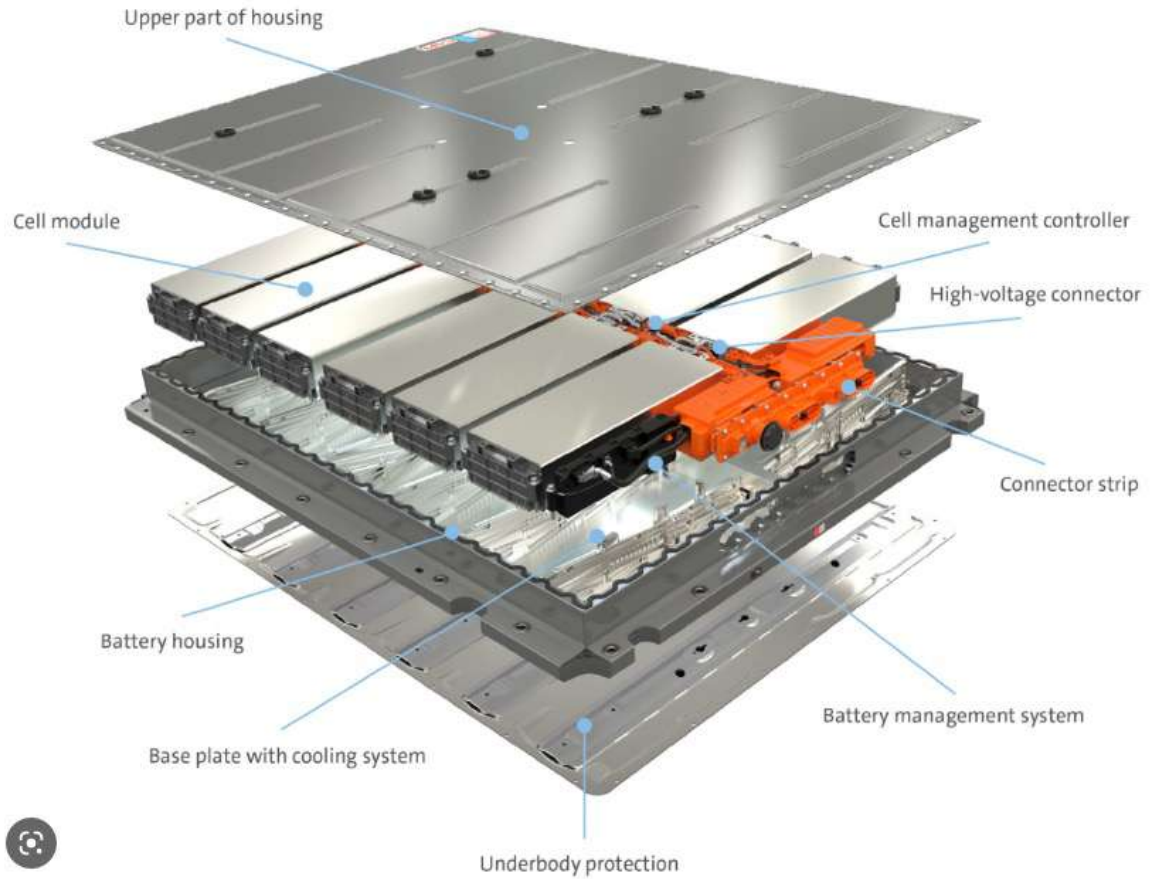
Shakti Green - Formed 100% Subsidiary on Dec 2021 to enter into EV Solutions like Motors, Controller, Chargers

Akshay Pitti: See, right now, most of the EV products are imported from China, which are consumed in India. There are many people in the North of country who are doing it as a cottage industry. As you must be aware, they are

Battery

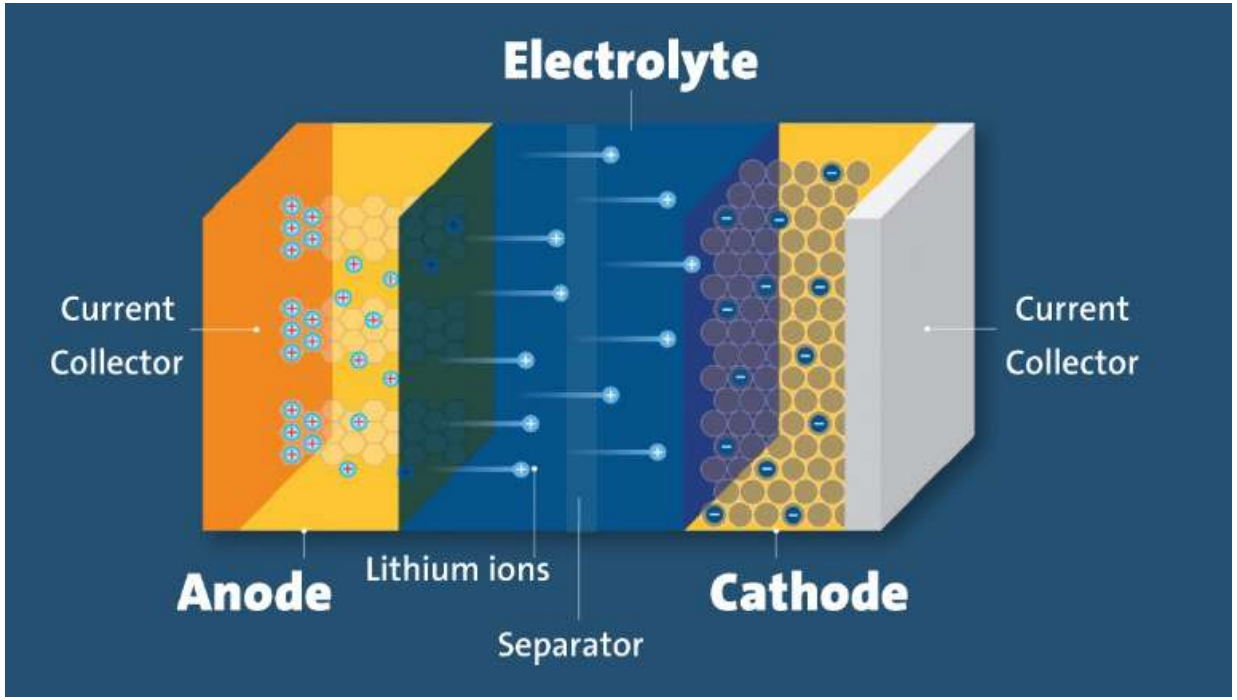
Battery

- BMS hardware & Software
  - IC
  - Mosfet
  - Capacitors
- Sensors
  - Current – Shunt / Hall Effect
  - Voltage Sensor
  - Temperature Sensor
  - Pressure sensor
- Cells
  - Cathode
  - Anode
  - Separator
  - Electrolyte

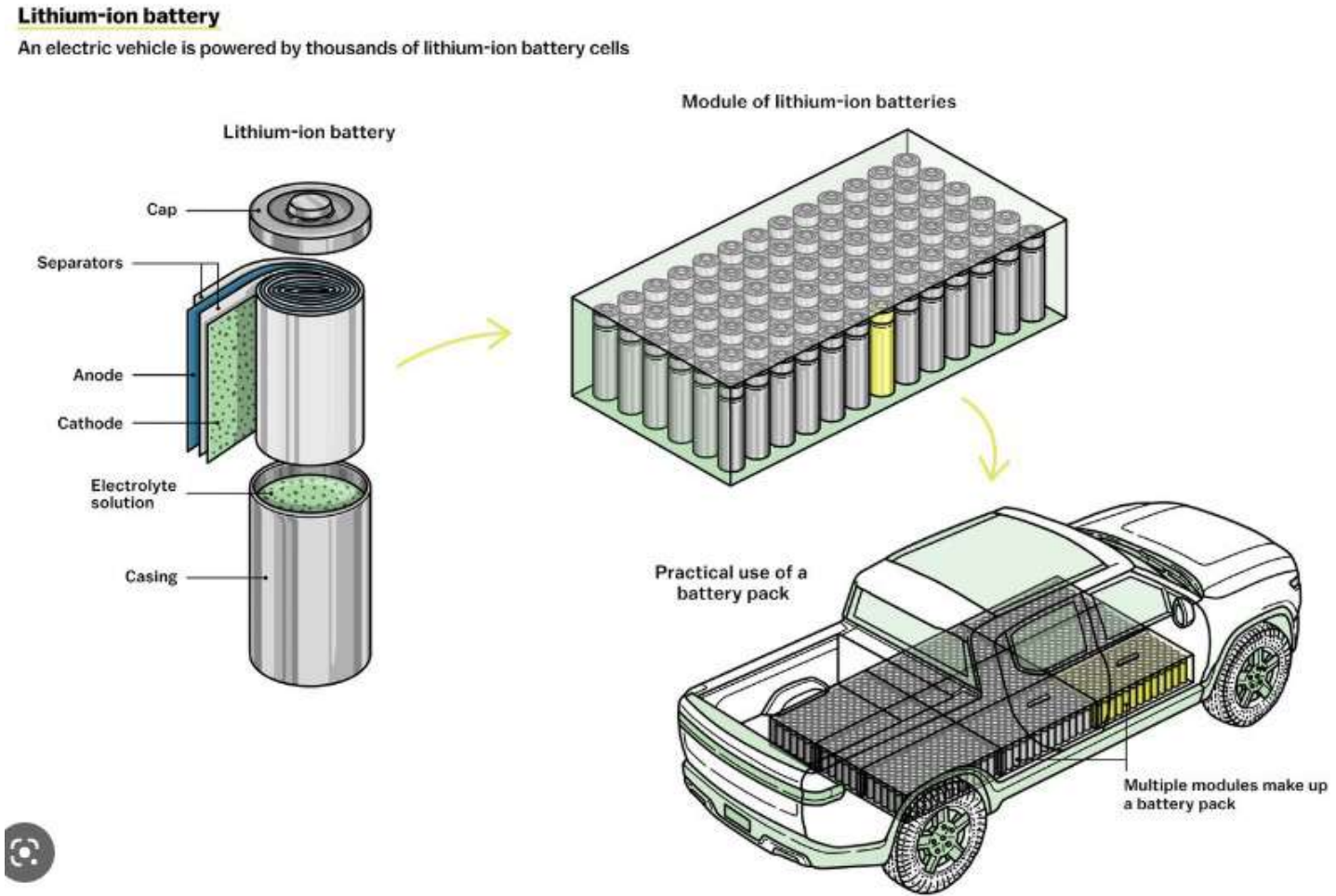


- Switches
  - Mosfet – No players in India
  - Contactors / Relays
- Electrical components
  - Busbar
- Mechanical
  - Sealant
  - Cooling systems

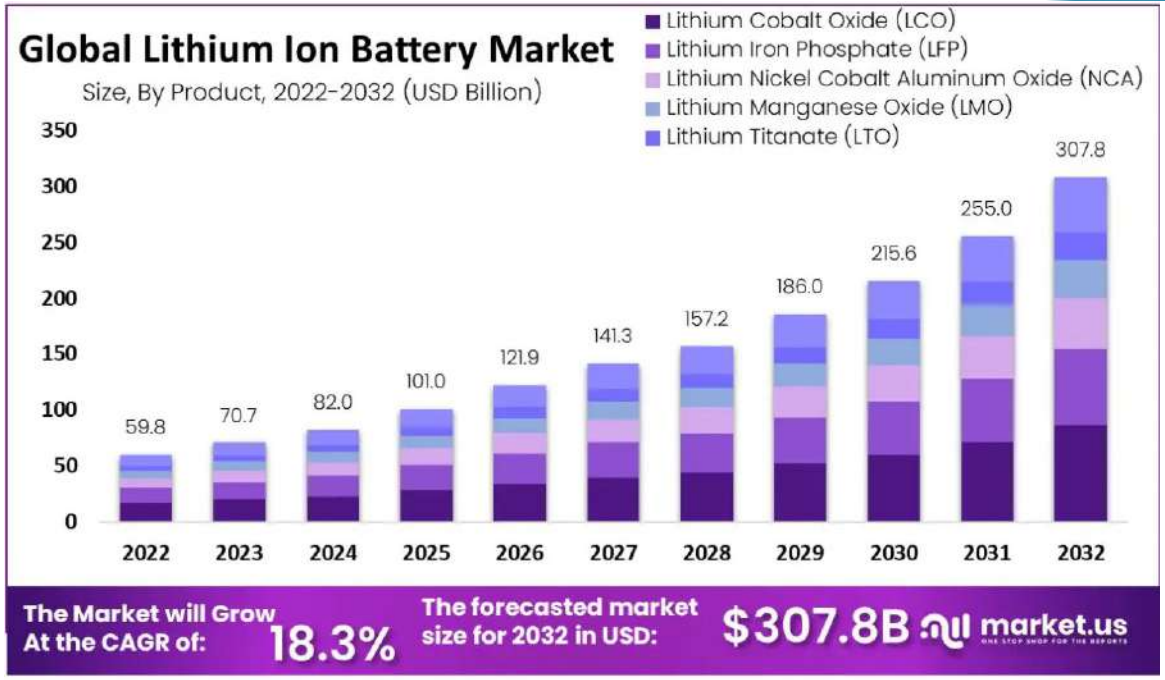
Deep Dive - Cells

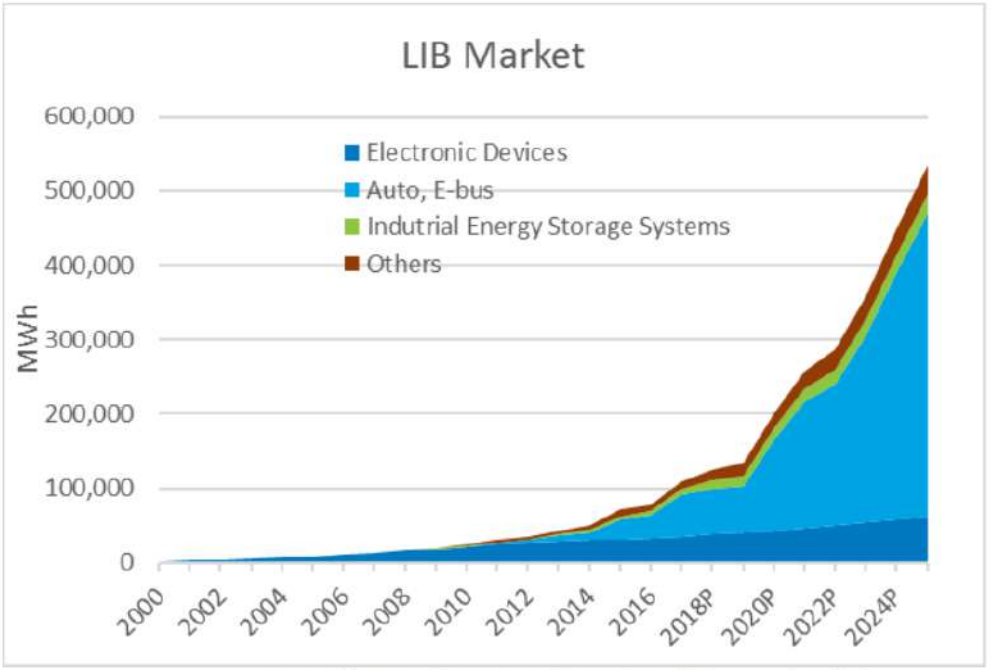


Terminology



Lithium ion Batteries – Market Size

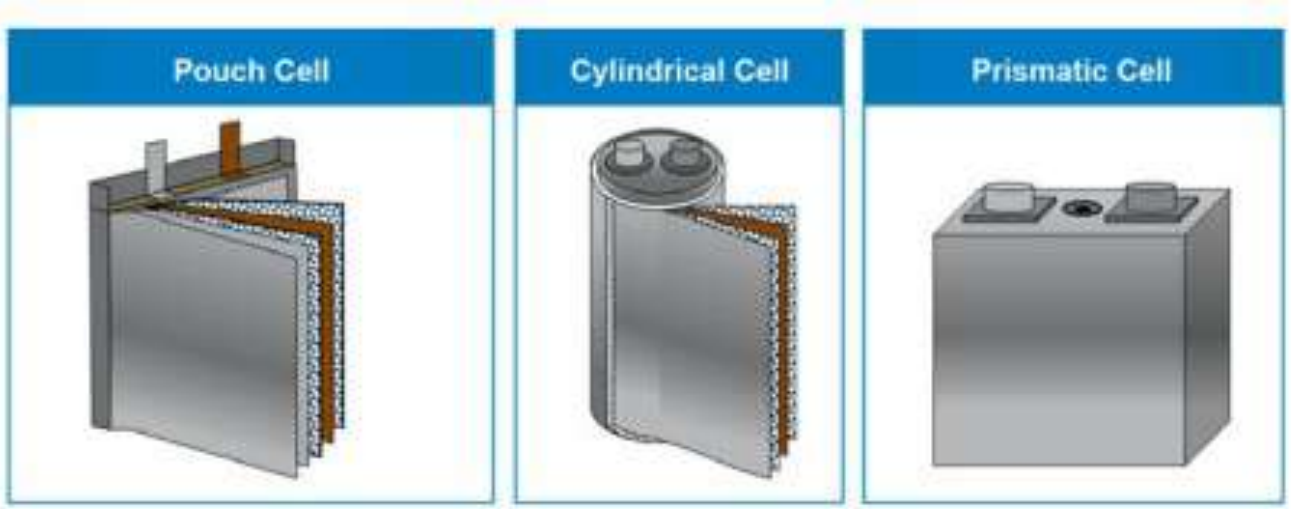




Source of data: BNEF 2017, Avicenne 2017, Navigant 2016, NREL analysis 2018

- Currently, consumer electronics is the biggest LIB application.
- LIB for xBV's will dominate in the near future.

Lithium ion cells



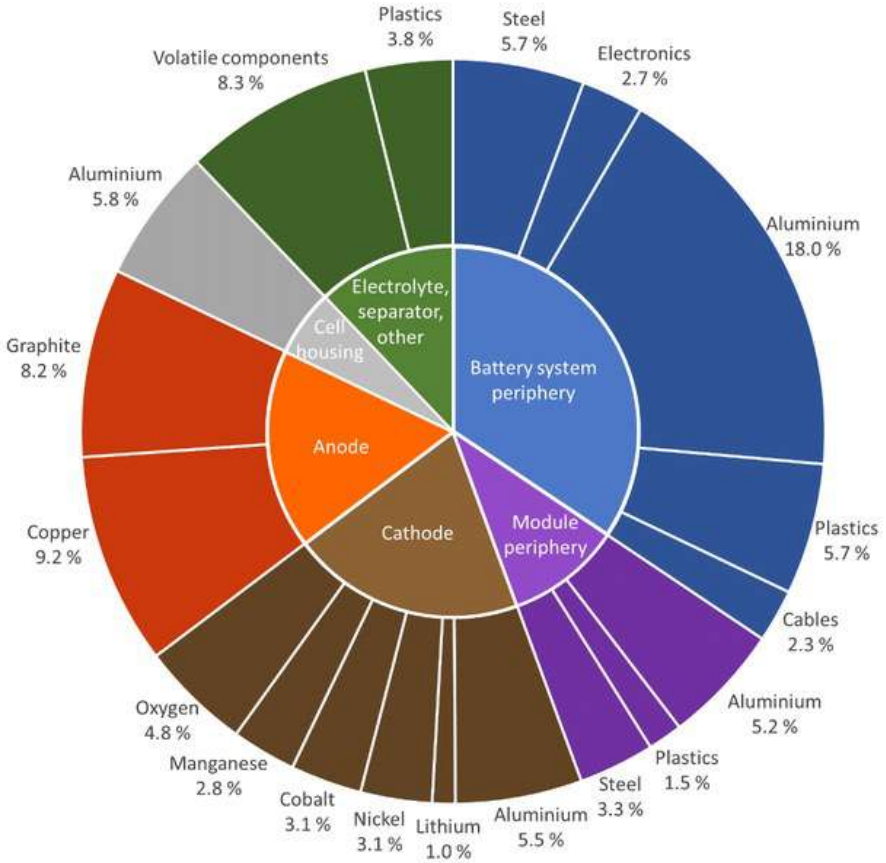
Overview of cell formats

Source: PEM, RWTH Aachen University

Cost sensitive 2W , 3W, Battery swapping etc.

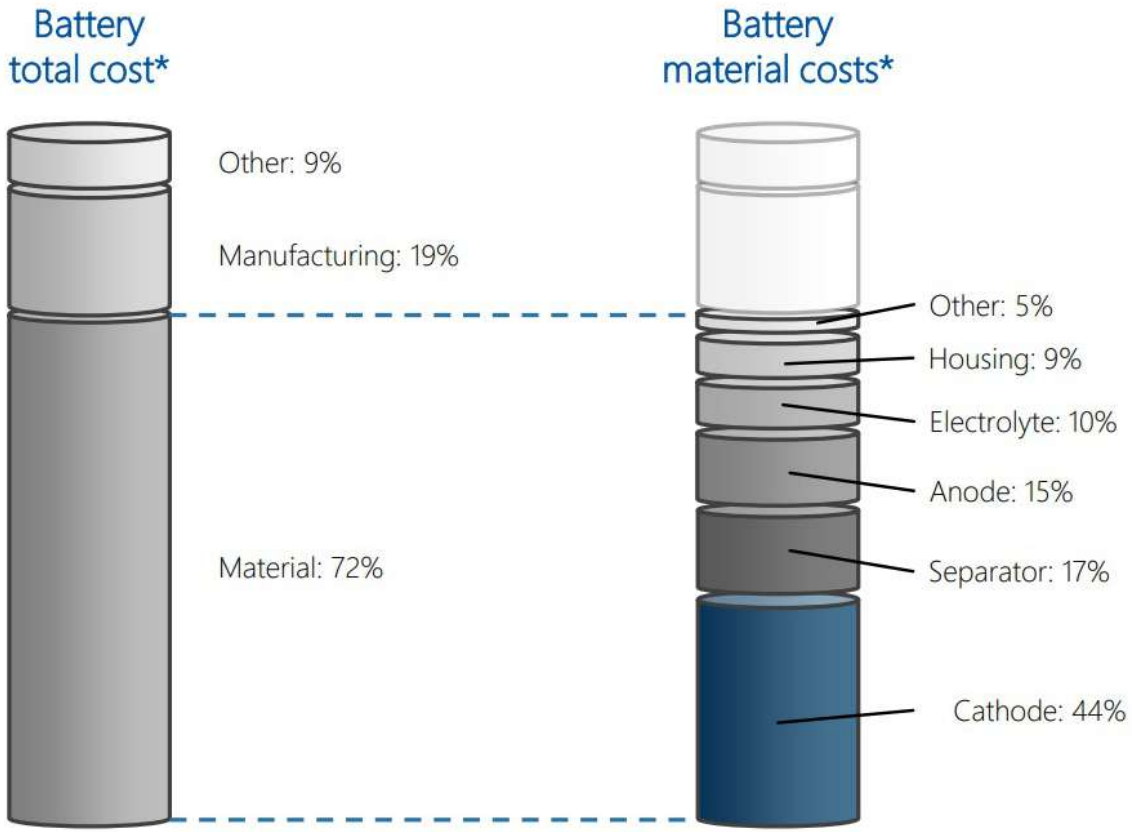
Takes more space, better cooling, low mechanical stability
2W and 4W

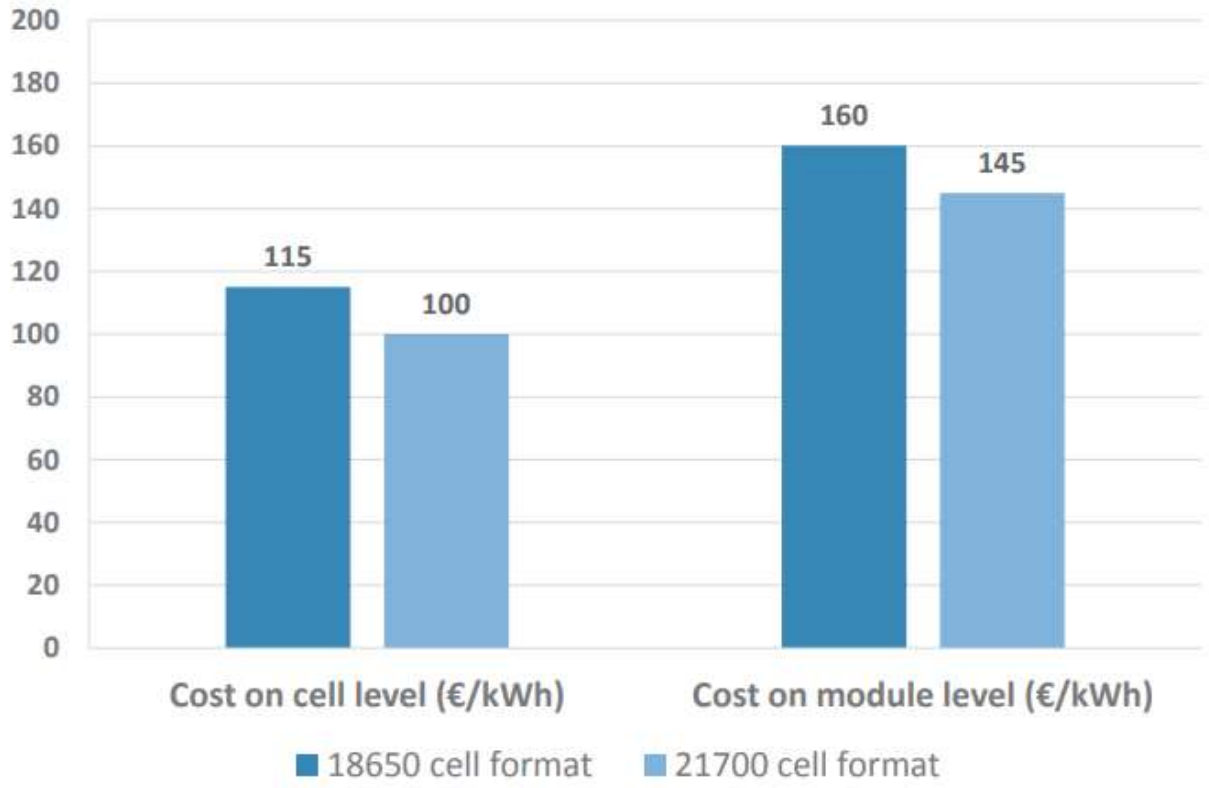
Compact packing, stable
Generally 4W



https://www.researchgate.net/figure/Material-composition-of-a-generic-Li-ion-traction-battery-with-an-NCM-cathode_fig7_323727659

Cell composition



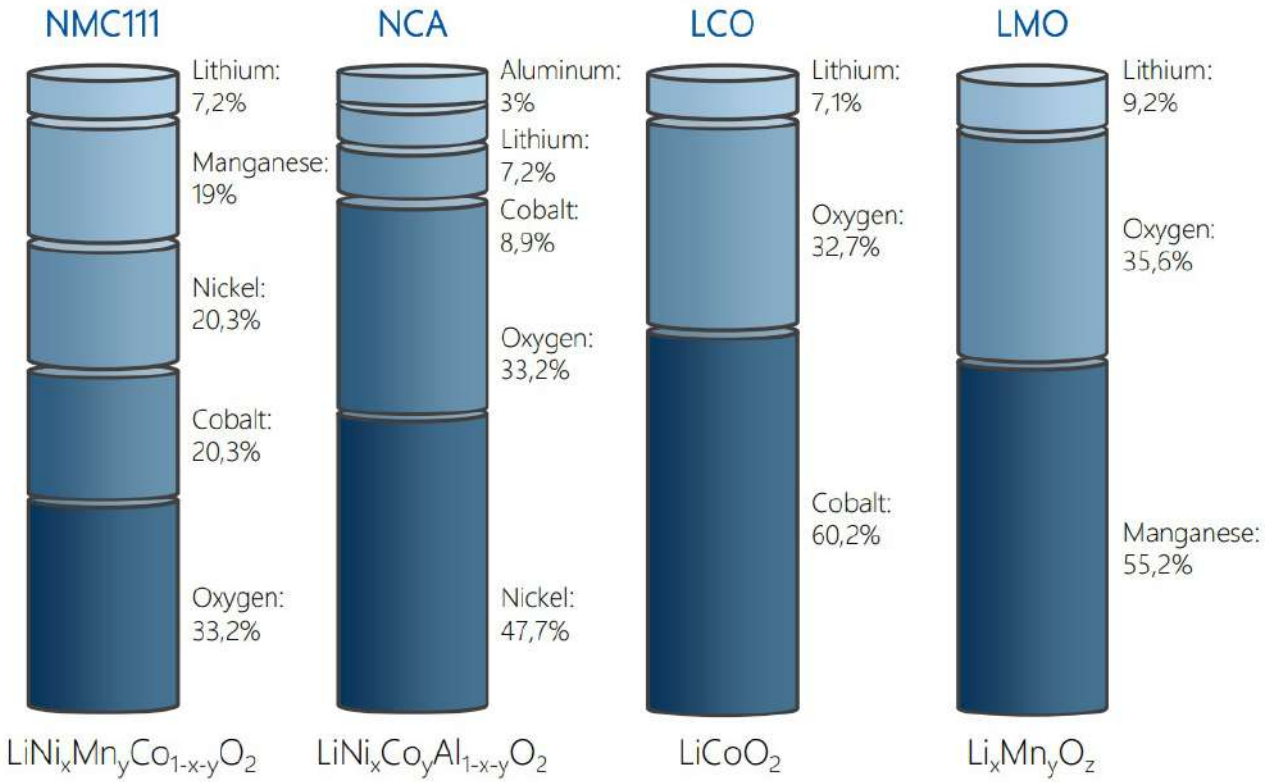


Source : Kampker et al. "Component production of a lithium-ion battery cell," 2019; Friedrich et al. "Recovery of Valuable Metals from E-Waste and Batteries by Smart Process Design," RWTH Aachen, IME, 2019; Kwade, A., Haselrieder, W., Leithoff, R. et al. "Current status and challenges for automotive battery production technologies," Nat Energy 3, 290-300 (2018).

Composition

Cathode composition

Fundamentals



Projected used batteries collected, as of 2020*.

- NMC: 3,700 tons
- LCO: 2,700 tons
- LMO: 1,500 tons
- LFP: 250 tons

Disposal costs

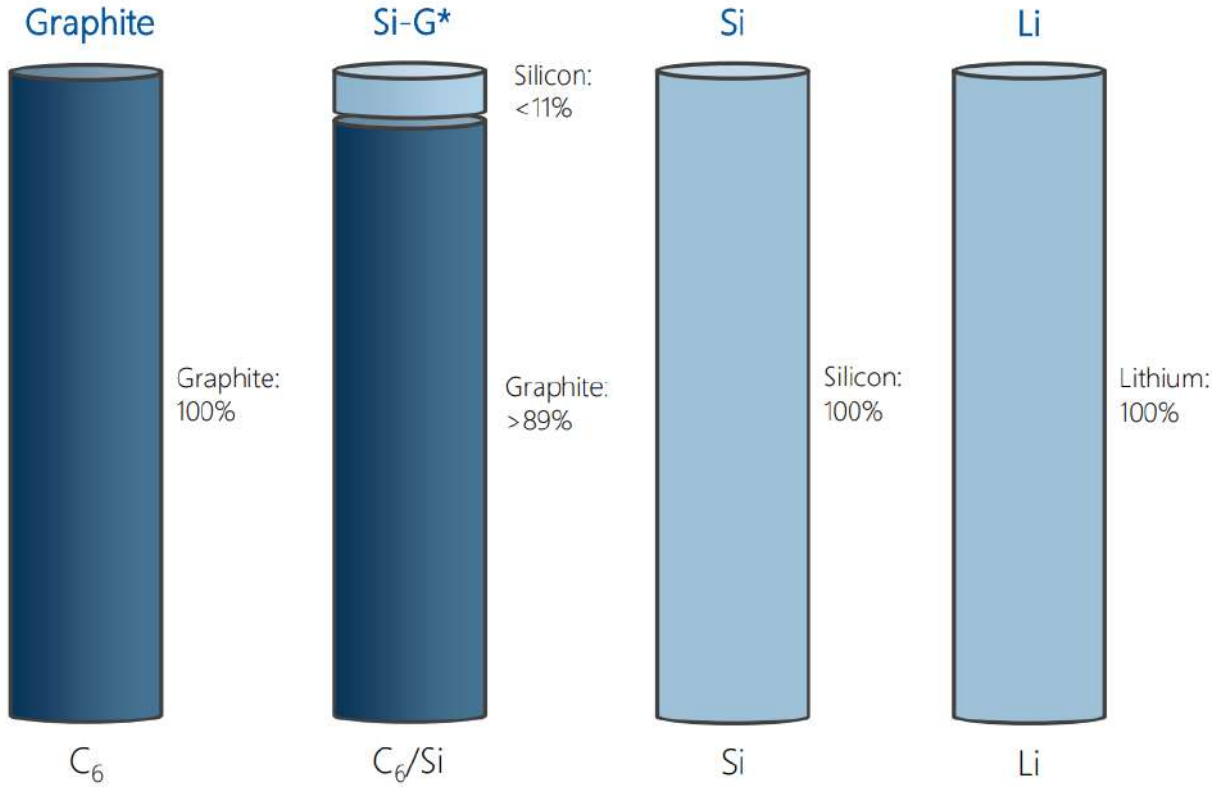
- Currently, companies that put batteries on the market have to plan for high disposal costs and build up appropriate reserves.

Friedrich et al. "Recovery of Valuable Metals from E-Waste and Batteries by Smart Process Design," RWTH Aachen University, IME, 2020. Mayyas et al. "The case for recycling: Overview and challenges in the material supply chain for automotive li-ion batteries," 2018.

Composition

Anode composition

Fundamentals



As of 2023 – Pure graphite is the most relevant
Addition of silicon improves energy density but reduces life

HEG Limited
February 20, 2023

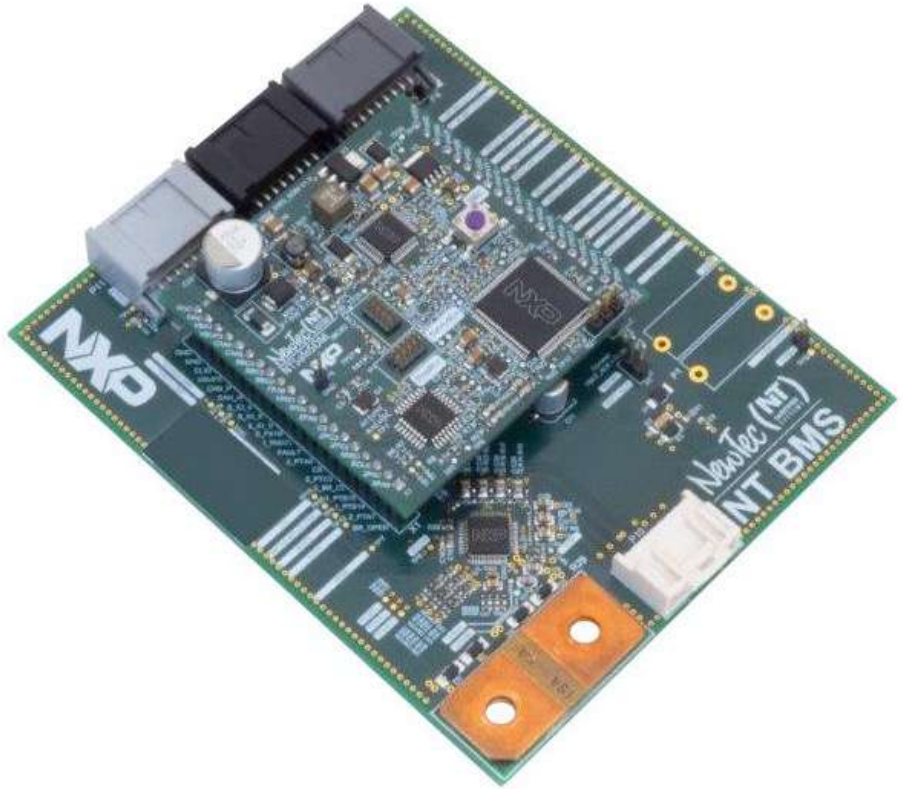
incorporated a wholly owned subsidiary of HEG in the name of TACC Limited for this new business, and our Board has approved a budget of INR 1,000 crores for setting up manufacturing facility of 10,000 tons of anodes per annum in Phase 1, which should be in operation by Q2 of calendar year 2025. At present, cells and battery packs are all imported into India, and soon there will be a huge domestic demand for graphite anode as cell manufacturing shifts to India. We see tremendous potential for this business in the next three to five years as more-and-more EVs get manufactured in India.

Electrolyte-Seperator-Binding Material

← Thread covers in full details

Deep Dive – BMS

- Chips
- Capacitors
- Integrated Chips
- Connectors
- BMS manufacturing



Integrated Chips

Our semiconductor solutions for battery management

Microcontroller
32-bit multicore TriCore™ microcontroller family, optimized for highly demanding powertrain applications (PRO-SIL™).

Power management IC
OPTIREG™ automotive PMIC: ISO26262-compliant, multi-rail power supply with microcontroller-, communication-, and sensor-supply rails and monitoring/supervisory functions (PRO-SIL™).

Power management IC
Battery management sensing IC offering 12-channel voltage measurement, 5 temperature sensor connections and a best-in-class communication protocol.

Power management IC
TLE9252V, a 14-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The dual power supply concept (state machine supplied by V_{BAT} „or" V_{CC}) avoids disruption of communication during V_{BAT} cranking.

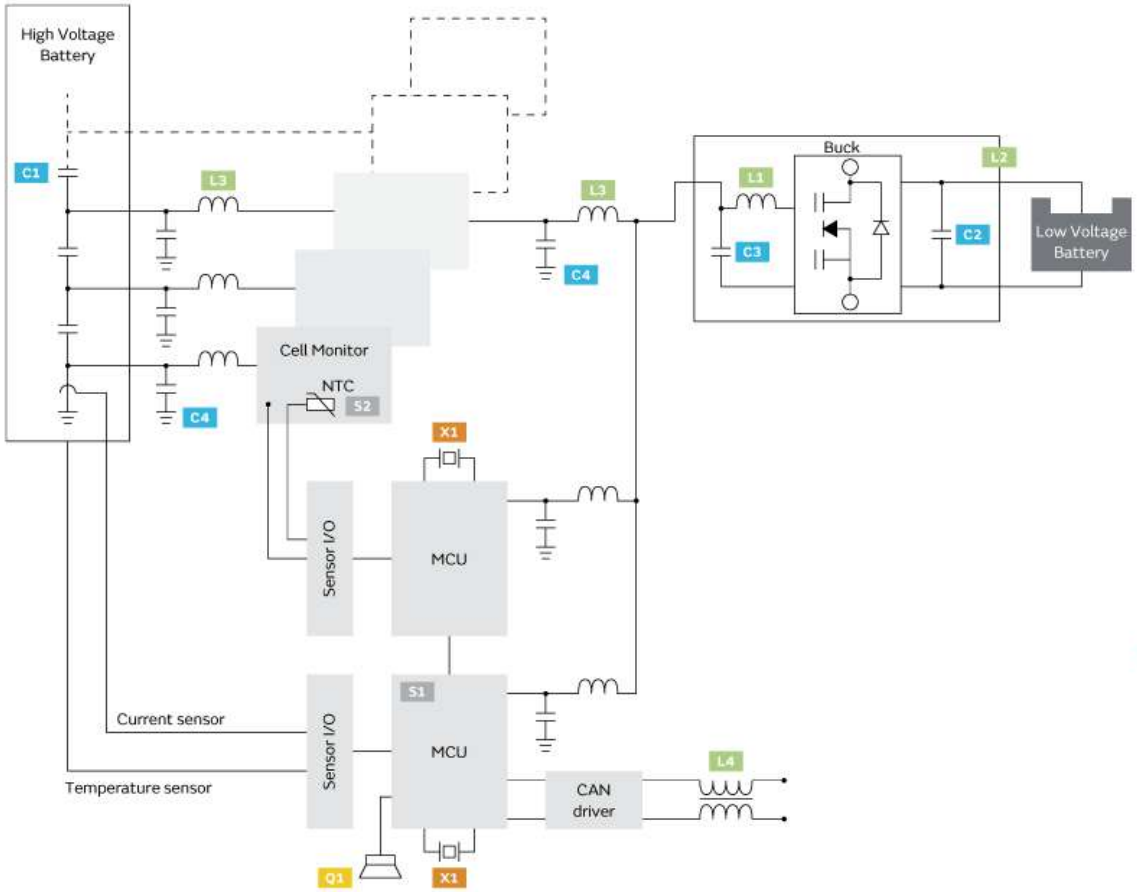
Power management IC
TLE9251V, a 8-pin automotive transceiver designed for HS CAN networks with Flexible Data-rate up to 5 Mbit/s in automotive and industrial applications. The TLE9251V which V_{CC} can even be switched off, while still being able to wake-up by signals on the CAN bus. Additionally TLE9251V with VIO input pin can interface either with 3.3 V or 5 V microcontrollers.

Top Players:
Infineon
NXP
Texas Instruments
Toshiba

Based on design, a Low Voltage BMS can have 5-6 IC-s performing various functions

https://www.infineon.com/dgdl/Infineon-Hybrid%20electric%20and%20electric%20cars%202019-ApplicationBrochure-v01_00-EN.pdf?fileId=5546d4625d5945ed015dc81f427b36a6

Capacitors – Resistors - Inductors



C1

› **Chip Multilayer Ceramic Capacitors for Automotive(Powertrain/Safety)**

GCM Series

› **Soft Termination Chip Multilayer Ceramic Capacitors for Automotive(Powertrain/Safety)**

GCJ Series

› **Metal Terminal Type Multilayer Ceramic Capacitors for Automotive(Powertrain/Safety)**

KCM Series

› **Leaded MLCC for Automotive**

RCE Series

› **150℃ Operation Leaded MLCC for Automotive**

RHE Series

› **Large-current Common Mode Choke Coils**

PLT10HH/PLT5BP Series

› **Chip Common Mode Choke Coils**

DLW Series

Very hard to predict the usage of such components as it is application dependent

https://www.murata.com/en-sg/apps/mobility/electrified/bms#mcu

Connectors

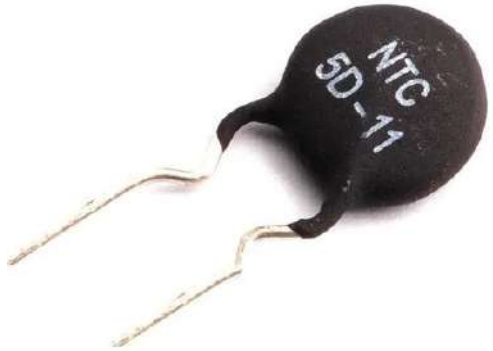
FC04 PRO Connector for
battery swapping applications

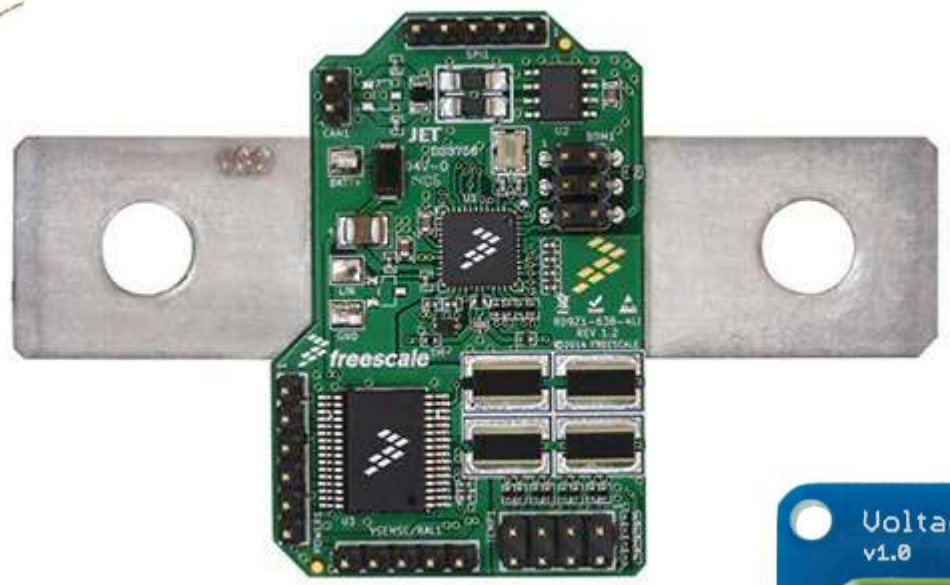
Design patent possible.

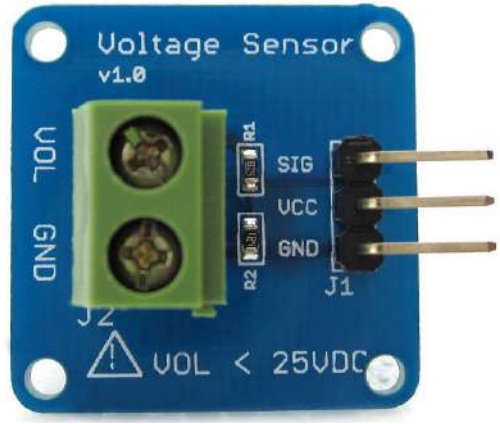
In case of niche application connectors can be expensive.

Deep Dive – Sensors

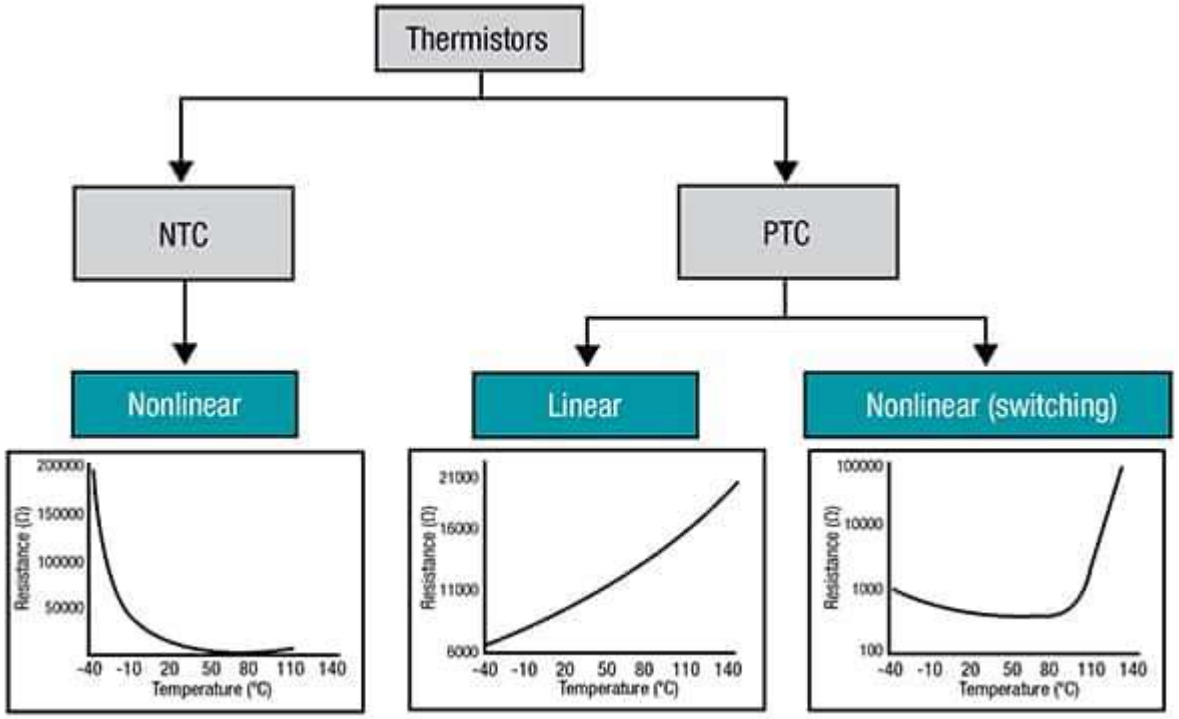
- Temperature
- Current
- Voltage

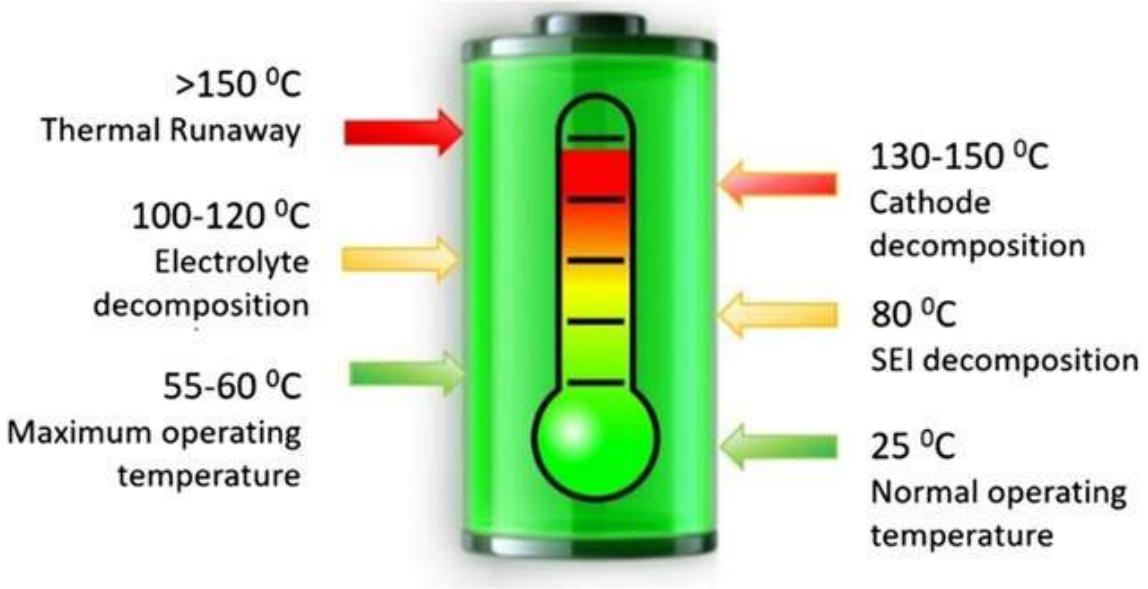






Temperature





Cheap sensors and possibly no scope of high margins

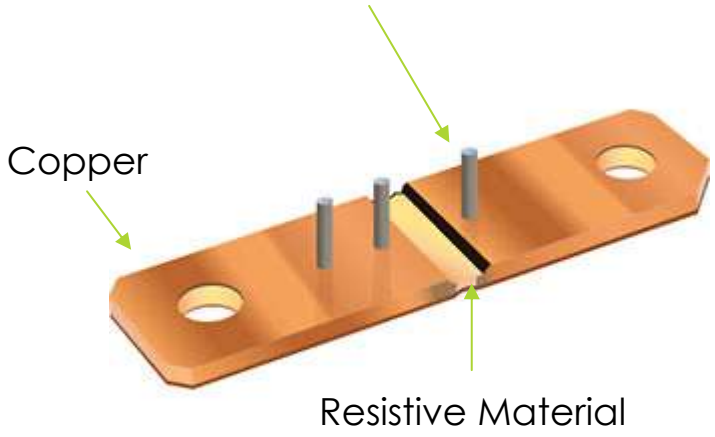
Approximately 2 sensor per 10 cells

https://onlinelibrary.wiley.com/doi/full/10.1002/aesr.202000059

Current

Shunt Sensor

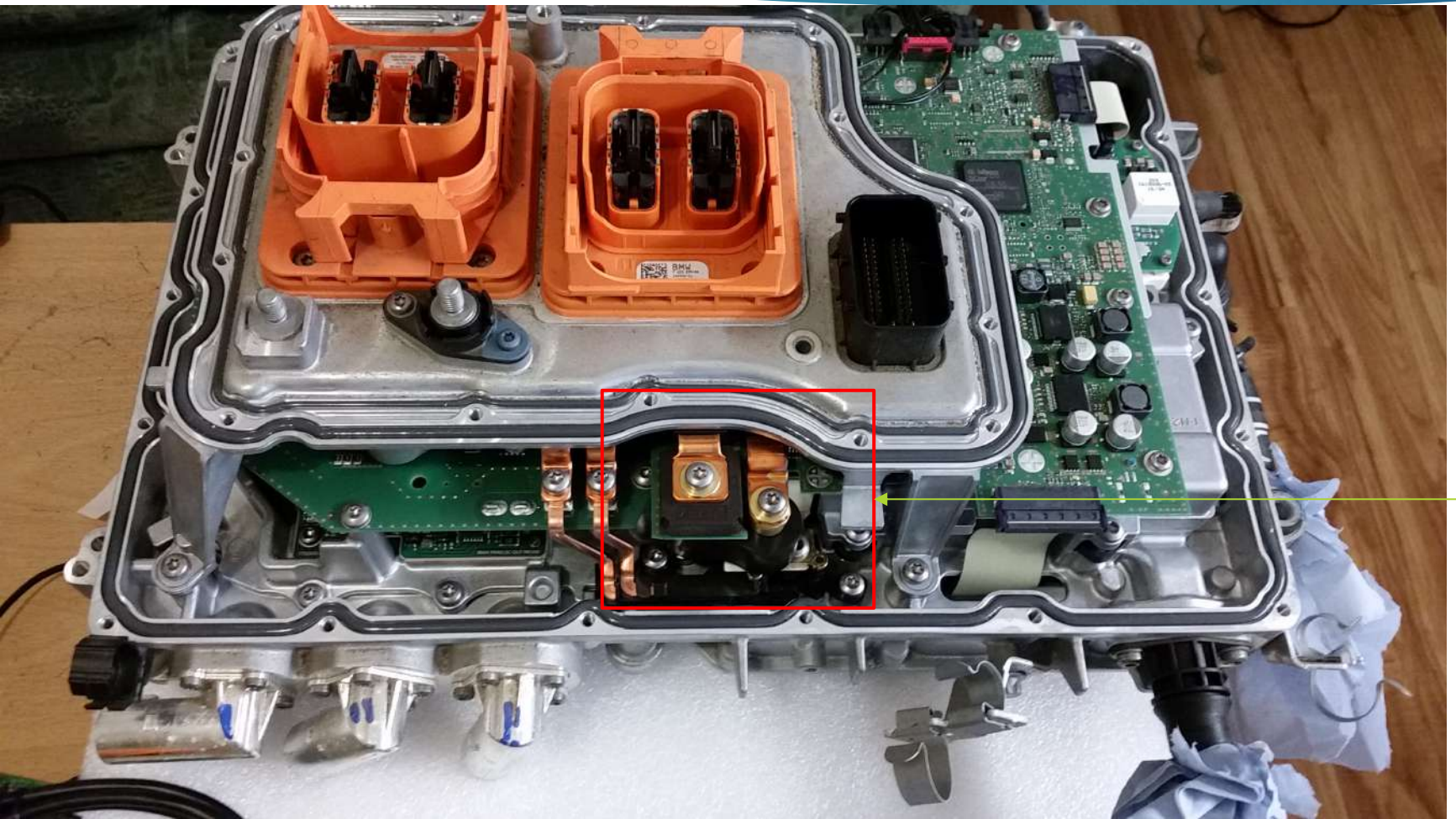
Leads for voltage measurement



1. Resistance should be constant across a temperature range
2. Resistance should not fluctuate due to current fluctuation
3. Suitable for DC current.
   For AC some modification in controller is needed
4. Control system is inexpensive

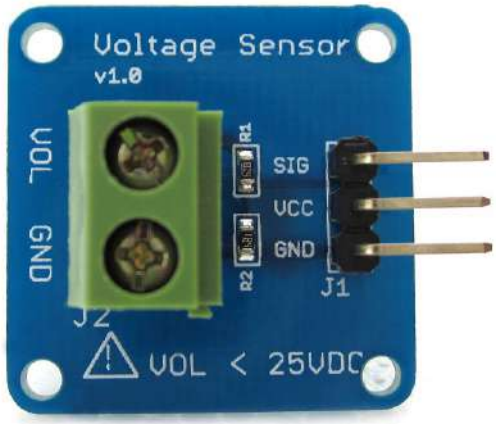
Hall effect sensor

1. Used along with Shunts in many cases
2. Accuracy can be lower
3. For AC application modifications are required



Hall effect Sensor for 3 phases AC current

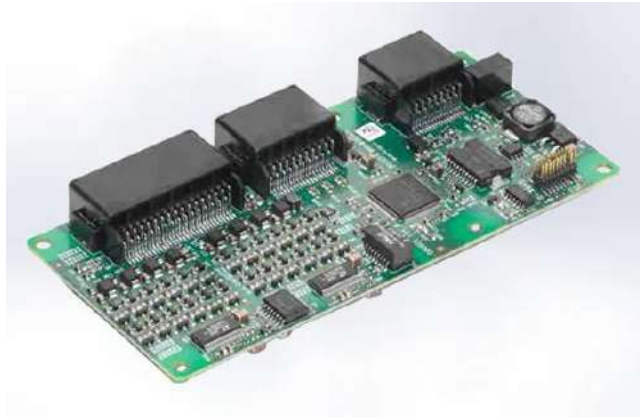
Voltage



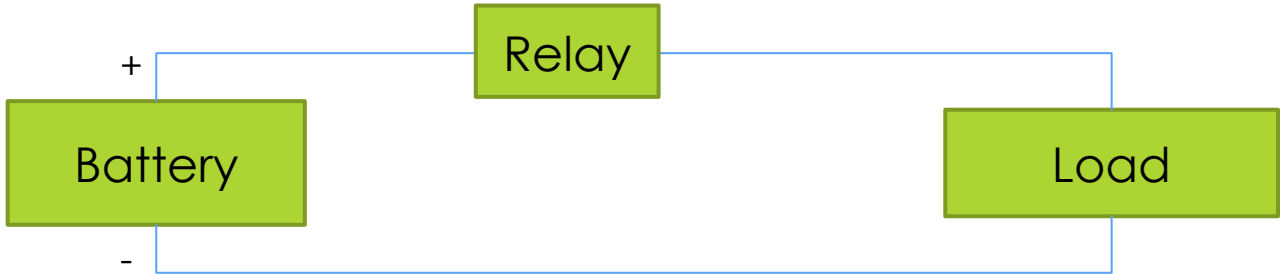
No special item, mostly a commodity

Deep Dive – Actuators

Contactors

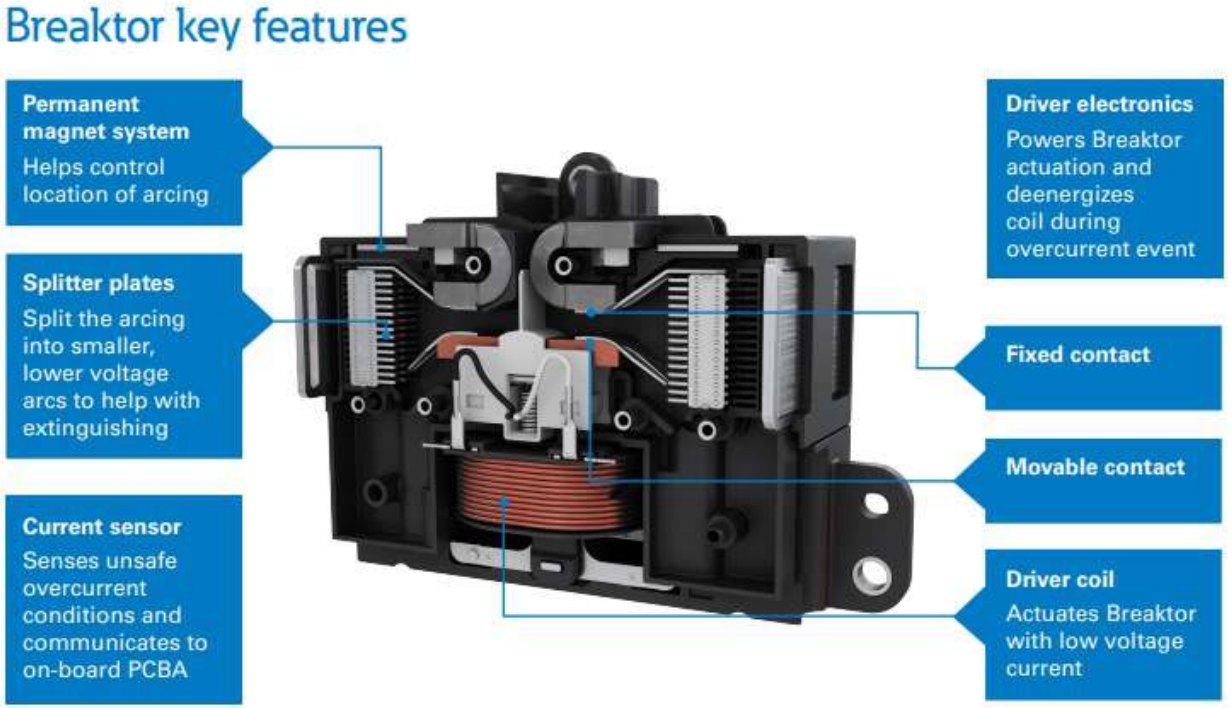


Contactors / Relays



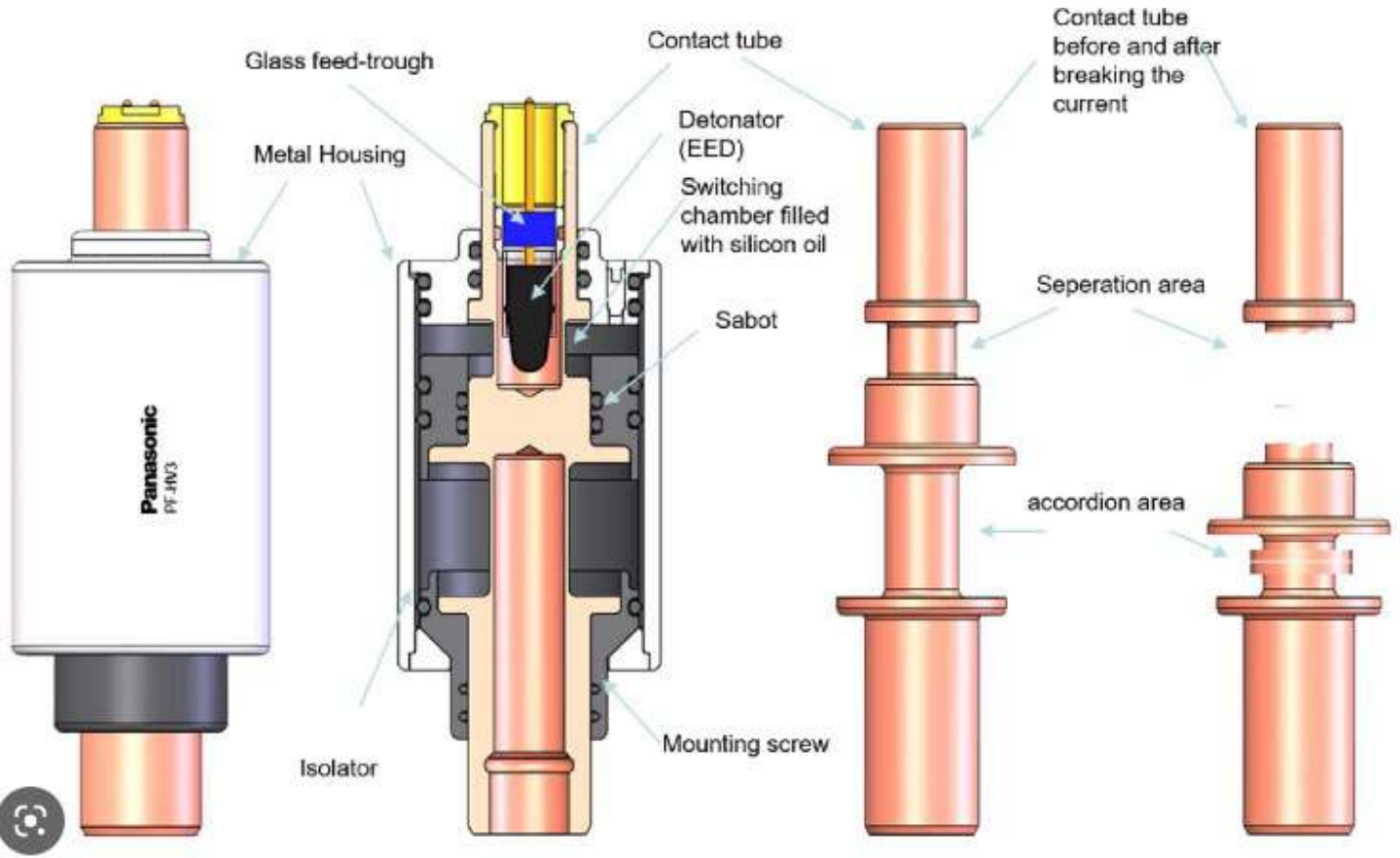
Companies specializing in this area : Hongfa , Eaton

No listed Indian play identified.



https://www.eaton.com/content/dam/eaton/products/emobility/power-distribution-protection/breaktor/eaton-breaktor-brochure-emob0002-en.pdf

Pyrofuse



No listed play identified

Lead Acid Battery

As of now, electric vehicles would also need a 12 V lead acid battery powering up the auxiliary units

Challenges of replacing the 12V supply with lithium

1. Safety
2. Cost

DCDC

DC-to-DC converters are devices that temporarily store electrical energy for the purpose of converting direct current (DC) from one voltage level to another. In automotive applications, they are an essential intermediary between systems of different voltage levels throughout the vehicle.

DCDC

- Electronic device similar to a BMS
- Possible Play in India
  - Varroc Engineering Ltd
  - Minda Corporation Ltd
  - Uno Minda Ltd
  - Minda Corporation Ltd
  - Sandhar Technologies Limited
  - Cosmo Ferrites Ltd
  - Sona BLW Precision Forgings Ltd
  - Bosch Ltd
  - Bharat Forge Ltd

Inverter

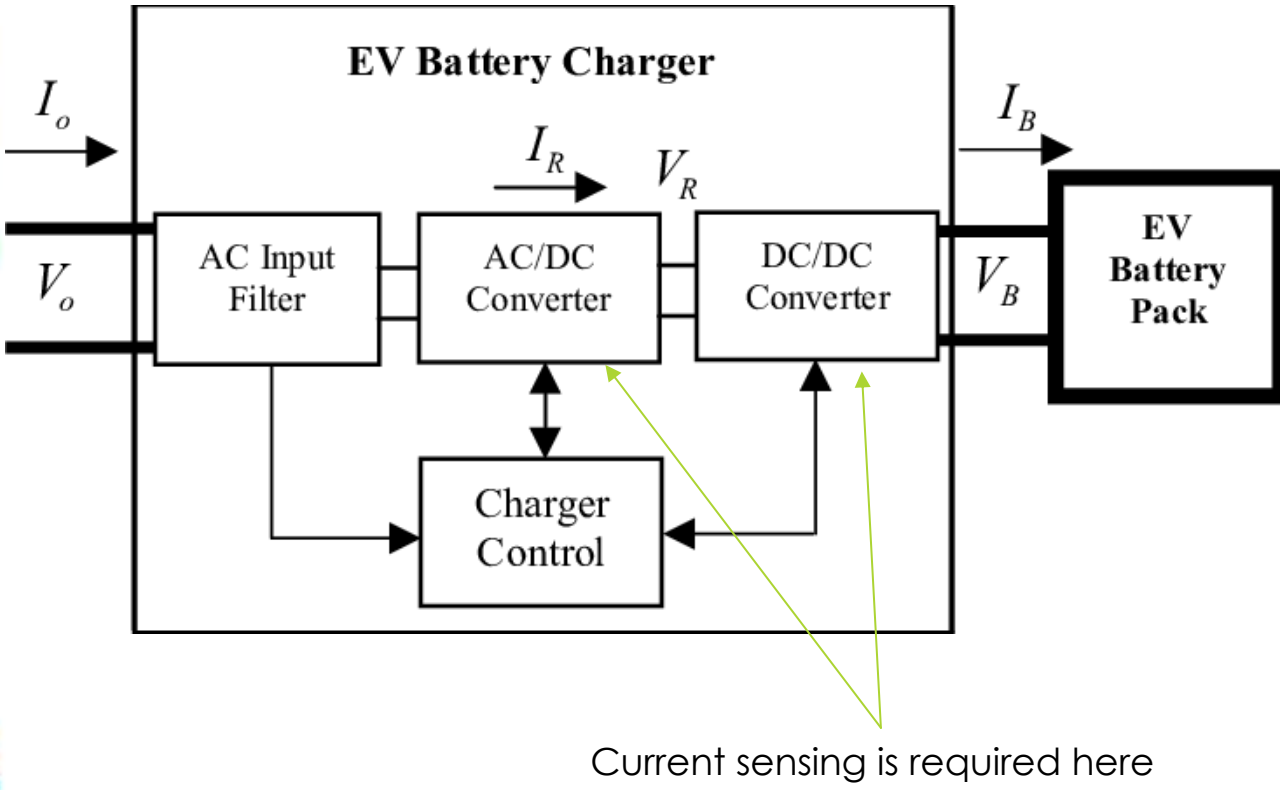
Charging

1. CHARGING COMPONENTS
2. INFRASTRUCTURE

Charging Category

CHARGING TYPE	POWER SOURCE	LOCATION	SPEED	APPLICATION	PROS	CONS
LEVEL 1	AC	HOME	SLOW	-Emergencies -Plug-in hybrids	-Charger often included with EV purchase -Beats walking	-Impossibly sluggish
LEVEL 2	AC	HOME/ PUBLIC	MEDIUM	-Everyday use -Long-term parking	-Best all-around charging solution -Low cost-per-kWh	-Costly installation for home use -Not ideal for public charging on road trips
DC FAST CHARGING	DC	PUBLIC	FAST	-Road trips -Long drives	-Lickety-split charging	-Regular use can degrade vehicle batteries -Per-kWh prices are higher

Components



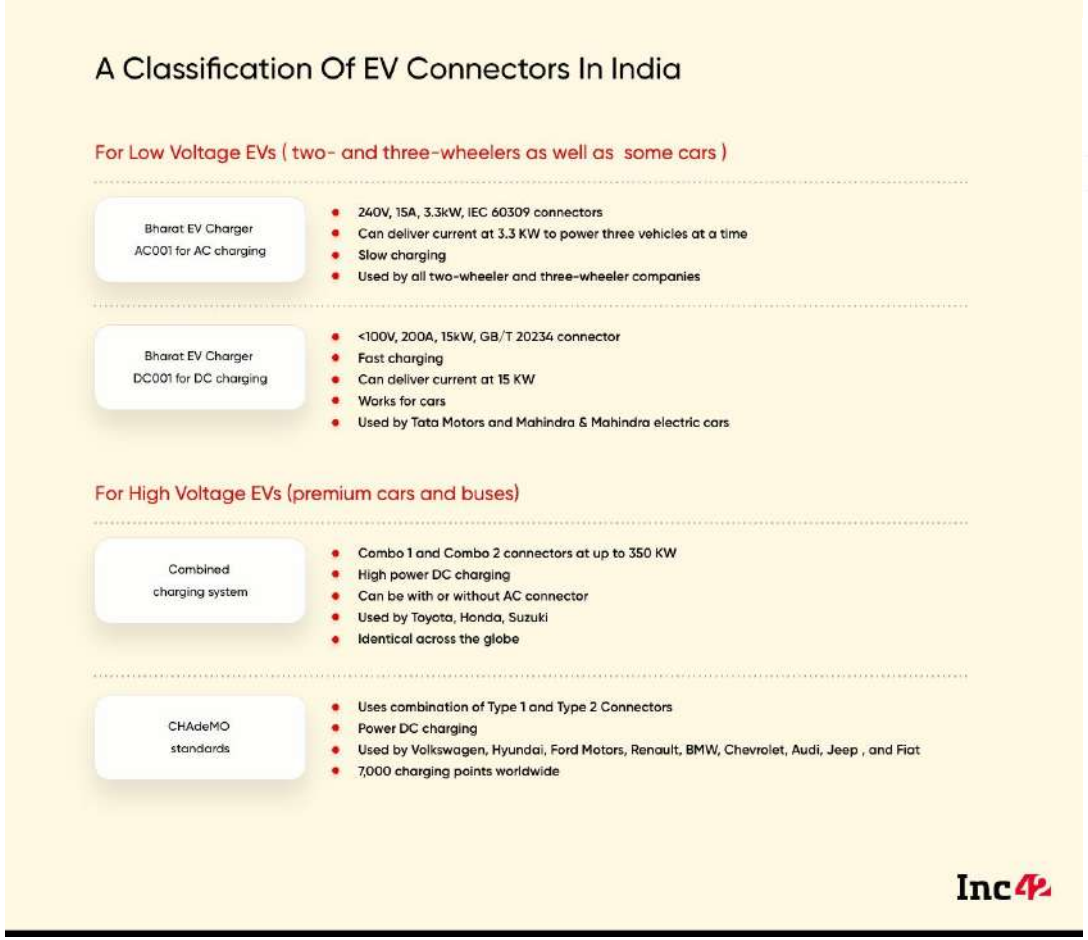
Current sensing is required here

Connectors - Globally

	N. America	Japan	EU *and the rest of markets*	China	All Markets *except EU*
AC	 **J1772** (Type 1)	 **J1772** (Type 1)	 **Mennekes** (Type 2)	 **GB/T**	 **Tesla**
DC	 **CCS1**	 **CHAdeMO**	 **CCS2**	 **GB/T**	

https://www.researchgate.net/figure/Types-of-electric-vehicle-chargers-30-i-Combined-Charging-System-Charger-CCS-This_fig2_356892277

Connectors - India



ETPrime

Centre gives Rs 800 crore to oil companies for setting up over 7000 charging stations under FAME II

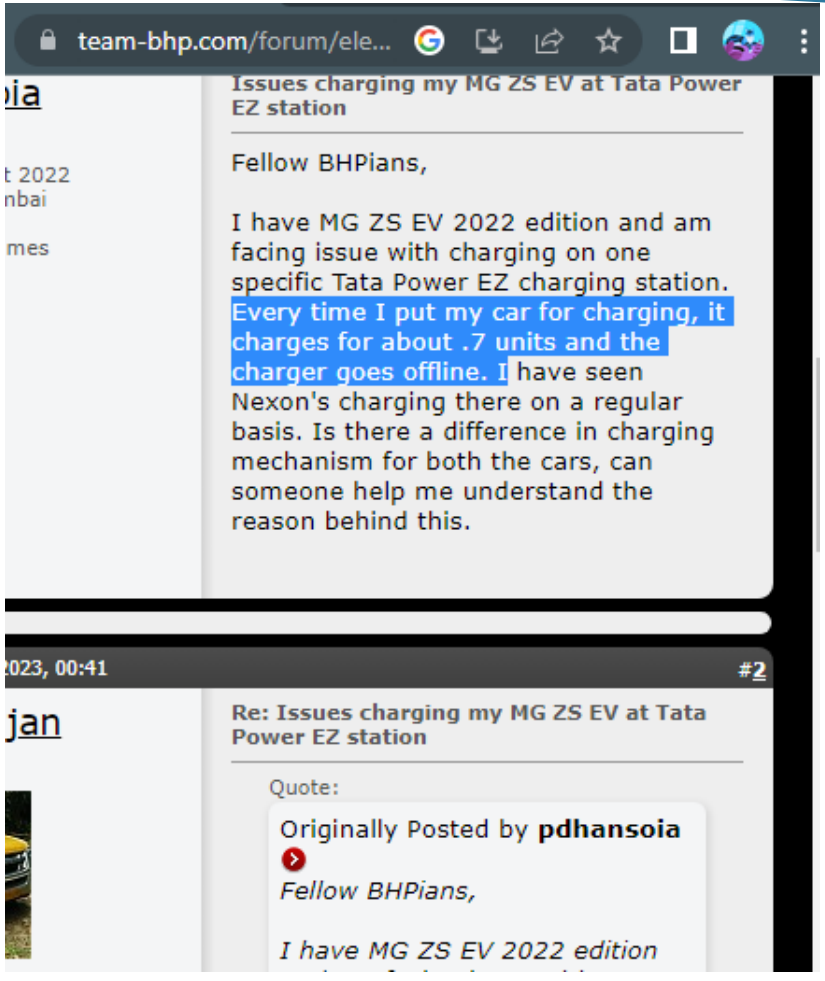
By Twesh

The fact is that at the end of 2022, India had 2,700 public charging stations and 5,500 charging connectors.

The country is likely to have 10,000 public charging stations by the end of 2025, according to Counterpoint Research.

The country may require some 20.5 lakh charging stations by 2030 - a mammoth task that has to be complemented with a surge in EV sales till that time.

Charging moat → Network Effect



Hypothesis:
As the vehicle ages, it draws more current. This leads to higher energy consumption leading to higher revenue for the charging solution provider

Charging Cable

- Aluminum
- Copper
- Connectors
- Location

Trying to find a play –
Motherson Sumi Wiring India Ltd
Minda Corporation
AXISCADES Technologies Ltd
Salzer Electronics Ltd
Talbros Automotive Components Ltd

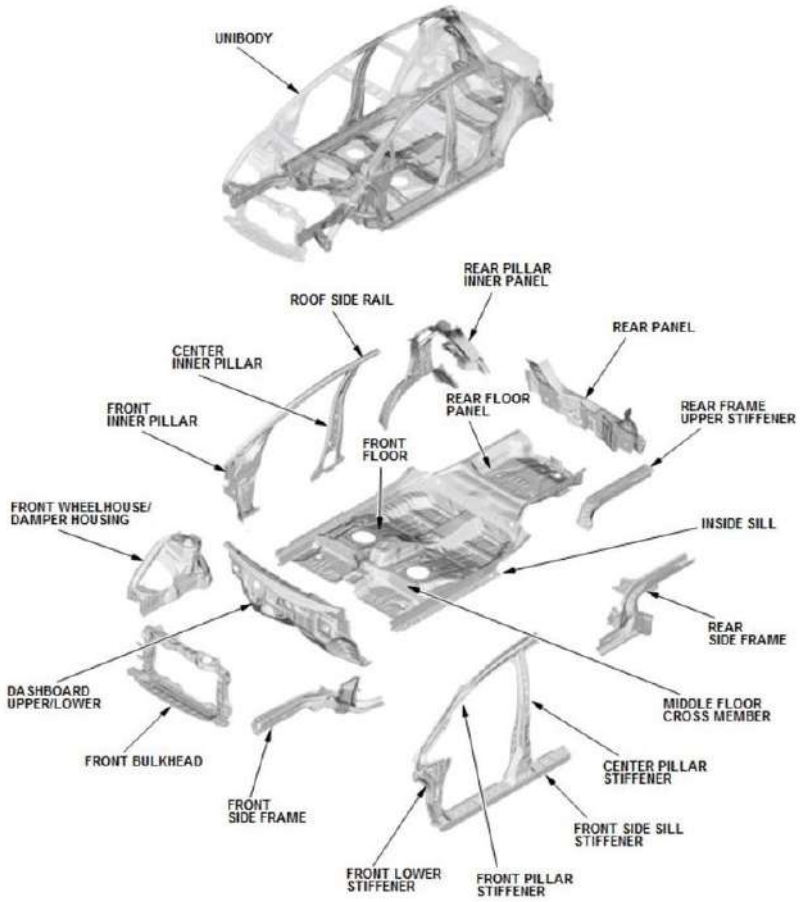
AC and DC charging control board

- Similar to BMS and other controllers

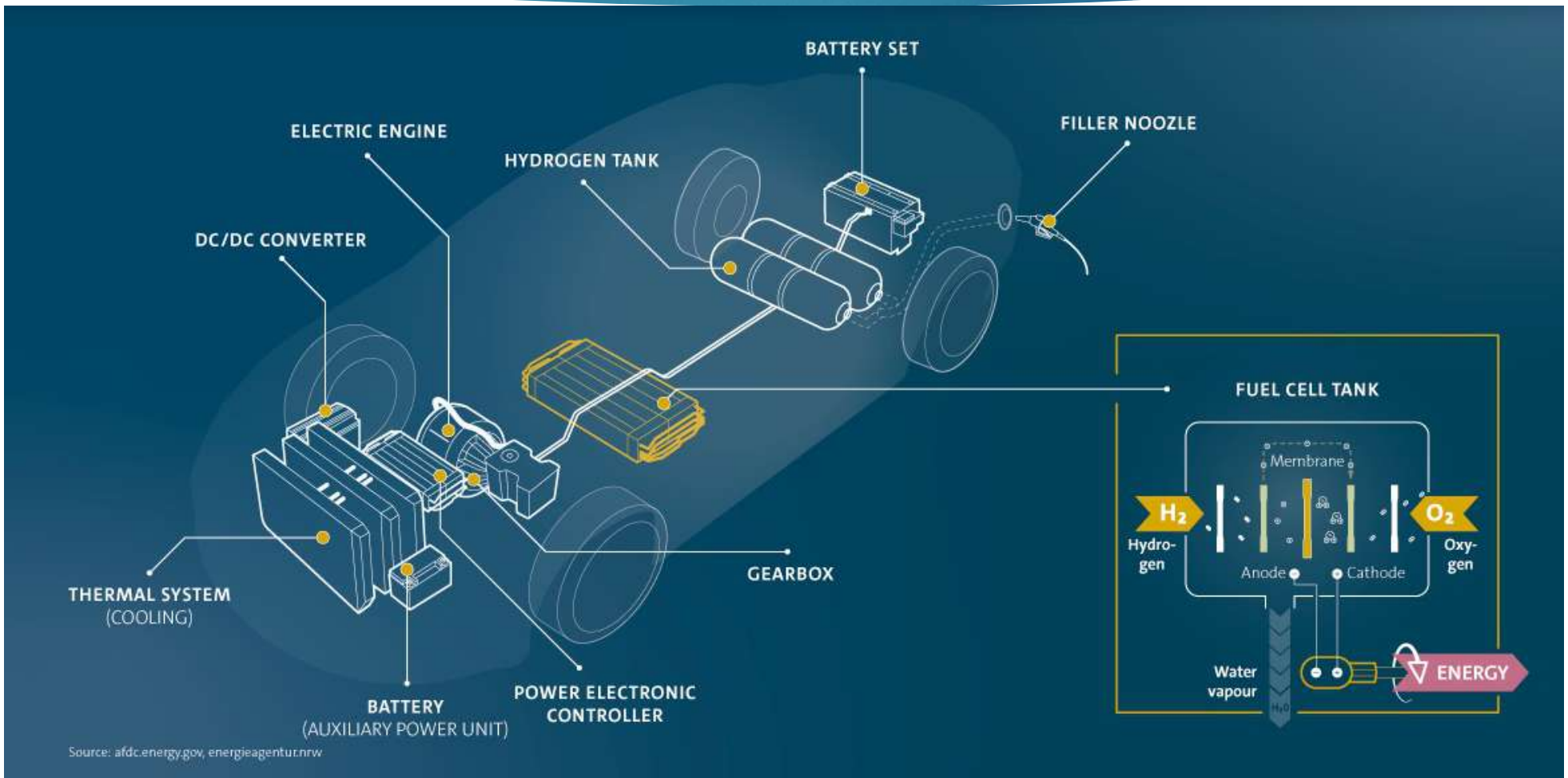
XPRO – Electrolytic Capacitor
Syrma SGS Technology Ltd
Gujarat Poly Electronics Ltd

BIW

- Outsourcing of Body In White work to India.
- Mainly involves simulation work using CAD CAM
- High Margin activity and asset light
- India has large trained workforce from CTTCs
- OEM will not give the job to a single player
- Top Players
  - MoldTec - listed
  - ESCAD Engineering Pvt Ltd - DAIMLER, AUDI, VW, PORSCHE, JLR.
  - ASM Engineering Technologies PVT. LTD
  - CARLine Technologies Pvt Ltd.
  - Talbros Automotive Components Ltd.



Hydrogen Drive



Hydrogen Drive

Nozzle freezing

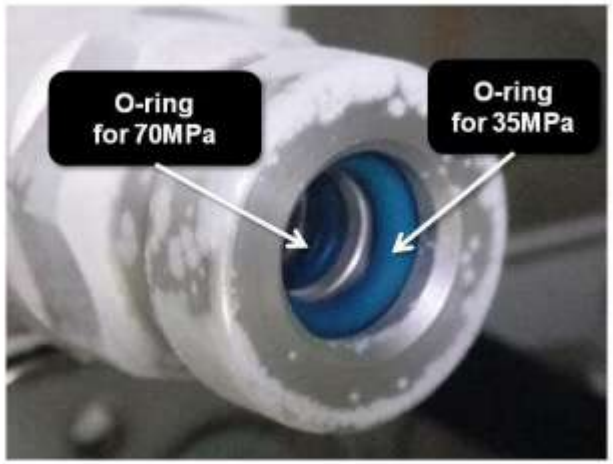


Figure 7. O-ring in receptacle after freezing

Storage Leakage

ECONOMY-WIDE LEAKAGE RISK SUMMARY

Figure 2 shows the results for economy-wide hydrogen leakage in terms of both tonnage (Mt) and percentage (of total hydrogen produced). The total economy-wide leakage for 2020 is estimated to be 2.4 Mt or 2.7 percent. This relatively low result is driven by both the scale of hydrogen demand (approximately 90 Mt/yr) and a generally small leakage rate assumption for industrial end uses.

The 2050 economy-wide leakage rate and total tonnage amount are higher than those for 2020 because the scale of the hydrogen economy will be much broader (528 Mt/yr), and certain leaky processes will be more widely used (if they were used at all) than they were in 2020 (see Figure 1). The leakage rate stands between 2.9 percent (low-risk case) and 5.6 percent (high-risk case), and the total leakage volume stands between 15.3 Mt and 29.6 Mt. This can represent a non-negligible contribution to global warming and up to a $59 billion/yr value loss of hydrogen (assuming $2/kg-H2).

Figure 2: Economy-wide hydrogen leakage by process, 2020 and 2050

Current status

Oct 18, 2022 - 03:18 pm

Shell quietly pulls the plug on hydrogen in the UK

FCEV | HYDROGEN | HYDROGEN FILLING STATION | ITM POWER | MOTIVE | SHELL | UK

Shell has closed down all its hydrogen filling stations in the UK, saying the installed "prototype tech had reached its end of life". However, this is just a small part of the story since the oil and gas corporation now wants to refocus – on bigger vehicles.

Instead of waiting for the very few fuel cell cars to come and refill, Shell wants to explore opportunities to build "multi-modal hubs for heavy-duty trucks" in the UK.

Refuelling a hydrogen car: How five minutes can turn into an hour

PETRINA GENTILE >
SAN DIEGO, CALIF.
SPECIAL TO THE GLOBE AND MAIL
PUBLISHED JULY 4, 2022

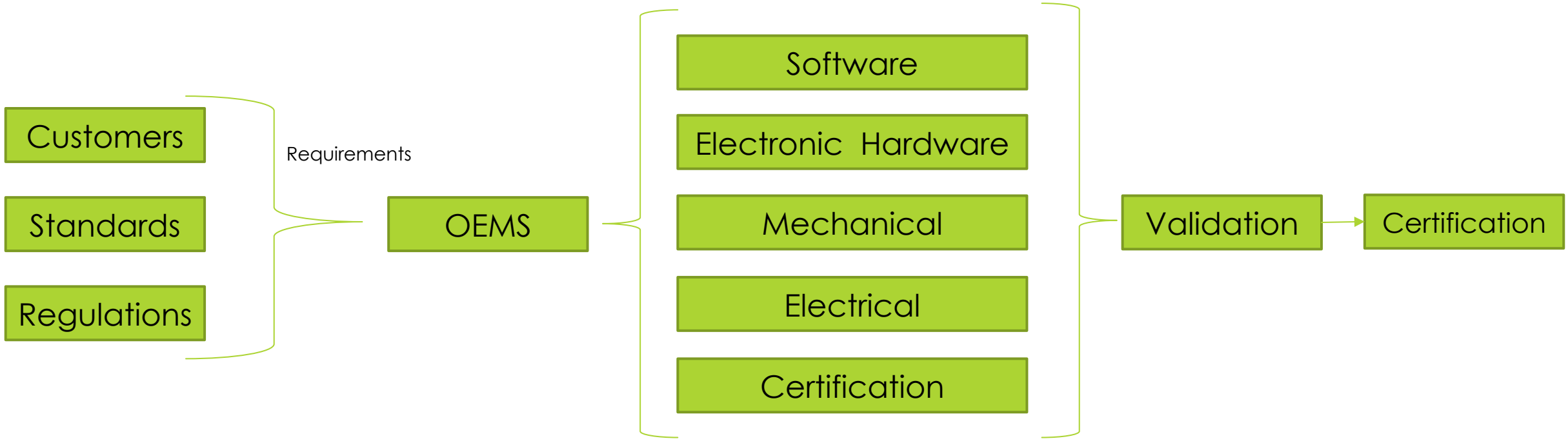
Flex Fuel

- To Be done

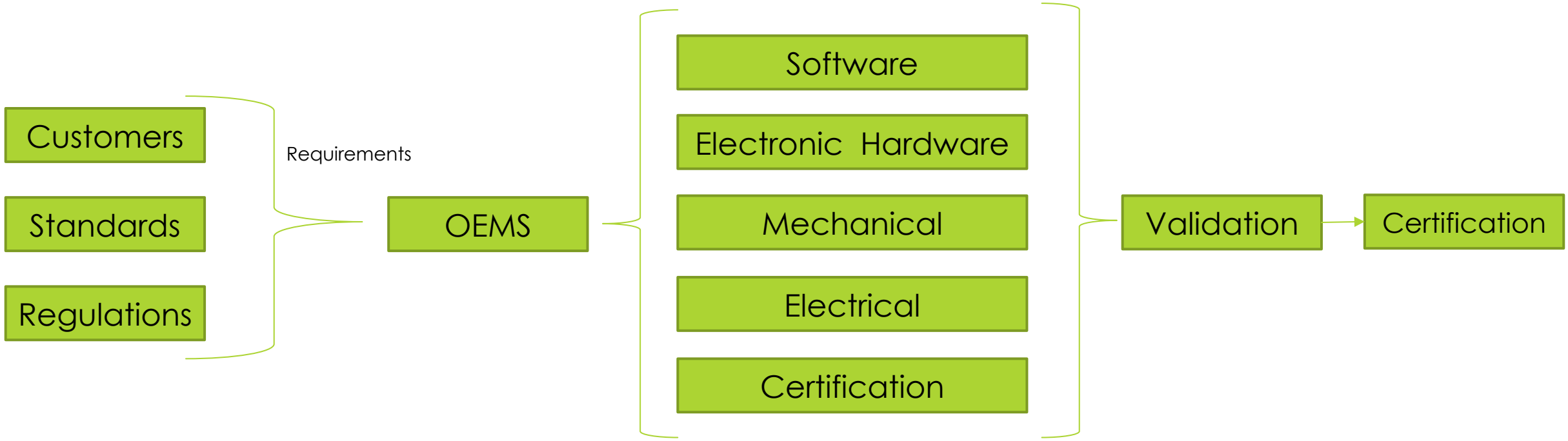
Thank You

Back Up Slides

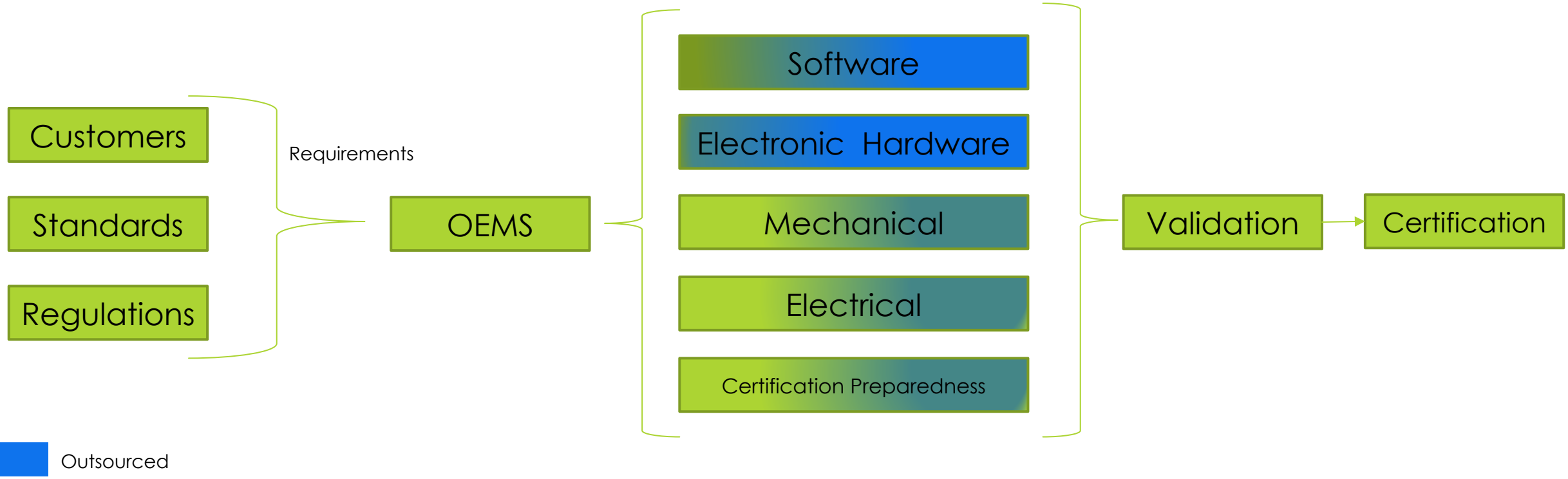
Product development cycle - OEM

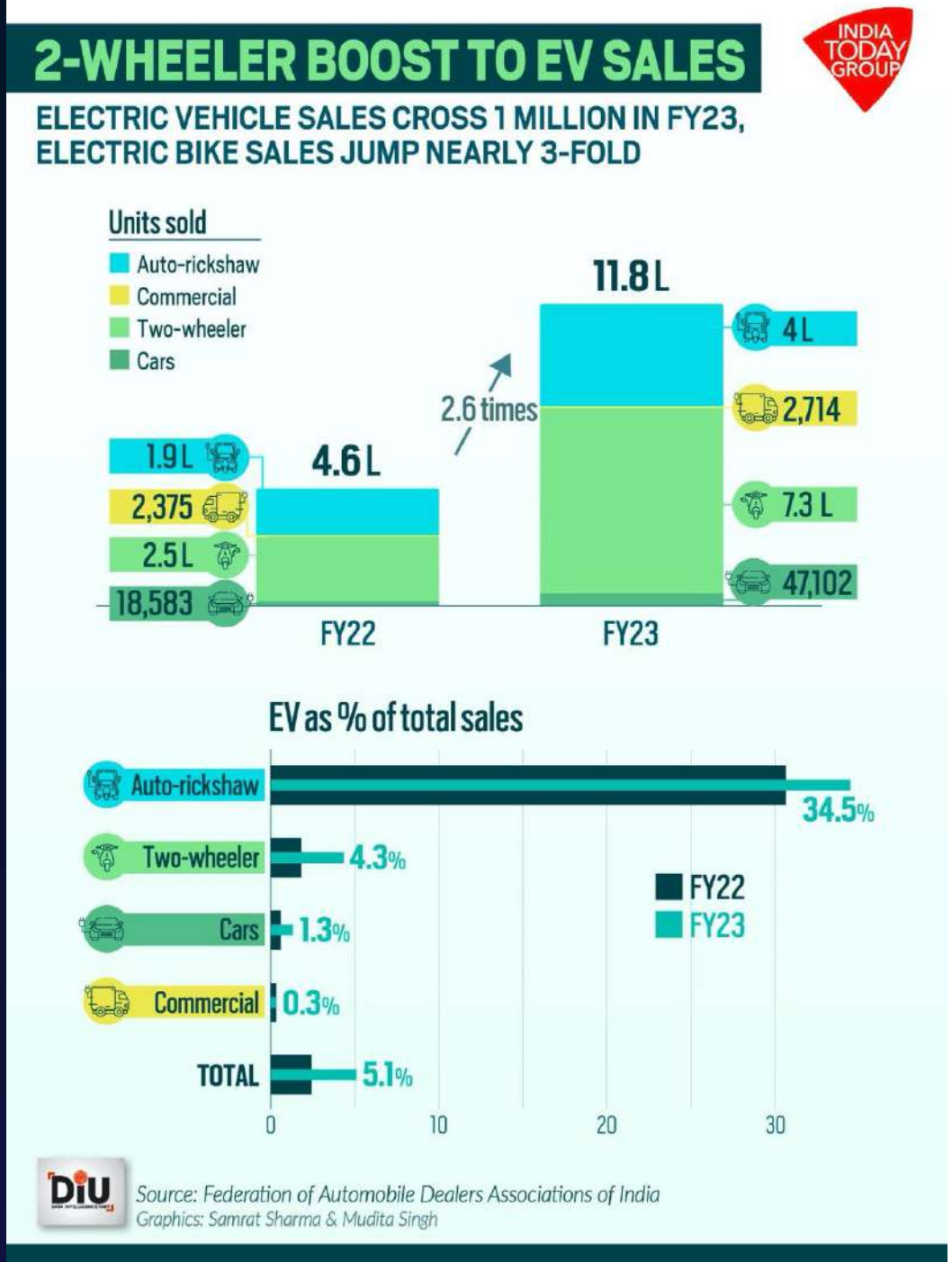


Product development cycle - OEM



Supplier concentration





With EV and ride sharing, is the auto sector cyclical any more?

Observed Macro Trends - OEMS

- OEMs are getting more vertically integrated
  - Differentiation is done in terms of luxury, branding, personalization, safety.
  - The low segment EVs are becoming more commoditized.
  - Lower barriers to entry.
- Tier-1s and Tier-2s are losing margins or facing existential risks
- Newer companies are entering the value chain (Think Batteries, induction motors)

Terminology

- BEV – Battery Electric Vehicles
- PHEV – Plug in Hybrid Electric Vehicles (large battery + IC engine, needs charging)
- MHEV – Mild Hybrid Electric Vehicle (battery + IC , no charging needed)
- Rolling Chassis / Skateboard – Only the powertrain is provided

Infrastructure

- More power available in car 0.5 kWh →100 kWh leading to quicker addition of SW / HW etc.

EV charging Franchise

- Approximate profit of 3 rupees per unit. Monthly estimate 90K @ 3 charging unit
- Charging a Nexon – 90 rupees for full charge + additional services like washing, food
- Cost of installation of charger – 13-15 lakhs (50% subsidy present for dc fast charging)
- 2 manpower needed