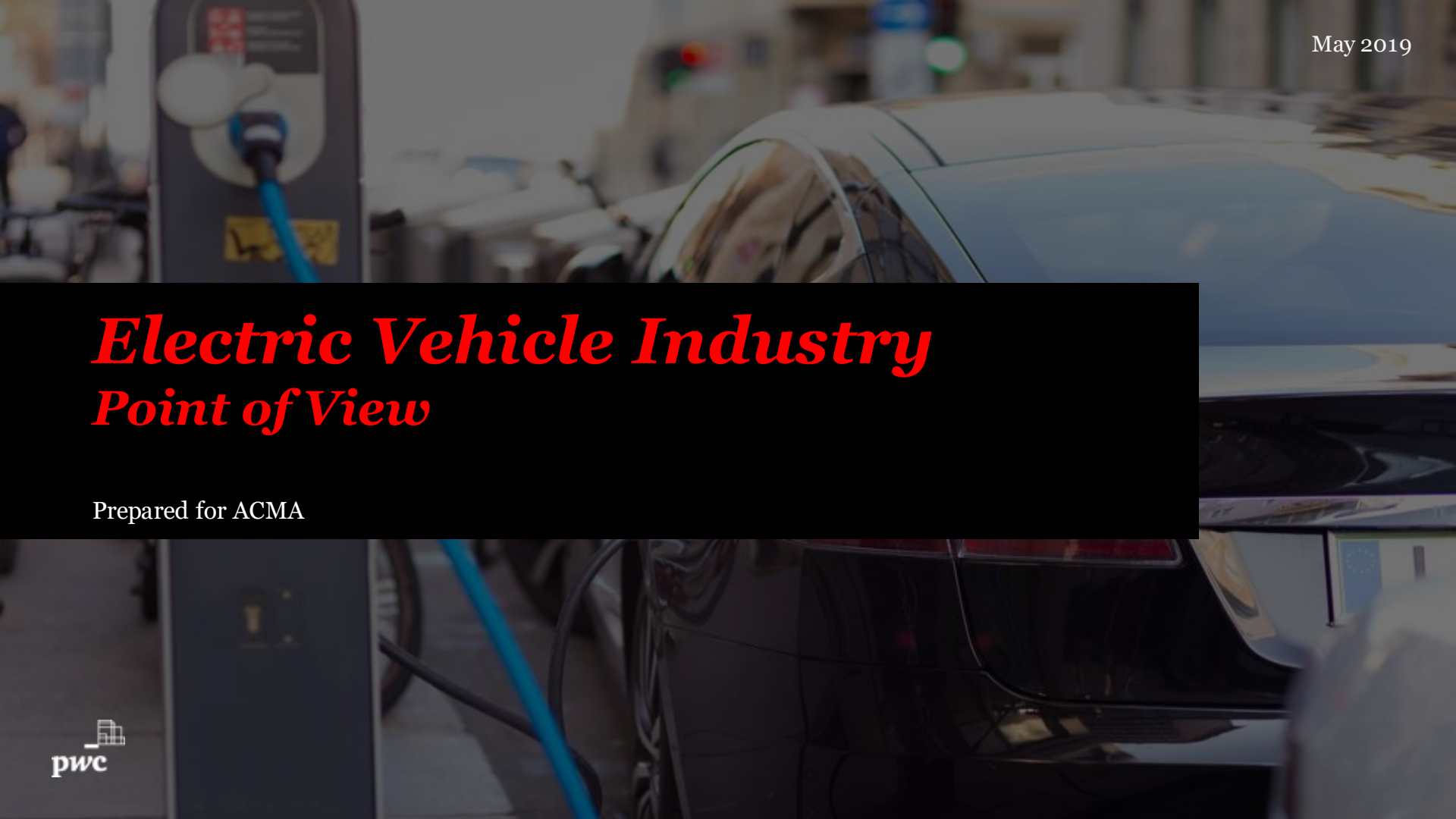


May 2019

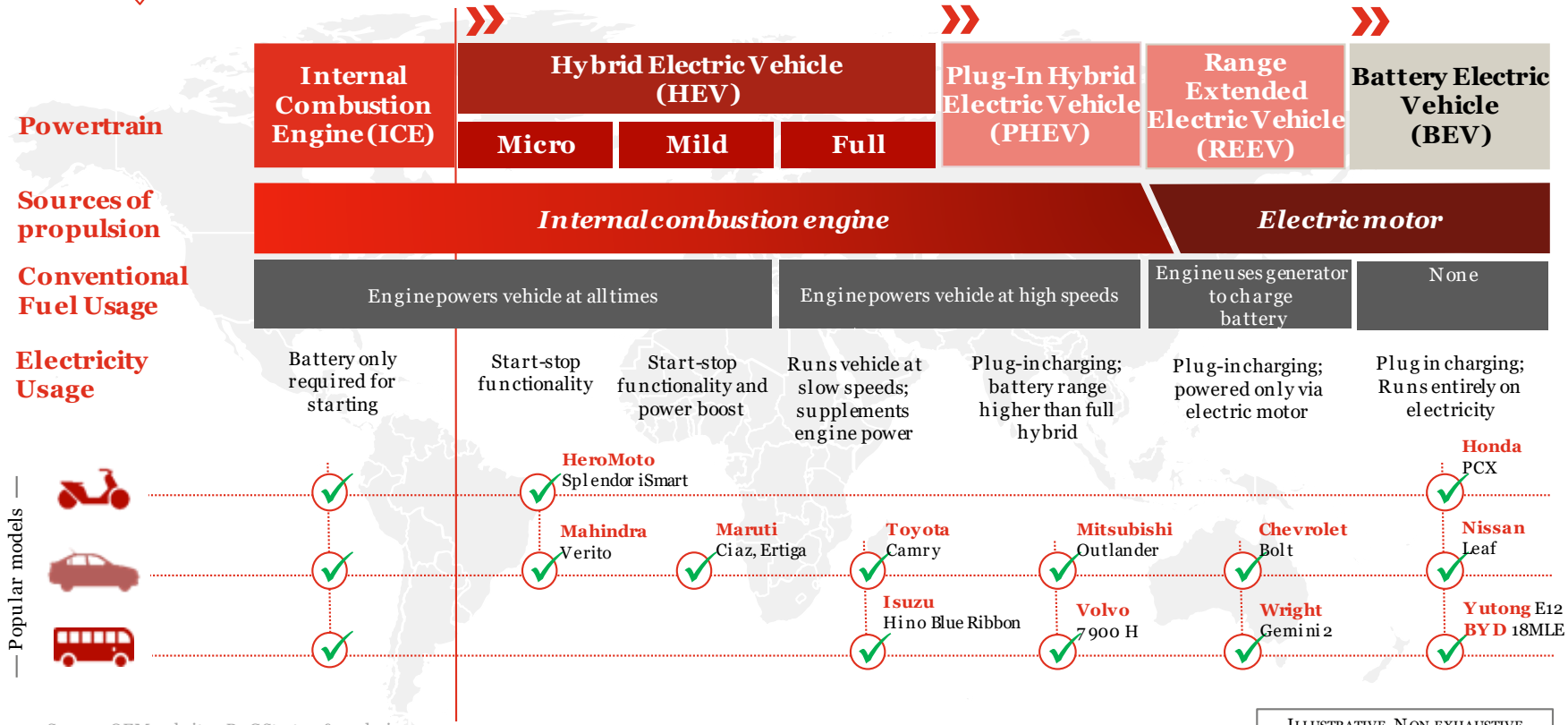
Electric Vehicle Industry
Point of View

Prepared for ACMA

pwc

Contents

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



Source: OEM websites, PwC Strategy& analysis

ILLUSTRATIVE, NON-EXHAUSTIVE

Global xEV market is ~$125 bn industry and is expected to reach $580 bn by 2025; growth driven by government push and improving TCO

E-2Wheelers

6%

(By Market Value, 2017)

Note - includes scooters & motorcycles only

- Higher penetration in developing countries due to rapid urbanization; Asia-pacific contributes to 72% of E-2W market
- E-scooters is the biggest sub-segment

Major Regions units sold: China, Japan, US

Major Players

E-Buses

27%

(By Market Value, 2017)

- e-bus markets are focused around metropolitan areas driven by growing concerns over urban air quality, carbon emissions and potential operational cost savings
- 99% of the global fleet of e-buses in China strongly driven by national sales targets, supportive subsidies and municipal air quality targets

Major Regions units sold: China, Europe, US

Major Players

E-PVs

67%

(By Market Value, 2017)

Note - includes hatchbacks, sedans, SUVs

- Reducing battery cost, government subsidies, and changing customer perceptions driving e-PV adoption
- Norway has the highest penetration ~40% new car sales are electric

Major Regions units sold: China, US, Japan

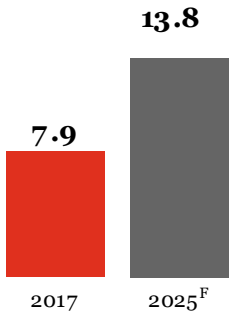
Major Players

Source: PwC research, IEA, Allied Market Research 2018, PS Market Research Report 2018

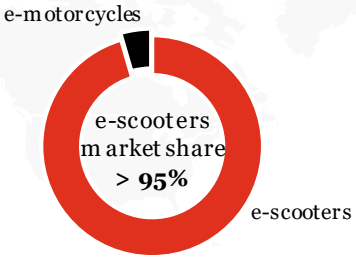
*Excludes – micro mobility and CV

e-2W market will see rapid growth in BRICS, rapid urbanization and changing customer perception is driving adoption in other markets as well

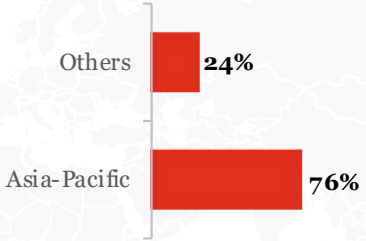
Global e-2W market size
(US$ Bn, CY)



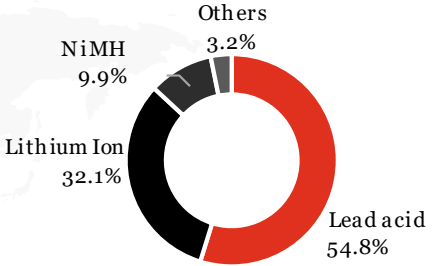
Global e-2W market value
by sub-segment (CY17)



Global e-2W market value
by region (CY17)



Global e-2W market share
by battery type



Rapid urbanization, traffic congestion in developing economies including BRICS create strong demand for e-2W for short distance commute

Boom in food & beverages (F&B) sector - rising demand for delivery options e-2W vis-à-vis traditional delivery vehicles

Growing female rider population drives e-scooters, mopeds demand

Market for e-motorcycle is expected to grow faster till 2025 due to entry of auto OEMs into e-motorcycle (Harley, MV Agusta, etc), and rising disposable income

Government subsidies, increasing household income & rapid urbanization major factors for e-2W adoption in Asia-Pacific region; China, Japan, and India are the major e-2 wheeler markets in APAC

Falling Li-ion battery prices and greater life span of Li batteries paving way for faster adoption

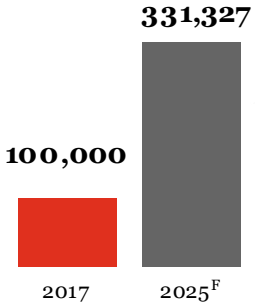
China accounts for 60% of the global lead acid 2W market

Technical difficulties at conversion facility to produce battery grade Li remains a challenge and is expected to be addressed

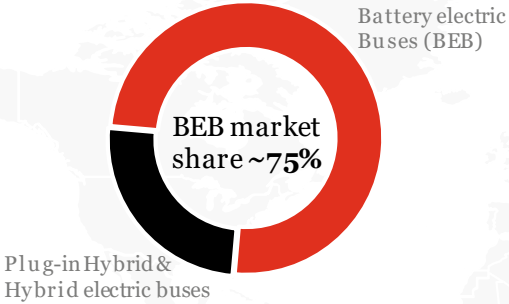
Source: Allied Market Research Report 2018, PS Market Research

Global sales of e-Buses will continue to rise, owing to government push for lower carbon emissions, urban air quality

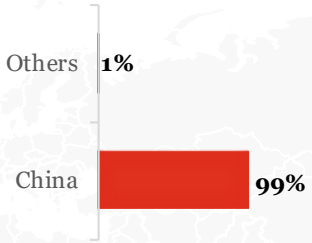
Global e-bus market volume
(units, CY)



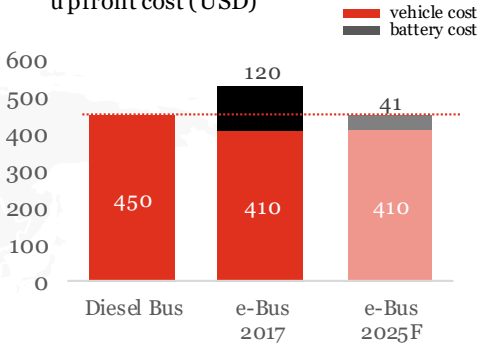
Global e-bus market value
by sub-segment (CY17)



Global e-bus market volume
by region (cumulative sales till 2017)



e-bus Vs. diesel bus
upfront cost (USD)



Growing concerns over **urban air quality, carbon emissions and potential operational cost savings** is driving e-buses adoption – forecast to register a CAGR of 16.6% till 2025

Declining battery prices and improving charging infrastructure driving Battery electric buses (BEB) growth

National sales targets, municipal air quality targets and supportive subsidies driving strong domestic demand in China

e-buses now comprise 17% of the total Chinese bus fleet and pure electric buses clearly dominate over plug-in hybrid buses

e-buses have the potential to reach cost parity vis-à-vis diesel buses -$120k to high volume prices of $41k

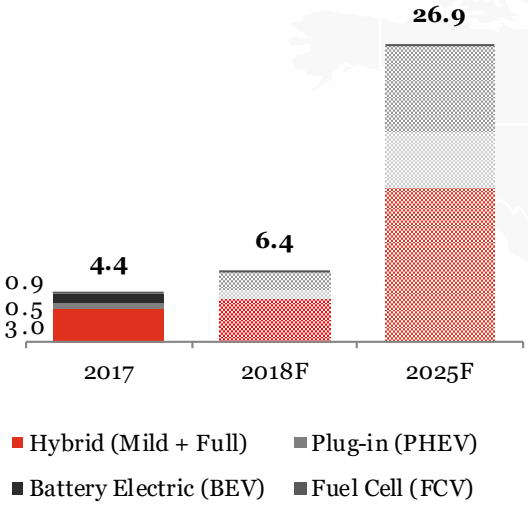
At around 80,000 kms the 350kWh e-bus reaches TCO parity with a diesel bus[1]

Falling Li-ion battery prices and innovation in battery technology

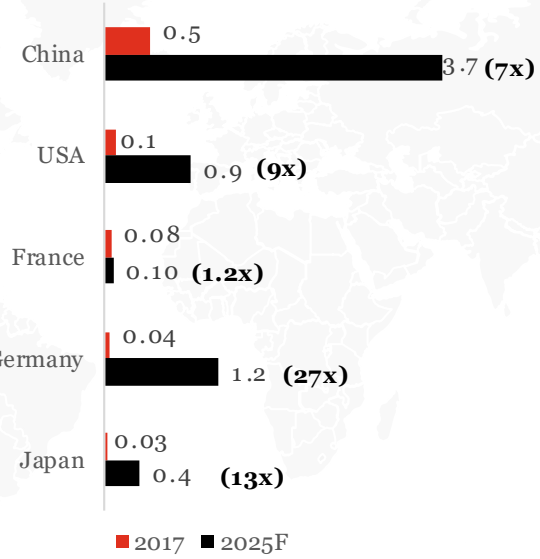
Source: [1]Bloomberg, AMR 2018, PS Market Research

BEV is the fastest growing sub-segment - China leads the market in terms of vehicle stock , charging infrastructure ; Norway leads e-PV penetration

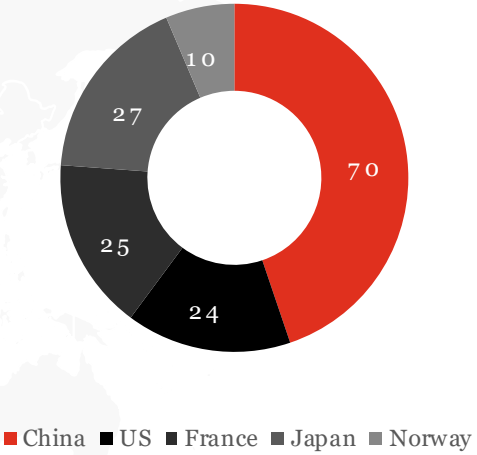
Global Alternative Fuel Powertrain
2017 – 2025F (units million)



Top 5 countries leading the BEV market
2017 vs 2025F (units million)



Geographical Distribution of EV Charging Infrastructure (Charging Stations)
Top 5 countries - 2018 ('000 units)

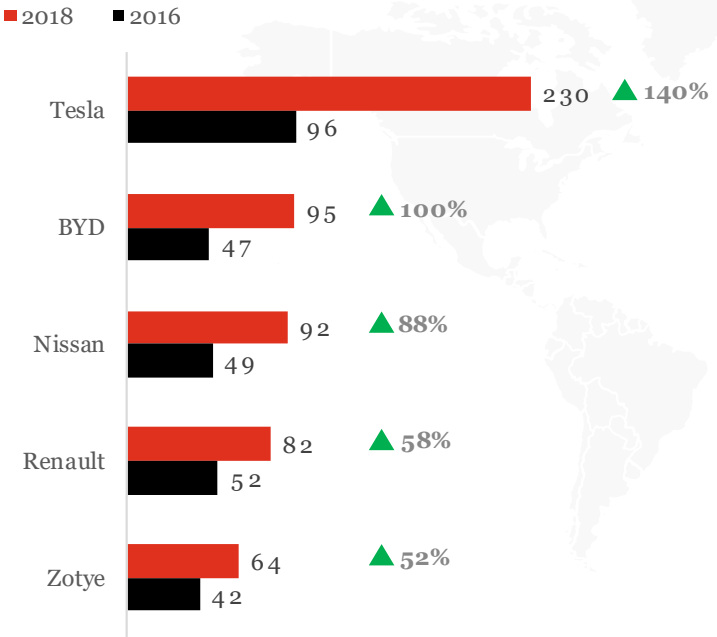


*Forecast considerations: All major markets were driven by strict regulatory requirements to reduce fossil-fuel based CO2 emissions with a perspective to full abatements by 2050 based on the now-effective COP21 convention

Source: PwC Autofacts Forecast Release, EMIS

Nissan-Renault-Mitsubishi Alliance is challenging Tesla's position as BEV market leader with launch of various models

BEV Sales by Brand ('000 unit)



Total market size ~ 1,261 k vehicles

OEMs	Announced BEV plans
Toyota	10 all-electric models by the early 2020s, ~$13 bn into battery technology development in 2030
Hyundai/ Kia	38 new models by 2025
Daimler	40 electric models by 2025
Ford	40 electrified models by 2025
Honda	2/3rd of 2030 sales
Nissan	1 million electrified vehicles a year by 2022
Tesla	0.5 million sales in 2018; 1 million in 2020
Volkswagen	2 – 3 million annual sales by 2025,50 fully electric models by 2025
Volvo	1 million cumulative sales by 2025

Source: PwC Autofacts, JATO, News articles

Aggressive market development models, billion dollar investments on charging infra, stringent policies imply higher xEV penetration.

	Policy Overview	Details of Regulatory Framework
China	Stringent regulations for manufacturers, scaling back incentives	**Proportion of total cars : 0.8% | Charging stations: 70,000** • NEV credit system for manufacturers • Scaling back of subsidies for EVs with a range of less than 300 km by 30% in 2019 and completely in 2020; 10% increase in subsidies for midsize and large EVs with a range of 400 km or more
US	Tax credits and other monetary & non-monetary benefits	**Proportion of total cars : 0.2% | Charging stations: 24,000** • Federal IRS tax credit of $2,500 to $7,500 per new EV purchased • Other incentives may include additional tax credits, vehicle or infrastructure rebates or vouchers, vehicle registration privileges, grants, special low-cost charging rates, and high-occupancy vehicle lane exemptions
France	Financial incentives & waivers	**Proportion of total cars : 0.3% | Charging stations: 25,000** • Purchase subsidies of up to 6,000 euros for electric and hybrid vehicles • Diesel scrappage plan that offers up to 4,000 euros for trading in old diesel vehicle • Tax breaks and waiving off annual registration fees
Japan	Subsidies and charging infrastructure	**Proportion of total cars : 0.2% | Charging stations: 27,250** • One-time subsidy for purchase of new EV and waiving of other one-time taxes • Eliminating range anxiety through availability of charging infrastructure
Norway	Tax exemptions and other financial incentives	**Proportion of total cars : 6.4% | Charging stations: 10,000** • Exemption from 25% VAT on purchase and annual road tax • Parking, road toll and ferry charge for EVs with upper limit of 50% of full price • Fiscal compensation for scrapping of fossil vans when converting to a zero emission van

Source: IEA 2018 report, News articles, PwC analysis

FY19 sales for the Indian BEV market stood at 0.76 Mn units ; future growth looks positive with government regulations and investment outlays

E-2Wheelers

16.4%

(By volume, FY19)

Note - includes scooters & motorcycles only

Unlike global market, EV adoption in Indian market is led by e2W category rather than passenger vehicles (global)

E-3Wheelers

83%

(By volume, FY19)

Note - includes auto & rickshaws

Increasing regulation and organization of 3W market is expected to drive future market growth

E-PVs

0.5%

(By volume, FY19)

Note - includes hatchbacks, sedans, SUVs

Although present market penetration is low, incentives and wider choice is expected to drive future growth

E-Buses

0.1%

(By volume, FY19)

Electric bus adoption is increasing owing to push by central government, state transport authorities towards electrification of fleets

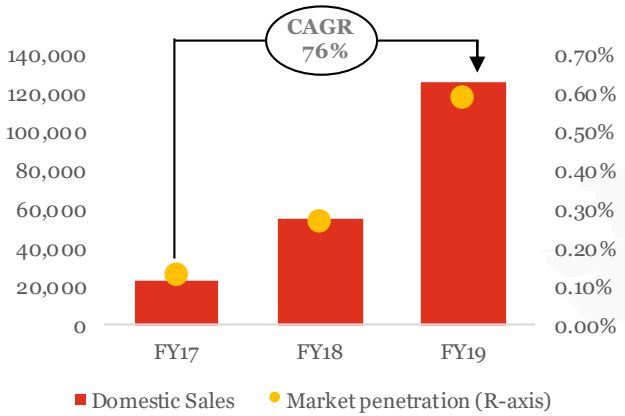
Major Players

HERO ELECTRIC, TORK, ATHER, KINETIC GREEN, Electeca, SMART E, ATUL AUTO LIMITED, Mahindra ELECTRIC, NISSAN, MARUTI SUZUKI, RENAULT, HYUNDAI, TATA, BYD Build Your Dreams, Ashok Leyland, VOLVO, Olectra

Source: SMEV, NewsArtides

While e-2W sales have increased, the Indian market still has a long way to go to meet FAME II target for overall electrification of vehicles

Domestic sales, market penetration
(units, % of total 2Ws)



Key models available in market


Hero Electric Photon


Hero Electric Flash


Okinawa Praise


Ather 450


Yo Electron

Customer Adoption

Customer Segments	Likelihood of Adoption
Govt	NA
Fleet	★★☆
Individual	★★★

Growth Drivers

- Lower total cost of ownership (**TCO**) in comparison with all other vehicles
- Usually used for short commutes so there is **no range anxiety**
- **Convenience in charging** - scooters can be charged quickly and easily, often using existing plug points in homes

Challenges

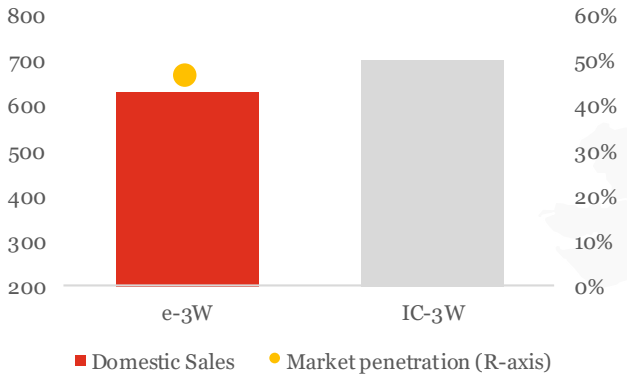
- Almost all electric scooters run on lead batteries to keep the prices low. This leads to lower life, battery failures, of batteries thus restricting sales

Source: SMEV, SIAM, ETAuto

e-3W witnessed the highest penetration in FY19 across segment; operator earning potential, relaxed vehicle registration norms being prime reasons

Domestic sales, market penetration

('000 units FY19, % of total 3Ws)



Key models available in market


Mahindra Treo


Mahindra e-Alpha mini


Kinetic Green Safar


Electeca Eco


Atul Elite

Customer Adoption

Customer Segments	Likelihood of Adoption
Govt	NA
Fleet	★★★
Individual	★★☆

Growth Drivers

- Increase in operator earning potential, **end of Permit Raj**
- E-rickshaws preferred by customers; **lower running cost** as compared with traditional 3w
- Emergence of **independent local assemblers**
- Absence of strict enforcement of regulations in 3w segment

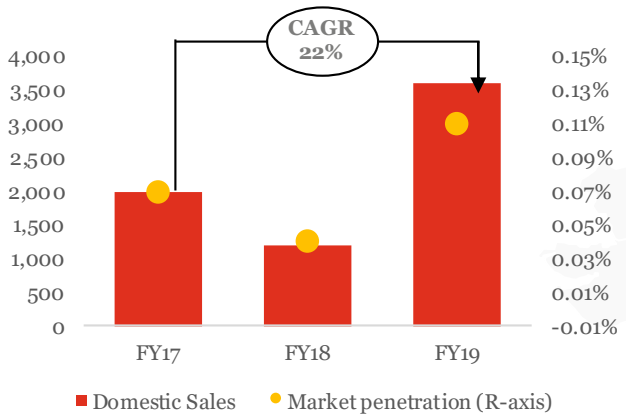
Challenges

- Operators rely on sub-standard charging equipment, electricity theft owing to unavailability of charging points
- Cost sensitivity of segment, which makes li-ion batteries commercially unviable
- 2W structural resilience in itself

Source: SMEV, SIAM, ETAuto

e-PV sales has largely been restricted to urban areas; segment characterized by preference shift towards higher power and longer range vehicles

Domestic sales, market penetration
(units, % of total PVs)



Key models available in market


Mahindra e20


Mahindra eVerito

Upcoming in June 2019:


Tata Tiago Electric


Mahindra e-KUV 100

Customer Adoption

Customer Segments	Likelihood of Adoption
Govt	★★★
Fleet	★★☆
Individual	★★★

Growth Drivers

- Growth restricted largely to **urban** areas -
  - Popularity largely limited to **corporate fleets** owing to players such as Lithium Urban; electrification of government fleet
  - **Charging Infrastructure** availability restricted to urban centres

Challenges

- Customer segmental preference shift towards SUVs ; need for higher power and longer range
- Next gen shift from vehicle ownership to sharing ; higher acquisition cost of vehicles for cab aggregators

Source: SMEV, SIAM, ETAuto

Government push for e-buses, with a planned shift to 100% electrification in the long term

E-buses in public transport

Cities

DHI selected 11 cities with plans to procure 390 electric buses in total

Operational	Planned	
Mumbai	Delhi	Ahmedabad
Shimla	Indore	Kolkata
Hyderabad	Jaipur	Guwahati
Lucknow	Bangalore	

Key models available in market


Olectra-BYD eBuzz


JBM Solaris Eco-life


Tata Motors Ultra


Ashok Leyland Circuit

Customer Adoption

Customer Segments	Likelihood of Adoption
Govt	★★★
Fleet	★★★
Individual	NA

Future Plans: E-buses

- GOI target as per Green Urban Mobility Scheme – 100% electric public transport by 2030 - deploy 10,000 electric buses in public transport fleet
- International players have tie-ups with Indian companies to setup assembly units in India

Source: SMEV, SIAM, ETAuto

Contents

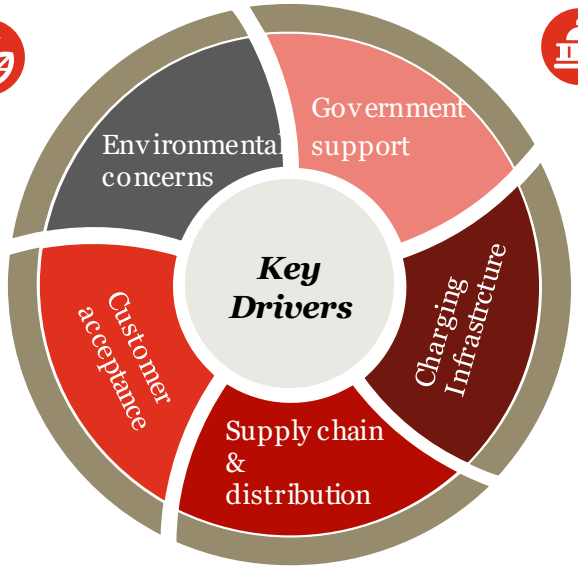
Interplay of five key factors will determine how the Indian xEV market evolves

1 Environmental concerns

- Indicators - Implementation plan for BS-VI, Falling Battery prices, Rise in crude oil prices, Reduction in solar tariff
- Stringent fuel efficiency norms (CAFÉ)
- Cause - Scarcity of fossil fuels, Increasing pollution in transportation
- Long term sustainability

2 Government support

- Creation of xEV demand in the market
- Promoting indigenous manufacturing of xEV
- xEV market segment prioritization based on ease of adoption and impact on the environment
- Driving the ecosystem to achieve government's multiple objectives
- Increasing xEV customer awareness



3 Charging infrastructure

- Developing charging infrastructure though investments from Govt & private players
- Establishment of charging guidelines and standards
- Integration of grid with charging stations to provide seamless service
- Charging convenience to reduce customer anxiety

4 Supply chain & distribution

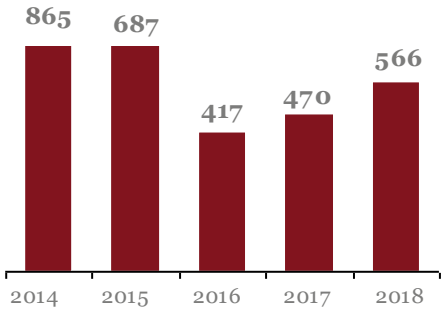
- Raw material availability in making xEV components
- Opportunity identification for xEV component manufacturing in India
- Building of local e-components manufacturing capability
- Dealer's motivation in driving sales of xEV products (incentives, margins etc.)

5 Customer acceptance

- Economic rationale in purchasing electric vehicle
- Vehicle performance & features
- Battery performance
- Range anxiety
- Awareness & education drives

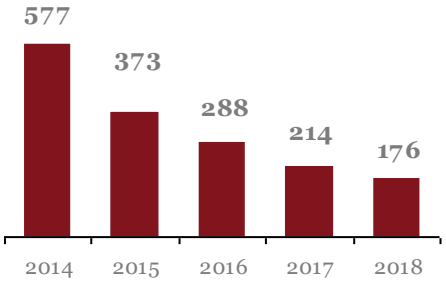
Deteriorating environment, fossil fuel scarcity create imperatives for xEV adoption; stringent new norms for IC vehicles

Crude Oil imports
2014-18 (in '000 Crores)



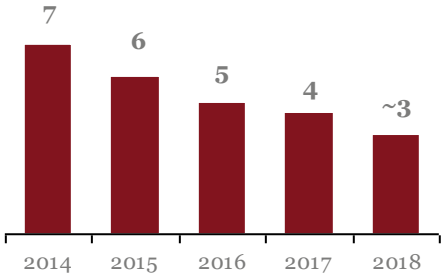
Rising crude oil imports bill
Rising oil consumption elevates climate risks from greenhouse gas emissions and imports increase budget deficit and inflation

Battery Pack Real Price
2014-18 (USD/ kWh)



Decreasing battery prices
Since batteries account for major part of xEV cost, lower battery prices are making EVs more attractive for customers

Solar tariff
2014-18 (INR / unit)



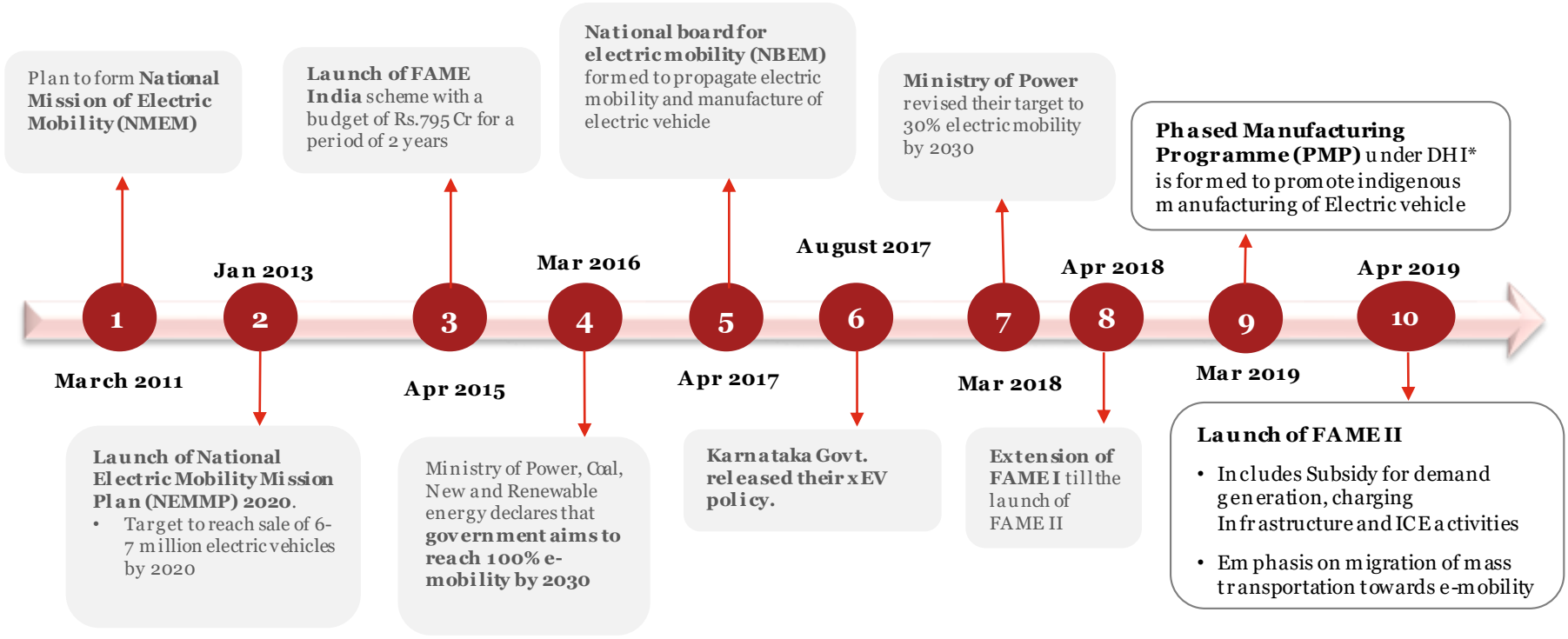
Decreasing solar tariffs
This would avoid burden shifting – shifting of emissions from roads to power plants

Other Considerations

- CAFÉ (Corporate Average fuel economy) norms require cars to be 30% or more fuel efficient from 2022 and 10% or more between 2017 and 2021
- Expected to impact IC vehicle price and push OEMs towards greater xEV production for CO_2 credits

Source: CEIC, Bloomberg NEF, MNRE, SECI

To tackle environmental concerns and ensure long term sustainability, Government has taken e-mobility initiatives since 2011



Source: PwC secondary research

*Department of Heavy Industries & Public Enterprises

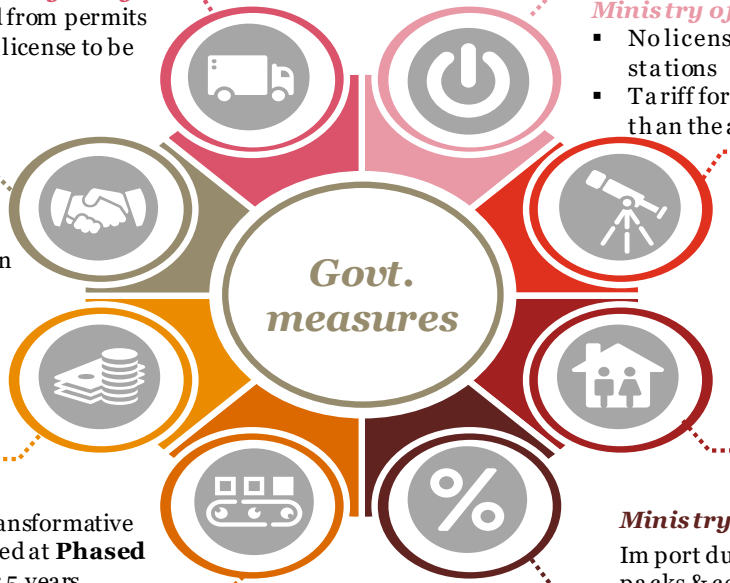
Various government organizations have provided holistic and integrated measures to transformation of e-mobility

Ministry of Road Transport and Highways
- Battery vehicles will be exempted from permits
- Gearless electric scooters driving license to be provided for age group 16-18
- BEVs will get green plates.

Ministry of Power
- No license required to operate xEV charging stations
- Tariff for private charging stations will not be more than the average cost of supply plus 15 %

NITI Aayog
To reduce capital burden, a **PPP agreement** is done to operate and maintain the e-buses in cities through OPEX Model

Indian Space Research Organization
Shortlisted 10 firms for transferring their Li-ion battery technology



Department of Heavy Industry
Cabinet approve **FAME II** scheme with a outlay of Rs.10,000 Cr to support 15.6 lakh electric vehicle for a period of 3 years

Ministry of Housing and urban affairs
Amended rules for charging infrastructure in private and commercial buildings

NITI Aayog
Cabinet approved National Mission on Transformative Mobility and Battery Storage which is aimed at **Phased Manufacturing programme** (PMP) for 5 years

Ministry of Finance
Import duty for all categories of vehicle, battery packs & cells have been rationalized

Recent schemes like FAME II & PMP will likely to have major impact on the adoption of xEV in the market

 Source: NITI Aayog

With a bigger financial outlay, focus on public transport and charging infrastructure, *FAME-II* provides the right impetus for e-mobility adoption

FAME-India (National Mission on Electric Mobility)

	Fame-I	Fame-II
Duration	FY15-FY17*	FY20 – FY22
Incentive type	Fuel efficiency based	Battery & vehicle performance based
Vehicle type	2W,3W,4W & e-bus	2W,3W,4W,e-bus & e-rickshaw
Budget	INR 795 Cr*	INR 10,000 Cr
Demand Incentive	INR 495 Cr	INR 8,596 Cr
Segment focus	2w & Passenger cars	E-bus,3w & private 2W
Battery type	All types	Li-ion and advanced
Nos. Supported	~0.2 Million	~1.6 Million

*Scheme extended till FY19 with budget increased to INR 895 Cr

FAME-II: Emphasis on shared mobility and private ownership of e-2W

Target Segment	Vehicles to be supported	Budget allocated (INR Cr)	Impact on segment level adoption	Key influencing factors
	1,000,000	2,000		Rapid urbanization
	500,000	2,500		Operational cost saving
	55,000	551		-
	7090	3,545		Supportive subsidies

Very high · High · Average · Low

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 stated by DHI

States such as Andhra Pradesh, Kerala Maharashtra, Karnataka, Uttar Pradesh, etc., have released their own xEV policy to promote EV and attract investment from private players

 Source: DHI, PwC Analysis

Government's localization push through PMP programme augurs well for the aspirations of Indian xEV component manufacturers

PHASED MANUFACTURING PROGRAM BY DHI

- **2-year programme** starting from 1st April 2019
- **Phased increase of Import duty (ranges from 0% to 15%)** in the next 2 years for various critical electric vehicle components to allow local xEV component manufacturers to plan their investments and build the capability of indigenous manufacturing
- Since imported parts shall get costlier it will certainly encourage EV makers to source the parts within India
- **Mandatory localization** of certain e-components necessary to avail FAME subsidy will force OEMs to seek local e-component manufacturers *(refer to Appendix -I for complete list of parts)*

NATIONAL MISSION ON TRANSFORMATIVE MOBILITY & BATTERY STORAGE

Objective: To drive clean, connected, shared, sustainable & holistic mobility initiatives

PMP plan:

- For setting up large scale, export-competitive integrated batteries and cell-manufacturing Giga plants
- Focus on large-scale module and battery packs in FY20 & Integrated cell manufacturing by FY22.
- Localize production of electric vehicle across xEV value chain
- Plan is expected to run for 5 years

Opportunity: Auto component manufacturers will look to diversify their product portfolio and increase their capabilities to cater to the future demands of xEV envisaged by the govt.

Source: PMIndia, NITI Aayog

Government's guidelines and investment on charging infrastructure with interest from private players will make the xEV makers upbeat

2700

charging stations to be built in mega cities, "Smart cities"

3 x 3 km²

grid planned to have at least one charging station

1000 Cr

will be used for developing infrastructure

25 km

Stretch of highway to have a charging station

- **Guidelines & standards** from Govt. for charging infrastructure - *Standards on CCS, CHadeMO, Bharat AC/DC connectors defined*
- Government encourages interlinking of **Renewable energy with charging grid**; *pantograph* and *fast charging* is also part of the plan
- Private charging at residences / offices
- Setting up of Public Charging System (PCS) shall be a **de-licensed activity**
- Encouraging Public-private partnerships (**PPP**)

Notable players - charging infrastructure

ATHER GRID, DELTA, ABB, Fortum, TATA POWER, ZEVpoint, magenta e-mobility Electric Vehicle Solutions, EVM

NON-EXHAUSTIVE

Source: News articles, PwC analysis, Ministry of Power

Raw material availability, manufacturing cost and dealer margins hold key to the future development of electric mobility in India

RAW MATERIAL

- Some of the xEV components has to be **customized for Indian climatic conditions** – such as *battery management system* (BMS)
- Manufacturers could explore investing in R&D for developing **magnet-less motors** as India doesn't have magnet resource
- **Battery recycling** will reduce Nickel and cobalt **import dependency**

LOCAL MANUFACTURING

- **Import duty rationalization** of many e-vehicle components will stimulate local manufacturing
- Govt. is indicating mandatory **localization of 50%** of the vehicle parts for availing subsidy
- Local manufacturers could also target the **EV exports market** (India as the manufacturing hub)

DEALER NETWORK (for OEMs)

- With a lower maintenance cost (hence service revenue) levers to attain **dealer profitability** would have to be revisited - e.g. dealer incentives to push the sales of xEVs
- Dealers' future **value proposition may get diversified, dealer touchpoints can serve as** charging stations, provision for battery swapping etc.

Recent developments

- Battery maker eyes India's $300 billion lithium-ion market
- Hyundai mulls options for sourcing EV components in India
- Researchers improve recycling process for lithium-ion batteries
- Avan Motors is looking to expand its dealership reach to 11 more states in the next few weeks

Source: Press search, PwC analysis

Increase in customer choice of electric vehicles with OEMs planning to launch a slew of electric vehicles in the market

Segments	Vehicles launched till 2019	Expected launches
	Hero Optima; Okinawa Ridge; Splash; Ather 450; Yo-Bikes	Bajaj bikes; Twenty two motors bikes; TVS Creon; KTM bikes
	Mahindra Alfa; Mahindra Treo; Smart E E-rickshaw; Lohia Comfort	Piaggio; Bajaj 3W; Atul Auto - JBM
	Tata Tigor EV; Mahindra E-Verito; Mahindra e20; Mahindra e-supro	Maruti eWagonR; Renault Kwid-EV; Tata Tiago-EV; Hector e-SUV; Nissan Leaf
	JBM Eco-life; AL CircuitF; Tata Bus; Olectra-BYD bus	VECV Skyline; AL CircuitS

ILLUSTRATIVE, NON-EXHAUSTIVE

To win the xEV market, manufacturers need to address key customer concerns

1

Economic Rationale

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

2

Battery performance

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

Make for India – e.g. battery management systems, magnet less motors

3

Range Anxiety

Provide ease of access to charging stations (network expansion) adopt technologies for fast charging, new business models such as battery swapping (2&3W)

4

E-vehicle performance

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

5

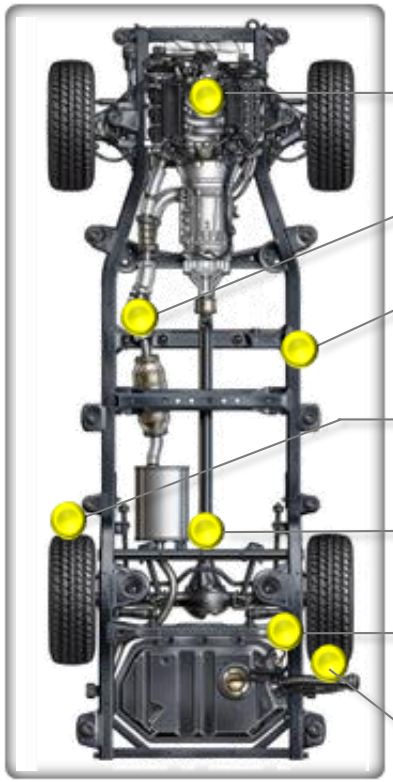
Customer awareness

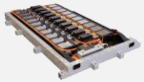
To create awareness (and hence demand pull) among the potential customers – educational drives, feature illustrations, DIY & charging procedures

Contents

xEV changes will manifest in different products across vehicle segments…

Replaced sub-systems, redesigned modules, use of new technology, light-weighting and so on

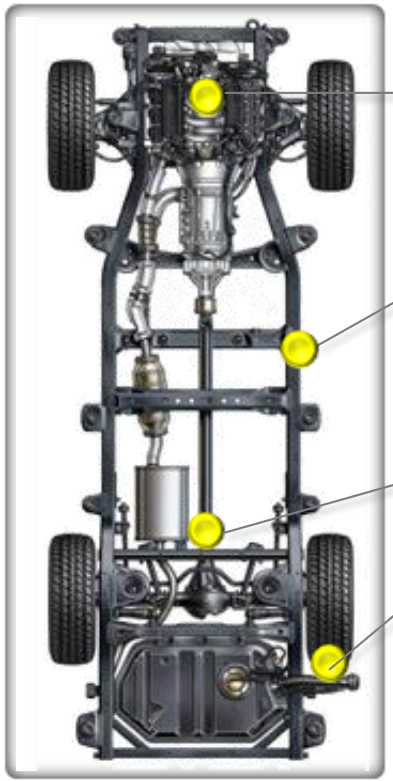


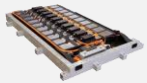
Sub-system	HEV	BEV	Changes to the sub-system
I.C. Engine	○ ● ○	● ○ ○	 On-board charger  Battery pack  BMS  Power electronics  Motor
Exhaust	○ ○ ●	● ○ ○	Only for Hybrids
Interiors & HVAC	○ ○ ●	○ ● ○	 Electric compressor **NVH & BSR** Enhanced specs
Braking	○ ● ○	○ ● ○	 Electro-mechanical brake boost  Aluminium disc braking
Transmission	○ ○ ●	○ ● ○	 One/Two speed low NVH gearbox, may / may not be Integrated with motor (BEV)
Chassis	○ ● ○	○ ● ○	Complete redesign for new weight distribution pattern
Wheels	○ ○ ●	○ ● ○	 Redesigned wheels to accommodate In Wheel Motors / Hub Motors

● ○ ○ Not applicable ○ ● ○ Moderately applicable ○ ○ ● Highly applicable

ILLUSTRATIVE, NON-EXHAUSTIVE

… component makers would need to innovate and capitalize on the recently announced incentives ; opportunity to diversify portfolio.

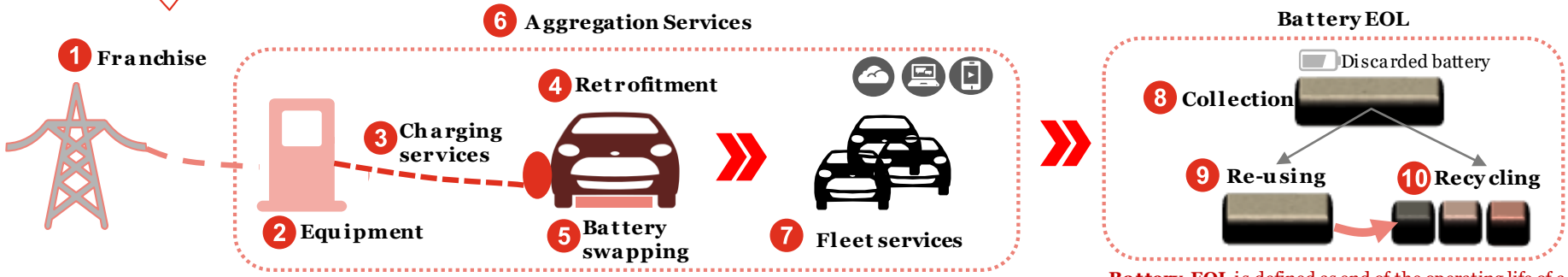


Sub-system	Potential opportunities	Incumbent Players
Engine	 On-board charger  Battery pack  Traction Motor	• AMPERE VEHICLES • ANAND AUTOMOTIVE • CROMPTON GREAVES (power & industrial solutions)
HVAC	 Electric compressor  HVAC	• ROCKMAN INDUSTRIES LTD.
Power electronics	 Circuit Breakers / Safety Devices  AC,DC charging inlets  DC-DC converter • Power & Control WH • Electronic throttle • Vehicle control unit • Traction motor controller	• TATA AUTOCOMP • COMSTAR AUTOMOTIVE • EXICOM TELESYSTEMS • JAY SWITCHES
Wheels	 • Wheel rim, • Rims integrated with hub motor	- NA -

NON-EXHAUSTIVE

Note : Refer Appendix-I for localization directive and complete list of parts related to Fame scheme

Similarly, plethora of opportunities will open up in services (direct & ancillary) in the e-mobility ecosystem…



Battery EOL is defined as end of the operating life of a EV battery as specified by the manufacturer; at this stage the battery is no longer suitable for EV application

1 Franchise

Private players can become franchises of Discoms to sell electricity for charging

2 Equipment

EV charging equipment manufacturing/ supply for the domestic market

3 Charging services

Provision of charging facilities to the customers – involves installation, maintenance and operating charging infra as a primary business

4 Retrofitment

Retrofitting the existing/new vehicles with the EV powertrain kits

5 Battery swapping

Battery swapping system as an alternative to spot charging

6 Aggregation Services

Cloud, software or application based services for aggregating the EV services

7 Fleet services

Operating a EV fleet- point to point or leasing

8 Collection

Establishment of used EV batteries collection infrastructure and making them available for the disposal process

9 Re-using

Repacking used EV batteries to make a smaller batteries suitable for stationary applications such as inverters etc,

10 Recycling

Recycling batteries to retrieve usable contents, thus minimizing the environmental impact of the dumped batteries

… globally, a number of business models have emerged to cater to the xEV ecosystem needs.

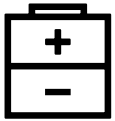
Sl. no	EV Business Model	Global Examples	India Examples
1	**Battery Swapping Model**	Gogoro	Sun mobility
2	**Battery Rental/ Leasing Model**	Renault	Sun mobility
3	**Charging Equipment Manufacturing**	ABB	EVteq
4	**Charging Infrastr. Partnership Model**	E-on	EV Motors, Fortum
5	**Electric Vehicle Leasing Model**	Swedish ICT SICS	Glyd
6	**Battery Recycling Model**	Renault, Umicore	-NA-
7	**High-end EV Sales + Fast-Charging Model**	Tesla	Emflux Motors
8	**EV Car Sharing Model** ***(Public-Private)***	Lyft	Blu-smart

NON-EXHAUSTIVE

Source: News articles, PwC Strategy& Analysis

Innovation across the xEV ecosystem

A glimpse into future-tech



Battery

- **Solid State Li Batteries, Graphene batteries, and Nanotech batteries** - lighter batteries, faster charging and long range per charge
- **Foam batteries, Sand batteries, Nickel-zinc batteries, Dual Carbon batteries, and Sodium ion battery** - cost effective alternate to Li batteries with improved battery life & faster charging

Structure & hardware

- **Lightweight Materials, composite materials** using carbon fibers/High Strength Steel to increase range of EV
- **'eAxle' technology** - electrically driven axle system for hybrid cars deliver torque vectoring; improve driving experience

xEV future tech

Charging

- **Wireless Inductive** charging to charge batteries during operation. **Autonomous park-and-charge** to charge batteries via sensory devices
- **Regenerative Braking, Ultrasound charging** to charge its batteries by harnessing power from kinetic and sound energy
- **Refillable Technology & Micro-super capacitors** to recharge faster & reduce discharge rates of batteries

Intelligent systems

- **Intelligent Battery Management System** using analytics & ML to increase battery life & efficiency
- **Intelligent Motor Timer System** to boost EV cruising range

Source: PwC research


Thank you

Appendix

Appendix I

To avail FAME Subsidy, the following parts have to be localized per the given timeline

Item Description	Segment
Wheel Rim	E-2w, E-3w, E-4w, e-bus
Power & control wire harness along with connectors	E-2w, E-3w

Item Description	Segment
Traction battery pack	E-2w, E-3w, E-4w, e-bus

Item Description	Segment
HVAC	E-4W
Power & control wire harness along with connectors	E-4W, E-bus
Wheel rim integrated with hub motors	E-2w, E-3w, E-4w, e-bus
DC-DC convertor	E-2w, E-3w
Vehicle control unit	E-3w*
On-board charger	E-3w*
Traction Motor	E-3w*
Traction Motor controller/inverter	E-3w*

Item Description	Segment
HVAC	E-bus
MCB Circuit breaker/electric safety device	E-4w, E-bus
AC Charging Inlet Type 2	E-4w, E-bus
DC-DC convertor	E-4w, E-bus
Vehicle control unit	E-2w, E-3w^, E-4w, e-bus
Electronic throttle	E-2w, E-3w, E-4w, E-bus
On-board charger	E-2w, E-3w^, E-4w, E-bus
Traction Motor	E-2w,E-3w^

Item Description	Segment
Electric compressor	E-4w, E-bus
DC charging inlet BEVCDC001	E-4w
DC Charging inlet CCS2/ CHAdeMO	E-4w, E-bus

Item Description	Segment
Traction Motor	E-4w, E-bus
Traction Motor controller /inverter	E-4w, E-bus

*Only E-rickshaws & E-carts
^ excluding E-rickshaws & E-carts

Source: DHI, March 2019

Appendix II

Scale-ups / start-ups foraying into the Indian xEV market

NON-EXHAUSTIVE

Electric Vehicles

- **e-2W**
  - Tork Motorcycles
  - Twenty Two Motors
  - Ather Energy
  - Amphere Vehicles
  - Orxa Energies
  - Emflux Motors
  - Okinawa Autotech
  - Ultraviolette Automotive
- **e-4W**
  - Strom Motors
- **e-3W**
  - Gayam Motor Works

EV Components

- **Battery Management System**
  - ION Energy, PuRE Energy
- **Battery**
  - PuRE Energy (Li & others)
  - Grinntech Motors (Li)
- **Power Electronics**
  - SimYog
- **Intelligent EV software**
  - ExoMobility
- **Embedded Systems**
  - MakerMax

Infrastructure

- **Fast charge & overnight charging solutions**
  - EV Motors
- **Charging station strategy**
  - PlugInIndia
- **Charging infrastructure & SaaS based network management**
  - Fortum
- **Battery energy storage systems & charging infrastructure**
  - Magenta Power & EV solutions

Fleet Services

- **Electric cab services**
  - Blu-Smart
- **Employee transportation services**
  - Lithium Urban
- **Premium transportation services**
  - Glyd (M&M)

Allied Services

- **Micro-mobility solutions**
  - RodoBikes
- **Modular batteries & quick interchange stations**
  - Sun mobility

Source: PwC research & analysis

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