June 2020

e-mobility in India

Market paradigms and ways to play

Point of View

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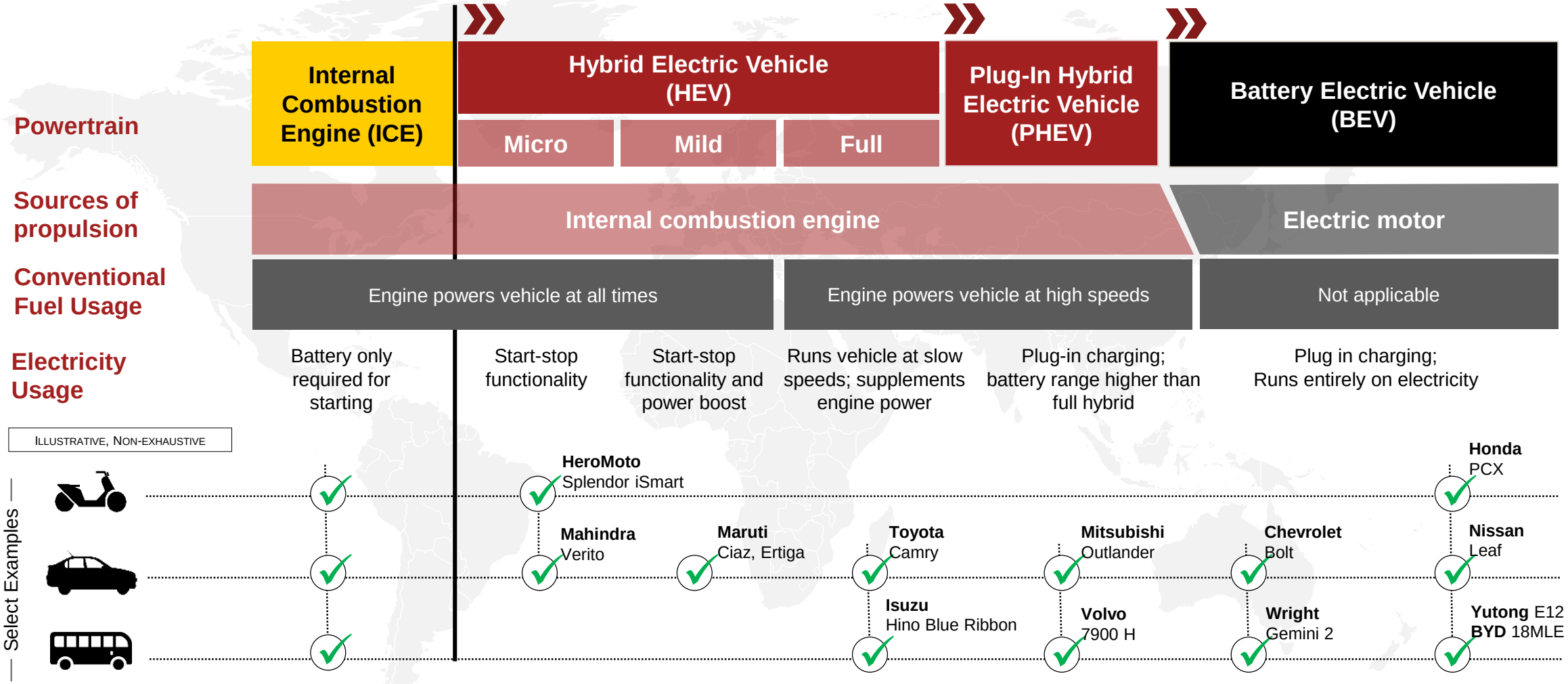
Contents

Globally, various power train technologies co-exist across xEV continuum and across vehicle segments

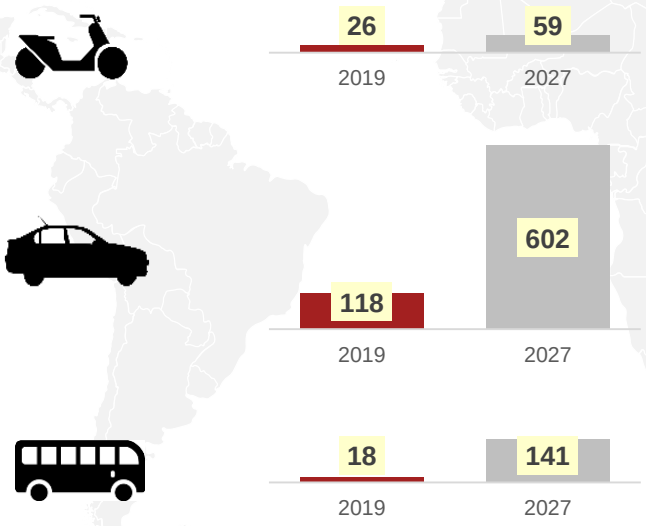


Note : Some studies define another intermediate segment : Range Extended Electric Vehicle (REEV) which use a generator to charge the battery, plug-in charging a& are powered by electric motor

The global xEV market was valued at ~$160 Bn in 2019; BEVs projected to have the highest growth (5X) within xEV sub-segments

		Hybrid Electric Vehicle (HEV)			Plug-In Hybrid Electric Vehicle (PHEV)	Battery Electric Vehicle (BEV)
		Micro	Mild	Full		
1 2019 xEV size	$ 163 Bn					
2 2027 xEV size (source : AMR#)	$ 802 Bn	»	46 %		23 %	31 %

3 xEV segment size ($ Bn)



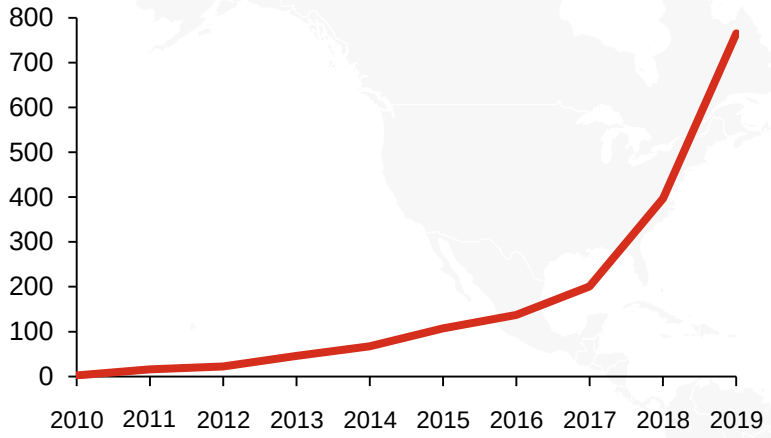
Key Insights

- Hybrid electric vehicles currently constitute the biggest sub-segment, supported by greater attractiveness in the market today. BYD is the market leader, with ~42% share, followed by Toyota
- However, **BEVs are projected to have the highest growth** within sub-segments **(5.1x)** at ~23% CAGR
- Factors such as stringent **environmental regulations, policy orientation, fluctuating oil prices, lower maintenance requirements** and improving **product technologies** (battery performance, higher torque & power etc.) make **BEVs a highly attractive segment**

PwC #Allied Market Research

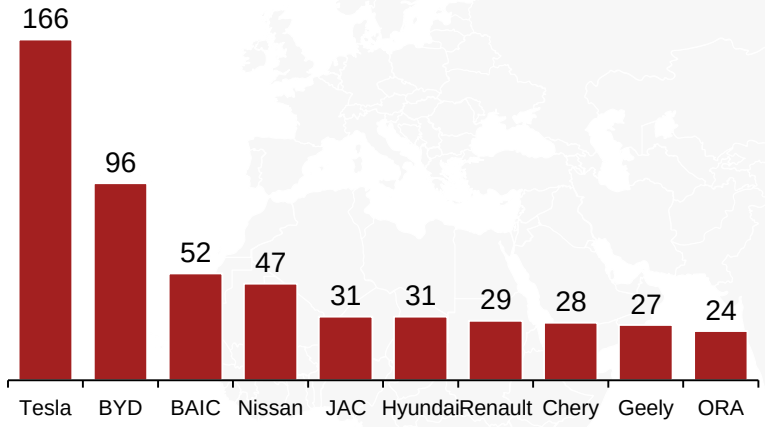
Global BEV sales increased by 92% in H1 2019 with close to 800K vehicles sold; BEVs accounted for 2.2% of overall vehicle sales

Global BEV Sales | H1 ('000 units)



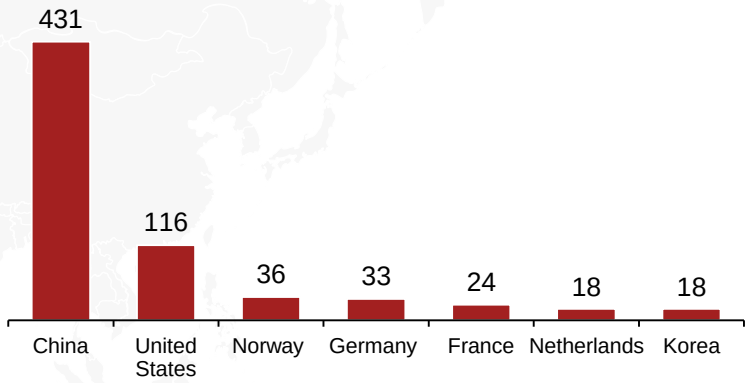
- Electric vehicles comprised **2.2%** of overall vehicle sales in H1 2019
- **87%** decline in battery prices between 2010 and 2019 lowering costs to affordability
- Stricter **environmental regulations** (emissions norms, Paris accords) helping push for sustainability in the mobility space

Top Selling OEMs | BEV: H1 2019 ('000 units)



- **Tesla Model 3** is the number one selling vehicle of 2019. Deliveries of Model Y SUV commenced in March 2020.
- Chinese brands **BYD and BAIC** sales were hurt by slowdown in domestic market, continued expansion internationally

Top BEV Markets | H1 2019 ('000 units)



- **China** saw a dip in sales as subsidy measures were rolled back by the government in H1
- European nations **Norway, Iceland** the best on market penetration for EV- strong emissions policies, existing infrastructure, cancelling licenses for old ICE vehicles

PwC Source: JATO, Allied Market Research, PwC analysis

Regulations play a key role for adoption and are getting increasingly supportive in driving e-mobility

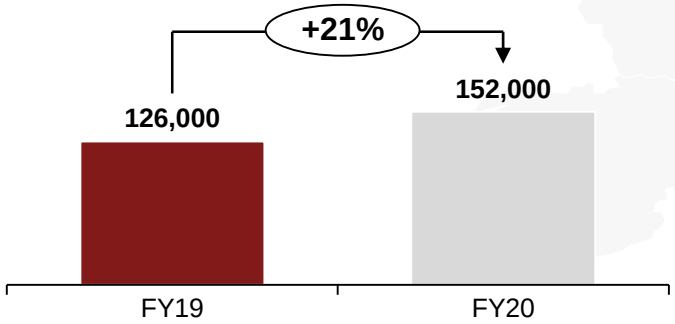
	China	United States	Norway	Germany
Charging Stations	**401,000**	**20,000**	**12,473**	**23,840**
BEV sold (H1 2019, 000 units)	**430.7**	**116.2**	**36.3**	**33**
EV Policy	• Comprehensive and strict electric vehicle policy for automotive industry in China (e.g. NEV 2019 mandate) • Auto OEMs in China subject to strict control on new production of ICE vehicles (e.g. by NDRC standards) • **Elimination of subsidies** for vehicles with under 250km range	• Tax credits and incentives to EV buyers, varies on a state-by-state basis • Federal **tax credit** between $2500 and $7500 **on purchase** • State-wise **tax exemptions** and incentives, most generous in California	• **Monetary and non-monetary privileges** for EV owners, strong charging infrastructure • Exemption from VAT, registration tax, ownership tax, road tax and road tolls • Permission to drive on bus lanes**, free charging** for BEVs and **elimination of public parking fees**	• **Focus on subsidies and incentives rather than emissions** • From 2020, **purchase subsidy** on lower-end BEV will rise to 3,000 Euros from 2,000 currently. • The **company car** (~64% of sales) tax rate will be lowered even further to 0.25% • Additional 50% **depreciation allowance** to be introduced

PwC Source: PwC Research & Analysis

In FY20, while overall vehicle sales in India dipped by 18%, BEVs posted a moderate 20% growth with much of the volume driven by 2Ws

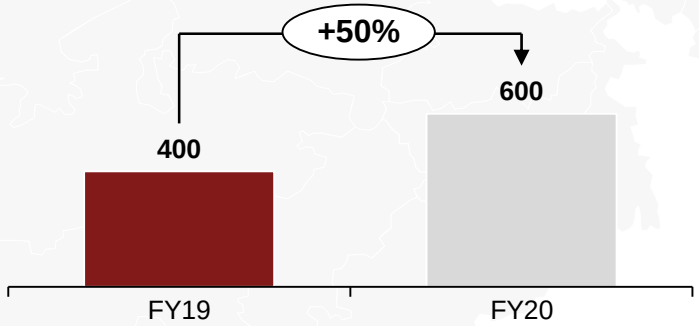
India domestic BEV sales (units)

Two -wheelers



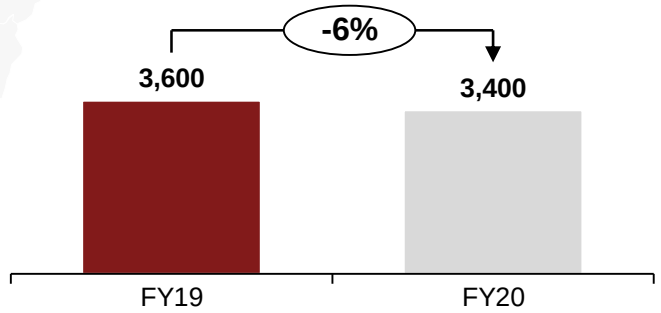
- Two-wheelers likely to be an early adopter of electric mobility- 28 different players involved in manufacturing today, from 15 in 2015.
- e-Scooters comprised **97% of new sales**
- However **FAME-II criteria** reduced the coverage for e-scooters by 93.4%
- **New players** : Ather Energy building new production facility, Okinawa tripling production capacity

Electric buses



- **Strong economic alternative** for mass transport - short routes, heavy usage, availability of charging stations at bus depots.
- States **preferring leasing model to outright purchases**: lower initial capex, rent charged per km travelled e.g. in Pune, 150 buses already taken on lease
- New **shared mobility providers** such as Freshbus act as **catalysts of adoption**

Passenger vehicles



- Range anxiety and charging infrastructure remain **key customer concerns** – deterring a faster adoption
- Consumer preference towards **high powered vehicles** (Utility Vehicles)
- Hyundai, Tata Motors, MG Motors **launched electric SUVs** in 2019
- M&M e-Verito, Tata Nexon, Hyundai Kona, MG ZS the **top-selling models** in the country

PwC Source: SMEV, PwC Research & Analysis

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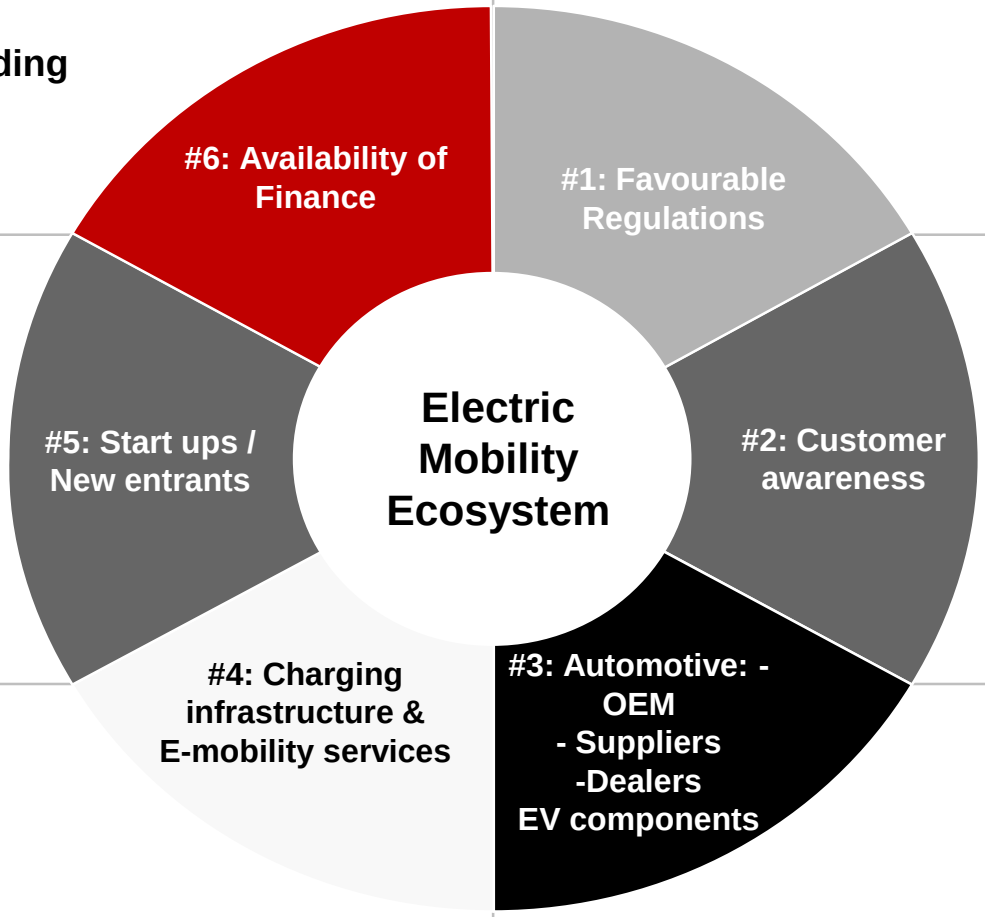
A holistic approach to E-mobility ecosystem development is necessary for sustained adoption

- Banking for vehicle purchase
- Angel/ Venture/ Private Equity funding
- Project financing
- Risk mitigation

- Demand creation incentives/ differential Tax
- State regulations
- Investment promotion policy
- Make in India

- Ease of doing business
- Level playing field
- Catalyst projects
- Collaboration with Academia
- R&D grants

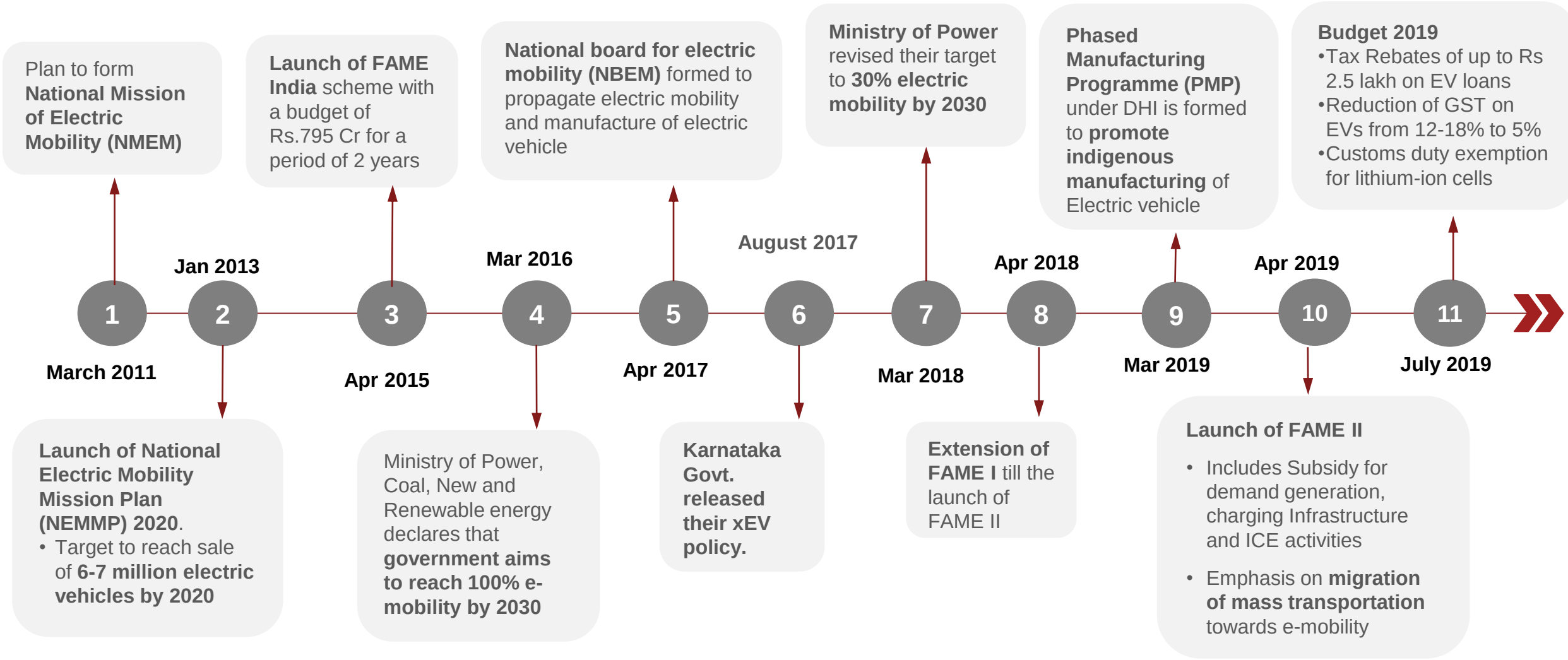
- Economic rationale
- Creating awareness
- Catalyst projects
- Shared mobility
- Public transport



- Bankable PPP Contracts
- Financial viability
- New business models
- Payment and Information

- Socio Economic impact
- Skill Gap
- Impact on Local suppliers
- Technology & RM availability

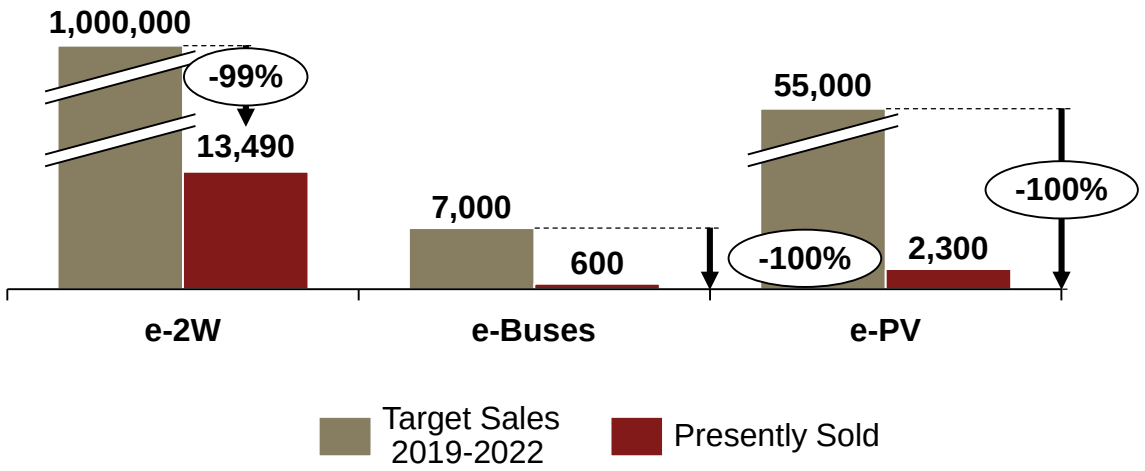
Various government organizations have provided holistic and integrated measures to transform e-mobility in India



PwC Source: DHI, SMEV, PwC Research & Analysis

FAME-II was formed with a bigger financial outlay - significant road to be to covered to meet targets ; ecosystem is heavily reliant on imports

Fame-II coverage : Target vs actuals (2019)



Eligibility criteria for availing FAME-II subsidy

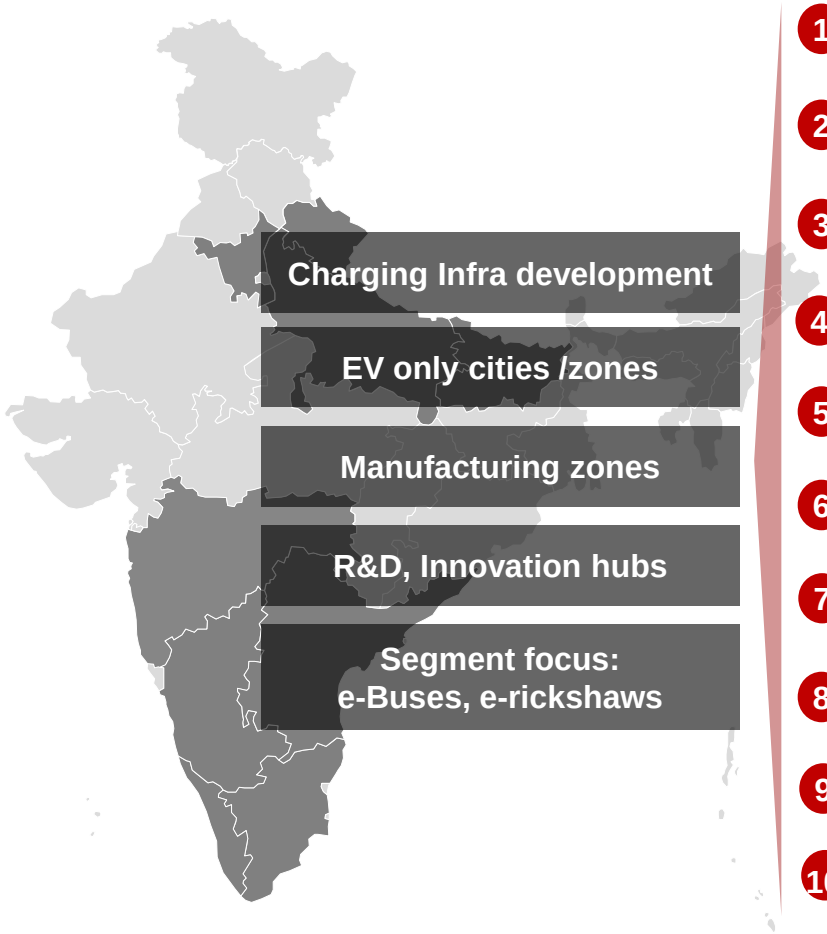
- OEMs registered with NAB/DHI; Vehicle's registered with CMVR
- Certain parts of the vehicle to be localized
- Vehicle to have regenerative braking system; Vehicle warranty of 3 years
- Battery should be "Advanced" (includes Li-ion, NiMH, Lithium polymers, etc.)
- Vehicle with 'fuel saved' monitoring device
- Advance battery, Minimum Max speed, battery range & battery density

Key insights

- **95%** of existing e-2W couldn't qualify for FAME II (Crisil) - withdrawal of subsidies for older models - **disrupting mass adoption** of e-2W
- Manufacturers are grappling with **capability development** of **"advanced batteries" ;** dependent on China and other countries at present
- **Import duty** on knocked-down EV was raised from 10% to 15% and 10% (from 5%) on lithium-ion cells in an effort to promote the growth of a local manufacturing ecosystem for EVs and EV components
- **Higher localization requirement** : Domestic infrastructure not adequate, **unavailability of parts** such as battery cells, magnet motors and controllers manufactured domestically ; reliance on imports for numerous components
- Added to that, **overall vehicle sales decline** (~18%) in FY19 - liquidity crunch, higher fuel & insurance costs, postponement due to BS VI transition and so on

PwC Source: DHI, Crisil, SMEV, PwC Research & Analysis

To push the e-mobility agenda further, different states are carving out their own EV policies ; focus on various adoption levers



	State	Key Focus
1	**Andhra Pradesh**	Focus on innovation, new technology and workforce training. Aim to convert entire public bus fleet to electric by 2024, plan to make **Amravati an EV-only city**
2	**Bihar**	Bihar is the fastest growing market for **e-rickshaws**. Focus on leveraging this to promote local e-rickshaw manufacturing
3	**Delhi**	Priority is reducing **air pollution and creation** of EV sales jobs**. Last mile transportation fleets** expected to shift 50% EVs by 2023.b20% **parking reservations**
4	**Karnataka**	First state to issue an EV-specific policy in the country. Focus on **R&D, productions**, services and customers
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**.10% parking reserved for EV in commercial spaces.
8	**Telangana**	**Skills development**, innovation and creation of special EV cluster
9	**Uttar Pradesh**	EV manufacturing hub, investment in charging infrastructure, development of **battery management**
10	**Uttarakhand**	Dedicated **EV manufacturing zones**, skills development, electrification of public transport. Development of **'green highways'** and requiring 70% local employment

PwC Source: Individual state policies, PwC Research & Analysis,

EV adoption would play out across multiple scenarios in India driven by - *cost economics, 'localized' shared mobility, availability of infrastructure & state-level EV policies*

Different scenarios

	Localized	Import Dependent
Increased Shared Mobility	**Mass, Cost & mobility driven** • Cost of ownership & acquisition favourable • EV fleets take to the roads • Government and Private operated EVs • Inter city rides • Private buyers prefer EV over IC	**Selective, Subsidies driven** • Cost economics not favorable except EV subsidies • Government driven subsidized transport applications of EV
Enduring Private Usage	**Selective, Cost driven** • Cost of acquisition favorable but ownership cost and maintenance not favorable • Shared mobility not a favorable option to choose • IC demand is replaced by EV by private buyers	**Selective, environment conscious driven** • Cost economics not favorable • Shared mobility not a favorable option • EV demand will be driven by environment conscious and prestige seeking customer segments

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In order to drive adoption in the e-mobility market, manufacturers and other ecosystem players need to address key customer concerns

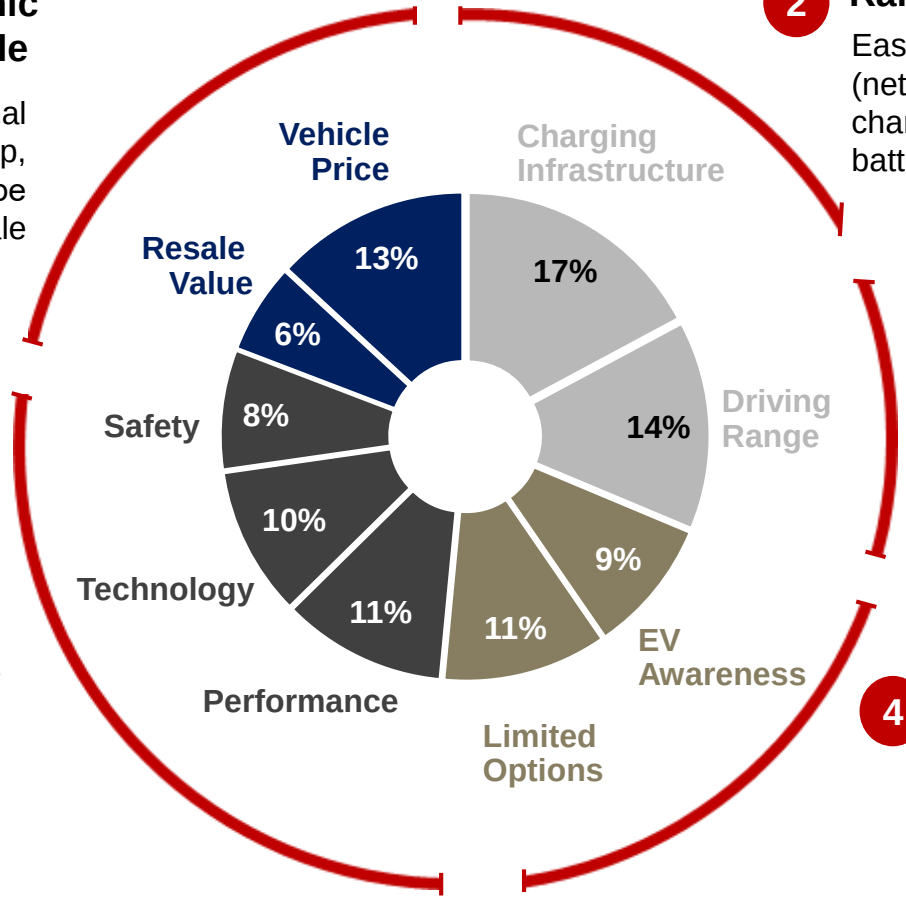
PwC Customer Survey : concerns about EVs

1 Economic Rationale

Government subsidy, OEM promotional discounts, lower cost of ownership, providing 'resale' assurance would be levers of bettering rationale

2 Range anxiety

Ease of access to charging stations (network expansion) adoption of fast charging, new business models such as battery swapping (2&3W)



3 Battery performance

Batteries with high density, high battery life and low cost is the need of the hour

Need for India-specific manufacturing e.g. battery management systems, magnet less motors

4 Customer awareness

Create awareness (and hence demand pull) among the potential customers – educational drives, feature illustrations, DIY & charging procedures

5 E-Vehicle performance

Products that address concerns on ride & handling, payload, top speeds etc. EVs comparatively are lower on noise and higher on torque

Source: Weighted sum index (n=106) , PwC & ASSOCHAM paper : "Towards e-Mobility: Putting the consumer at the wheel (2019)"

Batteries form a major portion of EV costs; global battery market est. at $116 Bn by 2030; significant reduction in prices expected at such scale

Various battery types

Non-exhaustive

Advanced batteries

Lead Acid Battery

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

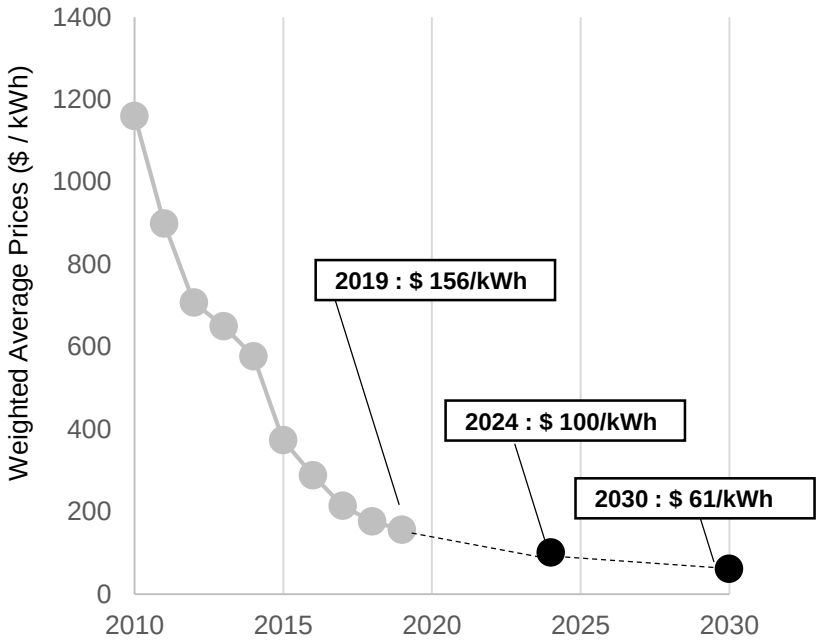
Nickel Metal Hydride battery

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, 2019

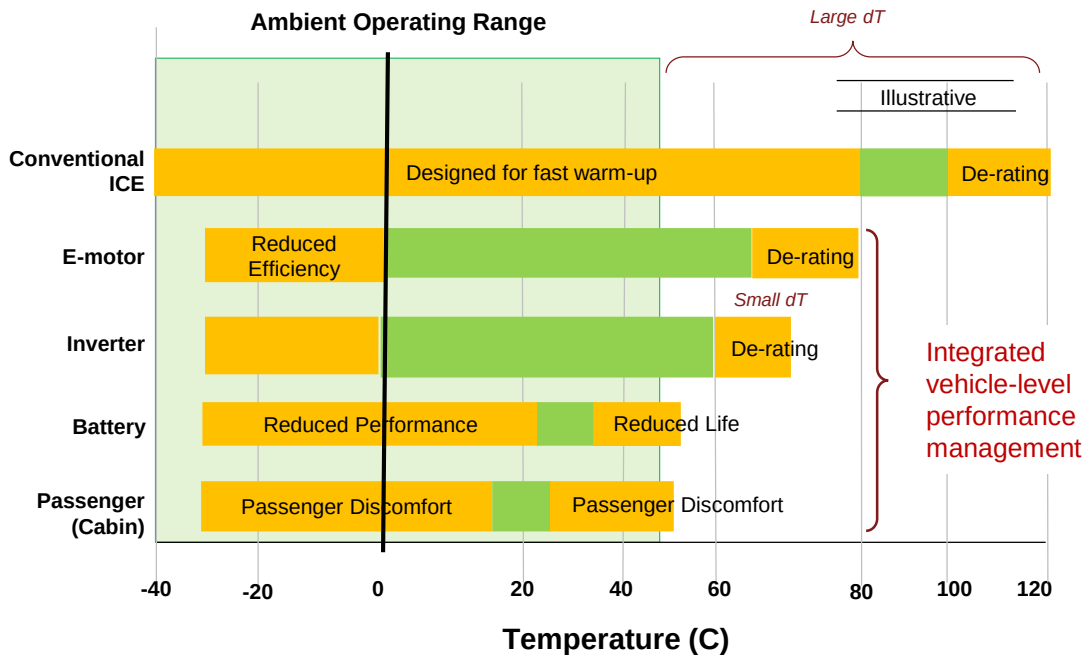
Key insights

- **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**

Wide array of cell types , vehicle-level configurations, different cooling technologies add to performance challenges at an integrated level

Different operating conditions : EVs vs ICEs

EVs operate at much lower temperatures compared to ICEs



Key insights

- **Various cell densities, cell shapes & packaging adding to complexities**
- **Price sensitivity to underlying metal prices -- lithium, nickel, cobalt and aluminum – depending on cell chemistry**
- **Vehicle type (e.g. PV, 2W etc.), Vehicle design, packaging, battery cooling technologies will have a deep impact on battery prices**
- **Challenges at 'vehicle-level' – integrated performance simulation**
- **Evolving 'battery cooling' technologies (esp. with fast charging)**

Battery manufacturing space has seen a rush of interest and investments into India recently

Recent activity in Battery manufacturing space

- **Li-ion batteries are primarily imported from Singapore, China, Japan and other markets**
- **India forecasted to require up to 20 giga-tonnes of Lithium-ion batteries to fulfil target of 30% EVs by 2030**

April 2017 (1)
Suzuki, Toshiba, Denso sign agreement on JV for lithium-ion battery pack manufacturing in Gujarat

October 2018 (2)
Tata Chemicals signs MoU with CSIR-CECRI for cathode material production

January 2019 (3)
Indian Space Research Organization selects 10 companies to provide lithium-ion cell technology

April 2019 (4)
Tata Chemicals signs MoU with ISRO for non exclusive access to lithium-ion technology

July 2019 (5)
Tata Chemicals announces plans to build plant to manufacture lithium-ion batteries in Gujarat with $560m investment

July 2019 (6)
CECRI announces plans to establish lithium-ion battery plant in Chennai with an investment of $14m, funded by CSIR

August 2019 (7)
NALCO, HCL and MECL sign joint venture to procure and supply necessary materials needed for domestic battery manufacturing

September 2019 (8)
Innolla Energy invested $31.5m in manufacturing lithium batteries, solar modules and EV products in Hyderabad.

Source: PwC research & analysis, BIS research

Reusability, minimization of wastage is paramount as manufacturers look to extract more value out of batteries; strategies in nascent stages

	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

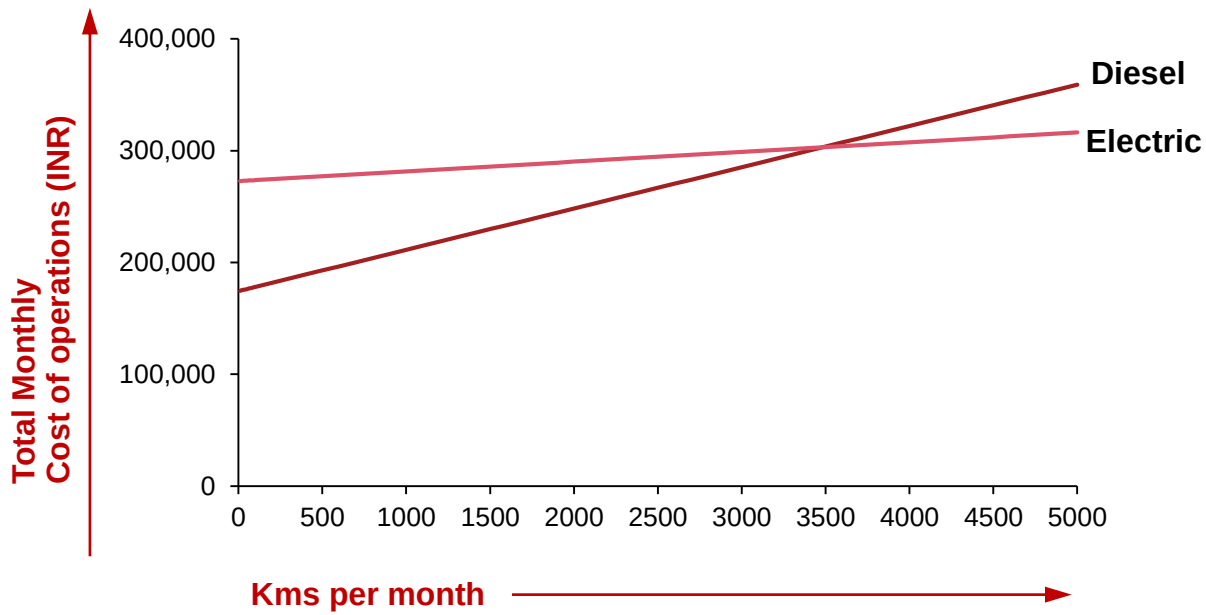
In addition to battery cost reductions, long term cost savings must be communicated effectively to buyers to overcome worries over higher initial cost

Levers of improvement in TCO

1. **Lowering Battery costs**
   Innovative R&D strategies (platform approach, integrated simulations, thermal design, etc.),supplier collaboration (sharing of development costs) localisation & robust sourcing capabilities
2. **Subsidies/Incentives**
   Subsidies and benefits provided (FAME, PMP, tax exemptions) are crucial to making EVs price competitive in the marketplace- currently Rs 20,000 per kW for e-buses, Rs 10,000 per kW for 2W, 3W and commercial 4W.
3. **Shared Mobility**
   Shared mobility players will have better asset utilisation rate and hence will have a better TCO proposition – more mileage, higher consumption of EV services (charging etc)
4. **Maintenance Costs**
   Electric vehicles typically incur lower maintenance costs- reducing lifetime cost to customer (~20 EV parts ~2,000 in ICE powertrains)
5. **Resale / buyback assurance**
   Buyback programs help establish customer trust in the product (examples - Tesla, MG, Enigma)

Illustrative TCO example : e-buses vs ICE-buses

TCO : Total Cost of Ownership



TCO scenario is modelled with following assumptions

- Model focused on fuel, lubricant, capital, interest and maintenance costs per Km basis.
- Data sourced from multiple industry sources.
- Model does not consider insurance or permit costs
- Model is based on a 20 year usage period

PwC Source: PwC Research & Analysis

With higher asset utilization shared mobility platforms act as *catalysts for EV adoption*; players testing out city-specific pilots

Two & Three-wheelers

- 2W and 3W space is likely to be an early adopter of e-mobility, with **strong unit economics**, particularly in shared mobility, compared to traditional ICE models
- **Growth of 12-17%** and 43-48% for 2W and 3W respectively by FY24 (Crisil)

Segment Examples

- Bounce, a dock-less scooter sharing service, currently operates in Bangalore and Chennai; conducting a pilot project with 1,000 e-scooters in Bangalore
- Plans to build an infrastructure using 'kirana' stores to deploy battery-swapping stations across cities (lower capex)
- **Players like Bounce, VOGO likely to shift entire fleets to electric, giving customers opportunity to sample e-bikes.**

Passenger vehicles

- **Catalyst projects** being taken up by aggregators to drive awareness & adoption; segment witnessing high investments
- Government recommending taxi aggregators raise the share of **EVs in their fleet** ~ 40% (by 2024)

Segment Examples

- Ola took part in a pilot project with Mahindra & Mahindra to build EV infrastructure in Nagpur. 200 EVs deployed, charging infrastructure built in specific locations (2017)
- Ola also has investments from Hyundai-Kia to partner on local e-mobility solutions and from Microsoft on digital and cloud services.
- **Focus on developing capabilities to extract value from various aspects - 'collaborate' OR 'compete'.**

Electric buses

- Buses is likely to be an early adoption segment for electric vehicles
- The FAME-II policy has sanctioned the purchase of 5595 e-buses for 64 cities.

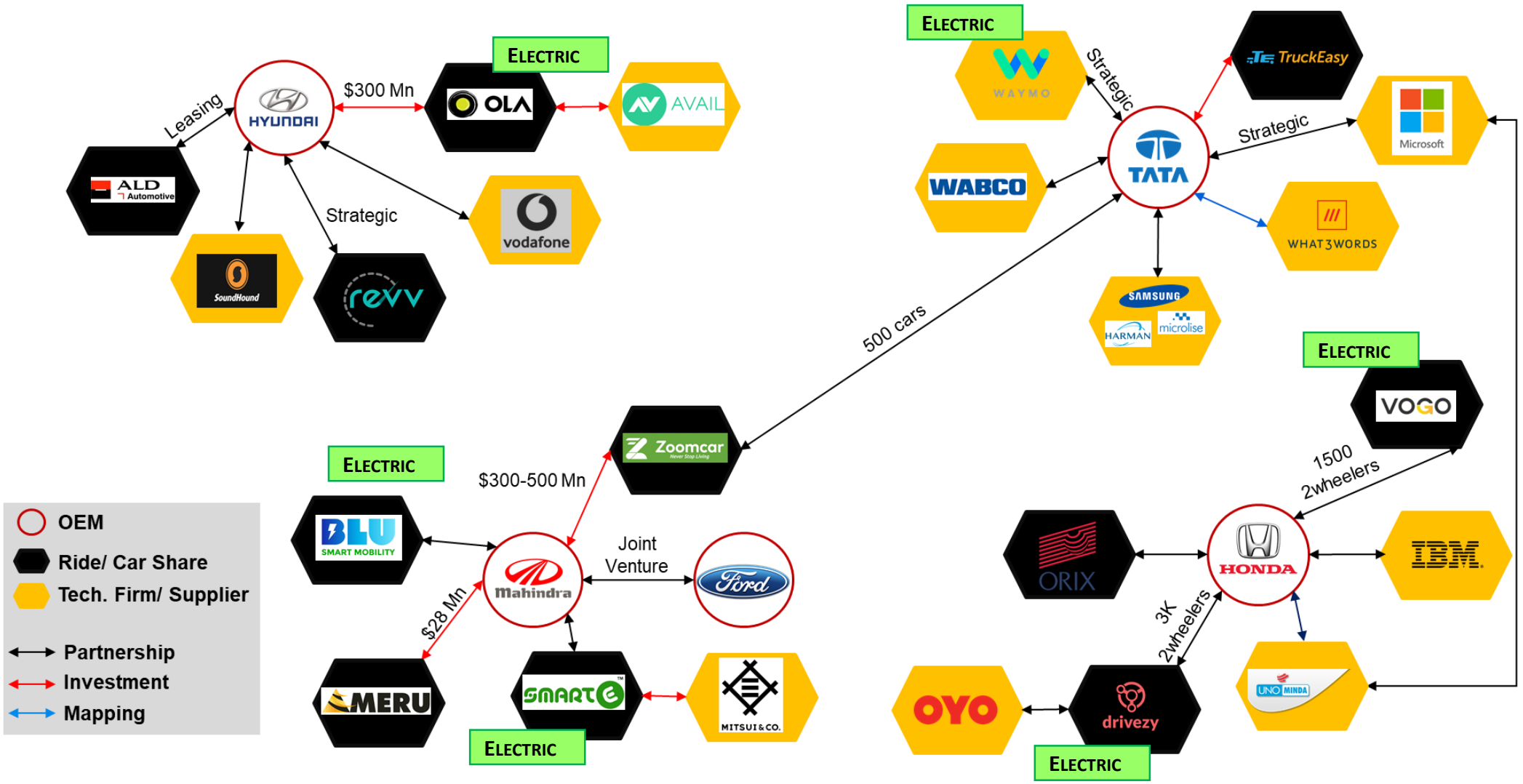
Segment Examples

- **Shuttl** is a bus aggregating platform, primarily in Noida and Gurgaon. Shuttl is partnering with **BRPL** to add 300 e-buses to its fleet, as well as setting up **50 charging points** in prime locations
- **Freshbus** is a modern-age bus service and aims to offer a differentiated customer experience through its **electric bus fleet** and **new-age front-end processes .** Operational in Telangana and Karnataka

PwC Source: DHI, Crisil, Company websites, PwC Research & Analysis

The Indian shared mobility ecosystem is an *'interconnected'* network

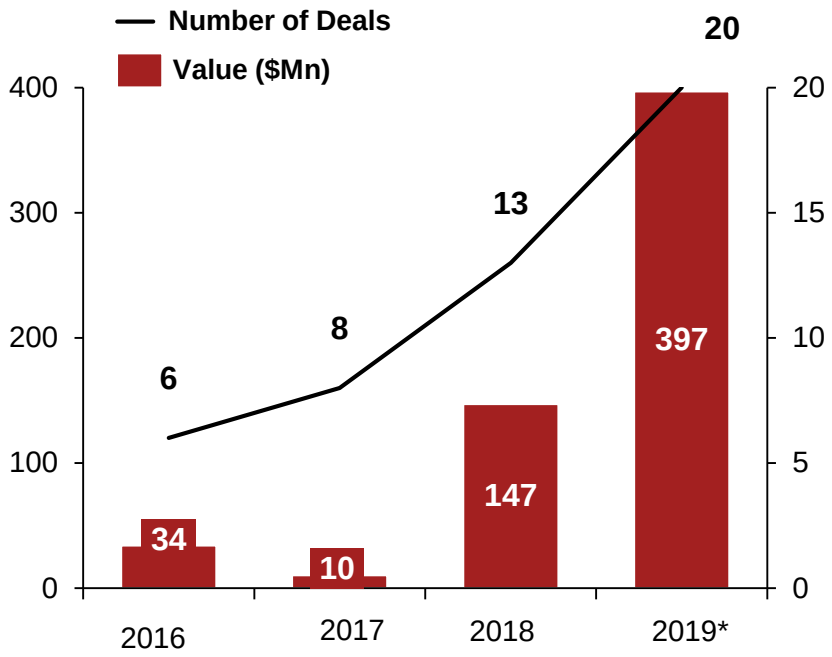
An illustrative view



Source : PwC research & analysis

The EV ecosystem is witnessing investments into various ‘value blocks’; new players are also going the VC route to raise capital

VC deals in e-mobility space in India



EV Investment in various ‘value blocks’ : Examples

NON-EXHAUSTIVE

Value blocks	Company	Total funding	Focus
Vehicle design & manufacturing	Ather Energy	$91 Mn	Electric scooter manufacturing, building of charging infrastructure
	Ampere Vehicles	$200 Mn	Acquired by Greaves cotton, manufacturing of electric bicycles, light vehicles.
Battery Research	ION Energy	$1 Mn	Battery management and intelligence platform
	Grinntech	Undisclosed	Building lithium battery packs
Shared Mobility	Ola Electric	$307.3 Mn	Ride-hailing, includes investments from Hyundai and Microsoft for EV solutions
	Shuttl	$122.3 Mn	Shared bus fleet operator, planning to induct e-buses into its fleet
Charging Infrastructure	Fortum	Undisclosed	Fortum is partnering with Indian Oil to launch charging stations, starting in Bangalore
	Magenta Power	Undisclosed	HPCL-backed startup, solar power-based charging solutions

 Source: Crunchbase, Venture Intelligence, PwC analysis, *Data until December

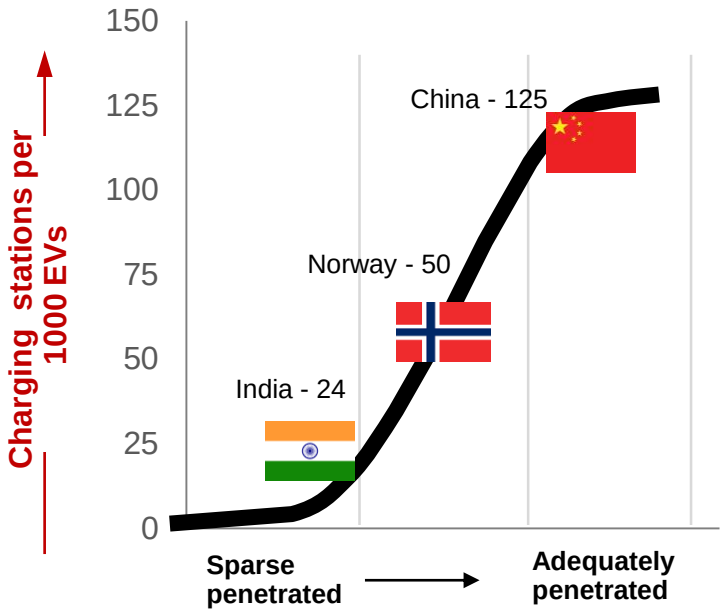
Globally, various Oil and Gas companies are also making strategic investments in EV technology to prepare for this shift

Oil & Gas Company Investments in EV Technology - Selected Examples

Companies	Comments
Saft, Total	• In 2016 Total acquired Saft battery business for US$1.1bn. In 2018 announced additional investment of US$230m+ in battery technology
newmotion, Shell	• In 2017 Shell bought Dutch-based NewMotion, owner of one of Europe's largest EV vehicle charging networks. NewMotion will operate in parallel to Shell's programme of rolling out fast charging points at its forecourts
StoreDot, bp	• In 2018 BP made strategic US$20m investment in StoreDot, Israeli developer of ultra-fast-charging batteries. Technology targeting EV charging in 5 mins.
NIO Capital, bp	• In 2018 BP and NIO signed MOU to jointly explore opportunities in advanced mobility in China and internationally
FreeWire Technologies, bp	• In 2018 BP invested US$5m in FreeWire, manufacturer of mobile rapid charging systems for EVs. BP to trial technology at selected retail sites in the UK and Europe during 2018
Saudi Electricity Company, TEPCO, Nissan	• Saudi Electricity Co signed a deal with Tokyo Electric Power Co and Nissan for first EV pilot project in KSA in 2018

EV charging is estimated to be a $27 Bn market globally by 2027; with new policy directives Indian EV charging market is poised to grow

Charging station penetration



Key Drivers of growth

- **Setting up PCS is a de-licensed activity**
- **GST rate on chargers and EV charging stations reduced from 18% to 5%**
- **3 x 3 km² grid planned to have at least one charging station (under Fame-2)**

EV Charging infrastructure types

Solving the charging challenge is key to wide e-mobility adoption and pushes diversified infrastructure development

	"My home/workplace – my charger"	"Public curbside"	"Charge to attract"	"Electric filling station"
Infra - type				
Use cases	• Slow overnight (home) charging • Daytime (workplace) charging • Daily demand is recharged	• Public charging in urban areas for users without access to private chargers • Daily demand or full charging	• Charging as secondary reason for stop, e.g., during shopping, dining etc. • Fraction of daily demand charged	• Next to long-distance routes • In cities for customers without access to other charging points • Fleet charging
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: Department of Heavy Industries, Ministry of Power, Markets & Markets, PwC Strategy& Digital Auto Report 2018, PwC Research & analysis

In order to offer customers with greater options, OEMs have lined up new launches across product segments & price categories

NON-EXHAUSTIVE

Two & Three-wheelers

Scooter/ Motorcycle

- **Hero** Optima
- **Okinawa** Ridge
- **Ather** 450
- **Piaggio** Ape
- **Yo** Electron
- **Revolt** RV300
- **Revolt** RV400
- **Bajaj** Chetak
- **22Kymco** Flow
- **Vespa** Electrica

3-Wheeler

- **Splash**
- **Kinetic Green** Cargo Model
- **Smart E** E-rickshaw
- **Mahindra** Alfa
- **Mahindra** Treo
- **Lohia** Comfort

Passenger vehicles

Mass

- **Tata** Tigor EV
- **Mahindra** E-Verito
- **Mahindra** e20
- **Tata** Nexon
- **Mahindra** eKIV100
- **Nissan** Leaf
- **Mahindra-Ford** Aspire EV

Premium

- **Hyundai** Kona
- **Jaguar** i-Pace
- **MG** ZS eV

Premium vehicles considered > Rs 15 lacs category

Commercial Vehicles

< 10 seater

- **Karma** Electric Van
- **Force Motors** T1N
- **BYD- Olectra** T3 MPV
- **Mahindra** e-supro

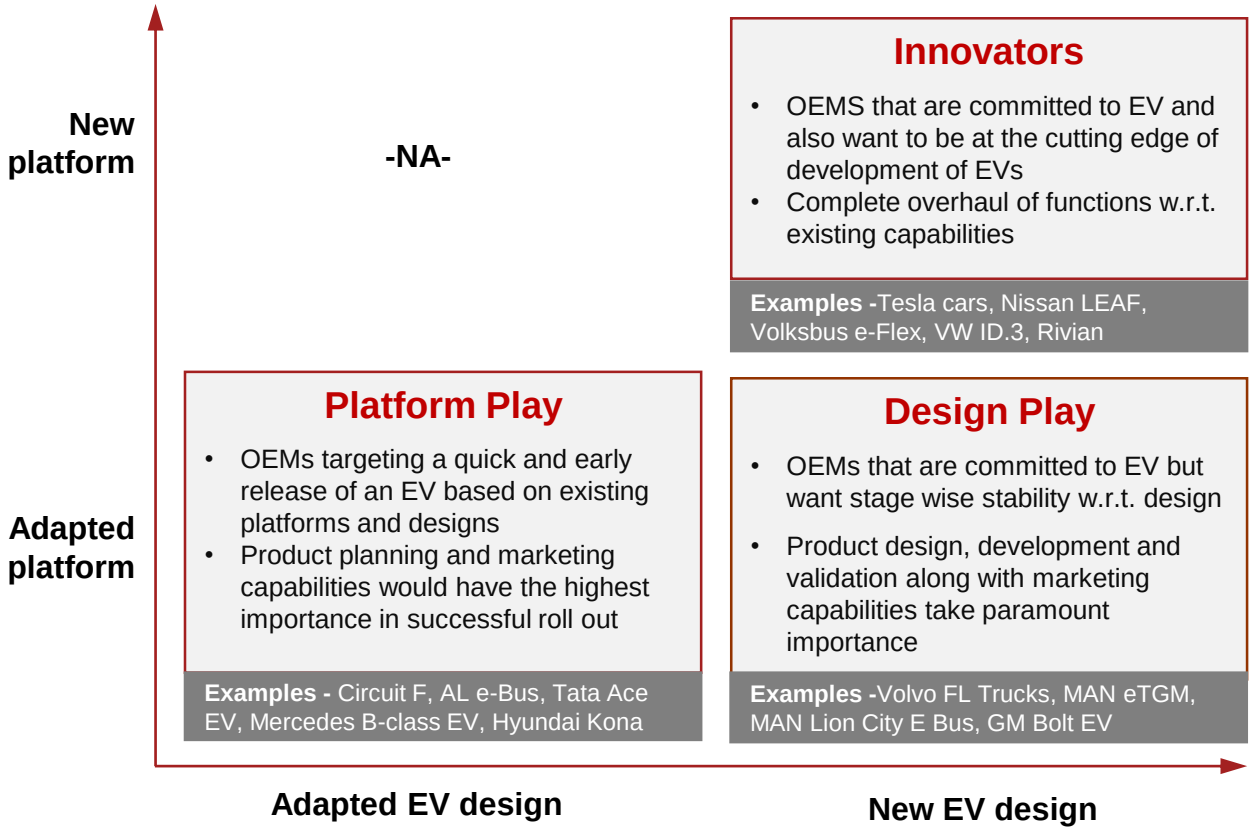
> 10 seater

- **Olectra-BYD** bus
- **JBM** Eco-life
- **TML Bus**
- **ALL** Circuit F
- **JBM** e9, e12
- **Olectra-BYD** C9

● **Existing models** ● **Recent launches** ● **Future launches (announced)**

There are 3 distinct ways to play in the EV market for vehicle manufacturers; while there is debate on the strategic choice …

EVs : Ways to play



Different strategies : Advantages & Challenges

Strategy	Advantages	Challenges
Platform play	• Lower fixed cost allocation, especially at low volumes. • Ability to use existing and proven designs and technologies • Faster go-to-market	• Trade-off on performance - lesser range, battery life, constraints on vehicle integration • Inflexible design • Often 'over-designed'
Design play	• Lesser capital investment • Fresh vehicle design with advantages in interior space, weight, compactness	• Less optimal thermal management capability, and battery performance from using old platform
Innovators	• Lower material costs • Design flexibility, superior vehicle integration • Better performance in range, acceleration & interior space	• Higher capital expenditure building platform • Need for engineering capacity

PwC Source: PwC Research & Analysis

… many OEMs have adopted the 'innovator' way of grounds-up development to gain flexibility & competitive advantage

OEMs adopting the 'innovator' play

	OEM	Platform name	Details
1	**Tata Motors**	Ziptron	In-house electric powertrain technology- all new EV launches to be built on this platform.
2	**Mahindra**	MESMA	Powertrain collaboration between Mahindra and SsangYong; to be used on various models.
3	**Hyundai**	Collaboration with Canoo	Hyundai is collaborating with Canoo to build new vehicles, under the new company Evelozcity.
4	**Volkswagen**	MEB platform	Flexible architecture- likely to be customized for Volkswagen, Audi and Porsche brands.
5	**Ford Motor**	Collaboration with Rivian	Rivian's flexible skateboard to be utilised in Ford's new electric line-up, including Lincoln Electric SUV
6	**General Motors**	Ultium	GM's EV architecture and battery solution- range of up to 400 miles
7	**Pininfarina**	EV skateboard	Produced in collaboration with Bosch and Benteler, to also be marketed to other automakers.
8	**Tesla**	Freight truck skateboard	Tesla freight truck skateboard utilized on upcoming Cybertruck

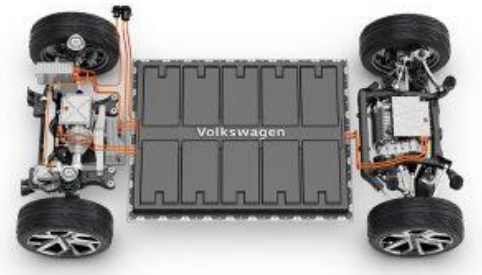
"EV Skateboards"

NON-EXHAUSTIVE

Tesla's GM Autonomy skateboard

Tesla's Model Y, which is set to arrive in 2020, will have seven seats despite being a midsized SUV model – **thus providing a clear competitive advantage!**

Volkswagen's MEB platform's flexible architecture will support compact to SUV-sized cars from VW, Porsche and Audi, **showing off the flexibility a standard skateboard can provide!**



Volkswagen's MEB platform

OEMs and component makers look to collaborate to bring down development costs and build capabilities

Platform-level capabilities required for ground up development

- Competency to develop platform supporting **multiple body types** and **performance specifications**
- Capability to create **flexible HV electrical architectures** to support **multiple vehicle platforms**
- Forming **modular mechanical architectures** to support multiple vehicle platforms
- Design & develop **modular EV powertrains** for supporting **multiple configurations** and performance specifications
- Development capability of modular batteries - various configurations for supporting **multiple performance levels (vehicles sizes, various applications)**
- End - to - end **Vehicle integration & testing capability**
- Capability to troubleshoot **product issues in aftermarket (**apart from aggregate replacement) . For example - software updates for performance tuning

Collaboration - *examples*

PV OEMs + Niche players

Hyundai has signed a deal with Canoo, a start-up automaker, to use its electric skateboard platform in future EV launches. Hyundai has announced 23 electric vehicles by 2025

Component makers + Niche players + OEMs

Pininfarina, a Mahindra subsidiary is partnering with Bosch and Benteler to build a new electric chassis, to be commercialized as well as licensed to other automakers (to gain cost advantages)

CV OEMs + Niche players

Hino Motors collaborating with REE, a pure-play skateboard startup, to build Hino's FlatFormer electric chassis

Source: Company websites, PwC Research & Analysis

With increasing maturity of BEVs, we can expect an industry-wide development of a dominant HV architecture

E/E-architecture vary by voltage and power levels

	Low Voltage (LV) E/E architecture	High Voltage (HV) E/E architecture
		
Voltage	5-12 V	240 – 800 V
Power	1 – 1000 W	5 – 400 KW
Product applicability	ICE, MHEV, PHEV, low powered BEVs	Med - High end BEVs (E.g. -Tesla Model 3, Nissan Leaf)

Going forward

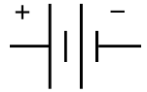
- Today‘s **HV architectures** of EV powertrains are **heterogenic**. As part of the **technology maturing process** we expect the formation of a **dominant architecture** within the next years
- **OEMs** have to **align** on or **set** an **industry standard**, to enable **cross-OEM synergies at** the supplier level
- **Suppliers** have to **build capabilities** and align their **product portfolio** on the industry standards

Source : PwC Strategy&, Research and Analysis

The HV architecture comprises of different components and presents wide opportunities for suppliers

Components

HV battery



DC/AC inverter

Motor

OBC

LV-DC/DC converter

Charging port

DC AC

BDU

BDU

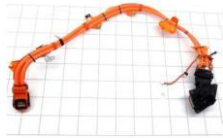
PDU

eA/C

eHeater

Wiring

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

Contents

With the above market perspective, following are the *key takeaways*

- The global EV market is forecasted to grow rapidly over the next decade, fueled by **stricter emissions norms, environmental concerns** and **improvements in electric vehicle technology**
- In addition to the regulatory push, there are **five key levers to drive adoption** of EVs in India, aligned to the customer concerns – by presenting the *economic justification* for owning EVs, through *battery price* reduction, *range performance* improvement, by enhancing *overall product performance* and by providing more *options – products, services & infrastructure*
- In India, **fleets and shared mobility** are likely to be the earliest adopters with comparatively better economic proposition vis-à-vis ICE vehicles (higher daily usage) ; they also serve as **catalysts for early adoption**, allowing customers the opportunity to experience using electric vehicles **without a high upfront monetary commitment,** and investing in their own charging infrastructure
- Solving the **charging challenge** is yet another key to a wider e-mobility adoption and pushes diversified **infrastructure development ;** India has a **huge headroom for growth**
- **Battery prices** will reduce with scale effects; significant road to be to covered in terms of **developing product development capability.** Indian ecosystem is heavily reliant on imports, **design complexities** arising out of various cell chemistries, vehicle configurations, variety of battery cooling technologies and so on
- **EV skateboards** are getting widely **popular** with different automakers; OEMs and component makers look to collaborate to bring down development costs and build capabilities. The **HV architecture** comprises of different components and presents wide opportunities for suppliers
- Players who are able to **collaborate** and champion the **required capabilities** (technical & non-technical), weave them into various EV business models (product sales, charging services, other monetization avenues) will be well positioned for the future.

Auto component players will need to make strategic choices and prioritize capability development to be well positioned for the future

EV Component Localisation Imperatives for Component Suppliers

1 Make strategic choices now

- EV focus vs EV agnostic
- Component vs system integrator for EVs
- New markets and new segments
- Business as Usual – Cost driven global market play (on shrinked volumes, globally)

2 Rejig capital planning & deployment

- Maintenance capex vs EV capex
- ROI vs future readiness
- Incremental steps vs big bets

3 Make re-skilling a priority

- New technologies & New materials
- New Regulations and standards
- Increased software and electronics content
- New manufacturing and quality control standards

4 Embrace open innovation / alliances

- Open innovation platforms
- Start up eco systems
- Co-piloting development with OEMs

Thank You

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