October 2023

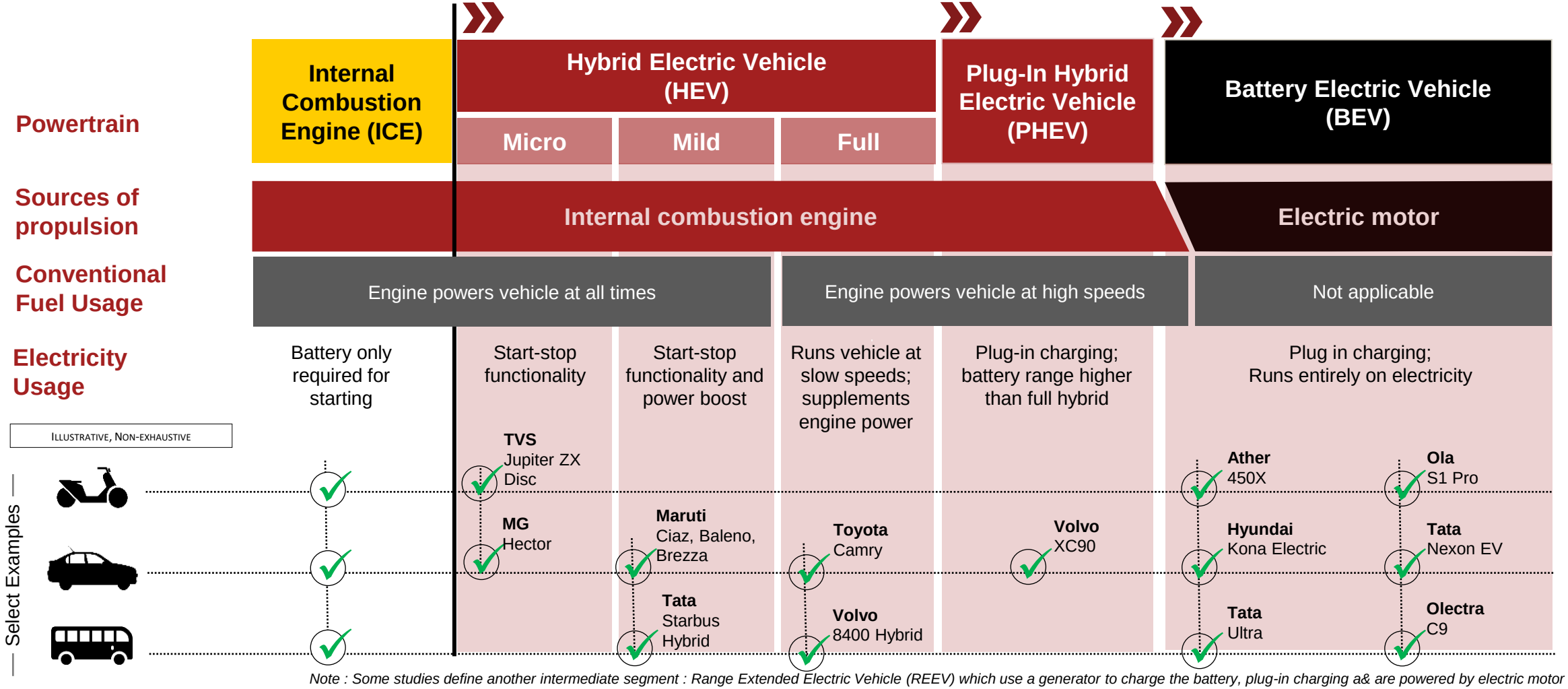
Electric vehicles & e-Mobility

Market overview & opportunities for auto-component manufacturers

pwc

Contents

Several power train technologies co-exist across xEV continuum and across vehicle segments



Note : Some studies define another intermediate segment : Range Extended Electric Vehicle (REEV) which use a generator to charge the battery, plug-in charging a& are powered by electric motor

Source: Company websites, PwC Research & Analysis

The global xEV market was valued at *~$385 Bn* in 2022*; *BEVs projected to have the highest growth* (5X) by 2028 (value terms)

		Hybrid Electric Vehicle (HEV)			Plug-In Hybrid Electric Vehicle (PHEV)	Battery Electric Vehicle (BEV)
1 2022 xEV size	$ 385 Bn	Micro	Mild	Full		
2 2028 xEV size	$ 1,318 Bn »	46 %			23 %	31 %

Global xEV market to **grow at a CAGR of~ 23%** between **2022 – 2028 period**

Factors making BEVs attractive

Stringent Environmental Regulations

- USA – *American Renewable Energy Act Of 2021*
- China – *PRC Energy Law Of 2022*

Volatile Oil Prices

Average VIX (Volatility Index) for crude oil prices;

- 2017-2019 – *31.043%*
- 2021-2022 (YTD) – *44.21%*

Policy Orientation

- USA – *Inflation Reduction Act Of 2022 (Amendment in IRC 30D)*
- China – *New Energy Automobile Industry Plan (2021-2035)*

Lower Maintenance Costs

- *Fewer moving parts* in electric powertrain
- *40% less TCO* for EVs vs. ICE vehicles

Improving Product Quality

New technologies coming to the fray;

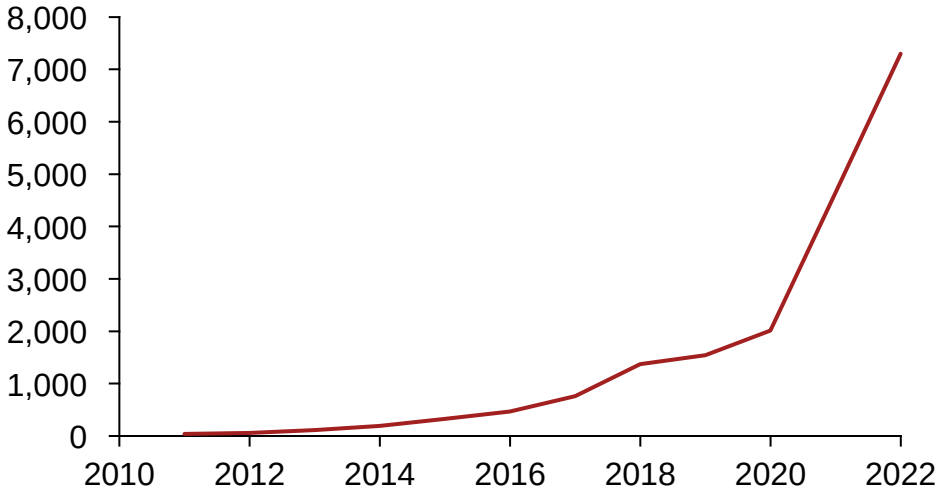
- Smart EV Charging
- Smart Battery Management
- Vehicle-to-Everything (V2X)

** 2022 refers to Calendar Year 202 (Jan '22 – Dec '22)*

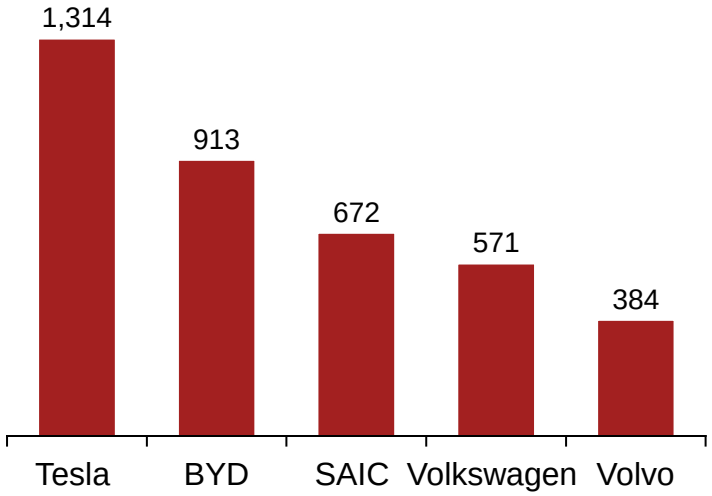
Source: Fortune Business Insights, Business Insider, US DoE, PwC Research & Analysis

Global light vehicle* BEV sales grew *~57%* in 2022**; *China accounted for over half of the sales*

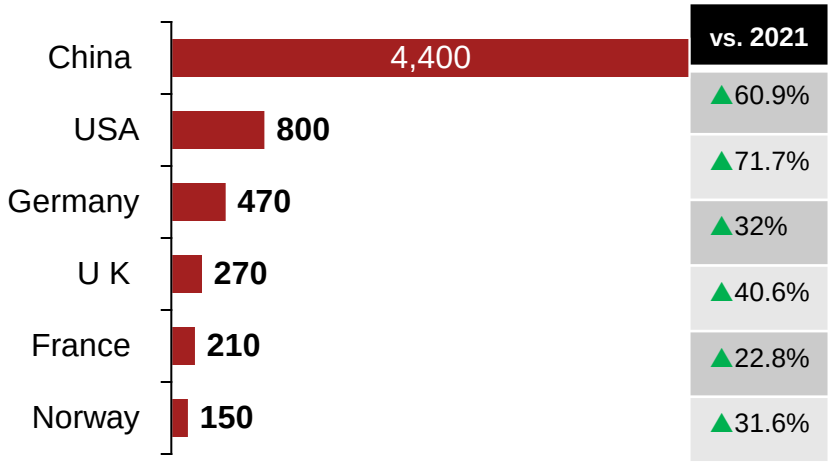
Global BEV Sales | ('000 units)



Top Selling OEMs | BEVs: 2022* ('000 units)



Top EV Markets | BEVs: 2022* ('000 units)



Source: IEA, ACEA, CAAM, EV-volumes, PwC Research & Analysis
** Does not include e2Ws*
*** 2022 refers to Calendar Year 2022 (Jan'22 – Dec '22)*

- Lithium-ion battery pack prices saw a **6% decrease from 2020 prices;** weighted average price at $132/kWh
- Strong **push on charging infrastructure**, & **ban on new ICE car sales** from 2035 by select EU nations, gave a strong push to e-mobility

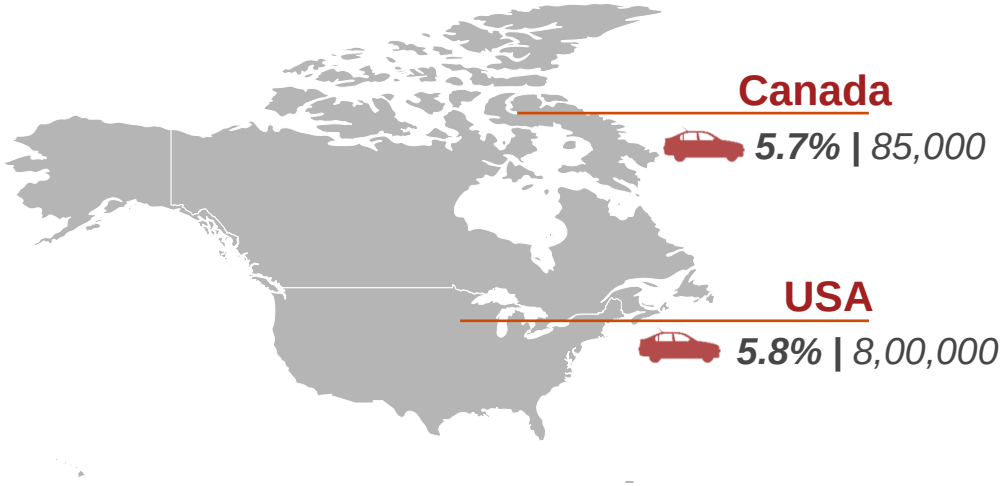
- **Volkswagen** has a **10% market share** globally – set to invest **$10.6 billion** to build electric vehicles and batteries in Spain
- **Hyundai** announced **new electrification strategy for 2030** – 1.87 Mn BEV sales annually, 17 new BEV models

- **China** witnessed a strong growth in BEV sales on the back of government support through subsidies & strong charging infrastructure growth
- European nations such as **Norway** and **Iceland** possess the highest EV market penetration – 65% and 45% of all new vehicle sales are EVs

**Light vehicles do not include e-2W and e-3W*

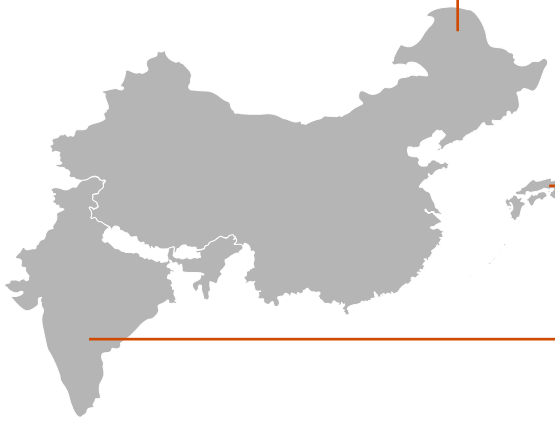
While major global auto markets' EV penetration rose in 2022, *European markets lead sales penetration levels* among the top nations

Penetration | 2022 Sales Volumes* | (% | units)



Canada
***5.7%** | 85,000*

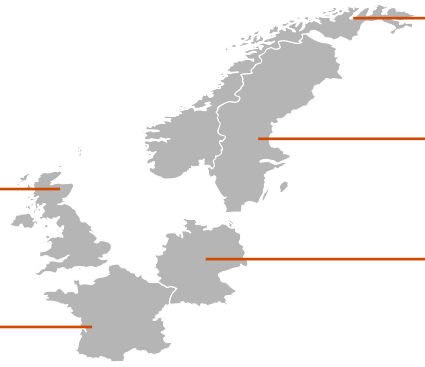
USA
***5.8%** | 8,00,000*



China
***18.7%** | 44,00,000*
***22%** | 4,600,000*

Japan
***1.5%** | 61,000*

India
***1.5%** | 48,000*
***1.5%** | 234,000*



Norway
***86%** | 1,50,000*

Sweden
***33.3%** | 96,000*

Germany
***17.7%** | 4,70,000*

United Kingdom
***16.7%** |2,70,000*

France
***13.7%** | 2,10,000*

Source: IEA, PwC Research & Analysis
**Sales numbers for all geographies for calendar year 2022; For China and India – 2W numbers are for xEVs; rest are BEV numbers*

Strong government support seen among nations with high sales volume/penetration of Battery Electric vehicles (BEVs)

	China	United States	Germany	Norway
BEVs Sold* (2022**, '000 units)	**4400**	**800**	**470**	**150**
EV Charging Points (2022**)	**1,760,000**	**1,28,000**	**77,000**	**24,100**
EV Policy	• **NEV Subsidy Scheme** – **$14.8 bn** in subsidies to buyers – scheme extended till end of 2022 • **Focus on charging infra:** – 2013 – **Uniform charging standards** – 2022 – **National Development and Reform Commission** guidelines on expanding charging infrastructure to every county • **Target: 40% new vehicle sales to be electric by 2030**	• **CAFÉ** – Fuel economy norms, revised in March 2020 • **NEVI program – $5 billion** to build EV charging infrastructure across the USA from FY22-26 • **EVs4ALL – $45 million** for development of advanced batteries for EVs w.e.f April '22 • **100% zero-emission govt. vehicle acquisitions by 2035**, including 100% light-duty acquisitions by 2027	• Offers **high end-customer subsidies**: – €6k for EVs priced under €40k – €5k for EVs priced over €40k • National-level charging incentives: – *Private* – **€900** incentive per charging point – *Public* – **€300 mn** in total incentives, subsidies upto **80%** of total cost for purchase and installation w.e.f FY22 • **Target: 10 mn EVs and 1 mn public charging points on road by 2030**	• **Strategy** –**Provide tax breaks,** not big incentives & grants; – No purchase/import tax – No annual road tax (1996-2021) – No VAT • **20-50% subsidy** on total cost of EVSE purchase and installation, up to €450 per charging point • **Target: All new car sales by 2025 to be zero-emission**

Source: IEA, PwC Research & Analysis
** Does not include e2Ws*
*** 2022 refers to Calendar Year 2022 (Jan'22 – Dec '22)*

Case study – China has regularly set ambitious EV targets backed by financial incentives, tightening of fuel norms & investment in charging infrastructure

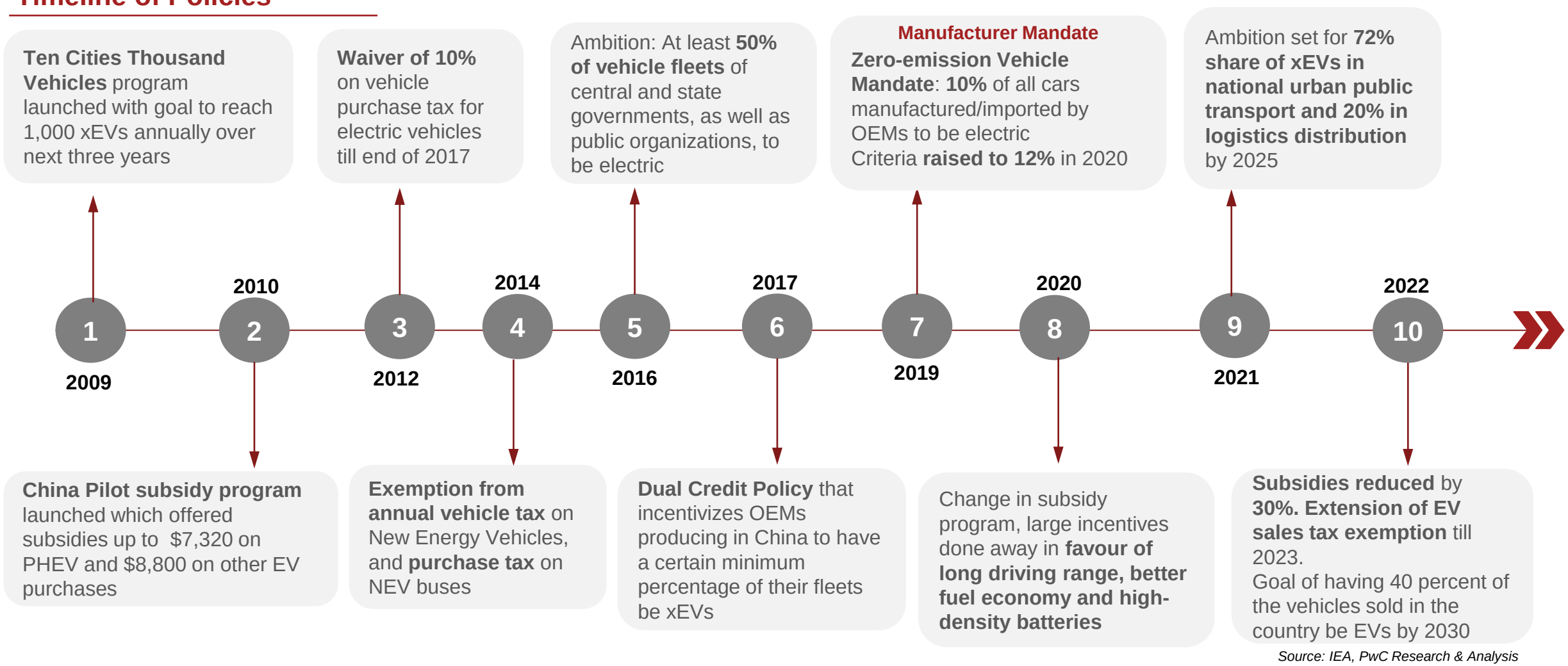
Highlights of EV policies

Focus Areas	Fuel Norms	Targets
Expansion of charging infrastructure, with focus on **battery swapping**	Initial push towards electrification was through **tightening of fuel economy standards**	By 2030: • **40%** new sales to be electric • **50 million** EV holdings • **200 TWh** demand for EV charging
Financial incentives on the purchase and manufacture of EVs	*2017:* **4.6L/100 km (WLTP) or 4.0L/100 km (NEDC)** by 2025 for all PVs	Presence of **charging infrastructure for over 20 million EVs** by 2025
Introduction of EVs in **public and commercial fleets** (buses, taxis, delivery vehicles)	*2018:* **41.6L/ 100km** for all HCVs registered after July 2021	Average electricity consumption of BEVs **≤ 12kWh/100 km** by 2025

Source: IEA, PwC Research & Analysis

Case study – The Chinese govt. has pivoted from providing expensive customer subsidies to enforcing EV manufacturing mandates on OEMs to drive EV adoption

Timeline of Policies



Source: IEA, PwC Research & Analysis

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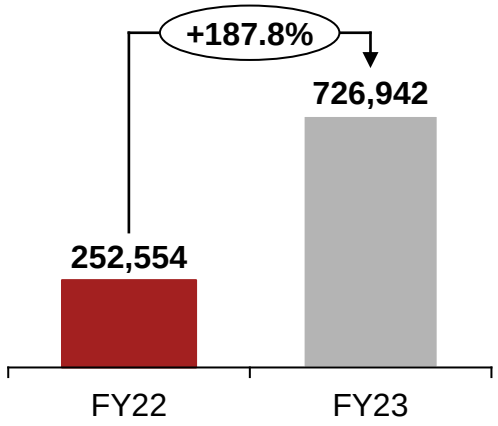
BEV sales in India recorded high growth across categories in FY23 despite the supply chain disruptions, macro-economic and geopolitical uncertainty, and high commodity and energy prices

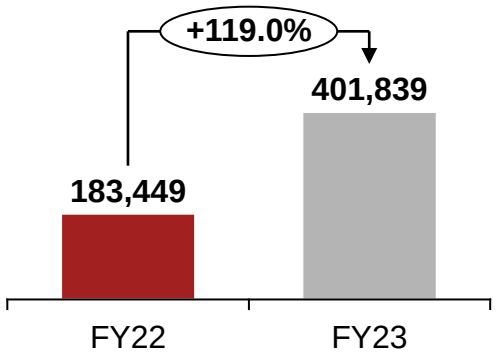
India Domestic BEV Sales | Units

Two-wheelers



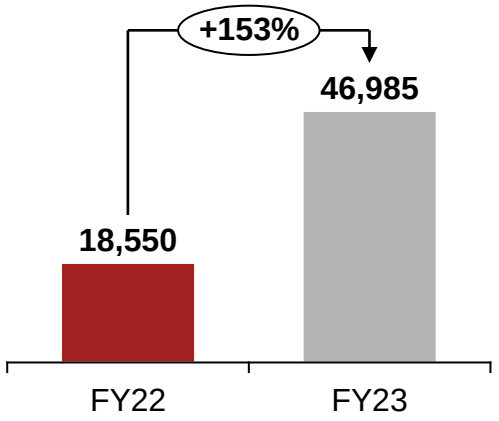
- Demand increase due to **last mile connectivity services**
- Share of high-speed models increasing – **new model launches driving growth**

Three-wheelers



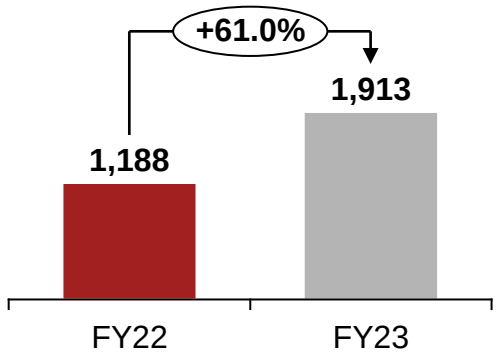
- **Favorable TCO** in urban & rural settings
- **Passenger** segment comprises **~90%** of sales
- **e-3Wh cargos** expected to do well in the next 3-5 yrs

Passenger vehicles



- Consumer preference towards **utility vehicles**
- Tata Nexon & MG ZS **top-selling models**
- **Several premium EVs** also launched

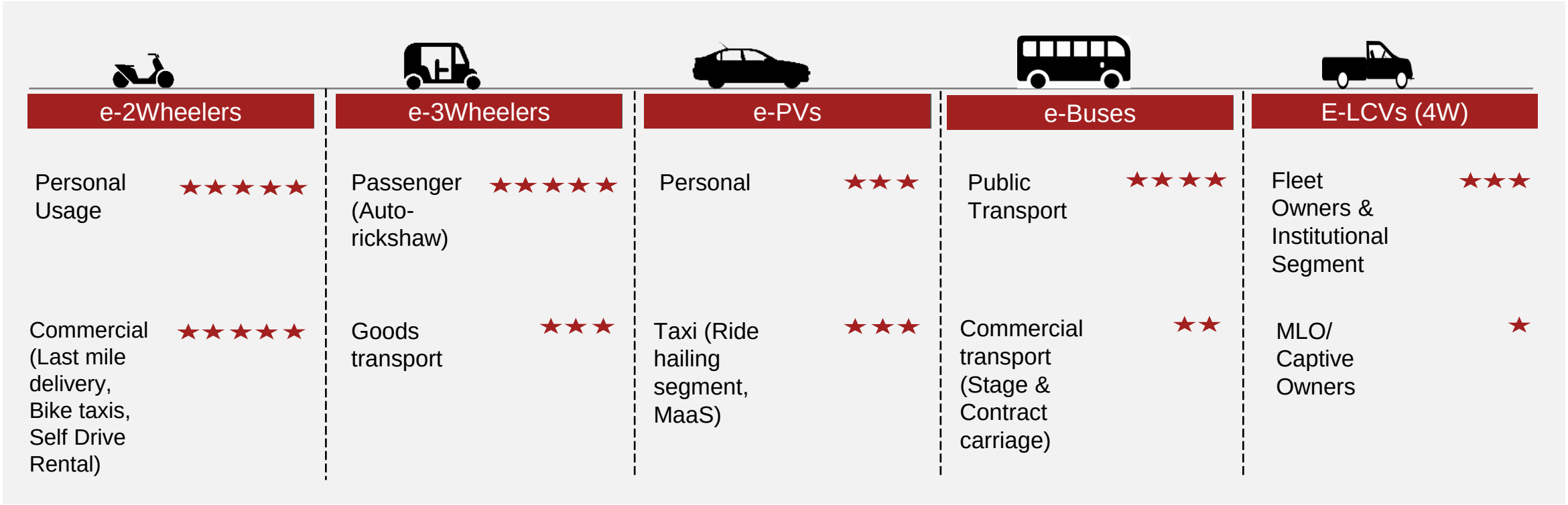
Buses



- **>95%** of sales volume driven **by govt. STUs**
- Procurement through **govt. subsidies**
- **Major manufacturers** have set up capacity

Source: Vahan Dashboard, PwC Research & Analysis

While *e-2Wheeler, e-3Wheeler & public buses* in India will be *early adopters*; Medium & Heavy-duty trucks to see least adoption



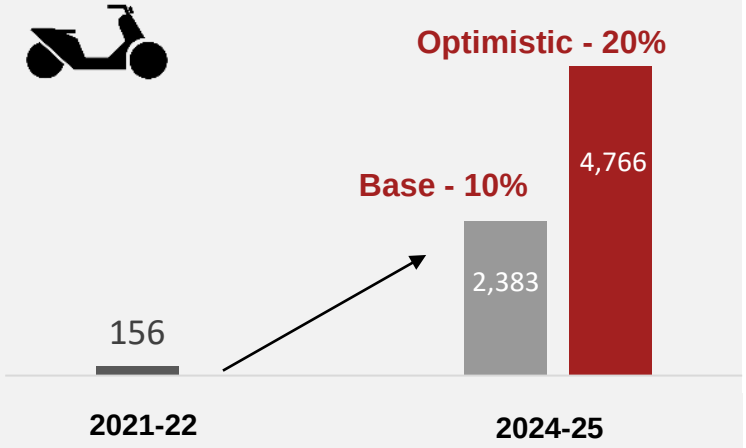
Source: PwC Research & Analysis

** MLO – Medium & Large Fleet Operators*

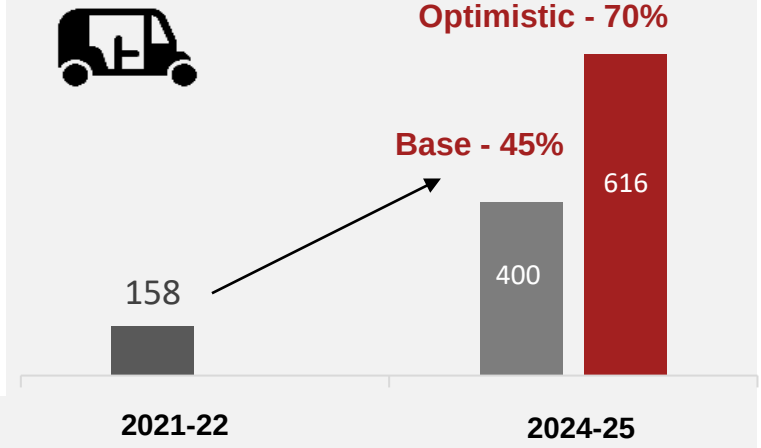
★ *Indicates the relative speed of EV adoption*

In the medium term, *e-2Wh & e-3Wh segments will show strong growth* due to favourable TCO[1] & lower delta in upfront cost of acquisition between ICE & EV

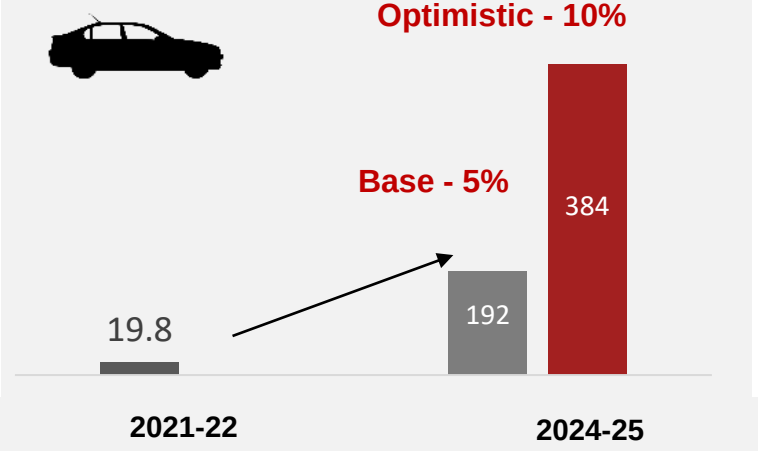
Electric 2W Market Forecast | '000 units
% of new vehicle sales



Electric 3W Market Forecast | '000 units
% of new vehicle sales



Electric PV Market Forecast | '000 units
% of new vehicle sales



Source: Vahan, SIAM, PwC Analysis

Key driving factors

Environmental Concerns
Tackling climate change through reduced emission norms

Fiscal Impact
High oil import bill & foreign oil reliance makes it challenging to manage fiscal deficit

Charging Infrastructure
De-licensing, definition of charging standards, promotion of interoperability

Supply Chain
Development of capabilities in local manufacturing, supplier maturity

Customer Acceptance
Purchase subsidies under FAME/ state govt. policies, improved battery ranges

[1]TCO – total cost of ownership

Environmental, fiscal & financial factors along with increase in supplier readiness will drive the growth of electric vehicles in India…

1

Environmental Concerns

- ***63*** Indian cities among world's ***100 most polluted*** cities[1]
- ***23%*** of ***GHG emissions*** due to ***vehicular emissions***[2]
- Pledged to ***reduce ~35% emissions by 2030*** from 2005 levels under Paris Agreement[3]

Sources – [1]IQAir World Air Quality Report, [2]Climate Action Tracker – Decarbonizing Indian Transport Sector, [3]PIB

2

Fiscal Impact

- ***$119.2 billion*** crude oil import bill in 2021-22, ranking ***3rd globally*** on oil spend[4]
- ***$10 increase in crude oil*** prices leads to increase in current account deficit by ***0.4%-0.6%***[5]
- ***50 – 60 basis points*** increase in CPI inflation for every ***$10 increase in crude*** prices[6]

Sources – [4]Petroleum planning & analysis cell (PPAC), [5]Edelweiss wealth research, [6]RBI- Confronting Supply-Driven Inflation (July 16, 2022)

3

Charging Infrastructure Push

- ***22,000*** EV charging stations planned to be installed by oil marketing firms[7]
- ***~₹1,000 crores*** incentives under ***FAME*** & state govt. policies for charging equipment & infra.[8]
- ***De-licensing*** of charging operations & guidelines on ***affordable tariffs*** for operators[9]

Sources – [7]PIB (Feb 19, 2022), [8]PIB (Dec 10, 2021), [9]Public information

4

Supply Chain

- ***₹25,938 crores*** allocated under **PLI for automobile** & auto-components[10]
- 5***% additional incentives on BEVs*** will promote local manufacturing ecosystems[11]
- ***18% share*** in advanced auto tech. targeted – will make India ***major supplier*** of critical BEV tech.[12]

Sources – [10]PIB (Mar 15, 2022), [11,12]Ministry of heavy industries – scheme document for auto PLI

5

Availability of Finance

- ***₹19.7 lakh crores*** required between 2020 & 2030 for India's EV transition[13]
- ***₹3,307 crores funding*** raised by ***EV startups*** in 2021[14]
- ***$300 million fund*** setup by ***Niti Aayog & World Bank*** for EV loans in India. Reduce financing cost by ***10% - 12%***[15]

Sources – [13]Niti Aayog – Banking on EV, [14]ETAuto – EV funding in 2021, [15]Niti Aayog press release

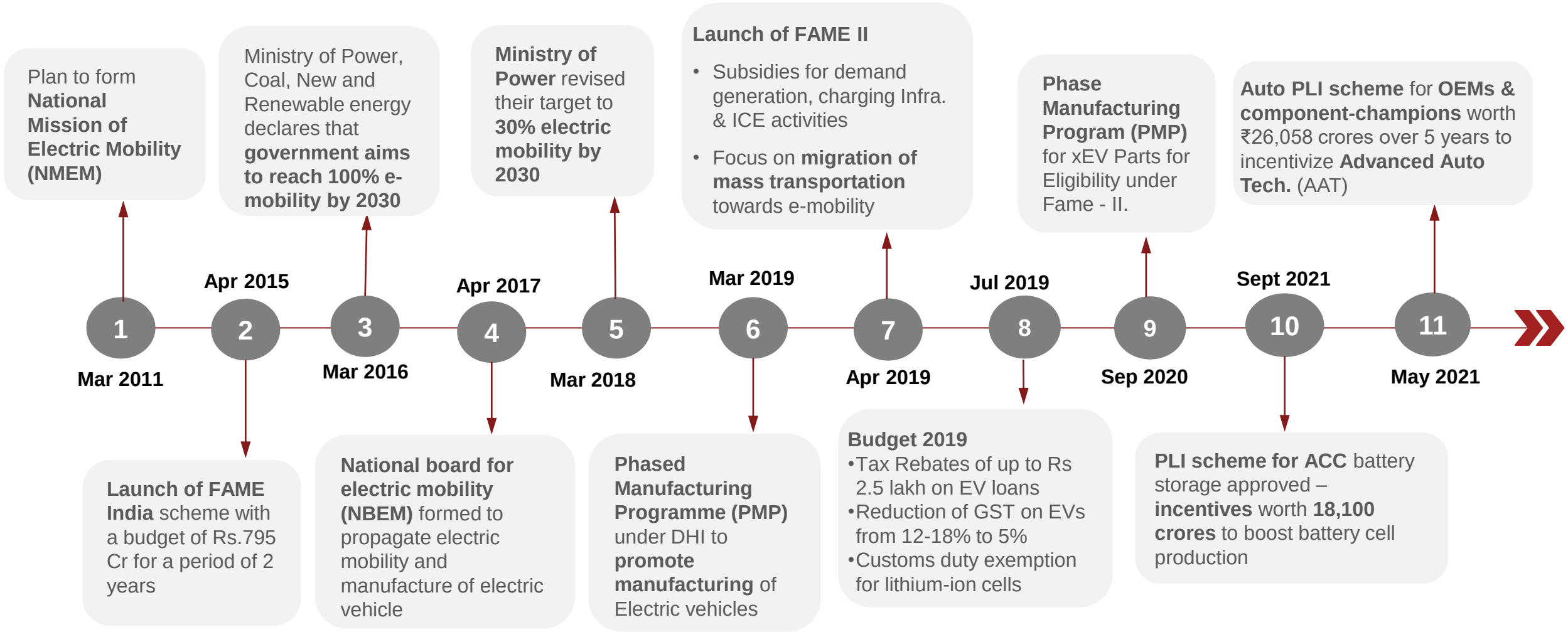
6

Customer Awareness

- ***66%*** of Indian customers willing to buy an electric vehicle[16]
- Focus on **Net Zero** emissions & **ESG goals** from several prominent corporate houses
- Campaigns such as ***Switch Delhi, Shoonya & Go Electric*** boosting customer confidence

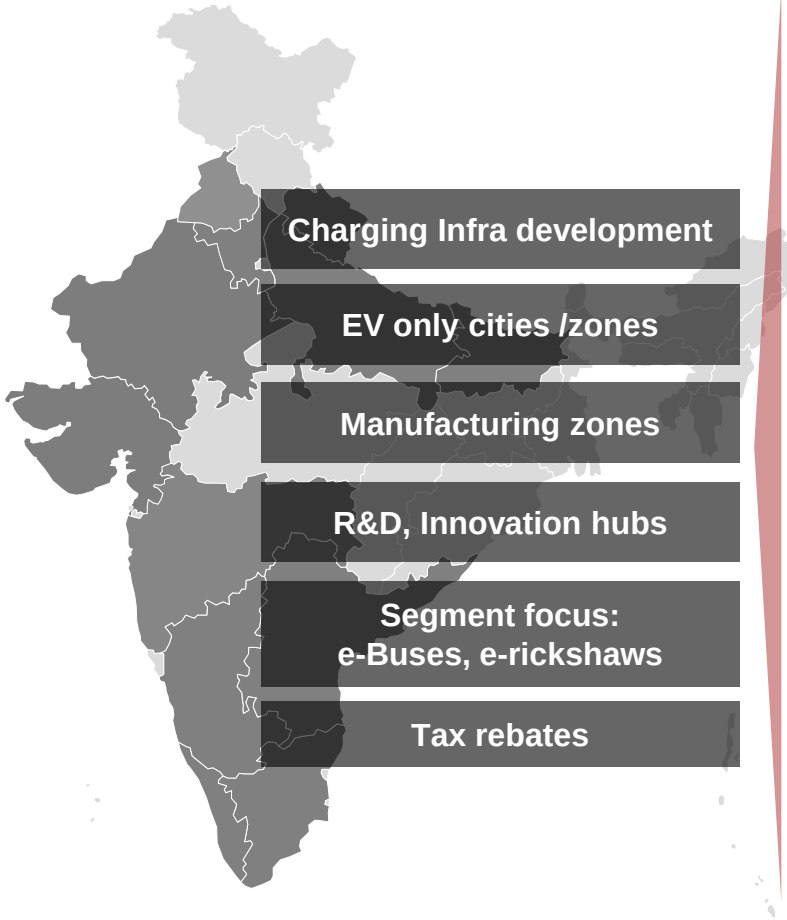
Sources – [16]CarDekho OMG study 2021

...coupled with strong government support; The central govt. has been actively supporting EV ecosystem growth over the past decade



Source: DHI, SMEV, PwC Research & Analysis

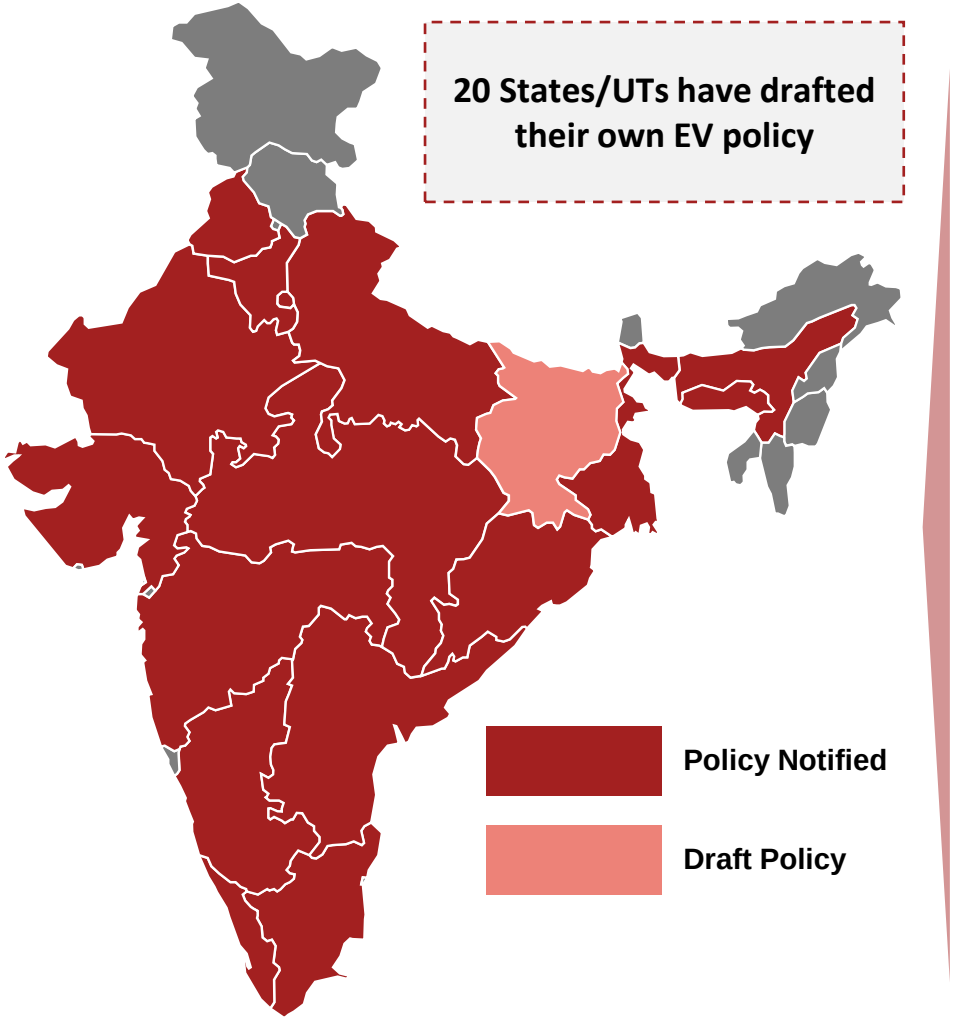
State governments have formed their own EV policies to drive rapid adoption in their respective states



	State	Key Policy Focus
1	**Andhra Pradesh**	Focus on innovation, new technology and workforce training. Aim: 10L EVs on road by 2024; replace public transport fleet across state by 2030
2	**Bihar**	Bihar is the fastest growing market for **e-rickshaws**. Focus on leveraging this to promote local e-rickshaw manufacturing
3	**Delhi**	Priority: Reducing **air pollution and creation** of EV sales jobs**. Last mile transportation fleets** expected to shift 50% EVs by 2023. Target: 25% share of EVs in sales by 2024.
4	**Karnataka**	First state to issue an EV-specific policy in the country. Focus on **R&D, productions**, services and customers. Aim: 100% e-mobility in auto-rickshaws, cabs, corporate fleets, and school buses/vans by 2030.
5	**Kerala**	Focus on EV manufacturing, particularly **e-buses**. Procurement of 6,000 electric buses by 2025, concessions to manufacturers setting up in the state.
6	**Maharashtra**	Scheme for **MSMEs** and large manufacturing, setting up of **charging points** at petrol stations.
7	**Tamil Nadu**	Focus on manufacturing, use of **venture capital and business incubation services** and commercial fleets. 10% parking reserved for EV in commercial spaces.
8	**Telangana**	**Skills development**, innovation and creation of jobs through shared mobility and charging infrastructure
9	**Uttar Pradesh**	EV manufacturing hub, investment in charging infrastructure, development of **battery management.** Aim: 10L EVs on road by 2024
10	**Uttarakhand**	Dedicated **EV manufacturing zones**, electrification of public transport. Aim: 100% electrification of public transport by 2030. Subsidy for EV manufacturing in the state

Complete list of 20 states not displayed

States have not only drafted EV policies but have also committed to following through with additional actions…



State	Additional Actions – Key Focus
Andhra Pradesh	**"Go Electric"** campaign initiated to promote EV adoption and development of charging infrastructure
Bihar	Fastest growing market for **e-rickshaws;** fifth largest EV market in India. **Subsidy for E-Bus** with maximum amount of INR 7,50,000.
Delhi	EV Capital of India – focus on **development of charging infrastructure and battery swapping stations**.
Karnataka	**Full exemption on road tax and EV registrations**. Aims to attract investments of INR 31,000 Cr and create employment for 55,000 persons.
Kerala	Focus on **EV manufacturing**, particularly **e-buses**. To procure 6,000 electric buses by 2025 & provide concessions to manufacturers setting up in the state.
Maharashtra	**Aim:** 10% of all new vehicle should be EV 2025, Mandated all public bodies for EV purchase.
Tamil Nadu	Aims to become an EV manufacturing hub and **attract investment in manufacturing facilities**.
Telangana	Aims to attract investments of 4,000 crore over next 5 years. Plan to set up **800 EV charging stations** by the end of 2022.
Uttar Pradesh	To roll out **1 million EVs on roads by 2024**. 1,000 electric buses and 200,000 charging stations by 2030. Electrification of 70% public transport by 2030.
Uttarakhand	**Incentive** of **10%** of cost on vehicle or INR 7,500 on e2Ws, and of **5%** or INR 50,000 on e4Ws

Source: State EV policy, PwC Research & Analysis
For in detail description of individual state policies, click here.

...resulting in the *initial wave of EV adoption* and encouraging manufacturers to allocate capital to EV manufacturing

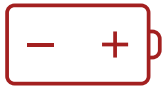
FY22 Sales (vs. FY21)

- **Uttar Pradesh**: 82,024 (↑ *159.6%*)
- **Maharashtra**: 51,422 (↑ *446%*)
- **Karnataka**: 46,180 (↑ *254%*)
- **Tamil Nadu**: 39,629 (↑ *231%*)
- **Delhi**: 34,522 (↑ *192%*)

Sales numbers include e-3Ws, e-2Ws & e-PVs

Investments in EV manufacturing

- **Simple Energy** – *INR 2,500 Cr* – manufacturing facility in Tamil Nadu
- **Pinnacle Industries** – *INR 2,000 Cr* – EV manufacturing units in Pune and Indore
- **TPEML** – *INR 725 Cr* – 300,000-unit manufacturing plant in Gujarat
- **Ather Energy** – *INR 650 Cr* – 400,000-unit capacity plant in Karnataka



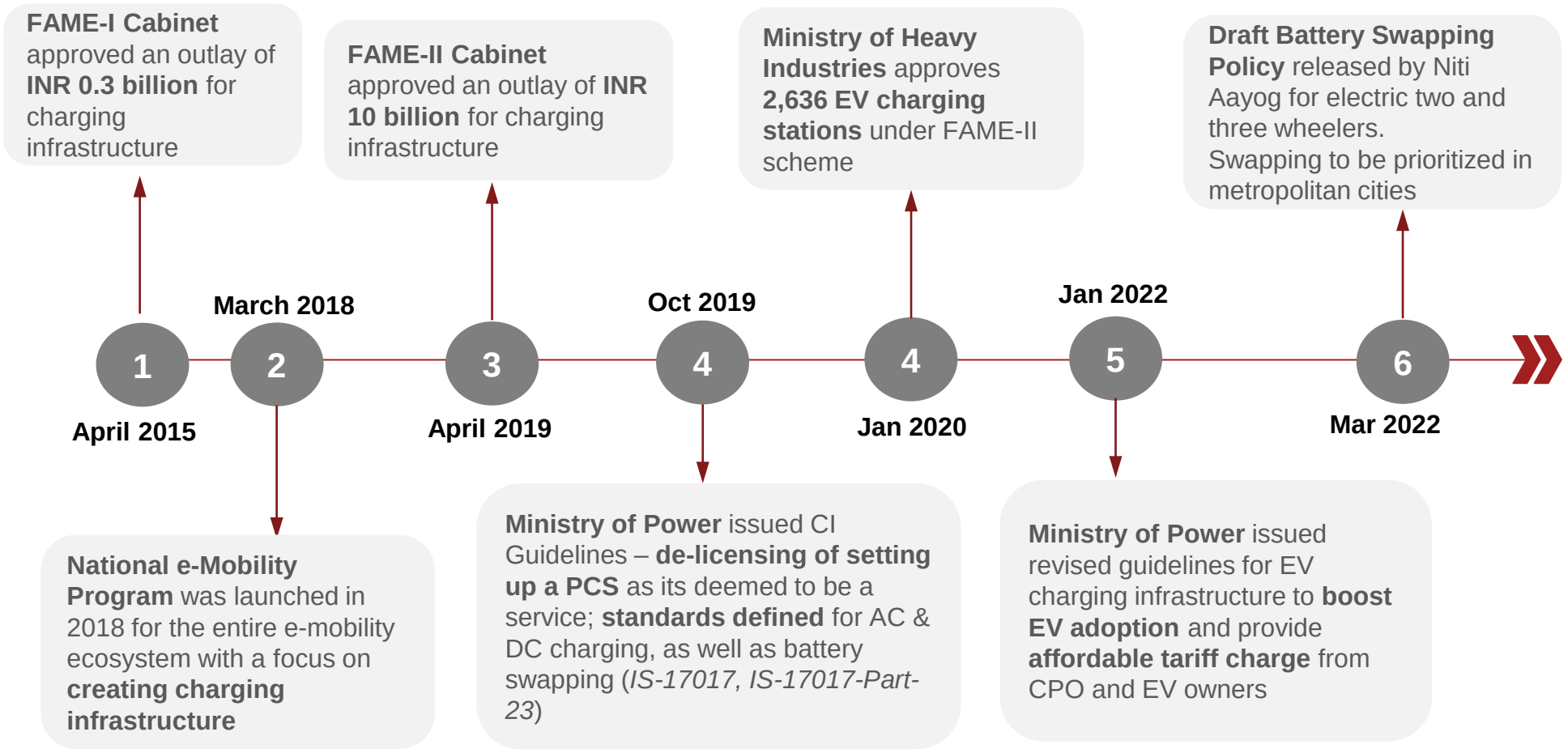
Investments in battery manufacturing

- **Suzuki** – *INR 10,445 Cr* – battery manufacturing plant in Gujarat
- **Exide Industries** – *INR 6,000 Cr* – lithium-ion cell manufacturing unit in Bengaluru
- **Ola Electric** – *INR 3,725 Cr* – Battery Innovation Centre (BIC) in Bengaluru
- **Cygni Energy Private Limited** – *INR 300 Cr* – 40,000-battery capacity plant near Hyderabad

Source: The Economic Times, Vahan Dashboard, PwC Research & Analysis
Note: USD to INR conversion taken from average of monthly settled prices for FY22

In order to drive the next phase of growth adoption, the government is focusing on *developing charging infrastructure*

Central Government initiatives to boost charging infrastructure and battery storage



Key Points

1. **22,000 EV charging stations** to be set up by public sector OMCs by 2023
2. **Revenue sharing model** for installation of public charging stations
3. Delhi government mandates allocating **5% parking for EV charging**
4. *Charging stations sanctioned under FAME II:*
   a. **1392** charging stations on 16 major highways
   b. **184** charging stations on 9 expressways
   c. **2877** charging stations for 25 states/UTs

Source: Public Information Bureau, PwC Research & Analysis

GoI has declared its *focus on interoperability,* which is attracting investments in the charging space to give the much-needed infra. boost

Battery Charging

1 Government focus on promoting interoperability

Public EV Charging Standards : *Bharat EV Charger AC001 and DC001*

Charging Protocols : *CHAdeMO, CCS-2, Type 2 AC (for 2&3W) and the Bharat Chargers will all co-exist*

Charging station setup : *De-licensed activity for public charging stations*

2 Several players have announced big plans

Player	Announcement
Tata Power	***10,000*** public charging stations in 5 years
REIL	***4,244*** public charging stations across India
Ather Energy	***5,000*** EV fast chargers across India by 2025
Volttic	***12,000*** charging points by 2025-26
Fortum	Partnerships with *Charge+Zone*, *Plug Mobility, IOCL*

Source: The Economic Times, PwC Research & Analysis

Battery Swapping

1 Government focus on promoting interoperability

NITI Aayog + Bureau of Indian Standards + Department of Science & Technology

Standards for battery swapping to promote interoperability

2 Players are steadily entering the swapping market

Player	Announcement
Sun Mobility	• ***500*** swap points within 2022 • ***$50 million*** fundraise from *Vitol*
Gogoro	Partnerships with *Hero Motocorp & Yamaha India*
LithIon	***200*** swapping centres in 2 years
Honda Power Pack	New subsidiary for battery swapping services

In the backdrop of infra. growth, EV adoption in India could be driven by – *preferences for shared mobility & quantum of vehicle usage*

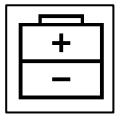
Possible adoption scenarios

	High vehicle usage (in kms)	**Low vehicle usage** (in kms)
Shared Mobility	Mass, convenience & TCO driven • Total cost of ownership key purchase factor • Government and captive owned EVs – fleet driven • Charging infrastructure owned by fleet • Private fleet buyers slow to adopt	Selective, Subsidies driven • Cost economics favorable only with EV subsidies • High passenger load factors but low operating range • Small fleet or individual owned EVs • Public fast charging infrastructure user
Private Usage	Selective, Cost driven • Cost of acquisition & operating cost favorable • Combination home/ workplace charging & public fast charging needed	Environment Conscious, subsidies driven • Improved cost economics with subsidies • Home/ workplace charging user • EV will be purchased as second/ third car

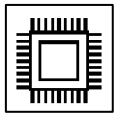
Contents

Opportunities for component manufacturers exist across EV components, *EV aftermarket* and *EV services*

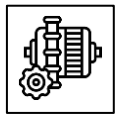
EV Components



1. **Battery Pack**



2. **BMS & Power Electronics**



3. **Traction Motors**

4. **Lightweighting** (AL Die Cast Structural, Battery Trays)

5. **Charging Equipment**

EV Mobility Services

EV Fleet Services

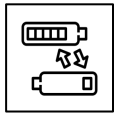
EV Manufacturing & Service Plays

EV Battery End-of-Life (EoL)

Battery Pack Recycling & Reusing

EV Services / Aftermarket

1. **EV Fast Charging**



2. **Battery Swapping**

3. **EV Retrofit Kits**

Source: PwC Research & Analysis

1

EV Components

Batteries form a major portion of EV costs; global battery market estimated at $116 Bn by 2030; significant reduction in Lithium-ion prices expected (dropped ~90% from 2010-2021)

Various battery types

Non-exhaustive

Advanced batteries

Lead Acid Battery

Primarily to supplement other batteries. High powered, inexpensive, short life

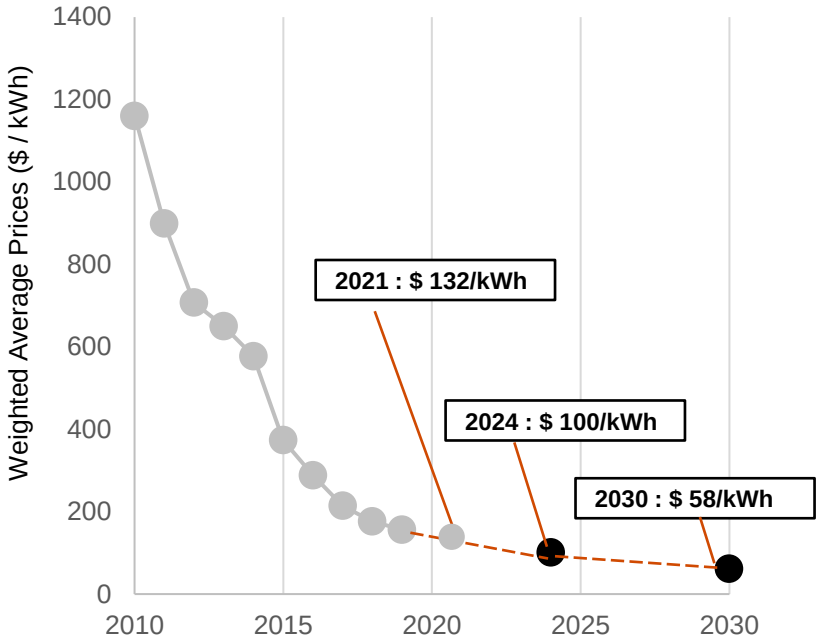
Nickel Metal Hydride battery

Used in hybrid vehicles, Expensive, high self-discharge rate, less effective (vs Li-ion)

Lithium-ion battery

Most commonly used battery in electric cars, Higher energy efficiency and temperature performance

Lithium-ion battery : Price outlook



Source : Bloomberg NEF Battery Price Survey, 2021

Key insights

- **Near to Mid term shifts from lead-acid to 'advanced batteries', high energy density cathodes**
- **In the longer term, new technologies such as silicon or lithium anodes, solid state cells and new cathode materials will help reduce battery prices further**
- **Sourcing strategies: Growth in BEV sale > Increasing order size > Better price negotiation**
- **New pack designs and falling manufacturing costs (economies of scale) expected to reduce prices further**

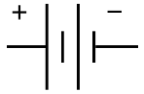
Lithium-ion battery manufacturing value chain houses several mature players; Competitors must consider intensity of competition & long-term sustainability to choose their battery plays

	Materials Supply	Cell Manufacturing	Module & Pack manufacturing	Power Electronics	Integrator and Controls	Construct and Maintain (EPC)	Development
Description	▪ Supply raw materials for cathode, anode, electrolytes, etc.	▪ Develop and manufacture cells	▪ Arrange cells into modules and pack ▪ Provide battery management software (BMS)	▪ Design and sell power electronics (such as inverters)	▪ Design & package the battery system ▪ Provide higher-level Energy Mgmt. software	▪ Ensure project design & installation, Maintenance, Replacement	▪ Sell to the end-customer ▪ Organize the implementation ▪ Provide financing
# of players	*>20*	*>20*	*>50*	*>100*	*>100*	*>250*	
2021 EBIT Margin	*-1% to +10%*	*-8% to +8%*	*+9% to +12%*	*+8% to +10%*	*+2% to +5%*	*n/a*	
Key trends	• Growing demand for materials such as Lithium, Nickel & Zinc • Compensated by increased bargaining power of battery manufacturers	• Pressure to decrease Battery prices is driving race to achieve scale • Battery makers are adding large amounts of new manufacturing capacity despite under utilization of existing capacity • Intense competition to improve Energy storage system economics for buyers leads to lower margin	• Industry has followed horizontal orientation for inverters, using standardized interfaces to allow mix-and-match assembly of devices	• Increasingly complex software to serve diverse applications • More players are entering the integration space from a variety of backgrounds & capabilities, increasing competitive pressure	• Increasing demand for contracts that include full set of guarantees) as developers look to place more risk on EPCs • Developers increasingly want to engage with larger, more stable EPC firms	• Deployments shifting from front of the meter to behind the meter as C&I customer adoption grows • Financers are increasing lending for energy storage projects as comfort with technology grows	

Preference for HV architecture in EVs opens opportunities across several power electronic components for suppliers

Power Electronics – Components

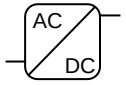
HV battery Junction Box



DC/AC inverter

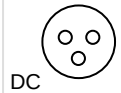
Motor

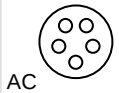
On-Board Charger



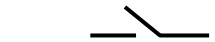
DC/DC converter

Charging port





BDU



PDU

eA/C

eHeater

Wiring Harness

HV AC connector

HV DC connector

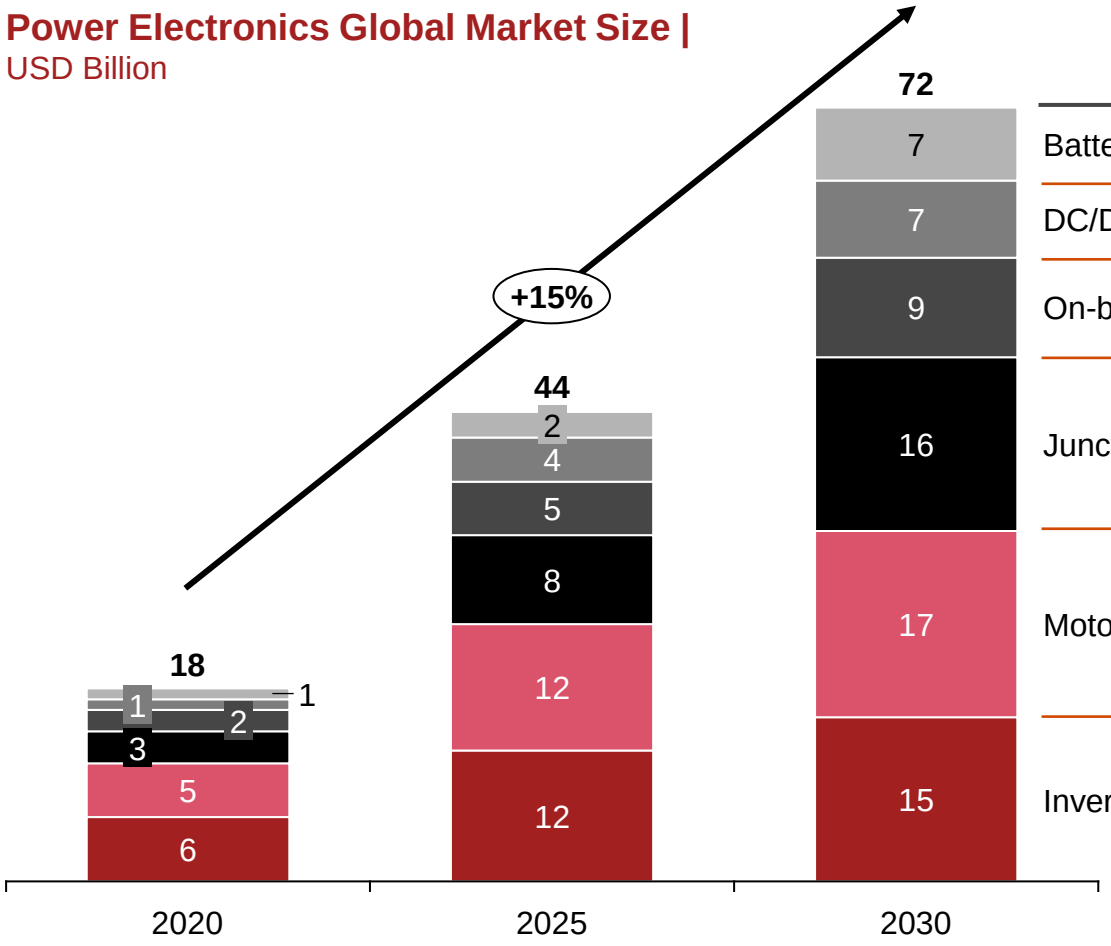
Integration

Mechanical integration	Electrical integration
Thermal circuit (cooling/ heating)	Functional component boundary

NOTE : eA/C: electric A/C compressor, eHeater: electric heater (air or coolant), PDU: Power distribution unit, BDU: Battery Disconnect Unit (contactors, fuses); OBC: On-Board-Charger

The power electronics market is expected to grow at a 15% CAGR from 2020 to 2030; High growth opportunities exist across several part categories

Power Electronics Global Market Size |
USD Billion



	CAGR (2020 – 2030)
Battery Mgmt. System	21%
DC/DC Converter	22%
On-board Chargers	17%
Junction Box	18%
Motor(s)	13%
Inverter	10%

Key Growth Drivers

1 Preference for HV architectures

- Increased ASP of converters due to high efficiency & low EM interference
- Separate converters required for infotainment & safety systems
- Complex control algorithms for HV applications to drive specialization

2 Accelerated global EV adoption

- Govts'. focus on battery safety to drive market premiums for BMS
- Improvements in EV performance & customer demand for feature richness to drive growth in junction boxes

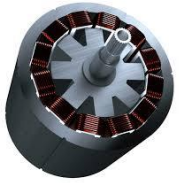
Traction motors shall remain an attractive segment for manufacturers; Useful to power electric vehicles and also drive in-vehicle applications

Various motors types used in EVs

DC series motor & Brushless DC motor (BLDC)

Permanent magnet Synchronous motor (PMSM)

3 Phase AC induction motor



Switched reluctance motor (SRM)

Attributes preferred by OEMs

- Increased life due to lower maintenance
- Compactness preferred for in-vehicle applications
- Improved comfort due to lesser noise
- Higher efficiency from better torque to weight ratio

Applications extend beyond powering an electric vehicle

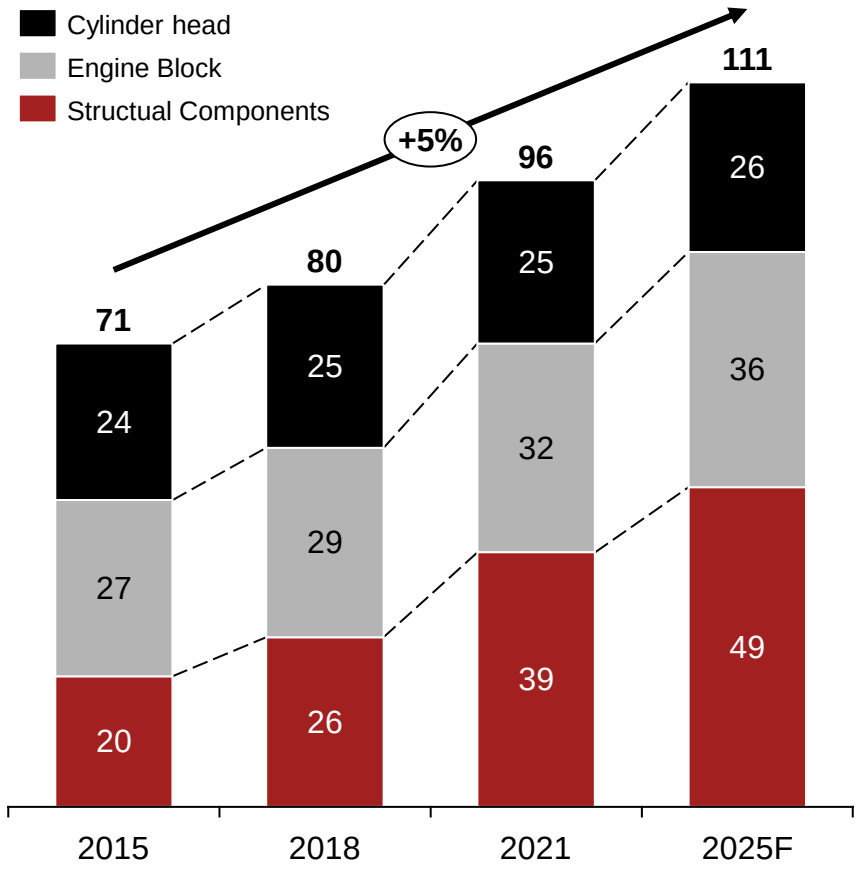
Modern automobiles use ~40 electric motors on average. Less than 25% of these motors are ICE specific

Radiator fan	Trailer hitch retract
Radiator shutters	Traction motors
Oil Pump	Trunk/hatch lift
Water Pump	Fuel/charge port flap
Fuel Pump	Sun shades
eTurbo	Power windows
eVVT	Sun roof
Folding side mirrors	HVAC dampers
Running board retract	Ventilated & heated seats
Mirror XY	Seat adjusters
Sliding doors	HVAC blowers
Ride stabilization	Door locks
Steering wheel extend/tilt	Pedal extend
Windshield wipers	Adaptive headlights
AC compressor	Power steering

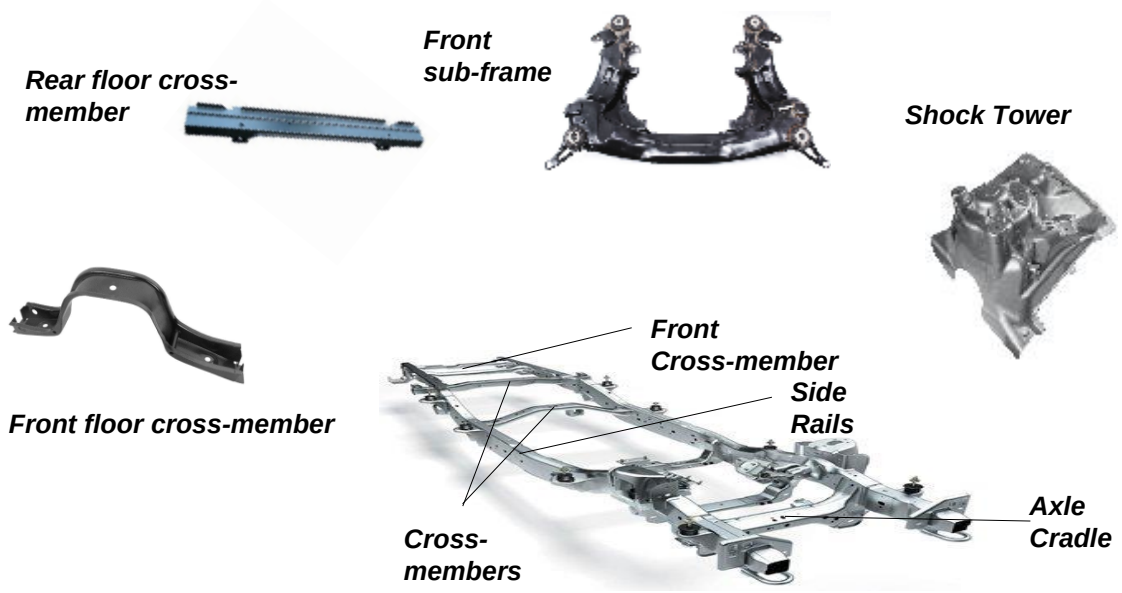
ICE applications Propulsion agnostic applications

The shift from ICE to EVs expected to increase focus on light-weighting due to enhanced battery range benefits from lighter vehicles; Sound opportunity for AL structural parts

Estimated Aluminum Casting Weight (kg/vehicle), Global



Examples of Automotive Aluminum Die Cast Components



Sample of Structural Components using Aluminum

Battery Trays are another structural element with favorable possibilities of weight reduction in exchange for enhanced battery range

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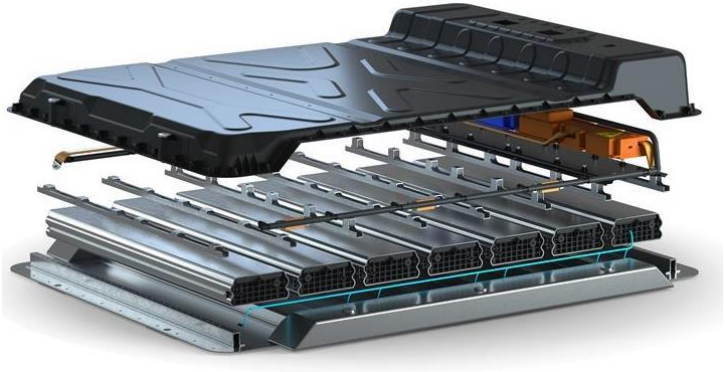
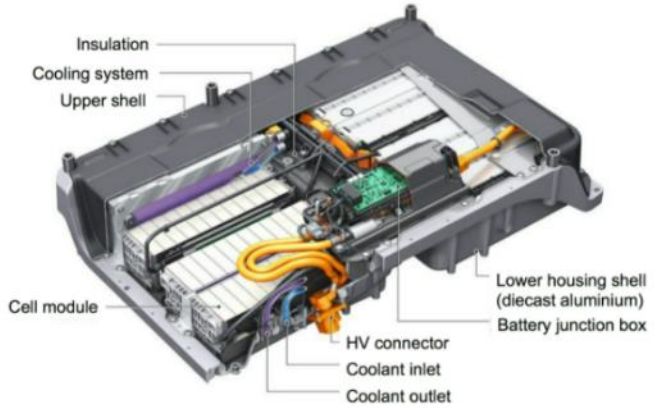


Sandwich architecture Battery tray, typically used for lightweighting

2



Battery tray for **Audi e-tron**

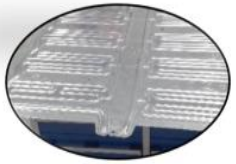
Key components of an EV battery tray

Top protection cover

- Upper seal of the tray
- Passenger compartment protection from heat / fire

Structural frame and cross members

- Protection from intrusions in a crash



Cooling plate / Thermal management

- Good thermal conductivity to ensure stable operating temperature of batteries
- Can be also integrated in the bottom cover

Bottom protection cover

- Protects the cell from undercarriage impact, road debris, etc.

EV charging equipment can be split into electrical components and power electronic components

ELECTRICALS

SWITCH DISCONNECTORS
- De-energize electric circuit by breaking the circuit
- Used when there isn't a need to draw power from the grid

MINIATURE CIRCUIT BREAKERS

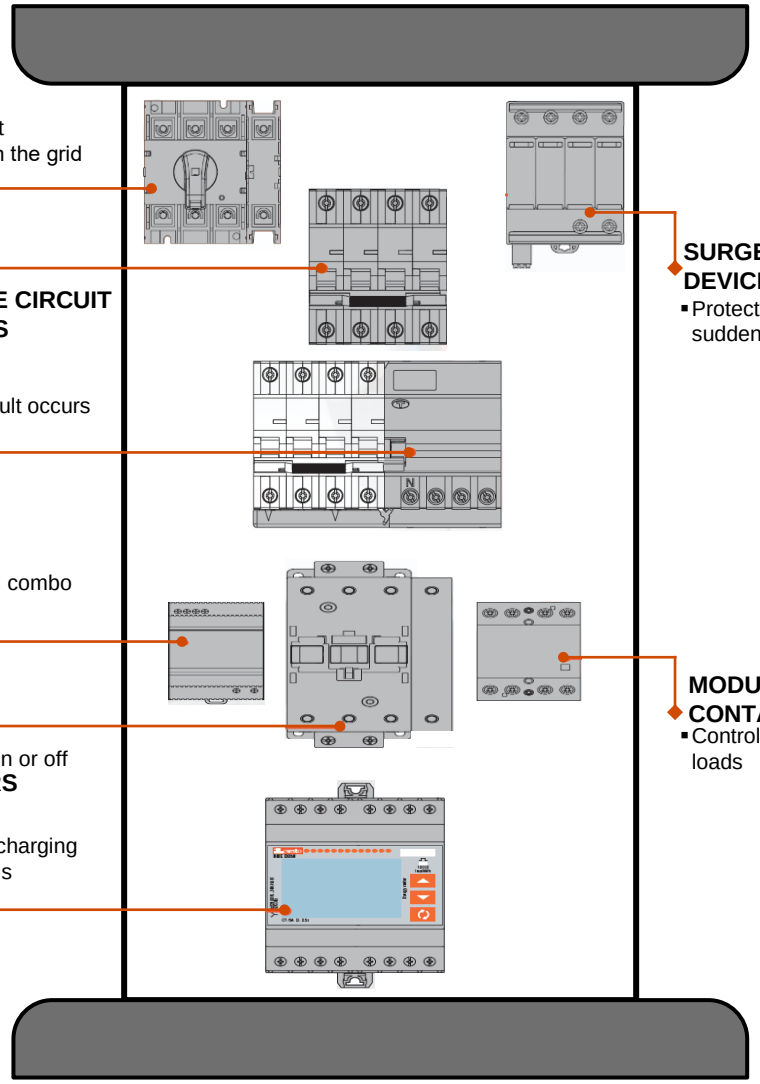
RESIDUAL BLOCKS FOR CIRCUIT BREAKERS
- Sense current & disengage circuit whenever a fault occurs
- Provide protection from electric shocks

SWITCHING POWER SUPPLIES
- Rectify & filter input voltage through regulator
- Switch input from AC to DC output or the desired combo

- Switch circuit on or off

CONTACTORS

ENERGY METERS
- Monitor the amount of AC energy consumed for charging
- Digitally integrated with billing & payment systems



SURGE PROTECTION DEVICES
- Protect circuitry from sudden voltage surges

MODULAR CONTACTORS
- Control small capacity loads

POWER ELECTRONICS

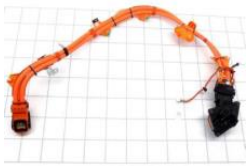
AC/ DC converter

DC/DC converter

Controller

Charging Connector

HV AC connector



HV DC connector

EV charging connectors are another opportunity, especially since one charging box can have up to three connectors with different standards

9.6 million estimated charging ports required by *2030*

Source: Edison Electric Institute

Home Charging
7.5 million

Workplace Charging
1.2 million

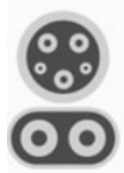
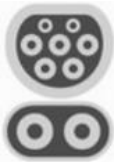
Public Charging
100,000

Destination Charging
800,000

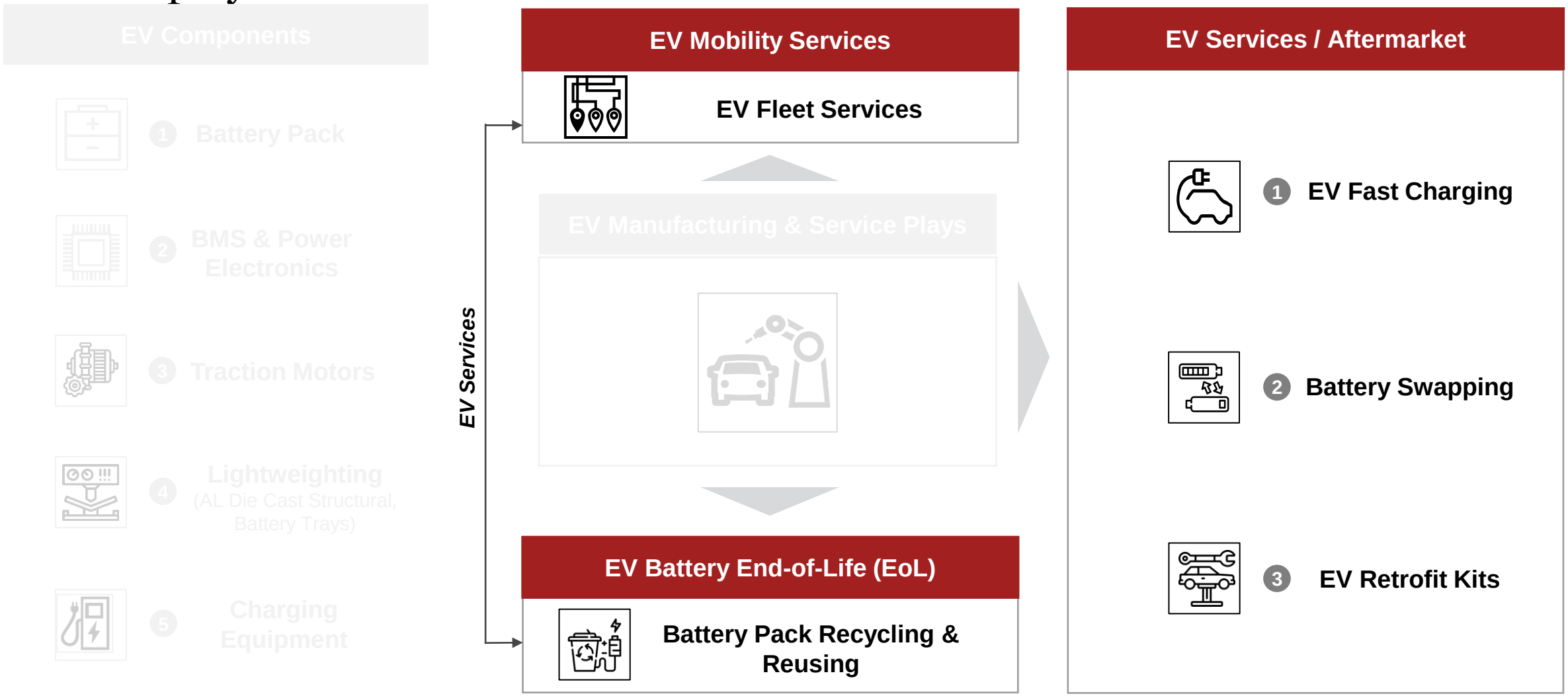
EV charging connector standards defined by **3 levels**

System Type	AC	DC
Level 1	120V single-phase Up to 16A and 1.9kW Typically 12A	200-450V Up to 36kW, 80A
Level 2	240V single-phase Up to 80A and 19.2kW Typically 32A	200-450V Up to 90kW, 200A
Level 3	AC charging above Level 2 Some EVs support three-phase AC up to 4kW	Also called DC Fast Charge (DCFC), 200-600V DC Up to 240kW, 400A

EV charging connector standards | connector pin layout

	AC	DC
Level 1	 *J1772 (Type 1)*	 *Combined Charging System (CCS1)*
Level 2	 *Mennekes (Type 2)*  *GB/T*	 *CCS2*  *GB/T*
Level 3	 *Tesla*	 *CHAdeMO*

Initial wave of EV adoption has resulted in a sizeable population of EVs on-road; component makers must now also focus on their *EV aftermarket* & *EV services* play



2

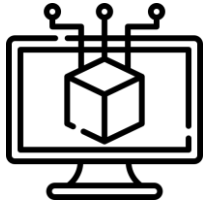
EV Aftermarket

There are various use cases for EV charging infrastructure; Fast charging use cases are found in *Away from Home* charging applications

Charging patterns	At Home	Away from Home		
	Home Charging	Work Charging	Destination Charging	Public/ Rapid Charging
General Use Case	Expected to be the majority source in developed nations. However, not most suitable in India	**"Near Home"** Users looking to charge when convenient, requires partnered offering (e.g., office spaces, retail areas). Would have to compete with at-home rates on price		**"Far From Home"** For users travelling far from home, less price sensitive as speed and availability are more important drivers
Description	Charge vehicle at home when not in use, **off-street**	Top up charge during the day at work	Top up charge when visiting **regular destinations**	- Charge your car from public charging point or charging hubs - Charge at strategic locations **for long journeys or for charging commercial fleets**
Charging Speed	**Slow charging**: 6-15h; 3 - 7kW	**Slow and Medium charging:** 6-5h & 2-4h; 5-7 kW & ~20 kW	**Fast charging:** 2 - 4h; 50kW	**Medium, Fast and ultra-fast charging:** 2-4h & 45mn; 22 kW & 50+kW
Customers / Location type	Homeowners with parking space	Companies with car parks	Supermarkets, hotels, restaurants, Car park operators, etc.	EV owners, E-taxis, highway service operators, petrol pumps, etc.
India Standards	**No specific standards defined,** generally used with a 230V/15A single phase plug	• Public EV Charging Standards : **Bharat EV Charger AC001 and DC001** • **CHAdeMO, CCS-2, Type 2 AC (for 2&3W) and the Bharat Chargers will all co-exist** in India in the near future. However, future products will have higher power requirements and hence they are designed to be compatible with the more globally accepted standards i.e. CCS and CHAdeMO		

Source: PwC Research & Analysis

EV Fast-charging offers *six possible value plays*; Players are integrated through a CPO[1] that delivers the charging service to customers



Charge Management System

Landowner

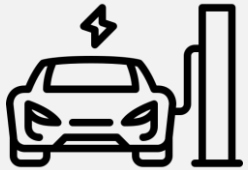
EV Supply Equipment

Energy Supplier

A CPO usually works with various stakeholders to procure infrastructure

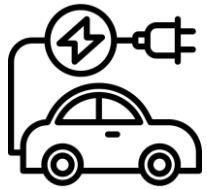
An e-MSP enables discovery of charging points & captures customer data

Master



[1]Charge Point Operator (CPO)

E-Mobility Service Providers (e-MSP)



End Customer (EV Owner)

e-MSPs provide **access to charging stations across their network** while a master e-MSP **aggregates multi-brand charging stations** and provides access to the customer

To scale EV charging infrastructure & deliver growth, players *need to build strategic partnerships*

Need for Partnerships

1. Revenue stacking:
   Club EV charging with additional revenue streams due to low utilisation rates currently (5% - 10%)

2. Cost control:
   Charge point operators (CPOs) can achieve commercial viability through partnering with players that control inputs to EV charging

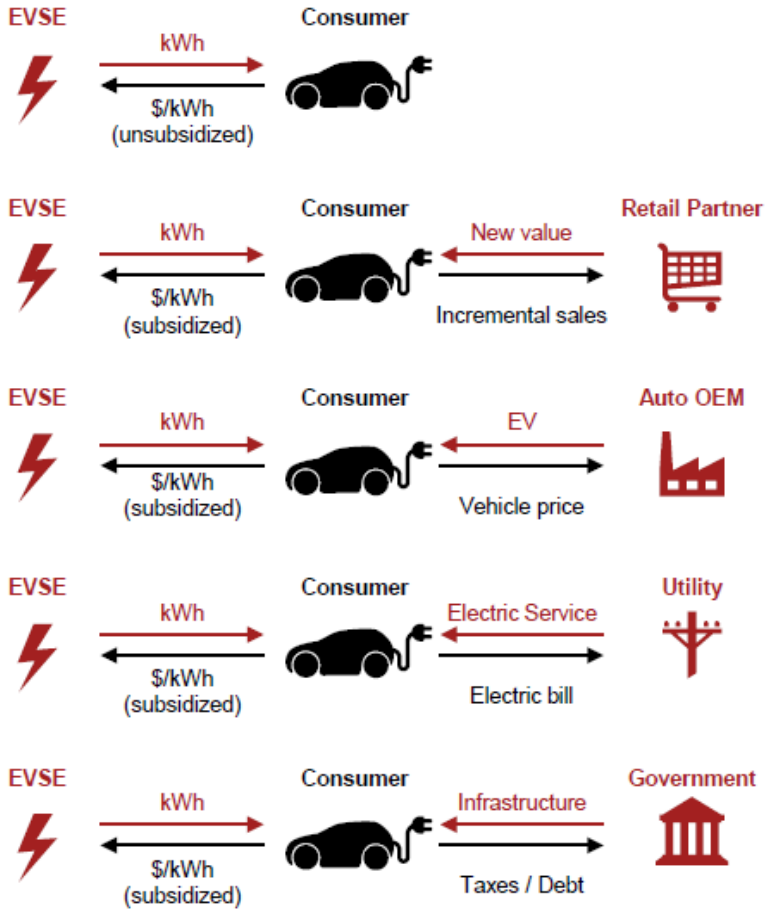
Overview of Partnership Options for Charge Point Operators (CPOs)

Key Criteria	Charging Segments			
	Home Charging	**Work Charging**	**Destination Charging**	**Public/ Rapid Charging**
				
Critical Now	• EV car manufacturers • Vehicle leasing providers	• Commercial estate management companies • Land owners	• Parking spaces at commercial hubs (supermarkets, gyms, retail hubs, etc.) • Land owners	• Metropolitan agencies • Universal card payment providers • Advertising agencies • Land owners
Important tomorrow	• Home builders • Municipal councils	• Vehicle leasing providers	• Advertising agencies	• Premium EV car manufacturers (large battery modules)
In the long term	• Retail energy suppliers • Renewable energy hardware (solar PV, battery storage)	• Advertising agencies • Specialist energy management companies	• Owners of experience centres (restaurants)	• Distribution network operators

Public-private partnerships key to succeed in EV fast charging as resulting *cross subsidized infra. models* provide favorable economics

Subsidized vs. Standalone Business Models

Standalone (Own and Operate)	• EVSE[1] company provides charging infrastructure and services without subsidization • Costs are passed to consumers in charging rates
Retail Host – Owned Channels	• Retail host utilizing EV charging to drive increased foot traffic • Subsidize EVSE investment and monetize investment via other means
Auto OEM Subsidization	• Auto OEMs help finance EVSE investment CAPEX • Price of EV infrastructure recovered in EV car sales price
Utility Partnership	• Work with electric utilities to incentivize EV adoption and EVSE charging infrastructure deployment • Potential to pass investment costs to customers via regulated rates
Government Run	• Subsidize EVSE investment with tax collections or government debt • Useful for segments that would not otherwise attract investment



1 EVSE – electric vehicle service equipment (charging equipment manufacturers)

Innovative new business models will be needed to sustain earnings from fast charging; Competitors currently relying on four prominent revenue models

	Revenue Model	Revenue Stream Descriptions	Example Players
Currently prominent models	Equipment Manufacturing / Sales	Selling to both authorized resellers and direct to customers, OEMs generate revenue on the sale of their **EV charging products**	DELTA, ABB, EXICOM POWER SOLUTIONS
	Own & Operate	Own, install, and operate charging station – generating revenue from **membership fees**, **station usage fees**, and **advertising**	TATA POWER, CHARGE ZONE POWERING THE FUTURE
	Host Owned	Sell, install EVSE, collect additional **network connection fees** and **payment transaction fees**; host owner sells and collects usage fees	magentapower Green Energy Solutions
	Hybrid-Ownership	Share installation, upfront costs with host, and **revenues from usage fees**	Fortum charge & drive, OKAYA NEVER STOP INDIA
Forward-looking services and revenue streams	App/ Network	Open networks and applications enabling **interoperability** between EVSE owners and other networks	Numocity, kazam, ElectreeFi
	Data Monetization	**Advanced data analytics** for users and station owners reveal energy usage trends, help partners make optimal investment decisions	sensorise connect & serve
	Fleet Services	Add-on **usage tracking**, **energy** and **load management** solutions, with potential **deployment** and **route planning**	BLU SMART MOBILITY

Non exhaustive

Source: PwC Research & Analysis

While fast charging is currently more established, *battery swapping is another method that can co-exist*

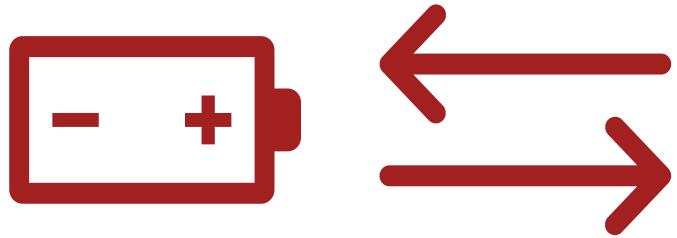
Charging

EV fast charging – Consists of plugging-in an EV battery to equipment which can recharge it

Rationale is to **top-up an EV battery** as quickly as possible to reach destination

Standards have already been well-established across markets; Easier to achieve interoperability

Requires battery to be sold along with the vehicle, increasing acquisition cost



Swapping

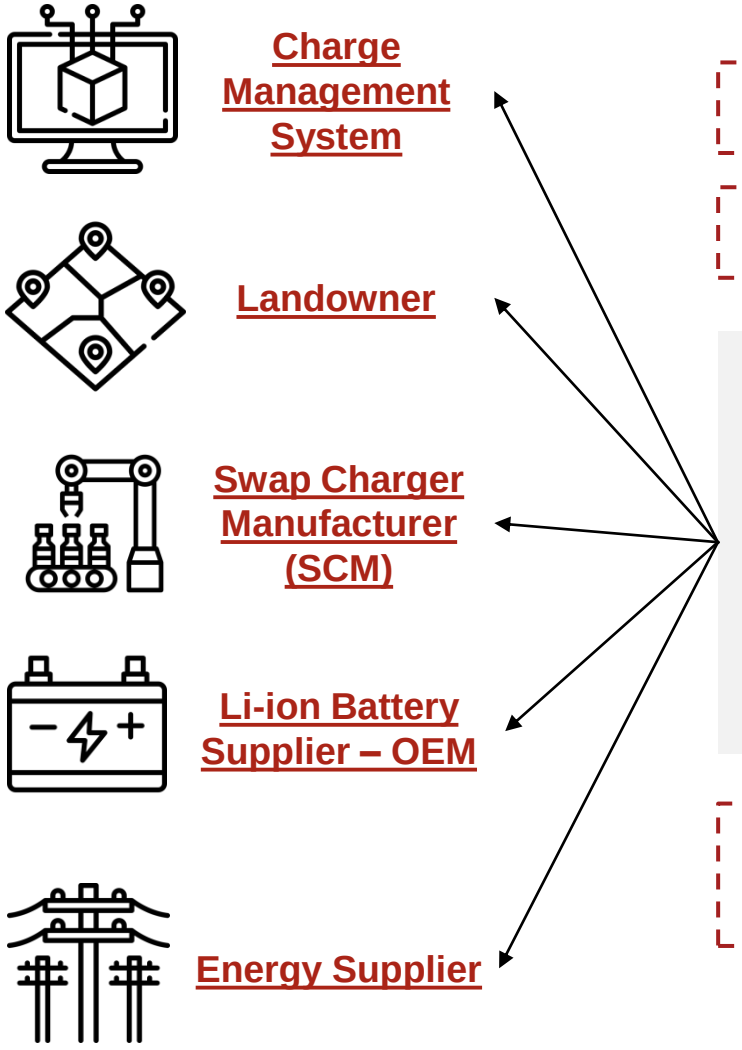
Battery Swapping – Consists of mechanically swapping a discharged electric battery with one that is already charged

Rationale is to **de-link the battery cost from EV cost** & minimize re-charging time by simply swapping a spent battery

Relatively new concept with standards in major markets yet to be established; Interoperability key for success but harder to achieve

Enables **innovative business models** such as **battery-as-a-service**, thereby reducing acquisition cost

EV Fast-charging offers *seven possible value plays*; Players are integrated through a SOO[1] that delivers the swapping service to customers



An SOO works with various stakeholders to procure & setup infrastructure

Swapping ,ore suited to e2Ws & e3Ws due to lower battery weight (<10 kg)

Idea is to transfer the battery cost – which accounts for 30-40% of the total EV cost – from the customer to an SOO

Source: PwC Research & Analysis

Case Study – PowerSwap, a Swedish battery swapping operator, has pioneered an interesting business model for Swap Outlet Operators

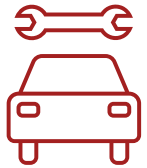
Key Features of PowerSwap's Business Model

Overall business model is based on **sales of battery swap equipment** as well as **licensing agreements** with OEMs and battery manufacturers

Power Swap System **automatically identifies the battery** in the vehicle and stores it in the charging compartment, swapping it with a charged battery

Swapping is executed horizontally, **through the side of the vehicle**, rather than from underneath thus reducing complexity

Drive-Thru Service: The entire process. as well as payment, is handled through a mobile application, thus allowing for easier access



Solution relies on **compact mechanical unit** – needing only 12 m^2 space – rather than a large "charging" station

Prioritize installation of swap stations in **existing petrol pumps/parking lots** rather than on unacquired land

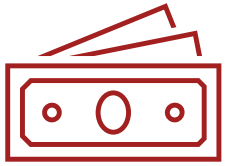
Zero emission source – electricity is sourced through solar, wind and hydro power

Lead time **< 3 minutes**, cost of a single PowerSwap unit is **under € 200**

Source: Company website, PwC Research & Analysis

Depending on the operating needs of the consumers, swapping can bring in major benefits

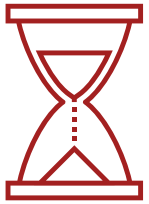
Advantages of Swapping



Lower Cost of Ownership

(based on operating needs)

- EV Battery = 30-40% of total EV cost
- Cost of ownership: Customer ► Operator



Higher Uptime, Asset Utilization

(saving on re-charging time)

- Works for commercial fleet-operated vehicles & private owners
- Only takes 3-5 mins (Supercharging: 20 mins)

Increase in EV penetration

Source: PwC Analysis, The Economic Times

Swapping will prove to be more prominent with e-2Ws & e-3Ws, while fast charging will most likely dominate the e-PV & e-CV space

Segment-wise EV Charging/Swapping Use Cases

			Plug-in Charging		Battery Swapping	
	Vehicle Category	**Capacity**	**Slow Charging**	**Fast Charging**	**Manual**	**Robot Assisted**
	2 - Wheeler	2 kWh	Must Have	Good to Have	Good to Have	Not Required
	3W Rickshaw	3x2 kWh	Must Have	Good to Have	Must Have	Not Required
	3W Auto	10 kWh	Must Have	Good to Have	Must Have	Not Required
	4-Wheeler	25 kWh	Must Have	Must Have	Good to Have	Good to Have
	3W Cargo	18 kWh	Must Have	Must Have	Good to Have	Good to Have

Most Preferred

Source: PwC Research & Analysis

Retrofitting of EV kits is an emerging niche to be explored; Favorable cost dynamics to dictate growth of retrofitment players

Retrofitment: A Brief Overview

Segmentation

Zero-mile
@OEM's assembly line

Aftermarket
@authorized service shops

Age of vehicle

Electrification

ICE > BEV
~80% components replaced

ICE > Hybrid
<25% components replaced

2016 Policy

2016
Policy on EV retro-fitment

Who can?
- ARAI approved kit supplier
- Kit supplier authorized shops

Which vehicles?
- ICE > BEV: RC date 1st Jan 1990+
- ICE > Hybrid: BS II+ | GVW <3.5T

What incentive?
15% to 30% of kit
Based on reduction in fuel consumption

Provided the initial push by bringing several startups and large Indian MNCs into the fray; incentivized retro-fitting from an operator's standpoint

2021 Policy

2021
Policy on EV retro-fitment

Which vehicles?
- Diesel vehicles
- 10+ years old

What incentive?
Bypassing of National Green Tribunal's ban if vehicle is retro-fitted with EV kit

Incentivized retro-fitting from a consumer's standpoint and provided a further boost to this space

Well Established Standards

Regulated by ARAI to approve EV retro-fitting kits

Approval procedure:
I. Kit component level
II. Vehicle level

Type Tests:
- AIS123 – Part 1: Hybrid conversion; light vehicles
- AIS123 – Part 2: Hybrid conversion; heavy vehicles
- AIS123 – Part 3: Electric propulsion kit for pure electric operation

Key Players

retro EV | STARYA | E-TRIO | REXNAMO

Source: PwC Research & Analysis

2

EV End-of-Life Services

Reusability, minimization of wastage is paramount due to high cost & scarcity of key battery elements; High innovation potential since strategies in nascent stages

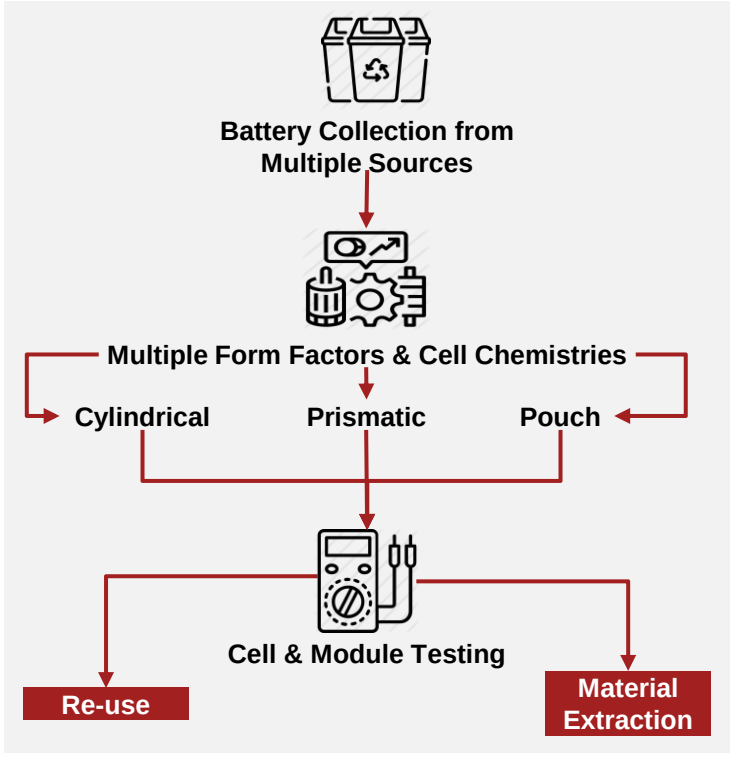
	First Life	*Second Life*	*End-of-Life*
	Swap	**Re-use**	**Re-cycle**
How does it work?	• **Battery leasing** • **Pay per use** • **Renting**	**~20% of the power capacity left in discarded EV batteries; can be used for stationary applications (for example - home charging)**	**Various chemical and metallurgical processes to extract reusable elements, rejuvenate the cathodes**
Pros	• Swapping allows for less time spent charging batteries, **higher on-road%** for EV • Allows for the use of **smaller battery sizes** and lighter construction • Initial **acquisition cost lowered** considerably (battery, power electronics)	• Re-using can extend battery life by **6-7 years** • Batteries used for **stationery applications**: provide high output, ease of use and faster charging • Reused batteries have strong market potential – India & globally (B2B and B2C)	• Crucial for **sustainability** of e-mobility • Recycling to help retrieve valuable minerals from batteries- reduce the need for further mining • Limited competition, early mover advantage
Challenges in adoption	• Limited by design standardization • Requires scale • Cost of carrying inventory • High investments	• Requirement of robust battery packaging capability • Highly competitive market including existing incumbent alternative technologies • Customer's willingness to pay for re-used batteries	• Need for further policy directions/interventions –collection & disposal, financing etc. • Limited awareness and lack of compliance • Slow market growth (maturity time), high investments

Source: PwC Research & Analysis

The battery End-of-Life business model consists of 3 key stages – recycling, re-use and material extraction

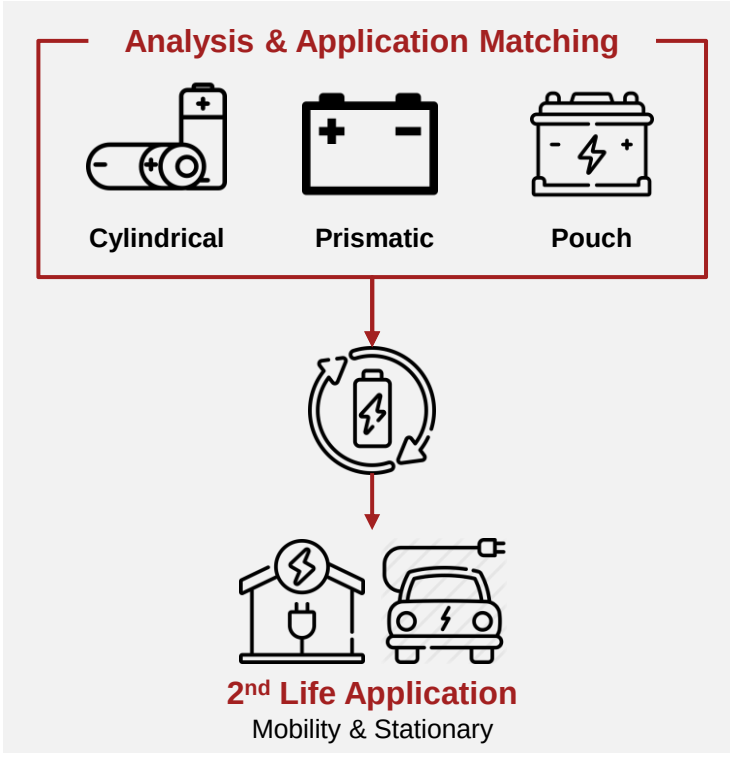
Recycling Business Model

Recycling



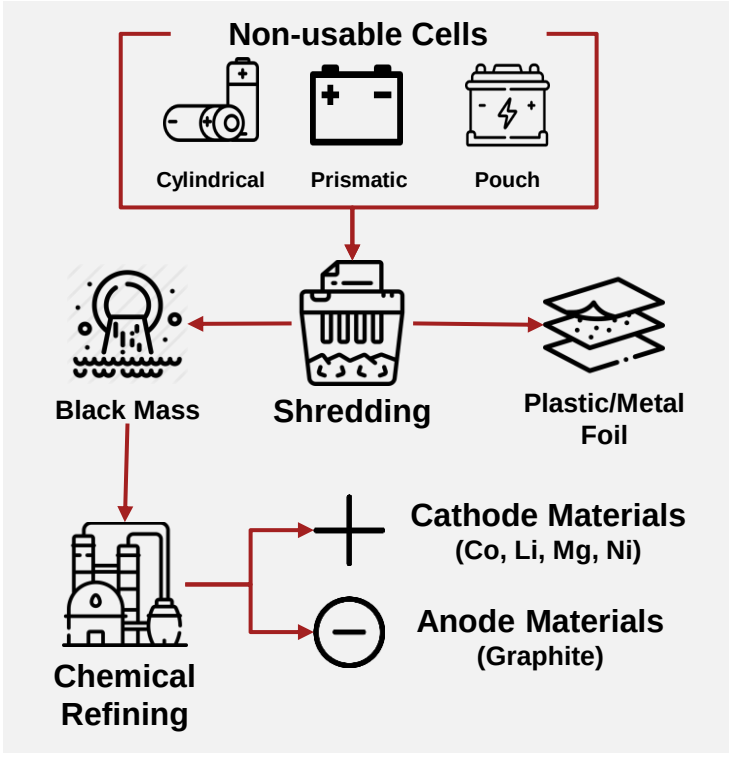
At each step of the chain, like collection to recycling factories value is added and business segment opportunities can be accessed

Re-use



Based on cell form factor and chemistry to manufacture 2nd life Li-ion for uses such as stationary energy storage and energy storage systems for residential or commercial and telecom solutions

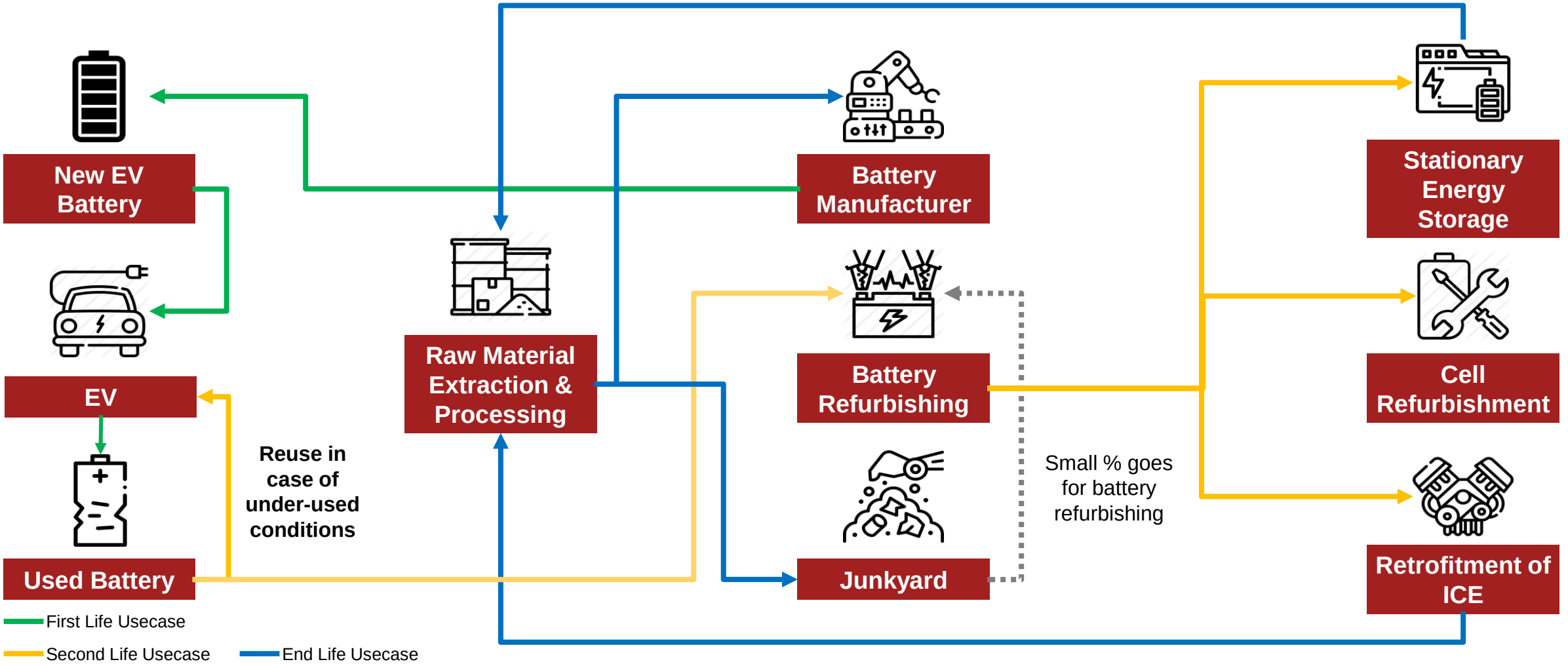
Material Extraction



Final stage when batteries can be used further – they are shredded, and rare-earth metals are extracted to be sold to battery manufacturing companies

Re-use – EV Batteries can have stationary 2nd life use cases before being recycled or discarded

Lifecycle of an EV Battery

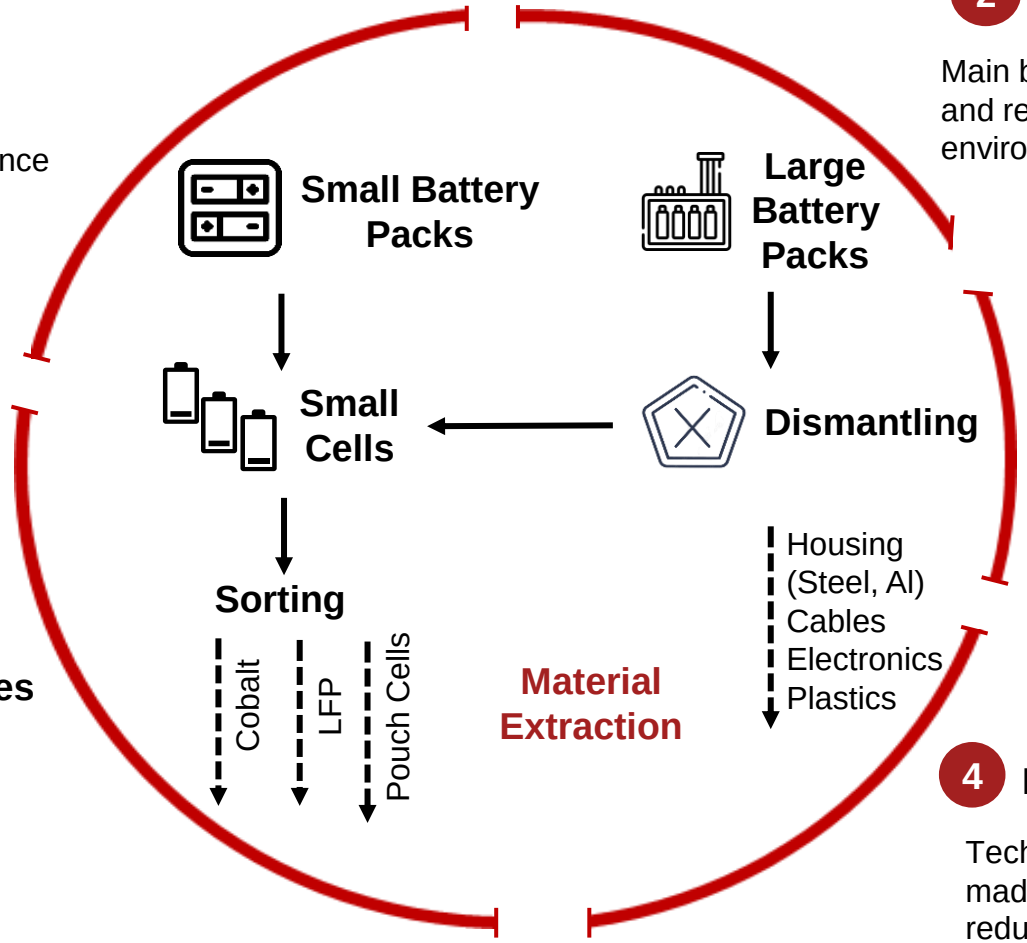


Recycle & Material Extraction – Li-ion battery recycling provides environmental & economic benefits to both customers & recyclers

Recycling Process and Benefits

1 Waste Reduction

E waste reduction, customer preference for recyclable and green products. Used batteries dangerous when disposed untreated in landfills



2 Expensive Metal Recovery

Main business value carrier to extract metals and reuse again in battery making saving from environmental effecting mining process.

3 No Hazardous Gases

Using latest technologies, the complex battery chemistry is controlled to not release any gases in the environment from battery dismantling

4 No Pollution During Recycling

Technologies used in recycling have made significant improvements for reduce wastage.

5 Lowers New Battery Prices

Incentives to customers when replace used batteries, which lowers the used battery price

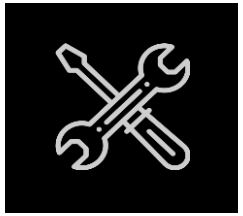
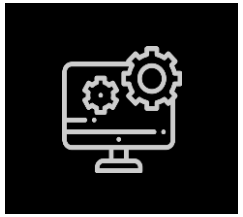
Source: PwC Research & Analysis

3

EV Mobility Services

EV Mobility & Fleet Services are an emerging area of high growth, presenting several ways to play within the value block (1/2)

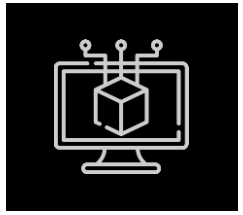
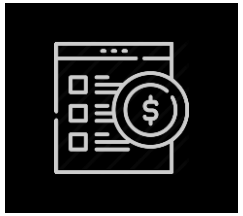
Opportunities Present within EV Ecosystem

	WAYS TO PLAY	KEY ACTIVITIES	TOOLS & SYSTEMS USED
	**Fleet Ops/Management**	• Maximizing EV asset utilization (vehicles, chargers) • Onboarding & training drivers/ operators • Identifying demand centres & onboarding customers • Undertaking marketing efforts for brand awareness • Building effective business models (operating model, pricing, staff)	• Route planning (with charging considerations) • Driver monitoring & coaching • Scheduling (utilization, maint., charging, etc.) • Ops. Management (telematics, etc.)
	**Asset Ownership & Leasing**	• Evaluating market dynamics • Defining asset purchase model (e-vehicles, charging infra, land) • Raising capital for purchase of assets • Building asset leasing/ pricing model (pay per km, pay per use, etc.)	• Demand forecasting & planning • Asset lifecycle management • Pricing analytics
	**Asset Maintenance**	• Monitoring EV assets' health & usage patterns • Repairing batteries, motors, chargers & mechanical parts • Sourcing of replacement parts • Training technicians and mechanics	• Battery health monitoring & diagnostic systems • Charger health & diagnostic systems • Predictive maintenance analytics • Remote assistance
	**Hardware & Software**	• Designing hardware systems for collecting EV asset-related data • Operating assembly units & sourcing hardware components • Building software applications for fleet operations optimization • Integrating hardware & software for fleet optimization	• Embedded systems • APIs

Source: PwC Research & Analysis

EV Mobility & Fleet Services are an emerging area of high growth, presenting several ways to play within the value block (2/2)

Opportunities Present within EV Ecosystem

	WAYS TO PLAY	KEY ACTIVITIES	TOOLS & SYSTEMS USED
	**Digital, Analytics & Connectivity**	• Building systems for transmitting & storing fleet data • Creating platforms & algorithms for analysis of fleet data • Developing dashboards & visual aids for fleet managers • Integrating data from multiple sources to drive impactful insights	• Data warehousing • Cloud capabilities (architecture, security, etc.) • AI/ Machine Learning • Data visualization
	**Charge Management System**	• Capturing asset operation info. for chargers deployed • Assisting in descriptive & predictive maintenance for charge points • Optimizing grid energy load management for charge points	• ERP integration • Software capabilities • Machine to machine communication (grid to charger smart energy management)
	**Price Accessibility/ Discovery**	• Accessing info. on asset utilization (peak times, load, etc.) • Developing platforms & algorithms for analysis of pricing data • Integrating customer pricing with digital apps & ERP systems	• APIs • Cloud capabilities • AI/ Machine Learning • ERP integration

Source: PwC Research & Analysis

Several competitors have made initial forays into the EV Mobility Services space, intensifying competition & creating innovative business models

Competitors within each Sub-Segment

Non-exhaustive, Illustrative

Fleet Ops/ Management

- ZYPP ELECTRIC
- BLU SMART MOBILITY
- ZYNGO LOGISTICS REDEFINED
- Lithium Tomorrow's Transportation.Today.

Asset Ownership & Leasing

- TATA MOTORS
- SWITCH
- Mahindra
- alt. mobility

Asset Maintenance

- UFO DRIVE ADVANCED EMOBILITY
- retro EV
- GREEN TIGER
- AUTOCRAFT Solutions Group

Hardware & Software Integration

- webfleet
- FEV
- BOSCH
- WATEA by Michelin

Digital, Analytics & Connectivity

- voltaiq
- TWAICE
- Coulomb AI
- INTANGLES A DIGITAL TWIN COMPANY
- vodafone

Charge Management System

- driivz
- Numocity
- +EVteQ-
- CHARGELAB
- kazam

Price Optimization & Accessibility

- Quantzig
- e·on
- SYNTELLI SOLUTIONS

Source: PwC Research & Analysis

EV fleet services plays also allow platform owners to monetize data collected, creating auxiliary revenue streams & a strong value proposition (1/2)

Data Monetization: Value Pools (1/2)

Use cases can be under at least one of three value pools:

Non-exhaustive, Illustrative

		Digital Advertising		Insurance
1	**Personalization** *(tailored to individual needs)*	**Location-based promotions combined with driver insight** *Based on vehicle-provided geo-data and customer insight, e.g. restaurant for lunch*	**Pay-for-performance promotions** *Targeted, pay-for-performance promotions to customers with monitored ROI*	**Individual driver pattern for personalized pricing** *Insurance firms can reduce risk and improve pricing based on driver usage pattern & vehicle monitoring, (e.g. time-in-car, driving pattern, routes, speed data, etc.)*
2	**Product Enhancement** *(development of more innovative products & services)*	**Auto-display nearest charging points** *Based on vehicle geo-data, advertise nearest chargers & respective pricing*	**Car-to-car communication** *Car-to-car communication facility to interact with others on social networks or work intranets, etc.(social, work…)*	**New insurance products** *Create new specified insurance products based on personal patterns (e.g. parking accident insurance, voltage-fluctuation insurance)*
3	**Resource Utilization** *(enable more efficient use of resources)*	**Create micro-communities for monetization in advertising** *Based on driver/traveler data, detect micro-communities and sell access to advertisers*	**Loyalty-based mobility card** *Launch loyalty-based mobility card with partners to combine different modes of transport and monetize cross-modal customer insights*	**Provide customer access for targeted sales of insurances** *Act as insurance broker, recommending insurances based on customer profile (e.g. "cheapest", "most valuable features", etc.)*

EV fleet services plays also allow platform owners to monetize data collected, creating auxiliary revenue streams & a strong value proposition (2/2)

Data Monetization: Value Pools (2/2)

Use cases can be under at least one of three value pools:

Non-exhaustive, Illustrative

		Travel & Tourism	Automotive Suppliers
1	**Personalization** *(tailored to individual needs)*	**Personalized location-bound recommendations** *Based on location information, provide on-trip recommendations where to stay, go next, have dinner, etc. (via own platform or provide access to partners)*	**Usage patterns & driver preferences** *Provide usage patterns to equipment manufacturers and preferences (e.g. 20% of fleets would pay ₹5000 extra for TPMS sensors)*
2	**Product Enhancement** *(development of more innovative products & services)*	**Geo-directory solution platform** *Real-time maps solutions to consumers and businesses (beyond drivers) based on sensor data (e.g. road condition, traffic condition, speed pattern)*	**Failure statistics and predictive maintenance** *E.g. Motor with problems after 50k kilometres in humid climate conditions; when using ABC company parts, motor will fail after 1 lac kilometres*
3	**Resource Utilization** *(enable more efficient use of resources)*	**Provide service data to mobility providers and govts** *Vehicles collect valuable insights on road conditions and chargers collect insights on grid conditions which can be used by government institutions (e.g., municipal corporations)*	**End-to-end spare parts & service management** *Coordinate maintenance, service and repair value chain with various players – enabled by sensors monitoring status of parts and maintenance needs*

High development costs across digital fleet services offerings means that component players need to carefully select areas for investment

e-Vehicle Fleets – Digital Technology Stack

- **User experience / Human-Machine Interface (HMI)**
  Compelling user experience, dashboards
- **Applications/ functions**
  Innovative software in fleet management, charging management, etc.
- **Cloud platform and cloud services**
  Enrich asset data and utilize cloud/edge computing resources
- **Backhaul connectivity and services**
  Secure V2X communication and OTA updates
- **Platforms and analytics**
  AI/ML based decision engines analyzing data
- **E-Vehicle/ fleet operating system**
  Management of in-vehicle computing resources & software services
- **Vehicle/ Charging management platform**
  Enabling software functionalities on powerful embedded hardware
- **In-vehicle connectivity and services**
  Secure communication between domain platform computers
- **Electronics and power components**
  Controlled electronics and embedded software components
- **Security and compliance**
  Automotive-grade cyber security & data compliance

Most Areas of the technology stack with **high investment need** are driven by **technical complexity** and need for **innovation**

Being an **innovation leader** & **first to market** not be possible in all areas. Players need to **carefully select areas** for investment

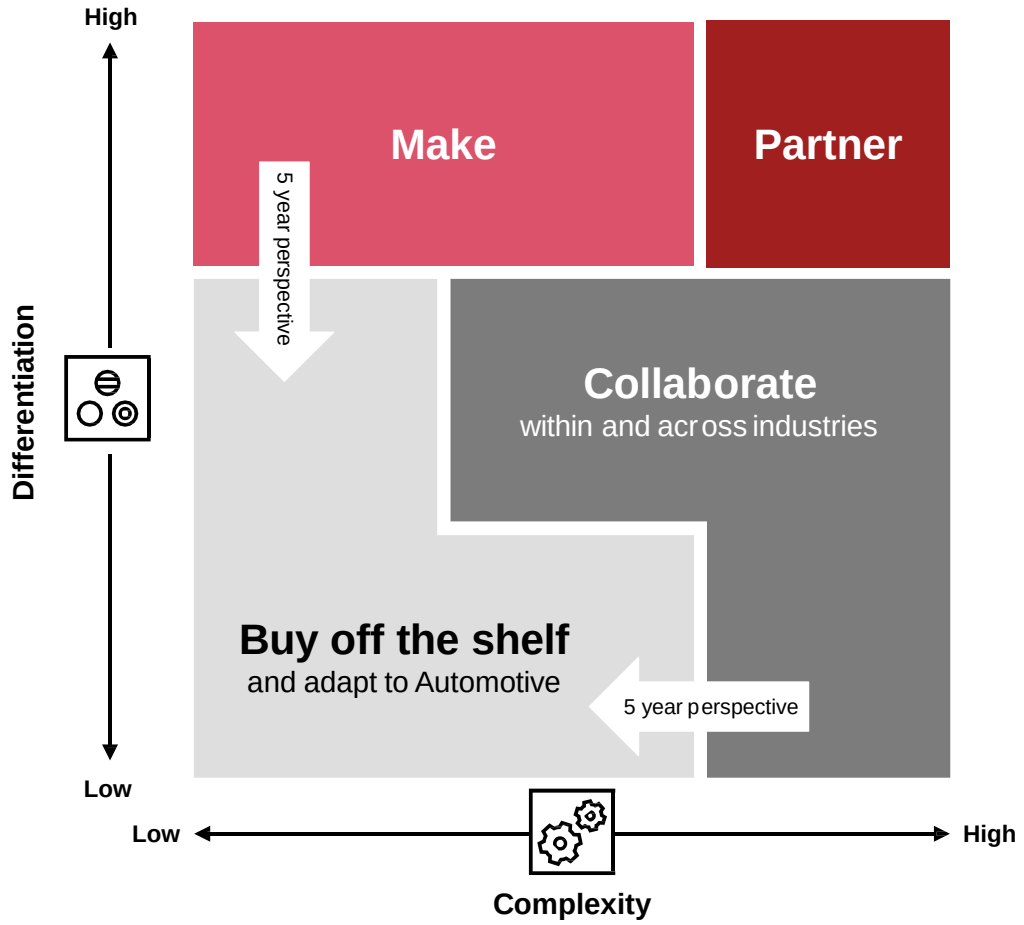
Collaboration with **technology players** and **competitors** in **new forms of partnerships** will scale economies and present more available talent

Transforming employees' mindset – particularly in R&D, procurement, partner management and controlling – will be key for innovation

Contents

To play in the EV aftermarket, EV EoL & EV fleet services markets, component-makers must first focus on strategic sourcing decisions

Sourcing Strategy Matrix



- **Component manufacturers** will need to decide **how** they will source their solutions since developing in-house may **not be possible** financially or organizationally
- **Strategic sourcing decisions** need to **focus on three factors**:
  - I. Targeted **differentiation** matching the brand promise:
    - Perceived customer value
    - Competitive advantage
    - Monetization potential
  - II. Anticipated **complexity** of the product and technology:
    - Availability of products/alternatives
    - Maturity of technology & market awareness
    - Availability of skilled/ experienced resources
    - Forecasted expenses
  - **III. Sustainability** of the targeted differentiation:
    - Today's differentiating assets might become commodities in 5 years
    - Significant reduction of complexity and risk for 2nd mover
- **Collaboration** with **automotive** and **technology players** should be favored for **areas with high complexity**

Source: Strategy&, PwC Research & Analysis

Thank You

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