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JUNE 2022 | MAGAZINE

WHAT'S INSIDE

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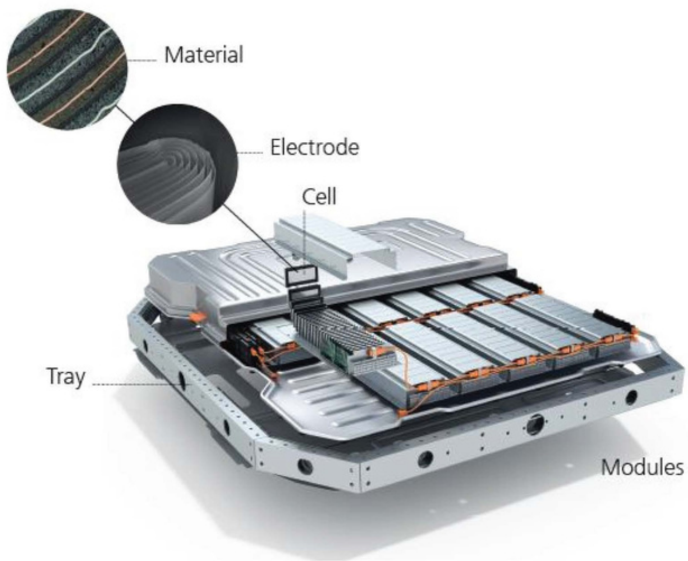
EV Component Inspection Services

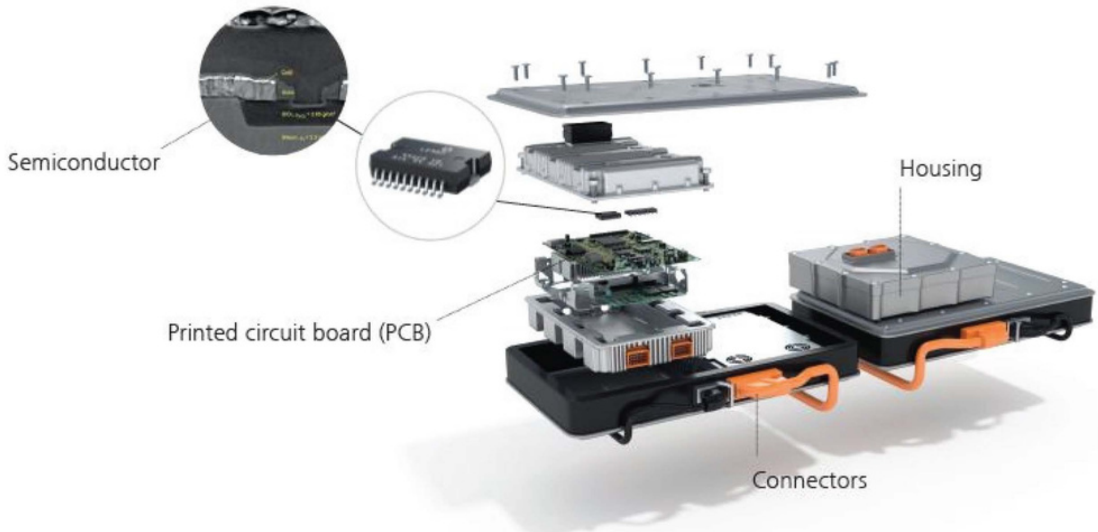
ZEISS

Seeing beyond

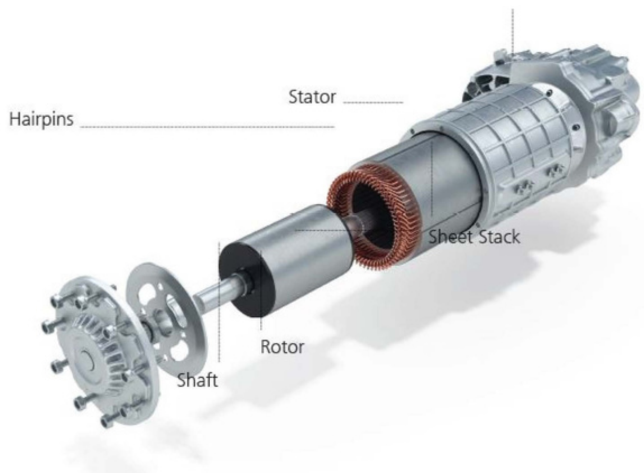
For Battery Tray and Cell Inspection



For Power Electronics



For Electric Motor



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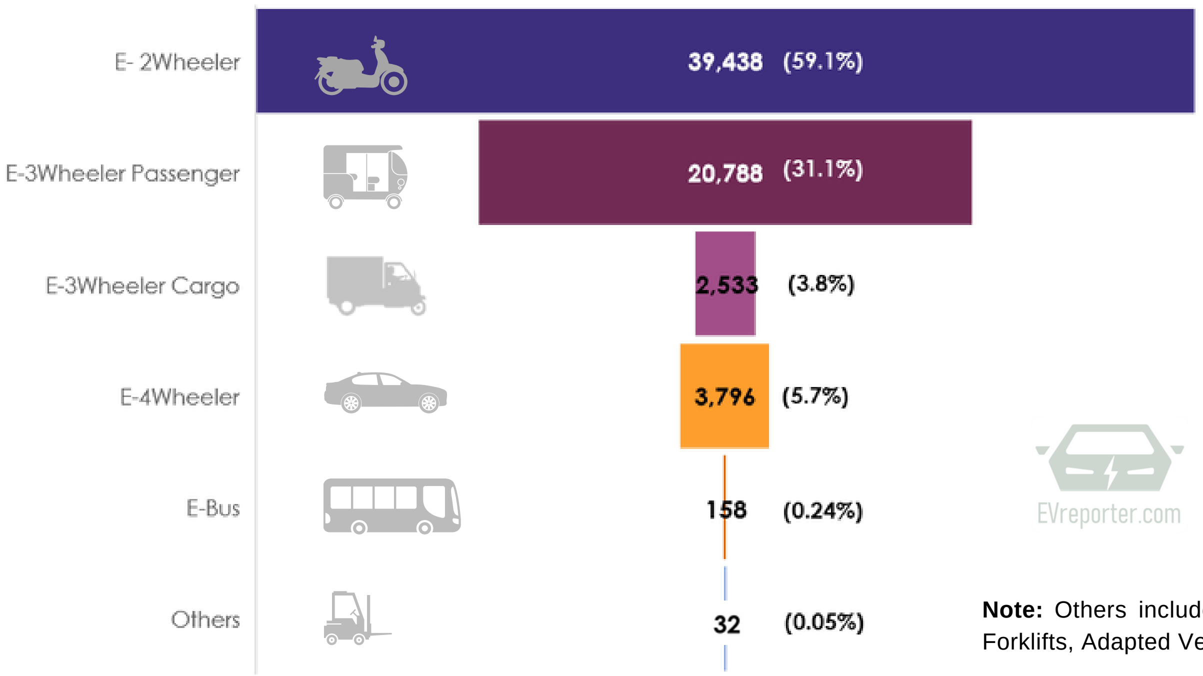
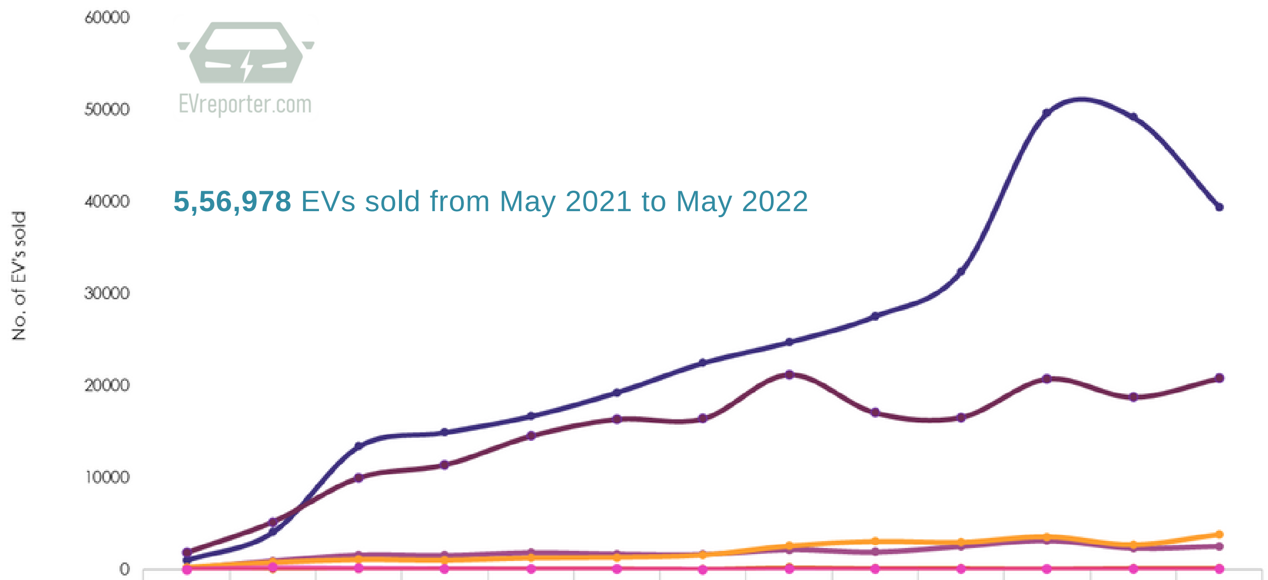
Category-wise Electric Vehicle sales, May 2022

Total Registered Electric Vehicle Sales - **May '22 - 66,745** | Apr '22 - 73,093



Note: Others include Tractors, Forklifts, Adapted Vehicles, etc.

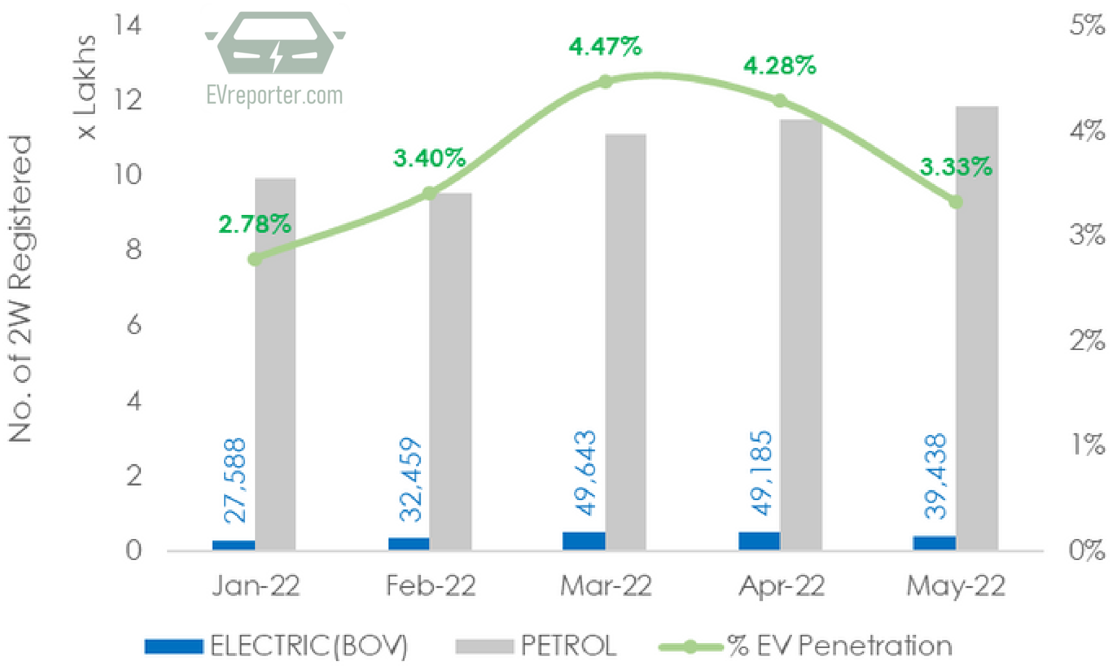
Category wise-Sales Trend from May 2021 to May 2022



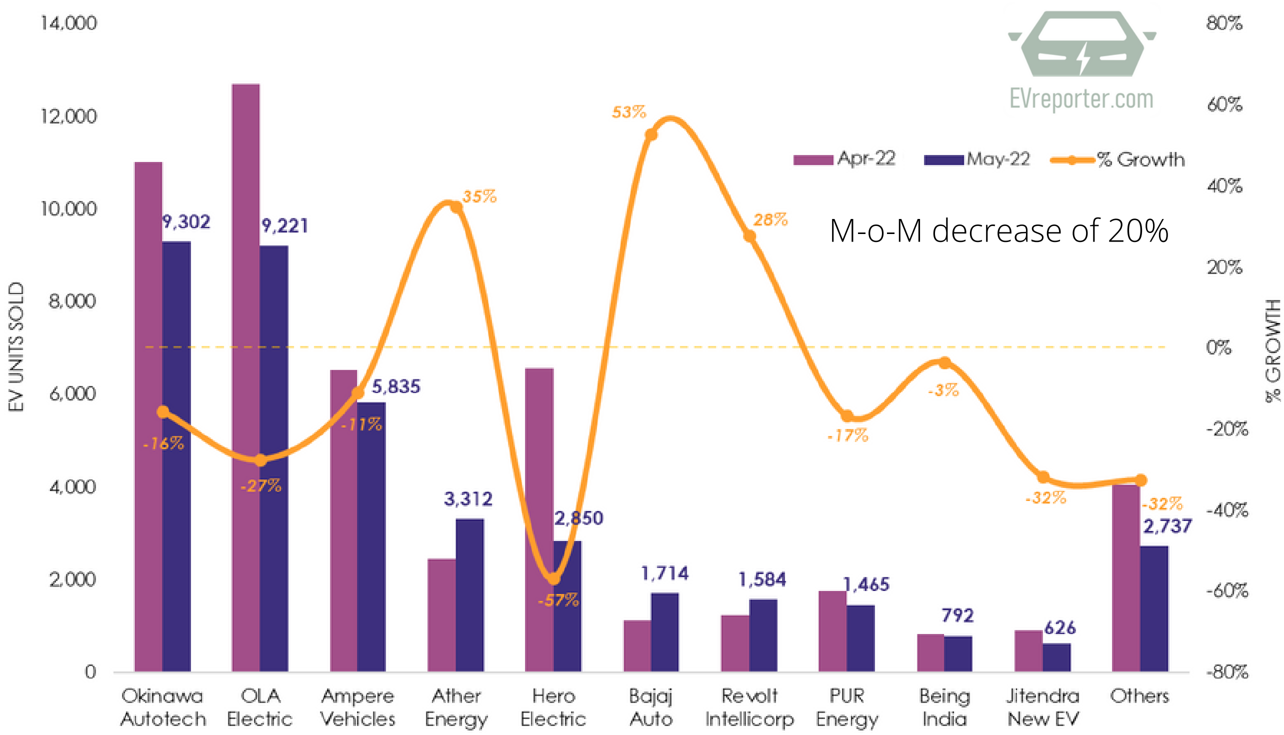
	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22
2W	1040	4073	13389	14911	16672	19264	22474	24732	27555	32416	49642	49182	39438
3W Passenger	1805	5147	9962	11366	14505	16340	16383	21208	17039	16540	20731	18735	20788
3W Cargo	139	923	1582	1519	1825	1671	1632	2162	1893	2509	3146	2318	2533
4W	241	766	1063	999	1250	1320	1559	2548	3.020	2933	3.545	2668	3796
e-Bus	84	70	44	80	79	84	34	221	126	133	76	164	158
Others	2	219	142	86	47	43	18	25	27	21	29	26	32
	3311	**11198**	**26181**	**28961**	**34379**	**38722**	**42108**	**50899**	**49660**	**54552**	**77169**	**73093**	**66745**

Source: Vahan Dashboard. Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs

Fuel wise 2-Wheeler Sales Trend, Jan to May 2022

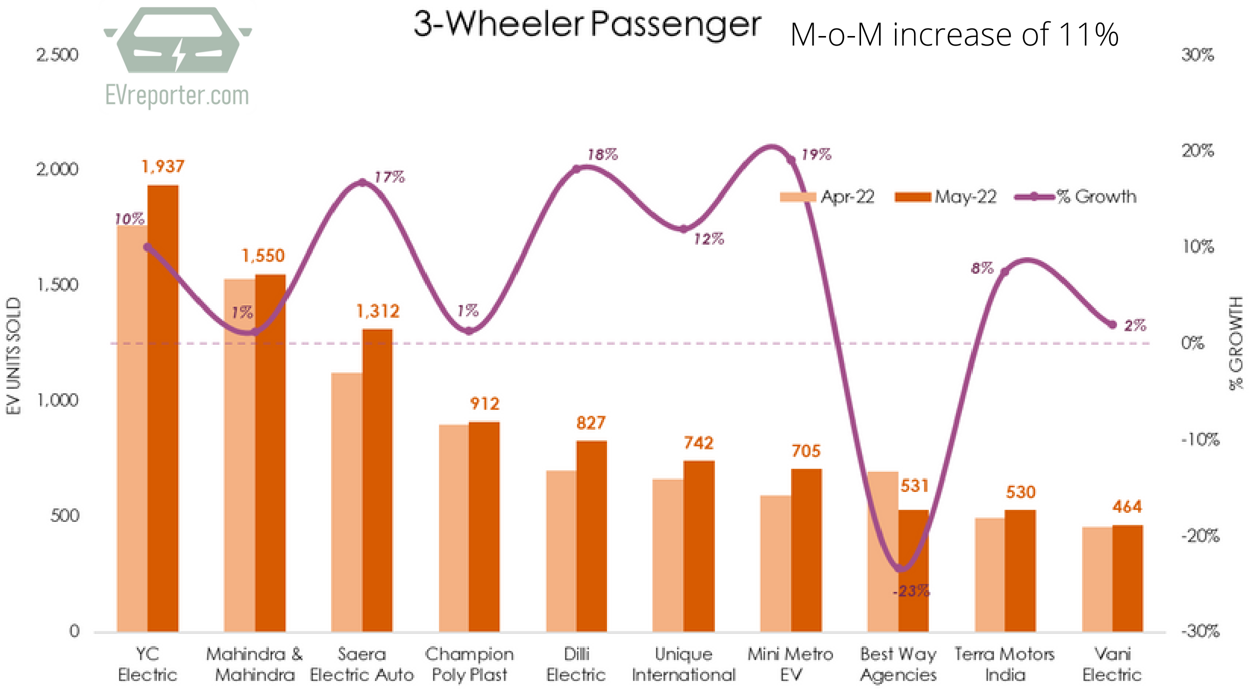


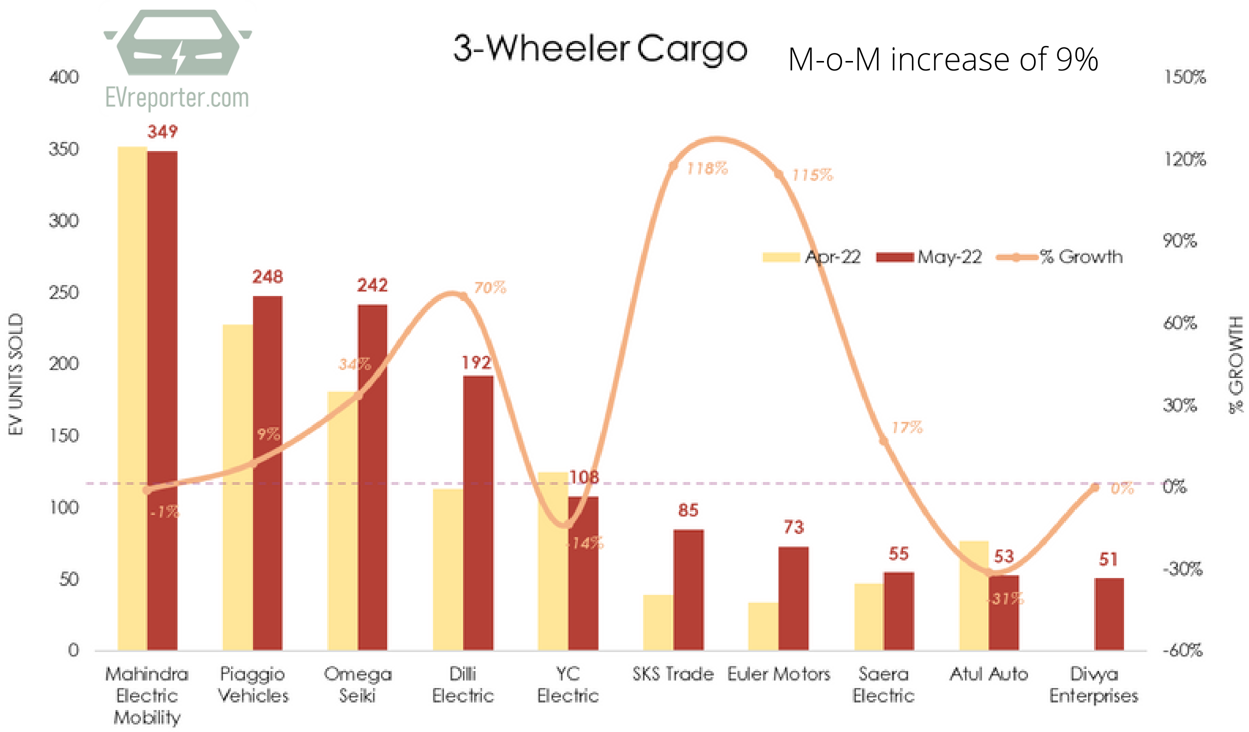
High Speed E - 2W Sales Trend by OEM, May 2022



Source: Vahan Dashboard. Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs
Note: Low speed Electric 2 Wheelers data is not included

Electric 3 Wheeler Sales Trend by OEM, May 2022





For E-3W Passenger and Cargo vehicles, the top 10 OEMs contributed only 46% and 57% of the sales respectively, in May 2022.

Source: Vahan Dashboard. Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs. The aim of these graphs is to represent an overall trend of the new EV registrations in India.

Manufacturer-wise Electric 4W Sales - May 2022

	OEM Manufacturers	April	May	Difference	% Change	% Market Share May 2022
1	Tata Motors	2322	3454	1132	49%	91%
2	MG Motors	245	233	-12	-5%	6%
3	Hyundai	21	40	19	90%	1%
4	BYD	23	26	3	13%	1%
5	BMW	17	9	-8	-47%	0.24%
6	Mahindra & Mahindra	13	9	-4	-31%	0.24%
7	Audi	8	8	0	0%	0.21%
8	Others	19	17	-2	-11%	0.45%
	Total	**2668**	**3796**	**1128**	**42%**	100%

Others include Mercedes, JLR, Porsche, etc.

Source: Vahan Dashboard, Company press releases.
Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs.

Manufacturer-wise Electric Bus Sales - May 2022

	OEM Manufacturers	April	May	Difference	% Change	% Market Share May 2022
1	Olectra Greentech	30	61	31	103%	30%
2	JBM Auto Limited	49	50	1	2%	29%
3	PMI Electro Mobility	47	27	-20	-43%	23%
4	Tata Motors	38	18	-20	-53%	18%
5	Mytrah Mobility	0	2	2	0%	2%
	Total	**76**	**164**	88	116%	100%

Source: Vahan Dashboard. Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs.

ABOUT CHARGE+ZONE

CHARGE+ZONE is building Electric Vehicle Charging Service Infrastructure globally integrated with its indigenously developed IoT based Charging Station Management System (CSMS) & Mobile Application. The company was incorporated in July 2018 and has made strides by installing more than 750+ charging points across India as of March 2021.

CHARGE+ZONE™
AN EV CHARGING COMPANY

SPECIFICATION

Video Wall, 7.7kW AC Type 2 Dual Gun Charger

- **Input:** 415V AC 3 Phase, 32A Max., 50 Hz
- **Number Outputs / Guns:** 2 Each Output connector rating : 240V AC, 32AMx, 50 Hz
- **Output Power:** 7.7 KW x 2
- **Output connector type:** IE C62196 - 2 Type 2 Plug, 5m cable
- **Protection:** Over Voltage, UnderVoltage, Over Current, Residual Current, Short Circuit, Over Temperature, Ground Fault, Surge Protection
- **Push Buttons:** Emergency Stop
- **Ambient Temp.:** -25°C to +45°C
- **Humidity:** <95%, Non condensing
- **Altitude:** Up to 2,000m
- **User Interface:** Vertical 55" HD Display, status indicators,
- **User authentication:** QR code / RFID / OTP
- **Communication:** OCPP 1.6J Forced Cooling, Floor Mounting
- **Complies to:** IEC61851-1, IEC61851-21-2
- **Installation:** Semi Outdoor
- **Communication Interface:** Ethernet / Wi-Fi / GSM
- **Mechanical:** 850x2250x300MM (Appx)
- **Ingress protection:** IP54

SPECIFICATION

8" Screen, 7.7kW AC Type 2 Dual Gun Charger

- **Input:** 415V AC 3 Phase, 32A Max., Number of Outputs :2
- **Each Output connector rating:** 240V AC, 32A Max,50 Hz
- **Output Power:** 7.2 KW x 2
- **Output connector type:** IEC 62196-2 Type 2 Plug, 5m cable
- **Protection:** Over Voltage, Under Voltage, Over Current Residual Current, Short Circuit, Over Temperature, Ground
- **Fault Push Buttons**: Emergency Stop
- **Ambient Temp.:** -25°C to +55°C
- **Humidity :** <95%, Non-condensing
- **Altitude :** Upto 2,000 m
- **User Interface:** 8" LCD screen, status indicators, user authentication by QR code/ RFID/ OTP
- **Communication:** OCPP 1.6J Natural Cooling, Floor Mounting
- **Complies to:** IEC61851-1, IEC61851-21-2
- **Communication Interface:** Ethernet/WiFi/ GSM
- **Mechanical:** 350W x 300D x 1525H (**all Dimensions are in MM)
- **Ingress protection:** IP54 50 Hz

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- Measuring Motor Torque Vibrations and Measuring Resolver Rotation Angles
- Performing Layer Short Testing of Motor Windings.
- Measuring Winding Resistance, Measuring Motor Coil Inductance and Measuring Motor Weld Resistance.

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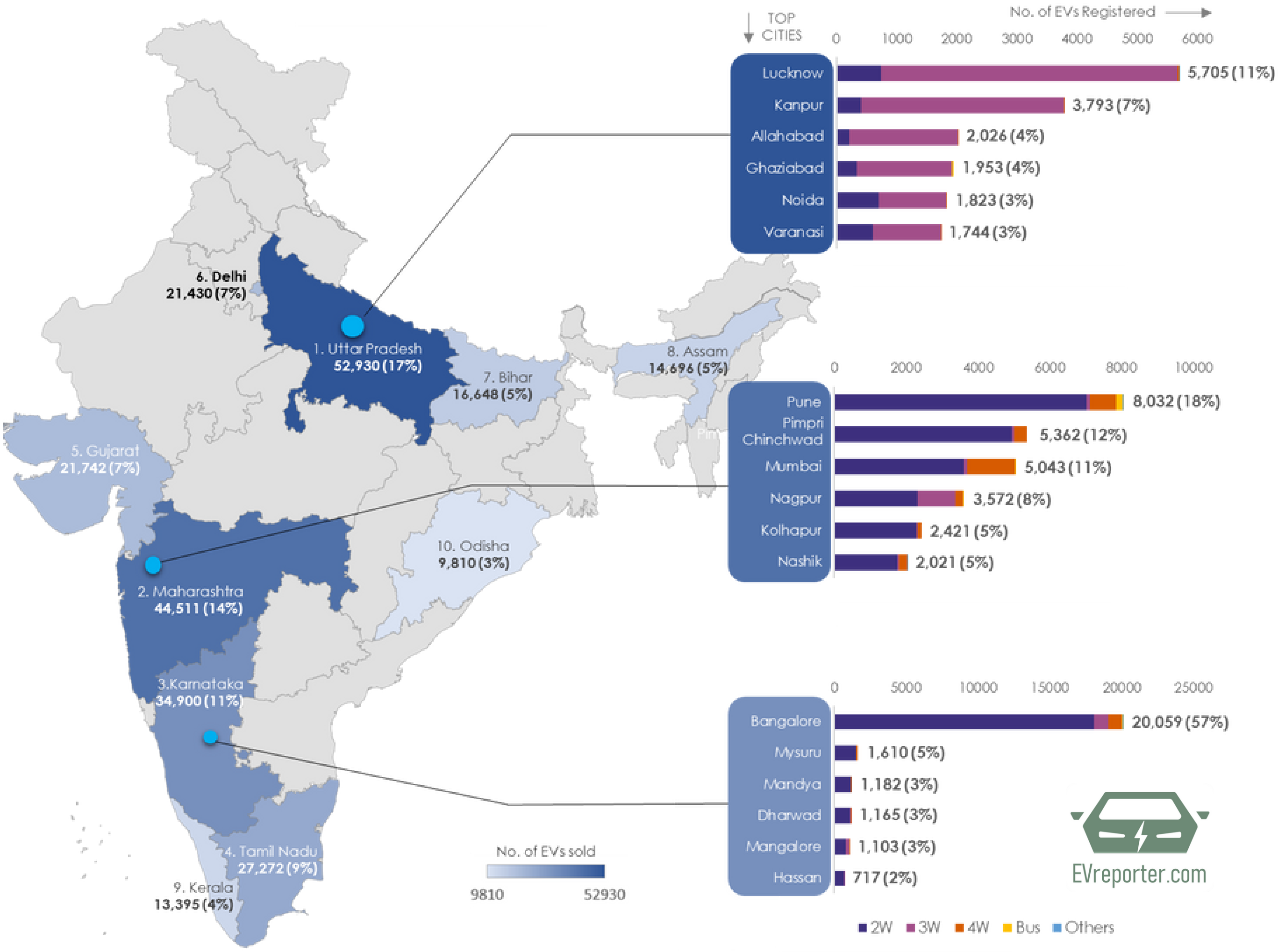
INDIA'S REGION WISE EV MARKET JAN-MAY 2022

Top States and Cities / Urban areas - EV sales from Jan'22 to May'22

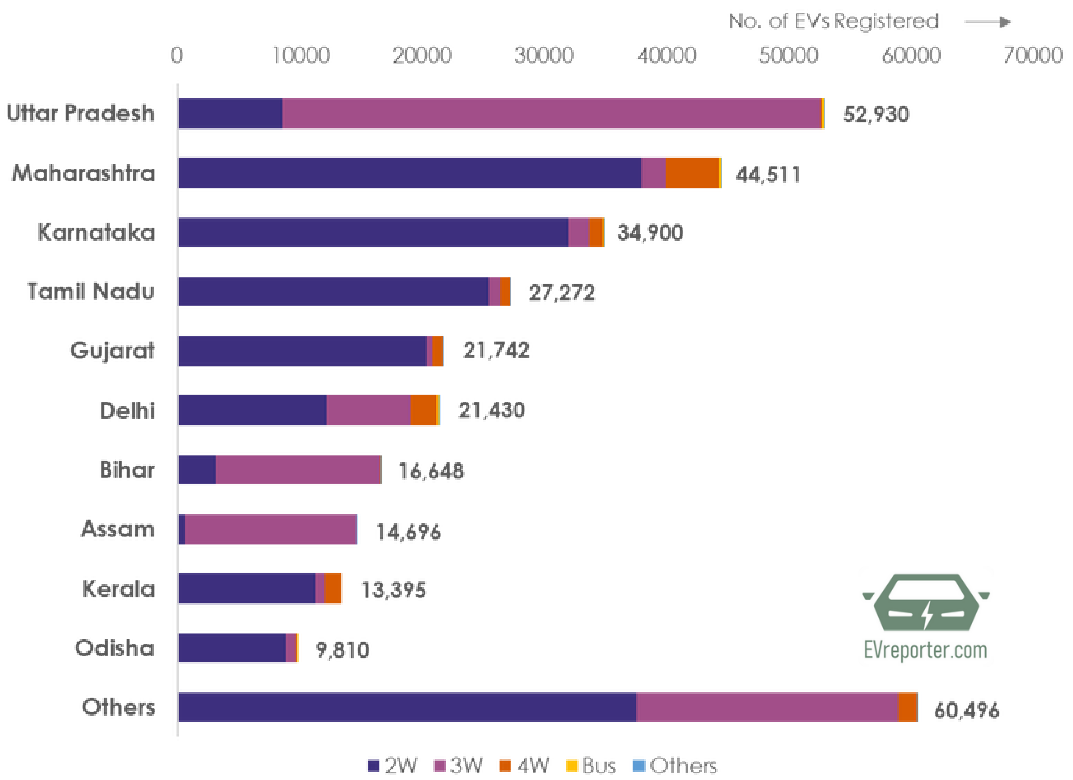


EVreporter analysis. Source: Vahan Dashboard. Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs. Low speed e2W not included. Telangana and Madhya Pradesh data not considered for this analysis.

- From Jan to May 2022, a total of 3,17,830 EVs were sold in India.
- High-speed electric 2Ws accounted for 61% of unit sales, e-3Ws - 33%, and e-4Ws - 4% of all EVs sold in India.
- The top 10 states contribute 81% of EV sales.
- Uttar Pradesh accounted for 17% of the sales with 52,930 units, followed by Maharashtra with 44,511 units (14%) and Karnataka with 34,900 units (11%).
- **Whopping 83% (44,042) of vehicles sold in Uttar Pradesh are e-3Ws, followed by high-speed e-2Ws with 8,586 units (16%).**
- Lucknow recorded the highest EV sales in Uttar Pradesh with 5,705 units followed by Kanpur and Allahabad with 3,793 and 2,026 units respectively, all dominated by e-3Ws.

- **85% (37,962) of EVs sold in Maharashtra are e-2Ws followed by e-4Ws with 4,375 (10%) units. Electric 3-Wheelers in Maharashtra contribute only 4% (1,985) market share.**
- The major City / Urban area that has a major share of EVs in Maharashtra is Pune and Pimpri Chinchwad with a combined share of 13,394 units (30% market share) followed by Mumbai with 5,043 units and Nagpur with 3,572 units.
- **Bangalore City** dominates by EVs sales in Karnataka with the highest market share of 57% (20,059 units) followed by **Mysuru** and **Mandya** with sales of 1,610 and 1,182 units respectively and all **dominated by e-2Ws.**
- Of all the electric vehicles sold in Bangalore, 90% (18,090 units) are 2Wheelers followed by 3Wheelers and 4Wheelers with 969 and 931 units respectively. 65 E-Bus were sold in Bangalore during the time period.

Category-wise EV sales in Indian states from Jan'22 to May'22



Source: Vahan Dashboard. Data as per 1481 out of 1616 RTOs across 34 out of 37 state/UTs

- **Maharashtra, Karnataka and Tamil Nadu** contribute to 48% of all **high-speed e-2Ws** sold from Jan 2022 to May 2022, with individual sales of more than 25,000 units each.
- **Uttar Pradesh, Bihar and Assam** registered the maximum sales in the **e-3W category** with an approximate sales share of 41%, 13% and 13% respectively.
- **Maharashtra** has the highest sales of **e-4W** with 4,375 units (35%) for the time period followed by Delhi and Kerala with 2,110 (17%) and 1,379 (11%) units sold respectively.
- **Uttar Pradesh, Maharashtra and Delhi** have the highest **e-Bus** sales with 197, 186, and 186 units sold respectively from Jan to May 2022.

Tata Motors introduced the new **Nexon EV MAX at INR 17.74 lakh** with a 40.5 kWh lithium-ion battery pack and a range of 437 km. 0 - 100 km/h in under 9 secs. Charging time - 6.5 hours with 7.2 kW AC charger or 0-80% in 56 mins with 50 kW DC fast charger. Battery and motor warranty of 8 years or 1,60,000 km. Vehicle warranty of 3 years or 1,25,000 km

Tata Motors has launched the all-new **Ace EV – the electric version** of its popular Small Commercial Vehicle **TATA Ace intended** to serve a variety of intra-city applications. **Range - 156km, payload capacity of 600kg, cargo volume - 208 ft3. The EV features Tata Motors' EVOGEN powertrain.**

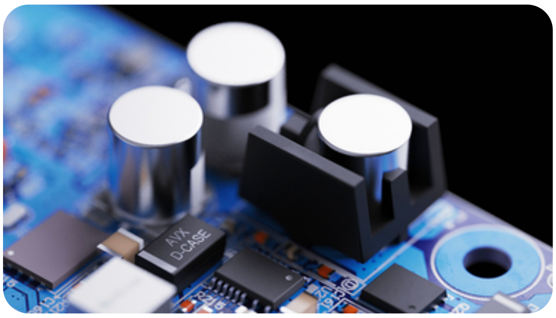
Tata Motors has signed of a strategic MoU with Amazon, BigBasket, City Link, DOT, Flipkart, LetsTransport, MoEVing and Yelo EV, which includes delivering 39,000 units of the vehicle.

Kia EV6 launched in India in two variants - GT RWD (rear-wheel drive) and the AWD (all-wheel drive) version. The AWD version is priced at Rs **64.96 lakh (ex-showroom)**. The EV has been brought to India through the CBU import route and the deliveries will start in Sep 2022. Comes with a 77.5 kWh battery pack and a claimed range of 528 km per charge. 0-100 kmph in 5.2 seconds.

Omega Seiki Mobility launched its electric truck M1KA 3.0. GVW - 5500 kg and Curb Weight - 3055 kg.

The truck comes with a 200 km certified range on a single charge powered by a 96kwh LiFePO4 battery and a 130kW motor. Vehicles are available for customer trials in selected cities.

TVS Motor launched the new TVS iQube Electric scooter in three variants - iQube, iQube S and iQube ST. The top variant iQube ST comes with a range of 140 km and a top speed of 82 kmph. The other two variants go up to 100 km on one charge and have a top speed of 78 kmph. The iQube starts at an on-road price of INR 1,12,230 (in Bangalore) after the FAME subsidy of INR 51,000, exclusive of the charger.



ION Energy's advanced electronics business unit, Maxwell Energy Systems (MESPL), is being acquired by Endurance Technologies Ltd., a leading Tier-1 automotive component manufacturer, **for $40M (INR 308 Crores)** in an all-cash transaction. Founded in 2016, MESPL is a subsidiary of ION Energy Inc and its flagship product is **Battery Management System.**

MESPL has deployed over 65,000 smart BMS in electric vehicles and stationary storage systems and has an active order pipeline of over $19.5 million (INR 150Cr) from OEMs in India & Europe, said a company statement. ION Energy will continue to own and operate its software as a service (SaaS) business – Altergo, an asset management platform for energy storage systems.

Global investor **Abdul Latif Jameel** has committed USD 220 million to Greaves Electric Mobility and **will make an initial investment of USD 150 million [INR 1160 Crores] for a 35.8% stake.** Greaves Electric Mobility manufactures electric 2W under **Ampere Electric Vehicles** and 3W under the brands Ele (e-rickshaw from **Bestway**) and Teja (e-auto from **MRL Auto**). The Jameel family (who own Abdul Latif Jameel) are also the third-largest shareholders of **Rivian**.

The e-mobility division of ABB has agreed to acquire a **controlling stake in Bengaluru based Numocity, a digital platform for electric vehicle charging in India**. ABB will increase its shareholding to a controlling majority of 72 per cent and has the right to become sole owner by 2026. The financial terms of the transaction were not disclosed. ABB had also made an initial investment of 7 per cent as part of seed-stage VC funding of the start-up three years ago.

Ather Energy announced the completion of its **Series E** round of funding with the signing of investment agreements amounting to **$128 million** with National Investment and Infrastructure Fund Limited's (NIIFL) Strategic Opportunities Fund (SOF), and Hero MotoCorp, a significant shareholder of Ather, and additional investors.

Electric ride-hailing platform **BluSmart** has raised $25 million in an extended Series A round ($15 million in equity and $10 million of venture debt). This is a follow-up to the Series A funding round closed in September 2021, bringing the total amount raised in **Series A round to $50.7 million.**

Jindal Mobilitric Private Ltd, a subsidiary of Jindal Worldwide Limited **acquired the Mumbai-based startup Earth Energy EV**. Jindal Mobilitric will set up a manufacturing plant in Ahmedabad which will supplement the existing Earth Energy manufacturing facility in Maharashtra.

IIT GUWAHATI TEAM RECOMMENDS DRIVETRAIN AND BATTERY SIZING FOR E-2W IN INDIA

Need for India specific drive cycle

The primary purpose of any drive cycle is the performance assessment of a vehicle in terms of emissions, fuel consumption, and mileage. Drive cycle patterns are different for different countries. It depends on traffic intensity, road profile, driving skill, and geographical location. India is home to diverse climatic conditions ranging from tropical to monsoon. Moreover, the acceleration and deceleration profiles for standard drive cycles available in the country are soft, which is far from reality as traffic congestion is one of the significant issues in India.

For an efficient and economical design of drive train, heat exchanger, and even for research purposes, there is a dire need for an India-specific drive cycle for different regions based on diverse factors such as rural, urban, tropical, and monsoon conditions.

Key findings of the report

Assuming EV powertrain in place of Internal combustion engines, the performance needs of electric two-wheelers have been studied by the E-Mobility Lab, IIT Guwahati. **The team analyzed different kinds of motors, ways of mounting motors, battery ratings, etc., that our EVs would demand to achieve parity with original vehicles on their respective drive cycles.** Also, parameters such as the presence and absence of a pillion, motor optimization for acceleration figures or everyday driving, etc., were kept in mind. Battery ratings thus obtained were also extrapolated to decent range targets.

The key findings in different aspects such as drive cycle metrics, energy regeneration, fuel consumptions, emissions, Continuous Variable Transmission (CVT), battery ratings, motor ratings, and torque ratings for diverse conditions are as follows.

Drive cycle metrics

Kinetic Intensity (KI) - For Electric Vehicles, higher values of **Kinetic Intensity usually indicate more stop-and-go driving and, therefore, more opportunities for regenerative braking.**

The results show that the Renukoot drive cycle has the higher Kinetic Intensity, followed by Hyderabad Drive Cycle. Hence, a higher regeneration efficiency can be observed in Renukoot and Hyderabad Drive cycles.

Sl.No	Drive Cycle	KI [1/m]
1	Renukoot (U.P)	0.0048
2	Telangana (Hyderabad)	0.0046
3	Guwahati	0.0021
4	WLTC	0.0010
5	MoRTH	0.0024

Relative Positive Acceleration (RPA) - Relative positive acceleration can be used to distinguish between soft driving and harsh driving. **Higher values of RPA generally indicate a harsher driving pattern.**

The Hyderabad drive cycle is dynamic, and the metropolitan characteristics are inferred with a higher RPA value.

Drive Cycle	RPA [m/s^2]
Renukoot (U.P)	0.0384
Telangana (Hyderabad)	0.0828
Guwahati	0.0241
WLTC	0.0099
MoRTH	0.0147

Fuel Consumption and Emissions

Lesser Emissions – Driving Optimized Motor - For any payload (150 kg/ 70kg), a motor optimized for driving would decrease fuel consumption as peak torque requirement would be lower than a motor optimized for acceleration case. This results in lower fuel consumption and lower emissions.

Better Acceleration – Acceleration Optimized Motor - For any payload (150 kg/ 70kg), an acceleration-optimized motor can deliver higher torques to achieve better acceleration performance. However, it will result in higher fuel consumption and higher emissions.

Regenerative Braking

The possibility for good regenerative braking is higher among the drive cycles with more stop-and-go durations. **An efficient regenerative braking system can produce considerable regeneration (around 10-20%) in two-wheelers**.

Drive Cycle	KI [1/m]	Regenerative Braking System Efficiency (%)	
		Payload - 150 kg	Payload - 70 kg
Renukoot (U.P)	0.0048	69.7	73.4
Telangana (Hyderabad)	0.0046	68.9	69.1
Guwahati	0.0021	63.3	67.3
WLTC	0.0010	59.6	58.5
MoRTH	0.0024	68.7	60.1

Drive Cycle	Fuel Consumption Reduction (%)	
	Payload - 150 kg	Payload - 70 kg
Renukoot (U.P)	18.4	19.5
Telangana (Hyderabad)	21.6	17.4
Guwahati	10.5	3.8
WLTC	5.3	9.3
MoRTH	11.2	8.7

- Renukoot and Hyderabad Cycles have higher KI (0.0048 1/m and 0.0046 1/m) with higher regeneration efficiencies (73.4% and 69.1%).
- Around 18-20% improvement in fuel consumption is observed in Hyderabad and Renukoot drive cycles.

CVT Analysis

Improved Efficiency - CVT allows seamless change of gear ratios over a continuous range. In contrast with the traditional gear shifting technique used in two-wheelers, CVT enables the engine/motor to operate at better efficient points. An Optimized CVT ratio would result in higher operating efficiency for the motor's same Power and Torque ratings. 10-15% improvement is observed in operating efficiencies for the proposed rule-based CVT mode.

Sl.No	Drive Cycle	Cyclic Efficiencies Without Optimized CVT		
		IM	PM	SynRel
		%	%	%
1	Renukoot (U.P)	59.8	66.9	65.3
2	Telangana (Hyderabad)	51.6	57.4	56.0
3	Guwahati	48.8	56.4	55.6
4	WLTC	46.3	53.4	53.1
5	MoRTH	60.7	67.7	67.2

Sl.No	Drive Cycle	Cyclic Efficiencies With Optimized CVT		
		IM	PM	SynRel
		%	%	%
1	Renukoot (U.P)	72.2	77.1	75.2
2	Telangana (Hyderabad)	59.8	64.2	62.6
3	Guwahati	65.7	70.6	68.9
4	WLTC	59.8	64.5	63.2
5	MoRTH	73.2	78.1	75.5

Mileage Improvement - With improved efficiency, the fuel consumption would be comparatively lower, resulting in better mileage.

- Guwahati drive cycle experiences the maximum reduction in Fuel Consumption of around 17-25 % in acceleration optimized case and about 11-18 % in driving optimized case for proposed rule-based CVT mode.

- Hyderabad drive cycle has a minimum reduction in Fuel consumption of around 2-8 % in acceleration optimized case and about 1-7 % in driving optimized case for proposed rule-based CVT mode.

Sl.No	Drive Cycle	Fuel Consumption Without Optimized CVT		
		IM	PM	SynRel
		kWh/100km	kWh/100km	kWh/100km
1	Renukoot (U.P)	3.8	3.3	3.4
2	Telangana (Hyderabad)	6.1	5.3	5.5
3	Guwahati	5.2	4.4	4.4
4	WLTC	5.3	4.4	4.5
5	MoRTH	4.1	3.6	3.6

Sl.No	Drive Cycle	Fuel Consumption With Optimized CVT		
		IM	PM	SynRel
		kWh/100km	kWh/100km	kWh/100km
1	Renukoot (U.P)	3.4	3.2	3.2
2	Telangana (Hyderabad)	5.5	5.2	5.3
3	Guwahati	3.9	3.6	3.7
4	WLTC	3.9	3.7	3.8
5	MoRTH	3.2	3.0	3.1

Motor Optimized for Driving				
Sl.No	Drive Cycle	Reduction in Fuel Consumption		
		IM	PM	SynRel
		%	%	%
1	Renukoot (U.P)	9.8	4.8	4.5
2	Telangana (Hyderabad)	6.9	1.7	1.5
3	Guwahati	17.9	12.3	11.1
4	WLTC	16.1	10.0	10.1
5	MoRTH	2.5	2.2	1.8

Motor Optimized for Acceleration			
Drive Cycle	Reduction in Fuel Consumption		
	IM	PM	SynRel
	%	%	%
Renukoot (U.P)	11.1	5.5	5.3
Telangana (Hyderabad)	8.7	2.8	2.7
Guwahati	26.2	18.0	17.4
WLTC	25.3	17.4	16.0
MoRTH	21.4	15.6	12.9

Regeneration with CVT

An intelligently controlled CVT ratio has a higher regenerative braking efficiency than a vehicle with a constant gear ratio. Hyderabad and Renukoot provide the maximum regeneration opportunities with 0.015 kWh/km and 0.009 kWh/km, respectively. Over 27% improvement in fuel consumption is observed in Hyderabad and Renukoot drive cycles for CVT with Regeneration compared to CVT without Regeneration.

Drivetrain and Battery Ratings

Torque requirement for economy mode with reduced acceleration requires a lower peak torque than sports mode acceleration, so the motor's efficiency also increases. Further, lower torque ratings can highly benefit electric bikes to have relatively small motors, which will improve the driving range of the bikes.

For the exact range requirements, the kW ratings of the battery would change based on the type of motor being used. The choice of motors for an optimal battery size for different kinds of two-wheelers considered in this study follows the following order:

PMSM > Sync Rel > IM,

And for hub motors, the order is PMSM Hub > SyncRel Hub > IM Hub

Recommendations on Drivetrain and Battery Sizing

The optimal drive train parameters can be decided depending on vehicle type, expected range, and driving profile. For the analysis purpose, a PMSM motor is chosen. An efficiency of 0.8 at peak torque operating point, converter efficiency of 0.9, and battery utilization factor of 0.8 is considered for the 150 km range requirement.

Commute Scooter Category

a. Motor Output Ratings:

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Motor maximum speed [rad/s]	365.2	365.2
2	Motor base speed [rad/s]	208.7	208.7
3	Peak torque of motor [Nm]	34.2	38.7
4	Rated torque of motor [Nm]	19.0	21.5
5	Rated power of the motor [kW]	4.0	4.5
6	Peak power of the motor [kW]	7.5	8.5

b. Battery Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Battery size [kWh]	8.25	8.30
2	Maximum C-rate	1.2	1.4

c. Converter Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Nominal Voltage [V]	48 / 60 / 72	48 / 60 / 72
2	Peak Power Rating [kW]	9.0	10.0

Sports Bike Category

a. Motor Output Ratings:

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Motor maximum speed [rad/s]	474.8	474.8
2	Motor base speed [rad/s]	271.3	271.3
3	Peak torque of motor [Nm]	27	37.9
4	Rated torque of motor [Nm]	15	21
5	Rated power of the motor [kW]	4.5	6
6	Peak power of the motor [kW]	7.5	10.5

b. Battery Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Battery size [kWh]	5.0	6.0
2	Maximum C-rate	2.0	2.5

c. Converter Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Nominal Voltage [V]	48 / 60 / 72	48 / 60 / 72
2	Peak Power Rating [kW]	9.0	12.5

Mid-Range Bike Category

a. Motor Output Ratings:

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Motor maximum speed [rad/s]	395.8	395.8
2	Motor base speed [rad/s]	247.4	247.4
3	Peak torque of motor [Nm]	32.4	34.7
4	Rated torque of motor [Nm]	18	19.3
5	Rated power of the motor [kW]	4.5	4.8
6	Peak power of the motor [kW]	8	9

b. Battery Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Battery size [kWh]	8.0	8.2
2	Maximum C-rate	1.4	1.5

c. Converter Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Nominal Voltage [V]	48 / 60 / 72	48 / 60 / 72
2	Peak Power Rating [kW]	10.0	10.5

Retro Bike Category

a. Motor Output Ratings:

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Motor maximum speed [rad/s]	273.1	273.1
2	Motor base speed [rad/s]	156.1	156.1
3	Peak torque of motor [Nm]	59.4	97.2
4	Rated torque of motor [Nm]	33	54
5	Rated power of the motor [kW]	5.2	8.4
6	Peak power of the motor [kW]	9.5	15.5

b. Battery Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Battery size [kWh]	8.5	10.0
2	Maximum C-rate	1.5	2.1

c. Converter Ratings

S.No	Parameters	Optimized for Driving	Optimized for Acceleration
1	Nominal Voltage [V]	48 / 60 / 72	48 / 60 / 72
2	Peak Power Rating [kW]	11.0	18.5

Leading Electric 2Ws closest to recommended sizing

As per this analysis, we found that **TVS iQube, Ather 450X, and Bajaj Chetak electric 2-wheelers are the vehicles in the current Indian market which are closest to recommended sizing for their respective categories.**

About the author(s)

*We would like to thank **Dr.ing. Praveen Kumar** (Professor - IIT Guwahati) (L) and **Mr Mulpuri L N Sai Krishna** (Research Scholar at EML - IIT Guwahati) (R) for sharing their research findings with our readers. The full report is available with the E-mobility Lab, IIT Guwahati.*

Delhi Government released the operational guidelines for the delivery of **demand incentives for e-cycles**. The incentive on electric cycles is valid for the **first 10,000 electric cycles** (passenger and cargo). E-cycles are eligible for a purchase incentive of 25% of the e-cycle price (not exceeding **INR. 5,500 per vehicle**). An additional INR 2,000 incentive is marked for the first 1,000 individual owners of e-cycles. While E-cargo cycles are eligible for a purchase incentive of 33% of the e-cycle price (not exceeding **INR 15,000 per vehicle**).

E-cargo cycles will also be eligible for a scrapping incentive of up to INR 3000 under the Delhi EV Policy, against the scrapping of old ICE vehicles.

Rajasthan government has approved the State Electric Vehicle Policy and a budget provision of INR 40 crore for SGST reimbursement on the purchase of electric vehicles. The state government has announced to reimburse Rs 5,000 to Rs 10,000 SGST amount for e2Ws and Rs 10,000 to 20,000 for the purchase of e3Ws depending on the battery capacity.

Toyota Kirloskar Motor and **Toyota Kirloskar Auto Parts** have signed an MOU with the **Government of Karnataka** to invest INR 4,800 crores for local production of electric powertrain parts and components.

Tata Passenger Electric Mobility Limited (TPEML) and **Ford India** Private Limited (FIPL) signed an MOU with the **Government of Gujarat** for the **acquisition of Ford's Sanand vehicle manufacturing facility** including Land & Buildings, Vehicle Manufacturing Plant, Machinery and Equipment and transfer of all eligible employees of FIPL Sanand's vehicle manufacturing operations.

FIPL will operate its powertrain manufacturing facilities by leasing back the land and buildings of the Powertrain unit from TPEML. TPEML would invest in new machinery and equipment to make the unit ready for an installed capacity of 300,000 units per annum, which would be scalable to more than 400,000 units. This unit is adjacent to the existing manufacturing facility of Tata Motors Passenger Vehicles Ltd at Sanand.

Hindustan Motors has signed an MoU with a European automobile company for a **joint venture to manufacture EVs**. The plant will come up on HM's 295 acres of land in Uttarpara (West Bengal) at an investment of 400 Cr, reported Business Standard.

LML Electric is looking **to invest Rs 350-crore** in the business, including in setting up a new manufacturing plant. In September 2021, **the company had announced its plans to re-enter the market with electric vehicles**. LML Electric is looking to unveil three EV products—a hyperbike, an e-bike and an electric scooter—by September 2022 and their subsequent launches between February and August 2023.

Three Wheels United (TWU), a fintech startup that provides financing for EVs, **has raised $10 Mn in a Series A round of funding led by Delta Corp Holdings.** Existing investor Techstars, along with new ones such as Grip Invest with a few investors in the Middle East and Europe also participated in the funding round. TMU aims to expand to new geographies within India and abroad.

The electric vehicle manufacturer **HOP Electric Mobility has closed a funding round of USD 2.6 million as part of an ongoing USD 10 million pre-series fundraiser.** The company is gearing up for the commercial production of Hop Oxo, an electric motorbike which is expected to launch in July 2022. Hop Electric is also 1 of the 6 successful applicants in Govt of India's PLI Scheme for the Automobile and Auto Component Industry in India under New Non-Automotive Investor (OEM) category.

Electric mobility platform **MoEVing has raised USD 5 million,** in addition to the seed funding of USD 5 million secured earlier in Dec 2021.

Log9 Mobility, a wholly-owned subsidiary of battery-tech startup Log9 Materials, **announced that it has availed INR 10 crore debt-financing facility from** financing firm **cKers** to accelerate the deployment of EVs integrated with Log9 Material's fast-charging batteries under a Mobility as a Service (MaaS) model.

Mumbai headquartered EV startup **eBikeGo announced the completion of a USD 5-million fund infusion.** The company is now looking to raise USD 25 million more. The fundraise will help the company launch the e-scooter Muvi and trike Velocipado next year. The company has also partnered with Log9 Materials to launch 10-min charging technology for Velocipedo.

Telangana based **E-bike sharing start-up Hala Mobility** raised Rs 6.5 crore in pre-seed funding round led by Magnifiq Securities.

Electric two-wheeler manufacturer company **Revamp Moto has raised $1 million in Pre-seed funding round from Veda VC and Venture Catalysts**. The funding round also saw participation from IDBI Capital, Deven Bhandari and Sharks- Aman Gupta, Anupam Mittal, Ashneer Grover, and Peeyush Bansal. The company plans to use the funds for hiring top talent, product development, and pre-launch partnerships. **Revamp Moto first made headlines during the first season of Shark Tank India, where they raised INR 1 crore from Aman & Anupam.**

Autonomous driving technology start-up **Minus Zero** raises its seed round of **$1.7 million led by Chiratae Ventures**. The round also saw participation from JITO Angel Network, and a stalwart profile of angels including senior leaders from NVIDIA AV Team and **Lyft** based out of Silicon Valley among several others.

EV CHARGER MANUFACTURING IN INDIA - CHALLENGES & OPPORTUNITES

Pune based Electrical and Electronics manufacturer **Ador Digatron** makes ARAI approved EV fast chargers (60KW and 120KW) and plans to launch a 30KW single gun variant and a 180KW hyper charger product line this year. Team EVreporter interacted with **Ravin Mirchandani** to better understand the EV charger manufacturing space.

What is your analysis of the current EV charger market in India?

Many sectors are evolving within this market – AC chargers, DC chargers, government tenders and the growing Charge Point Operator (CPO) market. It would be fair to say that all of these sectors are growing rapidly.

- AC chargers serve destination, office and home charge markets and will proliferate in millions soon in India.
- DC fast chargers typically address the fleet and long-distance drive market. This segment will grow over time as cities electrify public transport and more options become available for buyers of electric cars for long-distance driving.

Please tell us about Ador Digatron's approach to manufacturing chargers.

In 2018 when we first set out to make fast chargers in India, we tried to license overseas technology from Europe and experienced severe reticence to license to an Indian company. However, today we consider that these European companies did us a big favour as we went ahead and instead designed India’s first truly atmanirbhar fast charger.

Our analysis demonstrated that the growth of the electric mobility sector in India is being hampered by not just the lack of charging infrastructure – but the fact that **many of the chargers installed often do not work**. Our focus has been to build a line of relentlessly reliable products, offering our customers a guarantee to bring chargers back in service within 24 hours should they experience any service issues.

Very early in the life of Quench Chargers, we were clear that **we would never be a Charge Point Operator;** our “one thing” is to provide relentlessly reliable chargers to charge point operators who care for quality, resilience, and charger availability. Our role is to facilitate the growth of electric mobility service providers and charge point operators.

Can you share what is your current scale of production and sales?

Our manufacturing capacity is **1,000 fast chargers per month (60/120/180KW)** at the moment, which is adequate for the markets we are addressing in 2022.

What kind of safety mechanisms need to be built in to manufacture reliable chargers?

We designed our chargers on the philosophy of what we call the “4 Fries”:

- the charger should not fry the car
- the car should not fry the charger
- neither the car nor the charger should end up frying the user/human, and finally
- the charger should not fry the grid.

Electricity can hurt someone when the design of power electronics equipment is inherently careless or unsafe. Adequate measures have to be taken for human, EV & EV charger safety by providing **safety for earth leakage, Overload and Short circuit protections, Input under & over voltage protections, Insulation Monitoring, GND fault, Over temperature, Smoke detectors** etc.

Apart from these, the charger needs to be certified as per **IEC 61851 /IS 17017 relevant clauses from a certified agency like ARAI/TUV.**

Can you share what are the main constituent parts of an EVSE unit?

The **heart of the DC Fast charger constitutes the software controller and the DC power converter (rectifier)**. Besides this, there are heavy due electrical components, and safe street furniture design that is not adversely impacted by severe dust or weather conditions such as flooding.

As charger capacities go beyond 180KW, one must also consider thermal management of the housing and liquid cooling of cables, where things start to get interesting.

For making the EV chargers in India, what are your current import dependencies?

Certain parts of the EV value chain just do not exist in India today. For example, even **fast charging cables and CCS2 connectors presently need to be imported** until local supply partners can be developed to provide adequate quality supplies.

What are the other frequently encountered manufacturing challenges?

Manufacturing was always a complex endeavour, given the many moving parts within a design BoM that need to be managed for a product to be ready for delivery. The present dynamic or collapsing supply chain environment has seen many companies sleepwalk into a supply chain crisis. Today, our challenges **include ensuring the availability of all the constituents of our fast chargers (which is increasingly starting to prove difficult**) whilst also ensuring the quality of supplies. Our intent is to source 100% of our components from India, and this entails facilitating the building of the entire EVSE ecosystem in India.

Please tell us about your export capabilities and focus.

We have already **exported the first Quench units to the UAE and southern Europe.** We are excited to be exporting reliable EVSE products from India **rather than importing for trade sales into India, as usually is the case**. Our intent has been to provide European quality at a price point that creates value for our customers; consequently, we don't envisage our exports to be limited to any regions in particular.

You mentioned that sub-standard products in the EV charging space could ruin the market. What are your recommendations to ensure we do not go the solar route?

China will always be able to provide cheaper electrical and power electronics products than India because of the sheer scale of manufacturing that exists there. Most Chinese plants can make in a week what plants in India will manufacture in a year – so the economies of scale they have over India are significant. Then there is the higher cost of inefficiencies in India that result from us not being so high up on the scale of ease of doing business. We are forced to accept many costs in India that are just not levied on Chinese exporters. So **a level playing field does not exist.** At the same time, we don't want to go back to being a protected licence raj, which will inevitably facilitate poor local production. Instead, we have to have a more nuanced approach that rewards the products which are reliable, support the local economy and are built for the local conditions.

To build a sustainable ecosystem from EVSE design and manufacturing in India, the buying policies of both government and private buyers **cannot continue to be a digital zero/one game based on price**. We have to collectively evolve the maturity in the buying process, and recognise whole of life cost, MTBF (mean time between failures) rates, charger design resilience and operating reliability. I am **not advocating quotas to "buy Indian", but a procurement grading system that recognises quality and rewards performance.**

Can you comment on the need for building advanced features such as load balancing capabilities in the EVSEs at this point?

Load balancing or dynamic allocation of power to various EVs at a charger/or charging station as vehicles turn up to charge, has just started its evolution in Europe. It is a more recent innovation that allows a charger to allocate power to 2 or 3 vehicles and works very well in environments where there is a sizeable population of EVs. Essentially, the charger controller splits power dynamically between guns on one charger. As the demand for power from the first car's BMS starts to reduce, the charger gradually increases the power supply to the other waiting vehicle/s.

There is a cost for such features. The question for infrastructure service providers, CPOs and EMSPs (electric mobility service providers) is – when the right time is to include such a feature on charging networks in India? **Eventually, all charging stations globally will have to be capable of dynamically allocating power to vehicles.**

EVSE utilization is a concern, specifically for the personal vehicle segment. In your opinion, how can the profitability of running an EV charging business be improved?

Some CPOs/EMSPs prefer to wait for the demand base to build before investing in charging infrastructure, whilst other companies prefer to facilitate the demand by investing ahead of actual demand. **The latter will experience low daily utilisation likely until 2024** when the first Giga factories will come on stream in India, greatly impacting the economics of E-Mobility in India. 2024 is also the year we will witness a plethora of EV launches in the country at affordable price points.

Consequently, the utilisation of chargers will increase over a 3 year period exponentially. CPOs aggressively investing in charging infra today will likely have a head start resulting in greater premiums during the early years and a more loyal & sticky customer base as competition in the sector heats up.

So there is a **trade-off** to consider here. **Invest aggressively early and absorb low utilisation in the early years,** so that you have loyal customers when the competition heats up OR **wait for demand to be evident and invest then in a more crowded market** where differentiation is hard to achieve and most companies will rely on pricing as their advantage.

Mahindra Group has tied up with Volkswagen to equip its electric cars with **electric motors, battery system components and battery cells from Volkswagen AG's MEB platform**. Volkswagen will deliver major e-components to Mahindra and also assess the potential to jointly localize these components for local market needs.

The Italian manufacturer of street legal and off-road electric motorcycles **TACITA SRL** and **OKINAWA Autotech** Pvt. Ltd will create a new company based in India, that will start manufacturing what is being described as the "Platform 11" in 2023. Tacita will provide the design support for the vehicle and the teams will jointly work on the powertrain components for performance 2Ws to be launched starting next year.

Sona BLW Precision Forgings has partnered with US-based **C-Motive Technologies** to develop electrostatic drive motors for electric vehicle applications, for which serial production will likely start in 2026. Wisconsin-based C-Motive Technologies has developed the world's first commercially viable electrostatic motor. As part of the tie-up, Sona BLW will participate in C-Motive's latest financing round.

Sona BLW will invest about $130 million over next three years towards its electrification push.

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MG Motor India and **Castrol India** are set to collaborate with **Jio-bp to explore mobility solutions for electric cars**. The companies will explore setting up four-wheeler EV charging infrastructure and expand **Castrol's existing auto service network to cater to EV Customers.**

SUN Mobility has announced its partnership with **Greaves Cotton Limited** to deploy swappable EV batteries. Greaves Electric Mobility aims to use the infrastructure and battery for both electric two-wheelers and three-wheelers. According to SUN Mobility, its Quick Interchange Station network, which is spread across 14 cities.

Bounce Infinity announced a partnership with **Bharat Petroleum Corporation Limited, to provide EV battery swapping facility at every Bharat Petroleum station.** This partnership focuses on urban markets and complements BPCL's overall EV charging roadmap of setting up fast-charging corridors across major highways in the country.

AsahiKASEI

XYRON™
mPPE Lightweight Material for Battery Applications

Application possibilities with XYRON™

Application Areas

- Automotive industry
  (relay block, structural parts of lithium-ion batteries)
- Energy industry
  (photovoltaic junction box, connectors)
- Other industries (water-related applications)

Properties	Unit	Method	PP/PPE	PS/PPE			
			TF701	340Z	540Z	443Z	G601Z
Specific Gravity	g/cm^3	ISO 1183	1.08	1.08	1.08	1.10	1.17
Tensile Strength	MPa	ISO 527	48	55	69	62	84
Tensile Elongation	%	ISO 527	12	14	12	14	4
Flexural Strength	MPa	ISO 178	70	90	107	96	136
Flexural Modulus	MPa	ISO 178	2300	2400	2500	2200	3700
Charpy Impact Strength (Notched)	kJ/m^2	ISO 179	5	15	19	42	10
Deflection temperature under load (DTUL)	°C	ISO 75 (1.8 MPa)	108	96	112	108	118
Flammability	-	UL 94	V0	V0	V0	V0	V0
CTI	-	UL 746A	-	PLC 3	PLC 0	PLC 0	-
RTI	°C	UL 746B	65/65/65	105/105/105	110/105/110	105/105/105	50/50/50

Properties of various XYRON™ grades

XYRON™ (modified polyphenylene ether or mPPE) is an engineering plastic with unique properties due to various possible alloy combinations of PPE with polystyrene (PS), polyamide (PA), polypropylene (PP), polyphenylene sulfide (PPS) or other polymeric materials.

XYRON™ PS/PPE features excellent dimensional stability, electrical properties and is suitable for PV junction boxes and connectors, contributing to downsizing.

XYRON™ PP/PPE has a low density and also electrolyte solvent resistance. This feature makes it suitable for lightweight automotive battery parts.

Key Properties

- Use of Halogen-free flame retardants
  (UL94 V-0 to HB)
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- Low density
- Excellent dimensional stability
  – low mold shrinkage
- Low water absorption
- High resistance to acids and alkalis
- Excellent electrical properties

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Switch Mobility, the EV arm of Ashok Leyland, **will invest INR 1,000 cr in a dedicated EV plant, likely on the outskirts of Chennai**, to manufacture E-LCVs and Electric buses. The plan is to set up 30,000 units of E-LCV capacity and 10,000 units of electric buses, reports Economic Times.

E-bus manufacturer Olectra Greentech, part of the Hyderabad headquartered Megha Engineering and Infrastructures Ltd, has announced securing the **order for 2,100 e-buses from Bhrihanmumbai Electric Supply and Transport (BEST)** worth Rs 3,675 crore. Evey Trans Private Ltd (EVEY), an arm of Olectra, has obtained the letter of award from BEST after being declared as an L1 bidder. The order is to supply e-buses on the Gross Cost Contract/Opex model for a period of **12 years**.

e-bus maker **PMI Electro** announced that it is setting up a commercial vehicle manufacturing plant in Pune and the facility will commence commercial production by October 2023. The facility will annually produce 2,500 electric CVs in multiple variants and electric trucks. Incorporated in 2017, PMI also operates a manufacturing facility in Delhi NCR with a production capacity of about 1500 electric buses per annum.

Tata Motors Limited has incorporated a wholly-owned subsidiary, viz., 'TML Smart City Mobility Solutions Limited' for undertaking urban mass mobility business under an own, operate and maintain model. The company intends to bring specific focus to its EV segment as a service offering across its portfolio of commercial vehicles.

TATA Motors has nearly 650 EV buses plying on roads across various cities in India and has operationalized 250+ EV buses in FY22. In addition to existing State Transport Units (STUs) and government fleets, TSCMSL will also cater to business opportunities across passenger mobility applications, said a company statement.

French automaker **Citroen has announced that it will introduce a low-cost compact electric car first, followed by other EVs in the Indian market starting from 2023.**

Tata Power will install its EZ Charge fast chargers (DC 60 kW) at **Hyundai Motor India Limited (HMIL)'s** existing 34 EV dealer locations across 29 cities along with supply, installation, and commissioning of home charging for HMIL's EV customers.

Currently, all 34 HMIL dealer locations are equipped with AC 7.2 kW chargers, and the company aims to expand the fast charging network across its pan India dealerships.

Greta Electric Scooters launched Harper ZX Series-I. The customers can choose Battery and Charger in line with their usage. The base price (ex-showroom) of Greta Harper ZX Series-I will be ₹41,999. The batteries can be chosen from:

- V2 48v-24Ah for 60 km range (₹17,000 - ₹20,000)
- V3 48v-30Ah for 100 km range (₹22,000 - ₹25,000)
- V2+60v-24Ah for 60 km range (₹21,000 - ₹24,000)
- V3+60v-30Ah for 100 km range (₹27,000 - ₹ 31,000)

The price of the Charger would range from ₹ 3000 to ₹ 5000. The company also announced the opening of a new manufacturing facility at Faridabad with an annual production capacity of 30,000 units.

Hero Electric has partnered with digital consumer lending platform **RevFin** to provide loans to EV riders across the country. The partnership aims to finance and lease 2.5 lakh vehicles over the next three years.

Mahindra Electric Mobility has partnered with Delhi based Terrago Logistics. Terrago currently has a fleet of 65 Mahindra Treo Zor cargo vehicles deployed in 3 cities with Big Basket and Porter. In the coming months, Mahindra Electric will supply additional EVs to Terrago for its fleet expansion.

Indian global automotive components manufacturer **Advik Hi-Tech announced that it has signed a Joint Venture with Australian clean energy Company Pure Hydrogen Corporation Limited** to establish a hydrogen production facility in India, which intends to sell, transport, and distribute hydrogen across India. The company will also be in a position to supply HFCEV buses and trucks. The JV will see Advik hold a 51% share with Pure Hydrogen holding a 49% share.

The company also entered into a Technology Licensing agreement with Spanish Firm Entecnia'. With Entecnia's patented technology in electric vacuum pumps and ADVIK's manufacturing capabilities, the product will cater to electric vehicles & internal combustion engines for automotive applications.

ADVIK
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Badve Engineering Ltd, a Tier-1 automotive manufacturing company, has signed a commercial agreement with **Israel's EVR Motors** to manufacture **patented EV motors (Trapezoidal Stator – RFPM electric motors)** for Indian and International markets.

Continental has launched two new sensors for EVs: the Current Sensor Module (CSM) and the Battery Impact Detection (BID) system. A company statement said that the high-voltage CSM provides the current and temperature information to keep the battery safe and ensure long-term durability. The BID system saves up to 50 per cent of weight in electric cars and provides underfloor protection at the same time, compared to current metal underfloor protection.

UNDERSTANDING FACTORS THAT IMPACT THE CYCLE LIFE OF A LITHIUM-ION CELL

It is important to know how to deal with imported Lithium-ion cells that are assembled in a battery pack. One of the major characteristics of Lithium-ion cells is **irreversible capacity fade, which decides the cycle life of Lithium-ion cells**.

The cycle life of a cell is defined as the number of charge-discharge cycles the cell undergoes at a particular (DoD) depth of discharge until the battery has degraded to a specific capacity compared to its original capacity. At this point, the cell is considered to have reached end-of-life (EOL) for the application where it is being used. It is a matter of time before the cell will fail if it continues to be used in the same application. ***This is a concern in electric vehicles and other applications where the cells are fast charged and discharged at high power.***

When it comes to Lithium-ion cells, there are a few factors that decide their cycle life. Let's discuss the two major factors that have an adverse effect on the cycle life of Lithium-ion cells and lead to cell failures.

1. Temperature can be categorised as storage temperature and operating temperature.

a) Storage Temperature

Since India does not mass manufacture Lithium-ion cells as of today, the cells are imported. The **import time by sea freight varies between 15 to 35 days** depending on the port of loading, port of unloading, vessel availability and whether it is LCL (less than container load) or FCL (full container load). Not to forget that Lithium-ion cells come under DG (dangerous category) shipment category. If we observe the datasheet of most Lithium-ion cells, we can see that they **can be stored up to 45°C in the first three months after production**. One can safely assume that during the first three months, the cells go through storage in the factory, sea freight to India, and reach the battery pack manufacturer's facility by road. What is the storage temperature after 3 months? The temperature **should not exceed 35°C for more than 3 months and up to 6 months of storage.** Provided battery pack manufacturers store the cells at room temperature with decent air ventilation; it does not exceed 35°C.

The major temperature challenge comes when the cells are stored for **more than 6 months of production. At this point, the temperature should not exceed more than 25°C.** Since room temperatures are more than 25°C in most places in India, this poses a challenge to the cells. Although most battery pack companies make a battery pack and dispatch it within the 3 months, if the cells are sitting idle in the battery pack manufacturer's facility at room temperature beyond 3 months, it alters the original parameters of cells.

What happens if Lithium-ion cells are stored in temperatures exceeding the specified limits in the datasheet?

The cells undergo an irreversible capacity fade, which means the cell's capacity to store energy reduces. This leads to a lower range in electric vehicles and a lower backup time in energy storage systems from day one of usage.

b) Operating Temperature

The operating temperature of Lithium-ion cells is a major factor in cycle life, which is important for all types of batteries, including Lead Acid batteries. Operating temperature is influenced by the battery's environment and the speed (C rating) of charging and discharging. Faster charging and discharging operations raise the battery's temperature, and it leads to lower efficiency.

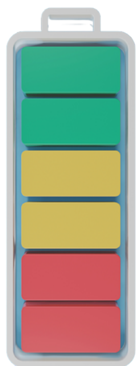
The ideal operating temperature for the battery operation is 25±2°C. Batteries operating at higher temperatures can provide higher discharge output but will go through faster degradation (irreversible capacity fade); batteries operating at below sub-zero temperatures have lower discharge output. There is also a difference in the battery's energy storage capacity at various temperatures due to charge-transfer resistance. Lower temperatures, such as sub-zero temperatures, have higher charge-transfer resistance. Hence, the battery cannot hold much energy leading to lower voltage output and lower energy storage capability.

The graphs of the percentage of outputs and capacity degradation at various temperatures are mentioned in the cell datasheet. If not, one can ask the manufacturer to share the data. The buyer has the right to get their hands on these data before they assemble the cells into a battery pack.

Depending on the cell chemistries, high-quality Lithium-ion cells should not have more than 15% loss in cycle life when operated at 35°C as compared to the cycle life at standard 25°C operation. Operating temperature is taken more seriously during charging, and hence most cell manufacturers recommend the cells don’t go beyond 45°C during charging. During discharging, the cell manufacturers allow the cells to reach up to 60°C.

What happens if Lithium-ion cells operate at high temperatures?

A BMS (battery management system) with good quality and reliable components is supposed to cut off the battery during charging or discharging when it senses high temperature inside a battery pack. **But battery pack companies in India are observed to buy BMS that allow more than 45°C temperature during charging and more than 60°C during discharging, even as the cell manufacturers strictly advise against it. This very common aspect tends to be missed out when EV battery fires are investigated.** Allowing higher temperatures for charging and discharging operations leads to various complications internally.



Battery pack companies set higher temperatures to avoid BMS cutting off the battery operation during charging and discharging to provide a smooth battery operation to the end-users when the battery is heated due to various reasons such as surrounding temperature, acceleration, vehicle overload, road gradient (slope), etc. But allowing the batteries to operate at higher temperatures impacts the safety of the battery. As an alternative measure, BTMS (battery thermal management systems) can be adopted to manage/dissipate the heat from the surface of the cells.

2. Voltage can be discussed further as overvoltage and undervoltage.

a) Overvoltage

The cell manufacturers recommend the overvoltage value of a Lithium-ion cell. **Most manufacturers mention it as 3.6V for LFP cells and 4.2V for NMC cells.** Some mention up to 3.65V for LFP cells and 4.25V for NMC cells. **Charging to these voltage values ensures that maximum energy is stored in the cell.** Charging cells to the max voltage increases the internal resistance and leads to heat generation. Energy losses during charging at this time are on the higher side; the heat generated during this time is energy that has been wasted during charging. Higher internal resistance during this time also leads to slower charging.

One can notice that most companies promise fast charging only up to 80%, some promise up to 90% but not beyond that. The reason is that when nearing 100% SoC (state of charge), the charger shifts from CC (constant current) mode to CV (constant voltage) mode. Charging during CV mode tends to be slower because the overvoltage of a Lithium-ion cell is almost achieved. Then the charging current tends to drop, and the charger disconnects when the current comes down to a certain value. Most cell manufacturers recommend disconnecting the charger when the charging current comes down to 0.05C rate.

Charging the Lithium-ion cells to their fully recommended voltage will lead to higher temperatures, which in turn will lead to faster degradation (irreversible capacity fade). Hence, it is **recommended to cut off the charging at a lower level**. It will lead to charging the battery to a level lower than a full charge, but **it will ensure the high life of the battery.** Since no cell manufacturer recommends 100% DoD (depth of discharge), this can be followed. The cut-off value depends on the cell's chemistry and various other factors. It needs testing at a cell level and also at a battery pack level where there is tolerance from BMS and charger. **Determining this value and setting it as overvoltage can help the cell last longer.**

What happens when Li-ion cells are charged beyond the specified overvoltage limit?

The cells tend to heat up even more, and it is a matter of time before the battery will experience a thermal runaway. Thermal means heat, and runaway means release. This phenomenon can result in fires in chemistries such as NMC, NCA (used in long-range Tesla cars) and LCO (used in mobile phones).

b) Undervoltage

The undervoltage value of a Lithium-ion cell is recommended by the cell manufacturers. **Most manufacturers mention it as 2.5V for LFP cells and 2.75V for NMC cells**. Some mention up to 2.0V for LFP cells and 2.5V for NMC cells. Just because it is the recommendation from the cell manufacturer, it does not mean that a battery pack must discharge its cells until this voltage. It is always recommended to cut off the voltage on the higher side when there is not much energy output.

- In an LFP cell, one can see that there is not much energy delivered after the cell voltage drops from 2.95V during discharge. Hence it is highly recommended to have an Undervoltage cut-off of 2.9V when operating between 0.5C to 1C discharge. **The undervoltage value must be lower when discharging at higher C rates**. Other variables such as temperature and tolerance in the BMS while cutting off also play a vital role in determining the ideal undervoltage.

- Similarly, NMC cells do not deliver much energy below 3.15V during discharge. Hence, it is highly recommended to have an Undervoltage cut-off of 3.10V.

In electric vehicles, the controller cuts off the battery when it senses low voltage. Similarly, in an ESS application, the inverter cuts off the battery when it senses low voltage. **The tolerance of the controller and inverter play a vital role in deciding the Undervoltage cut-off of a battery.**

When the above aspects are correctly followed along with the procurement of good quality cells, a Lithium-ion battery tends to have a very good cycle life and experiences low on-field failures. It can further work in second life battery applications, where additional cycle life can be expected when charged and discharged at lower C rates.

Recently Tesla's research partner published details about NMC 532 (cathode) based cell that can last for a really long time (up to 100 years) by ensuring that the cells do not charge beyond 3.8V as compared to the traditional charging of NMC cells to 4.2V and by being operated at standard temperature 25°C (made possible by BTMS). This paper was published in the Journal of the Electrochemical Society and it is titled "Li[Ni0.5Mn0.3Co0.2]O2 as a Superior Alternative to LiFePO4 for Long-Lived Low Voltage Li-Ion Cells".

About the author

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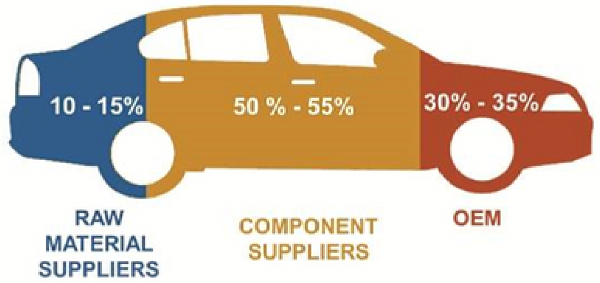
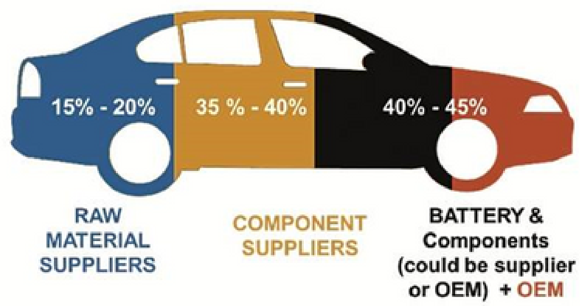
AUTOMOTIVE INDUSTRY STAKEHOLDERS AND IMPACT OF EV TRANSFORMATION - CHAPTER 3

The transformation of automobiles from ICE to EV powertrains will have a long-lasting impact on the automotive ecosystem. The third article of the series by **Dr Maruti Khaire (Head EV and Special Projects at SKF India)** is focused on the vehicle system-level impact of vehicle electrification.

Automotive Vehicle Value Add Perspective



a) Current ICE vehicle value add



b) Expected EV value shift

Figure 1 - The expected shift in the value add to the vehicle (source: www.autocarpro.in)

The automotive vehicle is the successful product of many partnerships with full value chain partners, including raw material suppliers, component manufacturers, service providers, and OEMs themselves, who play the dominant role in integration and configuration building for the vehicle.

A report by Autocar Pro says that **component suppliers add more than half the value to an ICE vehicle** by employing design, manufacturing, and in some cases, innovation. Manufacturers are largely dependent on supplier partners for some systems like fuel injection systems. Raw material suppliers add value to the ICE vehicle in the range of 10-15%, and OEM adds the remaining value to complete the vehicle offered to the customers [Refer to Figure 1 (a)].

However, with vehicle electrification, the supplier value-add will increase significantly. Battery and components/operating system suppliers will play a bigger role. OEMs and electrical system suppliers need to work together to get the vehicle's optimum performance. More than half of the value [cost] of the vehicle will be accumulated by energy storage devices and motors. Even though other components that are part of vehicle control and occupant comfort and safety-related systems will be required for the vehicle, I believe their value-add will reduce compared to the powertrain system. New raw materials, light-weighting, as well as electrical insulation/safety requirement perspective, raw material suppliers' value-add, will increase [Refer to Figure 1(b)].

Deep Dive into Vehicle Systems and Impact due to EVs

The vehicle powertrain is a subsystem of the vehicle system that has a substantial role in vehicle propulsion. Other systems complement it to ensure occupant safety, comfort, and vehicle control. Hence, vehicle electrification and its impact on complete automotive vehicles need to be assessed for all the subsystems. Though EV powertrain adoption impacts the ICE powertrain adversely, it also generates opportunities for other systems. In this section, let's understand major vehicle systems and the impact on them due to vehicle electrification.

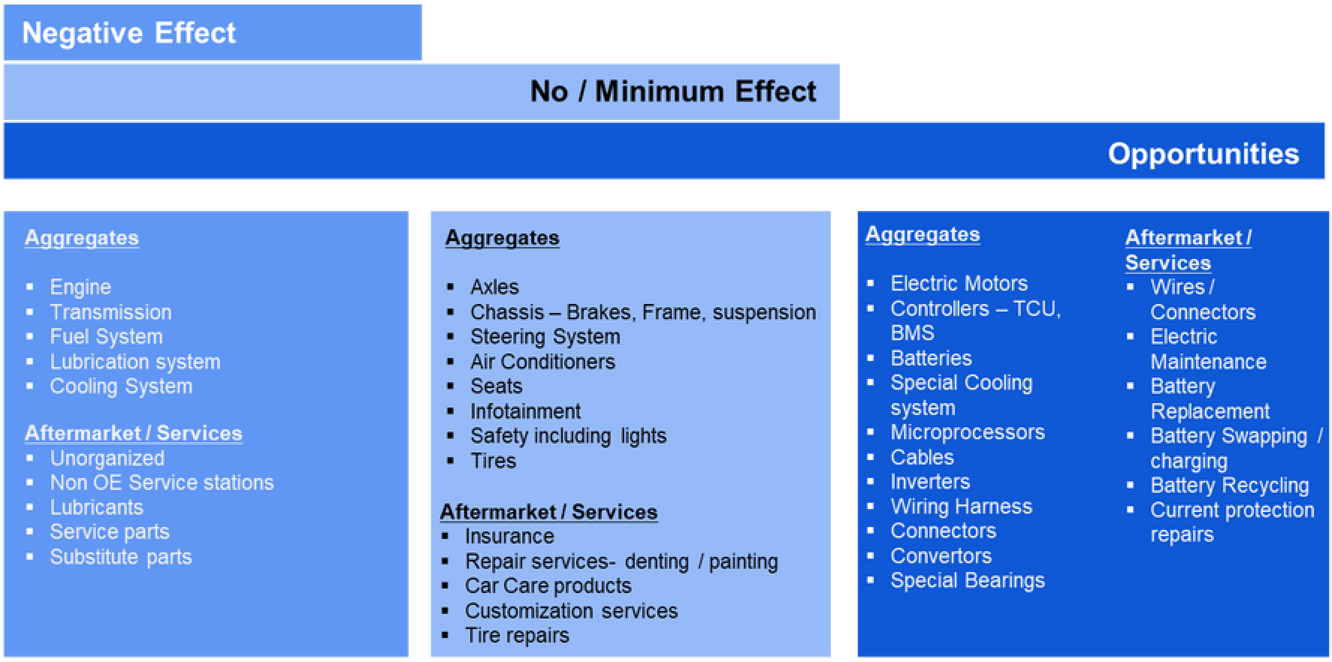


Figure 2 - Summary of EV powertrain impact on different vehicle systems

Negatively Impacted Sub-systems

The automotive powertrain is transforming into an electric powertrain and naturally, the first impacted vehicle subsystem is the engine, transmission, and related systems. It is important to mention that vehicle electrification and its impact are compared with the battery electric vehicle and not with other electrified vehicles such as hybrid vehicles. In the case of hybrid vehicles, engine and transmission do not have as much negative impact.

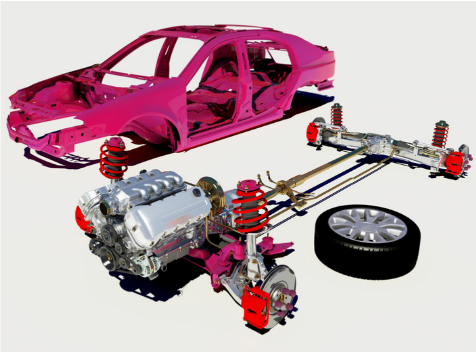
In Battery electric vehicles, engines and related systems are replaced directly with e-Motor and MCUs. Transmission in EVs is simpler, and it is fixed stage transmission. The gear shift system is replaced with the electric or simple direction control system. The fuel system is replaced with a wiring harness carrying the electric charge from the battery to the e-Motor (s). Engine cooling system, which contains radiators, fans, pump, and complex piping, is not present or present in the simpler form of a battery cooling system.

As the propulsion system gets simpler and there are fewer relatively rotating parts, it has lesser requirements for lubrication / anti-wear products. As the powertrain becomes simpler, the need for maintenance reduces significantly.

It is important to note that vehicle electrification simplifies the mechanical system; however, it has complex electronics and control systems. Electric vehicles have more sensors, electronic hardware, and software codes to manage these complex systems to achieve the optimum performance of the vehicle. From a vehicle service, maintenance, and human resource perspective, electrification has a negative impact on the automotive ecosystem in the short term, and it demands reskilling or new skilling to human resources in the ecosystem.

No / Minimum Impacted Sub-systems

Besides the powertrain, a vehicle needs other systems to operate reliably, safely, and comfortably. Vehicles aggregates like Axles, Chassis – Brakes, Frame, suspension, Steering systems, Air Conditioners, Seats, Infotainment, Safety, including lights, and Tires are likely to have minimal or no impact. However, **these systems will need customization and a redesign to accommodate new powertrain requirements**.



Chassis frames will be significantly different in the case of EVs compared to conventional vehicles. In the case of EVs, batteries will have higher mass, and the chassis frame needs to carry that mass safely. The infotainment system will have more information besides basic information about the vehicle including battery state, temperature, etc. Tires will be customized for the electric vehicles, to run more efficiently. Car repair services, customization, car care products, etc., will continue with the same or minor upgraded products.

When it is mentioned that the above aggregates or subsystems will have minimal impact, it means these subsystems will be present in the vehicle in one or another form. Requirements for the aggregates may be different and they may be present in the vehicle in a different form (geometry) for doing the intended function.

Electric vehicles will have the axle to transfer the torque from motor to wheel in case of conventional vehicle layout. However, axles for EVs and axles for the ICE will have significant differences in their weight, geometry, and components arrangements. In the case of the “in-wheel motor” arrangement, each wheel will have a separate motor to drive, and hence the role of the axle will be either integrated into the chassis, or it will play the role of support and not torque transfer. The minimum impact mentioned here is from the point of view overall ecosystem. However, the said aggregates will experience significant customization to adapt to electric vehicles.

In addition to automotive aggregates and systems, other complementing important stakeholders of the automotive ecosystem are facilitating systems like insurance, vehicle financing, car customization or care system. ICE automotive ecosystem is well established for these facilitating products. However, even though EV ecosystem needs are similar in nature, the experience and risk are still unknown to these stakeholders.

EV insurance is expensive, and very few insurance companies provide insurance for electric vehicles. Similarly, the availability of EV finance options is limited. In my opinion, these are short-term challenges, and in the long term, they may complement as well as nullify the overall impact.

New Opportunities

Any technology transformation also generates opportunities. Alongside challenges, EV transformation is also generating huge opportunities within the ecosystem.

Key focus areas to improve performance

Motors	Placement – hub (outrunner, inrunner), frame, axle
	Technology – BLDC, PMSM, switched reluctance, synchronous reluctance | Flux – Axial, Radial
	Integration with Braking & Thermal Management
	Material – Al, C for performance & lightweighting
Motor Controller, BMS, Converter, PDU	Control algorithms
	Switching mechanism – MOSFETS; IGBT
	AI, ML, analytics | Interface with other components
	Material trend – SiC, GaN
Charger & EVSE	Placement - On-board, Portable, Fixed (AC/ DC)
	Rectifier/SMPS
	Control Interface

Figure 3 - Key components and systems to improve the performance. Source - YES Bank CGA Insights report

Electric motor development, optimization from a performance as well as cost perspective, and customization based on vehicle requirements are opportunities for automotive system ecosystem players. Refer to Figure 3, which summarizes powertrain areas mainly related to the electrical power management system. Motor, electronic motor controller, battery management system, converters, battery – packs, battery cell chemistry, associated electronics including IC, and, most importantly, charging systems are newer opportunities evolving due to vehicle electrification.

ICE vehicles were also equipped with electronic and software systems; however, the extent will magnify with vehicle electrification. In the new automotive world, services around these systems are required to be built. Vehicle repair and the nature of vehicle issues will significantly change and call for reskilling or highly skilled resources in the system.

Similarly, the nature of aftermarket requirements will change with EVs. Wires, connectors, battery maintenance and recycling will have more emphasis than conventional components. Battery charging will have significant retailing business opportunities, which will cannibalize business from fuel stations.

In summary, EV transformation will hurt powertrain systems like engines and associated systems, as the transmission will be simpler than ICE vehicles. Few aggregates will have minimal impact as a result of EV adoption. However, the EV transformation will generate considerable opportunities in electronics, batteries, and battery charging. The new world of automotive ecosystem and partners will emerge considering the latest technologies and complex systems interactions.

In the July 2022 issue, let us reimagine the automobile ecosystem with vehicle electrification.

INSIDE NEXCHARGE'S FULLY AUTOMATED BATTERY PACK ASSEMBLY PLANT

Nexcharge, a joint venture between Exide Industries and Leclanché SA, recently announced the inauguration of its fully automated **Lithium-ion battery pack manufacturing** plant at Prantij, Gujarat. The company has invested more than **INR 250 Crore** in this manufacturing facility. We caught up with **Stefan Louis, CEO at Nexcharge,** to learn more.

What are the current offerings by Nexcharge?

Since commencing operations in India in 2018, Nexcharge has been working to fast-track India's transformation towards sustainable energy solutions. We cater to the diverse market segments by offering Li-ion batteries of different chemistries, viz. **NMC, LFP, LTO** and form factors viz. **Pouch/ Prismatic/ Cylindrical**.

Cylindrical Module Line

HV Pack Line

Nexcharge offers battery packs for electric 2W, 3W and commercial vehicles in the transportation business; telecom, UPS, inverter battery packs in Industrial and Utility; as well as large format ESS. Our current product range is substantial and our new production lines warrant us the flexibility to assemble products of different sizes and designs. **We can now make 3V to 1000 V battery packs with sizes varying from 10 centimetres to 2 meters.**

Tell us more about the Prantij facility.

The plant covers a total area of 6,10,098 sq feet and is India's largest for making Li-ion battery packs and modules. This facility has a **1.5 GWh installed capacity** and **six fully automated manufacturing lines** and testing labs. Production setup is divided into three sections:

- **Module Assembly**, which has 3 production lines for assembling Cylindrical, Pouch, and Prismatic Cells.
- **Pack Assembly**, which has 2 lines for High Voltage and Low Voltage packs.
- **Finished Goods Testing section**, which has a set of 20 testers for charging and discharging cycle and BMS functioning.

Nexcharge is also supported by an in-house R&D facility in Bangalore.

What does full automation entail?

As an example, if you look at the production line for 2W battery packs, it is a high capacity line and fully automated. It means that the **operators do not touch the products. The operators only load the production line with components. The components are assembled by the robots**. At the end of the production line, there is one operator removing the completely assembled product from the production line. So, all of the processes are fully automated. There are two reasons to do this. One is speed, as it is a high capacity line which can handle **4500 cells per hour**. The second reason for this high level of automation is quality management.

If I look at another production line, for example, our prismatic line, there are a few processes that require manual intervention, but again most of the processes are automated. So wherever the process or operation can potentially impact product quality or wherever a process requires such a speed that it will require too many operators, we have automated those.

Can you talk about your process for testing incoming cells for quality control?

1. First, when we select a cell for a particular product design, we have to ensure that the cell will work well for that specific application. For this, we have an R&D lab to characterize the cell in various ways – Can it deliver the power? Can it deliver the energy? Will it not get too hot under Indian circumstances? And will it have the life that the customer expects from it?

2. Once the design is complete and we go to production, we also have to test the cells that will come in. **Every cell is automatically tested by the production line that automates the assembly of the cell into the module.** The testing parameters are different for different types of cells. For some cells, we will automatically measure the size of the cell to ensure that it fits in the battery pack. We will always check the open-circuit voltage and the AC internal resistance.

Quality Lab

3. Once the battery pack is completely assembled, it goes into our **finished goods testing line** where we basically measure the capacity of the battery pack. For example, if a battery pack is supposed to supply 10 kWh, we actually charge the battery, discharge it completely and recharge it ready for shipment. The discharge is done to actually measure if the battery will supply that 10 kWh. If there is one cell in the battery pack that has a problem, the battery will not be able to supply the 10 kWh. In addition, all the cells in one battery pack also have to match each other. For cylindrical cells, we ensure that by an automated process of matching the cells with each other. When it comes to the prismatic and pouch cells, this is undertaken by the cell manufacturer.