Consulting & Analytics Club
IIT Guwahati

Accelerating EV Growth in India

Spoken Track Available

Decarbonising Mobility

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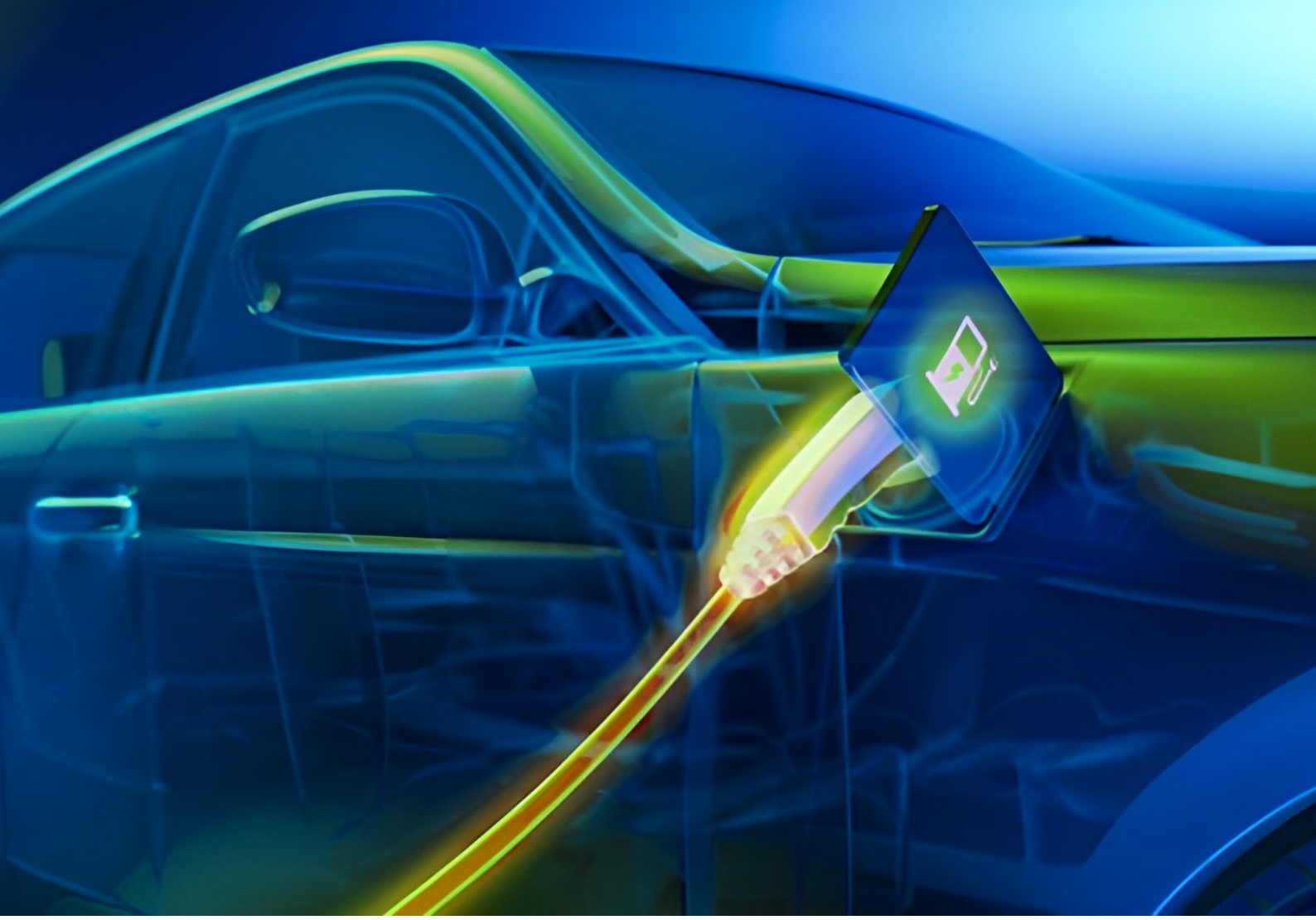
Preface

Mobility is an essential part of every nation, connecting people to critical services and contributing to economic growth. Transport has the highest reliance on fossil fuels of any sector and accounts for 37% of CO_2 emissions from end-use sectors and 20% of overall greenhouse gas (GHG) emissions. Out of this, road vehicles account for almost 75% of total transport-related GHG emissions. Transport will have a critical role in our road to achieving net neutrality across all sectors. Global passenger demand continues to grow and is notable in advanced and developing economies. The time to act is now — with the timeframe for action shrinking, industries must move at an ever-faster rate to create new technologies to curb emissions. At the same time, government policies should be introduced to incentivise and support the introduction of these technologies.

One such solution is adopting electric vehicles and switching to renewable energy sources. EVs are the future of mobility and primal in our efforts to decarbonise mobility. We'll see the challenges in our journey in adopting them and those that could arise in the foreseeable future. We'll discuss the need for specific policies, business models and sustainable solutions to promote modal shifts to less carbon-intensive options and drive growth.

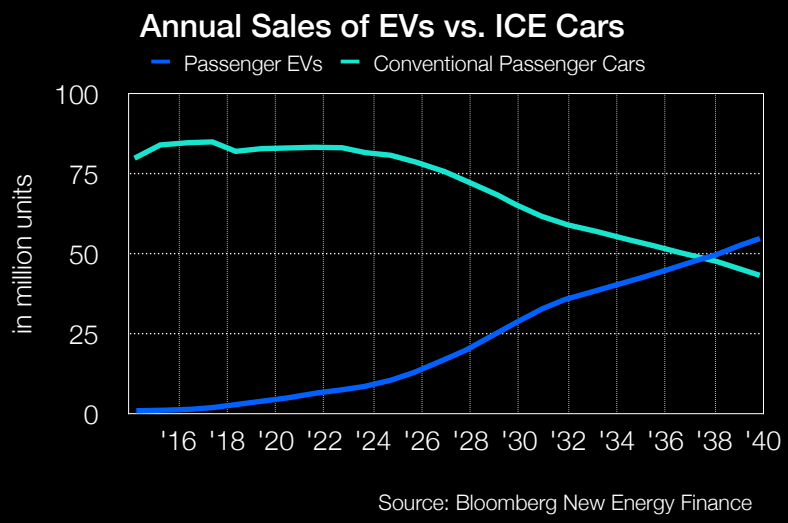


Electric Vehicles: Towards a Brighter Future

Electric vehicles have been around us for a while. First introduced in the late 1890s, the development and sales of electric cars have recently gained momentum, thanks to our search for alternative fuels and due to governments worldwide setting zero-emission targets to tackle climate change. This section aims to give an overview of EVs and how they possess the potential to navigate our lives towards a sustainable future. We'll discuss in detail the so-called 'charging dilemma' associated with buying an EV, along with a brief on the success stories of Norway and the Netherlands.

Passenger Vehicles: EVs vs Conventional Cars

The global sales of electric vehicles are skyrocketing as more and more customers switch to environment-friendly choices. Recently, automakers worldwide have been putting additional effort into research and development to produce newer electric models. It is expected that, by 2038, annual sales of electric passenger vehicles will outnumber gasoline ones.



Advantages of EVs

Electric vehicles are energy efficient and allow for significant physical constraints associated with combustion engine vehicles. An EV has only one moving part, i.e. its motor, while traditional cars have hundreds of them. Fewer moving parts mean that EVs require less periodic maintenance and are more reliable than ICE cars. They don't need oil changes or exhaust system repairs. EVs slow down through a process called regenerative braking - this results in reduced wear and tear on brake pads and rotors while also saving energy. Most importantly, EVs are cheaper in the long run and maintain a robust fuel-to-cost advantage due to cheap electricity. Also, EVs can provide better aesthetics and drive comfort than conventional vehicles.

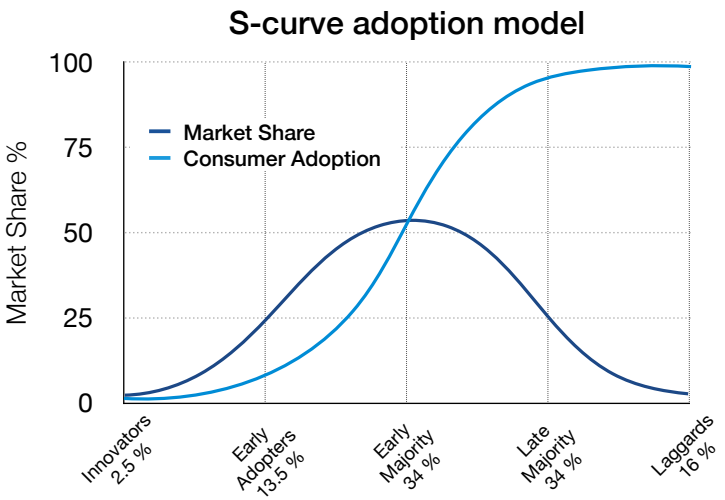
Disadvantages of EVs

The limited range offered by most electric models and the lack of proper charging infrastructure create a sense of ‘range anxiety’ in the minds of prospective buyers, possibly driving them away. However, EV batteries wear out over time, post which the batteries will need to be replaced. They’re heavier and create near-instant torque off the line, causing the tires to be replaced 30% more frequently than traditional internal combustion engine cars.

EVs in Corporate Fleet: Although EVs have fewer moving parts than combustion engine vehicles, our service network doesn't know much about them. The EV service network of most OEMs is not yet up to a substantial level despite having extensive service and dealer networks across India. Automakers will have to reskill their employees before EVs can be adopted for commercial use because they will constantly need maintenance, servicing, and repair of their vehicles. In the absence of a proper service network, there will be disruptions in the supply chain.

The EV Revolution

The growth of the internet was disruptive, changing the way we almost do anything. And it followed a familiar 'S'-shaped pattern, commonly referred to as the sigmoid curve. At the turn of the last century, the internal combustion engine followed the same trajectory. So did steam engines, video games and printing presses. And electric vehicles will do the same.



Presently, EVs are just 5% of total car sales, but it shows we're already entering the steep part of the S. According to the latest forecast by the investment bank UBS, 20% of all new cars sold globally will be electric by 2025.

That will leap to 40% by 2030, and by 2040 virtually every new vehicle sold globally will be electric. Researchers say that we have already crossed the tipping point, and the industry is on a path of exponential growth; reasonably, after looking at the sales figures, we couldn't presume otherwise.

Global EV Market and Sales

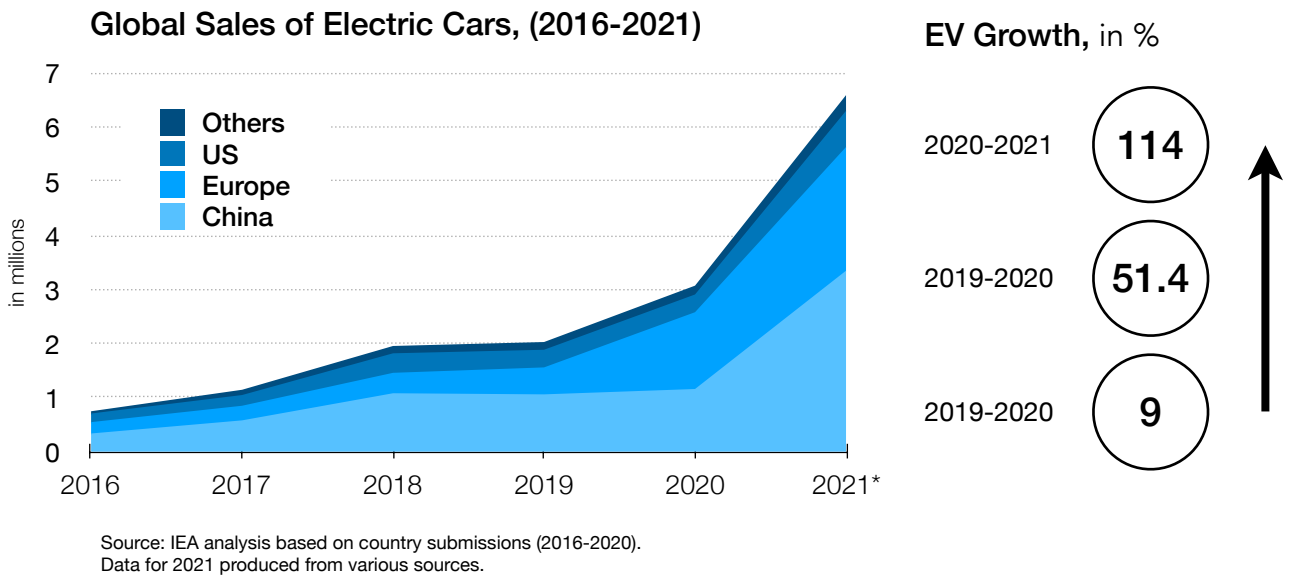
Despite the COVID-19 pandemic and passenger car sales decline, EV car registrations increased in major markets in 2020. Governments worldwide spent $14 billion on direct purchase incentives and tax deductions for electric cars in 2020, a 25% rise year on year.

The upward trajectory followed in 2021, with about 6.6 million units in overall annual sales, doubling compared to the previous year. Globally, EV sales represented 8.57% of all passenger car sales last year. Although government policies remain the key driving force for global electric car markets, their dynamism in 2021 also reflects a very active year in the automotive industry — although supply chain concerns continue to affect international timelines. The rise in sales could also be attributed to the increased driving range of new electric vehicles, with the mean capacity rising to 360 km in 2021 from 200 km in 2015.

Moreover, buying trends revealed that demand is shifting towards premium and higher capacity vehicles. The most significant growth is and could continue to be in luxury vehicles and SUVs among all categories of passenger vehicles. In 2021, the majority of the OEMs updated their product portfolios to include electrified SUVs, causing a surge in product sales.

Sales Analysis by Region

Notably, Europe overtook China as the biggest EV market in 2020 due to increased value for money, rising environmental concerns and government-supported incentive schemes. China regained the top position in 2021, with a growth of 154% YoY and about 3.3 million units in sales. Due to their ultra-affordable prices, mini-EVs drove the sales in China, amounting to a quarter of the total sales during the first half of 2021, causing the Chinese automaker BYD to outpace Tesla's overall market share.



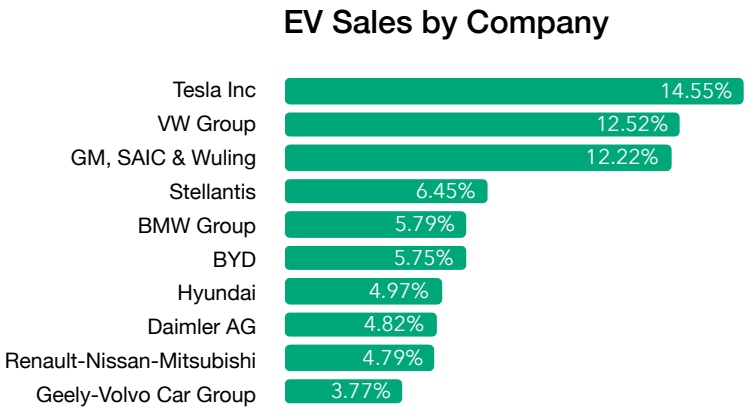
Source: IEA analysis based on country submissions (2016-2020).
Data for 2021 produced from various sources.

The US EV market witnessed a growth of over 83% in 2021. Industry data reveals that the EV market in Europe has considerably increased over the last few years, with annual sales crossing the 2 million mark in 2021.

Sales Analysis by Company

Tesla led the global EV sales with a market share of 14.55% in the first half of 2021, with sales amounting to 421,000 units. Volkswagen followed this with 12.52%, General Motors (including SAIC-GM-Wuling) with 12.2%, and Stellantis with 6.45%. Significantly, some OEMs plan to reconfigure their product lines to produce only electric vehicles, with targets set for 2030 and beyond. And it's not just the premium brands.

- Ford will sell only electric cars from 2030.
- GM is investing $27 billion in electric and autonomous vehicles in the next five years – up from the $20 billion planned before the onset of the COVID-19 pandemic. Also, it intends to be carbon neutral by 2040 in its global products and operations.
- Volkswagen aims for 70% electric car sales in Europe and 50% in China and the United States by 2030. It has earmarked around €16 billion for investment in the future trends of e-mobility, hybridisation and digitalisation up to 2025.
- Stellantis aims for 70% of electric cars sales in Europe and 35% in the United States.



Largest Automakers by Market Capitalisation

Tesla	$925 billion
VW	$126 billion
BYD	$103 billion
Daimler AG	$93 billion
GM	$72 billion

- Toyota has dedicated over $70 billion to support its electrification plans, half of which will go to fully electric models. The company aims to sell 3.5 million EVs by the end of the decade, almost double its target in early 2021.
- The Renault-Nissan-Mitsubishi alliance plans to secure 220 GWh of battery production by 2030 and reduce battery costs by 65% by 2028.
- South Korean carmaker Hyundai has reportedly decided to halt IC engine research and development at its Namyang R&D Centre to support its plans.

The world's most valuable automaker, Tesla, forecasts its deliveries to grow by 50% YoY. The company is working to achieve full self-driving by the end of 2022. The company's upcoming AI supercomputer, DOJO, will continuously train and improve its full self-driving software on its own.

Brand Stories

The Tesla Story: Since going public in July 2010, Tesla has been on top of alternative powertrains in the passenger vehicle industry. Valued at $925 billion, three times that of Toyota, its research and development expenses reflect the brand's commitment to innovation. While the United States continues to be Tesla's most important target market, the company aims to tap into the Chinese and European markets as well. With a growth rate of over 157 per cent in 2021, Tesla is one of the fastest-growing brands worldwide. Most of its models are electric passenger cars, particularly sedans and crossover vehicles, but plans to release its first electric light-duty truck in 2023 are underway. ***Direct sales, home services, and the supercharger network*** make Tesla cars the customers' choice.

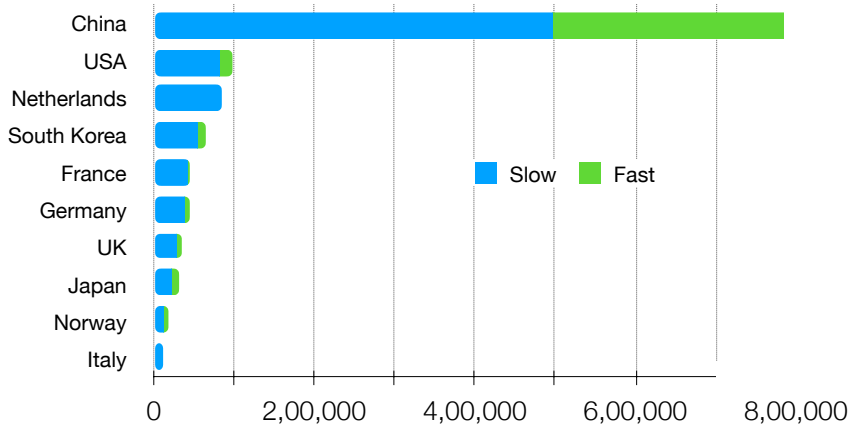
Why is Volkswagen ID.4 gaining momentum in sales? The ID.4, launched as a rival to Tesla's Model Y, has a very appealing design and is a first in many aspects. First of all, it boasts of a battery that has a claimed per-charge range of 520 km. The car has a 210 mm ground clearance, and VW is betting big on its off-road capabilities. Initial reviewers reported that the vehicle offered a marginally better ride quality and comfort than the Model Y. Most importantly, ID.4 is $20,000 cheaper than Model Y. Amid shifts in consumer preference, VW continues to change its lineup towards electric vehicles-especially eSUVs.

SAIC and China: SAIC is one of the largest manufacturers of micro-vans in China and has a joint venture with US's General Motors called SAIC-GM-Wuling. Known as *xiao mianbao che*, or "small bread-box cars", these pint-size commercial vehicles are no larger than a compact car and have sold well even with the poorer interior. One of its popular micro-vans is the Wuling Sunshine. Selling more than 450,000 units per year, SGMW has claimed no one model outsells it in China.

Solving the EV Charging Dilemma

Consumers who consider buying their first EV have many anxieties - wondering if they might get stuck on the highway if there are not enough charging points. While many EV drivers use privately-funded chargers at home or work, about half of charging will come from chargers on the road and at destinations, depending on the region. So, without a public charging infrastructure, the adoption of electric vehicles will continue slow.

Number of publicly available EV chargers as of 2020, by major country and type



NOTE
China's public EV charging infrastructure is 8 times larger than the United States', with more than 8 lakh EV chargers installed at various locations across the country.

Data Source: Statista

The government must work with players across the EV ecosystem to create a ramp-up master plan, including location, time, type, and the number of charging points. They should communicate the plan's goals to all stakeholders as clearly as possible. And the creation of key players should be encouraged until the private sector is ready to intervene. Such a system would be less profitable but necessary, especially along highways or in sparsely populated areas. Only then can the dilemma of creating conditions for private investment and creating a self-sufficient market structure that is economically viable without subsidies be resolved.

Many consumers are hesitant to buy an electric vehicle until they know they can charge it when and where they want it. A global survey of licensed drivers found that 46% of respondents said they would only buy an electric vehicle if charging stations were as common as gas stations.

Most charging points are slow devices installed where the owner is away from the car for a long time, such as in homes, offices, shopping malls, and commercial buildings. But checkpoints along highways, short-term parking lots, and checkpoints in rural areas where drivers can stop en route to recharge their cars should be faster.

The government's response to this problem has been by launching public funding markets for charging infrastructure. But in general, they did it without any plans to expand the market, and it was left to the open market to decide. The results of these initial efforts were often confusing. For example, in the early days of the Berlin program (2010-2015), the government provided various subsidies to develop charging infrastructure. Still, the existing EV charging stations were not fully utilised because appropriate regulations or requirements were not set. It is not commercially viable.

In the United States, competing standards have prevented many CPs from servicing more than one type of vehicle. As a result, the driver arrives at the checkpoint they find on the map but finds it unavailable, a situation that undermines confidence in the EV charging process. Governments must develop a national master plan for EV charging infrastructure and economics that supports the EV ecosystem, has the proper framework for public-private partnerships and ensures that the private sector is an attractive sector worthy of participation. All CP locations should be pre-mapped, considering the mix, distribution, and use of different types of sites where people can charge their vehicles. For example, a government may place a fast charger every 50 miles on a highway and a charger in each zone of a specific size, such as every 50 square miles. It is also essential for the government to provide comprehensive and convenient charging access for low- and middle-income users who cannot easily upgrade their homes to charge their electric vehicles.

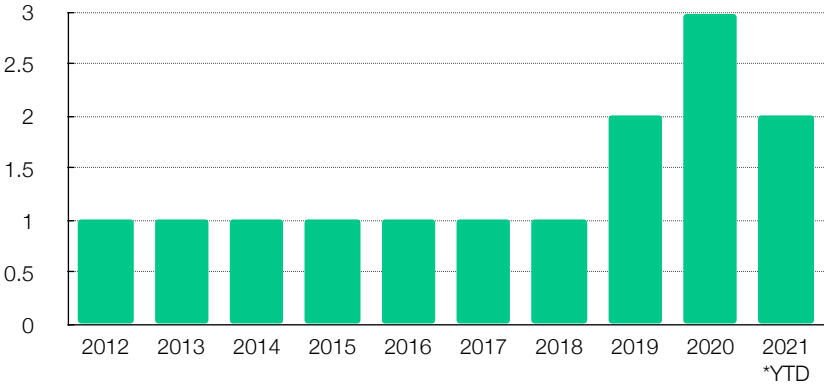
A possible solution can be devised by establishing a governance body so that the first stakeholders (municipalities and government agencies such as the Ministry of Energy, Transportation, Technology, and Environment) and other ecosystem participants can coordinate and agree on how to proceed. This governing body must define an EV charging ecosystem that will ultimately include a variety of players such as OEMs, utilities, charging professionals (providing access cards, apps, payments, and user experiences), investors, entrepreneurs, and NGOs. Many of these participants need a business case, including grants, incentives, and other government-backed guarantees to move forward. Others are relevant at a basic level.

For example, governments can engage grid operators to facilitate the connectivity of electric vehicle charging infrastructure by choosing less constrained grid locations. For instance, in 2009, six grid operators established the Elaad foundation in the Netherlands to install electric vehicle charging infrastructure in cooperation with municipalities. Now, let’s dive into the leadership stories of two European nations, Norway and the Netherlands.

How did the Netherlands achieve its EV dream?

The Netherlands has always had a leading role in the adoption of EVs. Around three in every ten of the 400,000 new cars sold annually are electric. One of the main reasons that can be attributed to it is the network of some 75,000 charging stations – which accounts for nearly a third of the entire EU total. Besides that, the Dutch have their own charging points at home, accounting for almost 190,000. In towns, every electric car user has the right to access charging stations within 200 meters of their home, and in the countryside, motorists have their own posts. Around 75% of the generating electricity is rendered by solar power.

BEV* per charging point ratio in Netherlands



The graph shows that the number of battery electric vehicles (BEVs) per charging point has stayed roughly the same throughout the year because of the main focus on charging infrastructure. However, compared to Norway, another leader in electrification, Netherland has the current ratio of two BEVs per charging point compared to 17 BEVs per charging point ratio that Norway has.

Data Source: Statista
*Only electric cars have been considered.

Also, the government incentivises the ownership process to promote EV growth in the country. The owner can claim up to €4,000 on buying a new car. Now let's move on to the question, "How easy is it to claim in the Netherlands?" The answer is straightforward. Roaming protocols adopted more than a decade ago allow multiple operators in the market to take advantage of roaming opportunities. This way, drivers can top up anywhere with one card or app instead of the various cards required in different countries.

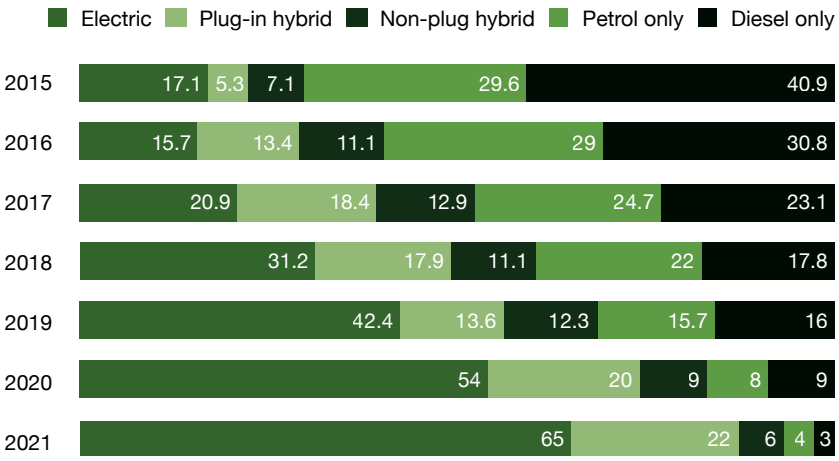
Second, the deployment of slow charging has traditionally started in supermarkets, parking lots, or shopping malls. But over time, municipalities began to intervene, adding to the network when electric vehicle drivers requested a charging station near their address to charge on the road. This is an essential benefit for apartment occupants who are reluctant to purchase electric vehicles because there is no place to charge them. Many operators are on the market, such as MisterGreen, Shell, FastNed and Allego.

In general, the Netherlands shows that financial incentives can be decisive for adopting electric vehicles. Still, despite the lack of many stimuli at present, the number of available charging stations and having no worries about charging creates a positive impact. This allows the Netherlands to remain a leader in electric vehicle adoption despite lower incentives.

Cost Comparability of EVs in Norway

EVs made up almost two-thirds of Norway's overall sales in 2021, making it the country with the highest proportion of electric vehicles among all other nations. Industry representatives expect the sales to grow to as much as 80% of the overall market in 2022. The country is the only one in the world in the third stage of a disruptive trend, and further growth of EVs in the country is inevitable.

Norway new car sales, in %, market share by type



In fact, Norway leads the world in EV uptake, 60% of new cars sold are EVs, compared with 3% in the United States.

Data Source:
Norwegian Road Federation

This high uptake is a testament to the progressive electric vehicle policies implemented by the government over the past several years. The acceleration was mainly caused by the ***vehicles becoming cheaper*** as Norway exempted fully electric cars from taxes imposed on those relying on fossil fuels - owners benefited from waivers on purchase/ import taxes, annual road tax, and exemption from 25% VAT. EV owners needed to pay only ***half of the fee levied*** for using ferries and municipal parking. Conversely, it raised taxes on traditional combustion engine cars, including high incompliance fees incorporating carbon tax, NOX tax, and scrapping fees. Also, because Norway is a small country, people don't need to drive long distances in most cases. On top of these, the Norwegian Parliament recently declared its new zero-emission target, requiring all new cars sold by 2025 to be electric (or hydrogen).

Also, renewable electricity is a key to successfully decarbonising transport systems. Norway being a pioneer in offshore wind systems and hydropower, this couldn't be achieved in any better way. All of this combined has caught the attention of many multinational corporations, which resulted in Norway being at the ***forefront of EV technology development.*** Companies are also planning to start battery swapping stations in the country.

Batteries in Electric Vehicles

Although lithium-ion batteries (NMC Li-Ion batteries, to be specific) are preferably used in EVs, many alternative technologies are being used in the automotive industry.

Lithium-ion Battery

- High Energy Density
- Not subject to memory effect
- High efficiency
- Good performance even at high temperature

➤ **Scope for improvement**

- Recycling and material recovery
- Overheating issues and safety

Ni-Metal Hydride Battery

- Reasonable energy and power capabilities
- Abuse tolerant
- Long life cycle
- Safe

➤ **Scope for improvement**

- High cost and high self-discharge
- Hydrogen loss

Lead-Acid Battery

- High Power and inexpensive
- Safe
- Easy to produce and recycle
- Used to power electrical circuit of accessories and other components

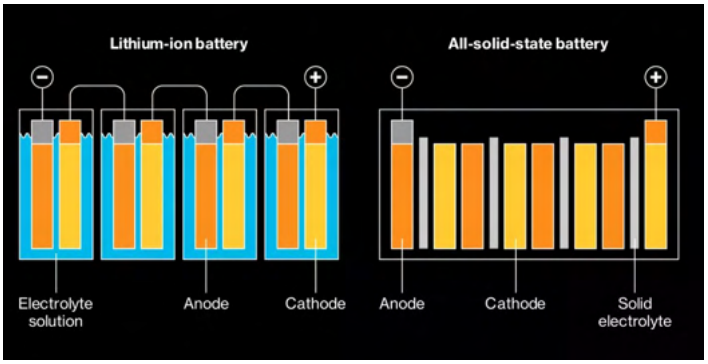
➤ **Scope for improvement**

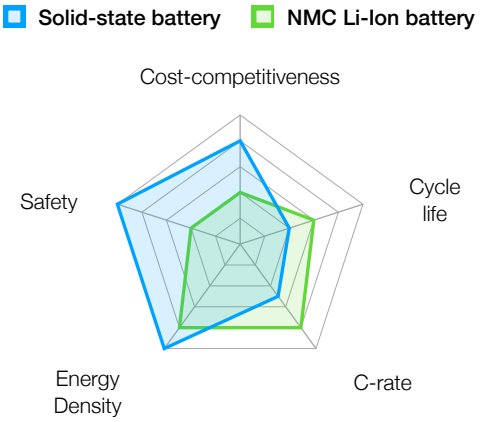
- Low specific energy
- Short life cycle

Solid-State Battery: The future of battery technology

A solid-state battery uses solid electrolytes, unlike liquid solutions used in Li-ion batteries. Lithium-ion batteries risk getting damaged under external force or high amounts of stress, while solid-state batteries have improved stability as they maintain form even after getting damaged. Although solid-state batteries for usage in electric vehicles are still in the early stages of development, the initial results are promising. The solid-state battery market will expand at a CAGR of over 30%, growing over 13 times from 2021 to 2031.

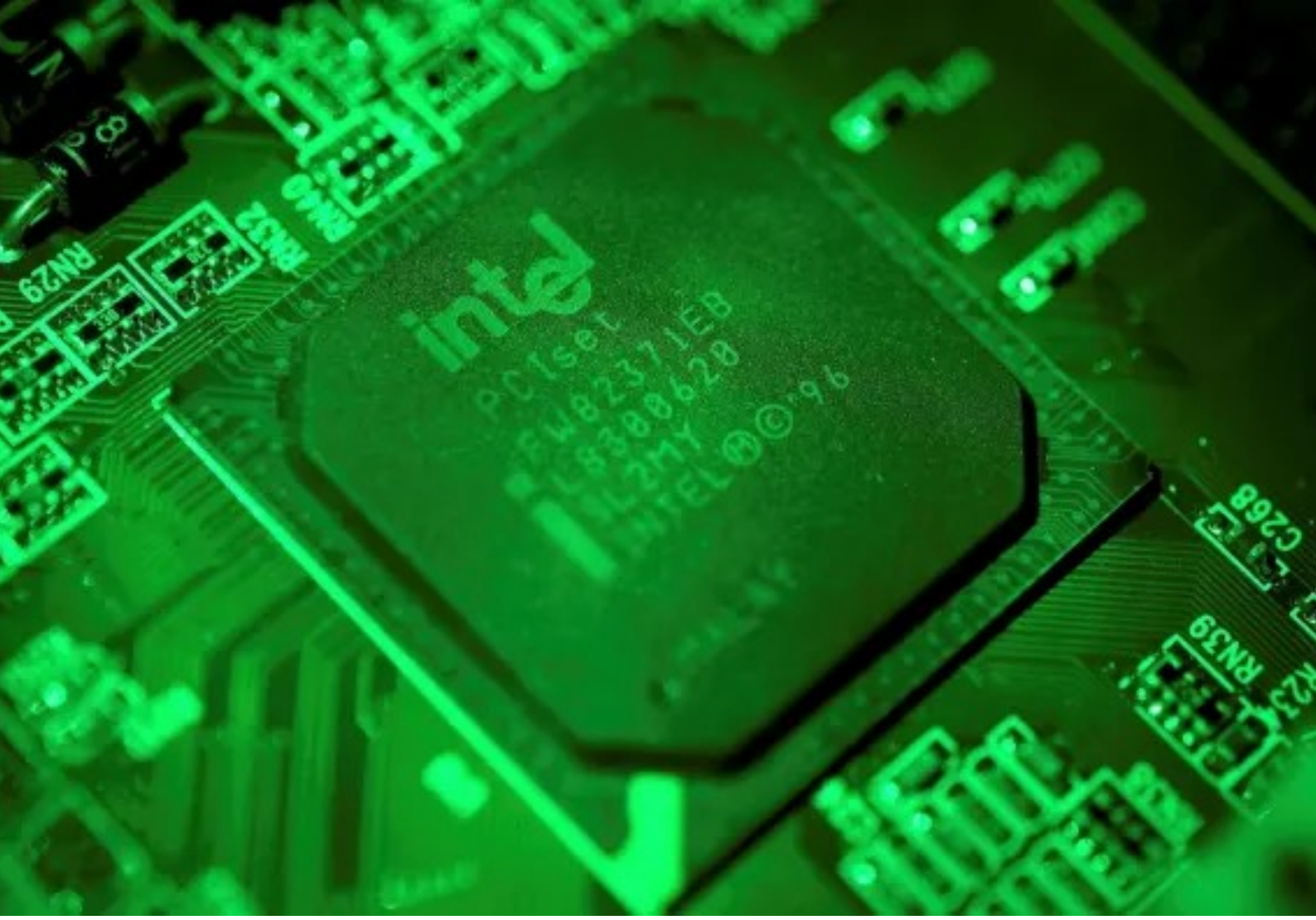
Solid-state Batteries vs. Lithium-Ion Batteries





Enhancing battery performance using Nanotechnology

EV batteries are very costly and have a short charging life. To overcome this difficulty, we can adopt some applications of nanotechnology, which have produced some great results in the past few years. If we use carbon nanomaterials instead of micrometre-sized particles, the efficiency and capacity of the battery will improve. Also, the diffusion rate will decrease, which results in current density increment in electrode and mobility, conductivity will also increase. This will result in electrochemical reactions working more efficiently, undoubtedly increasing the battery's efficiency. Some of these materials are in the early stages of their commercial manufacturing, but some are readily available. Further research could improve safety and cost-effectiveness and give us better insights.



Semiconductors and Electric Vehicles

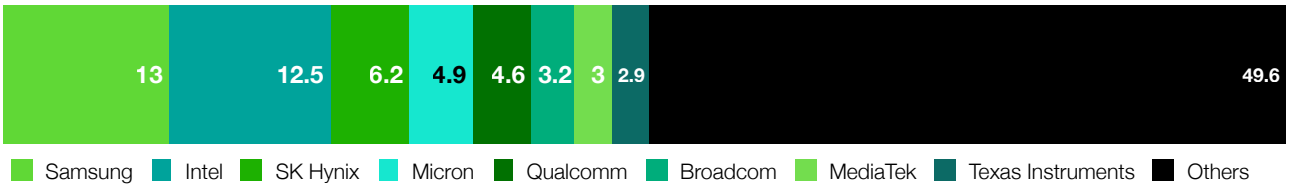
It is the promise of technology that gives impetus to the adoption of electric vehicles worldwide. Semiconductors form the heart of an EV.

In this section, we'll mainly deal with addressing the semiconductor shortage and how the semiconductor and automotive industries are interconnected with each other, driving each others' growth.

The Semiconductor Industry: Market Structure

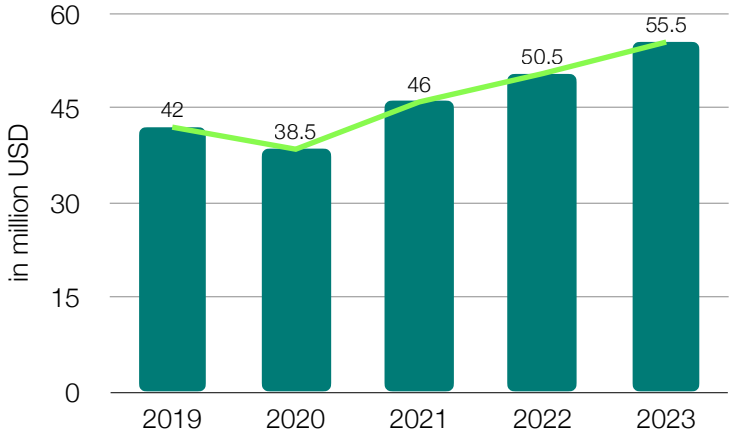
The semiconductor industry is highly competitive, innovation-driven, and continuously growing but is subject to rapid changes and volatility. Also, the semiconductor industry is recognised as a critical driver and constantly adds value to the electronics sector. The structure is based on the foundry model, mainly consisting of semiconductor fabrication plants (foundries) where devices such as integrated circuits are made. The competitive environment requires technological upgrades, significant capital requirements, and investment in research and development for scalability.

Semiconductor Companies Market Share Worldwide, as of Dec 2021



Samsung took the market leader position within the global semiconductor industry in 2021, with a market share of 13 per cent. Intel ranked second among vendors, occupying a market share of 12.5 per cent. Among the biggest semiconductor companies, a large proportion is based in the US, with other dominant positions occupied by companies from the Asia-Pacific region, including Taiwan, South Korea, Japan and China.

Projected global automotive semiconductor market size from 2019 to 2023



Data Source: Deutsche Bank

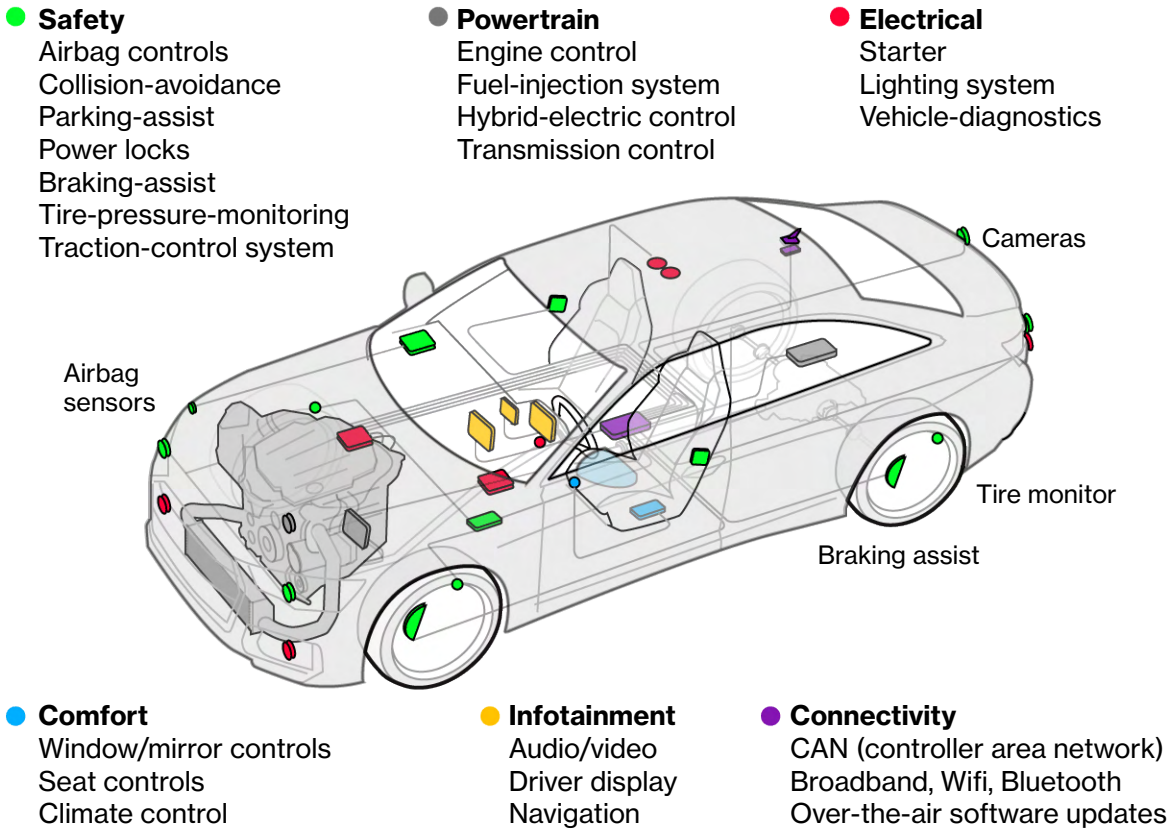
The global automotive semiconductor market was valued at $38.5 million in 2020, a decrease of 8.33% compared with the previous year caused due to the worldwide semiconductor shortage. This affected several major automakers and suppliers, resulting in a slowdown in vehicle production. However, the market grew in 2021 despite having low production rates, mainly due to vendors taking orders on extended delivery lead times. The market is expected to grow with an estimated CAGR of 10-18.75% and surpass the $100 million mark as early as 2026-'27.

Applications

Components developed by the semiconductor industry are used in various products, viz. smartphones, PCs, IoT devices, and data centres. Besides that, the demand for automotive semiconductors is projected to grow, with cars getting more intelligent and more connected as days pass by.

How do semiconductors drive the growth of EVs?

The checklist reflecting the users' preferences and concerns has always been long and growing. However, to make this a reality, the pace of innovation in the automotive industry should accelerate. For the automotive industry, this is only possible by sharing relevant data and frequently collaborating with the semiconductor industry. The average car is packed with 1,400 semiconductors that control everything from airbags to the engine. Modern vehicles simply cannot run without chips. Let's see this through.



Source: AlixPartners

EVs use high voltage batteries, which require accurate cell monitoring to ensure smooth performance during long rides. Although the daily commute is less than 50 km for most users, having battery monitors and balancers enables accurate tracking to provide more efficient battery use, leading to longer runtime and reduced battery size and cost.

It is essential to improve a vehicle's stability and limit the traction between tires and the road in various conditions. This is achieved by using a proper **electronic stability program** and **traction inverter system**, which allows the driver to maintain ideal motor torque while improving overall efficiency.

Advanced driver assistance systems (ADAS): Automakers create a safer, collision-free future by integrating automation into the vehicle's core. Using highly accurate radar SoCs (system on a chip), powerful processors, high-resolution cameras, and power management products enables automakers to build high-performance ADAS.

Functional safety standards have improved the driving experience with advanced safety features, reliability and better performance. Active safety is critical in every system. The semiconductor industry effectively creates a safer driving experience using various integrated systems. Almost all new vehicles feature wireless devices that offer seamless connectivity across devices and premium audio systems to provide the best sound and user experience, requiring various semiconductor devices.

Faster Charging: As EVs move towards faster, high-voltage charging technologies, they need sophisticated power topologies with other microcontrollers to enable quick and efficient charging. Moreover, wireless battery management systems remove the need for bulky wiring while improving driving range, performance and overall maintenance.

The Global Semiconductor Shortage

We've been experiencing a shortage in the supply of integrated circuits since late 2019. The ongoing semiconductor shortage has damaged the global automotive industry, affecting over 150 sectors, costing about $200 billion in revenue and an estimated production loss of 7.7 million vehicles. The imbalance in the supply chain was mainly caused due to the following reasons:

- COVID-19: Working from home during the pandemic led to a steep increase in the demand for electronics. Home networking gear, webcams, and monitors were set up at home for a work office environment. Chips used in the automobile industry needed less computing power, giving the manufacturers an incentive to build more sophisticated and expensive chips, shifting their attention away from legacy chips used in automobiles.

  Simultaneously, the pandemic instigated demand for private transport vehicles, driving people away from public modes of transport - creating a supply-demand imbalance in the industry. As a result, the pandemic indirectly forced a snowball effect, resulting in the global crisis.
- Automobiles Sales Hike: Automakers who cut back drastically early in the pandemic underestimated how quickly car sales would rebound once the lockdown was lifted. There was a sudden increase in the demand for semiconductor chips by the automobile companies to meet the car sales demand. However, semiconductor manufacturers could not meet the needs because their attention was diverted, and they had already started supplying the electronics sector with faster chips.
- Stockpiling: PC makers had warned about semiconductor shortage by 2020. Huawei, a Chinese smartphone maker that also dominates the global market for 5G networking gear, began hoarding chips to ensure it could survive US sanctions that were set to cut it off from its primary suppliers (China-US trade war). Soon, other companies followed suit, leading to an increase in China's chip imports from $330 billion in 2019 to $380 billion in 2020.

- **Adverse Weather:** A severe winter storm in February 2021 forced the closure of two plants in Austin, Texas, owned by NXP Semiconductors and Samsung, causing a month-long delay in production. Also, TSMC experienced a shortage of ultra-pure water required for cleaning the machinery due to severe drought in the country.
- **The US-China Trade War:** The ongoing economic conflict between the world's largest economies further fuelled the semiconductor shortage.
- **Occupational Disasters:** In October 2020, a fire broke into an Asahi Kasei semiconductor plant in Miyazaki, Japan (specialising in ADC and DAC components). Another Japanese factory owned by Renesas Electronics caught fire in March 2021; the company is responsible for 30 per cent of the total global market for microcontrollers for cars.

The US-China Trade War

The ever-rising bilateral US trade deficit in goods with China and its inflexible exchange rates have been subject to criticism from the US government on multiple occasions. Alarmed by China's large-scale economic policies, the Obama administration accused China of unfair trade practices, including exporting goods at dumping prices and subsidising aluminium and steel production, initiating a series of anti-dumping investigations against China. On top of that, the US government imposed tariffs on Chinese textiles to shield domestic producers. The trade relationship between the two countries weakened further when former US President Donald Trump formally launched his trade war against China in 2018.

Economists don't disregard the chances of an economic decoupling with rising tensions between the two nations, resulting in China losing access to American technology, capital, and markets. The United States and its allies are taking the necessary steps to align their motives and reduce reliance on Chinese goods.

Image Source: Shutterstock

For China, the costs of achieving self-sufficiency would be unsustainably high. A quarter of China's food imports come from the US, and its efforts to reduce dependence have seemingly failed as the cost of replacing these items with domestic supplies will be prohibitively inexpensive.

Moreover, China has dramatically underestimated the challenge of establishing a sanctions-proof chipmaking industry. The foundation of global technology supply chains is specialisation, and no single country or company can dominate or monopolise the entire supply chain.

Due to multiple process mechanisms and requiring over 300 different inputs when making chips, even the US, the industry leader, cannot build a fully indigenous semiconductor supply chain. While China reportedly plans to spend $1.4 trillion over the next five years pursuing that goal, it is less likely to achieve fruition.

The Indo-Pacific region spans two oceans and several continents, making it essential to U.S. maritime interests. This year, 42 per cent of the world's exports and 38 per cent of global imports are expected to pass through, according to a recent UN report. With the formation of the Quadrilateral Security Dialogue (QUAD) consisting of the United States, India, Japan and Australia, strengthening its economic and security ties in the region, China is left with limited options to address its financial vulnerabilities.

Response to the Semiconductor Shortage

Some of the existing measures that companies take to deal with the shortage of chips include changing their product configurations and buying chips directly from stockists. They are also looking to use different kinds of chips in components where the supply is most affected.

Here are some of the steps that have been taken worldwide to deal with the crisis:

- The European Commission announced a public-private semiconductor manufacturing alliance to increase the global chip manufacturing share to 20% by 2030.
- The South Korean government has also provided incentives to attract $450 billion in investment to the semiconductor industry by 2030.

Today, the United States still dominates microprocessor research and development. However, it lacks many other sub-industries, including photolithography tools and factories for building other advanced devices. Taiwan is leading in advanced manufacturing industries, while South Korea produces numerous materials and manufacturing equipment.

China is making progress in both semiconductor development and production with government support. In addition to significant investments in manufacturing capabilities, the United States is accelerating its investment in advanced semiconductor research and development to drive the next generation of innovation and maintain American leadership in this vital technology. Meanwhile, Asian manufacturers are responding to opportunities in the US.

Samsung Electronics recently announced plans to build a state-of-the-art semiconductor manufacturing plant in the United States. An economic impact study conducted in Texas shows that an upcoming $17 billion project named Project Silicon Silver will also create about 1,800 jobs in the first decade.

India's Response and Impact

Despite being able to create a cost-effective ecosystem, the existing structure in India ***lacks the speed of decisions*** it should make to compete in a competitive global market. Multiple companies have reported experiencing ***delays of several months for getting approval and NOCs*** to set up their plants in India.

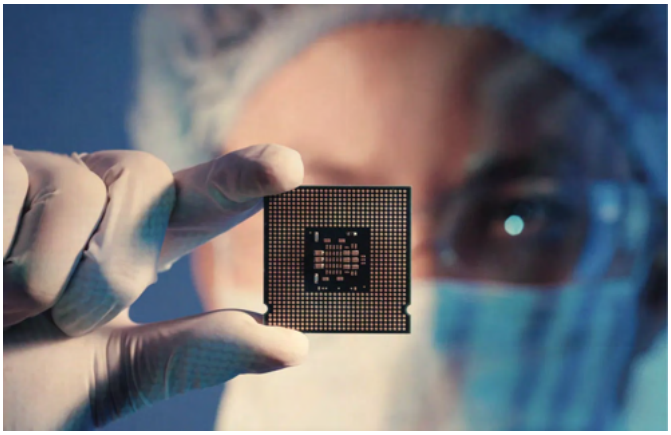


Image Source: Semiconductor Industry Association

Although India imports all of its semiconductors costing $10 billion annually, recent advancements in chip architecture have resulted in India becoming a design hub for various integrated device manufacturers (IDMs), employing about 20,000 engineers skilled in IC design. India recently declared its plans to become a self-sustaining entity in semiconductor production through various incentives, envisaging investment of $10 billion (INR 76,000 crores) over the next five years. It will spend an additional $20 billion to serve the development of its plans during the timeframe.

The government has approved an INR 76,000 crore incentive scheme to promote semiconductor manufacturing and demonstration. Experts say this will be a strategic benefit for India, especially when facing a semiconductor shortage. This initiative will accelerate the development of a complete semiconductor ecosystem in design, manufacturing, packaging and testing.

More about the PLI scheme announced by GoI

- The scheme designed to incentivise the sector is as follows:
- Foundries or semiconductor fabrication units will be offered financial support of up to 30% to 50% of project cost based on manufactured node size.
  Display fab units will be supported for up to 50% of the project cost with a limit of 12,000 crores.
- Sensors, compound units and ATMP (assembly, testing, marking, and packaging) / OSAT (outsourced semiconductor assembly and test) facilities will be offered financial support of up to 30% of capital expenditure to approved units.
- Fabless entities will receive a design-linked incentive of up to 50% of eligible expenditure (maximum INR 15 crores per application) and a product deployment-linked incentive of 4-6% on net sales for five years (up to INR 30 crores per application).
- The government also offers a clear twenty-year roadmap to generating highly skilled employment opportunities. It also established an "Indian Semiconductor Mission" to assess long term opportunities prevailing within the sector.

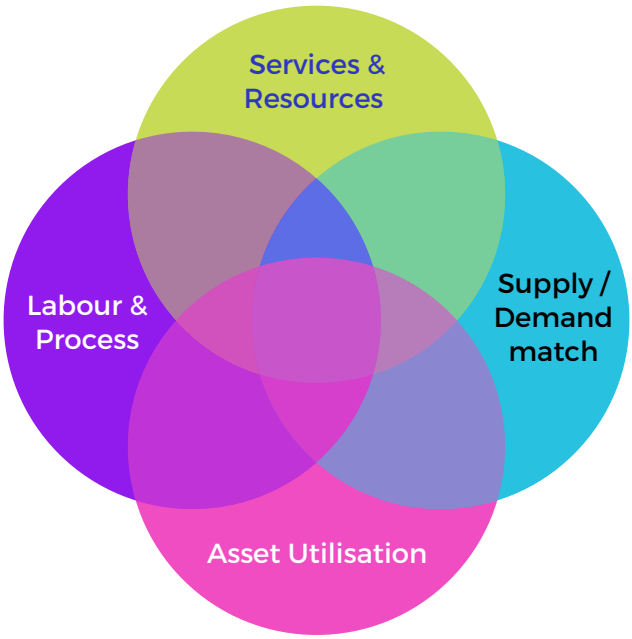
It is worthy to note that the government has taken a double-edged approach to generate new sources of revenue through semiconductor production whilst consolidating its position as a paramount entity in chipset design by offering design-linked incentives to promote research and development.

Increasing domestic semiconductor production has a tremendous strategic advantage given that labour costs are low and production capacity is ample. This will help domestic companies reduce their dependence on semiconductor imports and help generate income through overseas exports and become more competitive in the global market. Currently, Tata Group, Intel, Foxconn from Taiwan, and other manufacturers have expressed interest in setting up manufacturing plants in India.

Identifying the value drivers and Taking action

Labour & Process: Automakers and top-tier suppliers should gather and analyse more sophisticated data about the semiconductor value chain and where chips could be manufactured. Better decisions are made when business leaders can redefine the competitive landscape by weighing the technological applications for prioritisation at the level of the individual chips required.

Services, Resources, and Asset Utilisation: Using predictive maintenance and remote maintenance mechanisms can reduce maintenance costs. Flexible routing and predictive maintenance technologies will help minimise as large as 50% of machine downtimes. Intelligent IoTs can improve productivity rates considerably.



Supply-Demand Match: Data-driven demand prediction, open innovation, and optimisation algorithms will reduce inventory costs and ensure adequate supply to match demand. Manufacturers have complained of a lack of transparency regarding actual demand levels as automakers are ordering processors and other devices in excess. In the long term, the industry should rethink how supply contracts be structured.

A consistent, balanced risk-sharing plan across the value chain can also help drive growth. All the stakeholders must align their business goals to ensure a better supply-demand match.

Driving EV Growth in India

Before we wrap things up, we will discuss the problems in India's EV market. We have also suggested multiple business models for and about the technicalities and their feasibility in the Indian Market and the scope of import and export.

Considering various hotspots in India, the best sites for EVs companies to set up have also been discussed. Existing government strategies and strategies to raise awareness and reach people have also been discussed.

The Indian EV Market

India's automotive industry is the fifth-largest globally and will become the third-largest by 2030. It is expected to reach $150 billion by 2030. Global adoption of electric vehicles has increased significantly, with sales exceeding 2020 figures in the first half of 2021. A similar trend can be seen in India. The Indian electric vehicle market is projected to reach a CAGR of 90% from 2021 to 2030. In terms of penetration, EV sales accounted for only 1.3% of all automobile sales in India in 2021. The demand for electric vehicles is mainly due to favourable regulatory frameworks and has attracted foreign investment. Many state governments in India have already started taking steps towards net-zero emission and sustainability in business. About ten states and union territories (UTs) are increasing the usage of electric vehicles in three areas: manufacturing, infrastructure, and services. Being a part of the global automotive quartet (which also includes the US, China, and Japan), large-scale changes in the Indian market will affect the industry's global presence.

Despite India's ambitious goals, the electric vehicle market in India is still in its infancy. But looking the other way, India offers the world's largest untapped market, especially in the two-wheeler sector. This sector is 100% FDI accepted through an automatic route. Electric two-wheelers continue to sell in large numbers; however, electric cars are experiencing a slow uptake, accounting for less than 1% of the country's total 2.5 million passenger car sales. The share of battery electric vehicles (BEVs) in all passenger cars sold in Europe was 5.4% in FY2020, compared to just 0.2% in India. However, as the ecosystem improves, the share of electric vehicles is estimated to increase to 12% of all passenger cars by 2026, according to the JMK Research Report. Over the past few years, there have been considerable advancements in the industry and are now keeping up with other countries.

While the approach to becoming a marketing hub varies between states and UTs, the general trend suggests one central point: most states aim to become hubs for producing electric vehicles and their components. Environmentally friendly battery production, processing, and storage are stimulated everywhere. States governments of Maharashtra and Uttar Pradesh have been taking the necessary steps to ensure such facilities' development.

With natural resources and cheap labour, India is becoming one of the most prominent hotspots for manufacturing and exports. Currently, the growth in the Indian automotive market is driven by factors such as the increase in domestic manufacturing, rapid urbanisation, a booming economy and growing environmental concerns. Fueled by the ongoing US-China trade war, many global automakers have shown interest in India. Additionally, e-car sales in India have increased since 2019, increasing by 361.78% YoY in 2020. As of July 2021, the number of registrations has increased further, exceeding the sales volume in 2020. It is estimated that about INR 940 billion (US$12.6 billion) will be invested in electric vehicle manufacturing in India over the next five years across the entire value chain.

Major EV players in the country

TATA: Tata Motors has formed an electric vehicle subsidiary, Tata Passenger Electric Mobility Limited (TPEML), to manufacture electric and hybrid vehicles. TPEML will not own any manufacturing plants but acquire output and assets from passenger vehicle factories. TPEML plans to have ten products by FY26, catering to all drive ranges. TATA currently holds a 71 per cent share in the EV market. The company is clocking sales of more than 1,000 units of EVs every month. During FY21, the company had clocked revenues of ₹500 - ₹600 crores in the EV business. An intelligent strategy with a clear focus on breaking the key EV barriers and partnerships with group companies such as Tata Power, and Tata Chemicals for establishing the EV ecosystem, dubbed the TATA 'uniEVerse', has paid dividends for the company.

Mahindra: Mahindra Electric Mobility Limited is an Indian automobile company that designs and manufactures compact electric vehicles. The company adopted its current name after Mahindra acquired Reva Electric Car Company in 2010. After the acquisition, the company launched the electric hatchback e2o in 2013 in the Indian market. Mahindra Electric recently became the first Indian car manufacturer to cross 170 million kilometres. Mahindra has yet to announce its roadmap for India; however, it has pledged to invest around INR 3000 crores to develop electric vehicles.

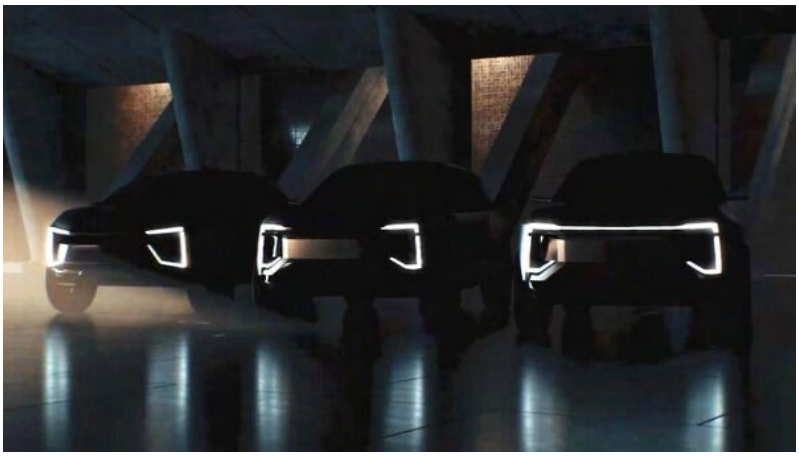


Image Source: Mahindra

Points of Concern

We've already compared EVs against conventional vehicles. Now, we'll look at the problems concerning the Indian automotive industry while also taking locally relevant issues into account. These include multiple factors like a supply-demand mismatch and uneconomically low volumes, leading to high costs when manufacturing EVs. Here's a brief on some of these issues:

Less competition leading to slower growth: Not many automobile manufacturers had entered the EV race. Hence, the development of EV technology has been relatively uneventful in the last decade.

Low Compatibility with Autonomous Driving Technology: Auto analysts say that advanced driver assistance systems on EVs will be tough to deploy on crowded Indian streets. Stray animals, including cattle, and potholes on the road are a further problem.

Image Source: Siyuwj - Own work, CC BY-SA

Lack of skilled labour: EV Technology is still evolving, and hence there is a lack of professional workers in the country. It also requires engineers to be more proficient in using semi-autonomous technologies. Their expertise in dealing with EVs is currently in the primitive phase, which will ultimately cause inconvenience to the consumer.

Issues in the supply chain: The EV market faces problems ensuring an end-to-end supply of components. The sector is dependent on importing the battery and power electronics from other countries, constituting almost two-thirds of an EV. Moreover, there is a lack of standardisation of battery packs, compromising quality and different safety standards. Returns don't have a definite structure, costing OEMs much money.

Negligible Charging Infrastructure: Minimum requirements to ensure EV readiness in buildings and parking lots and the deployment of publicly accessible chargers on highway networks and in cities are also crucial to increasing EV adoption and boosting consumer confidence. According to the Ministry of Heavy Industries, the total number of EV charging stations installed in India is just over 1000, significantly lower than the total number of EVs running in the country. Moreover, there are only a few charging stations on highways, so running EVs during long-distance journeys will be challenging and inconvenient. By 2026, India will need at least 40,000 public charging points to support the rising number of electric vehicles - requiring us to move at an ever-faster rate to meet the targets.

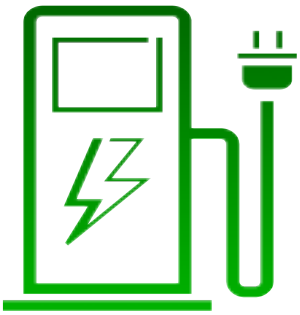
Competition With Economic Upliftment: 80% of the world remains underdeveloped, requiring massive capital expenses to uplift people to decent living standards. Capital-intensive technologies like EVs are simply not affordable for the majority of people.

Low Mileage: One of the major drawbacks of owning an EV is that it usually doesn't provide an acceptable driving range. On the one hand, electric cars do not have a regularised infrastructure whereas conventional vehicles can be refuelled at petrol stations. Also, it takes up to an hour to charge 80%, which is undoubtedly a long wait, and due to this drawback, most Indians do not prefer to opt for EVs.

EV Charging Structure in India

The distribution of installed chargers can be seen as unequal, most of them being in the big cities. Delhi has 12 times as many electric charges as India's largest state (Rajasthan), but Delhi also has six times more sales of EVs than the national average. The government of India is taking the initiative of scaling it up.
Some of the provisions that it has made are:

- To expedite the development of public EV charging infrastructure across the country, the Ministry of Power has issued "Charging Infrastructure for Electric Vehicles – Guidelines and Standards", mentioning the roles and responsibilities of various stakeholders at the Central & State levels.
- For the National-level rollout of charging infrastructure in the country, It has also designated the Bureau of Energy Efficiency (BEE) as the Central Nodal Agency.
- It has ordered all gas stations to install a supply of at least one new-generation fuel, among which is EV charging points.
- The government has also directed all commercial and institutional buildings with a parking space/capacity of more than 100 vehicles to set aside 5% of their parking space for EV charging.



- In the next three years, the nation's largest oil firm, Indian Oil Corporation, is planning to set up 10,000 charging stations for Electric Vehicles (EVs)
- EV charging stations are being set up every 40-60 km on national highways.
- Some states (for instance, Karnataka) are especially dedicating budget and resources to set up EV chargers.

Ola Electric has recently announced that the company is installing more than 4000 hyper-chargers at government-owned Bharat Petroleum Corporation Limited (BPCL) pumps and in residential complexes across India throughout 2022.

Tata Power has also established a network of 1000 chargers throughout the nation. Magenta, a Mumbai-based startup, has begun installing streetlamp-integrated EV charging stations at railway stations and aims to install 4500 chargers across petrol stations, hotels, and residences. Ather Energy, another prominent EV maker in the country, plans to set up chargers in 500 locations.

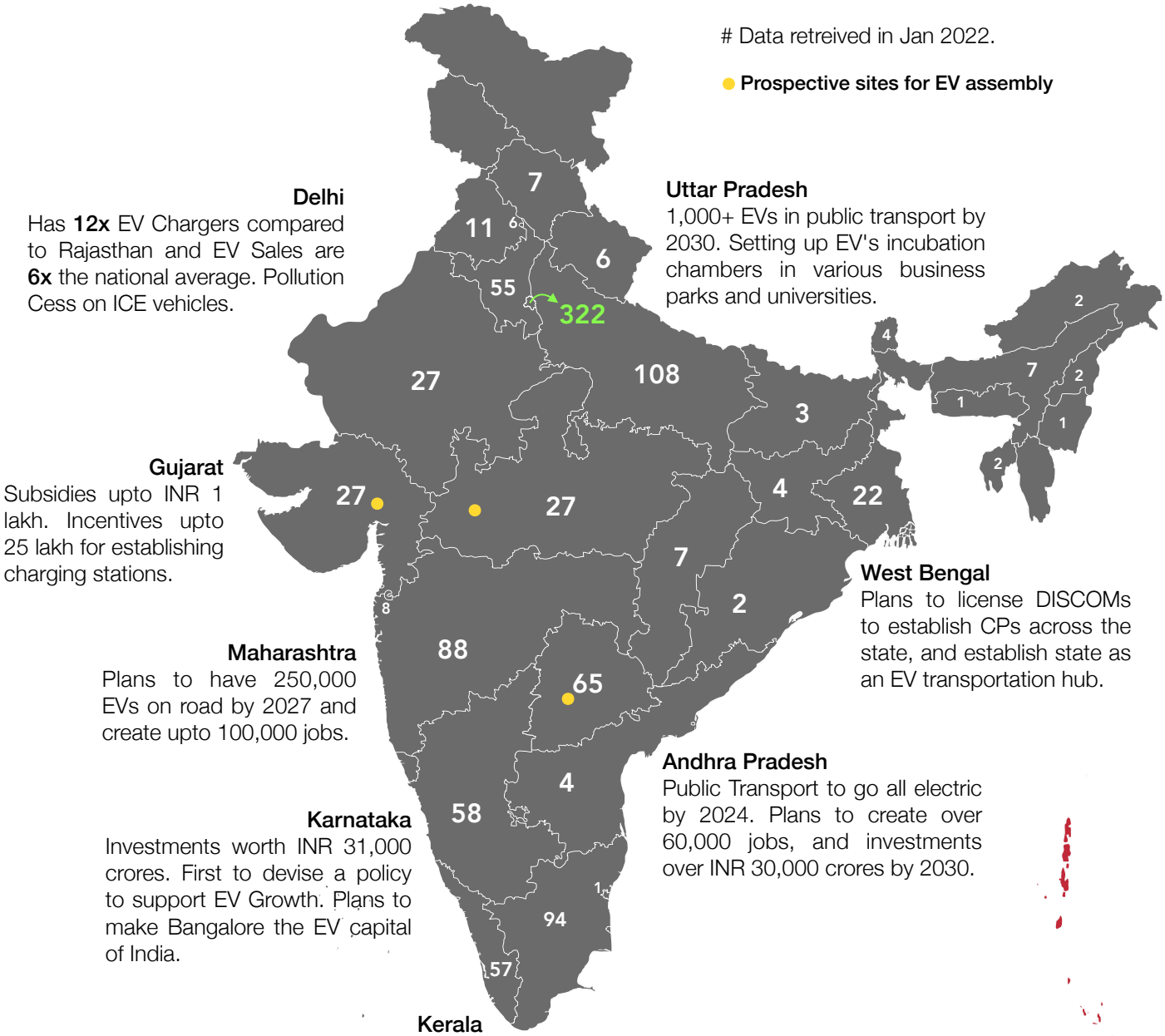
Despite these, EV adoption across India is seen to be slow-moving. Though India is picking up the pace in setting up the charging infrastructure, it is not on par with other regions like European Union (EU), the USA, or China. High operating costs, DISCOM load, and the uncertainty related to utilisation rates of charging stations are creating a barrier for the charge operators from expanding their current reach.

A state-wise summary of government initiatives and charging points in India

Numbers represent charging points in that particular state/union territory.

Data retreived in Jan 2022.

● **Prospective sites for EV assembly**



Delhi
Has **12x** EV Chargers compared to Rajasthan and EV Sales are **6x** the national average. Pollution Cess on ICE vehicles.

Uttar Pradesh
1,000+ EVs in public transport by 2030. Setting up EV's incubation chambers in various business parks and universities.

Gujarat
Subsidies upto INR 1 lakh. Incentives upto 25 lakh for establishing charging stations.

West Bengal
Plans to license DISCOMs to establish CPs across the state, and establish state as an EV transportation hub.

Maharashtra
Plans to have 250,000 EVs on road by 2027 and create upto 100,000 jobs.

Andhra Pradesh
Public Transport to go all electric by 2024. Plans to create over 60,000 jobs, and investments over INR 30,000 crores by 2030.

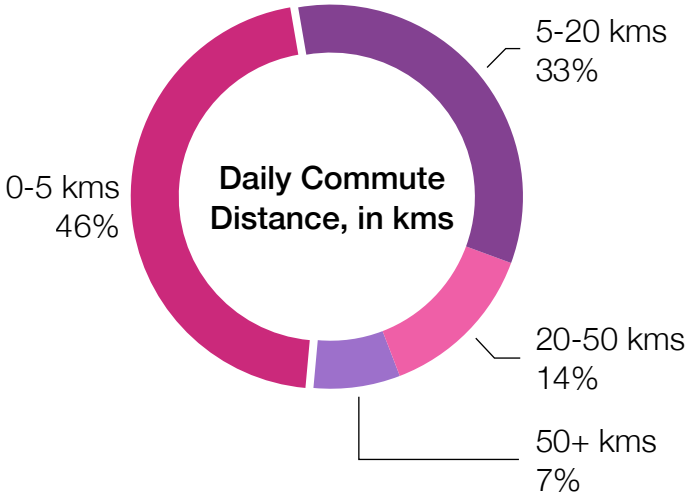
Karnataka
Investments worth INR 31,000 crores. First to devise a policy to support EV Growth. Plans to make Bangalore the EV capital of India.

Kerala
Targeting 1 million EVs and full electrification by 2030. Plans to have over 6,000 EVs in public transport. Introduced reskilling plans for workers.

FAME Programme: As part of the NEMMP 2020, the Ministry of Heavy Industries formulated a scheme, namely Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme in 2015 to promote the adoption of electric/hybrid vehicles in India. FAME-I came into operation on April 1, 2015, and ended on March 31, 2019. It supported about 2.8 lakh EVs with total demand incentives of ~ INR 359 crore. FAME-II commenced on April 1, 2019. 92,393 Electric Vehicles were supported as of now under FAME-II by way of demand incentives amounting to about $1.4 billion.

Targeting the post-pandemic vehicle buyer

As a part of our market research, we surveyed a group of people. After closely examining the results and simultaneously checking with the prevailing market conditions, we arrived at the following conclusions:



60%

of respondents prefer private vehicles over public transport.

46%

of new car buyers cite lack of proper infrastructure as reason for not choosing EVs over gasoline vehicles.

It was visible that the ***pandemic caused people to use public transit less frequently than before or not at all*** - fuelled by the growing popularity of home delivery services and a work-from-home culture. Meanwhile, 29% of new buyers cited a lack of cost competency for not choosing EVs over gasoline vehicles. The majority of the respondents agreed that they are very likely to consider an electric car over traditional vehicles if the administration addresses their concerns adequately.

We identified three kinds of prospective car buyers: the **Conventionalist**, the **Frugalist**, and the **Innovationist**. The conventionalist maintains a neutral attitude towards EVs, citing a lack of clarity regarding EVs and the non-availability of proper charging infrastructure. They find it difficult to use new technology used in EVs. They're less flexible and are not open to changes even after recognising ecological factors, primarily because it involves lifestyle changes. Hybrid vehicles appeal to this segment as they come with minor lifestyle changes. If a proper support system is available, these users will likely consider switching to electric cars.

The second type of user, the frugalist, maintains a mildly negative attitude towards EVs, citing high costs and the availability of cheap alternative powertrains. However, when informed of the long term advantage of using EVs, they replied that they were likely to reconsider their decision in about 7-10 years.

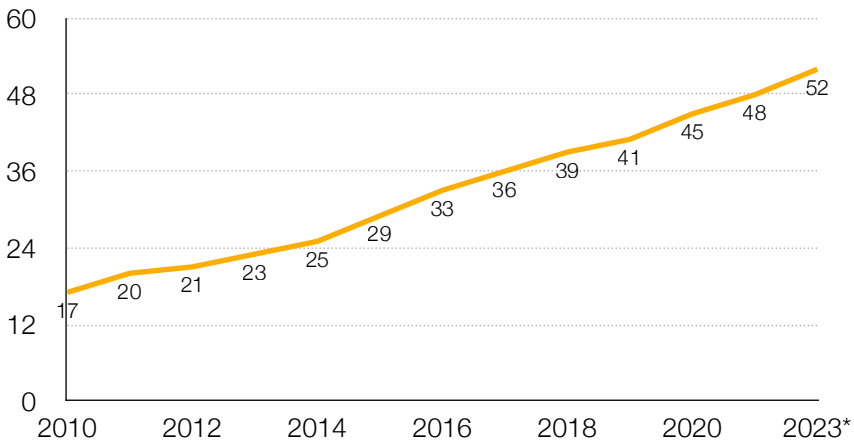
Finally, the innovationists were an environmentally-conscious segment and were willing to adapt to new changes by changing their lifestyles, believing that pollution and climate change are genuine threats.

The buying preferences can be summarised as follows:

	Frugalist	Conventionalist	Innovationist
Overall Attitute towards EVs	Mildly Negative	Neutral	Highly Positive
Range Anxiety	High	Extremely High	Low
Curiosity about Innovation	Neutral	Extremely Low	High
Desired customizability	Extremely High	Low	High
Concern on affordability	Extremely High	Moderate	Moderate

Working professionals, ages 25-55, living in cities and suburbs with small families will be the major buyer segment driving growth. They are likely to disregard the cost imparity between EVs and traditional vehicles and opt for long term gains.

Share of SUVs in global car sales



The most notable growth has been observed and is likely to continue in luxury cars and SUVs of all passenger car categories.

Data Source:
2010-2019 - IEA Analysis,
2020 & 2021 - IHS Markit,
2022 & 2023 - Estimated from global sales projections and growth in other segments.

The average cost of a car purchased in the US is $45,000 (~35 lakh INR), while the same in India is $10,000 (~7.7 lakh INR). So, despite being sold in the US, the EV segment will serve India's premium/luxury segment. Also, the data shows that demand is shifting towards premium cars and greater capacity.

Comparing the total cost of ownership over five years, electric cars turn out to be about 10% cheaper[1] than their ICE counterparts. They require less frequent maintenance, and the annual maintenance costs associated with EVs are 85% lower than ICE cars. All three users had expressed concern over the lack of cost parity between EVs and combustion engine cars. Therefore, in a price-sensitive market like India, it is essential to stress the cost benefits of buying an EV and for customers to be made aware of their buying choices.

EVs are set to enter a new phase where supply-related processes and sustainability will be considered critical in the transition to clean energy. We shall now discuss various strategies that can be adopted to hasten this process at present and beyond, as well as existing policies that can be modified to be implemented in India.

Methodology

1. Tapping into new value pools

Micromobility: It encompasses a range of lightweight vehicles, including e-scooters, e-bikes, and e-rickshaws and provides travelling services for short distances, accomodating at most two passengers at the same time. The sector is expected to make a robust post-pandemic recovery owing to strong support from governments worldwide. The industry currently finds applications in the shared mobility sector and niche areas like mail delivery.

ADAS systems will further expand the market, possibly beyond their use in public transport. The advent of computer vision-based systems with collision avoidance capabilities will provide safer rides, giving micromobility options their long-awaited push to grow beyond the current mix. Adopting such models by ride handling services will enable them to offer cheaper end-to-end services to everyone and access a significant portion of the market, irrespective of their scale of operations.

The uptake of micromobility solutions will vary by region — and offering a portfolio that matches local demands is key to success; penetration into 70% of the transport sector is achievable in the long term.

Shared mobility: It includes pooled ridesharing, e-hailing services, rentals, and taxi services. The sector was hit hard by the COVID-19 pandemic but is expected to make a recovery and double in market size by the end of this decade. Shared mobility companies have attracted investments of over $100 billion since 2010.

Image Source: University of Leeds

Adopting small-format models that are perceived safe due to ease of maintaining social distancing and fewer points of contact, the industry can generate better revenues amid the pandemic causing customers to drift away from shared modes of transport. Electric two-wheelers and three-wheelers are efficient means of transportation for long-distance trips, thereby meeting the rising demand for last-mile delivery.

eRoaming: Opening up CPs to all EV drivers through roaming agreements between e-mobility service providers and charging point operators can result in a more profitable business for operators and better capacity utilisation. However, a uniform interoperability standard is vital for its success. Operating decentralised digital hubs can solve the dilemma, where EVs and charging points work seamlessly together based on an already-accepted interoperability protocol — resulting in an open network that anyone can use. Payment-based services can be added on top of this, creating a self-sustaining business model.

Battery leasing: Battery leasing solutions will enable the manufacturers to sell EVs without a battery, and consumers can opt to buy or lease EV batteries from an external source. Under this model, when buying an EV, it will come with a battery leasing arrangement that is prorated depending on the annual distance that the driver expects to cover. EV batteries deteriorate at about 2% annually — and battery leasing models guarantee the condition of battery packs as they're replaced once their capacity falls below a certain level (usually at around 65-70% of the original capacity).

Image Source: iStock

Subscriptions: This model seems very promising for developing countries like India. Companies provide flexible options for customers to choose from, and the customer can upgrade or downgrade from their existing subscription according to their preferences.

Direct Sales: Companies can save up to 25% in dealer margins and other incentives by adopting a direct/ online selling strategy. Although 5% of the global sales are made through online sales, it is expected that over half of the overall sales will be online by 2030.

2. Customisability

We've seen how important it is to make customers aware of their options. Additionally, cost comparability cannot be achieved in the sector unless global automakers can believe the Indian EV market is bankrollable- and therefore remains a long term target. Hence, the customers should get as many variants on the same brand- enabling them to choose the one that satisfies their requirements. For example, a company can provide two or more variants on the same model, differentiated by their driving range. Since there is a precise segmentation of EV buyers based on needs, the companies can cater to each of these segments.

3. Targeting the right audience

Communicate Explaining: The key advantages of EVs must be explained and demonstrated in all communication opportunities. Experiments are part of the client learning process. Everyone should drive to understand the benefits of electric vehicles, but many haven't done so yet.

Think anew: Commercials and attractive and detailed descriptions are incompatible. Traditional auto retailers are so accustomed to commercial forces (incentives, campaigns) that it is challenging for sales teams to apply this approach consistently. The concept of "agent" retailing alongside the "Product Genius" used by BMWi seems to be a good option for electric vehicles due to the low product competition in this market segment.

Go social!: Customer education is a top priority in product marketing. Sales consultants should bet on social media for easy access to their customer base using text, images, and video.

Emphasise the 'novelty': Almost all vehicles are great but very similar! Most customers change cars and motorcycles and never get a fundamentally new product. And electric vehicles are new — a new sense, a new economy, and hence new restrictions. Every innovation has its flaws, but novelty is the selling point.

Storyboards: Inviting existing customers worldwide to share their own experiences with the company. Every ownership experience is unique. So when customers from diverse backgrounds share what made their car special, this will, in turn, inspire other users and even convince prospective buyers into buying an EV over its alternatives. Customers receive gift cards or free charging at partner charging points in exchange.

Image Source: v3b

A similar system could be introduced in India, subject to the availability of charging networks.

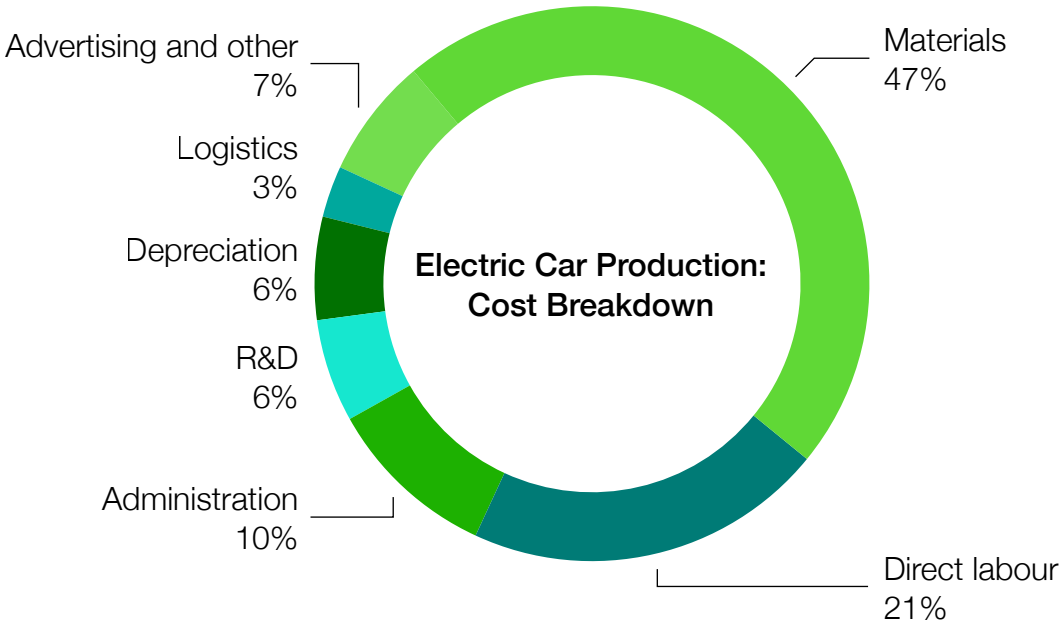
4. Short Term Strategies

In a world of increasing global competition, the industry needs to have the capacity to innovate and upgrade. A targeted approach could achieve critical development in exports of product categories where India has a competitive edge. Possible collaborations with global suppliers relocating manufacturing operations to India could further reinforce these efforts and help build new capabilities.

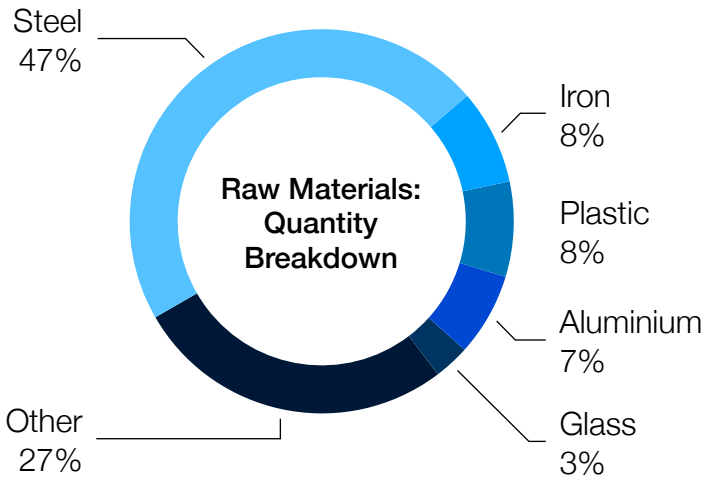
Staying ahead in adopting new technology: Companies should integrate digital analytics and automation into their everyday operations. Advanced analytics, process digitisation, robotics and automation could accelerate transformations necessary to evolve for the future. By physically integrating various EV components, we can create more efficient thermal management solutions. Also, EV powertrain components are usually smaller than their ICE counterparts, making room for other systems and multiple options for creating new designs. Since most customers are tech-savvy, companies must keep up with others in the game and equip their products with advanced technology. It is also essential to democratise technology by cutting profit margins or vertical integration with partner firms.

Partnering and collaborating with Competitors: A struggle for profitability usually accompanies the transition towards electrification. As companies have to repurpose their tools and platforms for manufacturing electric vehicles, collaborating with other manufacturers can ease the burden by reducing fixed costs, research and development and achieving total operational efficiency. High volume procurement of raw materials results in better profit margins which wouldn't have been otherwise possible if the companies went alone. There's a tremendous increase in volume over the same base, bringing down costs by up to 12%.

Minimising Costs: Also, there is a cost parity of about $12,000 between electric vehicles and ICE vehicles. An exhaustive analysis of various segments revealed that OEMs could cut 15 to 25% of total costs — on categories like real estate, IT, insurance, logistics, packaging, etc., that are traditionally deprioritised, focusing on material cost.



Raw materials contribute about 47% to the cost of a vehicle. Steel alone contributes to almost 22% of an automaker's operational costs. Any fluctuation in global steel prices has a direct impact on profitability.



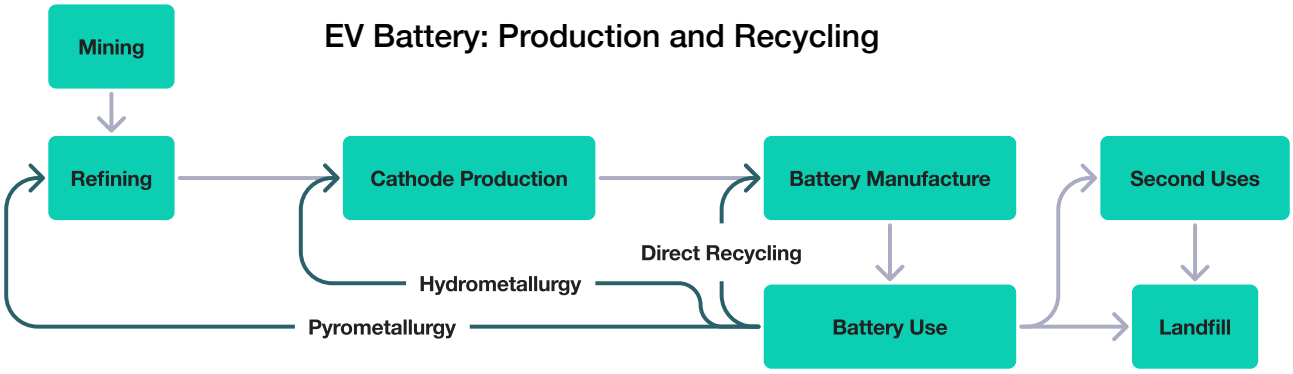
Reinforced plastics can be used to build multiple interior and exterior parts of electric vehicles, including under-the-hood body parts. Using a straightforward body styling with uncomplicated interior trims and reducing the design complexity by eliminating extra electronics and additional structures can also help optimise costs.

With advancements in material technology, alternative materials like glass fibre reinforced plastics (GFRP) and carbon fibre reinforced plastics (CFRP) can now provide adequate structural performance at comparable or lower costs than steel.

We shall discuss the impact of using reinforced plastics and other strategies in a later part of this section.

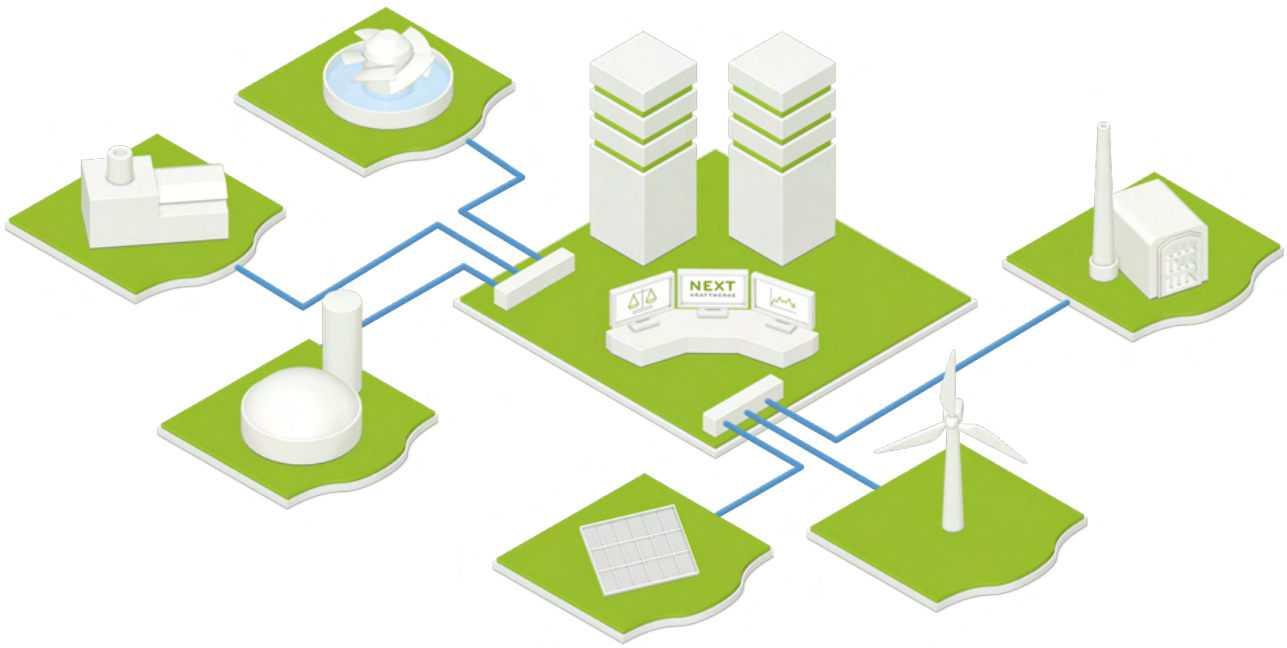
5. Direct Recycling of EV Batteries

EVs run without any tailpipe emissions over the course of their run, thanks to their batteries. But when these batteries reach the end of their life cycle, their benefits fade. These are intricately engineered devices, and if they end up in municipal waste — 91% of which end up in landfills or get incinerated, they can release various toxins, including chances of heavy metal toxicity. Even recycling can prove to be a hazardous process. Regarding the techniques used for recycling, **direct recycling** is preferred to the widely used recycling processes as it keeps the cathode mixture intact.



Although direct recycling is focused on single cells and yields just tens of grams of cathode powders, it can be adapted for large-scale models and become viable in the future.

6. Long Term Strategies: Virtual Power Plants



Virtual Power Plants, or VPPs, efficiently utilise power from individual energy sources in grid balancing or trading in the electricity market (at peak times for energy arbitrage).

VPPs allow renewable energy to be transferred into the grid from not just one but thousands of small-scale energy storage systems, backup generators, biomass, household solar batteries, etc.

This energy can be deployed to respond to energy shortfalls, voltage imbalances, and local disruptions and even provide network support and frequency control ancillary services. Electric vehicles with vehicle-to-grid capability can also be used to provide grid services. The presence of many EVs can destabilise grid operations — decentral transformers and substations can get overloaded when not adequately managed. However, there is flexibility in the recharging associated with each of the driving cycles of EVs. Power companies could tap into the energy stored in batteries at times of peak demand.

This concept has opened up a new avenue for revenue generation for businesses based on fleet operators, bus operators, etc., that can play a VPP architecture role. A VPP will require a power network integrated with the secure communication network, protocols for data sharing and cyber security, etc., to operate, which, concerning India, could be possible on a medium to long term horizon.

7. Long Term Strategies: Local EV Assembly and Battery Production

Usually referred to as gigafactories, these plants make lithium-ion battery cells and provide end-to-end renewable energy solutions. They're essential for the foundation that will sustain individual industries in the foreseeable future.

Giga Nevada. Image Source: Tesla

Despite receiving support from the government and being subject to an industrial push in EV production, international brands are yet to announce any plans to set up such plants in the country. We've identified three core areas that provide suitable battery production and EV assembly- Ahmedabad, Hyderabad and Indore *(Map on Page 24)*.

The industry is open to foreign direct investment, and this remains the most viable path to export-led growth and the establishment of new technology-intensive clusters in any country. Moreover, the cost advantage of local production facilities drives adjacencies' future growth, especially in automation, electronics, and energy.

Cost Comparison between imported and locally assembled units

	CBUs#	CKD-1#	CKD-2#
Import Taxes, in % of base price	up to 100%	up to 30%	15%
Excess Logistics Charges, in %, compared to locally built units	100%	50%	30%
Excess Labour Charges, in %, compared to locally built units	60%	30%	15%
Raw Materials and Other, Excess charges in %, compared to locally built units	up to 25%	up to 25%	up to 25%
Total Excess, in % of retail price of locally built units	**up to 170%**	**up to 65%**	**up to 40%**

CBU: Completely Built Units
CKD-1: Completely knocked down units containing engine or gearbox or transmission mechanism in pre-assembled form
CKD-2: Completely knocked down units containing engine, gearbox and transmission mechanism not in a pre-assembled condition

Companies can save up to two-thirds of costs incurred when electric vehicles are entirely built in India — which converts to a small gap in achieving cost parity between electric vehicles and ICE vehicles. And to facilitate the local assembly of electric cars in India, companies will have to address very immediate industrial needs and spend up to $1 billion to set up a local manufacturing plant. However, by partnering with local OEMs with fully functional factories in India, high volume procurement will help both parties save an additional $2,000 per $10,000 spent in the long term. Moreover, 70% of the components used in EVs are the same as internal combustion engine vehicles. With the government offering subsidies up to 50% of project cost, combined with cheap labour and raw materials, the break-even period can be brought down by 4-5 years.

Impact and Sustainability

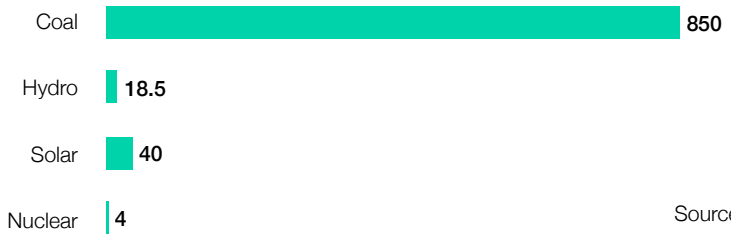
In addition to bringing social and environmental change, sustainable initiatives can contribute to a business's overall success. Studies show that the most sustainable companies are also the most profitable. Environmental, social, and governance (ESG) metrics can determine how ethical and sustainable an organisation is — and organisations with higher ESG ratings consistently outperform market projections, both in the short and long term.

Carbon and Cost

Are EVs truly sustainable? They're greener than internal combustion engines, but the goal of being 100% green might still be years away. EVs produce negligible tailpipe emissions, but this might not be the case when accounting for the GHG emissions during manufacturing and battery charging. Still, electric vehicles create a lower carbon footprint over their lifetime than cars and trucks that use traditional engines.

In India, the average carbon intensity of electricity generated stands at 540 gCO_2 per kWh, about 14% higher than the global average of 475 gCO_2 per kWh. This is exclusive of other GHG emissions, which, if factored in, could lead to 600 gCO_2e per kWh generated in total.

Emission Intensity of electricity generated, in gCO_2e / kWh



GLOBAL# 475 gCO_2 / kWh

INDIA# 540 gCO_2 / kWh

#Exclusive of emissions due to other greenhouse gases.
Source: Various, Estimated from Industry Data and IEA Analysis.

Currently, electric vehicles in India generate about 124 gCO_2 per km. This can be reduced by 30% in 2035 and 75% in 2050. A critical step to achieving this is decarbonisation in power generation, which requires **phasing down unabated coal-fired power plants** and most fossil fuel subsidies. **Virtual Power Plants** will help reduce the frequency of maintenance in the grid, the effects of which will also reflect in net emissions. Efforts to cut down pollution across various industries are expected to reduce the environmental impact of EV production further.

GRID DECARBONISATION

COST	GHG EMISSIONS
30%	75%
reduction in grid maintenance costs	reduction in overall EV emissions by 2050

REINFORCED PLASTICS

STRENGTH	GHG EMISSIONS
2.6x	43%
compared to the strongest steel	lower carbon carbon emissions than steel

Approximately 0.6% reduction in emissions can be achieved for every 1% **reduction in vehicle weight**. The usage of **fibre-reinforced plastics** for making EV parts is highly recommended to reduce vehicle weight, provided that necessary steps are taken for managing microplastic contamination in extreme cases. Some reinforced plastics are up to 2.6 times stronger than the most robust steel used. The lifetime emissions of reinforced plastics are up to 16% lower than aluminium and 43% lower than steel.

Cleaner battery production technologies involving **direct recycling of used batteries** have been suggested to reduce reliance on raw materials like manganese and cobalt. **Direct recycling** has generated profits of $7-20 per kWh capacity recycled in countries including China, the US, South Korea and Belgium; however, the use of hydrometallurgical and pyrometallurgical recycling techniques resulted in losses of about $12-24 per capacity recycled for the same set of countries evaluated.

Recycling in India

There has been an increase of 43 per cent in the e-waste generation in India between FY18 and FY20. The pandemic-induced increase in electronic devices is set to accentuate this problem soon. A study by KPMG and ASSOCHAM stated that computer equipment accounts for almost 70 per cent of e-waste in India, followed by telecom (12%), electrical equipment (8%), and medical equipment (7%).

95% of the e-waste produced in India is recycled in the non-formal sector, and 5% of the e-waste volume is handled in a standard unit. In and around metropolitan cities in India, there are over 3000 units engaged in the non-formal sector for e-waste recycling. Non-formal units of e-waste recyclers are distributed all over India. Considering the number of e-waste recycling units in the country and the e-waste generated, the government needs more recycling units. E-waste (Management) Rules, 2016 were enacted on October 1, 2017. Over 21 electronic products were included under this rule. The government has also strengthened the Extended Producer Responsibility (EPR) to ensure the take-back of end-of-life products. A new configuration called Producer Responsibility Organisation (PRO) has been introduced to bolster EPR further.

Recycling as a business: Recycling is not just a matter of recovering recyclable material; it also forms the basis of a complete business frontier. Companies can turn the rising demand for recycled products into a competitive advantage by getting into strategic alliances and profitable partnerships with suppliers, distributors and other stakeholders. With governments realising the potential of recycling and setting future goals, the industry should boom further.

Conclusion

It's hard to tell what the future holds for electric vehicles. Still, it's evident that they have much potential in creating a sustainable future, revitalising the industry, and tackle climate change. Policymakers are taking necessary steps to promote EV growth, but further incentivisation can be vital in delivering greater chances of success. Alternative business models in adjacent sectors — forming new clusters and an end-to-end supply chain can minimise risks involved within the process and are crucial for achieving better transformation rates. We've also discussed sustainable initiatives that provide savings in both cost and carbon emissions over time.

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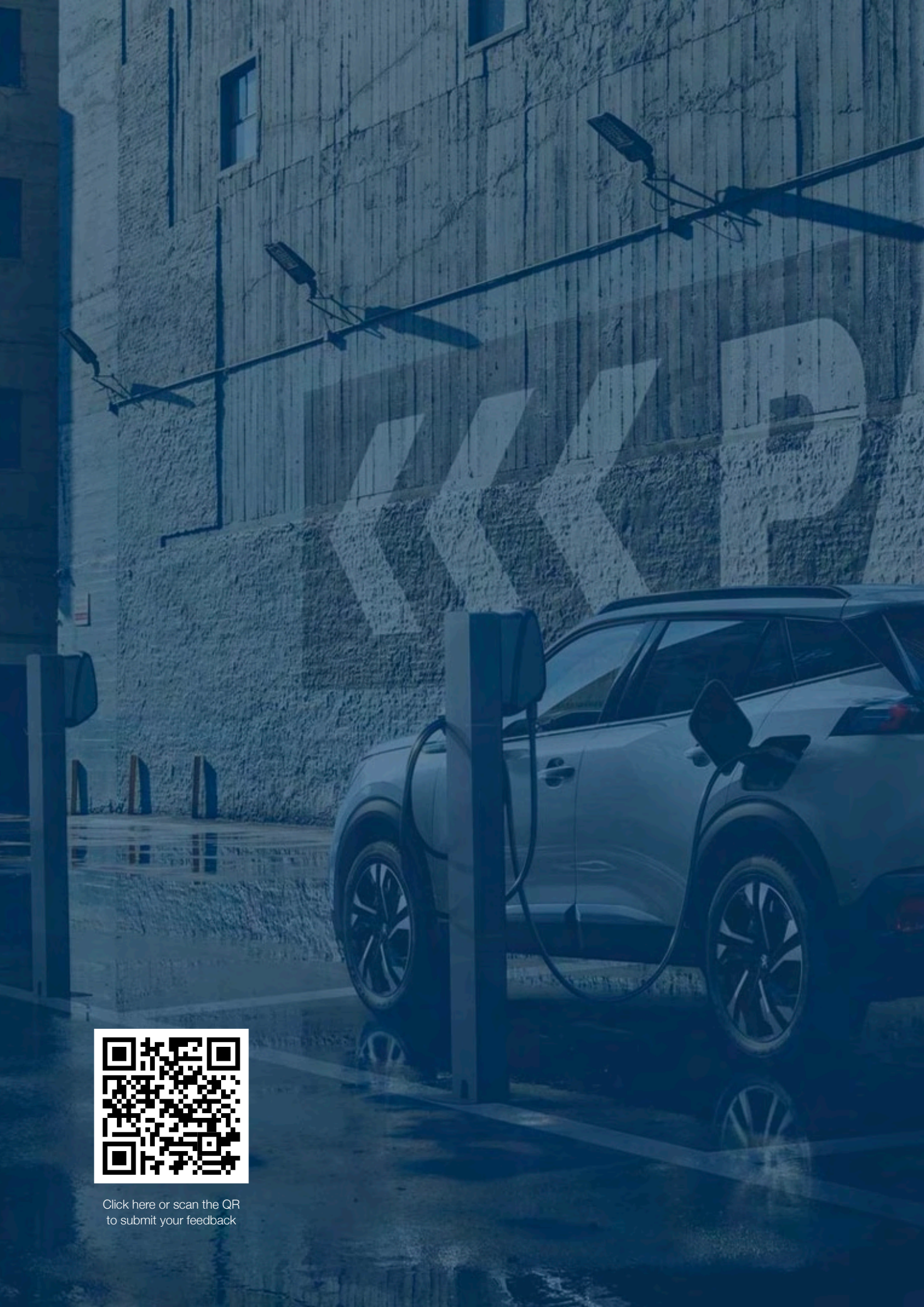

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