

# Global Electrification: Journey so far, and the road ahead

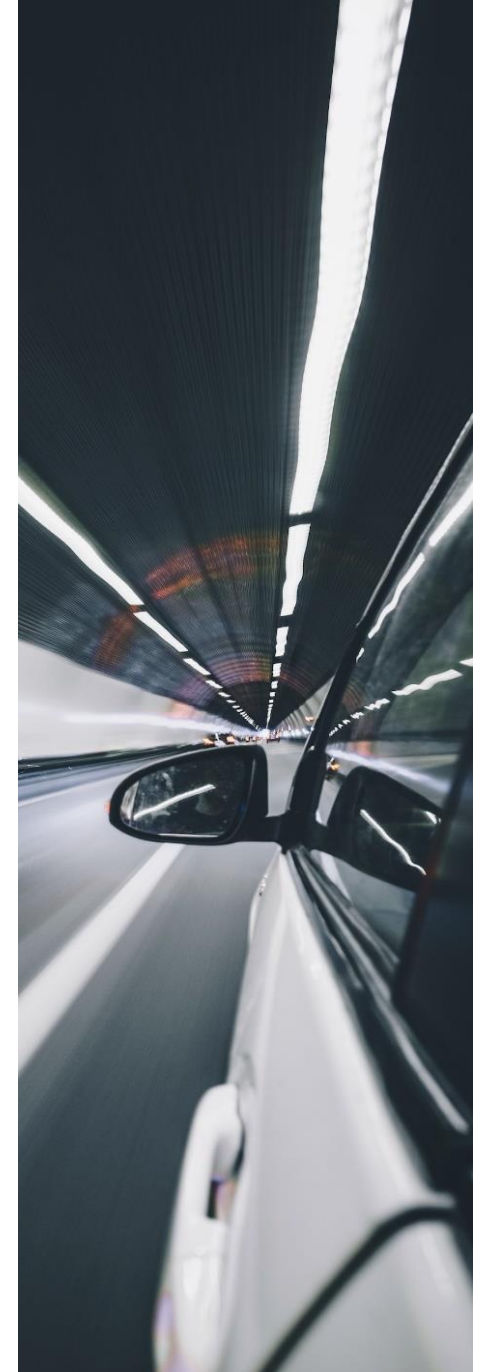
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14<sup>th</sup> WORLD RENEWABLE ENERGY TECHNOLOGY CONGRESS  
(Renewable Energy, Energy Efficiency & Sustainable Solutions for a  
Green Economy)

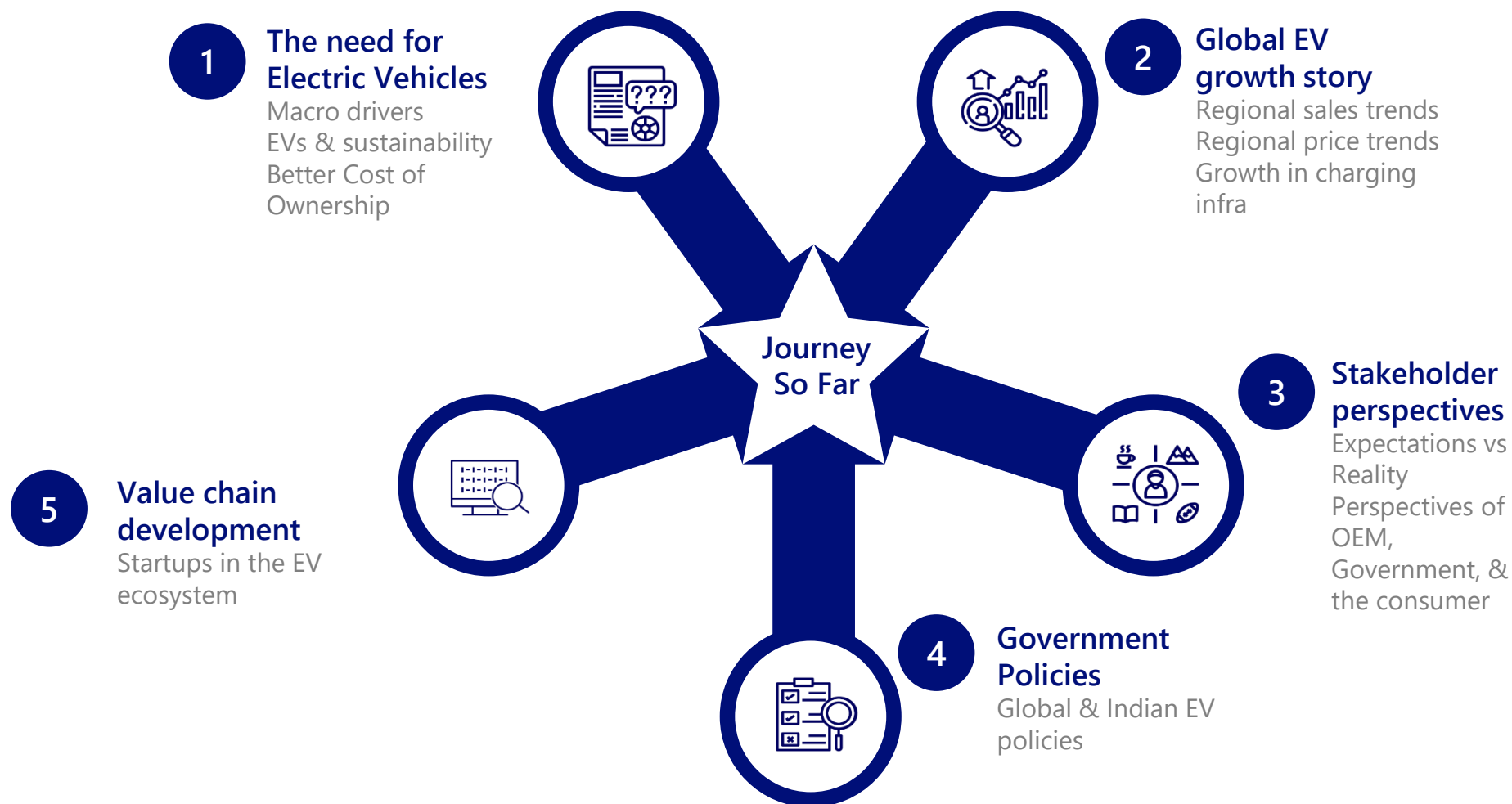
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# Globally, vehicle electrification is a topic that is being undertaken by stakeholders across the value chain



## 1 The need for Electric Vehicles – Macro drivers

# Carbon emission commitments & energy security are the key drivers of the shift towards Electric Vehicles

### Environmental benefits



- EVs produce **significantly fewer emissions than gasoline and diesel vehicles**, which can help to mitigate the effects of climate change and **improve air quality in urban areas**.
- Countries have made **commitments towards de-carbonization of transport** and EVs shall play a key role in the same

### Energy Security



- Many countries **rely heavily on imported oil** to meet their transportation needs, which can **make them vulnerable to price shocks and supply disruptions**.
- By transitioning to EVs, countries can **reduce their dependence on imported oil and increase their energy independence**.

## 1 The need for Electric Vehicles – EVs & Sustainability

Mass adoption of EVs can complement the achievement of SDG goals (5/17) set by the United Nations

EV industry and its role in making India sustainable



Four UN SDGs are the greatly impacted by this EV transition, namely Affordable and Clean Energy (Goal 7), Industry, Innovation, and Infrastructure (Goal 9), Reduced Inequalities (Goal 10), Sustainable Cities and Communities (Goal 11), and Climate Action (Goal 13).

## 1 The need for Electric Vehicles – Better Cost of Ownership

With increasing scale, the value proposition of electric vehicles is becoming apparent to more consumers

### Total cost of ownership across different EV segments in India

- On average, the purchase cost of EVs is 1.5x for Passenger Vehicles (PVs), between 1.5x – 2x for 2-Wheelers, & 1.33x for 3-Wheelers
- Total cost of ownership is lower on account of lower running costs
  - Payback period of 4-5 years for PVs used in commercial applications subject to high usage
  - Payback period of 1-2 years for commercial 2Ws provided the daily running is higher

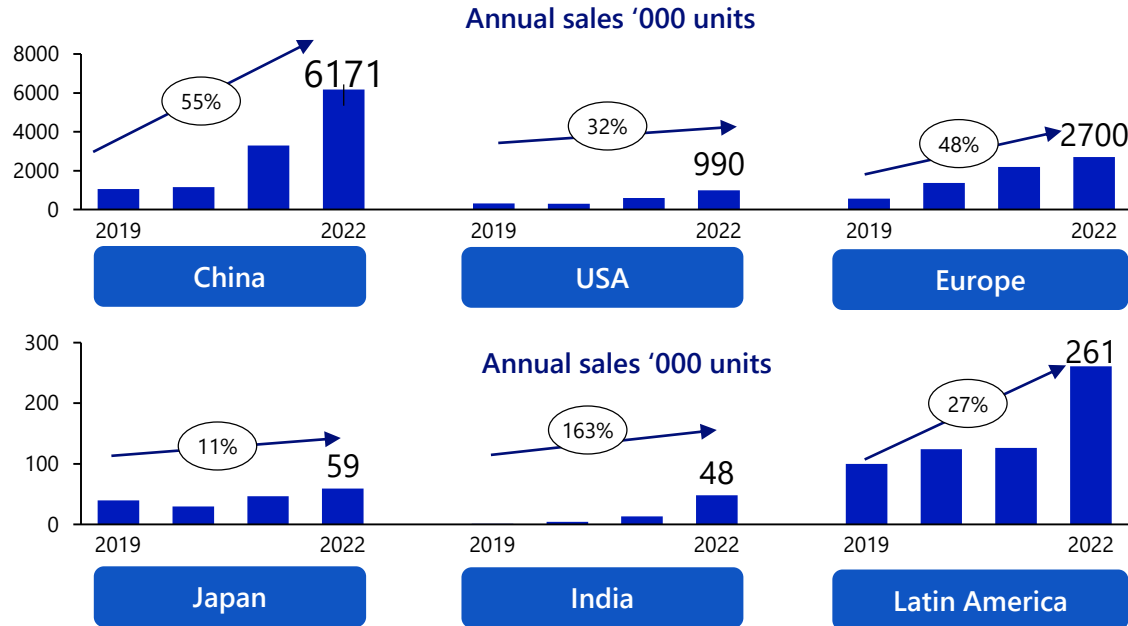
	Purchase cost – ICE (INR)	Purchase cost – EV (INR)	Payback period (Personal use)	Payback period (Commercial use)
4W PVs	800K-900K	1200K-1300K	9-10 years	4-5 years
2W	70-80K	130K-150K	2-3 years	1-2 years
3W	200K-250K	300K-350K	N/A	1-1.5 years

## 2 Global EV growth story – Sales trends

# Growth in electric vehicle sales have been observed across all geographies and segments

### Global EV Sales trends across major regions

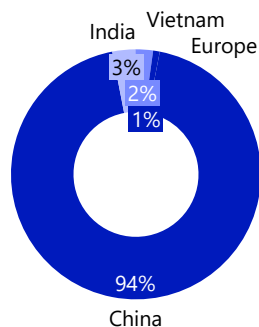
E-4Ws



- Electric car sales accounted for 9% of the global car market in 2021 – four times their market share in 2019.
- China and Europe accounted for more than 85% of global electric car sales in 2021, followed by the United States (10%), where they more than doubled from 2020 to reach 630K.

- EV sales are still lagging in emerging and developing markets due to pricing being on the higher side

E-2W/3Ws



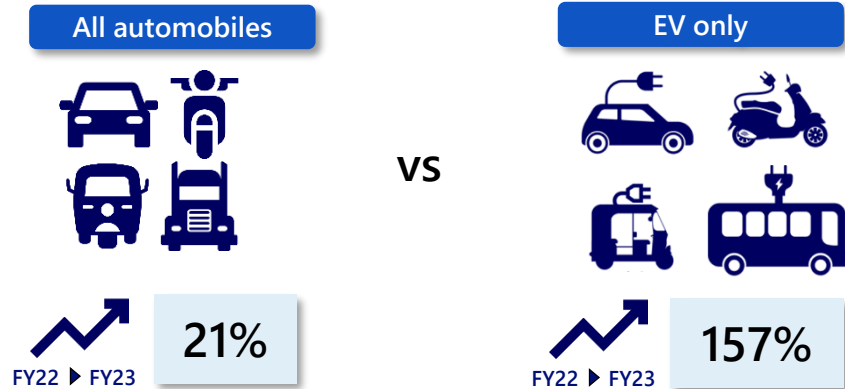
- China accounted for nearly 95% of nearly 10 million electric 2 & 3 wheelers sold in 2021 followed by India which sold over 1 million e-2Ws in 2022
- The highest level of e-2W & 3W sales penetration has been in China where 50% of new vehicles sold are electric

## 2 Global EV growth story – India

The post-pandemic economic recovery has supercharged India's EV story with increasing penetration across all segments

Current state of the electric vehicle market in India, including sales, models, and infrastructure.

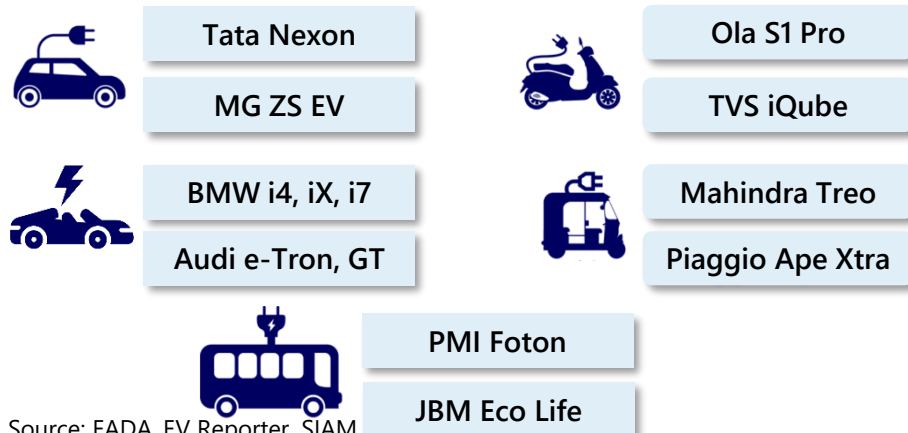
### % Y-o-Y Sales growth



### Segmental EV penetration (Mar-23)

	Sales (Mar-23)	Sales penetration	% Y-o-Y Growth
	8.5K	2.5%	139%
	85.7K	6%	73%
	45.3K	52%	92%
	0.09K	7%	14%

### Top selling models



### Extent of Charging infra (2022)

DC ⚡	AC 🔌	Swap ↻
478	3502	1125



## 2 Global EV growth story – Types of charging solutions

# Charging ecosystem deployment is being accelerated in order to allay customer worries regarding range

### Charging infrastructure ecosystem mix



#### Plug-in charging stations

##### Advantages

Convenient charging for customers at public places

Support for fast charging the EV

Simplicity in usage akin to gas stations

##### Challenges

Poor electricity grid

Lack of standardization of charging connectors

High upfront costs



#### Battery swapping stations

Lower stress on the grid

Compact installation space

Battery maintenance by the operator rather than customer

Capex heavy business model

Higher GST on standalone batteries

Applicability in light EVs only



#### Mobile chargers

Caters to on-demand customer needs

Allays range anxiety

Can be used for applications other than EVs

Limited charge capacity due to battery weight

Higher downtime compared to fixed charging

The needs of customers will become diverse as the EV market grows. This will give rise to novel charging solutions not limited to the slow charging stations dominant today

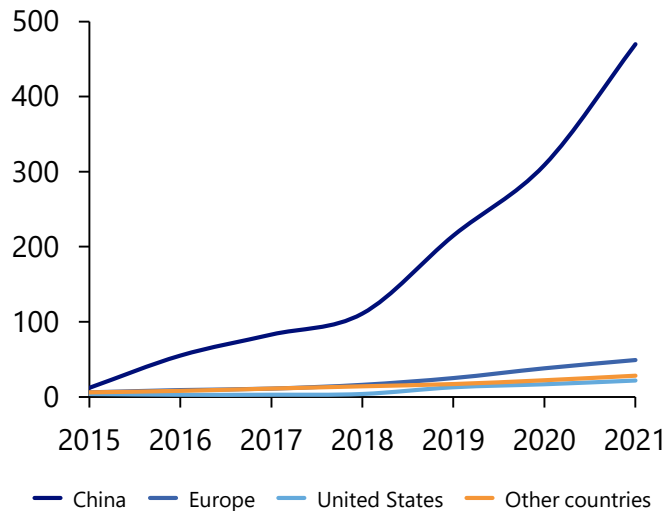


## 2 Global EV growth story – Charging infra trends

# China leads the world in the installation of both fast and slow charging infrastructure; Taiwan in battery swapping

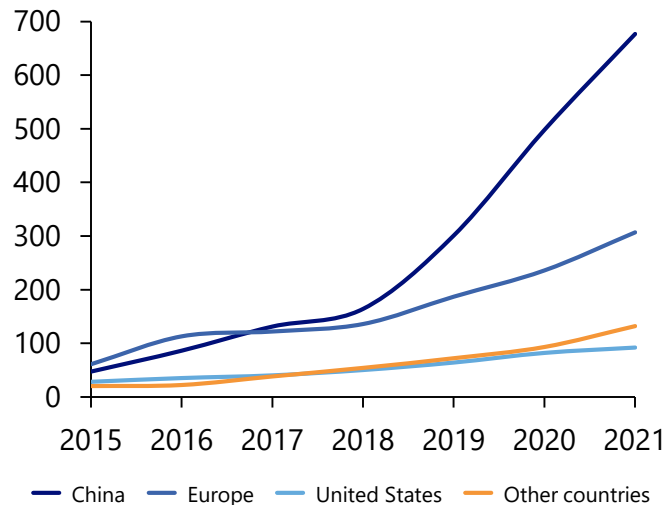
### Charging Infrastructure trends across the globe

Fast charger stock ('000 units)



- Nearly 500K chargers were installed globally in 2021, which is more than the total number of public chargers available in 2017.

Slow charger stock ('000 units)



- In 2021, nearly 1.2 Million chargers were installed with China accounting for over 55% of the installations

Battery swapping



- The current global battery swapping market is dominated by 2W & 3W battery swaps

### 3 Stakeholder perspectives – OEMs, Government, and consumers

EVs are the most promising form of sustainable mobility, however, sustenance also plays a major role in defining the future course of action for stakeholders

#### Motivations of stakeholders in the EV transition

##### OEM perspective



A fine balance between Sustenance & Sustainability

##### The case for sustenance

- OEMs require large **investments to maintain compliance** with emission norms in ICE
- OEMs must **balance ROI** of existing ICE development **with EV investments**
- OEMs must also **balance the affordability and value proposition** of their EV offerings

##### The case for sustainability

- **OEMs are helping Govt. meet COP targets** by bringing more EVs in portfolio
- Setting **GHG Scope 1 & 2 emissions reduction & RE power purchase targets**
- Exploring technologies for medium term path towards cleaner offerings

##### Government perspective



EVs for a Sustainable future

##### The case for sustenance

- EV shift could **create new jobs in the mfg. as well as in supporting infra.**
- Reducing dependence on foreign oil, governments can **improve energy security and reduce forex risk**

##### The case for sustainability

- Through EV push,, govt. can **reduce carbon footprint/ mitigate climate change impact**
- **Reduction in air pollution** with EVs can have significant public health benefits.
- EVs can **boost the RE sector** as they can be powered by variety of RE sources

##### Consumer perspective



Sustenance tips sustainability

##### The case for sustenance

- For personal use buyers, **upfront cost is a key buying criteria to shift to EVs**
- **Savings in running cost** against ICE vehicles is a key reason for the shift
- For commercial use, **uptime of vehicle** can be addressed largely with battery swap EVs

##### The case for sustainability

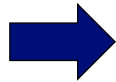
- Some consumers who already own a PV and are interested living sustainably, **purchase EVs as an additional vehicle** in their portfolio

### 3 Stakeholder perspectives – Expectations vs Reality

While the rapid growth of electric vehicles in India paints a bright future for electrification, many pieces need to fall in place to make this dream a reality

#### Expectations vs reality of the EV market in India

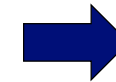
Steadily declining battery prices?



Rising cost of raw materials have bumped the curve

- Recent battery prices have failed to continue the downward trend that had been observed in the last decade.
- This stagnation is caused by several variables, but the cost of raw materials like cobalt, nickel, and lithium is by far the largest one.

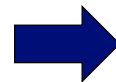
EVs in all segments?



Least price sensitive segments have the highest options

- A number of electric four-wheeler prototypes have been showcased in the recent years, however most of them are yet to hit the market.
- Multiple factors like the Covid19 pandemic and the ensuing semiconductor shortage may have slowed down their release.

ICE-EV range parity?



Range anxiety is still a major factor for potential customers

- As the required charging speed increases, the cost increases proportionately.
- The low running cost of an affordable EV could be trumped by a long charging time, as the fast charging times in the order of a few hours is nowhere close to its ICE counterpart.

EVs use clean energy?







India still generate a significant amount of electricity from coal

- India's installed solar capacity is 61.96 GW which fell short of the 100 GW grid-connected solar power plant as set by the National Solar Mission in 2010
- India's electricity generated from coal results in carbon emissions significantly higher than other countries

## 4 Government policies - Global

EV policy directions across countries have different areas of focus including purchase incentive, tighter emission norms, and ICE phasing out targets etc.



Policy Area	Indonesia	Japan	USA	Germany	China	Norway
 <b>Light Vehicle Support</b>	Δ → ○ Subsidy announced for e2W/e3W from '23	○ → ● Increased subsidy scheme	○ ACC II Rule, Tax credits for private cars	● → ○ BEV subsidy phase-out till 2025	● → ○ National incentive phased out in 2022	● → ○ VAT re-introduced. Reduced tolls. Special lanes still in place
 <b>Heavy Vehicle Support</b>	Δ Subsidies for 134 e-buses in pipeline	● \$1 Bil subsidy under IRA	○ → ● \$1 Bil subsidy under IRA <sup>2</sup> . Global MoUs	● 60% additional cost of vehicle covered. Investment into infra	○ Targets for EV buses & trucks	○ Target for EV buses & trucks
 <b>Charging Infra</b>	Δ Ease of regulations for setting up	○ → ● \$1.5 Bil under NEVI <sup>1</sup> . IRA <sup>2</sup> tax credit. Target ~150k stations by 2030	○ → ● \$1.5 Bil under NEVI <sup>1</sup> . IRA <sup>2</sup> tax credit	○ → ● Additional budget for chargers. Shenzhen Target of ~800k chargers	● State-wise subsidies	○ Charge Right for people in buildings. Shenzhen Target of ~800k chargers
 <b>Manufacturing</b>	○ EV in national manufacturing plan. Export Ban for downstream minerals	○ Push around battery mfg.. 100 GWh by '30. Investment into magnets	Δ → ○ IRA <sup>2</sup> to promote local manufacturing	○ → ● EU's green deal industrial plan. Critical raw materials act	● Regional production targets. Supply chain support	○ → ● EU's green deal industrial plan. Critical raw materials act

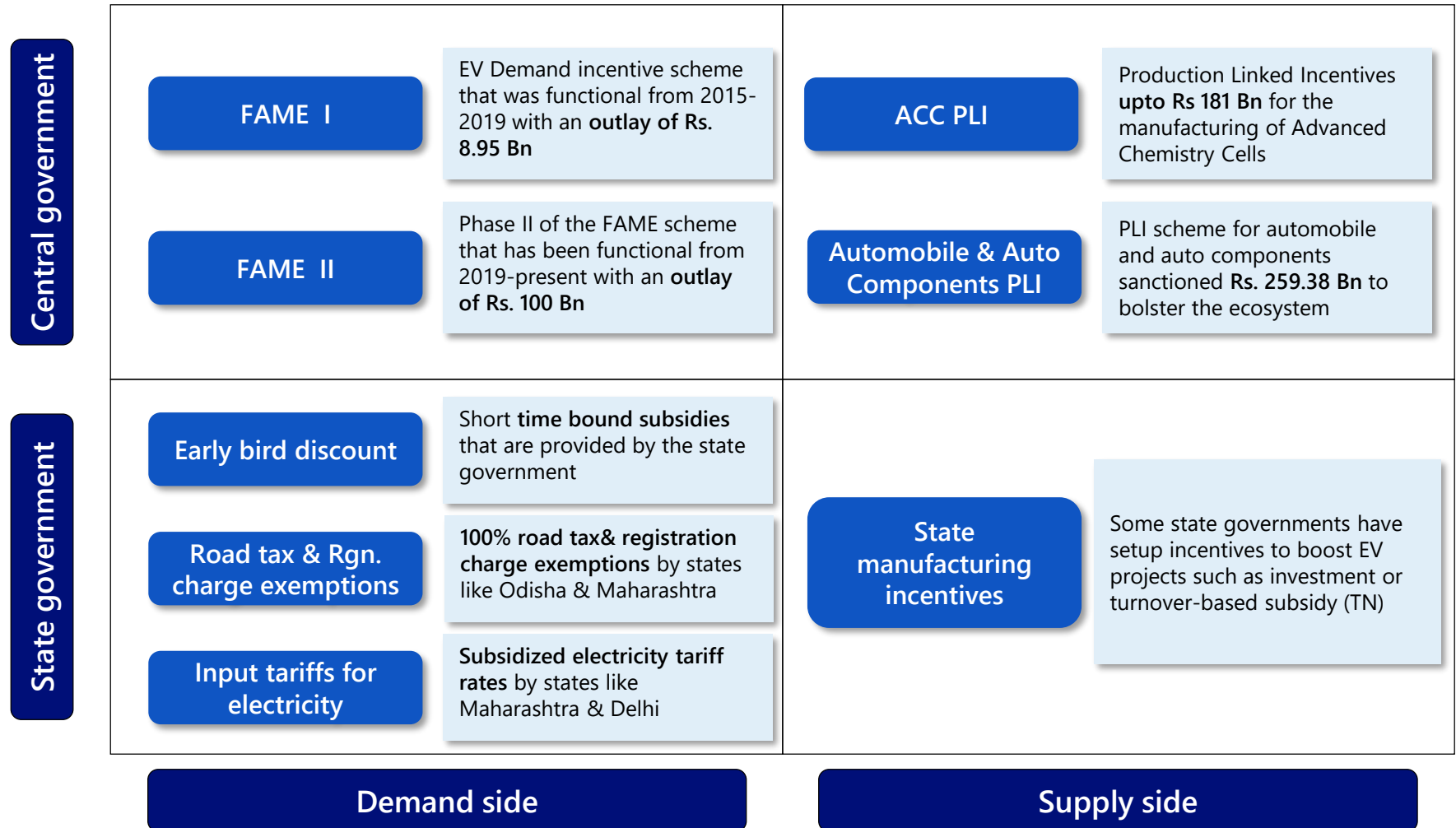
1. NEVI: National Electric Vehicle Infrastructure
2. IRA: Inflation Reduction Act

△ Low ○ Medium ● High

## 4 Government policies - India

# Central government's decisive actions to promote the clean mobility ecosystem are complemented by efforts from the State governments

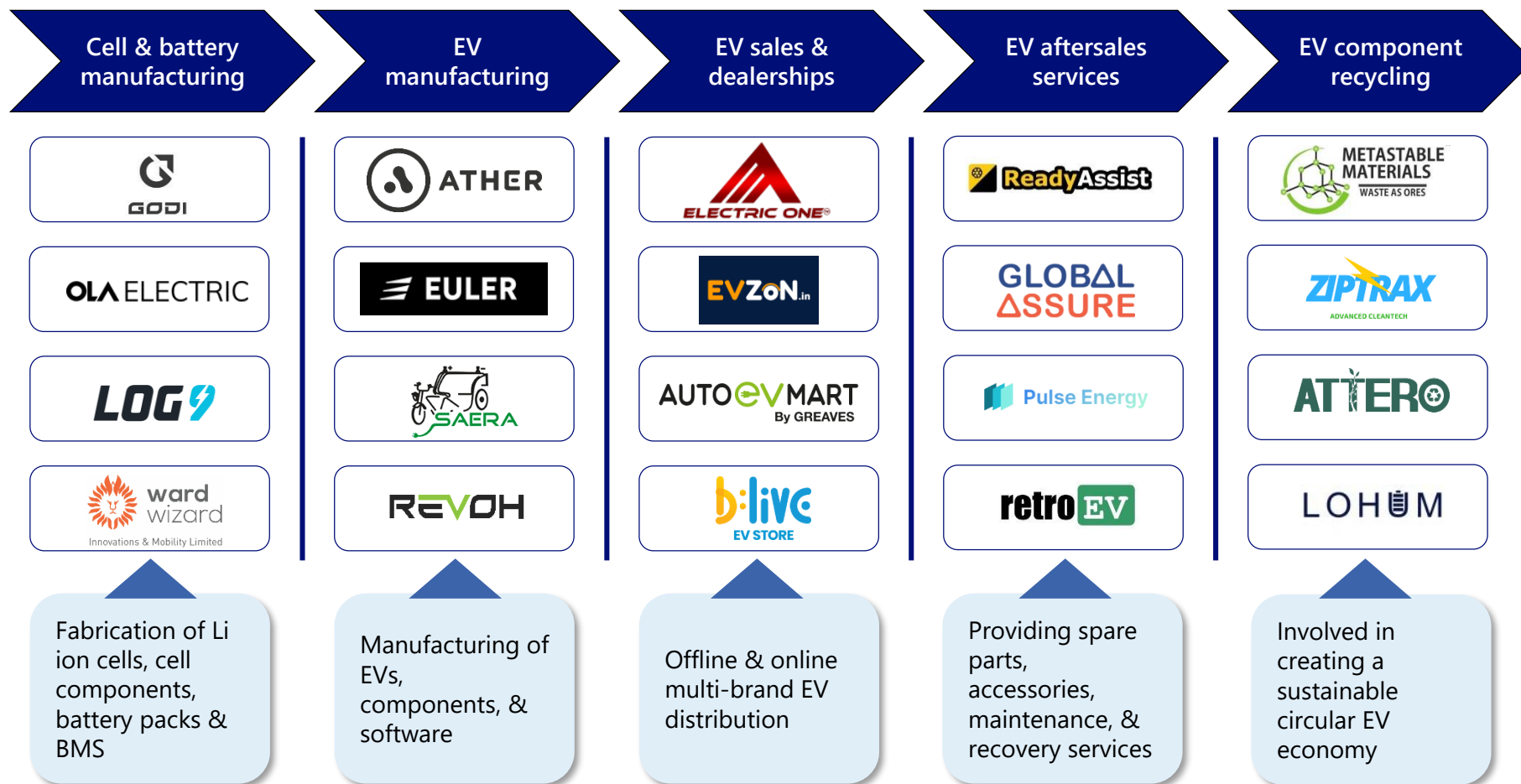
Government policies & initiatives to promote electric mobility in India, including incentives, subsidies, & regulations



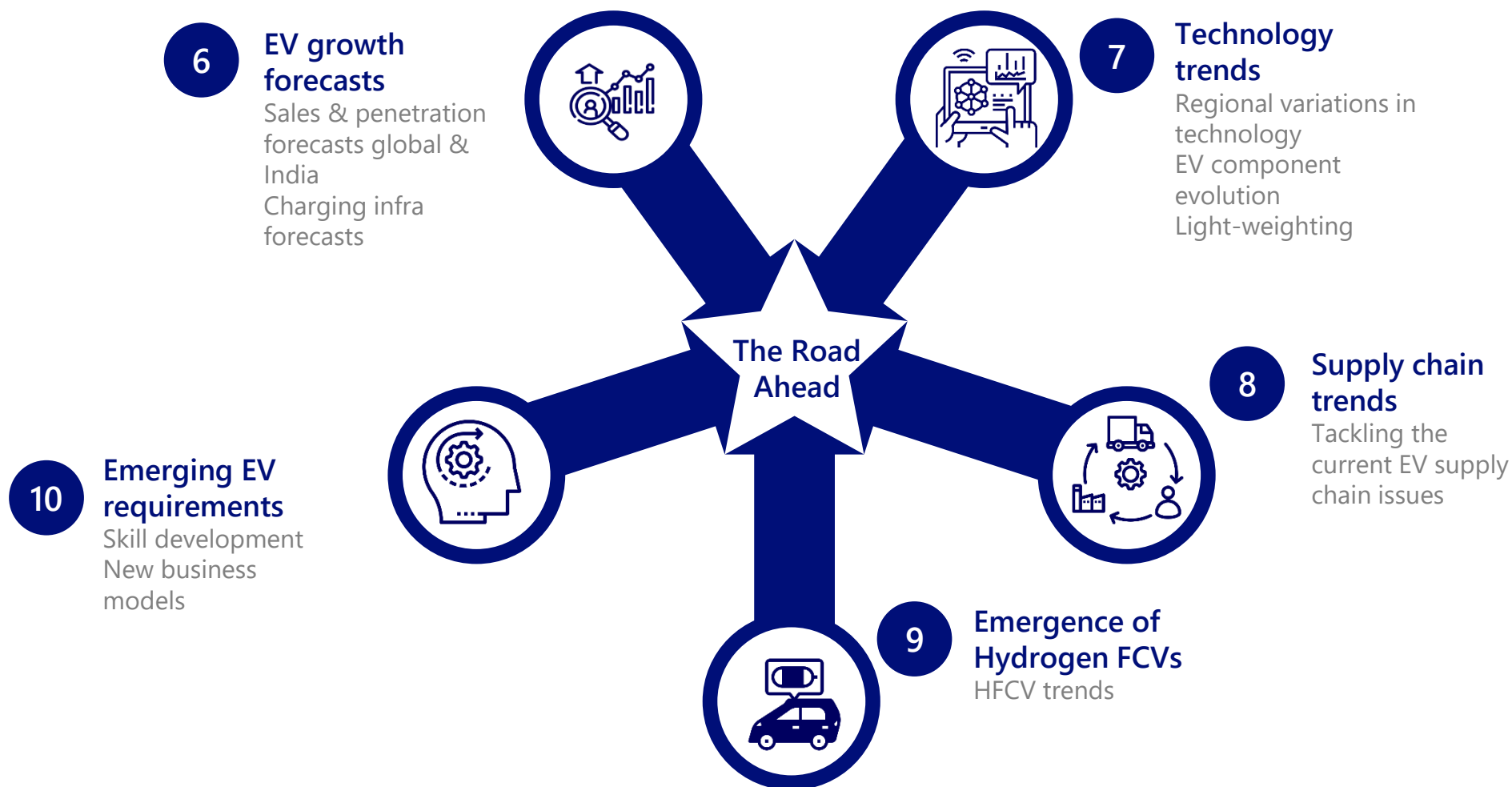
## 5 Value chain development

The rapidly changing EV market in India has produced a number of lucrative whitespaces that new age businesses are attempting to fill

Staying competitive to make the start-up ecosystem robust



# Sustaining vehicle electrification efforts will require a holistic approach to combine technological R&D and supply chain investments





## 6 EV growth forecasts

Countries around the world have set out aggressive electric vehicle adoption targets. India is also set to see a significant EV penetration by 2030

### Global ICE vehicle phase-out targets



- California, Massachusetts, New York, Oregon, Vermont, & Washington have set **100% phase out targets of pure ICE vehicles by 2035 and allowing the sale of BEV, FCEV, & PHEVs**



- UK aims to **sell only BEVs and FCEVs by 2035** in the car, van & light-truck segments
- UK has also committed that all new trucks (>26 tonnes) will be **100% zero emission by 2040**



- There have been **no official phase-out targets** announced by the central government, however there have been province level initiatives.
- By 2030, the **Hainan province of China plans to phase out the sale of new diesel and petrol passenger cars**, light commercial vehicles, buses and coaches, setting the most ambitious goals in all of Asia.



- Germany has sought a **full ICE phase-out but also sees value in an exception** for ICE vehicles fueled on sustainable and e-Fuels



- Chile targets to **sell only BEVs and FCEVs by 2035** in the car, van & light-truck segments
- Chile has also committed that all new trucks will be **100% zero emission by 2045**

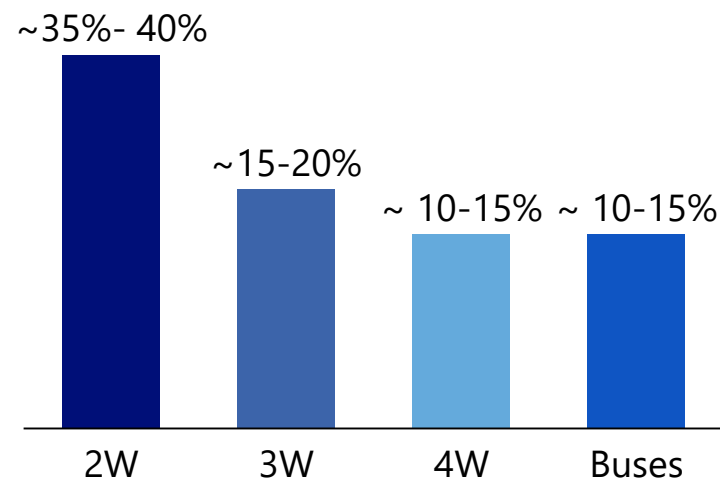


- Morocco has signed on to the **Zero Emission Vehicle Declaration (2.A)** which commits to a **2040 phase-out target** for cars, vans and light trucks

### India's expected EV penetration by 2030



EV volumes are expected to increase significantly in the future across vehicle segments in India



Note- Figure shows expected range for EV penetration as a percent of total vehicles in that category

## 7 Technology trends - Global

# Broad opportunities in vehicle electrification are galvanizing efforts from industry and institutes to improve performance and lower costs

### Technology trends across the globe



#### Advanced cells & battery packs

- General trend is **towards production of batteries that provide greater range** which translates to higher energy density, larger size batteries, reduced the number of interconnections



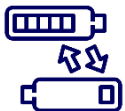
#### Better efficiency in EV subsystems

- Technological shift is happening towards **high voltage systems to the order of 800V**
- There is also a **move away permanent magnet motors**, due to limited supply & high cost of rare earths like Dysprosium and Samarium



#### Fast charging infrastructure

- The introduction of more **800V models will necessitate the upgrade of the charging infrastructure** to e.g. **400 kW charging stations** in order to realize the benefits of fast charging times of these EVs.



#### Affordable EV technologies

- **Low cost EVs are at the forefront in emerging EV markets** where the objective is to reduce the upfront cost to purchasing an EV
- **Battery swapping** aims to solve this by allowing the customer to pay as much as an ICE vehicles and refuel at a 30% lesser cost
- **Retrofitted EVs** is an emerging option in Asia to accelerate the switch among existing ICE users



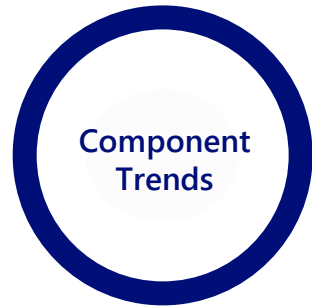
#### Climate & terrain sensitive designs

- **Battery chemistries such as LFP** which are safer to use in **hot and humid countries** as well as battery pack design meant to withstand the inconsistent terrains are in development

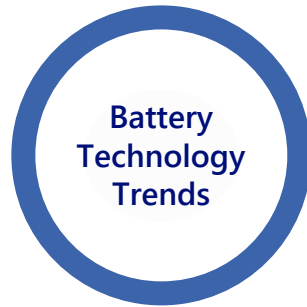
## 7 Technology trends – Elements of the Ecosystem

Elements of the EV ecosystem require continuous improvement to keep up with the evolving needs of consumers

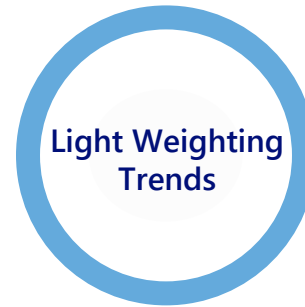
### Technology trends across the ecosystem



- Finding **new battery chemistries**
- Improving **BMS systems** and **power electronics**
- Improving **e-motors**



- Increasing focus on **safety** and **demand** for **better performance** leading to development of battery technologies such as **NMC** (As-is mass-market), **LFP** (expected mass-market), **LTO** (Niche segment) etc.

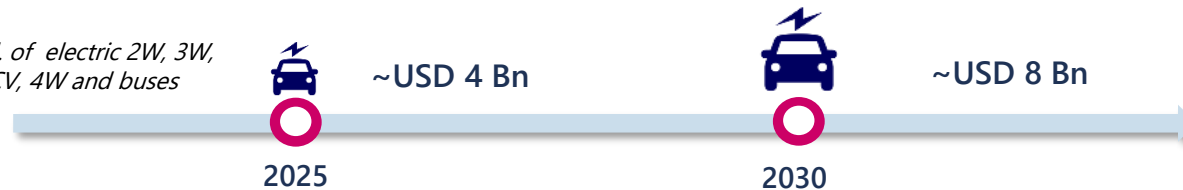


- **Body in white:** Cast panels, lighter materials
- **Chassis:** CFRP
- **Powertrain:** Reduced weight of motors
- **Trims:** Composites
- **Battery:** High energy density, reduced interconnections

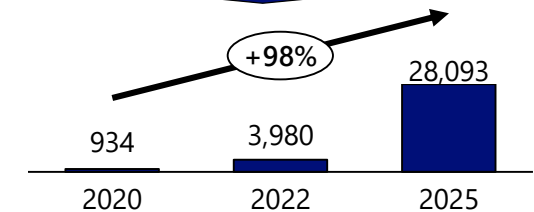


- Shift towards **faster charging**
- **Battery and charger** design modification to **handle high voltages**
- **BMS** system to manage ultra fast battery charging, while maintaining battery **health/safety**
- **Power electronics** upgrade to support higher **voltages**

Figure Incl. of electric 2W, 3W, LCV/SCV, 4W and buses



~\$6.5 Billion opportunity across battery, power train & power electronics. Chassis & Other body parts have an opportunity of ~\$1.2 Billion by 2030



## 8 Supply chain trends

# Disruption in traditional EV supply chains due to geo-political reasons have led to the exploration of lateral opportunities

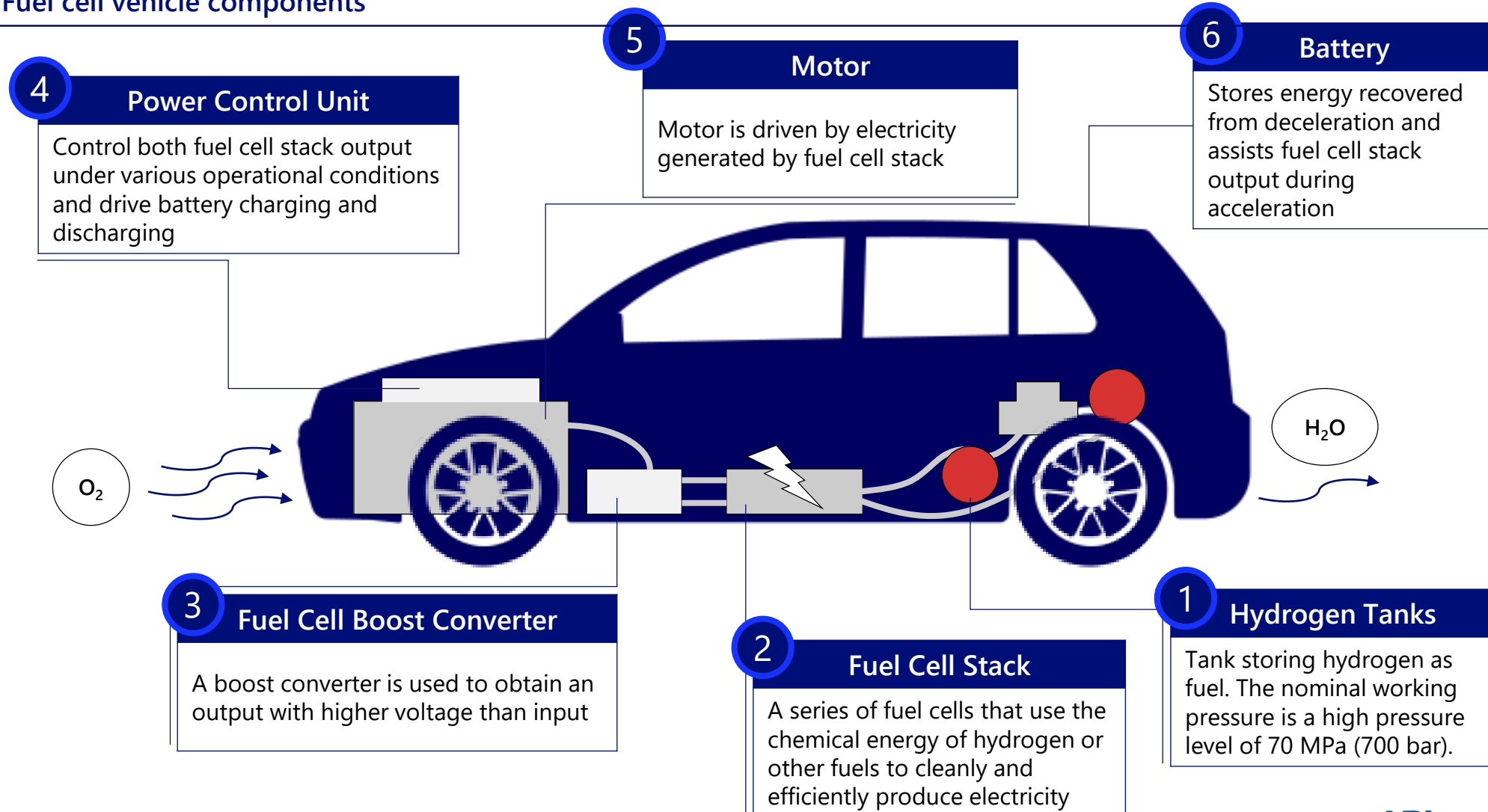
### Supply chain trends across the globe

	Context	Global cases
<p>Due to raw material scarcity</p> <p>↓</p> <p>Alt. materials &amp; recycling</p>	<ul style="list-style-type: none"> <li>Lithium, nickel and cobalt, the key metals used to make EV batteries are expected to be in shortfall for the global mining capacity</li> </ul>	<ul style="list-style-type: none"> <li><b>Recycled materials</b> from batteries could serve <b>between 20-50% of the new EV requirement in USA by 2050</b></li> <li><b>Alternate battery chemistries</b> like LFP are being introduced into the market due to limitation in Nickel &amp; Cobalt which is used in NMC batteries</li> </ul>
<p>Concerns around mining</p> <p>↓</p> <p>Ethical sourcing</p>	<ul style="list-style-type: none"> <li>Extraction and processing of raw materials for EVs have concerns around environmental impact, human rights violations, fair trade etc</li> </ul>	<ul style="list-style-type: none"> <li>Tesla is committed to ethical sourcing and thus has also established a supplier code of conduct in accordance</li> </ul>
<p>Disruption along the supply chain</p> <p>↓</p> <p>Backward integration</p>	<ul style="list-style-type: none"> <li>China hold substantial leads in material processing and refining, cell component and battery manufacturing, and EV production</li> </ul>	<ul style="list-style-type: none"> <li>Amidst a restrictive commercial environment, <b>US company Ford has announced plans to co-operate with Chinese battery manufacturer CATL to build an EV battery factory in Michigan.</b></li> </ul>
<p>Control of equipment supply</p> <p>↓</p> <p>Indigenous manufacturing</p>	<ul style="list-style-type: none"> <li>There's an embargo on equipment sale/ tech transfer to China</li> <li>Sustainable technologies ex. DLE are available with select countries only</li> </ul>	<ul style="list-style-type: none"> <li>Chinese government has earmarked <b>\$140 billion</b> that could <b>include subsidising the purchase of domestically produced chip making equipment</b></li> <li>India can utilize sustainable technologies, such as Direct Lithium Extraction (DLE) for the extraction of Lithium found in J&amp;K</li> </ul>

## 9 Competitor to EVs – Hydrogen FCVs

While electric vehicles offer the greatest opportunity at present, alternative technologies could see growth in specific use-cases

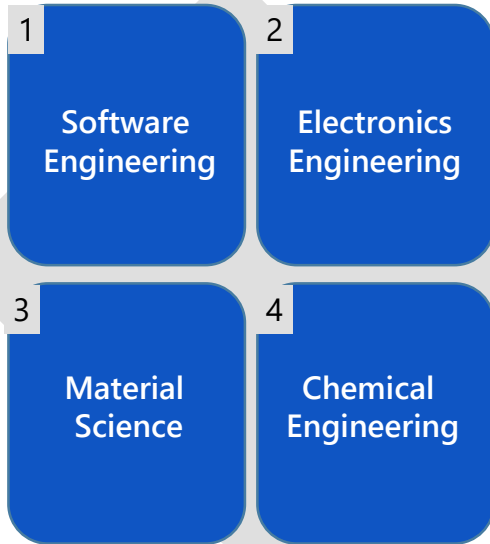
### Fuel cell vehicle components



## 10 Emerging EV requirements – Skill development, Business Models and Collaboration

Push towards electrification will require skill upgradation in specific disciplines, innovation in business models, & continuous collaboration among stakeholders

### Skill Development



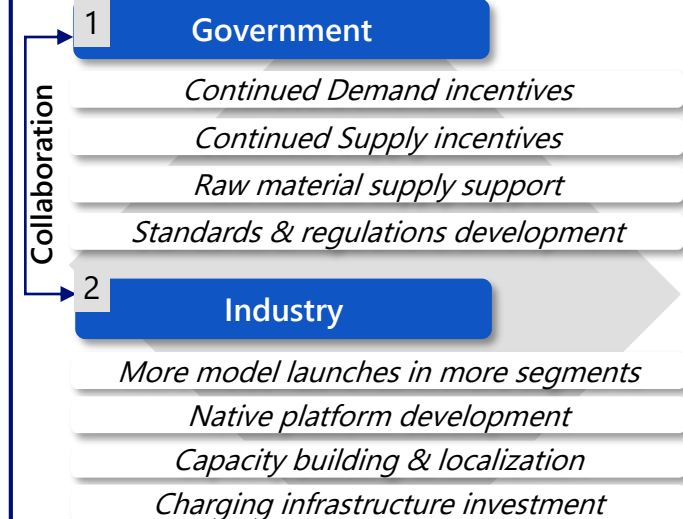
1. Increased software content (50-100% more than ICE vehicles)
2. Efficient power transfer requirement from charger to the motor
3. Light weighting requirements
4. Advanced materials, electrochemical systems requirement for batteries etc.

### Business Models



1. Enable customer to concentrate on core business rather than fleet mgmt.
2. Waiting during idling is negated because battery swaps happen quickly
3. Avoid having to buy the car outright or commit to a lease
4. Transitional solution for those who don't have the capital for new EVs

### Stakeholders Collaboration



1. Continuation of FAME schemes, introduction of supply incentives, developing relations with mining and supplying nations, and bringing a long term regulatory roadmap
2. Exploring more segments for EV, developing more EV platforms, localisation, capacity building, and charger installation



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