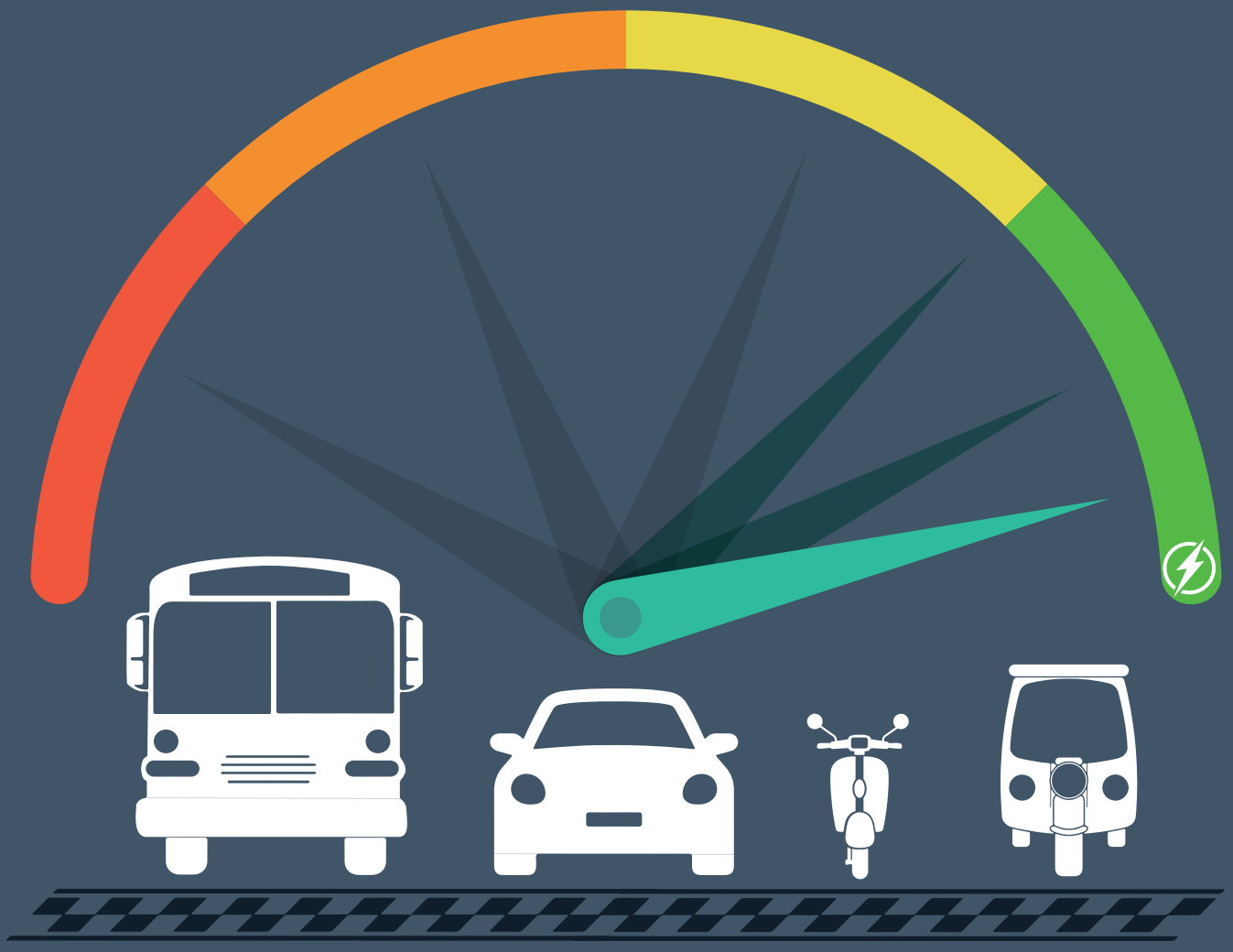

TOWARDS A ZERO-EMISSIONS MANDATE POLICY

Analysis of stakeholder perceptions

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This is a collaborative study between the Centre for Science and Environment and the CITIES Forum.

The Centre for Science and Environment is grateful to the Swedish International Development Cooperation Agency (Sida) for their institutional support.

Shakti Sustainable Energy Foundation (Shakti) seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following sectors: clean power, energy efficiency, sustainable urban transport, climate policy and clean energy finance.

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Part 1: Why this study?

India's electric vehicle (EV) programme is on the cusp of change but requires additional measures to accelerate the zero emissions transition. There is considerable conversation around a high level of ambition for market transformation to meet the clean air and low carbon growth path. But all levers of change have not yet been fully explored and utilized to enable that transformation.

It is necessary to include all key policy instruments of change to build the scale of the EV programme and to contribute to India's global commitment to the net zero goal by 2070, reduce one billion tonne of carbon and to cut emissions intensity of the economy by 45 per cent from 2005 levels by 2030. Additionally, India has signed on to the Declaration for 100 per cent transition to zero emission vehicles by 2030–40 with a specific mention that all governments need to support the transition of two- and three-wheelers to zero emissions as they dominate the fleet. India is also a member of the Zero-Emission Vehicle Transition Council (ZEVTC) that was set up with representatives from 17 largest vehicle markets—representing 50 per cent of the global car market.

To this are added India's own domestic imperatives of meeting the public health goals associated with clean air. Under the ongoing National Clean Air Programme (NCAP), 132 cities are implementing clean air action plans and all states are additionally preparing their respective state level clean air action plans to achieve at least 20–30 per cent reduction in particulate pollution by 2024. This planning process has also integrated the strategies for zero emissions transition to promote electric vehicles and the attendant ecosystem.

There is also an imperative to achieve energy security and reduce dependence on oil. The transport sector in India is the largest user of oil and the second-largest source of CO_2 emissions worldwide.[1] With a growing middle class and rapid urbanization, India's small vehicle fleet relative to its large population is expected to grow rapidly. Since 2010, the growing demand for internal combustion engine (ICE) vehicles has more than doubled the sector's energy consumption and related emissions.

Further growth in transport emissions will also exacerbate air pollution and mortality, placing an increasing strain on an already overburdened public health system, as well as increasing traffic congestion, which are both contributing to reduced productivity and welfare gains.

Vehicles produce greenhouse gases throughout their life cycle from raw material extraction, production and manufacturing up until charging and disposal. Zero-emission vehicles can reduce these emissions substantially. Battery-electric vehicles can achieve decarbonization at a much faster rate and for feasible costs. Currently, the Indian transportation sector accounts for one-third of the total crude oil consumed in the country, where 80 per cent is consumed by road transportation alone.

Electrification is one of the major interventions needed to decarbonize the transport sector apart from demand-side management interventions. It is reported that India's EV market is expected to grow at a compounded annual growth rate (CAGR) of 90 per cent in this decade to touch USD 150 billion by 2030. Even though a substantial part of the electricity is still sourced from coal power plants, the upstream source of electricity is also expected to decarbonize rapidly with India's commitment to generate at least 50 per cent of its electricity from renewable sources by 2030.

While the Government of India has taken several steps toward faster adoption of EVs, several challenges and gaps exist in the EV ecosystem that must be addressed to build the confidence of consumers and the industry.

Currently, the central government's policies have focussed on providing incentives for adoption of electric vehicles. Faster Adoption of (Hybrid &) Electric Vehicles II (FAME II) has been created with a corpus of Rs 10,000 crore to support about 15.6 lakh vehicles, including 10 lakh two-wheelers, 5 lakh three-wheelers, 55,000 passenger cars and 7,000 electric buses. But as of March 2022, FAME II registered only about 19.3 per cent of the planned fleet target. Due to the underutilization of its funds, the programme has been further extended till 2024 with some amendments that include increasing the subsidy for electric two-wheelers and adoption of the model of demand aggregation for e-bus procurement. It is expected that the FAME incentives will be further extended to improve price parity with the ICE vehicles and stimulate demand and enable large-scale fleet conversion related to public transport, delivery fleet, ride hailing, etc.

The other central government incentive programme includes the production-linked incentives (PLI) to support giga-scale advanced cell manufacturing of up to 50 GWh. PLI of Rs 18,000 crore has been earmarked for manufacturers to set up production units of at least 5 GWh. PLI provides incentives linked to the incremental sales revenue and incremental exports revenue. This aims to promote local manufacturing of the value chain related to raw materials, electrochemistry, and end-of-life treatment of cells, modules, and battery packs.

Simultaneously, about 21 state governments are implementing their respective electric vehicle policies that have taken on broad, ambitious electrification targets within a five-year time frame. While one group of states have set absolute goals of 10 lakh EVs by 2030, others have set percentage targets within a range of 10–30 per cent EV penetration in sales in five years. There are outliers too who aim for 80-100 per cent EV penetration.

All this promises to add up to a substantial figure by the end of the decade. But that will be possible only if the policies are further refined and are implemented fully and effectively. Significant leveraging is possible if these policies are designed with mid- to long-term regulatory targets, enabling mechanisms and compliance strategy. However, at this stage there is considerable variation in scope and structure of the state policies.

Despite these developments the level of overall fleet electrification is very low—less than 1 per cent of new vehicle sales. One of the weakest links in the policy is lack of regulatory targets and mandate for time-bound zero emissions production. Even though from time to time, there have been several government level announcements of the intended target of electrification by 2030, these are not backed by regulations. The level of ambition ranges from the minimum 30 per cent by 2030 to the NITI Aayog's stated ambition of 70 per cent electrification of all commercial cars, 30 per cent of private cars, 40 per cent of buses, and 80 per cent of two-wheelers and three-wheelers by 2030.

Similarly, the Society for Indian Automobile Manufacturers (SIAM) has proposed a voluntary roadmap of 40 per cent electrification by 2030 and has highlighted issues related to bridging the viability gap, enabling charging infrastructure, domestic manufacturing, creating public awareness, etc. to become EV ready. On the other hand, Society of Manufacturers of Electric Vehicles (SMEV) has asked for a strategy to ensure that at least 50 lakh to 1 crore good quality vehicles come on the road with front loading of incentives, backed by a mandate, and with support for initial adoption including fleet renewal based on electric vehicles.

None of these intended targets are backed by any regulatory target and mandate for a long-term policy roadmap to build confidence in the market. This also weakens the impact of the incentive-based programmes. Without a regulatory mandate the ecosystem changes in terms of infrastructure development, charging facilities, funding strategies, and product development cannot be driven at the scale and speed needed for higher levels of ambition.

Currently, the low levels of adoption of electric vehicles are attributed to low model availability, inadequate charging facilities and insufficient promotion of the new technology, apart from a skewed cost-to-benefits ratio. It is also clear that the expected scale of change requires participation of the vehicle industry to commit to targeted transformation.

Governments globally have announced aggressive electrification goals, with many nations targeting a 100 per cent electric share in the 2020–50 timeframe. These markets are increasingly adopting targeted zero-emissions vehicle (ZEV) regulations to accelerate the rate of deployment. The ZEV mandate is one such instrument that is being implemented in California and nine other US states, China and some Canadian provinces. ZEV mandates require manufacturers to sell a minimum specified number of zero-emission vehicles as a share of their overall sales in the market.

Fixing sales targets needs consultations, market feedback and consideration of demand factors. Sales targets can progressively increase to reach the government's electrification targets. Target-based regulations are needed in addition to policies supporting consumer incentives, charging infrastructure deployment, and other financial and non-financial incentives.

With an ambitious electrification target outlined by NITI Aayog, ZEV mandates and targets can ensure wider availability of electric vehicles product range, incentivize OEMs to access financial resources for technology innovation and product diversification, and also increase consumer confidence to drive the EV demand.

Incentive-based strategies that can help producers and consumers overcome cost barriers are in place but this needs to be strengthened further. Only incentive-based strategy is not adequate to stimulate investments to establish the EV programme nation-wide. Therefore, the policy design has to be a combination of regulatory targets and mandate- and incentive-based strategies.

A mandate-based strategy provides certainty and gives strong signals to the investors and industry to develop plans to achieve targets. Already the CNG programme in Delhi has demonstrated the importance of a binding mandate. The Supreme Court directive of July 1998 had asked for the entire public transport, including buses and para transit vehicles, to move to CNG within a well-defined period and accordingly the mandate for its refuelling infrastructure was defined. This stimulated CNG bus manufacturing and gave other ancillary development for a quick makeover and penetration of the new technology.

Formally defined targets can inform a roadmap to include a zero-emission vehicle production mandate combined with a credit system and an effective emission target standard that will provide a push for the production of zero emission vehicles. A credit trading mechanism could provide an incentive to manufacturers to not only build EVs to win ZEV and emission credits, but also look forward to a fresh revenue stream from banking and trading of over-compliance credits. The zero-emissions mandate and targets require advanced thinking and creative market-oriented models.

This study

The Centre for Science and Environment in collaboration with Cities Forum as a Technical Partner has initiated this study with the main objective of analysing the role of zero-emission mandates in accelerating electric vehicle demand, how this needs to be designed and its implications for the Indian vehicle industry.

This study has reviewed the current EV market and policy initiatives of the central and state governments; carried out the EV sales forecast using the discreet choice model for up to the next ten years; and conducted stakeholder consultation with the original equipment manufacturers (OEMs), retail and bus transport consumers and urban transport experts, to examine the potential application of the ZEV mandate.

The key output of this investigation is an outline of suggested mechanisms for ZEV targets and mandates and a high-level cost assessment to implement such a strategy. This has mapped out the perception of the key stakeholders, based on stakeholder's consultation and survey, with respect to adoption and implementation of ZEV mandates and demand drivers.

The scope of this study includes the following:

i. Current EV market status in India and vehicle segment-wise EV market forecast up to 2030.
ii. Consultation with OEMs to understand their thoughts and opinions on EV transition and the role of production linked zero emissions mandates and targets to drive market growth. Diverse sets of OEMs encompassing the segments of two-wheelers, three-wheelers, cars and buses. Exclusive electric vehicles OEMs and start-ups were also approached for feedback.
iii. Consultation with urban transport experts, practitioners, researchers and academicians to understand their thoughts and opinions on EV transition and the role of mandates and targets to drive market growth.
iv. Consumers consultation (including individual retail consumers and State

Transport Undertakings - STUs) to assess the demand perspective and the factors that are important for EV consumers. This task has informed EV forecasting and modelling.

v. Review of Global Use Cases on ZEV mandates and targets.
vi. Established vehicle segment-wide ZEV mandates and targets under various scenarios based on the demand forecast and consultation findings.
vii. Review and comment on the cost implication of zero-emissions mandates and targets for the industry.
viii. Actions and way forward.

Summary findings and the way forward

The specific purpose of this report is to understand the perspectives of the key stakeholders, primarily OEMs, who will be impacted by a potential ZEV mandate. This also includes the consumer perspective as ZEV mandate will also have to be supported by demand creation. In order to understand the pathways to the ZEV mandate, urban transport experts were also consulted.

As the ZEV mandate has implications for the OEMs and requires phased preparedness for ZEV manufacturing to replace ICE vehicles, a perception survey was carried out to understand the industry perspective. This initiative has reached out to a diverse set of OEMs including those i) involved with ICE manufacturing, ii) ICE and EV manufacturing, iii) only EV manufacturing and the EV startups. This consultation has tried to gauge the willingness and readiness of the OEMs.

OEM surveys have attempted to capture their views on the government's EV targets, their own plans for growth, and their perspective on ZEV mandate adoption. OEMs across various segments—two-wheeler, three-wheeler, four-wheeler and commercial vehicles—were surveyed using a structured questionnaire approach followed by an interview with the corporate strategy team. Feedback has come under the condition of anonymity. A total of 14 companies have been surveyed as part of the consultation exercise.

Also keeping in mind that for the ZEV mandate to work effectively the EV products need to meet the consumer requirements and expectations, another set of surveys was carried out with the consumers including both retail and state transport undertakings (STUs). This was done to understand the consumer behavior, factors that influence the decision to buy an EV, and price sensitivities to shift towards EVs.

To understand the consumer preferences and the factors that would influence the decision to buy an EV, a consumer survey has been undertaken using a web-based

survey tool. Samples were collected in more than 15 cities spread across India. The findings from consumer surveys have also been used in building the discrete demand choice model while modelling consumer preference to choose between an EV and an ICE vehicle. More than 3000 samples were collected as part of the consumer survey.

As the electric bus demand is being driven by STUs, consultation with STUs were also carried out. A total of 4 STUs were consulted as part of this process.

This exercise has also been supported by yet another perception survey of urban transport experts working on the urban transport and electric mobility area, to understand their opinions with respect to targets, adoption and implementation of zero emission mandates. The consultation has used a structured survey design followed by a telephonic interview process.

The key highlight of the perception survey is that EV industry stakeholders are willing to support the EV transition targets, but they are not confident about consumer demand in the near term in certain segments and want continued support until a purchase price parity is achieved.

Highlights from the stakeholder survey

Perception of two- and three-wheeler OEMs: According to the majority of two- and three-wheeler OEMs, the industry may see a growth of upto 40 per cent per annum over the next five years. A few even believe that it can be as high as 50 per cent. Most of them feel that low battery range, high charging time and inadequate charging infrastructure are inhibiting mass penetration of EVs. Close to 80 per cent of the OEMs are either considering or already setting up a charging infrastructure network. Nearly all of them have their own after sales service network. OEMs are targeting office goers, delivery companies and students as their primary customer base. Nearly all OEMs. especially the start-ups. have pointed out that financing, low demand and access to production material are among their key challenges.

The two- and three-wheeler OEMs are supportive of the ZEV mandate. Majority of them believe that such a measure can be effective in driving EV growth. However, majority are of the view that any mandate should start with upto 10 per cent target that can be gradually ramped up as the EV demand matures without subsidy.

Perception of four-wheeler OEMs: The four-wheeler manufacturers in the car segment are more conservative in their expectations about future growth. The

majority of OEMs consulted believe that the industry is unlikely to see a growth of more than 5 per cent per annum over the next 5 years. Less than 10 per cent believe that close to 10 per cent EV penetration is possible.

According to them, high upfront cost, public hesitation due to inadequate public charging, low battery range, and low level of innovation and limited models are the key inhibiters. This group is targeting office goers, cab operators, private companies and institutions as their key consumer base. They are concerned about access to adequate finance, production material and demand. The current consumers of the EV car segment are mid-segment buyers whereas the ICE car market is principally driven by entry segment buyers. This difference is likely to remain in the near term until purchase price parity and model availability across all segments improve.

Four-wheeler OEMs have stated that ZEV mandate can be somewhat effective provided demand is established to a certain extent with government financial support to meet the viability gap. However, they believe that ZEV mandate should start with no more than 5 per cent considering current level of acceptance. The mandate can be gradually ramped up as the demand for EVs gets established.

Perception of electric bus (e-bus) OEMs: Majority of e-bus OEMs believe that the industry is likely to see a growth of upto 30 per cent per annum over the next 5 years. This industry has primarily targeted state transport undertakings, and government owned companies as their consumers. For the e-bus OEMs, lack of demand is the most serious concern followed by access to finance and production material. They strongly believe that this segment will require continued support and the support cannot remain limited to only state-owned bus operators. It is necessary to target the private bus operators as their consumer base.

All e-bus manufacturers have said that a measure like ZEV mandate can be somewhat effective and it can start with no more than 5 per cent target for the manufacturers considering current level of acceptance. The mandate can gradually scale up as the demand for EVs matures among the private operators. Upfront purchase cost as well as total cost of ownership (TCO) are discouraging the private players. The policy should equally focus on state-run operators as well as private operators to stimulate demand and reduce purchase prices.

Electric bus procurement is primarily driven by the state-run transport operators. The decision to buy an electric bus is influenced by the FAME II subsidy available and the electrification mandate from the government. They have concerns that

limiting financial support to only government operators compounds the problem of lack of demand.

According to the e-bus OEMs, most government tenders are being offered on Gross Cost Contract (GCC) basis, transforming their business from an EV manufacturer to an EV operator. This is posing organizational challenges. They are looking at collaboration for operations as a near term strategy while assessing the market size. In the long run, making an informed decision to enter the operator space is something they cannot rule out.

Perception of exclusive EV only OEMs: The EV only OEMs, as the term denotes, produce only EVs. They are more optimistic about ZEV market growth. The start-ups and the EV only OEMs—that include two-wheeler and e-bus manufacturers—are not constrained by the legacy of ICE vehicles and produce 100 per cent EVs as part of their product portfolio. Nearly half of them believe that the EV industry is likely to see growth of upto 40 per cent per annum over the next 5 years. About 40 per cent of them believe that it can even be 50 per cent.

They hold lack of robust policies and incentives, high upfront costs, high charging time, low battery range, and lack of public charging responsible for slow growth. They expect strong support from the government, including state governments, to bring price parity. Majority of EV only OEMs are building capacity to set up charging infrastructure and after sales service network. Access to financing and production material, and low demand are their biggest concerns.

EV OEMs have highlighted the importance of government policies. Though effective policies have begun to take shape, more robust policy instruments to support EV penetration are needed.

Overall takeaway from the OEM consultation

These surveys and consultations with all the groups of OEMs have brought out several perspectives that can inform the policies to address the barriers to implementing a ZEV mandate. High upfront cost and lack of product options across various segments are seen as the two main challenges for a higher uptake of EVs. The OEMs are working on technology upgrades to bring down the battery cost. However, the parity is unlikely to be achieved in the car segment in the short run. Nevertheless, demand-driven measures can bring down the EV cost in two-wheeler and three-wheeler segments sooner and with TCO parity already achieved, price parity can be reached soon.

Though government policies are driving the EV growth, OEMs are of the view that more financial incentives, especially access to economic financing for consumers and financial incentives for the entire EV value chain, including supply chain, logistics etc. is important.

More than half of the OEMs are considering expanding into charging as a service business through collaboration or their own networks. Interestingly, some OEMs are also considering offering vehicles as a service platform to gain market confidence.

OEMs think that the main factor in EV sales is purchase price parity, as the consumers are more concerned about higher upfront costs. While looking at operating costs, consumers have higher sensitivity towards upfront capital costs and they greatly influence the purchase decision. Unless purchase price parity is achieved using a combination of factors including incentives and technology improvement to bring down the costs, EV sales are unlikely to be achieved as per the government targets, especially in the four-wheeler segment.

Due to this uncertainty around EV demand, OEMs cannot take a long-term market view, which is the biggest bottleneck for them.

Due to business reasons, OEMs are reluctant to share their future expansion plans. However, it seems the market is getting ready for a 10–20 per cent production increase in the next five years.

While in the two-wheeler and three-wheeler segments OEMs are planning to expand by about 30 to 40 per cent a year in a consolidated manner, they plan to double the current EV production capacity in the next five years.

OEMs are of the view that they will follow any government mandate which is launched with requisite consultation and associated measures. OEMs still believe that in the near term, government support to achieve purchase price parity can be significant in spurring demand, catalysing innovations and reducing costs.

Though most OEMs believe that financial incentives are more effective in increasing demand, the ZEV mandate, if any, should not exceed 10 per cent. OEMs have also pointed out that each state in India is publishing their respective EV policies with varying targets. If the ZEV mandate also has regional differences, there will be skewed demand-supply issues across various states. OEMs believe that the targets should be defined at the national level.

OEMs on ZEV mandate implementation

OEMs support ZEV mandates as one of the instruments to drive EV growth. However, they believe that any such measure should be voluntary as market forces will come into play to drive EV growth.

In the context of the ZEV mandate OEMs have specific suggestions and observations:

- Access to financing and financial subsidies to the consumer will be more effective than implementing mandatory ZEV mandates.
- Any ZEV mandate, if implemented, should be designed differently for different vehicle categories. In certain categories where demand is still uncertain, like electric cars, it should be placed under a waiver category. Similarly, any mandate should have a different scale based on the size of the OEM.
- The Indian EV market is not yet mature and stable enough to accept a ZEV mandate of over 10 per cent.
- The vehicle market is likely to transform from a product market to a service market with new business models like "Vehicle as a Service" to drive EV growth. The Vehicle-as-a-Service (VaaS) model allows customers to use vehicles for a variety of periods ranging from hours to days up to years, via products such as subscriptions, vehicle leasing and short- and mid-term rentals among others.
- The ZEV mandate alone would not provide the required push to the EV industry. Such a mandate should be implemented with additional funding allocated to R&D alongside the current policies. Consider schemes like price differential funding in the interim until price parity is achieved.
- two- and three-wheeler OEMs are more supportive of ZEV mandate compared to bus and car manufacturers.
- Two- and three-wheeler OEMs have noted that given the current status of sales, a ZEV mandate of up to 20 per cent may be a good starting point.
- EV OEMs have suggested that in order to boost the EV Demand, the government may consider offering free and dedicated public parking and free charging initially and incentivize zero emission freight.

Clearly, views differ across the segments—two/three-wheelers, cars, buses and pure EV players. While the ZEV mandate is being supported by the two- and three-wheeler segments, the cars and buses OEMs take a conditional view that it can work only with stronger and extended financial incentives for both consumers and industry. This requires industry-wide dialogue to build a consensus on the ZEV mandate implementation plan.

Electric bus OEMs have expressed that the government needs to implement a mandate for STUs to procure only electric buses and expand the flexibility associated with the FAME scheme to include school buses and private intra-city buses. This will drive both demand and supply.

Car OEMs would prefer a stringent emission reduction mandate supported by a voluntary ZEV mandate. This would encompass real world emission regulations for Bharat Stage VI (BS VI) vehicles, more stringent BS VII and much tighter fuel economy standards to drive the technology pathways.

Two-wheeler OEMs are generally in agreement with the ZEV mandate. However, they are not ready for any mandate of more than 20 per cent.

Three-wheeler OEMs are of the view that with improvement in charging infrastructure and battery swapping, their industry can make quicker transition to becoming fully electric in urban areas. But they are concerned about the power availability for mass adoption.

The general industry view is that any mandate should be implemented in a phased manner, and it needs to be voluntary. The government needs to assess its feasibility and initiate an industry-wide dialogue to deliberate on modalities associated with it, including credit schemes, credit transfer policies and regulations for pure-play EV OEMs to sell their credits.

The mandate for two- and three-wheeler segments can be prioritized for higher level of ambition and readiness action can be initiated to introduce a mandate for four-wheelers in a phased manner. The scale-up can be done based on this experience, the way it is being globally.

Perspective of EV consumers: Retail individual consumers and state transport corporations

The consultation with the consumer segments has given an important insight. The potential EV consumers have been segmented based on their plan to buy an EV in the next 2–3 years. The majority of these consumers fall in the age group of 25–34, followed by 35–44.

Average commuting distance to work for potential EV consumers is largely in the range of 5–15 km. Due to range anxiety associated with EVs, consumers with more than 15 km of commuting distance have low preference for EVs.

Potential EV consumers use public transport sometimes during a week or a month and are not regular public transport users. This shows that public transport users are still willing to continue with public transport modes rather than shifting to EV.

Commuters who use ride-sharing options are more likely to buy an EV than those who use public transport.

The majority of commuters willing to buy an electric vehicle already own ICE vehicles. The average age of their ICE vehicle is more than five years. The age of the existing vehicle influences the choice to buy an EV. It is important to do an age profiling of different vehicle categories to refine the EV forecast.

Almost 25 per cent of the potential EV buyers have shown willingness to buy with the current FAME subsidy structure. If the FAME subsidy was to double, then almost half of them would be willing to buy an EV. If EV models are available at the same price of an equivalent ICE, consumers will willingly shift to EVs.

More than 70 per cent of respondents in the two-wheeler segment are willing to consider an E-2-wheeler (E2W) for their next purchase choice.

Consumers expect that the battery efficiency on a single charge will be the same as the range given by ICE vehicles.

Majority of consumers are not satisfied with the product range available in the market. They expect a diverse range of products to choose from like the ICE vehicles categories.

Primary consumer concern is purchase price parity rather than TCO parity, as high upfront cost is a bigger concern.

Consumers are also concerned about the resale value of EV due to lack of clarity on battery replacement costs and spare part availability as the technology is changing very fast.

Perspective of state transport undertakings

The bus-based public transport system in Indian cities is primarily based on internal combustion engine buses, but STUs are gradually transitioning from ICE to electric buses to reduce carbon emissions.

The success of e-bus adoption will depend on several factors. The government needs to focus on capacity building measures so that STU officials have clarity regarding technology and procurement. Efforts are being made in this direction. Unless purchase price parity is achieved, the uptake shall be driven only by policy regulations rather than voluntary choice.

Towards ambitious fleet electrification target and ZEV mandate

If India has to meet the pledge of 100 per cent electrification (with focus on two- and three-wheelers) in the time frame of 2030–40, transformative change is needed by 2030. It is necessary to set regulatory targets to provide long-term policy vision to the vehicle industry and bring more certainty in the market.

NITI Aayog has outlined an EV sales penetration target of 70 per cent for commercial cars, 30 per cent for private cars, 40 per cent for buses, and 80 per cent each for two- and three-wheelers by 2030. In contrast, several ministerial announcements in the past have aimed for 30 per cent electrification by 2030. Moreover, the voluntary target of Society for Indian Automobile Manufacturers (SIAM) also borders on 40 per cent.

It is evident that the overall new vehicle sales are approximately 10 per cent of the total vehicle population and this sale's penetration target needs to be increased on year-on-year basis to move in the direction of full electrification.

With the continuation of government policies on EV incentives, setting up local supply chains, lower battery prices, availability of EVs across various price point categories and widespread charging infrastructure, the market can move from the realistic scenario to the optimistic scenario. While the realistic scenario is based on the expectations of the industry, the optimistic scenario is based on high levels of expectation as expressed by various stakeholders.

Several strategies will have to be strengthened including demand incentives, production linked mandates, product availability, battery technology improvement and management, charging infrastructure, among others, to contribute towards building scale. It is necessary to balance the scales and focus equally on all vehicle segments given their large numbers and the population they cater to.

With the government's increased focus on electrification of public transport and wider adoption of electric vehicles in the two- and three-wheeler market, the possibility of realizing the optimistic scenario is high if a wider set of policies along

with the financial incentives with some variability remain consistent over the next ten years. This also requires removal of the charging infrastructure bottleneck and effective reduction in total cost of ownership.

While several policy measures are taking shape, the ZEV target and production mandate for the industry have not yet been considered in India. Adopting the ZEV mandate binds OEMs to produce a certain percentage of their production as electric vehicles. This is needed to enable supply side push, stimulate innovation for a wider EV product range and reduce price parity gaps. Empirical research findings show that the ZEV mandate has a positive impact on increasing investment in research and development, forming partnerships for more product innovations, and thus it leads to a substantial increase in filing electric vehicle related patents. While this ensures steady shift from ICE production to EV production for mainstream producers, the OEMs producing only EVs also increase their market share, and the new investments of the conventional ICE vehicle OEMs are further directed towards EV-only production base.

As global and particularly California's experience shows, a regulatory target can be given to the vehicle industry to produce a minimum share of electric vehicles per year as part of their overall production. This industry-wide target is further disaggregated for each vehicle manufacturer depending on their product portfolio and production history and is further linked to their overall emission performance. This scheme allows trading of emission credits between those who overachieve their targets and those who underachieve. This nonetheless requires a minimum production target.

The ZEV mandate needs to be implemented in a phased manner from 2025 to 2030 in India. The government needs to initiate a dialogue with the industry and start the consultation process to arrive at a consensus to implement this program. Experts believes that the ZEV scheme can encourage OEMs to collaborate with financial institutions to support potential consumers with EV purchases. This can lead to more innovation and launch of products with multiple price points. New business models can come up, like vehicle as a service, to address the uncertainties and inhibition of the consumers.

Almost all experts interviewed are in favour of implementing ZEV mandates, with nearly 70 per cent of them feeling that this can be an effective tool to drive domestic innovation in the EV ecosystem and provide wide choice to consumers. However, experts have also cautioned that such a mandate should instill confidence in OEMs with continued support and subsidies for consumers and ease of financing EVs.

This study has tried to explore the possible minimum target for ZEV mandate up to the year 2030 based on the EV demand forecast and feedback from OEMs and urban transport experts. This should be implemented in a phased manner from 2025 to 2030 with a gradual increment.

The consultation with the vehicle industry has attempted to know what the industry feels about the potential market penetration of EVs by 2030 with present incentive mechanisms and policy interventions at the central and state levels. It is evident that the industry is expecting far lesser EV penetration in each vehicle category compared to the NITI Aayog's aspirational target and also the 30@30 target that has been expressed at the policy level from time to time.

The industry expects around 20 to 30 per cent market penetration for two-wheelers, 40 to 50 per cent for three-wheelers, 10 per cent for cars (including both commercial and private segment) and 20 to 30 per cent for buses in the next five years. The prominent ICE manufacturers, except a few, are still very conservative.

Since 2019, when FAME II implementation started, the growth rate of two-wheelers, cars and buses, has lagged behind with some variation. Only the three-wheeler segment has seen continuous double-digit penetration but largely due to e-rickshaws and e-carts. In 2021, three-wheelers and buses had a penetration rate of 42 and 11 per cent respectively, but this was also because of a reduction in the overall sales due to the pandemic.

Clearly, there is a need for the additional instrument of ZEV mandate for annual production as one of the key policy levers to drive the ICE industry to transition towards electrification. Only this can diversify the market and product range and stimulate growth.

This is challenging as presently ICE vehicles completely dominate the vehicle production and sales. As much as 98 per cent of the total sales of two-wheelers; 59 per cent of three-wheelers; nearly 100 per cent of cars and 90 per cent of buses are ICE vehicles (as per annual registration data of 2021). Although in the two- and three-wheeler segments, new start-ups and OEMs with 100 per cent EV production lines have entered the EV market, their overall volume is still very small. The conventional ICE OEMs have to transform their production base and enter the market in a big way to achieve scale.

Two possible scenarios have emerged from the industry consultation. If the industry's specific observations on the intended mandate are considered, industry

would prefer a lower bound target for production that can be implemented in a phased manner from 2025 to 2030. This minimum industry intended scenario that can be derived from the OEM consultation is outlined as 25 per cent target for two-wheelers, 50 per cent for three-wheelers, 5 per cent for four-wheelers and 15 per cent for buses by 2030.

This adds up to about 23 per cent electrification of the overall fleet against the minimal policy target of 30@30 target (considering only 2Ws, 3Ws, cars and buses, but not trucks and bigger commercial vehicles).

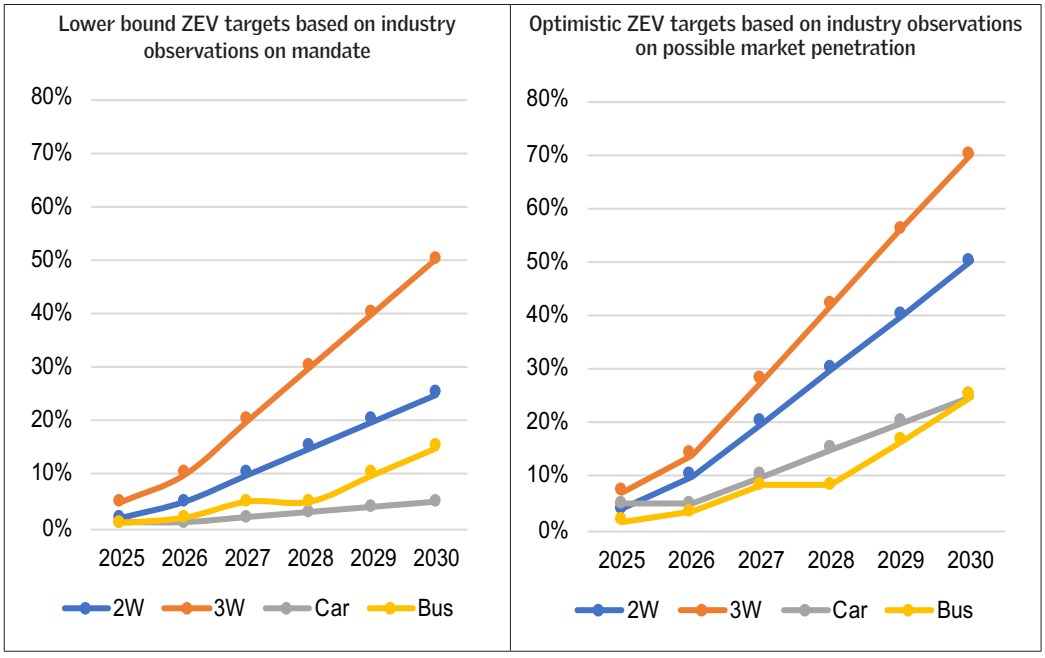
However, it is also possible to create a more optimistic scenario for the mandate from what the OEMs have said about the potential EV penetration in different vehicle segments over the next few years. This would be 50 per cent for two-wheelers, 70 per cent for three-wheelers, 25 per cent for four-wheelers, and 25 per cent for buses. If implemented, this can add up to achieve at least 47 per cent EV penetration across these categories by 2030.

This is still much less than the intended vehicle electrification target set by NITI Aayog that aims for combined EV market penetration of about 76 per cent.

Table 1: Possible lower bound and more optimistic ZEV mandate scenarios derived from the OEM consultation

Years	Industry recommended ZEV target				Optimistic ZEV target			
	2W	3W	Car	Bus	2W	3W	Car	Bus
2025	2%	5%	1%	1%	4%	7%	5%	1.7%
2026	5%	10%	1%	2%	10%	14%	5%	3.3%
2027	10%	20%	2%	5%	20%	28%	10%	8.3%
2028	15%	30%	3%	5%	30%	42%	15%	8.3%
2029	20%	40%	4%	10%	40%	56%	20%	16.7%
2030	25%	50%	5%	15%	50%	70%	25%	25%

Graph 1: Visualization of phased introduction of lower bound and optimistic ZEV mandate scenarios



Designing a ZEV mandate

Production linked ZEV mandate is proposed to be implemented from 2025 with the key terms defined. This can help achieve a more ambitious target and cost parity with ICE vehicles by 2030–32. This will require an industry-wide dialogue to build consensus amongst stakeholders.

It is necessary to notify a ZEV mandate scheme. There are several elements that will require attention while notifying the ZEV mandate in India. Some of these are as follows.

ZEV coverage: ZEV mandate needs to be implemented in a phased manner and it can start with an acceptable number that the OEMs can begin with and gradually ramp up as the demand picks up. This needs to primarily focus on battery electric vehicles and fuel cell electric vehicles while plug-in hybrid vehicles and strong hybrid electric vehicles can be eligible with lower credit points.

OEMs grading: OEMs need to be graded across the vehicle segments annually. Illustratively, this may include large volume OEMs or top five OEMs by sales volume in respective vehicles categories; mid-volume OEMs including sixth to tenth highest sales in the respective vehicles categories, and small volume OEMs that can include all others. Sales volume for a year may be calculated as annual

domestic sales volume in the previous year. Very small-volume manufacturers can be exempted from the mandate.

ZEV credit scheme: Each of the OEMs meeting the ZEV threshold criteria can earn credits based on the estimated savings on emissions. Saving calculations need to be standardized through a transparent tool. Higher the emissions saved, higher would be the credit allocated.

Each of the OEMs need to meet a minimum credit score each year. Minimum credit score shall be defined for each of the large and mid-volume OEMs. OEMs not meeting the threshold credit targets could be penalized as per predefined criteria.

Credit valuation mechanism: Each credit will have a monetary value and OEMs can trade such credits to get government financial support. Credit for battery electric vehicles or fuel cell electric vehicles can be higher than the plug-in hybrid vehicle and strong hybrids. The government financial support can be available only to OEMs meeting threshold ZEV target and threshold ZEV credit.

Credit transfer scheme: Credit can be transferred and traded in a free market environment.

Strengthen strategies to support ZEV mandate: Current EV-related policies are unlikely to drive EV demand to the extent of meeting the government targets for EV sales penetration. It is proposed that Indian policy makers consider adopting multiple measures that can be grouped across the following three areas:

- Strengthen demand focused policy package (FAME scheme) to expand its size, coverage and timeline.
- Consider implementing ZEV mandates as a supply focused policy package.
- Consider implementing an exclusive policy package to support the EV supply chain and associated ecosystem.

The coverage of this research is limited to assessment of implementing ZEV mandates and the following can be the key heads of terms to implement ZEV mandate.

The ZEV mandate will require several preparatory approaches:

- Level of ZEV targets to be adopted and mode of implementation including voluntary (as in Europe) or mandatory (as in the USA)
- Feasibility in terms of cost and benefits associated with implementation of ZEV mandates

- Deliberation on ZEV certificates and how such certificates can be allocated and used
- Discussion on modalities for banking, borrowing and transfer of ZEV certificates
- Exemptions based on manufacturing capacity and vehicle types can be proposed as per global practices. Small manufacturers (<4,500 vehicles per year in the US) are generally exempt from the mandate due to their reduced ability to decarbonize. Moreover, certain types of specially built vehicles can also be exempted given their small numbers.
- How to regulate the non-ZEV portion of the fleet, i.e., carbon reduction targets for the non-ZEV fleet.

Potential impact of ZEV mandates on the industry

The implementation of ZEV mandates will require OEMs to scale up from just a few thousand EVs to a much larger production base. The ICE vehicle OEMs would need to adjust their business process to expand EV production capacities either within the existing ICE manufacturing plants or through greenfield projects, and make related changes that affect vehicle design, factory architecture and assembly line processes.

EV production will be very different from ICE production. EVs have battery packs and no fuel tank; there is no intake or exhaust; and these typically have no conventional transmission. EV motors have very few moving parts; they do not require engine oil or transmission fluid. EVs need no exhaust systems, alternators, fuel injectors or starters. All of these familiar ICE vehicle components will be entirely absent from EV production lines. With fewer parts in an EV, compared to its ICE counterpart, the assembly process will be simplified. Fewer parts also mean lower labor costs.

These differences affect not only the assembly procedures and factory footprint but also change the preferred supply arrangements. For example, whereas an IC engine plant could supply multiple vehicle plants, battery packs may be too large and too heavily integrated into the chassis for this to be practical.

Producing EVs in manufacturing facilities that used to make ICE vehicles will require the reworking of entire assembly processes. This is largely due to the major design and construction differences between EVs and ICE vehicles. While some "brownfield" factories will mix EV and ICE production (at least for a while as per OEM perception survey), there will also be "greenfield" factories built from the ground up to manufacture EVs.

Further, with ZEV mandates in place, OEMs need to ensure that the product mix meets consumer demand, which is liable to change unpredictably, responding to developments in EV range, battery costs, government legislation and purchase incentives.

The integration of EV production into existing assembly sites can also present challenges. Most manufacturers are trying to retain common facilities such as paint or body shops to minimize capital spending. With such requirements, the industry is seeking a 'zero loss' modular manufacturing solution. A line can be re-tooled and re-modelled for a change without any loss of production and expensive cost implication.

The most important decision that OEMs need to make is to invest in a greenfield site for EV manufacture or to convert an existing ICE manufacturing plant into an EV plant.

Greenfield sites allow greater scope for optimization with fewer constraints, which is especially important for the logistics of parts supplied into the plant when, for example, hybrids, battery EVs and ICE vehicles are assembled in the same facility. However, they require a significant investment in new plants and infrastructure and present the challenge of relocating key suppliers and skilled workers.

With brownfield sites, the situation is reversed. Much of the legacy investment in facilities can be retained, provided any compromise to assembly efficiency is minimized. Existing suppliers and labour skills are already available in the immediate vicinity, assuming they remain relevant to the powertrain technologies employed.

To meet growing EV demand and to further meet the required ZEV mandates, OEMs must redesign how they develop new products, recalibrate their business processes for continuous transformation with technology advancement, and reskill their workforces for new technologies.

The integration of EV production with existing assembly sites can also present challenges. Most manufacturers are trying to retain common facilities such as paint or body shop to minimize capital spending, so optimizing the integration is very important. Otherwise, the all-important scale-up won't be achieved.

During the transition from internal combustion engines and until the technology matures, costs come down, and volumes reach the scale needed to make EVs profitable, the transition strategy from ICE to EV can follow multiple paths either through in-house investments or through partnerships and collaboration.

Operationally, OEMs need to decide how to convert their production facilities from ICE to EV manufacturing. The selected strategy will affect the ease with which companies can flexibly swing output to meet changes in demand between ICE and electric propulsion in future.

While many parts are shared between ICE and EV vehicles, EVs have less parts, so in fact, the likely long-term outcome from a move to EV manufacture is to free up space within a brownfield site. However, EV components are generally big and heavy, such as motors and batteries, so storage and transportation will need to be ready for this change.

As batteries are integral parts of EVs, battery packs are assembled on-site or very close to the manufacturing facilities. Further, with a wide variety of product range expectations, the battery pack needs to be customized for each type of vehicle. With such a requirement, the trend toward batteries being built up close to the manufacturing line will continue.

Repurposing to convert ICE assembly line to EV: As part of this transition, the company needs to undertake detailed comparative analysis between ICE and e-motor component manufacturing processes and identify certain ICE machinery, equipment and facilities with obvious potential for EV motor related repurposing.

A three-step methodology has to be followed to develop this repurposing strategy —Analysis of ICE Bill of Process (BOP); Analysis of EV BOP;
Comparison of ICE BOP and EV BOP with respect to EV Production.

This can be broadly categorized as re-use with minimal re-tooling: i) Those pieces of equipment that are flexible enough to accommodate major component changes easily, ex. robots/CNC machines; ii) Equipment which have re-use potential, but whose feasibility needs to be established, ex. test equipment and iii) ICE specific major re-tooling of equipment that would require modification to the fundamental base machine, ex. honing machines, etc.

The cost to convert ICE manufacturing to EV manufacturing depends on how well-equipped OEMs are. For most OEMs, it is a cost of a few fixtures as engines or electric motors are fitted manually. In production, the engines are sub-assembled on fixtures and then wheeled to the line for fitment into the vehicles. These fixtures need to be changed and are relatively cost effective. So, the answer is that there is some cost but it is not hugely significant. Only if it is a robotic line does this cost become significant.

This study has estimated a high-level broad cost that OEMs may incur to remodel their ICE facility to a purpose-built facility to produce EVs. The cost for greenfield expansion has been kept outside the scope of this study as that is generally part of a company's long-term investment strategy. This is only an indicative costing.

Cost to implement ZEV mandate

To implement the ZEV mandate and target for fleet electrification, the most obvious question is related to what will it cost the OEMs to shift from ICE to EVs as part of the mandate requirements; what will it cost the government to continue to provide incentive support to the consumers to build demand; and what will it cost to build the requisite charging infrastructure that is a precondition for stimulating consumer demand.

While there are a host of other costs associated with the transition, these are the most basic that need to be understood as these also have implications for the funding strategy.

Therefore, this study has estimated some high-level broad costs to implement the ZEV mandate based on certain assumptions and considerations. These are indicative and not absolute.

All the costs have been calculated considering two distinct scenarios, i.e., ZEV target derived from the specific observations of the industry on the setting of the mandate, and, optimistic ZEV target scenario derived from the best-case expectations of the industry with respect to potential EV penetration within a timeframe of 2025–30 (assuming ZEV mandate shall be implemented from 2025 onwards).

It may be noted that the NITI Aayog and Rocky Mountain Institute (RMI) India report of March 2021 'Mobilising Electric Vehicle Financing in India', has analysed that the transition will require a cumulative capital investment of USD 266 billion (Rs 19.7 lakh crore) in EVs, charging infrastructure and batteries over the next decade. It has further identified a market size of USD 50 billion (Rs 3.7 lakh crore) for the financing of EVs in 2030—about 80 per cent of the current size of India's retail vehicle finance industry, worth USD 60 billion (Rs 4.5 lakh crore) today.

Unlike the NITI Aayog study which has estimated an overall EV transition cost of Rs 19.7 lakh crore (USD 266 billion) between 2020–30 (that includes several aspects of implementation), this study has mainly focused on segment-wise OEM costs. This has been estimated by taking into consideration only ICE OEMs who

are expected to remodel their existing ICE factory to produce EVs. Assuming ICE OEMs will produce 25 per cent of their total EV production in their existing ICE factory, that will involve the cost of remodeling the units (cumulative number of units in between 2025–30) along with R&D cost, which would come to around Rs 2,000 to 5,500 crores (USD 0.27 to 0.73 billion), depending on the targeted scenarios.

The cost estimates have considered the fact that ZEV mandate will be implemented from the year 2025 to 2030 with separate ZEV targets for each vehicle category. It has also been derived from the feedback from OEMs that price parity will be achieved gradually over the next ten years.

It is assumed that OEMs shall have a mixed greenfield and brownfield strategy to expand their EV production capacity. Re-modelling cost for existing ICE facility to EV facility shall be lower for e-buses where limited fixtures need to be changed. The cost shall be relatively higher for two-wheelers, three-wheelers and e-cars where automation of engine mounting needs to be changed. The cost has been based on feedback from OEMs. R&D cost has been estimated based on 0.5 per cent of the cumulative total sales value of EVs in between 2025–30 without subsidy.

For successful implementation of the ZEV target and continued incentives for the program, two scenarios have been anticipated. The existing FAME II subsidy continues with the same amount of incentive to cover the same number of vehicles in the next phase i.e., 10 lakh two-wheelers, 5 lakh three-wheelers, 55,000 cars and 7,000 buses. But to support the optimistic scenario for the mandate that has been outlined above, it is assumed that FAME coverage in terms of number of vehicles will double across all vehicle categories. Thus, the government will require to spend an additional 6,800 to 13,600 crores (USD 0.9–1.8 billion) as subsidy, depending upon the scenario, in between 2025–30. This incentive along with lowering the cost of EV with scale shall improve the price parity for consumers.

As the charging infrastructure is critical for stimulating demand and to support ZEV mandate, an additional estimation has been done by applying the criteria developed by the Ministry of Housing and Urban Affairs (MoHUA) related to the slow and fast charger points required in different vehicle segments in relation to their total numbers. This is only to get an indicative estimate. Without an adequate charging network, it is difficult to build demand and to achieve the EV transition target. Application of this criteria shows that charging infrastructures in India, as per the MoHUA criteria, requires approximately Rs 18,000 to 70,000 crore (USD 2.4 to 9.3 billion) by 2030. For reference it may also be noted that a recent ICRA

Study[12] has estimated that Indian cities need 48,000 chargers by 2025 with an estimated cost of Rs 14,000 crores (i.e., USD 1.9 billion).

India needs to adopt production-linked ZEV mandate for the vehicle industry as a critical instrument to build the EV market. To build industry confidence, support for demand creation will be critical.

For successful implementation of the ZEV targets and mandate, it is necessary to promote a strong funding strategy. The 2021 NITI Aayog Report has stated that incentives are a critical first-order solution and re-engineering vehicle finance and mobilizing public and private capital will be critical to accelerating the deployment of 50 million EVs that could be plying on India's roads by 2030.

Therefore, the solutions require the inclusion of financial instruments such as priority-sector lending and interest-rate subvention, creating better partnerships between OEMs and financial institutions by providing product guarantees and warranties, and a developed and formal secondary market to improve the resale value of EVs and improve their bankability. This requires innovative financing models. However, the report has focused mainly on demand drivers and has not elaborated much on the supply side measures such as ZEV mandates.

Public-private partnerships (PPPs) should be encouraged while transitioning to EVs. While the consumer purchase subsidy can be procured through public funding, charging infrastructure, industry readiness with EV manufacturing, R&D and public awareness can be taken up by the private sector or multiple combinations of those can be deliberated upon. India has had successful experiences in public-private collaborations in various sectors and these are very effective in leveraging government funding. A similar approach can be considered to leverage the public rsources to promote ZEVs.

Globally, there are many examples of using the PPP approach to implement ZEV programs. Germany's ZEV purchase incentives from a total pool of €600 million in public funding are matched with €600 million from the OEMs. In the United Kingdom, £400 million have been committed to ZEV infrastructure wherein £200 million is contributed through government investment with a £200 million match by the private sector.

In California, while consumer purchase subsidy is funded by public coffers, the government adopted a PPP approach for ZEV consumer outreach. The state has incorporated a not for profit and tasked it with consumer awareness,

understanding, and consideration of electric vehicles. The not for profit is funded primarily through memberships and sponsors, which include the government and industry.

Consumer incentives are critical to address the price differentials between ICE and EV and improve market acceptance. In many markets, purchase incentives represent a major share of government outlays among the various government ZEV support programs.

Technological advancements and battery pack cost reductions allow for reducing fiscal support for electric vehicles over time. As cost parity between electric and conventional vehicles becomes a reality over time, governments can phase down their incentive programs to match reductions in electric vehicle costs. This is the main consideration while developing the cost model for ZEV transition.

ZEV mandates can be further enabled by driving demand through other means at the city level. This may include designation of low emission vehicles zones, preferential or discounted electricity rate structures for charging ZEV, reduced toll tax for ZEV, preferential and complimentary parking access for ZEV in public parking areas, among others. In fact, several state level policies have included some of these strategies that require stringent implementation.

PART 2: Detailed study

Section 1: Trends in motorization and electric vehicle sales

Motorization rate and vehicle ownership

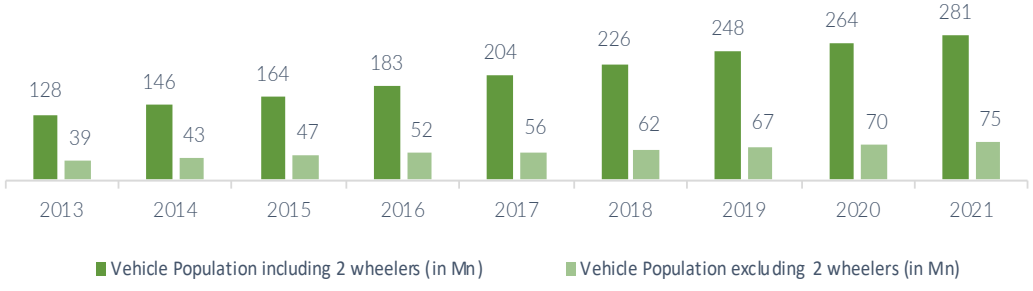
It is important to review the motorization rate as this will form the basis for the EV forecast. Currently, the transport sector is responsible for over 10 per cent of the total GHG emissions in the country. Emissions inventory and source apportionment studies in cities also show that vehicles are substantial contributors to health-threatening local air pollution.

Urbanization and growing vehicle ownership are enhancing this risk. While the share of urban population increased from an estimated 31.1 per cent in 2011 to 35.4 per cent in 2021, there were 28.1 crore vehicles in India as of 2021 (see *Graph 2: Level of motorization in 2021*).

Two-wheelers account for more than 75 per cent of the vehicles registered in India, representing the second-largest market globally for two-wheelers, second only to China. The average annual growth rate from 2013 to 2021 was approximately 10.3 per cent per annum.

With rising income and rapid urbanization, the Indian mobility market is expected to expand more rapidly. This is an opportunity to adopt strategies to rapidly decarbonize the new vehicle fleet.

Graph 2: Level of motorization in 2021

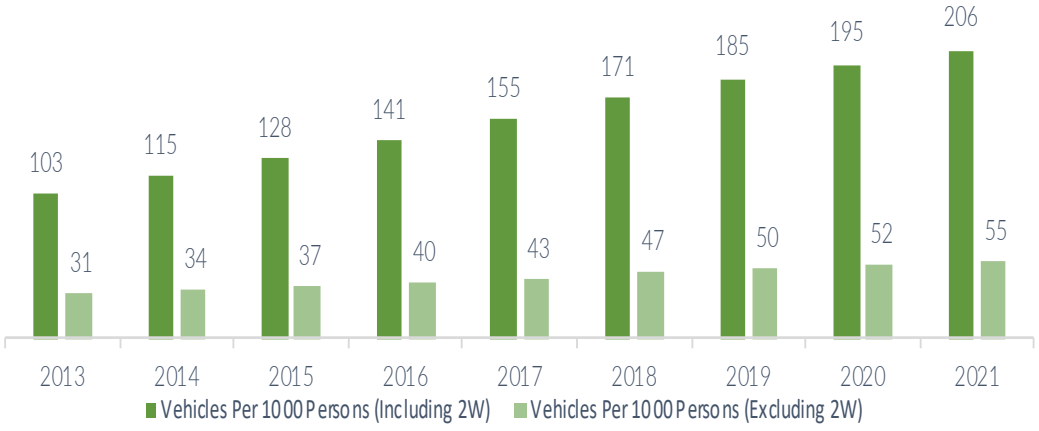


Source: Cities Forum

The rate of growth of motorization (vehicle per 1,000 population) was 9 per cent per annum during the period from 2013 to 2021 (see *Graph 3: Vehicle per 1,000 population in India*).

The car ownership rate in India is still low (approximately 22 cars per 1,000 people) compared to the global north. But ownership rates for two-wheelers are among the highest in the world. In India, the total registered vehicles per 1,000 population stood at 206 with two-wheelers and a substantially lower 55 per 1,000 persons without two-wheelers. But this is a sharp rise from about 30.5 in 2013. If two-wheeler ownership is considered. the quantum of personal motorization is quite high.

Graph 3: Vehicle per 1,000 population in India



Source: Cities Forum

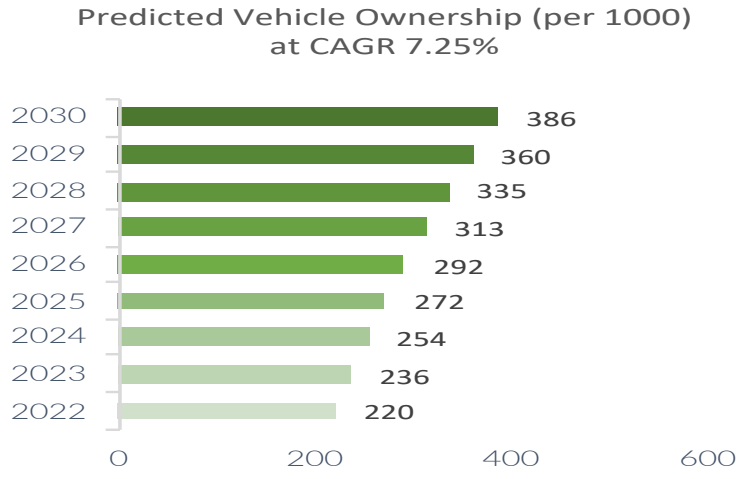
Vehicle ownership rate forecast

The vehicle ownership rate in the year 2021 was 206 vehicles per 1,000 population. The growth rate from the year 2013 to 2021 was 7.25 per cent per annum (excluding two-wheeler growth) and 9.05 per cent (including two-wheeler). The growth trend shows that the rate of growth is also increasing on a year-to-year basis.

If the government's huge investment in the public transport sector gives the intended benefit, then the rate of growth of vehicle ownership shall be 7.25 per cent over the next decade.

The forecasted vehicle ownership rate for the year 2025 was predicted to be 272 vehicles per 1,000 population; this would be close to the world average rate of 255 vehicles per 1,000 population. Further, this figure is forecasted to increase to 386 vehicles per 1,000 population in 2030 (see *Graph 4: Forecast of vehicle ownership rate*). This number is still far less than the US vehicle ownership rate which is currently at 849 vehicles per 1,000 population. The details of the motorization trend in India are provided in Annexure 1.

Graph 3: Forecast of vehicle ownership rate



Source: Cities Forum

EV market status and status of EV transition

EV fleets are expanding at a fast pace in several of the world's largest vehicle markets. In India, EV sales have historically grown slowly. From a mere 3,065 EVs sold in 2013 to 328,126 in 2021, the sales have grown more rapidly since the introduction of the EV incentive schemes.

However, in terms of total volume, EVs still form about 1.95 per cent of the total vehicles registered in 2021 in India, while forming only 0.37 per cent of the total vehicle stock in the country.

Category-wise EV status: In India, two-wheelers dominate EV sales, given their economic viability, both in terms of total cost of ownership (TCO) parity and ecosystem development. This is similar to China's experience where electric bikes and scooters laid the foundation for the EV market.

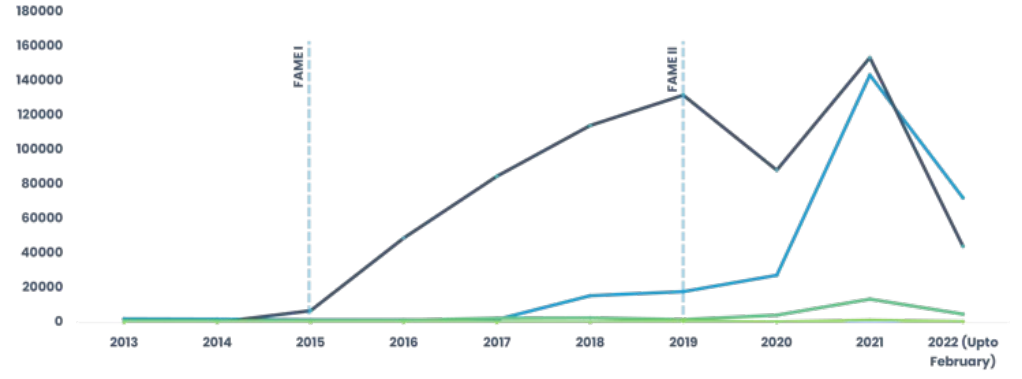
The penetration of EVs in the four-wheeler segment has remained extremely low at 0.1 per cent. Several gaps exist in the four-wheeler EV ecosystem, such as a limited number of products, high prices and TCO disparity, insufficient battery efficiency given the functional requirements, low performance, unclear after-sales service and secondhand sales market and an underdeveloped charging ecosystem.

Given these impediments, the growth of EV four-wheelers is expected to be slow over the next few years. Sales will pick up if the existing gaps are addressed (see *Graph 5: Vehicle category-wise EV sales in India*).

Despite several government incentives, the bus segment is yet to build scale. This is because government-run state transport undertaking (STUs) lack preparedness for EV transition. They require charging infrastructure and depot redevelopment. But with revenues falling short of the current operating costs, STUs are reluctant to speed up EV transition unless a strong incentive mechanism from the government is available

There is also a regional difference in e-vehicle segmentation. While Uttar Pradesh and Bihar lead in the three-wheeler segments, Delhi, Maharashtra and Karnataka are seeing traction in two-wheeler and four-wheeler segments. Detailed electric vehicle segment-wise analysis are in Annexure 2.

Graph 5: Vehicle category-wise EV sales in India



Sales (FY 2019-20)	152,000 (0.9%)	90,000 (14.1%)	3,400 (0.12%)	600 (0.08%)
Sales (FY 2018-19)	126,000 (0.6%)	100,000 (14.3%)	3,600 (0.11%)	400 (0.04%)

Source: Cities Forum

EV forecasting approach

With such a low base, calculating the growth rate and forecast based on historic sales is not relevant. Thus, a discreet choice model has been developed for EV sales forecast. Discrete choice models explain or predict a choice from a set of two or more discrete alternatives to meet the same purpose. Discrete choice models operate within a framework of rational choice; that means, people choose the option of maximal benefit or utility. This has been detailed out in a subsequent section.

SECTION 2: Review of EV-related policies in India

Several policy measures are taking shape that have bearing on the EV trajectory. As noted earlier, in the 2021 United Nations Climate Change Conference proceedings, India has pledged to reduce carbon intensity of the economy by 45 per cent and cut its total projected carbon emission by one billion tonnes by 2030, and become net zero by 2070.

As part of the Nationally Determined Contribution (NDC), initially there was no target set for the transport sector, despite it being India's fastest-growing source of carbon emissions. On 27 August 2020, NITI Aayog launched Nationally Determined Contributions (NDC) – Transport Initiative for Asia (TIA) India Component. The NDC-TIA program, a part of the larger International Climate Initiative, over four years, aims to enable the partner countries (China, India and Vietnam) to achieve their long-term targets by focusing on small-scale sectoral contributions. The platform established a multi-sectoral dialogue platform for decarbonizing the transportation sector in India with a significant focus on electric mobility.

While the central government has rolled out the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) policy, various state governments have published their respective EV policies and introduced several EV promotion-specific measures that include demand side and the supply side measures.

The Department of Heavy Industry, in 2012, had introduced National Electric Mobility Mission Plan (NEMMP) to encourage faster adoption of electric vehicles across the country. Under this initiative, the government envisaged nearly 60 to 70 lakh electric vehicles on roads by 2020. However, there were only 6 lakh EVs on the road as of 2021, and the reality is far from the target.

The government of India introduced the 'Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME)' scheme I, initially in the year 2015 with a running period of two years. Later, in 2019, this was extended as FAME II.

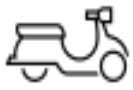
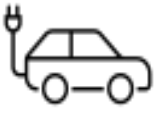
According to the study by NITI Aayog in 2020[9], the share of EV sales is projected to be 80 per cent for the two- and three-wheeler segment, 50 per cent for the four-wheeler segment, and 40 per cent for buses by 2030. However, to achieve this possibility, the market needs a CAGR of 91 per cent for two-wheelers, 41 per cent for three-wheelers, 92 per cent for four-wheelers, and 98 per cent for buses. For the market to grow at this pace, extensive and radical measures are needed.

The EV30@30 campaign has been launched in the clean energy ministerial (CEM) congress that sets an ambitious target for electric vehicle sales that, combined with the decarbonization of the power sector, will keep the world on track to meet our shared climate goals for 2050, while improving the quality of life for urban residents.

The EV30@30 campaign redefines the ambition of the CEM's Electric Vehicles Initiative (EVI), setting the objective to reach a 30 per cent sales share for EVs by 2030. This will be the benchmark against which progress achieved by all members of the EVI will be measured (i.e., total electric vehicle sales in all EVI countries / total vehicle sales in all EVI countries) and can be met through targets that differ across modes and jurisdictions. This intended target of EV30@30 is however not a regulatory target.

FAME II targets to phase in 10 lakh electric two-wheelers, 5 lakh electric three-wheelers, 55,000 electric cars and 7,090 electric buses with support of subsidies. However, the sale of electric vehicles in 2021 is far less than the target (see *Table 2: Sale of electric vehicles in 2021 falls short of target*).

Table 2: Sale of electric vehicles in 2021 falls short of target

				
Target	10 Lakhs	5 Lakhs	55,000	7,090
Sales (2021)	1.19 Lakhs	20,420	580	861

The low level of EV sales, despite the subsidies, shows that several challenges and gaps exist in the EV ecosystem and policies must address those to drive innovation and technology advancements and build scale.

It is evident that only an incentive-based strategy is not adequate to attain the ambition. This needs to be backed by the zero-emissions mandate and targets that demand advanced thinking and creative market-oriented models.

State-level EV policies: Several state governments have published state-level EV promotion policies. In several states these are primarily focused on supply-side

incentives to attract investment in the EV sector. The combination of demand incentives from the central FAME-II schemes and supply-side state measures is likely to bring down the upfront cost differential substantially for EVs if both industry and consumers take the maximum benefit out of this. The details of incentives and other EV targets in state Policies are presented in Annexure 3.

Table 3: Summary of state-level EV targets

State	EV related targets
Delhi (Electric Vehicle Policy, 2020-22)	25% of new vehicles to be electric by 2024. Delivery service providers to go 100% electric by 2025. 1000 e-buses by 2020.
Andhra Pradesh (Electric Mobility Policy 2018-23)	100% electrification of the state bus fleet by 2029. Phasing out of all ICE-based commercial fleets and logistic vehicles by 2030.
Uttar Pradesh (UP EV Manufacturing and Mobility Policy 2019-24)	1 million EVs by 2024. 2 lakh EV charging stations and swapping stations by 2024. 5 GWh storage manufacturing by 2024. 1000 e-buses by 2030
Karnataka (Electric Vehicle and Energy Storage Policy 2017-25):	100% fleet and commercial electric mobility in Bangalore by 2030. Fast Charging/battery-swapping station at every 50 km on highways.
Maharashtra (Electric Vehicle Policy 2021-25)	Increase the share of EVs to 10% among new vehicles by 2025. 25% of the urban fleet operated by aggregators/operators to transition to EVs by 2025. 25% electrification of public transport in 6 urban agglomerations by 2025. Starting 1 April 2022, all govt/semi govt/ULBs/govt funded organizations within cities to use battery EVs.
Kerala (State EV Policy 2019-25)	1 million electric vehicles by 2022. Electrification of more than 6000 public transport buses by 2025.
Madhya Pradesh (Electric Vehicle Policy 2019-24):	Share of EVs to be increased to 25% of all new transport vehicles by 2026. 100% conversion of commercial and logistics fleet to electric by 2028. 100% electrification of public transport bus fleets by 2028.
Tamil Nadu (Electric Vehicle Policy 2019-29)	Introduction of 1000 new e-buses every year.
Bihar (Electric Vehicle Policy 2019-24)	100% electric mobility by 2030. 100% e-rickshaws by 2022.
Telangana (EV and Energy Storage Policy 2020-30):	Phased adoption of e-buses to 100% by 2030. 100% electrification of intra-city goods delivery services by 2030. Increase electric 2W and 3W sales to 25% of new registrations during the policy period.
Punjab (EV Policy 2019-24)	100% electrification of public vehicle fleets in target cities in a phased manner by 2024. Replacement of 25% of public buses with e-buses by 2024. Increase share of electric 2W and 3W to 25% among new vehicle registrations by 2024.
Goa (Draft Electric Mobility Policy 2021-25):	30% of new vehicles to be electric by 2025. 50% of all ferries to be converted to electric by 2025.
Gujarat (State EV Policy 2021-24)	2,00,000 EVs by 2024

Assam (EV Policy 2021-25)	25% of new vehicles to be electric by 2026. 2,00,000 EVs by 2025. 100% public transport fleet to be electric by 2030. All govt vehicles to be electric by 2030. Purchase to be mandatory by 2025. 100% electrification of commercial vehicles and logistics fleets by 2030.
West Bengal (EV Policy 2021-25)	1 million EVs by 2025. 1,00,000 charging stations by 2025.
Haryana (Draft EV Policy 2021-24)	100% electrification of the STUs bus fleet by 2029.
Meghalaya (EV Policy 2021-26)	15% of new vehicles to be electric by 2025.
Odisha (Electric Vehicle Policy 2020-25)	20% of new vehicles to be electric by 2025. At least 50% of procured buses will be electric by 2025.
Chandigarh (Draft EV Policy 2022-27)	100% of new vehicles to be electric by 2030. 100% electrification of the city bus fleet by 2027. 100% electrification of govt vehicles by 2025. 1000 public charging stations by 2030. All auto-rickshaws, school buses, corporate fleets, and cabs to be electric by 2030

Summary of government policies and targets

It is intended that the policies and strategies outlined by the central and state governments will be a driving force for the growth of EVs in India. These policies are a good start but a lot more is needed to build the EV ecosystem to realize the intended benefits.

Each state has a varying EV target. If all individual targets are consolidated and aligned, the size of the EV market can be enormous. This needs a mission mode approach with an outlined action plan.

Approximately, as many as 50 lakhs electric vehicles need to be sold by 2030 to achieve the EV plan outlined by various state governments. Nearly each state has committed to an EV target. But a time-bound strategy is required to achieve this target. This is also an opportunity to start discussing the possibility of implementing ZEV mandates and targets for the vehicle manufacturers to leverage the financial incentive schemes.

Of the total vehicles plying on India's roads, a majority (about 73 per cent) fall into the two-wheeler category. While they may not be the highest contributors in terms of GHG emissions on per unit basis, considering the two-wheeler population, the total GHG emissions are sizeable. Further, two-wheelers are in fact among the biggest contributors of particulate matter (PM). PM 2.5 is a known cause of

cardiovascular and respiratory diseases as it is harmful even at low concentrations. With a little difference in TCO parity in two-wheeler segment and further consumer acceptance, the initial focus of several state policies are inclined towards faster pace of transition in the two-wheeler segment.

On the other hand, the heavy goods carriers and four-wheeler categories contribute the highest GHG emissions in the transport sector while holding a smaller share in the vehicle population (nearly 2 per cent and 22 per cent, respectively). Though, the EV policies in different Indian states incline more toward two- and three-wheeler segments and that needs to be prioritized, four-wheelers also need equally strident focus to build the critical mass of demand and make the desired impact. This focus is weak now. At this stage, freight vehicles and especially zero emission trucks are not included in this study.

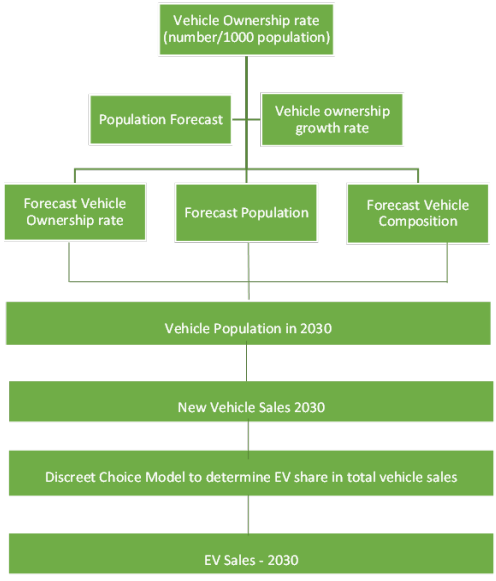
The next big steps need to include more refined strategies for demand creation and to build the supply side.

SCTION 3: EV demand forecast

Forecasting methodology

Due to a very low base number of EVs and lack of historical record over a longer period, this study has used a discreet choice modelling approach to forecast electric vehicles across the four categories of two-wheelers, three-wheelers, four-wheelers and commercial vehicles (buses) (see *Figure 1: Forecast model*).

Figure 1: Forecast model



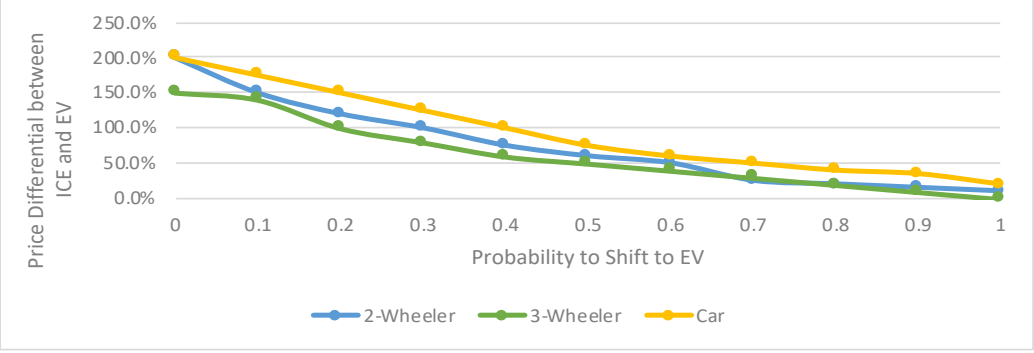
Discrete choice models are a typical method of research on consumer choice behavior originally applied in economics but increasingly being used in mobility planning to determine mode choice amongst the urban transport users.

Discrete choice models explain individual behavior with the assumption that the consumer chooses the most preferred option amongst the given options. Under certain assumptions, consumer preferences can be represented by a utility function that determines its choice over a set of defined options.

Based on consumer choice behavior theory, consumer's preference is influenced by consumer's satisfaction with available transport modes and their importance to the consumers. It is obvious that individual perception and aptitude to different transport modes differ due to the different socioeconomic status of individuals and different intrinsic characteristics of transport modes, which cannot be directly observed or measured.

For the purpose of this research, a utility function has been developed based on the data collected during consumer perception surveys. The utility function defines the choice of a consumer between an ICE or an electric vehicle based on the perceived cost of ownership between these two categories (see *Graph 6: Probability of shift to EV in response to price differential*).

Graph 6: Probability of shift to EV in response to price differential



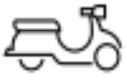
The model simulates consumer preference to switch to EV and determines electric vehicle market share based on the current level of financial incentive policy. NITI Aayog's electrification target has been modelled and three scenarios have been tested, the realistic scenario being more than 50 per cent of the consumers willing to consider EVs in their next vehicle purchase (see *Graph 7: Probability of shift to EVs by percentage of consumers*).

The forecast shows the likely size of the Indian EV market in the year 2030. The results are categorised under realistic, optimistic and most optimistic scenarios based on the Niti Aayog target for EV sales. Under a realistic scenario, total EV sales are forecasted to be a multiple of 63 times over the current EV sales.

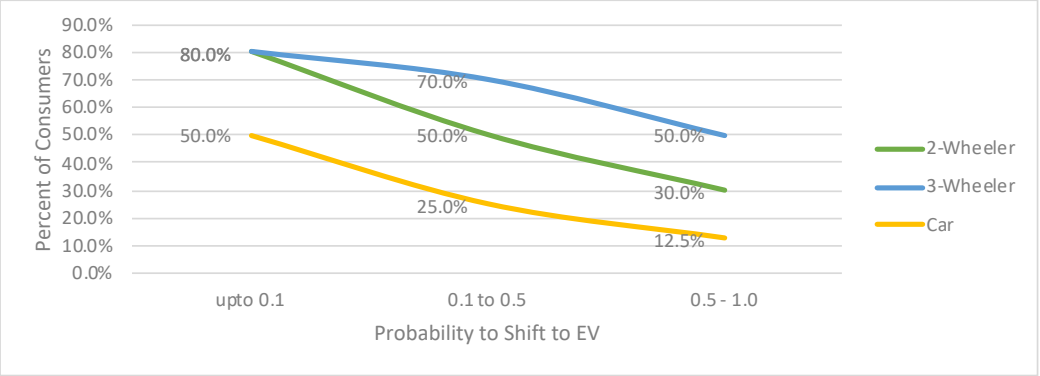
With the right government policies, setting up a local supply chain, lower battery prices, and widespread charging infrastructure, the market could move from the realistic scenario to the most optimistic scenario. With a faster adoption of electric vehicles in the two-wheeler and three-wheeler market, the possibility of realising the optimistic scenario is high if the right policies, including considering implementing ZEV mandates alongside the government financial incentive policies to remain consistent over the next ten years. *(see Table 4: EV forecast 2030)*.

If the charging infrastructure bottleneck and TCO parity for four-wheelers and commercial vehicles are not achieved, achieving a realistic scenario would likely be challenging despite government incentives and policies.

Table 4: EV Forecast: 2030

	Realistic	Optimistic	Most Optimistic (Niti Aayog)	Sales (2020)
	30% 1.28 Crores	50% 2.13 Crores	80% 3.41 Crores	0.9% 152,000
	50% 17 Lakhs	70% 23.8 Lakhs	80% 27.2 Lakhs	14.1% 90,000
	12.5% 7 Lakhs	25% 14.2 Lakhs	50% 28.4 Lakhs	0.12% 3,400
	12.5% 6.4 Lakhs	25% 12.8 Lakhs	50% 25.5 Lakhs	0.08% 600

Graph 7: Probability of shift to EVs by percentage of consumers

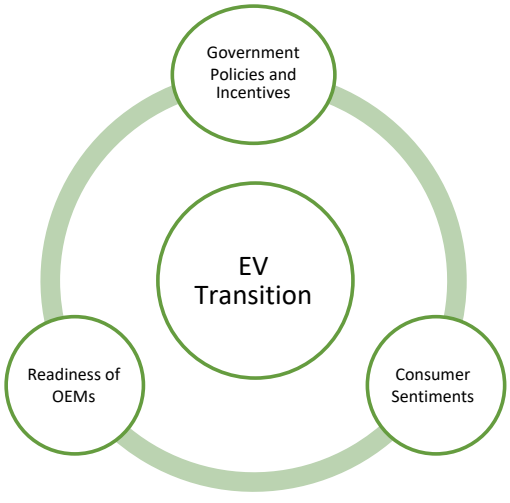


SECTION 4: Consultation with stakeholders

The key drivers of the EV ecosystem include consumers, industry partners and policy makers. To capture the thoughts and opinions of the EV market ecosystem, a perception survey was designed as part of the study. An important component of the perception survey was consultation with OEMs associated with vehicle manufacturing.

A perception survey has been a key element of this research. The findings from the perception survey have been used to take an informed view of EV demand forecast and ZEV mandate applicability.

Figure 2: Stakeholder consultation process: Key drivers of the EV ecosystem



Three specific groups were surveyed as part of this study:

Original Equipment Manufacturer (OEMs)
OEMs involved with ICE manufacturing
OEMs involved with both ICE and EV manufacturing
OEMs involved with EV manufacturing
EV startups

Consumer consultation: (Retail and STUs)
Understanding consumer behavior
Factors that influence the decision to buy an EV
Understanding price sensitivities to shift towards EV

Urban transport experts
A select group of experts have been interviewed for this study.

Method of consultation
This consultation was undertaken using a structured survey design followed by the telephonic interview process.

OEM surveys have been conducted to understand their views on the government's EV targets, their plan for growth, and their perspective on ZEV mandate adoption.

A total of 14 companies have been surveyed as part of the consultation exercise. This includes pure electric vehicle manufacturers and OEMs who manufacture only ICE or both ICE and electric vehicles, as well as startup companies.

OEMs across various segments—two-wheelers, three-wheelers, four-wheelers and commercial vehicles—were surveyed using a structured questionnaire approach followed by an interview with the corporate strategy team. They have provided their feedback under the conditions of anonymity and with a request to not to be named in any public document.

To understand the consumer preferences and factors that influence the decision to buy an EV, a consumer consultation exercise has been undertaken. Consumer surveys have been undertaken using a web-based survey tool. Samples were collected in more than fifteen cities spread across India. The findings from consumer surveys have also been used in building the discrete demand choice model while modelling consumer preference to choose between an EV and an ICE vehicle. A total of more than 3,000 samples were collected as part of the consumer survey.

Further electric bus demand is being driven by the decision of STUs to transition to EVs. In order to understand the perception of STUs about demand drivers for EV, consultation with them were also carried out. A total of four STUs were consulted as part of this process.

Perception of experts working on urban transport and electric mobility was also understood as part of this consultation exercise.

The main objective of the exercise is to capture the thoughts and opinions of experts with respect to targets and mandates on electric mobility transition and to further seek their views on ZEV mandate implementation and its structure of adoption.

Views of urban transport experts have been used in assessing the applicability of ZEV mandates in the Indian context and how such a mandate would influence and drive EV demand.

The key highlight of the perception survey is that while EV industry stakeholders are willing to support the government's EV transition targets, they are not confident in consumer demand in the near term in certain segments unless a purchase price parity is achieved. Until that point, the general view is that the government should continue and increase the financial support measures for both consumers and the industry to drive demand and innovation and achieve price parity.

Consultation with original equipment manufacturers (OEM)

As the ZEV mandate strategy affects the business processes of OEMs, and also requires EV products to align with the consumer requirements, a perception survey was undertaken to understand their perspective.

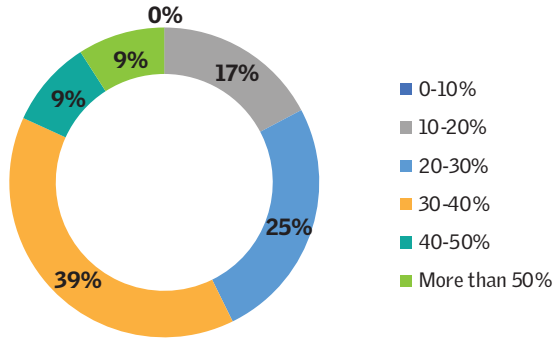
There is a variation in perspective across the vehicle segments. The perception is presented as per the questions asked to have a granular understanding.

Perception survey with two- and three-wheeler OEMs

The findings from the perception survey conducted with two- and three-wheeler OEMs is presented below:

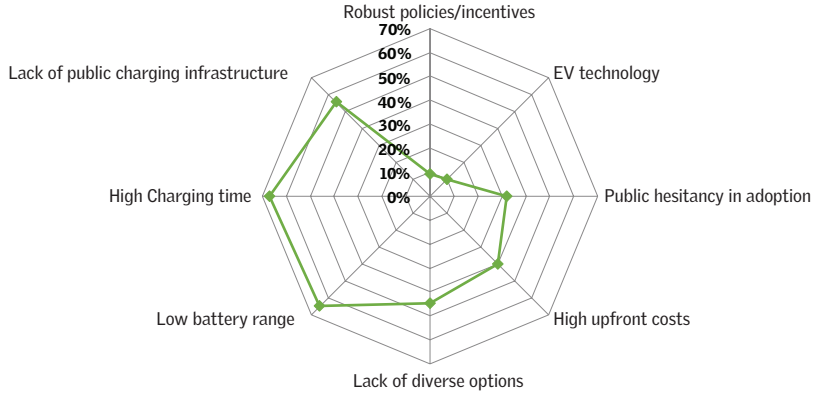
How much annual growth are the electric two- and three-wheeler industries likely to achieve in the next 5 years?

Majority of two- and three-wheeler OEMs believe that the industry is likely to see growth of upto 40 per cent per annum over the next five years. A smaller number of players believe that it can be as high as 50 per cent.



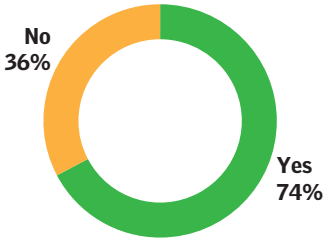
What are the main reasons for the low penetration of EVs?

Majority of two- and three-wheeler OEMs feel that low battery range, high charging time and inadequate charging infrastructure are among the key challenges that need to be resolved for mass penetration of EVs.



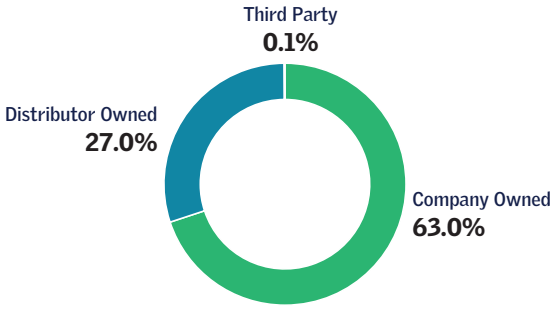
Are you interested in creating a charging station network?

Majority of two- and three-wheeler OEMs—close to 80 per cent—are considering setting up charging infrastructure network either on their own or through a charging partner.



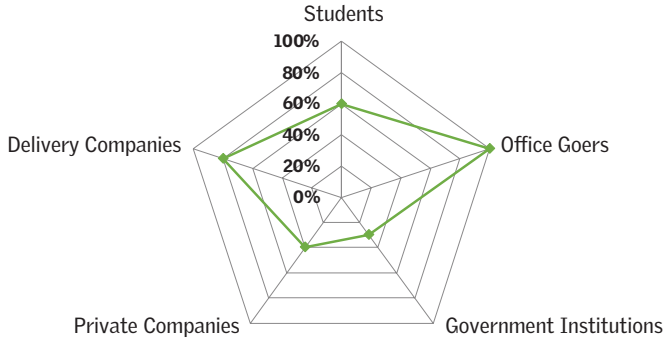
Details of the after-sales service network of EVs?

Currently, majority of two- and three-wheeler OEMs have their own after-sales service network. Three-wheeler OEMs rely on setting up a strong distributor owned after-sales network.



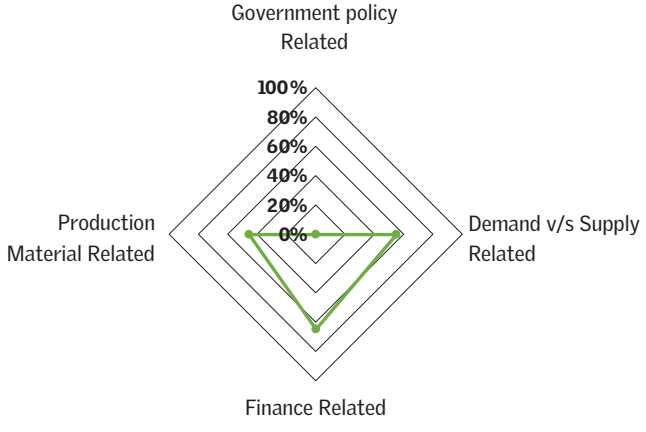
Who are your target consumers for two- and three-wheeler EVs?

Office goers, delivery companies and students are the key consumer segments that OEMs are targeting as their consumer base.



What challenges are you facing in the production of EVs?

Nearly all OEMs have pointed out that financing, demand and supply related concerns, and production material are among the key challenges. Financing is the biggest concern for start-ups.



Do you think that a ZEV mandate will drive innovation and growth in the EV sector?

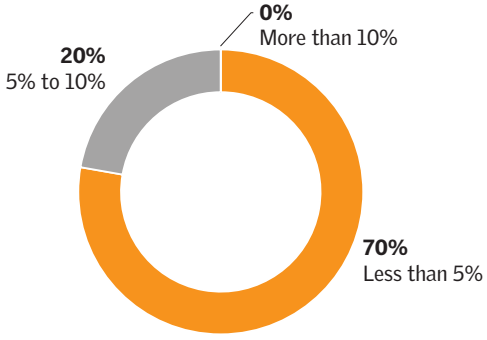
Two- and three-wheeler OEMs are very supportive of the ZEV mandate. All of them believe that such a measure can be somewhat effective in driving the EV growth ambition.

100%

2/3W OEMs believe a ZEV mandate can be somewhat effective

What should be the starting point of implementing ZEV mandate?

Majority of two- and three-wheeler OEMs are of the view that any mandate should start with upto 10 per cent target that can be gradually scaled up as the EV demand matures without subsidy and gets established.

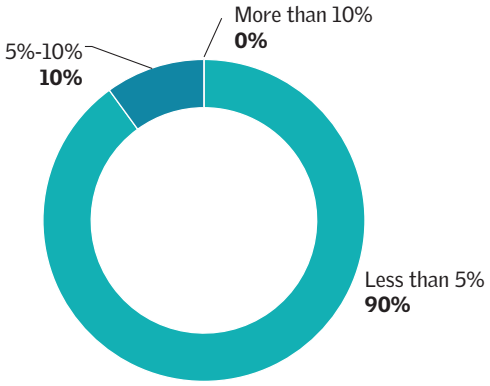


Perception survey with four-wheeler OEMs

Here is the perception of four-wheeler manufacturers. The four-wheelers largely include motor cars and not the commercial segments and heavy-duty commercial vehicles.

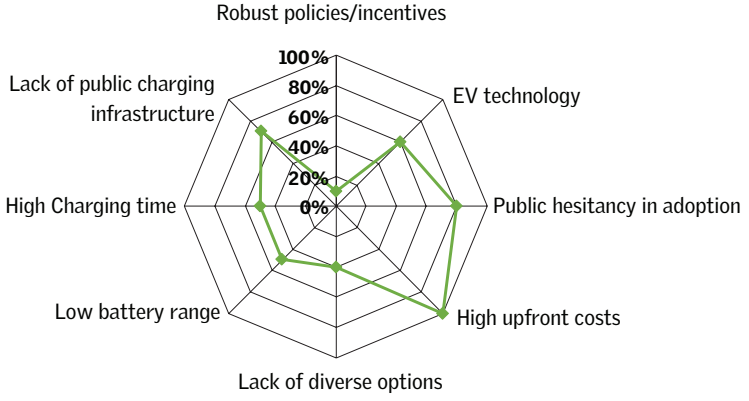
How much annual growth is the electric four-wheeler industry likely to achieve in the next 5 years?

Majority of four-wheeler OEMs believe that the industry is unlikely to see growth more than 5 per cent per annum over the next 5 years. The estimates are most conservative for this segment. Less than 10 per cent believe that close to 10 per cent EV penetration is possible.



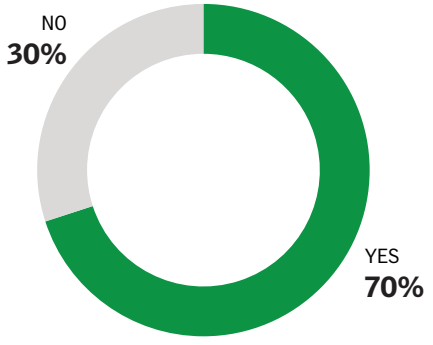
What are the main reasons for the low penetration of EVs compared to conventional vehicles?

Nearly all the four-wheeler OEMs believe that high upfront cost is the leading barrier followed by lack of public acceptance due to lack of public charging, low battery range, and low level of innovation and limited models.



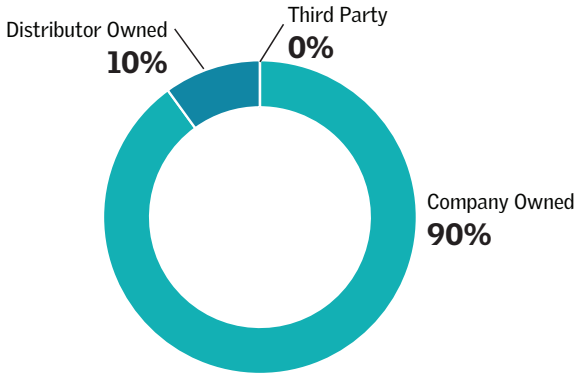
Is the industry interested in creating a charging station network?

Majority of four-wheeler OEMs are considering setting up charging infrastructure network either through their own or through a charging partner.



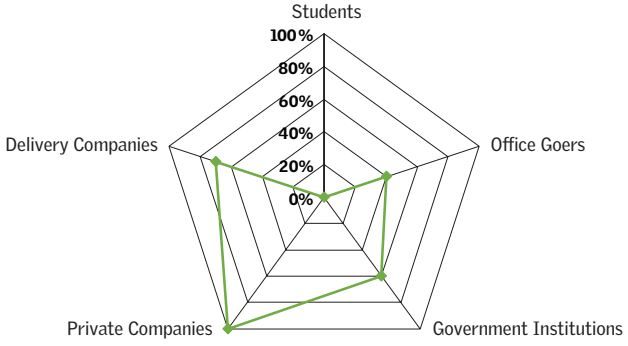
On after-sales service network of EVs

Majority of four-wheeler OEMs have their own after-sales service network for electric cars. A smaller number depend on the distributor owned services.



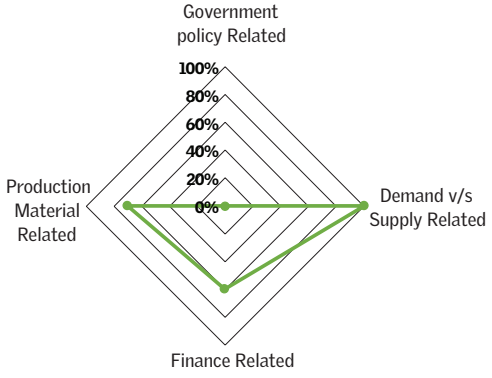
Who are the target consumers for four-wheeler EVs?

Office goers, cab operators and private companies are the key consumer segments for four-wheeler OEMs. This shows that institutional sales is the key focus at this stage.



What challenges are being faced in the production of EVs?

Demand-supply concern is the key challenge that almost all the OEMs are facing. Other challenges that need to be addressed are production material related and finance related.



Can ZEV mandate drive the innovation and growth of EVs?

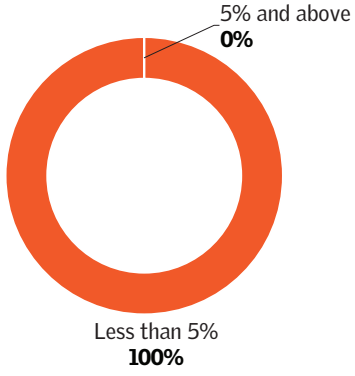
All Four-wheeler OEMs believe that such measures could be somewhat effective. However, they feel that such a measure can be very effective when demand is established to a certain extent, and there is government financial support to meet the viability gap.

100%

4W OEMs believe a ZEV mandate can be somewhat effective

What should be the starting point of implementing ZEV mandate?

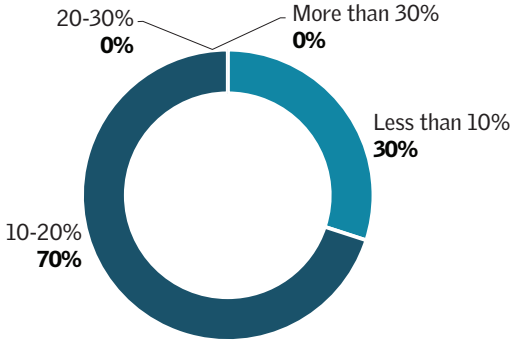
Four-wheeler OEMs believe that ZEV mandate should start with no more than 5 per cent considering current level of acceptance. The mandate can be gradually ramped up as the demand for EVs gets established.



Perception Survey with bus OEM

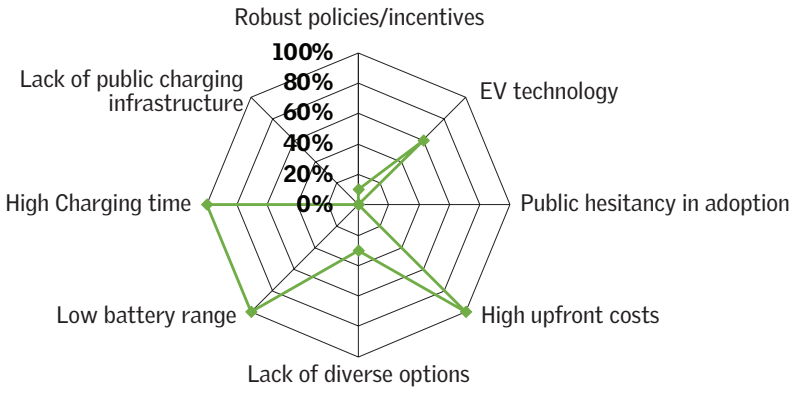
How much annual growth can be achieved in the next 5 years?

Majority of e-bus OEMs believe that the industry is likely to see a growth of upto 30 per cent per annum over the next 5 years.



What are the main reasons for the low penetration of e-buses?

The e-bus OEMs have listed high upfront costs, low battery range and high charging time as the key reasons for slow market growth.

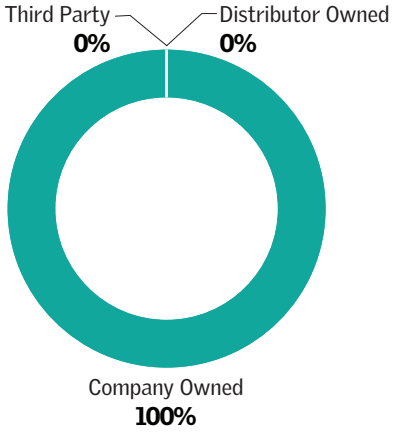


With regard to the creation of a charging station network?

Majority of electric bus OEMs are planning to offer one stop solution to set up charging infrastructure for bus charging. In fact, under the gross cost model, the OEMs take the responsibility of providing charging infrastructure.

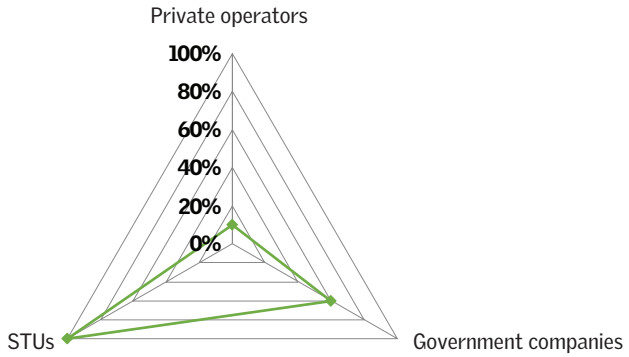
Details of the after-sales service network of EVs?

All e-bus OEMs have their own after-sales service network.



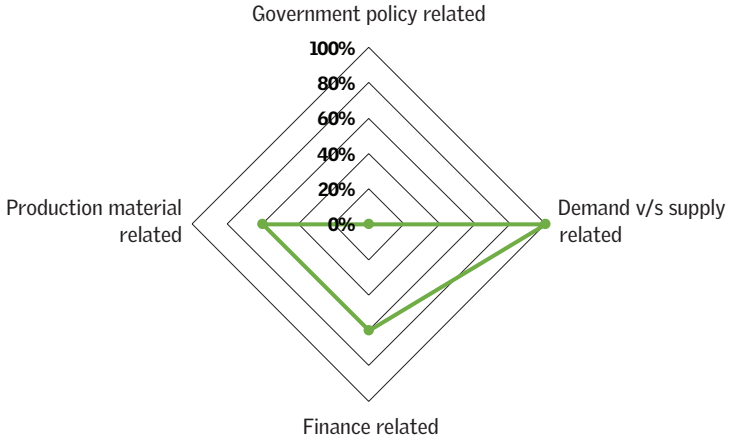
Who are your target consumers for electric buses?

E-bus OEMs have primarily targeted state transport undertakings and government owned companies as their consumers. Private operators are still a small market.



What are the challenges with respect to production of EVs?

For all the e-bus OEMs, lack of demand is the most serious concern followed by access to finance and production material.



Can production linked ZEV mandate drive innovation and growth in EVs?

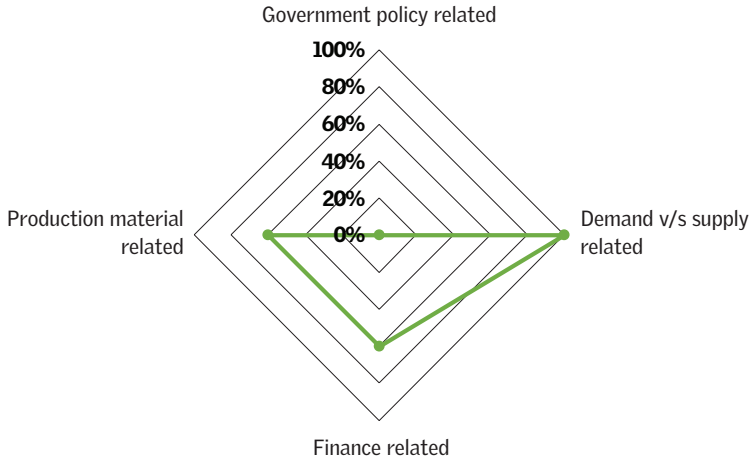
All e-bus manufacturers believe that such a measure can be somewhat effective. However, they are concerned about lack of demand and also the fact that the current focus of financial support is limited to government operators.

100%

Bus OEMs believe a ZEV mandate can be somewhat effective

What should be the starting point of implementing ZEV mandate?

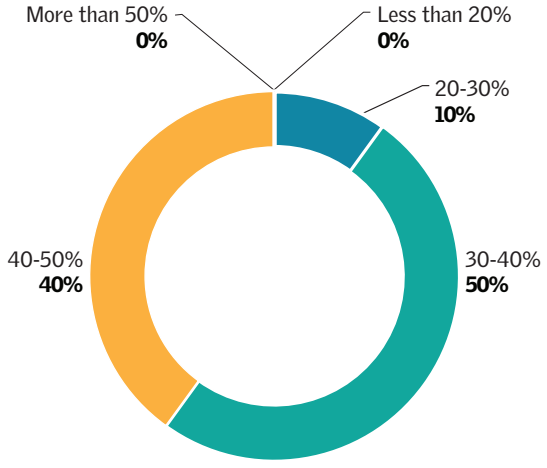
All e-bus OEMs believe that ZEV mandate should start with no more than 5 per cent target for the manufacturers considering current level of acceptance. The mandate could gradually scale up as the demand for EVs mature among the private operators.



Perception survey with exclusive EV OEMs

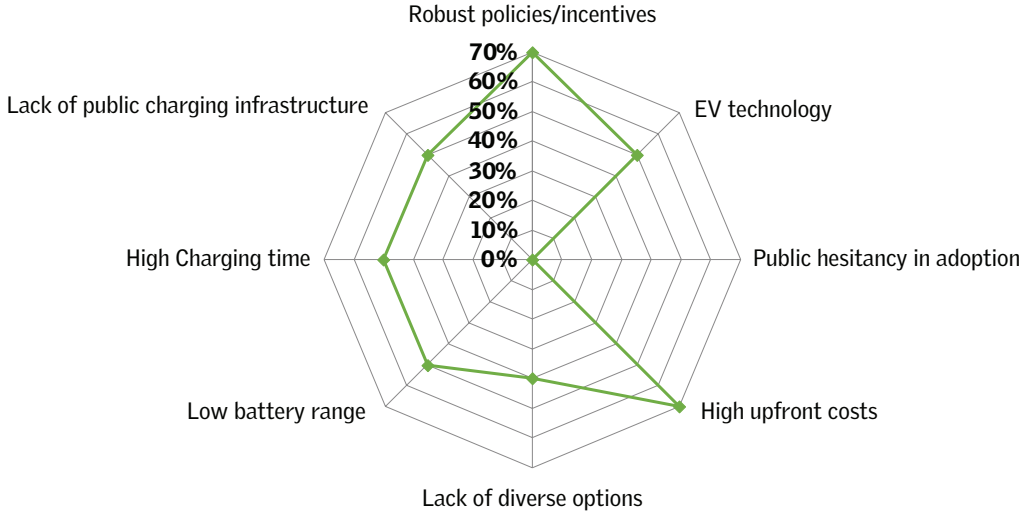
How much annual growth is the EV industry likely to achieve in the next 5 years?

Majority of EV OEMs or nearly half of them believe that the EV industry is likely to see a growth of upto 40 per cent per annum over the next 5 years. About 40 per cent of them believe that it can even be 50 per cent. The consultation with exclusive EV OEMs include two-wheeler and electric bus segments.



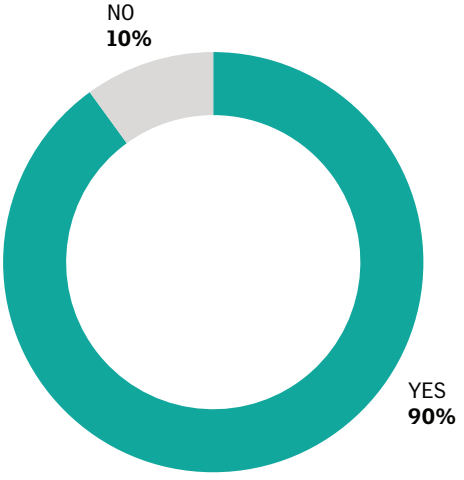
What are the main reasons for the low penetration of EVs?

The exclusive EV OEMs attribute the reasons to lack of robust policies and incentives, high upfront costs, followed by high charging time, low battery range and lack of public charging. Consultation show that they also expect strong support from state governments.



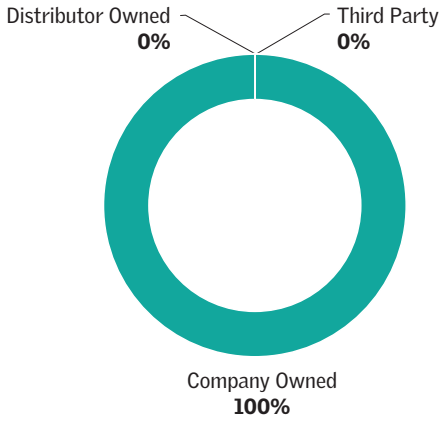
Are you interested in creating a charging station network?

Majority of EV OEMs are building capacity to set up charging infrastructure network either on their own or through a charging partner.



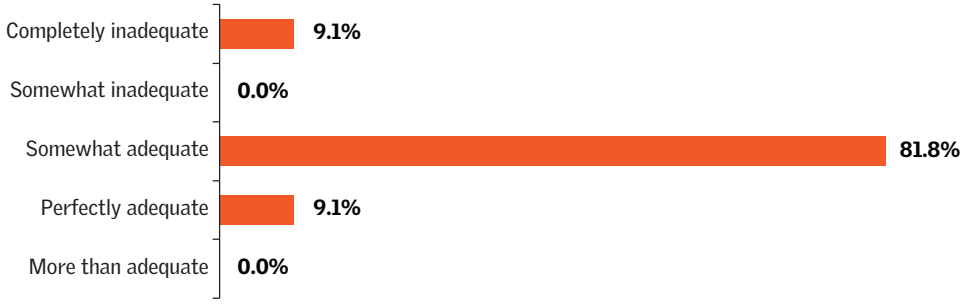
Details of the after-sales service network of EVs?

All EV OEMs have their own after-sales service network.



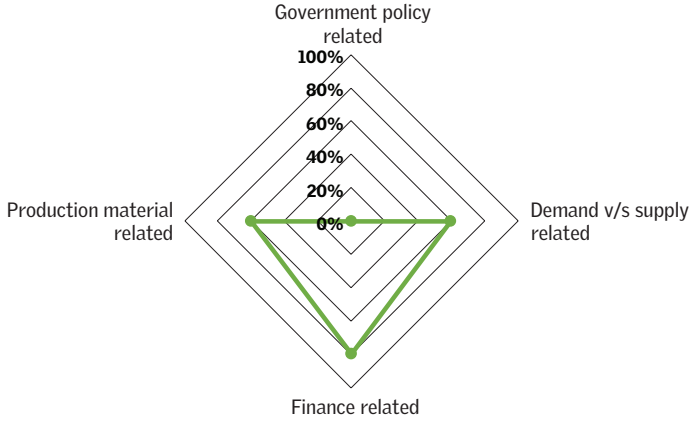
Do you think the current government incentives/policies are adequate to promote the growth of the EV market?

Majority of the exclusive EV OEMs feel that government policies are somewhat effective but more robust policy instruments are needed to support EV penetration.

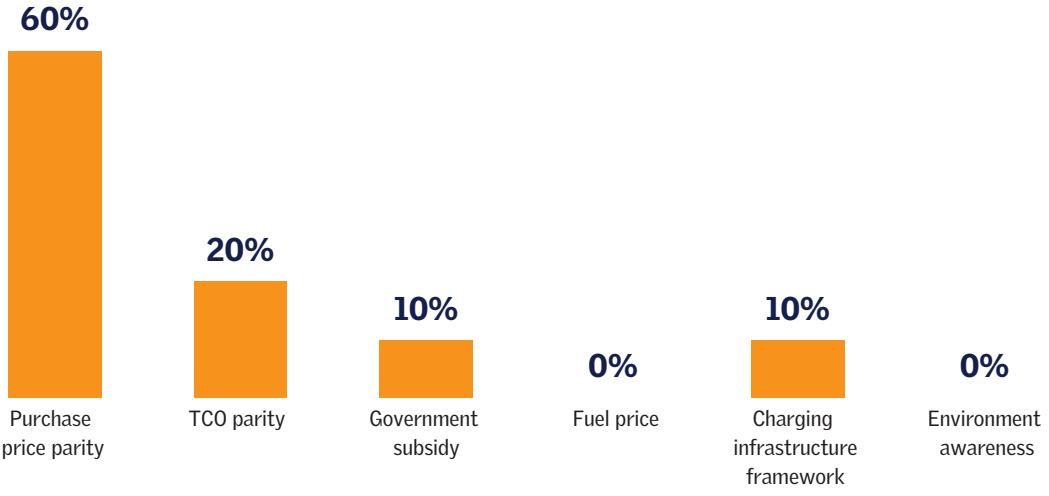


What challenges are you facing in the production of EVs?

Like all other segments, the exclusive EV OEMs have also identified access to financing, production material, and low demand as the biggest barriers.



Which factor do you think are most important in increasing the sales of EVs?
EV OEMs believe that price parity is the biggest factor which can result in faster EV uptake. They have stated that this can be addressed in the interim using government financial support.



OEM consultation: Key highlights

This broad-spectrum consultation has brought out some prospective trends.

The E2W market is expected to grow the fastest among all other segments registering around 20–30 per cent annual growth. The three-wheeler industry will also be part of the primary growth segment, with 90 per cent of the OEMs stating that the growth will be upwards of 30 per cent upward.

Due to limited choice of products and model availability and high cost of EV cars, the personal car consumer segment is not the primary target currently. The current consumers of EV cars include mid-segment buyer. This also keeps in view the fact that the ICE car market is principally driven by entry segment buyers. This is likely to remain in the near term until the purchase price parity improves along with diverse model availability across all the sub segments. OEMs believe that electric car growth upwards of 10 per cent in the near term is unlikely. With improvement in technology, this can grow but it is unlikely that it will be as fast as the two-wheeler segment.

Electric bus procurement is primarily driven by the state-run transport operators. The decision to buy an electric bus is influenced by the FAME subsidy available

and the electrification mandate from the government. Due to a wide difference in purchase cost and TCO between ICE and electric buses, private operators are still struggling to find a business case to shift to the electric bus.

OEMs are of the view that government policy should balance its focus equally on e-bus transition for both state-run operators and private operators. This can increase demand and push purchase prices downward.

High upfront cost and lack of product options across segments also impede higher uptake of EVs. OEMs are working on technology upgrades to bring down the battery cost. However, the parity is unlikely to be achieved in the car segment in the short term.

Demand-driven measures can bring down the costs of two-wheeler and three-wheeler segments. With the TCO parity already achieved, price parity can be reached soon.

OEMs are of the view that government policy needs to have equally strong focus on the state-run operators as well as private operators. This can increase demand and push purchase prices downward.

Though government policies are driving the EV growth, the OEMs feel that more financial incentives, especially access to economic financing for consumers and financial incentives for the entire EV value chain, including supply chain, logistics etc., need to be given.

More than half of the OEMs are considering expanding into charging as a service business through collaboration or their own networks. Some OEMs are also considering offering vehicles as a service platform to gain market confidence.

On electric bus OEMs, most government tenders are being offered on Gross Cost Contract (GCC) basis. Transforming their business from an EV manufacturer to an EV operator poses some organizational challenges. However, they are looking at collaboration in the near term as a strategy while assessing the market size. In the long run, they are likely to make an informed decision to enter the operator space. This cannot be ruled out.

OEMs believe that purchase price parity is key to building scale. The consumer is concerned more about higher upfront cost. Even though the consumers look at operating costs, the sensitivity to upfront cost is strong while making purchase

decisions. Unless purchase price parity is achieved with a combination of instruments including technology improvement, EV sales are unlikely to achieve the targets, especially in the four-wheeler segment.

Due to this uncertainty around the EV demand, OEMs cannot take a long-term market view, which is the biggest bottleneck that the OEMs are facing while deciding investments in the sector. Due to business reasons, OEMs are reluctant to share their future expansion plans. However, the market is getting ready for a 10 to 20 per cent production increase in the next five years.

While two-wheeler and three-wheeler OEMs are collectively planning to expand to aim for 30-40 per cent annual growth, they plan to double the current EV production capacity in the next five years.

OEMs are of the view that they will follow any government mandate and believe that any mandate should be launched with required consultations and associated measures. OEMs still believe that in the near term, government support to achieve purchase price parity will be a much more helpful strategy to spur EV demand, stimulate innovations and bring down their cost.

Most OEMs believe that financial incentives can be more effective in increasing EV demand. But if any ZEV mandate is implemented, it should not be more than 10 per cent. The consultation has also brought out that each state in India is publishing the EV policy with varying targets. If ZEV mandates are implemented uniformly there will be skewed demand-supply issues across states. OEMs believe that any such targets should be defined at a national level.

The OEMs are also of the view that financial incentives, especially access to affordable financing for consumers, for the entire EV value chain, including supply chain and logistics, etc. are also needed.

OEMs on ZEV mandate Implementation

OEMs support ZEV mandate as one of the instruments to drive EV growth. However, they believe that any such measure should be voluntary and not a mandatory requirement as market forces can come into play to drive the EV growth. It is necessary to hold an industry-wide dialogue to build a consensus on ZEV mandate implementation. Some of the emerging industry views on ZEV mandate are as follows:

- OEMs expect that any ZEV mandate, if implemented, will be set variably for different vehicle categories. The segments in which demand is still uncertain, like electric cars, can be in a waiver category. Any mandate should have a different scales based on the size of the OEM.
- OEMs have pointed out that the Indian EV market in totality is not mature and stable enough to accept a ZEV mandate of over 10 per cent.
- OEMs expect the vehicle market to transform from a product market to a service market with new business models like "Vehicle as a Service". The Vehicle-as-a-Service (VaaS) model allows customers to use vehicles for a variety of periods ranging from hours to days up to years, via products such as subscriptions, vehicle leasing and short- and mid-term rentals.
- OEMs feel that the ZEV mandate alone cannot provide the required push to the EV industry. The mandate should be implemented alongside current policies with additional funding allocated to R&D for EV product development. Consideration be given to schemes like price differential funding in the interim phase until price parity is achieved.
- Two- and three-wheeler OEMs are more supportive of the ZEV mandate compared to bus and car manufacturers.
- Two- and three-wheeler OEMs have noted that given the current status of sales, a ZEV mandate of up to 20 per cent may be a good starting point.
- OEMs feel that improving access to financing and subsidies for the consumer can be more effective compared to implementing mandatory ZEV mandates.
- EV OEMs have suggested that state governments should intially consider offering free and dedicated public parking and free charging. Further, governments should also enable and incentivize zero emission freight.
- Electric bus OEMs feel that the government also needs to implement a mandate for STUs to procure only electric buses and make the FAME scheme more flexible by including school buses and private intercity buses. This can address the demand and supply gap.
- Car OEMs are not so certain about implementing a ZEV mandate. They prefer a stringent emission reduction mandate supported by a voluntary ZEV mandate. This means that the mass emissions standards—including BS VI, BS VII and fuel economy standards—need to be tougher.
- Two-wheeler OEMs are generally more open to accepting a ZEV mandate. However, the industry is not ready for a mandate of more than 20 per cent.
- Three-wheeler OEMs are of the view that with improvement in charging and battery swapping, industry transition to fully electric can be substantial in the urban areas. But they are also concerned about the power availability for mass adoption.

Overall, the industry is of the view that the mandate should be implemented in a phased manner. It must be voluntary rather than mandatory.

The government needs to assess feasibility and initiate an industry-wide dialogue about adopting ZEV targets and to deliberate on modalities associated with it, including credit schemes, credit transfer policies and regulation on pure-play EV OEMs to sell their credits.

The government should also consider prioritizing the mandate for two-wheeler and three-wheeler segments with higher level of ambition for implementation and initiate readiness actions of introducing a mandate for four-wheelers in a phased manner.

The scale-up can be done with learning and experience, the way it is being done globally.

SECTION 5: Understanding EV consumers

A perception survey was designed to understand the perspective of potential and existing EV consumers. This was needed to understand the demand side perspective as that provides an important input to the OEMs in case the ZEV mandate is implemented. This survey has covered retail individual consumers and STUs.

Retail consumers: Key highlights

- Potential EV consumers were segmented based on their plan to buy an EV in the next 2–3 years. The majority of these consumers fall in the age group of 25–34, followed by 35–44.
- Average distance of commuting to work for potential EV consumers is in the range of 5–15 km. Consumers who commute more than 15 km have lower preference for EVs due to range anxiety.
- Potential EV consumers use public transport a few times every week or month but are not regular public transport users. This shows that public transport users are still willing to continue with public transport mode rather than make a shift to personal EVs.
- Commuters using ride-sharing options are more likely to buy an EV than those who use public transport.
- Majority of the commuters who are willing to buy an electric vehicle own an ICE vehicle. The average age of their ICE vehicle is more than five

years. The age of the existing vehicle also influences the choice for EV. It is important to do an age profiling of different vehicle categories to refine the EV forecast.

- Almost 25 per cent of the potential EV buyers are willing to buy with the current FAME subsidy structure. If the FAME subsidy was to double, almost half of them would be willing to buy an EV. If EV models were to be made available at the same prices as equivalent ICE models, consumers would be willing to shift to EVs.
- More than 70 per cent of the respondents within the two-wheeler segment are willing to consider E2Ws during their next purchase.
- Consumers expect the battery of EVs to provide the same range that an ICE fuel tank provides. Consumers in India expect the battery efficiency on a single charge to be same as one full fuel tank of an ICE vehicle.
- Majority of consumers are not satisfied with the product range available in the EV segment. They expect to see a range of products to choose from.
- Consumers have stated that shifting to EV is influenced more by purchase price parity than TCO parity. High upfront cost is a concern. Purchase price parity is the key factor that drives the Indian consumer's demand.
- Another factor that dampens consumer demand is the uncertainty around EV resale value, lack of clarity about battery replacement cost and spare part availability as the technology is changing very fast.

Perspective of STUs

The bus-based public transport system in Indian cities is primarily based on internal combustion engine (ICE) buses, and STUs are gradually making a transition from ICE to electric buses. E-bus procurement is supported under the FAME II programme of the Government of India.

According to the e-bus OEMs, success of e-bus adoption will depend upon many factors. The government needs to focus on capacity building measures so that STU officials have clarity regarding the technology and procurement process. They have also underscored the importance of price parity and lower purchase cost for quicker uptake. But this can be driven only by policy regulations and not voluntary choice.

Polices have to address the issues related to high cost, battery replacement, lower battery efficiency, lack of human resources, inadequate charging facilities and need for frequent charging, and the overall complex system.

SECTION 6: Towards ZEV target and mandate

NITI Aayog has outlined a very ambitious EV penetration target of new vehicle sales by 2030 for different vehicle categories—70 per cent for commercial cars, 30 per cent for private cars, 40 per cent for buses and 80 per cent each for two- and three-wheelers.

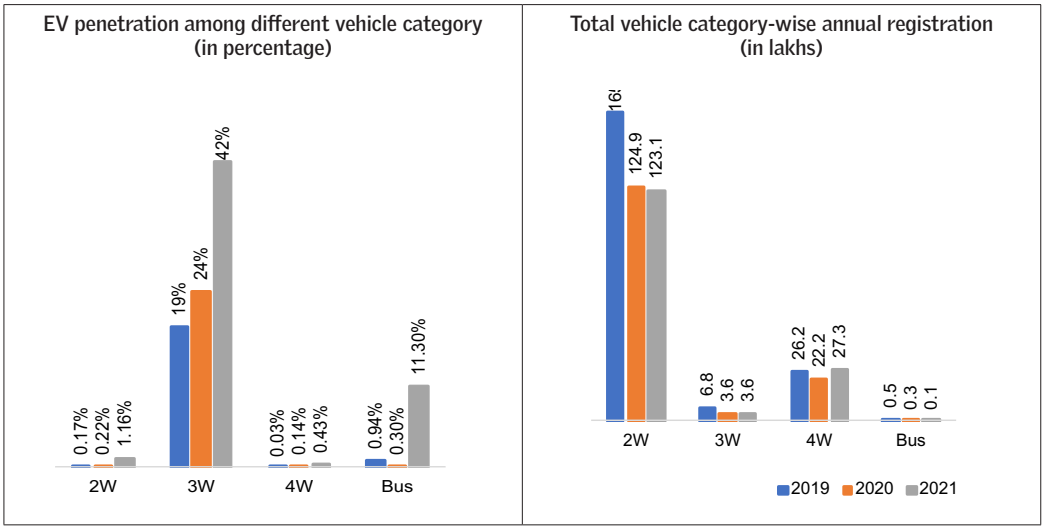
However, after detailed consultation with the vehicle industry, it has been observed that with the present incentive mechanisms, combined with the policy push from both the centre and states, the industry is expecting far lesser EV penetration in each vehicle category, i.e., around 20 to 30 per cent for two-wheelers, 40 to 50 per cent for three-wheelers, 10 per cent for cars (including both commercial and private segment) and 20 to 30 per cent for buses in the next five years.

They do not think that EVs can replace the ICE vehicles substantially, at least not in the coming decade, due to difference in prices (explained in detail in later section). All but a few big ICE market players are still hesitant to come up with new EV models, but have planned to introduce a series of ICE models in the coming years.

This raises the issue of what strategies may work to move closer to NITI Aayog's EV target within the specified timeline. In this regard, ZEV mandate can be considered as one of the key policy levers to drive the ICE industry to transition towards electric. This is needed to diversify the market and product range and stimulate growth.

Over the past three years, since the implementation of FAME II, only the three-wheeler segment has been able to make continuous double-digit penetration, all other segments including two-wheelers, cars and buses have lagged behind with some variation. In 2021, both, 3Ws and buses had best penetration rate, i.e., 42 and 11 per cent respectively. This high penetration rate of 3W and bus segment is relative. While their numbers have grown the overall registration of total numbers for both EVs and ICE have hugely declined. While overall registrations of three-wheelers have declined by 47 per cent, that of buses has declined by 79 per cent from the 2019 level.

Graph 8: Category-wise vehicle registration trends in between 2019–2021



Source: VAHAN Database

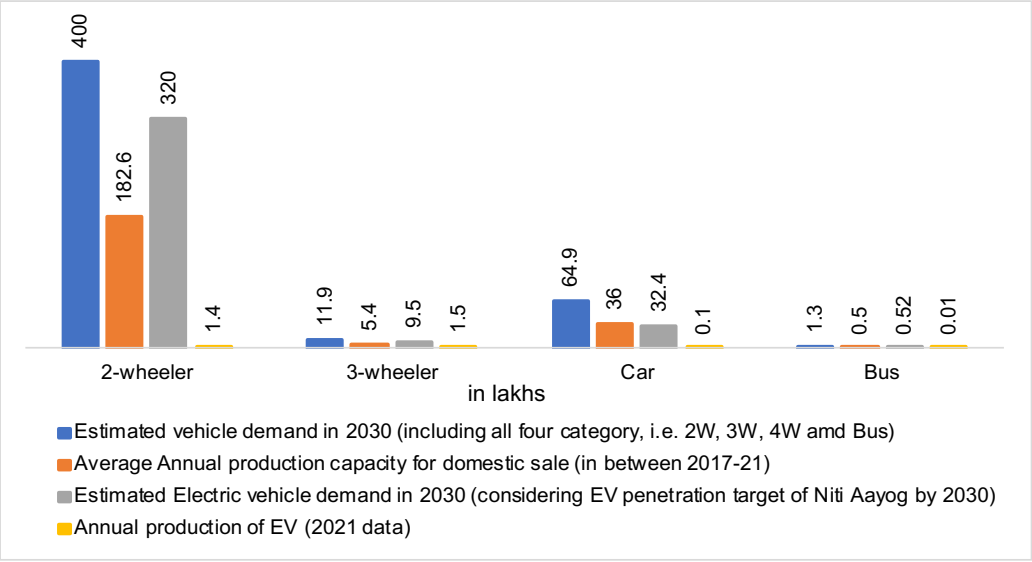
Even though the penetration rate of three-wheelers is better compared to others, it is interesting to note that almost 92 per cent of the registeredE3Ws are either e-rickshaws or e-carts.

If India has to achieve the EV penetration targets in 2030 as specified by NITI Aayog, then the vehicle industry has to ramp up production lines across all vehicle categories (see *Graph 9: Projected demand v/s production*).

Presently, total vehicle production is typically dominated by ICE vehicles and ICE manufacturers—98 per cent of the total sales of two-wheelers; 59 per cent of three-wheelers; nearly 100 per cent of cars and 90 per cent of buses. Although new OEMs with 100 per cent EV production lines have entered the market in smaller vehicle segments, like in two- and three-wheelers, their overall volume is still too small (see *Graph 10: Market share of EV and ICE vehicles*). Unless the larger ICE OEMs also do not enter the market in a big way, it will be difficult to achieve scale. The ZEV mandate can push them to make this transition.

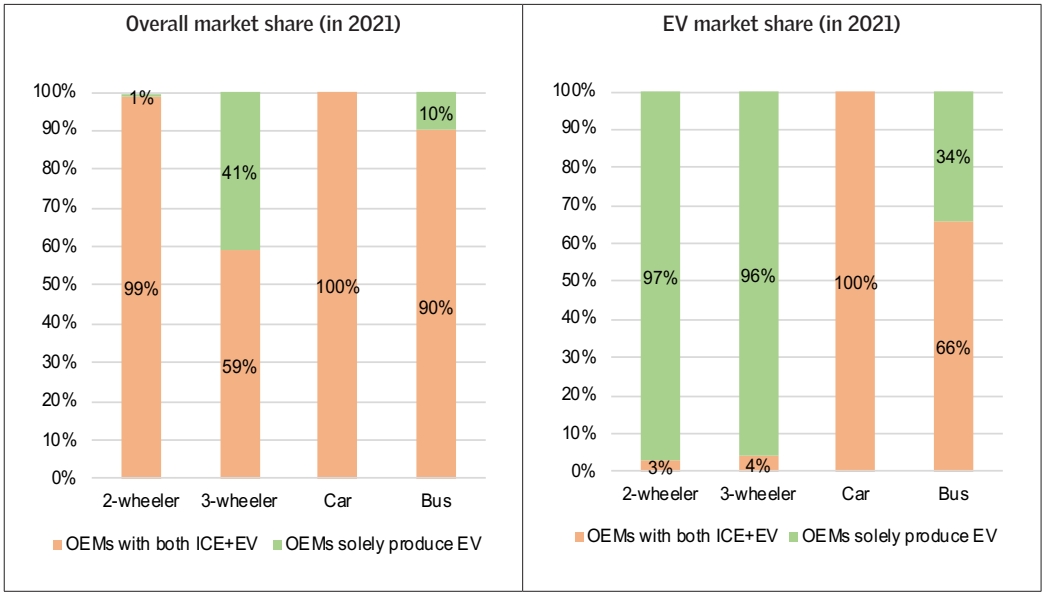
The next big question is—How can the ZEV mandate be designed to affect the ICE industry both structurally and financially to push ICE vehicle producers towards producing EVs. The sole EV producers are anyway producing only EVs.

Graph 9: Projected demand v/s production



Source: Statista, SIAM, Vahan and CSE's own projection

Graph 10: Market share of EV and ICE vehicles



Source: VAHAN Database

Designing ZEV mandate and target

Clearly, there is a lot of interest in providing an additional push to the market, along with creating a ZEV mandate supported by stringent fuel economy standards and grid decarbonization to drive the industry.

Survey of experts shows that almost all experts favour implementation of ZEV mandates. Nearly 70 per cent of them feel that ZEV mandate will be an effective tool to drive domestic innovation in the EV ecosystem and provide wider choice to consumers. Urban transport experts believe that if the ZEV scheme is launched, there is a possibility for OEMs to collaborate with financial institutions to support potential consumers with EV purchases.

However, at the same time, experts have cautioned that the ZEV mandate also needs several supportive mechanisms like fiscal and non-fiscal incentives, ease of financing for potential consumers, etc., to build confidence of the OEMs.

It is likely that the new FAME or equivalent scheme would be implemented after FAME II's completion. The new scheme can see a major shift on EV adoption. The ZEV mandate can be on a lower side upto 2027 (five years from now) and increase substantially as the market matures.

ZEV mandate when combined with demand-side policies can drive innovation in the EV ecosystem. Researchers in Canada found that a supply-focused approach that relies on a ZEV mandate provides the highest level of certainty that the 2040 ZEV sales target will be achieved.

A positive outlook of the industry on the mandate, expressed during consultation, makes it a more likely strategy for adoption. However, the industry has expressed conservative views and expects much lower targets to begin with. The possible targets that have emerged from the industry observations on ZEV targets for different vehicle categories by 2030, are on the lower side (see *Table 5: The minimal target for a mandate by 2030 emerging from the industry observations*). They also believe that lower-bound ZEV targets can be implemented in a phased manner from 2025 to 2030. In the meantime, the government needs to initiate a dialogue with the industry and start the consultation process for detailing. If the industry intended target is considered (considering only two-wheelers, three-wheelers, cars and buses, but not trucks and bigger commercial vehicles) about 23 per cent electrification of overall fleet is likely against the minimal target of 30@30 target.

Table 5: The minimal target for a mandate by 2030 emerging from the industry observations

Two-wheeler	Three-wheeler	Four-wheeler/Car	Bus
25%	50%	5%	15%

The target the industry is willing to consider as their mandate is much lower than the overall EV penetration level that several industry players expect over the next five years. If the industry expectations around possible penetration of EVs that have been expressed during the survey are considered, then a more optimistic target for the mandate is possible. Therefore, a more optimistic scenario is considered for EV penetration level in 2030 (see *Table 6: Optimistic ZEV mandate by 2030*). In the optimistic ZEV target scenario, 47 per cent EV penetration is possible in overall vehicle market consisting of two-wheelers, three-wheelers, cars and buses.

Table 6: Optimistic ZEV mandate by 2030

Two-wheeler	Three-wheeler	Four-wheeler/Car	Bus
50%	70%	25%	25%

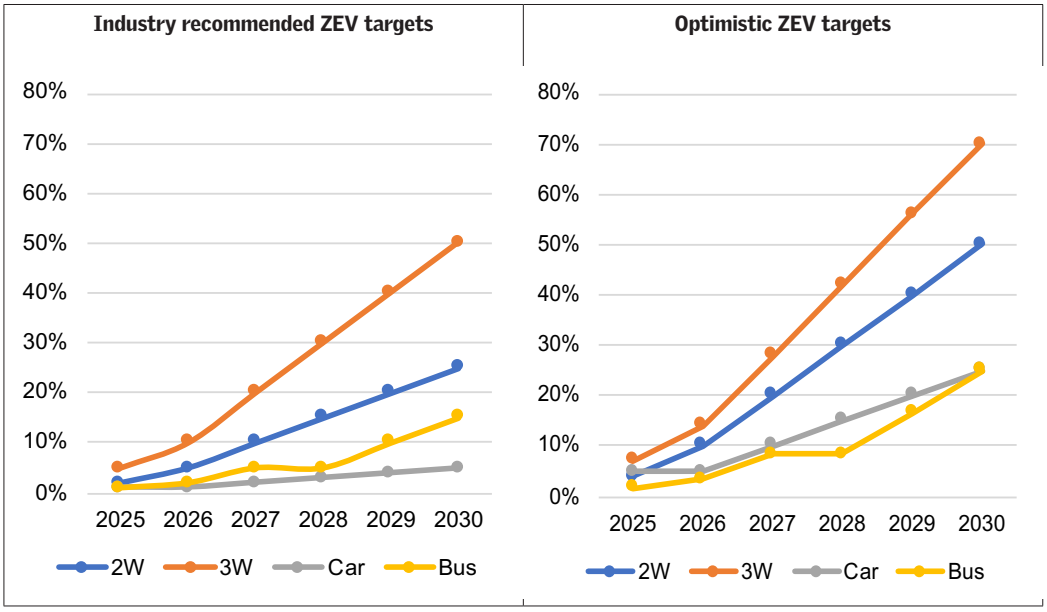
This will require a phased introduction on an year-on-year basis until 2030 (see *Table 7: Phase-wise details of lower bound mandate and more optimistic ZEV mandate* and *Graph 11: Comparison between two ZEV mandate target scenarios*).

It is important to mention that the vehicle electrification target set by NITI Aayog is even higher and if that has to inform the mandate setting process, the combined EV market penetration level for two-wheelers, three-wheelers, cars and buses needs to be 76 per cent.

Table 7: Phase-wise details of lower-bound mandate and more optimistic ZEV mandate

Years	Industry recommended ZEV target				Optimistic ZEV target			
	2W	3W	Car	Bus	2W	3W	Car	Bus
2025	2%	5%	1%	1%	4%	7%	5%	1.7%
2026	5%	10%	1%	2%	10%	14%	5%	3.3%
2027	10%	20%	2%	5%	20%	28%	10%	8.3%
2028	15%	30%	3%	5%	30%	42%	15%	8.3%
2029	20%	40%	4%	10%	40%	56%	20%	16.7%
2030	25%	50%	5%	15%	50%	70%	25%	25%

Graph 11: Comparison between two ZEV mandate target scenarios



Designing a ZEV mandate: What it takes

It is proposed that Indian policy makers consider adoption of multiple measures that can be grouped across the following three areas:

- Strengthen demand focused policy package (FAME scheme) to expand its size and coverage;
- Consider implementation of ZEV mandates as a supply focused policy package;
- Consider implementing an exclusive policy package to support EV supply chain and associated ecosystem.

ZEV mandate is not only about fixing the target for annual production but also a range of supportive and enabling measures that need to inform the designing of the mandate and activate the market. It is necessary to identify the key heads of terms to implement the ZEV mandate (see *Table 8: Key elements of ZEV mandate*).

Table 8: Key elements of ZEV mandate

Policy area	Proposed details
ZEV coverage	ZEV mandate to be implemented in a phased manner, starting with a lower-bound target to get a buy in from the OEMs and gradually expanding as the demand picks up
OEMs grading	OEMs need to be graded across three categories annually: - Large Volume OEMs: Top five OEMs by sales volume in respective vehicle categories - Mid Volume OEMs: From sixth to tenth highest sales OEMs in the respective vehicles categories - Small Volume OEMs: All other Sales volume for a year may be calculated as annual sales volume in India in the previous year. Small-volume manufacturers could be exempted from the mandate.
ZEV mandate requirements	After analysing the present level of penetration and the level of penetration we expect in 2030, ZEV targets seems achievable. For example, in an optimistic scenario: Two-wheelers: Starting at 4% and reaching 50% by 2030 Three-wheelers: Starting at 7% and reaching 70% by 2030 Four-wheelers: Starting at 5% and reaching to 25% by 2030 Electric bus: Starting at 1.7% and reaching to 25% by 2030
Eligible vehicles to ZEV	Battery electric vehicles Fuel cell electric vehicles Strong hybrid electric vehicles and plug in hybrid electric vehicles with lesser credit points
ZEV credit scheme	As is the global good practice, each of the OEMs meeting the ZEV threshold criteria would be able to earn credits based on the estimated savings on GHG emissions. Saving calculation to be standardized through a transparent tool. Higher the GHG emissions saved, higher would be the credit allocated. Each of the OEMs need to meet a minimum credit score each year. Minimum credit score shall be defined for each of the large and mid-volume OEMs. OEMs not meeting the threshold credit targets could be penalized as per a predefined criterion.
Credit valuation mechanism	Each credit shall have a monetary value and OEM can trade such credits to get government financial support. Credit for battery electric vehicle or fuel cell electric vehicle could be higher than the plug-in hybrid vehicle and strong hybrid electric vehicle. Government financial support shall be available only to OEMs meeting threshold ZEV target and threshold ZEV credit.
Credit transfer scheme	Credit can be transferred and can be traded in a free market environment.

Urban transport experts believe that if the ZEV scheme is launched, there is a possibility for OEMs to collaborate with financial institutions to support potential consumer with EV purchases. This will stimulate innovation and product launch with multiple price points.

Nearly 70 per cent of the experts surveyed feel that ZEV mandate will be a very effective tool to drive domestic innovation and the EV ecosystem and provide wide choice to consumers. However, experts also caution that a mandate needs

to be supported by continuation of subsidies for consumers to buy EVs and ease of financing EVs to build industry confidence. The ZEV mandate should be implemented in a phased manner.

Global experience shows that a strong ZEV mandate provides the highest certainty of effectiveness. It is proposed that Indian policy makers consider adopting multiple measures that can be grouped across the following three areas: Strengthen Demand Focused Policy package (FAME Scheme) to expand its size and coverage; consider implementing ZEV mandates as a supply focused policy package; and consider implementing an exclusive policy package to support the EV supply chain and associated ecosystem.

Potential impact of ZEV mandates on industry

With the ZEV mandate, OEMs will have to scale up from just a few thousand EVs today to a much larger production capacity by 2030. They need to make several changes that have bearing on vehicle design, factory architecture and assembly line process. The OEMs would need to adjust their business process to expand EV production capacities either within the existing ICE manufacturing plant or through a greenfield project.

EVs are fundamentally different from ICE vehicles. EVs have battery packs and no fuel tank and there is no intake or exhaust. An EV typically has no conventional transmission. These differences affect not only the assembly procedures and factory footprint but can also change the preferred supply arrangements. For example, whereas an ICE plant could supply multiple vehicle plants, battery packs may be too large and too heavily integrated into the chassis for this to be practical.

Producing EVs in manufacturing facilities that were designed for ICE vehicles will require reworking of entire assembly processes. This is largely due to the major design and construction differences between EVs and ICE vehicles. While some "brownfield" factories will mix EV and ICE production (at least for a while as per OEM perception survey), there will also be "greenfield" factories built from the ground up to manufacture EVs.

EV motors have very few moving parts. They do not require engine oil or transmission fluid. EVs need no exhaust systems, alternators, fuel injectors or starters. All of these familiar ICE vehicle components will be entirely absent from EV production lines. Because there will be so many fewer parts in an EV, compared to its ICE counterpart, the assembly process will be simplified. Fewer parts also mean lower labor costs.

With ZEV mandates in place, OEMs need to ensure that the product mix meets the consumer demand and expectations, which is liable to change unpredictably, responding to developments in EV range, battery costs, government legislation and purchase incentives.

Integrating and adapting EV production to existing assembly sites can present challenges. Most manufacturers are trying to retain common facilities such as paint or body shop to minimize capital requirement. The industry is seeking a 'zero loss' modular manufacturing solution. A line can be re-tooled and re-modelled for a change without any loss of production and expensive cost implication. The most important decision that the OEMs need to take is to invest in a greenfield site for EV manufacturing or to convert an existing ICE manufacturing plant into an EV plant.

Greenfield strategy: Greenfield sites allow greater scope for optimization with fewer constraints, which is especially important for the logistics of parts supply into the plant when, for example, hybrids, battery EVs and ICE vehicles are assembled in the same facility. However, they require a significant investment in new plants and infrastructure and relocation of key suppliers and skilled workers.

Brownfield strategy: With brownfield sites, the situation is reversed. Much of the legacy investment in facilities can be retained, provided any compromise to assembly efficiency is minimized. Existing suppliers and labour skills in the immediate vicinity are already available, assuming they remain relevant to the powertrain technologies employed.

To meet the growing EV demand and to further meet the required ZEV mandates, OEMs must redesign how they develop new products, recalibrate their business processes for continuous transformation with technology advancement and reskill their workforces with new technologies.

The integration of EV production into existing assembly sites can also present challenges. Most manufacturers are trying to retain common facilities such as paint or body shop to minimize capital spending, so optimizing the integration is very important. Otherwise, the all-important scale-up won't be achieved.

During the transition, the technology needs to mature, costs have to come down, and volumes need to reach the scale needed to make EVs profitable. The transition strategy can follow multiple paths either through inhouse investments or through partnerships and collaboration.

Operationally, OEMs need to decide how to convert their production facilities from ICE to EV manufacturing. The selected strategy will affect the ease with which companies can flexibly swing output to meet changes in demand between ICE and electric propulsion in the future.

ICE and EV vehicles may have some common parts, but EVs have a lot less parts. EV manufacturing will require freeing up space within the brownfield site. However, EV components are generally big and heavy, such as motors and batteries, so storage and transportation need to be ready for this change.

Assembly of battery packs: As batteries are an integral part of EVs, battery packs are assembled on-site or very close to the OEM manufacturing facilities. Further, with a wide variety of product range expectations, battery pack and battery management need to be customized for each type of vehicle. With such a requirement, the trend toward batteries being built close to the manufacturing line will continue.

Repurposing to convert ICE assembly line to EV: As part of this transition, any company needs to undertake a detailed comparative analysis of ICE and e-motor component manufacturing processes and identify certain ICE machinery, equipment and facilities with obvious potential for EV motor related repurposing. The repurposing strategy needs three steps:

- Step 1: Analysis of ICE Bill of Process (BOP)
- Step 2: Analysis on an EV BOP
- Step 3: Comparison of ICE BOP to EV BOP with respect to EV production

Based on the assessment, the categorization is generally done under the following three categories:

- Reuse with minimal re-tooling required: Those pieces of equipment are flexible enough to accommodate major component changes easily, ex. robots/CNC machines
- Reuse with some re-tooling required: Equipment which has reuse potential, but feasibility needs to be established, ex. test equipment.
- ICE specific major re-tooling: Equipment which would require modification to the fundamental base machine, ex. honing machines.

A Report by NITI Aayog states that OEM capital has recently focused on the migration of ICEVs to BS VI standards. The industry is also experiencing lower sales due to COVID-19 shock. This is hampering supply-side investment in EVs.

The cost to convert ICE manufacturing to EV manufacturing depends on how tooled OEMs are. For most OEMs, it is only a cost of a few fixtures as engines or electric motors are fitted manually.

In production, the engines are sub-assembled on fixtures and then wheeled to the line for fitment into the vehicles. These fixtures need to be changed and are relatively low cost. So the answer is that there is some cost but it is not significant. Only if it is a robotic line does this cost become significant. However, a detailed evaluation of the cost of this transition is needed. It is evident that when the industry moved from BS IV to BS VI, the cost of transition was passed on to the consumers by the OEMs. However, this was done in phases.

The stakeholders consultation has also highlighted the importance of a range of supportive measures including demand incentives at the state level to build demand to enable ZEV mandates. State level action includes designation of low emission vehicles zones, preferential or discounted electricity rate structures for charging ZEVs, reduced toll tax for ZEVs, and preferential and complimentary parking access for ZEVs in public parking areas. The key focus has to be on price parity and consumer familiarity. In many markets, purchase incentives represent a major share of government outlays among the various government ZEV support programs. Technological advancements and battery pack cost reductions allow for reducing fiscal support to electric vehicles over time. With improved cost parity, the government can phase down incentive programs to match reductions in electric vehicle costs. This is the main consideration while developing the cost model for ZEV transition.

Public private partnership should be encouraged while transitioning to EVs. India has had a successful experience in public-private collaborations in various sectors and these are very effective in leveraging government funding. While the consumer purchase subsidy can be funded through public funding, charging infrastructure, EV manufacturing facilities, R&D and public awareness can be taken up by the private sector or multiple combinations of these can be deliberated upon.

Globally there are many examples of using public private partnership approach to implement ZEV programs. Germany's ZEV purchase incentives from a total pool of € 600 million in public funding are matched with € 600 million from the OEMs. In the United Kingdom, £400 million have been committed to ZEV infrastructure wherein £200 million is contributed through government investment with a £200 million match by the private sector.

In California, while consumer purchase subsidy is funded through public funding, the government adopted public private partnership approach for ZEV consumer outreach. The state has incorporated a not for profit and tasked it with consumer awareness, understanding and consideration of electric vehicles. The not for profit is funded primarily through membership and sponsors, which include the government and industry.

SECTION 7: What will it cost?

The key question for the policy makers is what types of support for incentives, infrastructure and other programs are needed to support the ZEV mandate; for how long will this support be required; and how the costs compare to the benefits if such funding is allocated.

It may therefore be useful to have an indicative idea about the cost to implement the ZEV mandate. This is however not comprehensive but only indicative.

Table 9: The cost associated with implementation of the ZEV mandate is categorized

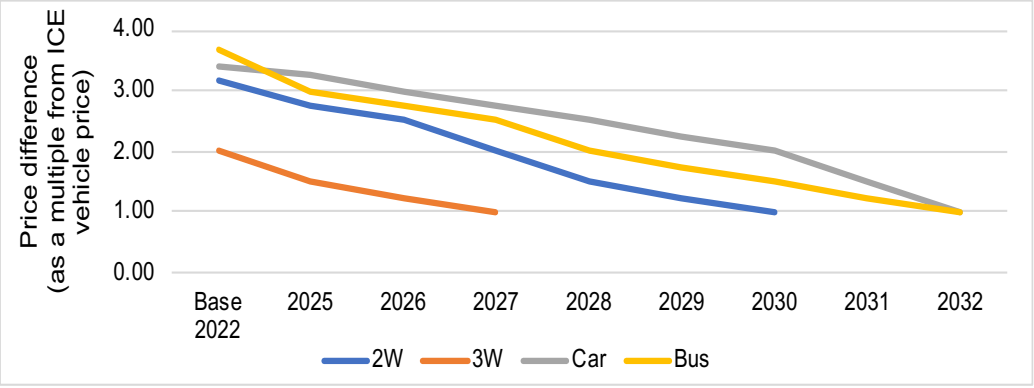
Cost head	Details
OEM cost	Cost to remodel existing ICE factory to EV R&D to develop new technology
Consumer cost	Cost differential to purchase EV (price parity subsidy)
Chargers cost	Charging infrastructure deployment

General assumptions for calculating costs

All the cost considerations are based on secondary data research, stakeholder consultations, feedback from OEMs and experts. Following are the key considerations/assumptions regarding cost estimates:

- ZEV mandate is proposed to be implemented from the year 2025 to 2030 with differentiated ZEV targets for each vehicle category.
- Price parity to be achieved gradually over the next ten years as per the feedback from OEMs (see *Graph 12: Vehicle category-wise price parity curve without subsidy*).

Graph 12: Vehicle category-wise price parity curve without subsidy



Source: Stakeholder consultation

Table10: Timeline for price parity between ICE and electric vehicles in different scenarios

Mode	Average ICE Vehicle Cost (INR)	Average E vehicle Cost (INR) without FAME Subsidy	FAME Subsidy (INR /KWH)	FAME Subsidy (capping)	Tentative subsidy amount	Price Parity Achieve by Year (OEM Feedback)
2W	50,000	1,59,000	15,000	40%	49,000	2030
3W	1,75,000	3,55,000	10,000	20%	80,000	2027
Car	5,00,000	17,00,000	10,000	20%	3,00,000	2032
Bus	65,00,000	2,40,00,000	20,000	40%	60,00,000	2032

OEM cost: For EV development and research

A. Converting ICE assembly line to EV

The cost of remodeling of ICE factory to EV factory has been estimated based on the volume of EVs that OEMs plan to build in their existing facility.

Special considerations:

- Based on the consultation with OEMs, it is considered that 25 per cent of E2Ws and 50 per cent of other modes, including E3Ws, e-cars and e-buses, shall be built in existing ICE factory until the 2030 horizon.
- Remodeling cost per unit: Rs 2.5 lakh for two- and three-wheelers, Rs 5 lakh for cars and Rs 1 lakh for buses has been assumed based on the market understanding.

Based on the above, total cost for remodeling the existing ICE factory to EV facility has been estimated at approximately:

- Industry recommended ZEV target: 87 crore
- Optimistic ZEV target: 196 crore

Details of both the cost estimates are provided below:

Table 11: Industry recommended ZEV target

Vehicle category	Annual EV production	Daily EV production per shift*	Percentage of EV built in existing ICE factory	Daily EV production in ICE factory per shift	Cost of remodeling per unit (In INR)	Total cost of Remodelling (in lakhs)
e-2W	1,00,00,000	11,111	25%	2,778	2,50,000	6,945
e-3W	5,94,000	659	50%	330	2,50,000	825
e-Car	3,24,000	360	50%	180	5,00,000	900
e-Bus	20,000	22	50%	11	1,00,000	11
						8,681

*Considered 300 production days in a year and production continues round the clock in three 8-hours shift.

Table 12: Optimistic ZEV target

Vehicle category	Annual EV production	Daily EV production per shift*	Percentage of EV built in existing ICE factory	Daily EV production in ICE factory per shift	Cost of remodeling per unit (In INR)	Total cost of Remodelling (in lakhs)
e-2W	2,00,00,000	22,223	25%	5,556	2,50,000	13,890
e-3W	8,31,000	923	50%	462	2,50,000	1,155
e-Car	16,22,000	1802	50%	901	5,00,000	4,505
e-Bus	33,000	36	50%	18	1,00,000	18
						19,568

*Considered 300 production days in a year and production continues round the clock in three 8-hours shift.

B. Research and development

OEMs need to invest in R&D to develop new EV models and bring innovations in vehicle design. R&D cost has been assumed as 0.5 per cent of the total sales cost/ consumer cost for purchasing EVs. Thus, R&D cost for different ZEV targets are as follows:

- Industry recommended ZEV target: 1,866 crore
- Optimistic ZEV target: 5,219 crore

Thus, total OEM cost, including cost of remodelling ICE factory to EV and R&D shall range between 2,000 to 5,400 crores or 0.26 to 0.72 billion US dollars depending on targets.

Supporting consumer cost: To purchase EV

Cost to consumers has been estimated on the basis of the amount the government has to spend as a purchase incentive for EVs.

The Government of India is providing financial support to buy EVs through its FAME scheme. The support amount depends on the battery size of the EV. As per the FAME 2 scheme, support is limited to up to 10 lakh 2-wheelers, 5 lakh three-wheelers, 55,000 cars and 7,090 buses, till 31 Mar 2024.

Special considerations:

- The consumer cost has been calculated assuming, like the present FAME scheme, similar number of vehicles (means 10 lakhs two-wheelers, 5 lakh three-wheelers, 55,000 cars and 7,090 buses in between 2025–30), shall be subsidized till 2030 to support potential EV buyers to meet the price differentials between the EV and ICE vehicles for industry recommended ZEV target scenario.
- Whereas, in optimistic ZEV target scenario, the cost has been calculated assuming the coverage of the FAME incentive shall be doubled (i.e., 20 lakhs two-wheelers, 5 lakh three-wheelers, 1.1 lakh cars and 14,180 buses).

Based on the above, consumer cost for purchasing new EVs has been estimated:

- Industry recommended ZEV target: 6,786 crore (USD 0.9 billion)
- Optimistic ZEV target: 13,571 crore (USD 1.8 billion)

Cost for setting up charging infrastructure

Other than the above costs, the government also has to build the necessary EV ecosystem to make the mandate successful. A broad estimate suggests that to support the kind of targeted penetration between 2025–30, India may require around 32 lakh chargers for industry recommended ZEV target, whereas for the optimistic scenario the numbers get more than doubled to 70 lakh. Cost to set these chargers will vary from around 18,000 crore to 70,000 crore.

Table 12: Cumulative number of chargers requird in different scenarios

Vehicle category	As per industry recommended ZEV target		As per optimistic ZEV target	
	Cumulative number of chargers required between 2025-30 (in lakhs)	Total cost of setting up chargers in between 2025-30 (in Cr.)	Cumulative number of chargers required between 2025-30 (in lakhs)	Total cost of setting up chargers in between 2025-30 (in Cr.)
e-2W	27.73	4256	55.46	8514
e-3W	1.65	80	2.32	112
Car	2.56	11560	12.79	57799
Bus	0.20	2079	0.34	3465
Total	32.14	17,975	70.91	69,890

SECTION 8: ZEV mandates and targets: Global experience

Governments worldwide have announced aggressive electrification goals, with many nations targeting a 100 per cent electric vehicle share in the 2020–50 timeframe. These markets are increasingly adopting targeted ZEV regulations to accelerate the rate of deployment. Such targeted regulations are in addition to policies supporting consumer incentives, charging infrastructure deployment, and other financial and nonfinancial incentives.

Lessons from the US, Europe and China highlight the importance of this strategy. California, for instance, uses an annual percentage share of production system that wins automakers ZEV credits. This is usually supported by a ZEV credit trading mechanism that encourages manufacturers which do not produce EVs to purchase excess ZEV credits from a competitor, and plan for production in the long run. A ZEV credit trading mechanism can bring in even those manufacturers who do not produce EVs into the fold; they can purchase excess ZEV credits from a competitor, and plan for production in the long run. The policy design exercise, therefore, has to be a combination of target, mandate- and incentive-based strategies.

A credit trading mechanism could provide an incentive to manufacturers to not only build EVs to win ZEV and emission credits, but also look forward to a fresh revenue stream from banking and trading over-compliance credits.

Automakers that do not build electric vehicles could buy surplus ZEV credits from those who do in order to avoid penalties. Automakers have the opportunity to offset credit requirements by overreaching GHG emission targets or winning over-compliance credits, thus boosting manufacturer commitment. Banking and trading surplus credits is common in the US and China. Manufacturers with little or no electric vehicles in their inventory resort to buying surplus credits in order to avoid penalties. Credits, however, have expiry dates, typically three years from the date of issue and they cannot be traded across segments. For instance, a car manufacturer can buy credits only from another car manufacturer and not a two-wheeler manufacturer. Credit deficits could invite penalties with its proceeds being channelized for EV awareness programs.

A mandate-based strategy is effective as it provides certainty around the outcome and will encourage investors with strong signals and also provide flexibility to the industry to develop plans to improve upon and achieve targets.

Manufacturers can qualify for ZEV program credits based on vehicle performance aligning with the FAME eligibility scheme for demand incentives. The performance parameters can cover electric vehicle range, energy density and power consumption for BEVs; and range and power of fuel cell for FCEVs.

Besides, a mandate is also a revenue neutral strategy for the government as it leverages market competition to promote a cost-effective roll-out of ZEVs. It can free up government capital for other equally important initiatives such as EV promotion, charging infrastructure, parking and road use incentives.

The right mix of incentives and funding support frameworks will encourage a competitive environment for innovation that can help India work towards securing a place in the global automotive value chain.

Linking energy efficiency and range with the ZEV mandate will ensure that low emissions and higher calibre vehicles will receive higher credits. Non-compliance with criteria for the vehicles should attract lower credits that can neither be banked nor traded.

With such a program, the product portfolio can diversify and technology can evolve more rapidly. Both national and state governments can specify mandatory quotas for segment-wise ZEV sales that will have to be complied with. Incentives can be designed to reduce manufacturing, operating and administrative costs.

Two-wheelers and three-wheelers can have a segment-wise, manufacturer-wise target much like four-wheelers, calculated using an increasing order of stringency. Two- and three-wheelers can be focus areas for ZEV mandate implementation considering their emission burden.

The government can therefore play the role of a facilitator by setting targets and timelines—for electric vehicle production and fuel efficiency. These targets should be ambitious and achievable at the same time. India has already experienced the impact of low targets with fuel efficiency. It leaves no incentive for companies to outdo it. Avoiding low targets could boost the process and help accomplish goals.

Linking energy efficiency and range with the ZEV mandate will ensure that low emissions and higher calibre vehicles will receive higher credits. At the same time, energy density of the battery should be prioritized over battery size and range of the vehicle, to promote battery technology advancement in the future. Non-

compliance with criteria for the vehicles should attract lower credits that can neither be banked nor traded.

In Europe, each automaker has a specific CO_2 emission target, which is aligned with the larger annual target across Europe and will have a discount ratio from 2025 onwards if the manufacturer is producing electric vehicles. The strategy, however, found traction only after the emission standards were tightened to values that drove the automotive industry to produce ZEVs. It offers flexibility to the industry to develop plans to improve upon and achieve targets. However, it is incumbent upon the government to set targets and timelines that are ambitious yet achievable. Low targets do not provide an incentive for companies to exceed it.

A mandate offers financial stamina too. It can be revenue neutral for the government, whilst providing car manufacturers the confidence to invest in manufacturing ZEVs in the country. It can harness market competition to promote a cost-effective roll-out of ZEVs, and can also free up government capital to be used to expand policies that promote market enablers such as charging infrastructure, parking and road use incentives.

In India, central and state-level EV policies are focused mainly on the demand side. Supply-side interventions such as ZEV mandate would be an important strategy to realize the expected EV penetration and break the EV conundrum.

Notable ZEV mandates

Implementing the ZEV mandate will force manufacturers to sell a certain proportion of electric vehicles in the total sales. ZEV instruments have been used in certain states in the US and in other countries to promote technological advancement in EVs and drive the EV demand.[10]

Two notable examples of implementing ZEV mandates are in California and China, where such mandates require manufacturers to put more ZEVs on the market.

California adopted its ZEV mandate in 1990 and has regularly updated the regulation to accommodate changing market conditions, technology readiness and evolving goals. Several other US states have joined California in adopting the ZEV mandate and collectively with California are called “ZEV States”.

The ZEV mandate requires automakers to deliver a minimum number of ZEVs for sale each year (the required number is based on the total number of vehicles they sell) or face compliance fines ($5,000 for every ZEV they do not produce). The

condition is a credit requirement; when original equipment manufacturers produce a ZEV, they receive credits which they can use to meet their requirements. OEMs can bank excess credits to use in later years to meet their growing requirement or sell them to other OEMs. For example, Tesla (which only produces BEVs) can sell all of its credits to other OEMs.

China's Ministry of Industry and Information Technology issued its New Energy Vehicle (NEV) Regulation in September 2017. The Chinese government mandated automobile manufacturers to manufacture or import 10 per cent of their automobiles as electric vehicles by 2019.

This was further increased to 12 per cent in 2020, resulting in more than 30,000 vehicles being imported into China. Manufacturers were allowed to bypass the mandate if they purchased credits from other companies that surpassed their quotas (see *Table 13: Zero emissions mandate in California and China*).

Table 13: Zero emissions mandate in California and China

	California ZEV Mandate	China NEV Program
Target OEMs	Sells more than 20k vehicles per year	Sells more than 30k vehicles per year
Mandate	7% in 2019 9.5% in 2020 7-12% by 2025	10% 2019 12% 2020 20% 2025
Credit per vehicle sold	0.4 to 4	1 to 6

Key impacts of implementing ZEV mandates

The key findings from the California ZEV mandate study are summarized below:

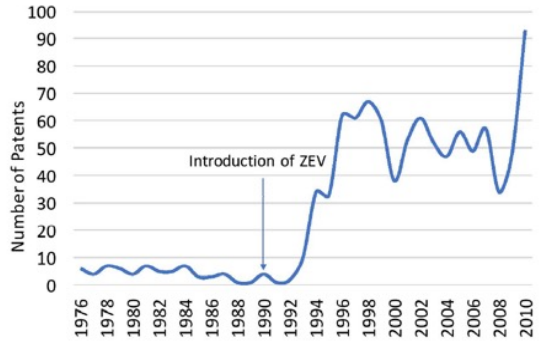
- The California ZEV mandate appears to have met its goals of accelerating industry investment in ZEV technology, discouraging industry procrastination, establishing initial supply chains, and signalling to the many governments that they should be engaging sooner with such targets to facilitate a quick transition to ZEVs.
- The California ZEV mandate appears to have met its goals of accelerating industry investment.
- Regions without ZEV mandates may want to consider implementing such regulations to accelerate the transition to ZEVs.
- The study shows that a stringent ZEV mandate has the potential to reduce greenhouse gas emissions from passenger transport.
- Several researchers have found that California's ZEV mandate has effectively influenced how automakers expedited technology innovation activities, leading to increased patent filing, the development of vehicle

prototypes for new models, and private companies forming partnerships.

- The research has also found that US states with a ZEV mandate tend to have a greater number of ZEV models available and higher ZEV sales than other regions.
- A North American modelling study found the potential long-term effectiveness of a ZEV mandate on ZEV passenger vehicle sales. It is important to note how a ZEV mandate may interact with other ZEV-supportive policies.
- Another finding from the study is that although a ZEV mandate regulation does appear to have higher social welfare costs than a carbon tax, it may be more politically acceptable in most regions and more likely to send a clear transformative signal to the industry.

While the data for China is not available, scholars from UC Davis have researched the impact of implementing ZEV mandates in California. The research findings indicate an association between increased ZEV sales and the presence of a ZEV mandate, though it is difficult to determine causality. Empirical research findings show that the ZEV mandate in California has had a positive impact on innovation activity with original equipment manufacturers increasing research and development, forming partnerships, and filing electric vehicle related patents. (see *Graph 13: Number of EV-related patents filed in California*).

Graph 13: Number of EV-related patents filed in California



Source UC Davis

The California ZEV program certifies passenger cars, light-duty trucks and medium-duty vehicles as ZEVs if they produce zero exhaust emissions of any criteria pollutant under all possible operational modes and conditions. Since credits are connected to the vehicle technology type and the range, ZEVs can go on a given recharge/fuel-up (higher the range or better the battery, higher the credit). Eligibility for over 3 credits per vehicle acts as an incentive.[11]

Given that, policymakers need to carefully plan a ZEV mandate and study how it interacts with other policies, regulations and initiatives to avoid duplications or conflicting policy mechanisms, reduce disruptions, and help build the larger ZEV ecosystem to promote investments and drive technology innovation.

While the focus of the electrification program in India is still prominently on the two- and three-wheelers category, this is followed by passenger cars in the four-wheeler section. A similar hierarchy is seen under the food vehicle segment, with electric three-wheeler delivery modes rising in number rapidly over four-wheeler freight.

In any ZEV program in India, it is imperative to balance the scales and focus equally on all vehicle segments owing to the larger population they cater to. This will make the India ZEV program unique with a scale up approach by gradually expanding on modes.

While FAME II prioritizes in terms of financial allocation, a ZEV mandate can be infused in a phased manner with focus on all associated interventions. Further looking at the current EV transition experience, such a mandate can be considered starting from the lower segment and moving upwards to ensure intended results and climate action goals.

Way forward

For India to fulfill its global pledge of 100 per cent electrification in the time frame of 2030–40, or to move towards NITI Aayog's aspirational target of 76 per cent electrification by 2030, several policy instruments will have to be strengthened and that will also require inclusion of regulatory targets for time-bound fleet electrification and ZEV mandate for the vehicle industry.

It is necessary to decide the target for ZEV mandate up to the year 2030 based on the EV demand forecast and feedback from OEMs and other stakeholders. This needs to be implemented in a phased manner from 2025 to 2030 with a gradual increment. With wider adoption of electric vehicles in the two-wheeler and three-wheeler segments, and targeted increase in four-wheeler and bus segments, the prospect of realizing the optimistic scenario improves. The stakeholder consultation shows that the industry would prefer to have a minimal approach to setting the mandate, though many of them expect higher market penetration in the next few years.

The ZEV mandate needs to be implemented in a phased manner from 2025 to 2030 in India. The government needs to initiate a dialogue with the industry and start the consultation process to arrive at a consensus to implement this program.

If the industry's specific observations on the intended mandate are considered, a lower-bound target would be preferred. This minimum industry intended scenario that can be derived from the OEM consultation is outlined as 25 per cent target for two-wheelers, 50 per cent for three wheelers, 5 per cent for four-wheelers and 15 per cent for buses by 2030. More optimistic ZEV target scenario can aim for 50 per cent two-wheelers, 70 per cent three-wheelers, 25 per cent four-wheelers, and 25 per cent buses. If implemented, this can add up to achieve at least 47 per cent EV penetration across these categories by 2030.

The ZEV mandate needs to be designed and notified with all the critical parameters. This needs to address the ZEV coverage to include all EVs and fuel cell vehicles, while plug-in hybrid vehicles and strong hybrid electric vehicles can be eligible with lower credit points. OEMs need to be graded across the vehicle segments annually based on the sales volume in respective vehicles categories. Small volume OEMs can be given waiver if needed. ZEV credit scheme needs to be introduced so that each OEM meeting the ZEV threshold criteria can earn credits based on the estimated savings on emissions. Saving calculations need to be standardized through a transparent tool. OEMs not meeting the threshold credit targets could be penalized as per a predefined criteria. Credit valuation mechanism and credit transfer or trading scheme also need to be introduced.

The ZEV scheme will require multiple measures including strengthening of incentive scheme for demand creation, implementing ZEV mandates as a supply focused policy package and support for EV supply chain.

To meet the growing EV demand and to meet the required ZEV mandate, OEMs need to develop new products, recalibrate their business processes for continuous transformation with technology advancement, and reskill their workforces with new technologies.

For successful implementation of the ZEV targets and mandate, it is necessary to promote a strong funding strategy. NITI Aayog has recommended financial instruments such as priority-sector lending and interest-rate subvention, creating better partnerships between OEMs and financial institutions by providing product guarantees and warranties, and a developed and formal secondary market

to improve the resale value of EVs and improve their bankability. This requires innovative financing models.

ZEV mandates can be further enabled by driving demand through other means at the city level. This may include designation of low emission vehicles zones, preferential or discounted electricity rate structures for charging ZEV, reduced toll tax for ZEV, preferential and complimentary parking access for ZEV in public parking areas, among others. In fact, several state-level policies have included some of these strategies but they require stringent implementation.

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