POLICY BRIEF

THE CASE FOR ELECTRIC

Building scale and speed for zero emissions mobility

Authors: Anumita Roychowdhury, Moushumi Mohanty and Shubham Srivastava

Research contribution: Sayan Roy and Anannya Das

Editor: Akshat Jain

Design: Ajit Bajaj

Layout: Kirpal Singh

Production: Rakesh Shrivastava and Gundhar Das

Maps are not to scale.

Citation: Anumita Roychowdhury, Moushumi Mohanty and Shubham Srivastava 2021. *Policy Brief: The case for electric—Building scale and speed for zero emissions mobility*. Centre for Science and Environment, New Delhi

Published by

Centre for Science and Environment
41, Tughlakabad Institutional Area
New Delhi 110 062
Phones: 91-11-40616000
Fax: 91-11-29955879
E-mail: sales@cseinida.org
Website: www.cseindia.org

POLICY BRIEF

THE CASE FOR ELECTRIC

Building scale and speed for zero emissions mobility

Contents

1. Why this study?

A global shift is underway from petro-economy to electro-economy. This is expected to gather momentum as countries move towards net zero climate goals to stabilize global temperature rise below 1.5 °C. This is also expected to contribute towards clean air and public health goals. Close to 126 countries have already pledged to achieve carbon neutrality by 2050, and the total net-zero commitments globally cover half of the world's gross domestic product. Towards this decarbonization goal, about 20 countries have already announced targets of 100 per cent zero-emission vehicles (ZEVs) and phasing out of internal combustion engine (ICE) vehicles in the time horizon of 2040–50. More countries are to follow. This scale of change can be hugely disruptive and will also impact India's automotive market. But what is happening in India?

International Energy Agency (IEA) estimates that if the global market has to stay on course towards decarbonization, the electric vehicle (EV) stock has to jump from around five per cent of global car sales in 2020 to more than 60 per cent by 2030. And to match this, annual battery production for EVs needs to leap from 160 gigawatt-hours (GWh) today to 6,600 GWh in 2030, which is like adding almost 20 gigafactories each year for the next ten years, and increasing the public charging points from around 1 million today to 40 million in 2030. This rapid scale of change is expected to unfold this decade. Global automotive companies have started to respond to the regulatory pressures in major markets to announce commitments to produce 100 per cent electric vehicles by 2040.

This global scale of change in major vehicle markets of the world signals the inevitability of this change. There does not seem to be an option of not doing it. Can India therefore afford to remain insular and conservative in the face of such a tectonic shift? While the environmental and public health reasons for this change towards ZEVs are non-negotiable, the economic reasons for attracting and retaining the new investments in the sector with other spinoffs are equally compelling. This cannot be ignored anymore.

India has always remained a laggard in the internal combustion engine trajectory and has struggled to keep pace with and to catch up in the vehicle technology race. India has leapfrogged to Bharat Stage (BS) VI emissions standards for ICE vehicles only recently, with substantial gains in emission reduction. But this has now brought in newer concerns around lifetime emissions performance of vehicles in the real world requiring more expensive and complex engineering solutions. The next round of revision of emissions standards and test procedures will be even tougher.

Electrification opens up new opportunities for India to not only lead the market, but also to meet its decarbonization and clean air goals. India has to meet the national ambient air quality standards under the National Clean Air Programme as well as step up its obligations under Nationally Determined Commitments (NDCs) to go beyond the target of reducing energy intensity by 30–35 per cent by 2030. At the same time, a growing crude oil import bill and resultant rise in current account deficit is yet another push factor. Bending the rising emissions curve in the transport sector continues to remain a critical challenge.

The inevitability of the zero emissions pathway will have no room for incremental change. Therefore, this will require a convergence of environmental policy as well as industrial policy to prepare for the big change.

Yet, despite the different policies and incentive programmes related to electric vehicles taking shape, there is no long-term policy visibility of the zero emissions target for the country to drive the change. From time to time, ministerial level announcements have been made to express the policy intent of achieving 30 per cent electrification of new vehicle fleet by 2030 for zero emissions transformation. NITI Aayog in 2019 had set the 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. But this intent is not backed by any regulatory mandate and long-term policy milestones to bring certainty into the market.

Without the regulatory target, automotive industry's voluntary targets have also lost steam. Society of Indian Automobile Manufacturers (SIAM) in 2019 had put out its own roadmap that aimed for all new vehicle sales for intra-city public transport fleets to be pure electric vehicles by 2030; and 40 percent of new vehicle sales to be pure electric vehicles by 2030. Finally, all new vehicle sales were to be pure electric vehicles by 2047.

Even though the electric vehicle policy development goes back to the early part of the last decade, there is no evidence of ground level transformation yet. India's original target was stated in its National Electric Mobility Mission Plan (NEMMP) of 2013 that targeted to have least 60–70 lakh electric vehicles by 2020. But that has remained a non-starter with a little over 6 lakh electric vehicles on ground by 31 March 2021, according to data released by the Ministry of Road Transport and Highways (MoRTH) on their VAHAN Dashboard.

Several policies are taking shape in India today at both central and state levels to incentivize electric vehicles under Faster Adoption of (Hybrid &) Electric Vehicles (FAME) schemes to make them affordable, to improve price parity with ICE vehicles and thus stimulate demand, to target large scale fleet conversion (public transport, delivery fleet, ride hailing, etc.), to provide production linked incentives to encourage local manufacturing to build local supply and value chains around electric vehicles, to build a battery ecosystem and support charging infrastructure, to source raw material for battery cells, and to design financing strategy. In addition, 15 state governments have drawn up electric vehicle policies.

But these are not adding up to build the market yet. The VAHAN database reveals that a substantial portion of the 6 lakh units comprises e-rickshaws that have expanded significantly without regulatory and pricing support in the unorganized sector. Their low acquisition costs and low life cycle costs are largely responsible for this expansion. Even though the electric vehicle growth rate has picked up in India, that is from a very small base and the quantum of vehicles sold each year, compared to conventional ICE vehicles, is miniscule. The market share for each segment is very small.

1.1 EV adoption programmes not designed for scale

If it is assumed that each vehicle segment will achieve the 30 per cent target by 2030, the current market share falls woefully short of that benchmark. Currently, electric two-wheelers (E2Ws) hold a mere 0.15 per cent of the market share, private electric four-wheelers (E4Ws) are at an even lower 0.02 per cent, electric buses are at 0.16 per cent, and electric goods vehicles are at 0.1 per cent. This is the yawning gap that the policies will have to bridge quickly to be able to achieve the policy intent of 30@30 by the end of this decade.

This will require the electric vehicle segment-wise growth rate to pick up quickly. According to a CSE study, to be 30@30, the average CAGR will have to be maintained at a minimum of 46 per cent of the current market share throughout the period. This is more or less in line with the growth rate that was observed during FY 2012–19 when the EV sector had an average CAGR of 45 per cent. But then the market was growing from a very small stock. Now it will become more challenging to grow at this rate or more as the numbers increase exponentially year after year.

Compare this with the current FAME incentive scheme with a corpus of Rs 10,000 crore that has been designed to support only about 15.6 lakh vehicles, including 10 lakh two-wheelers, 5 lakh three-wheelers, 55,000 passenger cars and 7,000 electric buses. This is too small and cannot have a catalytic effect for the bigger transition.

Not only is the target for support small, but FAME II had registered only about 6 per cent of the planned fleet target as of July 2021; with total sales of 94,252 vehicles—73,753 two-wheelers, 18,900 three-wheelers and 1,598 four-wheelers. This does not build confidence for scale. A segment-wise split of FAME II incentives allocated to electric vehicles till 2022 show 35 per cent will be spent on electric buses, followed by 25 per cent on electric three-wheelers including e-rickshaws and 20 per cent on electric two-wheelers. Thus E2W and E3W account for more than half of the FAME subsidy package. Charging infrastructure and four-wheelers come fourth and fifth in the pecking order.

The time horizon of FAME implementation is also uncertain with no longer term visibility of the future strategy for the incentive programme. Originally, the FAME II programme was expected to last until 2022. Due to pandemic conditions and underutilization of the fund, this has been extended until 2024. But this only extends the current unfinished programme without adding to the ambition and target or indicating the next steps post FAME II.

India's ZEV roadmap is not designed for scale and rapid penetration yet to enable at least 30–40 per cent transformation of the vehicle market nation-wide by 2030. There is enormous demand-supply gap, grossly inadequate charging infrastructure, and lack of clarity about the next steps towards transitioning to ZEVs. To achieve even 30 per cent ZEV sales by 2030, it will require tremendous effort and discipline to define and implement milestones according to a definite timeline. Institutions at the central and state levels will require properly delineated responsibilities to build ambition and also prevent delays. The role of state level policies in accelerating the growth rate is yet to unfold.

Is there a blue print to achieve this rate of change and build volumes or have a stronger ambition for electrification? Is it possible to achieve such a high growth rate without a regulatory mandate and a more holistic eco-system approach? Either a conservative target of 30@30 or higher ambition of 70 per cent as set by NITI Aayog requires clarity about the intermediate milestones to be implemented all along the way for the processes and systems to propel the change.

1.2 Summary of policy accelerators and way forward

Centre for Science and Environment has carried out a review of the status and progress of the key policy instruments that have been designed for electrification to identify the challenges and gaps and to suggest the way forward.

While the policy efforts to promote electric vehicles are not yet showing up in real numbers on road, several policies that are expected to act as accelerators have begun to take shape. This makes it necessary to understand the gaps in the current strategies that are weakening the impact of the policies.

The policy architecture needs to be reformed to address a range of issues from high costs to lack of e-vehicle models and charging infrastructure. The framework includes tax incentives, interest subvention on loans as well as support for charging infrastructure, EV charging protocols, facilitating EV charging services, capping of EV tariff for charging infrastructure, modifying Development Control Regulations and building codes for EV charging, and green license plates for EVs to further support the ecosystem. After the recent market disruption due to the pandemic, production linked incentives have been framed to support battery manufacturing for the EV industry. However, even six years after the FAME program was implemented, none of the EV manufacturing units have achieved scale economies.

At the same time, the EV transition is creating a new ecosystem and catalysing industry restructuring. Nearly every segment has witnessed considerable restructuring of the industry as new experiments with new business models are evolving. Simplicity of the EV technology has enabled entry of new players, a lot of whom were not in the automotive business earlier. This group is free from the legacy challenge of the ICE vehicles. While this is noticeable across all segments, two-wheeler segment has witnessed the maximum influx of new players and more product development. There are 20 manufacturers with 41 E2W models in the market. Only three out of the seven conventional ICE two-wheeler manufacturers have introduced products in the electric segment, while the 17 new companies form 84 per cent of the sector.

The response of the traditional original equipment manufacturers (OEMs) who are well entrenched in the ICE manufacturing industry is comparatively more rigid and slow. Start-ups and non-conventional players are moving more aggressively with innovative business models. A similar trend is playing out in the bus sector. The charging infrastructure is also catalysing new investment and private business. The start-up economy might find it harder to push the pathways when interest of the ICE industry is still overpowering.

In this context, it is necessary to understand the course correction needed to build strong ambition for the transition.

1.2.1 FAME incentive schemes: What must change?

The key strategy so far has been to leverage the instrument of demand incentives to build the EV market. India has gained enough experience with its FAME incentive schemes to assess further reform needed to make it more effective. It is now well understood that FAME I scheme that started in 2015 had limited impact on electrification due to poor design and lack of focus. FAME I had started two years after NEMMP with only five years to achieve its 2020 target of 60–70 lakh e-vehicles. Most of the incentive was diverted towards mild hybrids and it promoted vehicles without setting performance criteria—even fuelled by lead-acid batteries. Resources were also spread too thin among the segments.

FAME II made a strategic shift by prioritizing high performance vehicle models using a quality certification for incentives. Buses, three-wheelers, high-mileage commercial delivery and ride hailing fleet got special attention. Two-wheelers, being a dominant part of Indian fleet, were also included in the priority list.

However, as the 2021 WBCSD study noted, two-thirds of the intended FAME II scheme duration has elapsed (as of March 2021), but a significant portion of the fund remains underutilized (as of April 2021). Recently, government has extended the same FAME II scheme for another two years to utilize the unspent money. Thus, not only the scope of the programme is small but even what is available is not being absorbed by the market. This requires rethinking.

Different vehicle segments getting FAME support have different stories to tell. But there are some issues that are uniformly applicable to all vehicle segments. For instance, linking demand incentives with battery size (per kWh) runs the risk of reduced support for more efficient batteries. As battery technology develops, the batteries will shrink in size and improve in energy density, which effectively translates into higher range by as much as 20 per cent and also higher lifespan, along with being smaller in size. The currect Fame scheme thus runs the risk of deterring advancement in battery technology for future electric vehicles in India.

FAME and electric two-wheelers: NITI Aayog, in its ambitious target for 2030, has aimed for 80 per cent electrification of electric two-wheelers. These vehicles are also expected to achieve price parity quicker. There is also considerable optimism in the industry about the scaling up.

Initially, FAME I scheme had allowed cheaper, low-speed and low range scooters with lead acid batteries to invade the market. But this was corrected under FAME II scheme that laid out performance criteria requiring a minimum range of 80 km per charge and minimum top speed of 40 kmph while defining energy efficiency, minimum acceleration, and higher number of charging cycles. It also disallowed lead acid battery-powered scooters.

FAME II has lowered upfront costs and improved price parity to build demand. With the recently enhanced FAME II subsidy, the upfront cost can be reduced by an average of 35 per cent. In fact, if the FAME II incentives and incentives under Delhi government policy are combined, it can shave off an average of 57 per cent from the on-road price of the vehicle models in Delhi, achieving significantly competitive prices in comparison to popular petrol two-wheeler models.

But this alone may not accelerate the market to meet the ambitious target of 80 per cent set by NITI Aayog. It needs to be backed up by local ecosystem support in cities. This segment has now seen more innovation in business models in terms of ecosystem approach in which the manufacturers provide charging solutions around their products and have platforms for their users to provide longer term solutions. This segment is likely to reach the tipping point for scale much quicker if strategies are refined and supported. Already, sales are picking up to counter the high petrol prices.

FAME and electric cars: FAME II is not oriented towards personal vehicles as it has prioritized electrification of high mileage public transport and commercial vehicles. Very limited subsidies are available in the personal car segment. Lack of support and slow growth have stymied this market. Less than 10 vehicle car models are available in the market with range varying between 140 km to upto 300+ km. Most variants have a top speed of 80 kmph. Moreover, a depleted battery needs replacement which is also expensive. It is expected that as the battery economics improves, manufacturers will be able to pack even higher ranges into smaller batteries to increase consumer interest.

While FAME II subsidies are not available for personal cars, Delhi electric vehicle policy has allowed subsidy for e-cars. Waiver of road and registration tax is added to this. If all these incentives at the city level are combined, upfront price of the vehicle models can be reduced by an average of 19 per cent, though several models continue to be slightly higher priced than their petrol counterparts.

It is also important to note that to achieve 30@30 or stronger targets, cars will have to be part of the agenda. An ICCT estimate shows that of the total cumulative battery capacity needed in 2030 to support this target, the share of passenger cars will have to be at least 31 per cent. More ecosystem support, tax waivers, non-fiscal preferential incentives, reliable charging network and facilities, and initial support for a targeted fleet can help to build the e-car market. Consumers will also require stronger ecosystem support. Currently, lack of competition and a low fleet volume have dampened the e-car market as well as the import substitution efforts.

Moreover, the recent controversy in Delhi over Tata Nexon model falling short of consumer expectation of the promised range leading to disqualification of the model from the city's incentives signals the need to improve test procedures for vehicle certification and adoption of more exacting driving cycle to reduce the gap between the certified range and on-road performance.

However, e-cars for commercial application are eligible for FAME II incentives. Incentives and tax exemptions for commercial car segment allows 32 per cent reduction in the upfront price of the vehicle, though several models continue to be slightly higher priced than their petrol counterparts. Currently, price of some models is higher than their petrol versions even with incentives while for some variants it is within the price range of its petrol counterpart.

While direct fiscal incentives can be a powerful tool to make vehicle acquisition affordable and enhance attractiveness for the consumer, the key to scale will clearly be a combination of OEM price, government support, product diversity and model availability, and charging infrastructure.

FAME and electric buses: The clear thrust of FAME II on electrification of public transport buses is an appropriate strategy to decarbonize urban commuting, especially given the fact that a majority in India use public transport. But, the target of 7,000 buses sanctioned under FAME II incentives is too small. Electrification of buses has to be combined with the larger bus augmentation plan of India that will not only help to decarbonize the segment but also achieve economies of scale. According to a report published by the Department of Heavy Industries, India could emerge as the second-largest e-bus market by 2030 if 4 out of 10 buses sold are electric. Therefore, allocation under the Union budget of 2021–22 for funding of 20,000 buses this year also requires targeted electrification.

Yet, real change on the ground is very small. While FAME I could get less than 500 buses registered, FAME II so far has seen tendering of 2,450 buses and a lot of it could not be procured under the pandemic conditions. In the meantime, state government policies are emerging—as in Andhra Pradesh, Kerala, Tamil Nadu, and Telangana—for targeted e-bus deployment supported by tax incentives, subsidy or special tariff on electricity, etc.

However, electrification of buses faced serious barriers during the pandemic as nearly all state transport corporations have suffered massive losses in ridership and revenue and this has increased the viability gap funding requirement by nearly 70 per cent. At the same time, disruption of global supply chain has slowed down bus manufacturing and procurement. A turnaround will require a clear bus funding strategy both under FAME as well as part of the Rs 18,000 crore bus funding for this year.

The upfront capital investment required for e-buses is more than double that of the ICE buses—battery and charging infrastructure add to the cost. Generally, capex needed for ICE is 20 per cent of its overall cost. But in the case of e-bus, it is almost 45–50 per cent. The total cost of operation (TCO) for operating one e-bus, even after subsidy, is almost equal to its ICE counterpart. This will have to further inform the financing and incentive strategy.

Though FAME II tried to address several limitations of FAME I, including coverage, promotion of cleaner technology, setting up clear deployment targets along with dedicated fund allocation, etc., there is still a lot of space for improvement.

One challenge of FAME II strategy for buses is that it is spread too thin across states, which dilutes its impact. From that perspective, the new amendment in June 2021 seeking a strategy of aggregating demand for e-buses (also three-wheelers) for deployment in cities is a step forward. Accordingly, Energy Efficiency Services Limited (EESL) will aggregate demand for deployment in nine mega cities of Mumbai, Delhi, Bangalore, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat and Pune. This will help to create a few EV growth centres and demand aggregation can reduce cost and present a learning curve to other cities. This will be supported by expansion in EV charging infrastructure.

E-bus industry has also witnessed balancing of the traditional OEMs and the new entrants. Until 2020–21, about 74 per cent of the total e-bus supply order has been received by new market players like Olectra-BYD, PMI-Foton, JBM-Solaris, among others. But the traditional bus OEMs such as Tata Motors and Ashok Leyland, who together dominate the ICE bus market at 81 per cent, only form 26 per cent in the e-bus market. However, Tata Motors is the second highest seller of e-buses.

FAME II has further changed bus procurement and operations with a mandate that e-buses be purchased pn a gross cost contract (GCC) basis. This requires OEMS or designated operators to provide the buses and also operate and maintain them on behalf of STUs. The buses have to be operated on a payment per kilometre basis that will help de-risk STUs. E-bus deployment under GCC model requires holistic planning of the system including identification of bus routes, depot infrastructure, quality of power supply, and tariff, as these have a considerable impact on the cost of the project. This is expected to reduce upfront costs while improving the efficiency of services. E-bus procurement has made the tender process more service oriented as STUs now prefer to specify their service needs instead of only specifying the details of the vehicles. This is an important strategy that needs to be strengthened.

However, there is a view emerging that this mandate of GCC model is forcing some public transit agencies to adopt a completely new bus operating model that may require substantial changes even in their organization structure to manage it. The bigger STUs with their own infrastructure and human resource in place may not find it practical to operate a small e-bus fleet on GCC model and the rest on their own. Further, there are very few operators in India that can be inducted under the GCC model. As many big STUs in India have the organizational strength to manage their services, an open FAME incentive structure may provide more flexibility to the STUs to choose the appropriate operational model for themselves. Operational model should be made flexible so that more capable STUs with better ecosystem support can organize their operations as per their need and local planning and strength. Incentives should be more flexibly provided based on technical and financial viability of the projects. The fact that this needs to be addressed is evident in the slow and repeated tendering process in several states. This has further slowed down e-bus procurement.

Moreover, FAME II is providing capital incentives of up to 40 per cent of total bus cost and the whole subsidy amount is supposed to be paid within six to seven months of bus operations. This does not allow much scope for service guarantees. This can be further reformed to provide support for a longer operation period of at least seven years, considering battery replacement requirement. This can make the cost of operations almost equal to low floor diesel services.

FAME II subsidy should also be designed to create more options for a combination of charging technology. Currently, e-buses with only conduction charging facilities dominate the market. It should also promote charging options for DC Pantograph charging or battery swapping or any other approach. It is possible to adopt battery lease model (in which responsibility of the battery and setting up charging infrastructure is given to a private partner) to reduce the high upfront cost.

FAME II incentives also need to acknowledge that e-bus deployment requires detailed planning before deployment and city level comprehensive fleet planning for routes and charging. City level e-bus deployment plans are needed to provide for e-bus oriented transit infrastructure including depots, terminals, bus stops, etc. The state should also proactively assist the power sector to improve grid capacity by providing subsidy benefits.

FAME and electric three-wheelers: The E3W is yet another segment that according to NITI Aayog has the potential for 80 per cent electrification by 2030. This low volume, high frequency and short haul transport system for last mile connectivity makes it an attractive option for quicker electrification.

Manufacturing of lithium-ion E3W models conforming to safety norms have started even though e-rickshaw models continue to operate in the unorganized sector. Major issues faced by E3W companies range from limited access to capital, perceptions about range and access to charging. Banks are reluctant to lend to start-ups engaged in EV manufacturing due to lack of awareness about EV technology and its associated risks. Moreover, the practice of daily rentals for E3W operations creates additional challenges for repayment of loans.

Total cost of ownership parity is expected to be easier for this segment. There are special challenges in the 3W market as most of the vehicles are held on daily lease. This makes financing and monthly repayment a challenge. The requirement for a public charging network is significant. Out of the 23 most commonly sold E3W models in India, 17 of them or 74 per cent of the models have a range equal to or greater than 100 km. However, only 30 per cent can run 120 km or more on a full charge. The top speed of only 9 per cent models exceeds the 25 kmph mark.

As part of an intermediate public transport strategy in cities, a targeted mandate for fleet electrification could be useful.

FAME II and electric cargo vehicles: This is yet another segment that has received considerable policy attention as these vehicles are part of the cargo and delivery fleets in cities. These are also high mileage vehicles and suitable candidates for targeted electrification. In this segment, customers look for vehicles with high-payload capacity, lower total cost of ownership, and the ability to operate in ambient temperature and road conditions.

To be able to deliver high payloads, commercial use requires uninterrupted running times, or, larger range, in addition to public charging facilities to ensure minimal downtime. The minimal availability of public charging stations continues to deter the adoption of electric vehicles despite the advantages of lower operating costs.

The low cost of ownership and operating costs of the electric cargo vehicles make it an attractive option for intracity cargo applications. A commercial electric vehicle operates on 1/6th of the running cost of a petrol/diesel-fuelled vehicle, though with higher acquisition costs. A TCO comparison for electric and diesel vehicles suggests that electric vehicles are more favourable than diesel above 30 to 35 km of daily use. Since most commercial cars have an average daily use of 200 plus kilometres, electric cars offer a better cost option.

Product development and mandate for targeted electrification is important for this sector.

Fleet aggregators and feeders: Increasingly, the focus is shifting towards scalable models for large-scale deployment to create concentrated demand for EVs. The high utilization segments that are being targeted for fleet electrification include ride-hailing, urban freight/deliveries, and employee transport. All of them use cars, e-bikes and three-wheelers in varying degrees. Uber, Ola among others dominate this market now.

On-demand mobility options such as ride hailing and ride sharing are marked by larger efficiencies in comparison to the traditional taxi industry as they can more appropriately predict, capture and optimize rides. Players mainly work with two differentiating factors—price and waiting time—to win competitive advantage. The use of e-bikes and auto-rickshaws is yet another strategic shift in this sector. A 2018 NITI Aayog report has proposed inclusion of bike sharing within the scope of shared mobility for low cost last-mile connectivity.

Emerging evidence shows that high asset utilization allows the fleet operators to recover the cost of buying, operating, and maintaining the vehicle much sooner, making electric mobility a profitable prospect. The total cost of ownership of the vehicle forms the basis for establishing the financial viability of such fleet operated projects.

Economic factors have facilitated a phenomenal increase in last-mile deliveries across urban e-commerce, food/grocery deliveries and couriers in tandem with the growth of digital retail markets. They are primarily assisted by service providers such as e-Kart, Delhivery, GATI and others to transition their ICE fleets to more cost- and environmentally-effective EV variants. Multinational companies such as Amazon and Ikea have set global targets to move to electric vehicle deliveries. The Delhi government has partnered with Flipkart, Amazon, Zomato, Blue Dart Express, and 26 other companies to start using electric vehicles for deliveries under a project called 'Deliver Electric Delhi'.

But this sector faces challenges in terms of limited EV options for heavier delivery vehicles, permit concerns related to cross-sector usage of the same vehicle, and licensing system of two-wheelers. To drive early adoption may also require management of last-mile urban freight and deliveries, and regulation of daytime entry of heavier electric delivery vehicles in cities for a time bound period to drive early adoption.

As part of four-wheeler regulation, the government has asked ride-hailing giants Uber and Ola to convert 40 per cent of their fleet to electric cars by 2026, according to a Reuters report in June 2019. This segment will require more nuanced approach at the deployment level in cities. Further incentives are possible in terms of differential fares between e-ride services vs ICE vehicle based services. Incentives can also be linked with e-kilometers based on odometer reading. Many countries have used parking as a strong tool for speeding up electrification among fleet operators. These include reserved parking spaces specifically designated for fleet operators, preferential parking permits, preferential parking rates, priority queuing and even allowing limited parking of EVs without obstructing safety or traffic in restricted areas where parking is not usually allowed. This category also has special needs to have access to overnight charging, home based and neighbourhood scale roadside charging with discount, support and preferential electricity rates.

Yet another strategy gaining ground is electrification of feeder services linked to metro systems. The Delhi metro plans to electrify its last mile connectivity. The facility is now available at 29 stations, with an operational fleet of over 1,000 e-rickshaws. For mass electrification to become a reality, what is required is a clearly articulated change model that can drive multi-directional growth and achieve extraordinary scale that matches India's ambitions.

ICCT's assessment of ride hailing systems in three cities—Hyderabad, Bangalore and Delhi—shows that with the current cost and incentive structures and without considering any additional incentives, some models are cheaper than the comparable diesel and petrol cars in terms of 5-year TCO and cost per kilometre. For some, the per-kilometre cost is only marginally higher than the comparable diesel and petrol cars. This varies across the three cities. If additional incentives are also considered, the cost differentials decrease further. In the meantime, the base price of models is also declining. This is an opportunity for the sector.

Overall, it is necessary that all fleet aggregators sign an agreement with the service providers and commit to targeted electrification in a time bound manner. Delhi, for instance, is bringing in a new scheme to ensure that all ride hailing and delivery aggregators will convert 25 per cent of their fleet to electric within one year of the notification of the proposed scheme and 50 per cent in the subsequent year. Such an approach needs to be scaled up across all sectors.

Need disincentives for internal combustion engines: Reviews of global good practices have borne out that while designing aggressive and effective long-term incentive programme to catalyse demand and supply of EVs, it is equally important to disincentivize internal combustion engines (petrol and diesel) with tax measures, pricing policy, non-fiscal measures, or specific segment oriented phase out plans to improve competitive position and opportunities for the EVs. This has been widely practiced in Nordic and Scandinavian countries, and elsewhere in Europe, as well as in China. India also needs to design such a programme.

1.2.2 Need zero emissions mandate in India

The low levels of adoption of electric vehicles is attributed to low model availability, inadequate charging facilities and insufficient promotion of the new technology, apart from a skewed cost-to-benefits ratio. But electric vehicle production deficit can be addressed with a target and mandate program, a strategy that has offered considerable gains in other electrified vehicle economies.

A ZEV mandate could ensure a robust supply side with larger model availability guided by market economics that could lead to larger adoption. India could draft in such strategies from other electrified countries to meet its objectives in electric mobility. Lessons offered by the US, Europe and China include a combination of criteria whose compliance is built into permissions to sell automotive output.

The first step towards achieving this end can be a countrywide target to achieve larger percentages of electrification in a roadmap leading up to the target. Once the target has been formally defined, it can become the foundation for a definitive roadmap that can 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. In addition, 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.

A ZEV credit trading mechanism can be a powerful tool. It can even bring in manufacturers that 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 targets and mandate- and incentive-based strategies. 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.

The government can therefore play the role of a facilitator by setting targets and timelines—for electric vehicle production and fuel efficiency— targets that are 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.

Besides, a mandate is also a revenue neutral strategy for the government as it harnesses 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.

Incentive-based strategies that can help producers and consumers overcome cost barriers are already in place to an extent, but they require further tweaking to generate investor interest. 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.

Manufacturers can qualify for ZEV programme 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.

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 which can neither be banked nor traded.

Banking and trading surplus credits are 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.

This strategy of mandates and targets is needed urgently to drive scale. There is already a lesson from the legal mandate for large scale CNG programme in Delhi that was driven by the Supreme Court directive in July 1998. This had asked for the entire public transport and para transit to move to CNG within a well-defined period and accordingly the mandate for its refuelling infrastructure was defined. That catalysed one of the largest CNG programmes in Delhi. Once the mandate was in place, it stimulated CNG bus manufacturing and gave other ancillary development a quick makeover. Mandates become necessary to enable penetration of new technology in the face of strong competition from the well-entrenched mainstream technologies like petrol and diesel.

1.2.3 Leverage fuel efficiency regulations to accelerate EV market

Yet another accelerator for electrification is the fuel efficiency regulation for vehicles. A strong benchmark can accelerate electrification of the vehicle fleet. Other countries have leveraged these regulations to fast pace electrification. Consumer interest in electric vehicles, especially two-wheeler and three-wheeler segments, is expected to be strong now with the spiralling petrol prices.

India has implemented fuel efficiency standards only for passenger cars so far and not for other vehicle segments including heavy duty vehicles, two-wheelers and other commercial vehicles. But the standards for the passenger cars are too lenient to make a difference and represent a lost opportunity. The first ever fuel efficiency standards for passenger cars, termed Corporate Average Fuel Consumption Standards (CAFC), were implemented in

2017–18. The stage 2 standards are scheduled for implementation in 2022–23. The stage 1 standard of 5.49 litres per 100 km or 129.8 gmCO_2/km and stage 2 standard of 4.77 litres per 100 km or 113 gmCO_2/km are to be enforced from 2022 onwards.

An assessment of stage 1 standards shows that all car companies have not only met the 2017–18 standards but have also exceeded this by a margin. According to an independent evaluation by International Energy Agency (IEA), average fuel consumption of new light duty vehicles sold in 2018 had overreached the target by 9 per cent that year. India has not only set weak targets that the industry can meet easily, but it has further weakened the targets by giving away super credits or extra points for ineffectual technological approaches like six speed transmission that normally all big and luxury cars use or tyre pressure monitoring that depends on driver's behaviour. Initially, even mild diesel hybrids were allowed super credits that were removed subsequently from the eligibility list. But weaker targets and super credit for ineffectual technology approaches do not help speed up electrification.

In comparison, a well-designed super credit system combined with stringent fuel efficiency norms can help speed up electrification of the fleet, as is evident in Europe. Despite having heavier vehicles—compared to low powered smaller cars of India—Europe has set the corporate fleet-wide average CO_2 standard at 95 gmCO_2/km in 2020–21 as opposed to 113 gmCO_2/km in India. This has accelerated electrification of fleet in Europe despite the pandemic-led economic down turn. Europe is now aiming to meet 60 gmCO_2/km for cars in 2030 that is equivalent to what most two-wheelers meet in India.

India needs to take immediate steps to further tighten and implement the efficiency standards not only for passenger cars but also for heavy duty vehicles and two-wheelers.

1.2.4 Accelerating localization

As the market plummeted following the pandemic shock, the Government of India rolled out production linked incentive (PLI) programme to rebuild and support development of 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. It is also proposed to increase the import tax on battery cells from 5 per cent to 15 per cent after 2022. PLI provides incentives between 2–12 per cent of the incremental sales revenue and 4–7 per cent incremental exports revenue.

This is linked to the National Mission on Transformative Mobility and Battery Storage, 2019, to promote local manufacturing of the entire value chain related to raw materials, electrochemistry, and end-of-life treatment of cells, modules, and battery packs. The economies of scale are expected to lower the cost curve.

However, there are still broad concerns that could impact its take-off. First, a timeframe of five years is too short to drive adequate commitment from manufacturers. Given the size of the investment required for batteries (the PLI scheme defines Rs 225 crore for a 5 GWh plant) in an area of uncertain scale economies, evolving battery chemistries and high uncertainty about the short and medium-term volumes, it is too large a risk if the support structures and roadmap are not clear after five years. This requires greater clarity about the target to be achieved for localizing the capacity.

For PLI strategy to be successful, the EV segment has to grow big enough to catalyse a much larger EV market to build demand for batteries. Otherwise, investment in battery cell manufacturing will remain rigid and slow. This will require more strategic incentives for a wider genre of vehicle segments to build demand and scale. The FAME II incentive, which is two- and three-wheeler focused, can create demand for small battery cells. The 30@30 target will require much larger battery capacity. ICCT has estimated the expected growth in EV fleet by 2030 and shows that India will need annual addition of 246.9 GWh and cumulative addition of 824.7 GWh in 2030. Clearly, a much stronger strategy is needed to address this.

Second, the production linked incentives will be disbursed only on the basis of incremental sales from products manufactured in domestic units. Which means that a lack of matching demand from the EV sector for the planned production volumes of batteries could result in the manufacturer missing out on the promised incentives, thus hurting profitability. Thus, an EV market with long term incentives and mandate is critical.

Building battery ecosystem: Building a battery ecosystem to support an ambitious electrification target presents a challenge and requires well-defined strategies addressing each aspect of the ecosystem—battery production and raw material sourcing, battery assembly and management, among others.

A large part of the uncertainty for manufacturers rises from issues related to battery raw material security as access to mined materials for batteries has emerged as one of the biggest challenges to localization of battery cells in India and the industry continues to be dependent on imports. The programme has also highlighted India's vulnerability to geopolitical complexities and uncertainties in the global supply of material and minerals and battery technology. Securing supply chain for cobalt, lithium, nickel, and graphite will be a challenge as geo politics and price volatility add to the uncertainty.

The crucial issue for the future battery and electric vehicle industry is the scale that the industry will have to reach to be viable. The sector will require large amounts of capital and a plan to work at incremental growth that leads to economies of scale in battery cell manufacturing and battery pack assembly. Indian efforts at manufacturing battery cells will benefit from the gains in cost reduction achieved globally. In the last decade since 2010, battery price has reduced by over 85 per cent from around \$1,200 per kWh in 2009 to \$137 per kWh in 2020. Within a few years, battery costs may fall below \$100 per kWh. Policies should be able to promote diverse battery chemistry to reduce reliance on a limited set of raw materials.

Usually, once the battery capacity is reduced to about 70–80 per cent of the initial stated capacity, these are then either downgraded for further use or otherwise recycled. This will require proper collection, dismantling and disposal facilities. More importantly, recycling can help to recover lithium, cobalt, or nickel and requires appropriate technologies to improve the rate of recovery. This requires regulatory mandate to ensure collection of spent batteries and to have adequate scale for recycling. Mining battery metals will be critical. This requires standardized battery products with information on the chemicals used and streamlined networks for battery collection to be put into place before old batteries can be harvested for the expensive metals used in them. Recycling batteries offers the potential to recover expensive materials while avoiding the environmental cost of disposing off hazardous materials. Besides, used batteries can be repurposed and reused in stationary and storage applications. The reuse of batteries helps to reduce the life cycle cost of batteries, thus lowering the cost of electric vehicles and making them more cost-competitive.

India's Battery Waste Management Rules 2001 with directives for battery waste management and recycling provide for Extended Producer Responsibility (EPR) norms. This requires the battery manufacturer to create collection centres, have buy-back or exchange schemes, and make agreements with registered dismantlers or registered recyclers either individually or collectively or through a producer responsibility organization. This requires policy measures for adequate supply of retired EV batteries for energy storage applications. Directives on scalable recycling technologies and regulations on recovery rates for strategic resources such as lithium, cobalt, manganese, nickel, and graphite are also essential.

1.2.5 Accelerating charging infrastructure

Charging ecosystem is a critical barrier. A Deloitte global automotive consumer survey in 2018 found that 36 per cent Indians hold lack of charging infrastructure and charging anxiety as the primary deterrent to adoption of EVs, rather than the cost or range of the vehicle.

Several policy reforms have been initiated by Ministry of Power (MoP) including the notification titled 'Clarification on charging infrastructure for Electric Vehicles with reference to the provision of Electricity Act 2003'. The notification states that electricity consumed for charging a vehicle should not be considered as transmission or distribution or trading of electricity and no license should be required for it. It has further recognized battery swapping as a mode of charging. Further, Ministry of Housing and Urban Affairs (MoHUA) has revised the Model Building Byelaws in 2019 to provide for electric vehicle only parking areas within the premises of various building types. Building premises can now have an additional power load equivalent to power required for all charging infrastructure within.

Direct incentive for charging infrastructure started with FAME I. With the FAME II scheme, support for charging infrastructure was increased to 10 per cent of the Rs 10,000 crore total outlay. Besides direct financial incentives for setting up charging facilities, the government has also reduced the Goods and Services Tax (GST) on charging stations from 18 per cent to 5 per cent. But this benefit has not been extended to battery swapping that has a potential to grow further.

Several states in India are now coming up with their own strategy for establishing a network of charging stations to induce electric vehicle adoption. Immediate steps are needed to address the investment deficit in charging infrastructure. The cost of charging equipment, land and grid connectivity requires initial capital. Access to capital continues to be a challenge with banks as well as non-banking financial companies (NBFCs). Inflow of investment and financing of charging businesses, especially for the small players, remains a challenge and will require special attention.

It is time to develop robust EV charging standards. Indian manufacturers use the Bharat DC 001 and AC 001 connectors which are based on the Chinese GB/T connector standard. Since Bharat AC and DC chargers cannot charge all types of vehicles, new charging standards are required. Bureau of Indian Standards (BIS) and Department of Science and Technology (DST) are currently working on indigenous charging standards for India. An innovative low-cost AC charger (LAC) is supposed to be released soon. With a growing fleet, it is also important to focus on interoperability of chargers.

The 2021 WBCSD report further states that the sector still faces unclear rules on grid upgradation strategies; land availability for private investments in charging; absence of subsidy support to battery swapping; double taxation levied on charging services; and operational difficulties related to the open-access regulation threshold. It therefore underscores the importance of allocating affordable and accessible land for private investors, permit battery swapping to avail FAME subsidy, and reduce GST on charging and battery swapping services.

Though FAME II did not recognize battery swapping technology as an opportunity for the Indian market, an amendment dated 08 June 2020 to 'Charging Infrastructure for Electric Vehicles—Guidelines and Standards' (which was issued on 14 December 2018) covered that end by including incentives for vehicles sold without batteries. Batteries sold separately for vehicles will reduce the upfront cost of vehicles and the need for a dense recharging network. Swapping requires a standardized system of battery cavities, batteries and chargers, in order to enable interoperability, and a system that will work well for the commercial segment. Some states, such as Delhi, have allowed purchase incentives for vehicles sold without batteries to support swapping for four-wheelers as well. Wireless charging or inductive charging standards are not followed by vehicles in India currently and therefore this charging technology is not used.

The design for public charging infrastructure would depend on the Indian city's characteristics; cities with plotted development may find it easier to promote charging at home while those with dense and high-rise residential units may have to retrofit parking areas to provide for charging points. It is necessary that the city's mobility plan integrates a charging network plan. Several aggregators are setting up their own charging points and stations for captive use. But, given the small demand, they remain underutilized. These stations may be integrated with the larger public charging network in the city to improve utilization and access.

Infrastructure for EVs in public spaces like commercial centres, and institutional and office areas would also be required. It is also important to select the right kind of charging technology to scale it up for creating a citywide network. Varying usage patterns and charging requirements according to vehicle types makes the decision even more complex.

1.2.6 State level EV policy to drive electrification

About 15 states in India have either notified or drafted EV policies that support the national electric mobility agenda aimed at addressing barriers to electrification on the demand and supply side as well as market enablers such as charging. The states with approved EV policies include Andhra Pradesh, Karnataka, Kerala, Maharashtra, Odisha, New Delhi, Tamil Nadu, Telangana and Uttar Pradesh. The states with draft policies include Bihar and Punjab.

Most state policies chart out a multi-phased roadmap to electrification focused on facilitating EV and EV component manufacturing and consumer adoption. Seven states (Andhra Pradesh, Bihar, Karnataka, Maharashtra, Tamil Nadu, Telangana and Uttar Pradesh) have defined investment and job targets and designed packages according to the size of manufacturing capacity. Though most states have set segment-wise targets for 100 per cent conversion for two- and three-wheelers by 2030, three of these states (Andhra

Pradesh, Karnataka and Uttar Pradesh) offer only road and registration tax exemption for EV adoption on the demand side and skip purchase incentives completely.

The state level policies need to be shaped for ambition, and targeted transformation. The current policies have varying scope. While some policies focussed on manufacturing offer incentives such as interest free loans and reimbursement of GST for companies aiming to set up factories, some others offer facilitation of business infrastructure with subsidies on capital and support schemes related to land, water, electricity, waste disposal and testing facilities during the policy tenure of five years, barring Delhi where the policy tenure is three years. The state policies also reflect specific priorities of each state. Kerala focuses on retrofitting ICE vehicles, while only three (Odisha, Delhi and Punjab) provision for scrappage incentives. And only two states (Odisha and Delhi) define technical eligibility for availing incentives pointing at a disconnect with the national level policy ambition.

A review of state electric vehicle policies shows that among the 16 parameters listed under demand side incentives, Odisha scores the highest at 13, followed by Delhi (11) and Punjab (10). Regarding the twelve parameters listed under supply side incentives, Tamil Nadu scores the highest (11), followed by Uttarakhand (10) and Uttar Pradesh (9). Odisha and Andhra Pradesh score 6 out of 8 parameters under market enablers, while under recycling parameters, Odisha and Telangana have the best-defined policies.

State level policy can stimulate the market. It is evident from the Delhi Electric Vehicle Forum. Since the inception of the policy, E2W market has grown more than twice, electric car registrations have seen an increase of 18 per cent over last year and electric light goods market has taken off. The EV sales in total vehicle registrations have increased from 1.23 per cent to 3 per cent. This has been possible as demand incentives and other exemptions under the policy have been operationalized. This has been followed by mandate of reserving parking spaces in buildings and expanding charging infrastructure.

State policies also require alignment to create equal opportunities across states and prevent fragmentation of the market, across all states. Therefore, effectiveness of the currently designed policies requires an evaluation. Government of India has already carried out an evaluation of some of them including that of Karnataka to suggest modifications.

1.2.7 Address challenges of financing the EV market

In 2021, a joint study by NITI Aayog and Rocky Mountain Institute on Mobilising Finance for EVs in India (henceforth 2021 NITI Aayog report) has estimated that with EV sales penetration at about 70 per cent in 2030 across segments, the cumulative capital cost of India's EV transition is expected to be Rs 19.7 lakh crore by 2030 and the estimated size of the organized EV finance market around Rs 3.7 lakh crore. This requires strategies to mobilize capital and financing.

All this has not affected the financial market yet. However, at the state level, some efforts are being made to work with financial institutions. For example, Delhi EV Policy provides an interest rate subvention of 5 per cent on loans for buying e-autos and e-carriers. Delhi Finance Corporation (DFC) and its empanelled Scheduled Banks and NBFCs are developing a scheme on interest rate subvention. The Kerala Finance Corporation (KFC) has created a programme to provide low-cost loans for EVs in the state. But a lot more is needed. High financing cost and uncertainty around the nascent small market, fuzzy long term targets and concerns around the performance and resale value of these products have failed to build confidence in the financing sector. This has led to the problem of high interest and insurance rates, low loan-to-value ratio, and limited financing options for retail customers. This results in unsecured borrowing from the unorganized sector at even higher rates.

The 2021 NITI Aayog report states that the share of finance flow from the organized finance institutions—banks and non-banking financial institutions together is about 50 per cent to four-wheeler passenger vehicles, 40 per cent to commercial vehicles, and only 10 per cent to tractors and two-wheelers. The less expensive the segment and use case, the lower is the finance penetration in those segments. E-rickshaws have minimal organized sector financing due to the unregulated nature of the segment and the high risk nature of borrowers.

Different vehicle segments have different challenges and the economics for each use pattern will be different. For example, the total cost of ownership and its parity with the ICE segment for a rental electric two-wheeler model will be different than a private electric two-wheeler. Similarly, two-wheelers and buses will have very different parameters for financing. In addition, the charging infrastructure has its own funding demand. In fact, two/three-wheeler fleet operators need high daily vehicle usage to justify their business model viability to financial institutions. This in turn needs a robust charging infrastructure network to support operations and better model availability in the market. And since these two aspects are lacking in the Indian market currently, operators find it difficult to access financing.

Similarly, purchasing buses is not easy for operators due to the debt finance requirements involved such as bank guarantee, collateral and the debt issuance fees, which can be up to 1.5 per cent. As a result, bus operators may typically have to raise up to 25 per cent of the capital costs as equity, which is not ideal.

The 2021 NITI Aayog report has recommended that both central and state governments need to increase access to low-cost financing. RBI can include priority sector lending mandates for EVs to increase finance available for them. The central government or multilateral organizations can capitalize risk-sharing facilities to provide longer-tenure and lower risk financing. Lowering of interest rate for EV buyers can be mandated to lower the cost of financing for end-users. More states should come up with interest rate subvention in their respective state EV policies.

Ensuring product guarantees for the long term on products in the market can mean that more OEMs can partner with financing bodies due to assured vehicle performance and increased resale values. OEMs can also offer maintenance and repair services free of cost for specific time periods after the purchase.

Risk sharing mechanisms created by government and multilateral organizations can cover loan repayment risks for the financial institutions, making them more proactively send out loans. They can lower the cost of financing by capitalizing risk-sharing facilities. They can also offer low-interest loans and other financing products to start-ups, fintech companies, and more.

Banks are beginning to change their products. SBI started the Green Car Loan, the only specialized product for electric cars, in April 2019. This provides a discount. On average, the SBI Green Loan would charge an interest rate closer to 9 per cent, marginally less compared to other cars. To reduce costs, the processing fee for the first six months of the scheme is waived. The maximum repayment period has been increased. A loan to value ratio of as high as 90 per cent is offered. The focus of business model innovation and procurement schemes is on reducing upfront costs and technological risk by leveraging leasing, battery separation, and economies of scale.

Fleet operators can offer similar risk sharing mechanisms with financial institutions by providing guarantees for their driver partners including partial credit guarantees for full-time driver partners to share default risk with FIs. They can also offer utilization guarantees to driver partners to help achieve TCO parity while improving the fleet economics, innovate the business model and set target for fleet electrification.

Start-ups and fintech are part of the EV financing ecosystem. Venture capital funding is catalysing this sector with innovative business models and manufacturing. This can play a bigger role in two- and three-wheeler markets where financing penetration is low and can support first time EV buyers without credit history.

Scrappage policy as an EV stimulus: Yet another lost opportunity in India is the failure to leverage the vehicle scrappage policy to accelerate electrification. Post-COVID, there was strong expectation that the scrappage policy would be leveraged the way global governments have deployed it to expand electrification. But Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021 announced in March 2021 have not made that connection. In its current form, the policy is an instrument directed at material recovery and the sourcing value chain closing the loop with recycling and safe disposal.

The government expects the policy to affect around 51 lakh ageing vehicles (20-year-old) and their removal to build demand for new vehicles. But this regulation could have been designed for accelerating electrification as is the global good practice.

PART 1:

STATE OF ELECTRIC VEHICLES IN INDIA

2. Is India prepared for acceleration?

The electric vehicle programme in India is at a nascent stage. Policies are taking shape to create demand, stimulate supply, and support domestic manufacturing of vehicles and batteries. Nevertheless, scale and scope of change is still very small. There is no clarity about the policy levers that can act as accelerators to maintain a high level of ambition over a longer time horizon. The current market size of EVs is an evidence of this.

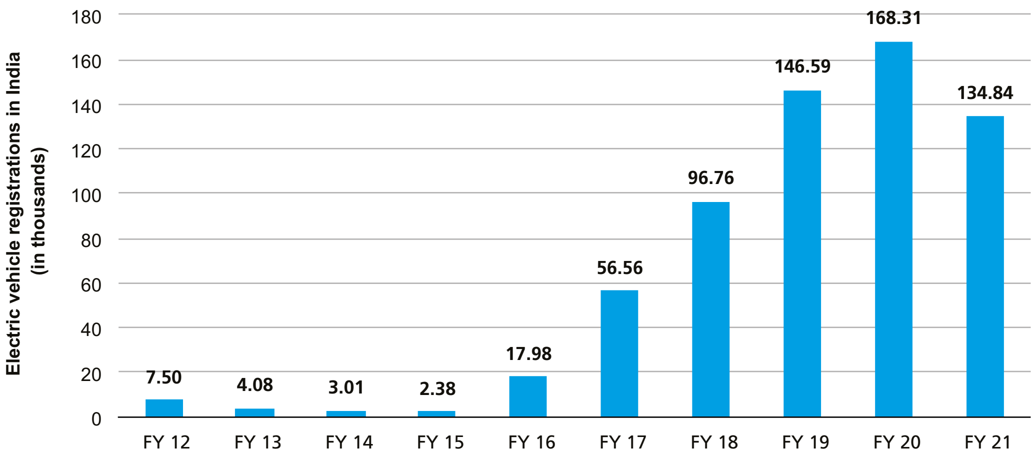
The current e-vehicle stock falls far short of the original target of National Mission on Electric Mobility of 2011 and the NEMMP of 2013 that aimed to roll out at least 60–70 lakh electric vehicles by 2020. FAME I did not have a target for number of vehicles to be incentivized, and ended up giving incentives to 2.8 lakh vehicles, most of which were mild-hybrids. The revised FAME II had aimed to incentivize 15.6 lakh vehicles in two years (now four), but only 5 per cent (84 thousand) EVs have been given incentives as of July 2021.

While the growth in EV stock is very small, the number of vehicle registrations has expanded over seven times in five years, from a very small base of 17,981 units registered in the country in 2016 to 1,34,844 vehicles in 2021, according to data released by MoRTH on their VAHAN Dashboard. However, the quantum of vehicles sold each year, compared to conventional internal combustion engine vehicles, is miniscule. E2Ws dominate this small fleet and constitute over 84 per cent of the registrations (excluding e-rickshaws) in 2021 (see *Graph 1: Electric vehicle registrations in India, FY 2012–2021*).

The market has not been able to match the original NEMMP target, and the current growth is also not strong enough to close the gap with the intended target of 30@30, let alone meet the higher ambition set by NITI Aayog in 2019 to achieve 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.

Against this intended ambition and despite the central and state level policies emerging to incentivize and support electrification, the current market share of EVs is less than 1 per cent of new sales. There are several estimates available of the number of EVs that India needs to sell to meet either lower bound or upper bound targets in 2030. According to a projection by ICCT, the 30@30 target virtually means adding about 2.4 crore two-

Graph 1: Electric vehicle registrations in India, FY 2012–2021



Source: VAHAN database (Note: Figures include e-rickshaw registrations between FY 2015–2021)

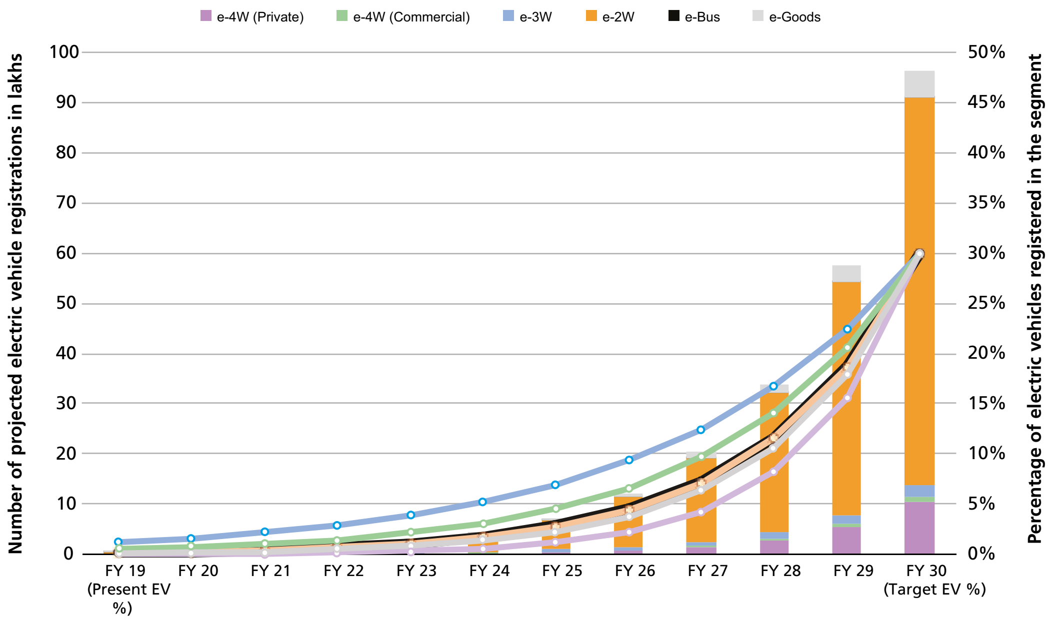
wheelers, 29 lakh three-wheelers, and 54 lakh four-wheelers to the fleet in the next 10 years. That amounts to adding an average of 32.3 lakh electric vehicles annually during the next decade.

These targets are too far away. Time has come to calibrate the policies and policy design to accelerate the rate of annual growth to meet the 30@30 goal. A CSE estimation of the annual growth rates required to realize the 30@30 goal bears out this fact.

The current market share of EVs amounts to less than 1 per cent. The Indian EV sector will have to grow annually at a rate of 46 per cent for the next ten years to achieve the 30 per cent objective (see *Graph 2: Projection of EV registrations and market share for 30@30*). This is based on the data of vehicle class types (four-wheelers: commercial and private, two-wheelers, three-wheelers, buses, and goods vehicles and their sub categories) defined by the Automotive Research Association of India's (ARAI) AIS-053 specifications under Central Motor Vehicle Rules (CMVR). Data from the VAHAN database maintained by MoRTH bears this out. The vehicle segments used in the study are—E2Ws, E3Ws, E4Ws, e-buses, and electric good vehicles.

This regression model has estimated total annual vehicle registrations segment-wise till 2030, using 2012 vehicle registrations data as the base to arrive at a value for projected EVs. An evaluation of compounded annual growth rate for EV market share from 2021 to 2030 was done to arrive at insights into the required pace of growth. An electric vehicle registration volume projection was done within the same time frame to understand results achieved in the first two steps. It is assumed that all EVs by 2030 will be based on lithium-ion batteries. Buses, four-wheelers, two-wheelers, three-wheelers and light

Graph 2: Projection of EV registrations and market share for 30@30



Note 1: In the E2W category, low speed scooters that are not recognized as motor vehicles under the AIS-053 and do not require a license to operate were excluded. But, low-speed scooters that can run between 25 kmph and 45 kmph with lithium ion and lead acid batteries were included. In the E3W category, e-rickshaws that are often not registered were also excluded.

Note 2: Since Q4 FY 2020 and Q1, Q2 FY 2021 were outliers due to the pandemic slump, the model used 2011–2019 data for projections of the estimate

Source: CSE analysis based on data downloaded from VAHAN database; data collected till 31 March 2021

goods vehicles will form a majority of EV sales in 2030. E-rickshaws and <25 kmph E2Ws will likely form a part of the EV stock in 2030 when they get recognized by government criteria. The vehicle segments considered for this estimation include—E2Ws, E3Ws, E4Ws, e-buses and electric goods vehicles. Due to the lack of authentic data, this has excluded e-rickshaws, because they are often unregistered, and low-speed scooters that are not recognized as motor vehicles under the AIS-053 and do not require a license to operate. Although, low-speed scooters that can run between 25 kmph and 45 kmph with lithium-ion and lead acid batteries were included. Since Q4 FY 2020 and Q1, Q2 FY 2021 were outliers due to the pandemic slump, the model used 2011–2019 data for projections.

This shows that the electric vehicle sector has grown at 45.02 per cent historically from 2011 to 2019 but from a very small stock. Moving forward, the sector will have to grow at 45.95 per cent CAGR to reach the 30@30 target. While the rate required to meet the target may seem close to the historic growth rate, it must be noted that these growth rates translate to exponential increase in numbers and, therefore, as the numbers increase each year, the subsequent year requires an even bigger market expansion to maintain the rate of growth.

Overall, from 2011–2019, the most number of registrations were in the E2W segment, which was growing at 19 per cent annually. The highest annual growth rate during the eight-year period, however, came from E3Ws at an average of 73 per cent. The passenger car segment registered the least growth at 7 per cent while goods vehicles (including goods carriers, goods three-wheelers, tractors and trailers) grew at 18 per cent.

To achieve the 30@30 target, vehicle segments will have to grow at a dramatic pace annually till 2030 to keep up with the fast growing conventional automobile market. E2Ws will have to maintain a 61 per cent average growth rate for the next 10 years, and passenger cars will have to grow by 77 per cent each year. The commercial E4W segment is expected to grow exponentially with government support and the potential onset of price parity with ICE counterparts by 2027. The commercial space will likely witness more rapid electrification compared to the private E4W segment due to lesser TCO when running longer distances. Buses will need a 53 per cent growth rate each year till 2030 to meet targets, while passenger three-wheelers and the goods segment will have to maintain a 34 per cent and 64 per cent growth respectively. According to CSE projections, to meet the 30@30 target, India needs to add 1.9 crore two-wheelers and 24 lakh passenger cars in the next 10 years.

The current incentive programme for electric vehicles is restructuring the market and changing the ratio between E2Ws and E4Ws and between E4W private and commercial vehicles in contrast to the conventional ICE market. During 2015–18, E2W volumes were about twice that of E4Ws. In 2019, FAME II was revised to continue to support personal two-wheeler segment and remove the subsidies from personal cars. The number of registered E2Ws was 12 times higher than that of E4Ws in FY 2020–21. In comparison, conventionally fuelled two-wheelers are seven times the number of four-wheelers. E4W commercial cars, that had a little over 20 per cent share in FY 2016–18, grew to 56 per cent of the E4W market in FY 2019–20 after the 2019 revision in FAME guidelines favouring the sub-segment.

The growth potential for electric commercial cars will likely expand further with app-based service providers such as Uber and Ola committing to shifting their fleets to electric. Undoubtedly, the ratio between E4W-private and E4W-commercial will continue to lean towards E4W-commercial unless there is a strategy to support the personal vehicle segment. Growing preference for ride hailing services and delivery aggregators and its effective growth potential will impact the four-wheeler private and commercial equation further.

The personal car segment is not included in the FAME policy design as the policy has strategically focussed on electrification of mass transport, delivery fleet and last mile connectivity. Private e-cars with near absent subsidy framework will require other strategies for a turnaround.

Indian policy has a special focus on electrification of commuting trips and has targeted electrification of buses and para transit including three-wheelers in cities. This is an opportunity in Indian cities where majority of the commuters use public transport and para transit. Zero emission commuting trips have enormous opportunity for decarbonization, but the current target of 7000 e-buses is too small for an ambitious transition and concentrated scale. A much smaller number of buses has come on road so far and these are distributed thinly across states. Scaling up in this sector will have to be linked with bridging the deficit in bus numbers in the country. There is an overall shortfall of over 150,000 buses nationally and this targeted increase needs to be linked with electrification.

E3W segment has the strongest potential for acceleration and 100 per cent electrification. E3Ws that qualify for registration in VAHAN database of MoRTH are still small in number but their potential is reflected in the explosive growth in e-rickshaws in the informal segment.

There is yet another challenge. Under the current policy design, the small fleet of EVs that has qualified for support and is on roads is spread very thinly across the 31 states and union territories. This works out to be a very small number in each state and is incapable of catalysing transformation and scale. Overall, 80 per cent of the sales under FAME I & FAME II were concentrated in the top ten states of the country but numbers in each state are miniscule (see *Box: Geographic distribution of EVs in India*).

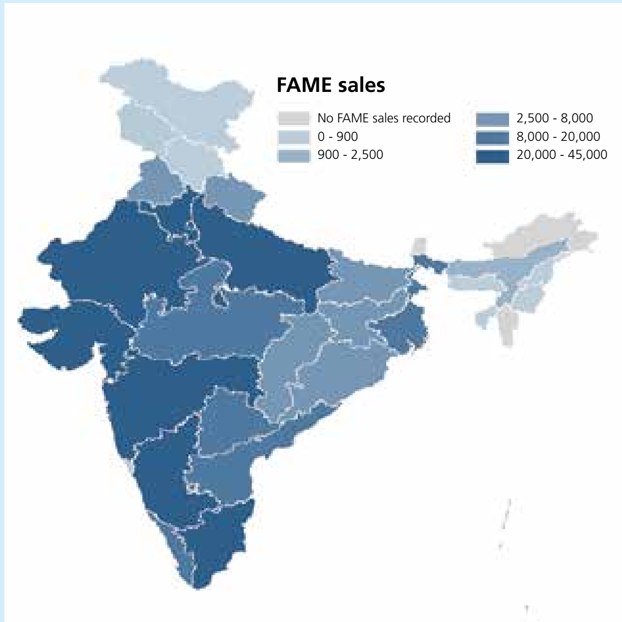
Pandemic takes toll on EV sales: While India is facing the challenge of building scale, pandemic slowdown has further dampened the market. The sales volume registrations in 2020 came to a near halt with the country going into lockdowns in March 2020 after the COVID-19 hit.

The automobile industry was already in a slump in 2019 with 5.52 per cent lower registrations as compared to 2018. The COVID-19 pandemic hit at a time when the numbers were starting to improve. April 2020 recorded an 83 per cent drop in total vehicle registrations, from 23.2 lakhs in March to just 3.8 lakhs. However, the numbers recovered, crossing the 7-lakh mark in July 2020. EV registrations witnessed an even

Geographic distribution of EVs in India

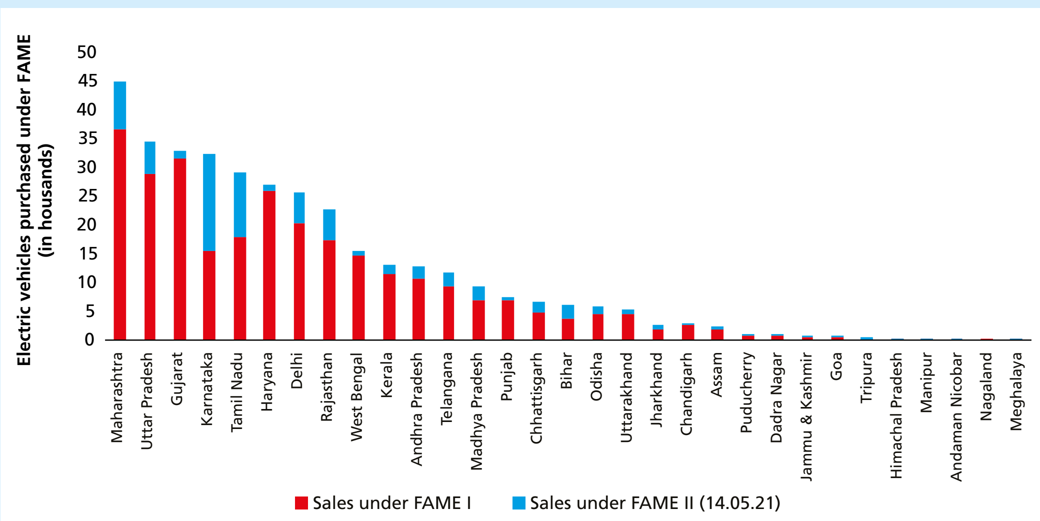
While the current EV stock is very small and thinly spread across the states, their distribution is also skewed. Overall, 80 per cent of the sales under FAME I & FAME II are concentrated in the top ten states of the country. But numbers in each state are miniscule—the largest fleet is 44,888 in Maharashtra, followed by 34,402 in Uttar Pradesh, 32,788 in Gujarat, and 32,213 in Karnataka. According to the cumulative sales graph from 2015 to 2021, Maharashtra bought the largest number of EVs since the time the incentives began to be rolled out (see *Graph: Cumulative EV sales (including three-wheelers) in the states under FAME subsidies* and *Map: Geographic spread of EV sales under the FAME scheme in India*).

Map: Geographic spread of EV sales under the FAME scheme in India till 14 May 2021



Source: CSE visualization of FAME data

Graph: Cumulative EV sales (including three-wheelers) in the states under FAME subsidies



Source: FAME I and FAME II official websites steeper drop of 93 per cent in April, which recovered to 2019 levels of over 16,000 units by January 2021. EV adoption picked up in March 2021 when the units sold crossed 26,000, but they dropped back to 14,000 in April 2021 as the pandemic worsened yet again.

This presents the double challenge of not only recovering the growth rate but also to find strategies to leap ahead. India requires policy preparedness for this. However, due to fuel prices sky rocketing, EV sales seem to have been stimulated.

3. Vehicle segment-wise trend and concerns

To move forward it is important to draw lessons from the current trends in different vehicle segments. The market imperatives vary across vehicle segments and require more granular understanding of the respective challenges.

For the electric vehicles to become part of the mainstream market, strong policy intent, consumer awareness and acceptance rate, improved battery economics, overall EV cost competitiveness, increased model availability and improved EV technology for reliability and convenience, and a better financing strategy will be needed. This will have to be driven by clear targets and mandates for acceleration. ICE vehicles will have to be disincentivized to achieve a structural shift.

3.1 Electric two-wheelers

The two-wheeler is an Asian dilemma but also the prime candidate for a faster rate of electrification. Small, cheap and low powered vehicles are very popular and numerous and optimism about achieving a quicker scale of change in this segment is higher. NITI Aayog in its ambitious target for 2030 has aimed for 80 per cent electrification of two-wheeler and three-wheeler segments. These are already among the largest segments in the EV market and their sheer numbers make them immediate candidates for an ambitious electrification target.

The momentum in E2W trends post COVID-19 lockdowns was driven by concerns over infection and contagion in public transport and shared mobility options, and a preference for independent mobility. Besides, policy and incentive support from the government motivated a bevy of new entrants into the segment leading to larger model availability that contributed to sales. The popularity of E2Ws has a lot to do with their small batteries that are easier to charge at home and often do not require public charging.

The E2W industry has seen interesting restructuring with a large number of new entrants without prior experience in the automotive industry. This is also a reflection of rigidity and conservative response from the well-entrenched traditional ICE manufacturers. This mirrors the trend across all segments.

The EV industry today is largely a start-up economy. This is evident from the difference in positioning of the conventional two-wheeler OEMs and the start-ups in the ICE and E2W segments. Of the 20 manufacturers with 41 E2W models in the market, only three (Bajaj, TVS and Hero MotoCorp) belong to the conventional two-wheeler manufacturers' club. Of these, only one—Hero Electric—figures among the top three players in the E2W market. All other players in this segment are new entrants. Start-ups and non-conventional players in this segment are moving more aggressively with innovative business models than the conventional players.

This relative positioning of the new entrants versus the traditional OEMs in the EV and ICE markets is reflected in the market data. In the ICE segment, Hero MotoCorp is the market leader by a substantial margin, contributing 36 per cent of the total 1.74 crore two-wheelers sold in 2020. Honda follows as the second largest manufacturer with a 27 per cent share of total sales. TVS's share is about 14 per cent, and Bajaj's about 12 per cent. The top six manufacturers collectively account for 96 per cent of the sales in the conventional ICE two-wheelers market.

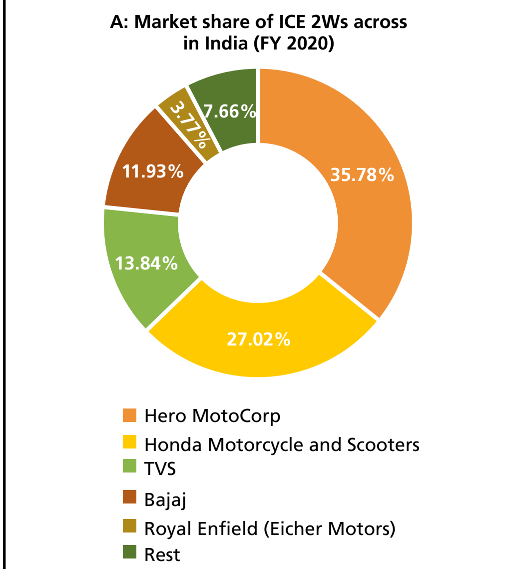
The situation has changed significantly in the E2W market. While Hero Electric, a subsidiary of Hero MotoCorp, has managed to maintain its rank as the top manufacturer with a 32 per cent market share in the E2W space in 2020, other top conventional players—such as Honda, TVS and Bajaj—have not shown the same proactive stance with EV technology.

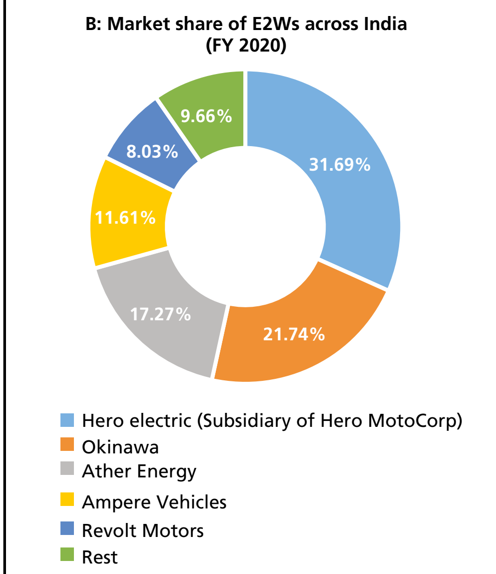
Therefore, the E2W market has new players with all-electric portfolios and production assembly lines. Okinawa has attained second place with a 22 per cent market share within four years of selling e-scooters in India. Ather captured about 12 per cent of the E2W market in 2020 (see *Graph 3: Market share of ICE 2W manufacturers across India and market share of E2W manufacturers across India*).

In the current market, manufacturers offering E2W models with high ranges are drawing more attention. About 34 per cent of the models in the market have a range higher than 100 km per charge, out of which 50 per cent are sold by the top four manufacturers—Hero, Okinawa, Ather and Ampere. Hero's Nyx HX claims a range of 212 km on a full charge; that is higher than many E4W models in India with much larger batteries. The high range models also include e-motorcycles, such as RV 300/400 from Revolt and F77 from Ultraviolette, which are more expensive than the e-scooters. Most E2W models have a top speed lower than 50 kmph, which is more than reasonable for intracity commute (see *Table 1: E2W models available in India*).

What sells the most is low speed: While the composite E2W numbers point at the potential in the market, what they do not reveal is that the volumes were composed of mostly low-speed scooters that can run at a maximum speed of 25 kmph. When there was no performance criteria under FAME I to drive incentives, close to 90 per cent of the E2Ws sold were low-speed scooters. What further worked in their favour was the exemption from registration with the transport authorities.

Graph 3: Market share of ICE 2W manufacturers across India and market share of E2W manufacturers across India





Source: Graph 17 Statista; Graph 18 Autocar India

Typically, these scooters are inexpensive and have a gearless design that offers a smooth driving experience. They are often used for short distances within city limits and therefore range is often not a big concern for the owners.

All of that, however, changed with FAME II that changed the eligibility for incentives, increasing the minimum range to 80 km per charge and minimum top speed to 40 kmph. Further, it defined requirements of energy consumption efficiency, minimum acceleration and number of charging cycles to make the cut.

Hero Electric and Ampere had to review their low-speed product portfolio as the new rules excluded more than 90 per cent of these models with less than 60 km range from the subsidy. FAME II also stopped subsidy pay-outs to scooters powered by lead acid batteries which are relatively lower costing than scooters powered by lithium-ion batteries.

However, demand for low speed E2Ws continued to grow in 2020, even without the FAME II subsidy, driven by their low cost of ownership. At the other end of the spectrum, OEMs such as Bajaj and TVS are now entering the high speed E2W segment that gets subsidy support.

Table 1: E2W models available in India

Sr. no.	Name of E2W manufacturers	Available models	Range	Max speed (Kmph)	Battery capacity (kWh)	Charging time (in hrs)
1	Ather Energy	ATHER 450	105	57.7	2.7	4
		Ather450	105	48	2.7	4
2	Ampere Vehicles	ZEAL	108	41.6	1.8	5–6
		Magnus	90	48	1.8	5–6
		Zeal VX1	84	41.6	1.8	5–6
		ZEAL-CA	90	42	1.8	5–6
3	Okinawa	RIDGE+	84	41	1.7	2–3
		Praise Pro	88	52	1.9	2–3
		iPRAISE+	139	51.2	3.3	6–8
4	Jitendra EV	JMT1000HS	90	40	2	3.5
		JMT 1000HS Cargo	88	50	2	
5	Hero Electric	Photon LP	91	51	1.7	4-5
		NYX HS 500 ER	127	45	2.9	4-5
		OPTIMA HS 500 ER	113	47	2.9	4–5
		OPTIMA PRO	50	25	1	4–6
		NYX Pro	50	40	1.3	5
		Optima e5	82	45	1.54	4–6
		NYX HX	212	45	4.6	4–6
		NYX e5	82	45	1.54	4–6
		N61a	92	45	2.17	4–6
		NYX N23a	92	45	1.9	4–6
6	Revolt	RV300	102	62.2	2.7	4.2
		RV400	147	40	3.2	4.5
8	TVS	TVS iQUBE Electric	86	40	2.25	6
9	Benling India	Aura	82	40	2.9	3–4
		Falcon	75	25	1.32	4
10	Bajaj	Chetak	95	70	3	5
11	Ultraviolette	F77	150	140	4.2	DC - 1.5 Standard – 5
12	Joy-Bike	Monster	75	25	1.6	4–4.5
13	Pure EV	ePluto	80	25	2.5	4
14	Gemopai	Ryder	90	65	1	Swappable battery
15	Odysse	Racer	70	45	1.3	5
16	Varcas	Eagan	100	25	1.72	3
		Falcon	100	25	1.72	3

Sr. no.	Name of E2W manufacturers	Available models	Range	Max speed (Kmph)	Battery capacity (kWh)	Charging time (in hrs)
17	M2GO	Civitas	120	85	2.1	3–4.2
18	Avan	Xero Plus	50–60	45	1.2	4–5 (Swappable battery)
19	BGauss	A2	110	25	1.3	2.25 (Swappable battery)
		B8	70	50	1.45	3 (Swappable battery)
20	BattRE	Electric scooter	90	25	1.44	3 (Swappable battery)
		Electric love	90	37	1.44	
		Electric IOT	85	110	1.44	

Innovating business model: This segment has also seen innovation in business models which is quite different from the ICE segments. Many E2W manufacturers are trying out different business models, such as an ecosystem approach towards their products, where the manufacturers are providing charging solutions, both public and home charging, dedicated to their products. Ather, for instance, has adopted an ecosystem approach to provide its consumers both the vehicle and charging solutions. The new players are currently investing in their own R&D to build a platform for their users to provide long-term reliable solutions. Currently, when the charging infrastructure support for EVs is not adequate, adopting an integrated approach gives them an edge over other E2W manufacturers. This also gives manufacturers more control on how their models perform.

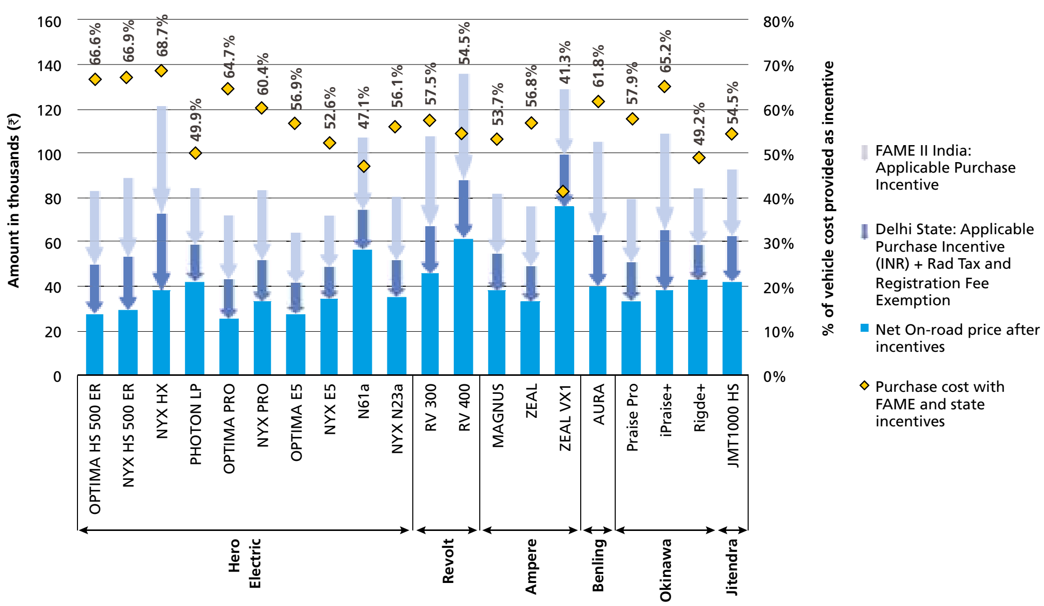
Making E2Ws affordable: The FAME II scheme has been incentivizing electric vehicles since 2019, and according to the live counters on the official websites, the scheme has managed to stimulate sales in the last two years. E2Ws were given a Rs 10,000 incentive per kWh, capped at 20 per cent of the vehicle cost, which, after the recent amendment in June 2021, has now increased to Rs 15,000 per kWh capped at 40 per cent of the vehicle cost. Department of Heavy Industries has revised the incentives linked with two-wheelers under the FAME scheme by increasing the incentive amount given per kWh of battery capacity and also by doubling the maximum incentive that a vehicle model can receive.

The decision came amidst the country's slow recovery from the COVID-19 pandemic, as a strategy to improv E2W sales as it is anticipated that more commuters will look at personal vehicles as their primary mode of transportation. Post-pandemic, E2Ws are also becoming popular among rentals and the ride hailing and last-mile delivery services.

A quick assessment by CSE shows that before the new amendment, an average two-wheeler eligible for incentives would receive a 22 per cent reduction in the purchase cost of the vehicle under FAME II. After the revision in the incentive structure in June 2021, an eligible two-wheeler can enjoy an average cost reduction of 35 per cent, which is a major improvement for the segment. Further, in India, 15 states have either notified or drafted a public electric vehicle policy. Many states are also offering fiscal incentives in addition to the FAME incentives. This, if added to the national FAME incentives, can further lower the upfront purchase cost and achieve better price parity with the ICE engines.

For instance, Delhi is an interesting case study as it has a stated ambition of 25 per cent electrification by 2024. Twenty electric two-wheeler models, manufactured by five OEMs, are eligible for state purchase incentives, and road and registration tax waivers. These incentives, in addition to the FAME India subsidies at the national level, further lower purchase cost. According to CSE's analysis, the state and FAME incentives together shave off an average of 57 per cent from the on-road price of the vehicle model in Delhi, achieving significantly competitive prices in comparison to popular petrol two-wheeler models such as Suzuki Access 125, Honda Activa 5G, Honda Dio, and Hero Pleasure+. The cost after incentives of all the E2W models studied in the analysis is reduced to a price much lower than the aforementioned ICE variants (see *Graph 4: On-road price of E2Ws in Delhi with and without incentives*).

Graph 4: On-road price of E2Ws with and without incentives in Delhi



Source: CSE estimates (Note: On road price includes road and registration taxes, insurance, and dealer handling charges; The FAME II incentive includes the revision on 11 June 2021)

Despite the substantial incentives by the government supporting E2Ws, and the relatively proactive front taken by manufacturers compared to other segments, the E2W market has not yet reached a tipping point to achieve 30@30. Significant change and scale is possible in this sector if the local ecosystem support can be scaled up in cities.

3.2 Electric cars

India is among the major ICE car markets with 3.4 million vehicles sold in 2019 in the pre-pandemic era. EV adoption has, however, been slow in this segment. One of the reasons is the policy focus on supporting electrification of high mileage public transport and commercial vehicles. Very limited subsidies are available in the personal car segment. It is in sharp contrast to the global trend in which e-cars are the primary drivers of electrification. It is expected that expansion of charging infrastructure, expansion of non-fiscal preferential incentives, and local fiscal incentives in cities can encourage individual buyers and stimulate the car market.

The interest taken by the four-wheeler industry in the EV segment has been sluggish. Today, less than 10 E4W models are available for Indian consumers. Automakers like Tata and Mahindra, which control over 80 per cent of the E4W market, have two models each. Mahindra has e-Verito and e-20 plus, while Tata's E4W portfolio includes the Tigor and Nexon EVs. The automakers sold about 3,000 units each in 2021, although Tata pipped Mahindra for most sales by a small margin. Among global players, Hyundai, MG Motors and Mercedes offer a model each. Hyundai Kona sold 183 units in FY 2021, while MG ZS EV fared much better with over 1,100 deliveries. In the meantime, the ICE major Maruti Suzuki has not yet entered the fray but has plans to roll e-cars by 2025.

The models available in India have a battery range between 140 km in Tigor EV to 471 km in the premium Mercedes Benz model EQC. The most economical entry level E4W models in India go up to a range of 300+ kms. All variants other than performance models, or roughly 37.5 per cent of the variants, have a top speed of 80 kmph. The high range batteries are bigger in size and costlier, which also means higher vehicle costs. The bigger batteries also have longer warranties of up to 8 years. Small battery packs such as the ones in Tigor and Nexon have a warranty of up to 3 years. A depleted battery needs replacement, which can cost up to 40 per cent of the vehicle cost. However, as battery economics improves, manufacturers will be able to pack even higher ranges into smaller batteries and the length of warranty will not be as big a factor for the buyer's decision when the cost of battery replacement goes down. The market has to attain scale to lower costs and push innovation (see *Table 2: Key players in India and their models*).

Table 2: Key players in India and their models

<table>
<tr><th>Manufacturers</th><th>Model description</th></tr>
<tr><td>TATA Motors</td><td>TATA Tigor EV
Range: 140 to 213 km
Max speed: 80 kmph
Acceleration: 0–60 km in 9.4 sec
Battery capacity: 16.2 to 21.5 kWh
Charging time: 80 per cent in 6 hrs.
Battery warranty: 3 years/1,25,000 km

TATA Xpres-T EV (A facelift of the Tigor EV model)
Range: 165 to 213 km
Max speed: 80 kmph
Acceleration: 0–60 km in 9.4 sec
Battery capacity: 16.2 to 21.5 kWh
Charging time: 80 per cent in 2 hrs (quick charge), 100 percent in 11.5 hours (slow charge).
Battery warranty: 3 years/1,25,000 km

TATA Nexon EV
Range: 312 km
Max speed: 80 kmph
Acceleration: 0–90 km in 7.8 sec
Battery capacity: 30.2 kWh
Charging time: 80 per cent in 8.5 hrs.
Battery warranty: 3 years/1,25,000 km</td></tr>
<tr><td>Mahindra and Mahindra</td><td>e-Verito
Range: 181 km
Max speed: 80 kmph
Acceleration: 0–60 km in 11.2 sec
Battery capacity: 15.9 to 21.2 kWh
Charging time: 100 per cent in 8.5 hrs (slow)
Battery warranty: 3 years/36,000 km
Car warranty: 2 years/40,000 km</td></tr>
<tr><td></td><td>e-20 plus
Range: 140 km
Max speed: 80 kmph
Acceleration: 0–100 km in 14.1 sec
Battery capacity: 15 kWh
Charging time: 100 per cent in 6 hrs (slow)
Battery warranty: 3 years/36,000 km
Car warranty: 2 years/40,000 km</td></tr>
<tr><td>Hyundai</td><td>KONA electric
Range: 452 km
Max speed: 167 kmph
Acceleration: 0–100 km in 9.7 sec
Battery capacity: 39.2 kWh
Charging time: 100 per cent in 6 hrs (slow) and 80 per cent in 1 hr (fast)
Battery warranty: 8 years/ 1,60,000 km
Car warranty: 3 years/ Unlimited km</td></tr>
</table>

MG Motors	**ZS EV** Range: 419 km Max Speed: 140 kmph Acceleration: 0–100 km in 8.5 sec Battery Capacity: 44.5 kWh Charging time: 100 per cent in 6–8 hrs (slow) and 80 per cent in 50 min (fast) Battery warranty: 8 years/1,50,000 km Car warranty: 5 years/Unlimited km
Mercedes Benz	**EQC** Range: 471 km Max speed: 180 kmph Acceleration: 0–100 km in 5.1 sec Battery capacity: 80 kWh Charging time: 100 per cent in 21 hrs (slow) and 80 per cent in 1.5 hrs (fast) Battery warranty: 8 years/1,60,000 km Car warranty: 5 years/Unlimited km

Making private e-cars affordable: Under FAME II, subsidies are not available for personal cars. It is, however, possible to estimate how the incentives available under the Delhi electric vehicle policy affect the prices. Under the Delhi EV policy, E4W models manufactured by Tata Motors and Mahindra are eligible for support combined with road and registration tax exemptions. The subsidy for e-cars, capped at Rs 1,50,000, is for the first 1000 registrations.

CSE has estimated how reduced on-road price of electric cars (post-subsidy) compares with that of the ICE versions of the same models. While incentives and tax exemptions lead to a reduction in the upfront price of the vehicle models by 19 per cent on an average, many models continue to be slightly higher priced than their petrol counterparts.

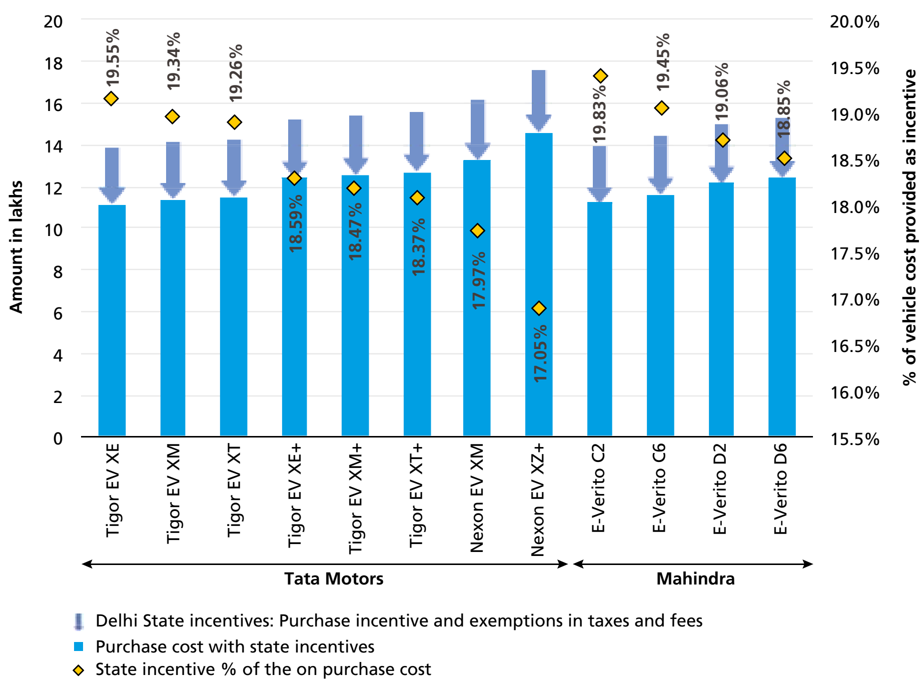
All the models of Tata's Tigor EV variant are priced higher than their petrol versions. In the case of Tata Nexon, the lower priced EV XM variant falls within the price range of its petrol counterpart, while the more expensive EV XZ+ costs slightly more than its ICE variant. In comparison, all of Mahindra's E-Verito models in Delhi are priced lower than the petrol models (see *Graph 5: On-road price of private E4Ws with and without incentives in Delhi*).

In fact, price reduction after incentives looks promising. It is comparable with the incentives offered around the world to push electric vehicle adoption and, in some cases, it is even better. A quick analysis of incentives offered to consumers in some countries indicates a wide range of support packages, some significantly higher than others. Chinese cities such as Shanghai and Beijing provided up to CNY 42,000 in 2018 to consumers buying BAIC EC220, an electric hatchback, which costs CNY 62,000, a 67.7 per cent purchase incentive. In Norway, the incentives offered can be as high as 57 per cent of the price of the car. They are around 24 per cent in the US and Japan. In Europe, they range between 12–17 per cent. The key driver of change in Europe is the combination of fiscal incentives and strong CO_2 emissions standards.

According to the VAHAN database, during FY 2020–21, Tata Motors sold 669 EV units, whereas Mahindra sold 277 (see *Table 3: Key players in India and their models*). Tata has managed to pack more range into their battery packs at a marginally higher vehicle price. Though the Tata battery packs are larger, their charging times are comparable with other models; and they also have significantly higher warranty kilometres. However, consumers will require stronger ecosystem support.

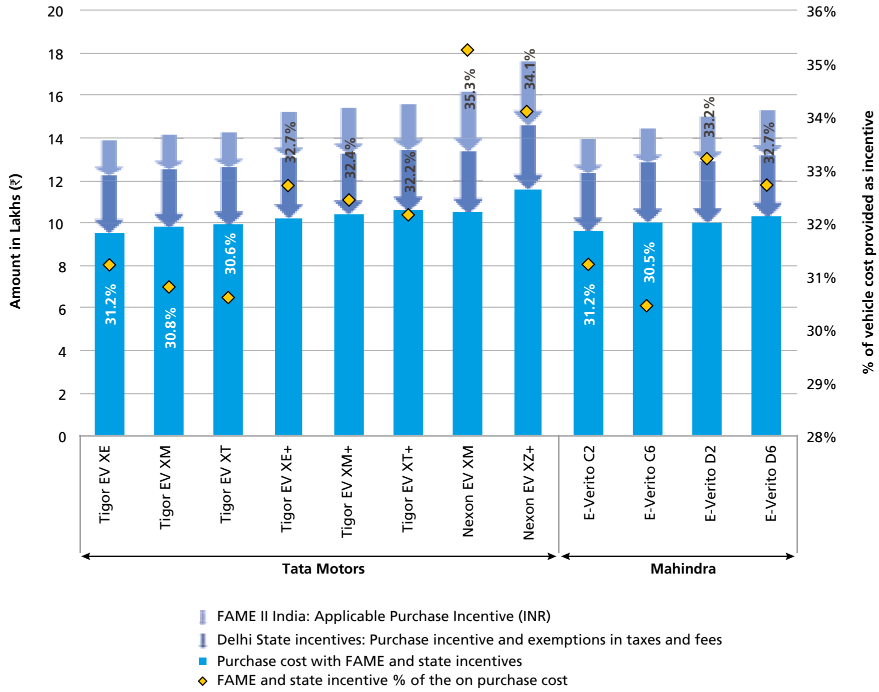
Even with the cost reductions from incentives, lack of competition and a low fleet volume have dampened the e-car market as well as the import substitution efforts so far in the E4W market.

Graph 5: On-road price of private E4Ws with and without incentives in Delhi



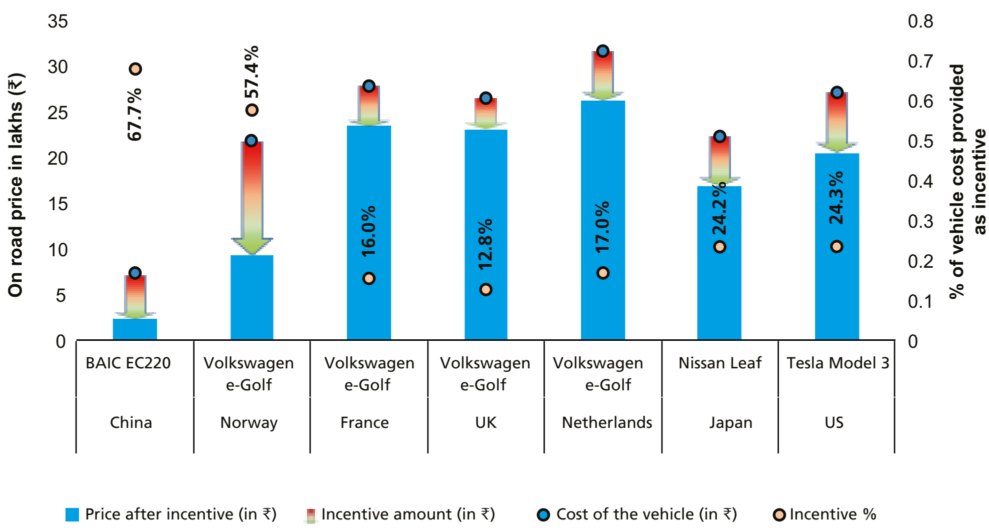
Source: CSE analysis (Note: On road price includes road and registration taxes, insurance, and dealer handling charges)

Graph 6: On-road price of commercial E4Ws with and without incentives in Delhi



Source: CSE analysis (Note: On road price includes road and registration taxes, insurance, and dealer handling charges)

Graph 7: EV Incentives offered to e-car around the world



Source: ICCT, 2019; CSE analysis (Note: The incentive amount includes both national and local/state subsidies).

Cars for commercial use: FAME incentives subsidize only commercial four wheelers. CSE has analysed the cost reductions in the on-road price post subsidy of the twelve eligible vehicle variants. This shows that while the incentives and tax exemptions for the commercial segment led to a substantial reduction of 32 per cent in the upfront prices of the vehicles, many models continue to be slightly higher priced than their petrol counterparts (see *Graph 6: On-road price of commercial E4Ws with and without incentives in Delhi*).

Even with incentives, all the commercial and private Tata Tigor EVs are priced higher than their petrol versions. In the case of commercial Tata Nexon EVs, the lower priced EV XM variant falls within the price range of its petrol counterpart, while the more expensive EV XZ+ costs slightly more than its ICE variants. Both Nexon EVs, if purchased as private vehicles, are priced higher than petrol models. All Mahindra's E-Verito commercial vehicles in Delhi are priced lower than petrol models, while the C2 and C6 variants in the private segment reach parity with the ICE variants.

Overall, it may be noted that India will require a strategy to accelerate electrification of cars to meet the 30@30 target. While direct fiscal incentives can be a powerful tool to make vehicle acquisition affordable and enhance its attractiveness for the consumer, the key to adoption will clearly be a combination of OEM price, model availability, charging infrastructure, and local level tax incentives, among others.

3.3 Electric buses

There is a strong case for prioritizing the e-bus programme under FAME II as buses play a crucial role in urban mobility. According to a report published by the Department of Heavy Industries, India could emerge as the second-largest e-bus market by 2030 if 4 out of 10 buses sold are electric.

Even though FAME I had supported e-buses, it could not accelerate the programme as it was not adequately designed to pay attention to technology selection, fleet planning and deployment strategies in cities. Less than 500 buses could be deployed during this phase.

FAME II was an improvement on FAME I with clear deployment targets of 7000 e-buses supported by fund allocation and bus operation models. It has provided a uniform demand incentive at Rs 20,000 per kWh battery size for a maximum of up to 50 lakhs (i.e., battery size up to 250 KWh) per bus. It has also prescribed an operational model based on gross cost contract. Accordingly, bus transport agencies do not have to make outright purchases of buses. Instead, OEMs or the designated operators take the responsibility of providing the buses as well as operating, managing and maintaining the fleet, and are paid on a per kilometre basis. This is done to reduce risk for the STUs. Incentives are limited to 40 per cent of bus cost with an upper cap of maximum 35 to 55 lakhs according to bus size.

In addition, state level support is available in terms of targeted e-bus deployment, tax incentives, subsidy or special tariff on electricity, etc. For instance, Andhra Pradesh has targeted 100 per cent conversion of bus fleet into electric—in major cities by 2024 and in the entire state by 2029. Delhi has pledged to convert 50 per cent of all stage carriage buses by 2022. Kerala targets to convert the entire bus fleet by 2025. Tamil Nadu aims to procure 1000 e-buses every year. Draft policies of Madhya Pradesh and Telangana have targeted 100 per cent conversion of their bus fleet by 2028 and 2030, respectively. Punjab has waived off permit fee and MV tax for private operators. Assam has decided to exempt e-buses from state GST.

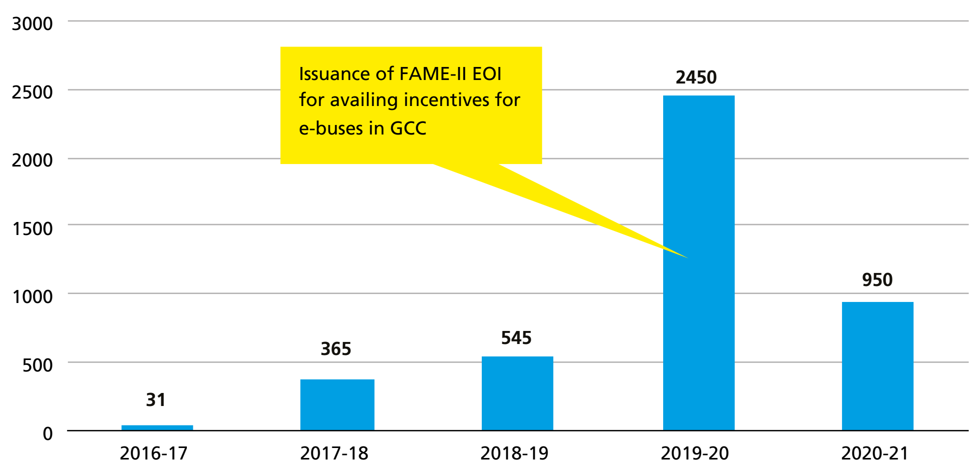
The COVID-19 pandemic has slowed down progress. Announcement regarding new invites for procurement of e-buses have got delayed. Disruption of the global supply chain has further added to the challenges. Even after receiving orders, manufacturers have not been able to supply buses. After a year of receiving a supply order of almost 2450 buses under FAME II, the bus manufacturers could supply just a few buses. The bus sector, which is already facing the problem of ridership and revenue losses, has been hit hard by the pandemic. This has increased the viability gap funding requirement by nearly 70 per cent. Sanitization protocols during the pandemic have added approximately Rs 17 lakh per 100 buses per month to the cost of bus operations. As a result, cash strapped bus agencies have put investments into e-buses on hold, at least in the short to medium term.

Additionally, COVID-19 and associated global slowdown have impacted the global supply chain. Almost all Indian e-bus manufactures are dependent on the global supply network and the disruption caused stoppages or production slowdowns. The Indian e-bus sector is dependent on China for technology, batteries and other components; that has also been affected by escalating tensions between India and China. As a result, even after a year of receiving the supply order of almost 2,450 buses under FAME II, the manufacturers were not able to provide buses.

In some cases, public transit agencies are refusing to take deliveries, citing concerns about low demand for public transport in cities. Delhi had planned to induct 1,000 e-buses into its city bus services by the end of 2020, but placed orders for only 300 e-buses in March 2021. In a revenue deficit environment, public transit agencies and city authorities have either delayed or cancelled the procurement process for e-buses (see *Graph 8: Annual progress of Indian e-bus market, including actual supply orders received by OEMs till FY 2020–21*).

FAME II was further amended in June 2021, as part of which the government has adopted the strategy of aggregating demand for e-buses for deployment in cities. Accordingly, the responsibility of aggregating demand for both three-wheelers and buses has been given

Graph 8: Annual progress of Indian e-bus market, including actual supply orders received by OEMs till FY 2020–21



Source: Multiple sources, complied by CSE

to the Energy Efficiency Services Limited (EESL), a joint venture of central public sector undertakings to create demand for remaining FAME II buses in nine mega cities of India that include Mumbai, Delhi, Bangalore, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat and Pune.

EESL is expected to lead to concentrated development of infrastructure that can help build scale, reduce costs and also support state governments. This needs to be implemented with comprehensive fleet planning to maximize benefits and demonstrate the pathways and generate a learning curve for others. Majority of these cities have already placed an order close to 300 or above buses. Approximately 2,500 or more buses are still to be procured (as only 4,500 out of total 7,000 buses have been tendered so far). EESL is assessing city level deployment strategy.

Additionally, EESL is also developing EV charging infrastructure in targeted cities. It has already planned to set up around 2000 EV charging stations across India in cities like Hyderabad, Ahmedabad, and Chennai. It has the authority to aggregate demand for better coordination and for creation of EV ecosystems in those cities.

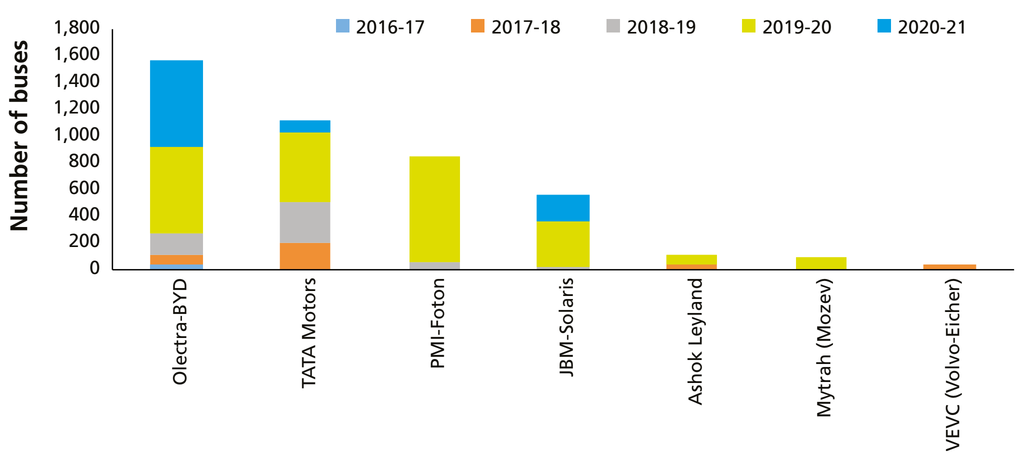
The bus sector is a high employment generator. Every bus can generate direct employment for 6–7 people, and indirect employment for a few more. Post-COVID, reviving this sector can address job losses as well.

It may also be stated that the Union budget for 2021–22 has sanctioned Rs 18,000 crores for procurement of 20,000 new buses. If half of this new fleet can be targeted for electrification, it can help build scale and achieve cost parity.

The e-bus sector presents a special challenge as its potential is dependent on a lot of things like the product portfolio offered by manufacturers, fleet planning and deployment strategies, revenue models, operational models for e-bus services, infrastructure development, and incentive programmes.

Changing profile of e-bus industry: Like other segments, the e-bus industry has also attracted new manufacturers while repositioning the traditional bus manufactures. Until 2020–21, about 74 per cent of total e-bus supply orders were received by new players like Olectra-BYD, PMI-Foton, JBM-Solaris, etc. OEMs such as Tata Motors and Ashok Leyland, who together dominate the ICE bus market at 81 per cent, form only 26 per cent of the e-bus market. However, in terms of individual positioning, Tata Motors is the second highest seller of e-buses. The e-bus policy has attracted investments from new and non-conventional players, thus increasing the diversity of the market. This is different from the ICE bus market that was largely dominated by a handful of players (see *Graph 9: Major OEMs in Indian e-bus sector, including actual supply and supply orders received till FY 2020–21)*.

Graph 9: Major OEMs in Indian e-bus sector, including actual supply and supply orders received till FY 2020–21



Source: Multiple sources, compiled by CSE

The incentive design is still not conducive to drive more innovation and build product diversity. For instance, FAME II incentive framework is linked to battery sizes, and larger battery sizes are eligible for more incentives than smaller ones. It does not provide a level playing field for all approaches like battery swapping or opportunity charging technology that can have smaller batteries. Only electric buses with supported conduction charging facilities dominate the market. Other charging options like DC pantograph charging or battery swapping or any other approach are currently limited to the initiative of only a few OEMs. By limiting the funding availability to only one kind of electric buses with conduction charging facilities, FAME II is limiting innovation. Smaller batteries can be innovated to have higher energy density. As the e-bus market is in a nascent stage, the product range is limited and low bus demand is not stimulating research and development.

Besides, production has slowed down, following reduced demand and pandemic induced disruption in the global supply chain. Even after a year of receiving supply orders, OEMs are unable to supply buses to cities/STUs. To address this challenge, electric vehicle policy requires a larger ecosystem approach that includes planning of upstream, midstream, and downstream technologies. The PLI programme that has been announced for batteries of electric vehicles needs to be leveraged well.

Bus manufacturers typically import e-bus technology—like motors, battery management systems and chargers—from China and Europe, while the chassis and bus bodies are developed locally.

Though the electric bus market has few players at the moment, several automakers have plans afoot for the segment. Edison Electric, Mahindra & Mahindra and AMS Electric are planning to enter the e-bus business, while Force Motors and Kinetic Green have plans for the mini bus (up to 7 m) segment in small cities.

An analysis of the e-bus market data reveals that Indian manufacturers in tie-ups with foreign players received the most number of supply orders (74 per cent of the total till 2020–2021) under FAME I & II schemes.

In terms of bus sizes that were popular among these orders, data shows a marked preference for 9 m buses. Almost 93 per cent of FAME II orders by cities/STUs preferred this size, according to UITP India's analysis of FAME II tenders across the country.

There is also a marked presence of joint ventures with Chinese shareholders among the companies that won these orders. Of the total orders for e-buses, 56 per cent were won by those in JVs with Chinese partners. Current dependence on China is largely because of lower costs offered by China, but the scenario is changing. Tata is setting up an indigenous supply chain in India, which will include batteries. It has also been reported that Tesla may tie up with Tata Power to set up charging infrastructure for electric vehicles. Clearly, the direction of change will depend on the long-term strategies for incentives and state government policies on EV linked public transport.

Changing business model: E-buses are also transforming the business models of OEMs. Buses are being purchased based on gross cost contract that requires the OEMs or the designated operators to provide and also operate and maintain the buses on behalf of the state transport corporations on per kilometre payment basis. In a majority of cases, OEMs are tying up with traditional private bus operators in India to provide these services. Nonetheless, bus volumes continue to be low and sales are entirely dependent on government subsidy. Low volumes deter the setting up of support infrastructure including after-sale service arrangements across geographies.

The upfront capital investment required for e-buses is more than double required for ICE buses—battery and charging infrastructure add to the cost. Generally, capex needed for ICE buses is 20 per cent of their overall cost. But in the case of e-buses, it is almost 45–50 per cent. A World Resource Institute (WRI) study in 2021 shows that without FAME subsidy, the TCO of 12 m standard e-bus with 320 kWh battery size is about Rs 77.75 per km while the same for 12 m standard diesel bus (high-cost diesel variant) is Rs 78.57 per km. However, with FAME subsidy, TCO of 12 m standard e-bus with 320 kWh battery size is reduced to Rs 65.90 per km.

Yet another study published in International Journal of Technology in 2019 has calculated TCO for a period of 25 years (considering the normal life of transport infrastructure in India). According to the study, the TCO for an electric bus is Rs 3.66 crore, while it is Rs 3.91 crore for a diesel bus. This also shows that with a well-designed incentive programme it is possible to achieve price parity and eventually scale.

However, the cost burden on operators still remains as they have to submit almost equal amount of bank guarantee for the entire project period. This will have to further inform the financing and incentive strategy.

While ICE buses are purchased directly by the public transport agencies for operations, e-buses are being procured on the basis of GCC model of bus operations under FAME II scheme. Buses are owned by the OEMs or the designated operators and not by the STUs and they take care of the investment required for procurement, developing charging infrastructure including technology selection and locations, and looking after operational performance and maintenance. They are paid on per km basis while conforming to the pre-decided service criteria. This has been done to reduce the risk for the operators. GCC model helps de-risk the STUs. This has also helped the STUs to operate their e-buses at fairly more competitive rates compared to diesel/CNG buses. E-bus deployment under GCC model requires holistic planning of the system including bus routes, depot infrastructure, power supply, tariff, etc. as these have a considerable impact on the cost of the project.

In fact, there is a strategic shift in the focus of bus procurement. STUs now prefer to specify their service needs instead of only specifying details of the vehicles. Tenders now mention requirements like expected service range in single charge, AC facilities, chargers in routes and depots, etc. Battery range and life are the major concern areas for transit operators, as operational efficiency and project costs are hugely dependent on it.

To make the tender process more service oriented, it is necessary to seek details related to expected daily km run per bus and daily operational schedules that could aid the OEM's e-bus deployment strategy to achieve the desired level of service delivery. Information on passenger load and occupancy factor for each route, congestion and traffic conditions, depot location and distance from route origin/destination have bearing on service planning and costs.

Yet another aspect of e-bus deployment is fleet planning strategy according to the service requirements on different bus routes. This affects the performance of the buses. Fast and slow traffic, passenger load, use of air conditioners, among others, affect the real-world driving range and ageing of batteries. Controlling oprational parameters is very important. Proper route planning is needed to optimize range and reduce dead mileage. These have a bearing on the TCO of e-buses as well.

Several cities including Navi Mumbai, Pune, Hyderabad, Bengaluru, Kolkata, Delhi, etc., that have embarked on an electric bus programme, are beginning to look deeper into granular planning to identify type, number, capability and location of the chargers, and the charging schedule to optimize the operation of the fleet. This improves staff awareness and skilling for deployment, management and monitoring of the fleet for verified fuel savings.

Installation of the right kind of charging infrastructure is important to increase operational efficiency of e-bus services. Depot charging facilities provide a safe and secure environment for charging of e-buses, but in the case of top-up charging requirement, buses have to travel long distances and that increases non-revenue kms. This also impacts the scheduling of the services and consequently the ridership. Similarly, installation of additional charging facilities at bus terminals to provide opportunity charging services adds to costs of setting up charging infrastructure. Even though battery swapping seems easier, it also requires a safe place with robotic arms to carry out the swapping activities. Two-thirds of the cities are opting for the most popular overnight depot charging options, along with opportunity charging in a few cases. Several STUs have kept their options open to allow OEMs to decide.

Among challenges faces by e-bus operators is the need to train the existing workforce, familiarize them with new technology and provision performance monitoring mechanisms for the new technology.

Reforming incentive structure for e-buses: An open FAME incentive structure may provide more flexibility to the STUs to choose the appropriate operational model for themselves. Currently, FAME II is providing capital incentive up to 40 per cent of total bus cost. The cost of the bus is calculated based on the prescribed formula and the maximum demand incentive is capped as per bus size (i.e., maximum 55 lakhs for >10m buses). Both FAME I and II have provided subsidy on capex only, although FAME II subsidy calculation is much more rigorous and takes care of discounted rates from present value for entire project duration. The whole subsidy amount is supposed to be paid within six to seven months of bus operations. However, instead of providing capex subsidy in initial days, if the government provides the same support for a longer operation period of at least seven years, considering battery replacement requirement, it will be equal to a subsidy of Rs 12 per km (considering an average daily operation of 180 km per bus). This can make the cost of operations almost equal to low floor diesel (at par with TATA/Volvo) bus services. This will also ensure operation of e-buses for a longer time. Additionally, when capex subsidy is provided, the operator does not have any control over price and OEMs tend to quote high prices. Without capex subsidy, private operators will be in a position to negotiate the price through bulk purchases.

Several established STUs have their own infrastructure, human resource, and operation and maintenance system for the entire fleet of buses including the ICE buses. It may not always be practical to have a GCC model for a smaller fleet of electric buses. More flexible options for bus operation need to be considered.

E-bus incentive design needs to create more options for the combination of technology and charging facilities. In addition to the battery-operated electric buses with only conduction charging facilities that dominate the market today, the policy could promote DC pantograph charging or battery swapping or any other approach. Flexibility in incentive design should take into account the technical and financial viability of the projects. Transit agencies should have the right to strategize e-bus deployment according to their local planning and strength. It is possible to adopt battery lease model (in which responsibility of battery and setting up charging infrastructure is offered to a private partner). This can reduce the high upfront cost and allow STUs or other public transport agencies to hold significant control over the system.

States have to prepare and align their EV policy to create more targeted opportunities for e-bus deployment. States/cities have to identify bus services as essential services—

not for profit—and prepare a long-term e-bus transformation plan including provisions for providing viability gap funding for bus operations. E-buses require detailed planning before deployment. City level comprehensive fleet planning for routes and charging should be done in advance for e-bus deployment. City level e-bus deployment plans are needed to provide for e-bus oriented transit infrastructure like depots, terminals, bus stops, etc. States should also proactivity assist the power sector in improving their grid capacity by providing some benefits to them as well.

State policies have to provide for category-wise targets of EV penetration, particularly focusing on e-buses. This will provide long-term policy visibility to the industry and also help in monitoring the progress towards policy objectives.

The central government's focus on advanced batteries under the PLI scheme can boost e-bus development, as locally made batteries will reduce the cost of buses substantially from their present value. Similar schemes for other electric vehicle component manufacturers will expedite the overall electric vehicle transition, especially for e-buses in India.

As the sector is entirely new, cities need to create all the required document/guidelines/regulations from an e-bus perspective. This has to include extensive training programmes for different categories of staff involved in e-bus operations.

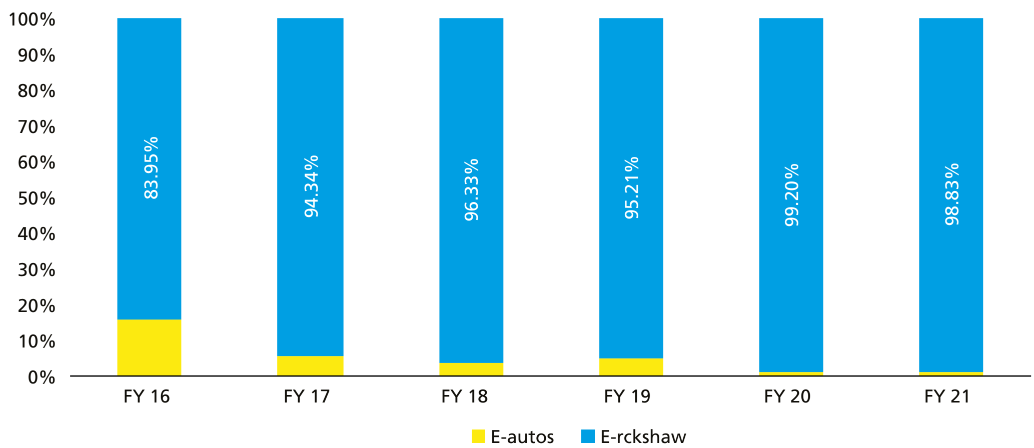
3.4 Electric three-wheelers

The E3W segment is part of the para transit in India and is a popular mode of transport. This low volume, high frequency and short haul transport system for last mile connectivity is an attractive mode of public transport and amenable to quicker electrification. The E3W market depicts trends similar to the E2W market. Out of seven conventional three-wheeler manufacturers, only three have introduced products in the electric segment and there are 16 new companies accounting for 84 per cent of E3W sector.

E-rickshaws are considered to be an undisputed outlier in the E3W market. According to the VAHAN database, between FY 2017 and FY 2021, the share of e-rickshaws was more than 90 per cent of the total passenger E3W market in India. However, the high number of these light-weight, compact battery vehicles being deployed on the roads is not necessarily a positive trend.

While there are many lithium-ion e-rickshaw models manufactured by the organized E3W manufacturers that conform to safety norms, a majority of e-rickshaw models continue to operate in the unorganized sector. The vehicle models are usually imported as non-standardized completely knocked-down (CKD) units that are assembled in local workshops and then sold at very cheap prices to local fleet operators. They use a lead-acid battery that needs a replacement every six to eight months, and the older unusable battery is disposed without any recycling or disposal protocols. Most e-rickshaws are not registered and operate under the radar taking advantage of the nature of the small scale last mile connectivity operations they are deployed in (see *Graph 10: Share of e-rickshaws and e-autos in the passenger E3W market in India*).

Graph 10: Share of e-rickshaws and e-autos in the passenger E3W market in India



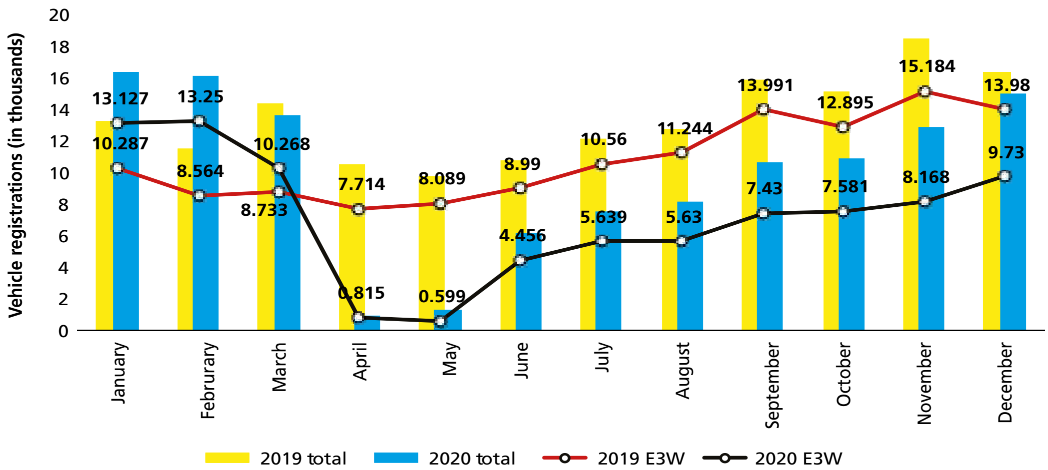
Source: VAHAN database

The E3Ws in the organized sector have witnessed larger numbers of registrations in Jan–March 2020 compared to the corresponding period in 2019 (see *Graph 11: Comparison of total electric vehicle sales and electric three-wheeler registrations in 2019 vs 2020*). This segment faces direct competition from e-rickshaws in the informal market.

Going by the numbers, E3Ws and E2Ws are expected to lead the country's electric mobility goals in the short to medium term and be a significant factor in meeting the 30 per cent target by 2030.

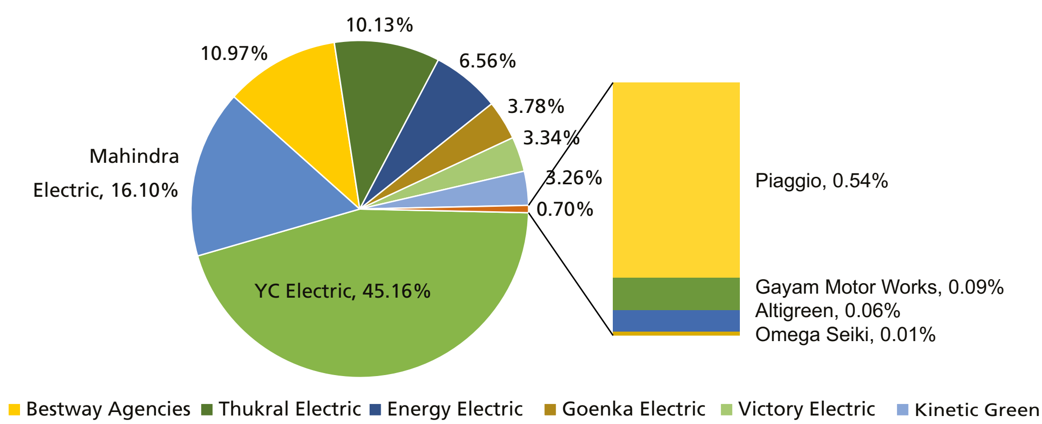
Due to uncertainties regarding charging facilities, battery performance piques the most interest with fleet operators. Several e-rickshaw manufacturers offer more than 100 kms of range with a single charge. Market information indicates that YC Electric's Yatri Super is the most registered e-rickshaw variant in India, with one of the highest battery ranges offered in the segment at 113 kms per charge. Mahindra Electric with its Treo Yaari has captured 16 per cent of the market in India (see *Graph 12: Market share of e-rickshaws* *and e-auto manufacturers in the passenger E3W market in India*).

Graph 11: Comparison of total electric vehicle sales and electric three-wheeler registrations in 2019 vs 2020



Data source: MoRTH 2020, *VAHAN Dashboard*

Graph 12: Market share of e-rickshaws and e-auto manufacturers in the passenger E3W market in India



Source: VAHAN database

The E3W market is still quite sparsely populated with only a handful of e-auto (L5M vehicle category) manufacturers (see *Table 4: E3W models available in India*). Apart from Mahindra's Treo, the second top selling model is OM Balaji's eVikas. Other manufacturers such as Champion Polyplast's Saarthi Shavak and Piaggio's Ape are selling little to none according to VAHAN registrations data. The story behind low registrations for e-autos could be the very similar build structures of e-autos and e-rickshaws. A slight difference in battery size and range leads to a substantial price differential.

Table 4: E3W models available in India

Sr. no.	Name of E3W manufacturers	Available models	Range	Max speed (Kmph)	Battery capacity kWh	Charging time (in hrs)
A	**Lithium variant**					
1	Mahindra Electric	Treo Yaari HRT	85	25	3.7	2–3
		Treo HRT	130	25	7.4	3–4
		Treo SFT	130	25	7.4	3–4
		Treo Yaari SFT	85	25	3.7	2–3
2	Kinetic Green	Kinetic SAFAR SMART LFP	112	25	3.7	2–3
		SAFAR SHAKTI LFP	100	25	4.1	2–3
		KINETIC SAFAR SMART	126	25	4.1	2–3
3	Champion Poly Plast	SAARTHI SHAVAK E AUTO	94	-	6.6	4–5
		SAARTHI SHAVAK DLX E - AUTO	94	-	6.6	4–5
		SAARTHI F2	105	-	4.4	4–5
4	Victory Electric International	VICTORY VIKRANT	136	-	5.2	5–6
		VICTORY +	136	-	5.2	5–6
5	Y C Electric Vehicle	YATRI SUPER	113	-	4.3	9–10
6	Bestway Agencies	ele ex	126	-	4.4	6–8
7	Goenka Electric	Prince Pro	100	-	7.7	-
		Prince Pro X	100	-	7.7	-
8	Energy Electric Vehicles	Premium Udaan	-	-	4.4	7–8
9	Thukral Electric	THUKRAL ER 1/ Grand/ Grand SS/ DLX	100	25	3.5	7–8
10	Piaggio	Ape e city	68	-	4.5	Battery swapping
11	Omega Seiki	Stream	100	40	6	3–4
		Ride	100	25	4	3–4
12	Gayam Motor Works	Urban ET	110	55	4.8	-
13	Altigreen	E3W Passenger	120	53	-	-
B	**Lead acid variant**					
1	Kalinga Ventures	VIDHYUT-E1		40	6.72	
2	Kinetic Green	DX	80	25	-	8–10
		Safar Shakti	80	25	-	10–12

Sr. no.	Name of E3W manufacturers	Available models	Range	Max speed (Kmph)	Battery capacity kWh	Charging time (in hrs)
3	Saera Electric	Mayuri Star	-	-	-	9–10
4	Khalsa E-vehicles	Khalsa Grand	95	-	-	9–10
5	Atul Auto	Atul Elite+	80-100	25		8–10
6	Terra Motors	Y4 Aalfa	100	25	4.8	8–12
		Y4A Sumo	100	25	4.8	8–12
7	Lohia Auto	Comfort	100	25	4.8	-
		Comfort plus	100	25	-	-
		comfort DLX	100	25	-	-
8	Gayam Motor Works	eShaft	60-90	25	-	5–6

Source: Compiled by CSE

For instance, the Mahindra Electric Treo e-auto offers 170 kms of range with a price tag of Rs 2.2 lakhs (ex-showroom price in Bangalore) and is eligible for a FAME incentive of Rs 66,000–68,000 while the Treo Yaari e-rickshaw with 130 km range priced at Rs 1.37 lakhs gets incentive of Rs 37,000. It needs to be seen how this influences buying decisions.

There are unique challenges in this segment. E-rickshaws in informal markets are much cheaper than e-autos, the range difference is not as big for a commercial operator and the build quality is also almost the same for both segments in current models. For example, after including incentives, the Mahindra Electric Treo e-auto (170 km range) is Rs 50,000 more expensive with a 40 km extra range than the Mahindra Treo Yaari e-rickshaw (130 km range). So, a fleet operator may still prefer buying the e-rickshaw which is cheaper, even if that means charging the battery more frequently. Since the battery already allows a 130 km range, a 40 km range deficit which an e-auto could've offered can be adjusted with route planning.

Major issues faced by E3W companies range from limited access to capital, perceptions about range and access to charging. Banks are reluctant to lend to start-ups engaged in EV manufacturing due to lack of awareness about EV technology and its associated risks. Industry executives feel customer awareness about range and the need for charging requires improved dissemination. With E2W owners, 90 per cent of charging is done at home. The requirement for a public charging network is significant for the E4W owners, particularly those deployed in commercial applications.

As part of an intermediate public transport strategy in cities, a targeted mandate for fleet electrification could be useful. This segment has the potential to achieve 100 per cent electrification quicker than other segments and that should be leveraged. Also, total cost of ownership parity is expected to be easier for this segment. There are special challenges in the 3W market as most of the vehicles are held on daily lease. This makes financing and monthly repayment a challenge.

3.5 Electric three- and four-wheeler cargo vehicles

This is yet another segment that has received considerable policy attention as these vehicles are part of the cargo and delivery fleet in cities. These are also high mileage vehicles and suitable candidates for targeted electrification.

There are several models in the market. Though the E3W segment was the least incentivized under FAME I, it clearly offers an opportunity going by the interest it has generated in the automotive industry. The potential business case that the segment presents has encouraged several entrants into the electric urban freight market both in the three-wheeler and in the four-wheeler segments. Both the models are available with lead acid and lithium-ion battery technology and their prices vary as per the battery size and technology.

Among the key conventional players, Mahindra and Tata are about to launch their E4Ws—Mahindra e-Supro cargo van and Tata ACE Electric. Others such as Croyance and Altigreen have developed E4W cargo vehicles, while companies such as Inncrypto Technologies and e-Trio are retrofitting E4W cargo vehicles.

In the E3W cargo segment, the entry of big players such as Atul Auto have encouraged smaller E3W manufacturers such as Kinetic, Lohia, Gayam Motors and Goenka Ecoyan to announce plans, while Altigreen and Volta are retrofitting three-wheelers with electric systems.

With the COVID-19 pandemic and increased doorstep deliveries, demand for E3W and E4W cargo vehicles has come from large retail houses such as Amazon. The e-retailer plans to introduce 10,000 electric delivery vehicles in India by 2025 including E3Ws and E4Ws. Grocery retailer Grofers has deployed 50 E3Ws in Jaipur and 100 in Delhi.

In the cargo segment, customers look for vehicles with high-payload capacity, lower total cost of ownership and the ability to operate in ambient temperatures and road conditions. To be able to deliver high payloads, commercial use requires uninterrupted running times or larger range, in addition to public charging facilities to ensure minimal downtime. Unavailability of many public charging stations continues to deter adoption of electric vehicles despite the advantages of lower operating costs.

Electric vehicles are expected to reduce last-mile delivery costs by up to 50 per cent. They can run for 60–70 km with a single charge, with a loadbearing capacity of 30 orders, costing Rs 20,000–25,000 per month.

The low cost of ownership and operating costs of the electric cargo vehicles make them an attractive option for intracity cargo applications. It has been estimated that a commercial electric vehicle operates on 1/6 the running cost of a petrol/diesel-fuelled vehicle, though with higher acquisition costs. A TCO comparison for electric and diesel vehicles suggests that electric vehicles are more favourable than diesel above 30 to 35 km of daily use. Since most commercial cars have an average use of 200 plus kilometres, electric cars offer a better cost option.

3.6 Fleet aggregators and electrification

Increasingly, focus is shifting towards scalable models for large-scale deployment to create concentrated demand for EVs. The high utilization segments that are being targeted for fleet electrification include app-based and conventional ride hailing services, delivery fleets for logistics and e-commerce companies, and employee transport services contracted by employers to transport employees; all of them use cars, e-bikes and three-wheelers in varying degrees.

Ride hailing: On-demand mobility options, such as ride hailing and ride sharing that are cost effective, are being preferred over personal vehicles. The ride hailing segment is often referred to as the 'platform' market since it uses a technology platform that connects drivers to riders or supply to demand. It is marked by larger efficiencies in comparison to the traditional taxi industry as it can more appropriately predict, capture and optimize rides. Being local in nature, it works within city environments with almost no physical product differentiation, a factor that enables stronger competition. Players mainly work with two differentiating factors—price and waiting time—to win competitive advantage.

The immense popularity of the ride hailing and rental applications segment is grounded in its persuasive economics. The short-term mobility option offered by ride hailing service providers is attractive compared to the long-term commitment required with owning a car that also includes recurring costs such as EMIs, insurance, repairs and maintenance, even as the vehicle's value depreciates annually.

App-based ride hailing services have grown explosively in the shared vehicle market while traditional/offline taxi industry still remains. The 2021 report of World Business Council for Sustainable Development (WBCSD) on India has estimated the size of the Indian taxi market to be $10 billion; that is expected to grow to $60 billion by 2030. Companies like Ola and Uber are leading this trend. According to WBCSD, 'both companies have deployed over $2 billion in the Indian market and have created an inventory of over 0.7 million cabs, catering to 3 million trips per day.' It adds that ride-hailing cars, that are about 1.2 per cent of the total car stock in India (as of 2019), contribute 6 per cent of the total emissions caused by cars in India. Electrification of the ride-hailing fleet as part of shared mobility strategy needs to get policy and regulatory support.

According to another report titled 'Online Taxi Services Market in India' by Research and Markets, Ola Cabs accounted for almost 72.44 per cent of the total revenue generated by the online taxi services market in India, whereas Uber India held a share of approximately 21.01 per cent. The rest is occupied by smaller players such as Meru Mobility, Mega Cabs and Carzonrent, which together held about 6.55 per cent of the overall market in FY 2019. Uber, however, has said in a report that it has more than 50 per cent market share in India, based on its internal gross bookings estimate. Both players offer services in two-, three- as well as four-wheelers. In fact, the structure of the new app-based mobility industry straddles across vehicle segments and even buses, offering services that range from ride hailing and ride sharing to delivery services and employee transportation.

The use of e-bikes and auto-rickshaws by these companies is strategic as they offer accessibility on routes that are not served by other modes of transport. These are also attractive in congested streets. The combined value of the trips taken by all of these app-based service providers, some of which have extensive geographical reach (Ola operates in 152 cities), presents an enormous opportunity for vehicle electrification.

As this service depends on deployment of diverse vehicle segments including cars, autos and two-wheelers, vehicle segment-wise policy support can be an enabler. This is particularly relevant to e-bike taxis and rentals. The 2018 NITI Aayog report has proposed inclusion of bike sharing within the scope of shared mobility for low cost last-mile connectivity. Several companies have begun to deploy electric bike taxis and bike rentals, such as Ola Bike, Bounce and eBikeGo. According to the WBSCD 2021 report, legalization of e-bike taxis and streamlining licensing of e-bike rentals through an easier and more efficient regulatory landscape can accelerate change.

This may however require regulatory support to legalize e-bike taxis and streamline licensing of e-bike rentals across all states. Some states have also started to promote e-bikes. In 2018, Haryana, Telangana, Gujarat and Uttar Pradesh issued bike taxi permits. Close to 14 states have now legalized bike taxis. Although, at the same time, Madhya Pradesh and Karnataka have banned bike taxis for safety reasons. Guidelines are needed for e-bike rentals. There are challenges with regard to licensing of app-based fleets in several states.

Ola has opted for diversification on an entirely different level—manufacturing. Ola's journey from an app-based mobility company to an electric two-wheeler manufacturer changed the entire ride-hailing narrative. Firm in the belief that electric two-wheelers will be much more relevant in a post-COVID world, Ola acquired Amsterdam-based electric scooter-maker Etergo and set up a manufacturing plant in Tamil Nadu with an investment of Rs 2400 crore. The plant has an annual production capacity of 2 million units and, to service those vehicles, Ola is working on laying a network of a lakh charging points across 400 cities. The company opened vehicle registrations on 15 July 2021, and ended up receiving over 1 lakh reservations for its two-wheelers in a day. The consumer response clearly indicates a shift in preference towards EVs for future commute.

The ride hailing business took a big hit during the pandemic lockdowns, wiping off revenues to the tune of 95 per cent in April and May 2020 for Ola, and leading to massive layoffs at both the companies. Cognizant of the enormous impact the pandemic had on revenues, Uber launched a new product in the form of grocery delivery.

Creating volume in the ride-sharing business model: A push for electrifying the commercial passenger four-wheeler segment can act as a catalyst to bring higher EV penetration in the 4W segment in the short run. High asset utilization allows fleet operators to recover the cost of buying, operating and maintaining the vehicle much sooner. The total cost of ownership of the vehicle forms the basis for establishing the financial viability of such fleet operated projects.

In 2017, Ola Electric ran a pilot project in Nagpur that included an electric fleet of e-cabs and e-rickshaws, running for over 7.5 million clean kilometres. In the study, it was concluded that the TCO at the end of 4 years or 1,80,000 kms for an electric vehicle running at special tariff proposed in the state EV policy was Rs 11.5 per km, whereas that of a CNG cab was Rs 8 per km.

It must be noted that Maharashtra did not have a notified EV policy in 2017 when the pilot project was launched. This meant no state subsidies on purchase of vehicles, and no registration and road tax exemptions. Therefore, the TCO analysis was done on a vehicle capex component almost twice as much as the CNG variant. The experiment shows that a reduction in TCO with incentive support could have an impact on fleet operator's EV orders. The TCO has five major components: purchase cost; maintenance cost; insurance cost; charging cost or fuel cost; and the charging infra cost.

The cost of maintenance is already low for EVs as compared to ICE vehicles. Charging costs can be reduced by setting up lower cost of electricity for fleet operators, augmented with reduced land lease rentals for charging infrastructure setup.

Delivery fleet: India has witnessed phenomenal increase in last-mile deliveries across urban e-commerce, food/grocery and couriers linked to the growth of digital retail market. This has increased traffic intensity and attendant problem of emissions of local pollutants and carbon while adding to traffic congestion.

The very high rate of fleet utilization and rising fuel prices make electrification a big opportunity. According to the 2021 WBCSD report, in 2020 Flipkart became the first e-commerce marketplace in India to commit to transitioning 100 per cent of their vehicle fleets to electric by 2030 by joining the EV100 global initiative. They are primarily assisted by service providers such as e-Kart, Delhivery, GATI and others to transition their ICE fleets to more cost- and environmentally-effective EV variants.

But this sector faces challenges in terms of limited EV options for heavier delivery vehicles, permit concerns related to cross-sector usage of the same vehicle, and licensing system of 2Ws. This may also require management of last-mile urban freight and deliveries and regulation of daytime entry of heavier electric delivery vehicles in cities for a timebound period to drive early adoption. FAME can subsidize certified retrofitting kits for heavier electric delivery vehicles, and adopt favourable regulations for cross-industry usage of E2Ws and a robust licensing structure.

Multinational companies such as Amazon and Ikea have set global targets to move to electric vehicle deliveries. Amazon has made a commitment of 1,00,000 electric vehicles in the delivery fleet by 2030 and Ikea says on its website that all deliveries by 2030 in 30 markets will be electric. Extending the pledge to India, IKEA has committed to the use of only electric vehicles for delivery services by 2025 in India.

The Delhi government has partnered with Flipkart, Amazon, Zomato, Blue Dart Express, and 26 other companies to start using electric vehicles for deliveries under a project called 'Deliver Electric Delhi'.

Even without government push, companies have already started delivering products using EVs. Zomato tied up with E2W rental platform eBikeGo in May 2019 to enable EV deliveries. Swiggy too has inducted electric bicycles in its delivery fleet across 10 cities in India. Amazon has tied up with Mahindra and has deployed close to a hundred Mahindra Treo Zor EVs in its delivery network in seven major cities in India, as part of its commitment to add 10,000 electric vehicles in its local delivery fleet by 2025. The cities include Bengaluru, New Delhi, Hyderabad, Ahmedabad, Bhopal, Indore and Lucknow.

Electrification of delivery fleets is globally seen as an optimal solution to curb transportation emissions. Amazon is leveraging opportunities in last mile logistics by forging a partnership with electric vehicle manufacturer Rivian. The online retailer expects the custom designed Rivian electric vans to help meet its corporate climate pledge to become carbon-neutral by 2040—10 years ahead of the international Paris Climate Agreement's goal.

In India, the government has reportedly ordered ride-hailing giants Uber and Ola to convert 40 per cent of their fleet to electric cars by 2026, according to a Reuters report in June 2019. For both the companies to achieve this target, they 'would need to start converting their fleet to achieve 2.5 per cent electrification by 2021, 5 per cent by 2022, 10 per cent by 2023 before hiking it to 40 per cent,' the report said.

Employee transport: Due to inadequate public transport system and poor accessibility in cities, corporate employee transport system has emerged as an attractive and popular option. The employers, largely the IT and BPO sector, outsource transport services that include cars and buses. According to the 2021 WBCSD estimates, this form of transport is about 23 per cent of the Indian taxi market. This market is projected to grow at 13.7 per cent (compounded annual growth rate or CAGR). Demand for this service has reduced during the pandemic due to the shift towards work from home but is expected to bounce back. This fleet has strong potential for electrification and companies such as Google, Amex, Accenture, Wipro and Adobe are reported to have deployed EVs for their employee transport in major Indian cities.

This approach creates concentrated demand that enables business investments in deployment and augmentation of independent EV fleets and charging infrastructure. Several service providers have emerged to provide this service including eee-taxi, Lithium Urban, Shuttl, Glyd and rydS among others. This sector will require policy support to improve business viability. FAME can be further strengthened for this fleet segment for significant market traction.

Electrification of feeders for last mile connectivity: The Delhi metro plans to electrify its last mile connectivity in a bid to provide seamless travel experience to commuters that is also emission free. In February 2020, the Delhi Metro had extended the facility of e-rickshaw services to 12 more stations across the rapid transit network. The facility is now available at 29 stations, with an operational fleet of over 1,000 e-rickshaws.

The Master Plan Delhi 2041 makes a projection of the number of trips citizens will make per day on the basis of the projected population growth by 2041. Even though a large

Case study: Employee transportation services

In metro cities, office goers typically work in dynamic shifts and meet clients according to their project deadlines. Employee transportation service providers help office goers avoid wasting time in finding public transport or waiting to be picked up to go to office. As employees are the human capital who drive growth, most companies prefer to organize commutes to enable productivity.

A Bangalore-based company Lithium Urban Technologies has acquired a technology enabled employee transportation solutions platform, SmartCommute, to address this requirement.

Founded in 2014, SmartCommute specializes in technology enabled Artificial Intelligence (AI) solutions for scheduling, rostering and routing in transportation services along with accessibility to charging stations. The acquisition will help Lithium Urban customers to transition from ICE vehicles to electric for employee commutes.

Pre-pandemic, the SmartCommute platform was used by approximately 30,000 employees in over 3,000 vehicles, across Bengaluru, Mumbai, Pune, Kolkata, New Delhi and Hyderabad.

Then, there is Shuttl, an app-based bus service that caters primarily to daily commuters. Shuttl is the organized and much-improved version of chartered bus services that operated in the pre-app era. The service is built on technology and data—the routes, pick-up points, and time slots are designed on the basis of customer feedback and the discoverability of these routes is solved through the consumer app. Gurgaon-based Shuttl operates in eight cities in the consumer and enterprise segments and does 60,000 rides a day. It raised $11 million from Amazon and Dentsu Ventures in July. Earlier, ZipGo, an on-demand AC bus service for daily commuters, raised $43 million from the Essel Group.

Employee transportation is a multi-billion dollar market in India. Experts estimate the size of the urban commute market in India's top cities at between $8 billion and $12 billion. Company expenditure on employee transportation comprises almost 90 per cent of this segment and many operators focus on working directly with companies.

This means they are likely to be profitable, in comparison to consumer mobility solutions providers such as Ola and Uber, which have been losing customers after they cut down on user discounts and introduced surge pricing as a revenue expansion tool.

section of the population is expected to be working from home, considering a larger shift towards service sector in the next two decades, Delhi expects to generate 46.2 million trips daily (excluding walk trips), with an average per capita trip rate of 1.58. Delhi plans to encourage electrification of many of these trips including shared mobility and on-demand mobility.

For mass electrification to become a reality, what is required is a clearly articulated change model that can drive multi-directional growth and achieve scale that matches India's ambitions. Technology improvements and commitments by ride hailing operators indicate that ride hailing fleets are poised to shift to electric vehicles. This can also help to increase public awareness and expand an efficient charging network.

Need technology options to improve cost parity: Ride hailing is a cost sensitive market. Quicker improvement in vehicle technology and operational performance can help improve cost parity. A study carried out by ICCT has evaluated 5-year total cost of ownership of four-wheeler battery electric vehicles used for ride-hailing and how this compares with petrol, diesel and CNG vehicle models in 2020. For this, the popular models of Mahindra eVerito D2 and Tata Nexon were considered. Delhi, Hyderabad, and Bangalore, the top markets for ride-hailing in India, were considered.

This shows that with the current cost and incentive structures and without considering any additional incentives, Mahindra eVerito D2 is cheaper than the comparable diesel and petrol cars in terms of 5-year TCO and cost per kilometre. For Tata Nexon, the per-kilometre cost is only marginally higher than the comparable diesel and petrol cars in Hyderabad and Bangalore, and it is lower in Delhi. If additional incentives are also considered, the cost differentials decrease further. In the meantime, the base price of the latest variant of Mahindra eVerito D2 has dropped by 16 per cent between 2019 and 2020 while the range of the vehicle increased by 29 per cent. This reduction further contributes to a 34 per cent decrease in cost per kilometre in Delhi and a 20 per cent decrease in cost per kilometre in Hyderabad.

Ride hailing and state policy: A number of state governments are batting for ride hailing and delivery services as a key focus area in their EV policies. Specifically, Delhi, Telengana and Karnataka, which have the highest number of electric vehicles compared to other states, see ride hailing, car sharing and delivery services as some of the key pathways for achieving higher volumes in vehicle electrification. According to the NITI Aayog-RMI report, the sector could grow anywhere between 50–100 per cent through 2025.

The Delhi EV policy expects ride hailing cars to play a significant role in its goal of 25 per cent EVs among all new vehicle registrations by 2024. The Delhi government, as part

Ola's and Uber's experiments

Uber signed a partnership with Mahindra in 2017 to deploy electric sedan eVerito and electric hatchback e2o Plus on the Uber platform in New Delhi and Hyderabad. Charging stations were to be set up across several cities using Uber's traffic and mobility data.

However, the experiment did not take off owing to the lack of charging infrastructure until a couple of years later when Uber deployed 50 Mahindra vehicles in Hyderabad. By October 2020, Uber had 100 electric vehicles such as Mahindra eVerito and Tata Tigor EV running on its platforms and decided to tie up with Lithium Urban in a bid to increase its electric vehicles ten-fold.

Much like Uber, Ola announced the roll-out of EVs in 2017 in Nagpur with an investment of Rs 500 million. The fleet comprised of e20 Plus hatchbacks from Mahindra, and Safar e-rickshaws from Kinetic. A Reuters report in 2018 revealed that 83 e-vehicles were registered in Ola's name, according to data from the Regional Transport Office at Nagpur.

The M&M e20 plus cabs were observed to have a practical range of about 100 kms on a full charge in summers and up to 115 kms during winters. The average operational daily run was 142 kms. Ideally the battery range should have been 140–150 km for a city like Nagpur. As a result, drivers needed to charge during the day. A full charge on a fast charger takes as long as 90 minutes, which affects business.

During the peak summer season, the battery was also observed to consume 50 per cent more electricity on a fast charger to reach full charge, and the charging time also increased to up to 200 minutes for a full charge. However, battery degradation was not observed even after the erratic charging patterns due to weather conditions.

Kinetic's Safar demonstrated an average range of 35 kms on a full charge and the drivers had to charge during business hours to complete their 66 kms of average daily run. Fast charging Safar takes up to 2 hours for a full charge.

To resolve the high waiting time issues, Ola installed several charging stations. 12 out of the promised 50 were installed only by January 2018. The new stations reduced the waiting times from 3-4 hours to 15-20 minutes, although the capital cost for setting up stations deterred the economic viability of the project.

Moreover, in 2017, Maharashtra did not have a notified EV policy, and therefore there was no subsidy on tariff for charging EVs in the state. Due to the high tariffs and limited fleet, fast charging utilization was restricted to only 25 per cent of the installed capacity. It was only after October 2018, when the state policy was notified, that the charging tariff were slashed by over 54 per cent.

Due to these issues, the programme appeared to have derailed and Ola drivers wanted to return their cars and switch to diesel vehicles instead, unhappy with long wait times at charging stations and high operating expenses. Out of the 20 Ola electric car drivers, almost a dozen wanted to switch to diesel.

of its electric vehicle policy, is bringing rules for taxis, ride hailing and delivery fleet to set a time bound target for electrification. This is an important strategy for quicker and scalable transition.

While Delhi offers incentives for all electric vehicles (Rs 10,000 per kWh), Telengana has planned special incentives for ride-hailing service providers for the first 5,000 four-wheeler commercial passenger vehicles. Karnataka seeks to convert all ride-hailing fleets to electric vehicles by 2030.

Along with incentivizing charging infrastructure, Telangana also aims to incentivize ride-hailing services for the first 5,000 four-wheeler commercial passenger vehicles registered by giving a 100 per cent exemption from road tax and registration fee. Although there are no near-term state targets in Karnataka, the state Electric Vehicle Policy seeks to convert all ride-hailing fleets to electric vehicles by 2030.

All three states have planned easier tariffs for charging electric vehicles, while Telengana and Karnataka propose to facilitate supply of renewable energy to charging stations, including rooftop solar plants. In addition, Karnakata offers a 25 per cent subsidy for charging station equipment for the first 100 fast charging stations in the state.

4. Policy drivers of EV programme

It is necessary to understand if the policies and regulations are being adequately designed to be effective accelerators of change.

The first-generation action to promote electric vehicles started with an ambitious target in 2013 for electrification of vehicles under the National Electric Mobility Mission Plan 2020. It, however, did not achieve its planned scale of change. Seven years after the plan was released, the NEMMP's ambition to have 60–70 lakh EVs on Indian roads by 2020 continues to be an aspiration.

This shows that only a policy intent, without clear mandate and effectively designed incentive programme and long-term policy visibility, cannot accelerate change.

FAME I, introduced under NEMMP by the Department of Heavy Industries in 2015, generated limited interest. Only 4 per cent of the set target of 70 lakh vehicles were sold by the end of 2020 under the FAME I scheme. That accounted for only 2.8 lakh vehicles, including 417 electric buses.

Besides, a majority of the sales volumes were not pure electric vehicles. Almost 95 per cent of vehicles sold under FAME I were mild hybrids, which ran on internal combustion engines and used small, low energy density batteries, often performing only a stop-start function in the name of electrification. Of the Rs 70 crores ear-marked for demand incentives in 2015–16, Rs 40 crores were spent on the diesel mild hybrid segment.

What was particularly disappointing about FAME I was its limited reach in segments that were clearly announced as the lowest hanging fruits and with the highest potential to get electrified—the E2W and E3W segments. The E2W segment, which accounted for 39 per cent of total sales under FAME I till 2019, was mostly fuelled by lead acid batteries, which are significantly cheaper and much less efficient compared to lithium-ion batteries. The E3W segment was the least incentivized segment under FAME I, accounting for less than 1 per cent of the total sales under FAME I.

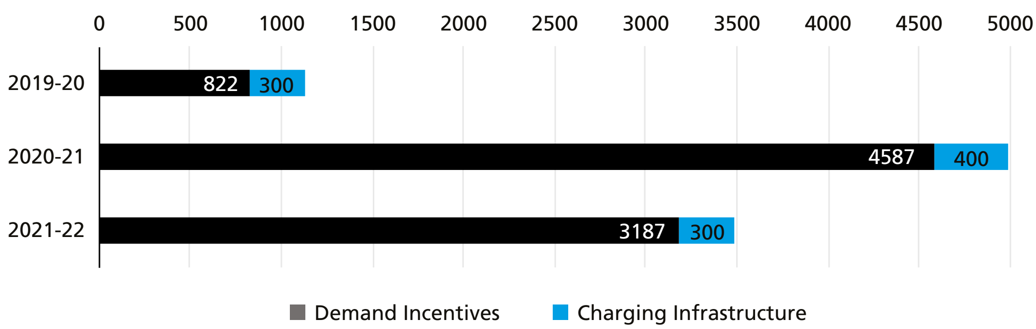
Besides, FAME I also had to work with a time lag in its implementation, as it started two years after NEMMP with only five years to achieve its target. Though it was later extended in 2019 with an additional fund of Rs 100 crores, it fell short on several counts, targets and expectations.

FAME II—Improved but not perfect: The learning curve offered by the FAME I experience leading to withdrawal of benefits from mild hybrids in 2017 and lead acid batteries in 2018 helped policy design to evolve and sharpen focus with FAME II. The second FAME stint which started off with a larger corpus (Rs 10,000 crore) and was armed with a definition of technology and deployment targets, along with a special plan for demand management of electric buses, also fell short.

Starting out with a goal 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, FAME II had till July 2021 registered about 6 per cent of the planned fleet target; with total sales of 94,252 vehicles—73,753 two-wheelers, 18,900 three-wheelers and 1,598 four-wheelers.

Prioritizing public and commercial fleets for electrification was a smart move as electric vehicle adoption for private use is still a subjective view. This way, the optimal use of available resources can be ensured.

Graph 13: Year-wise breakdown of purchase incentives under FAME II (2019–22)



Data source: DHI 2019, *Notification of FAME India Scheme Phase II*; compiled by CSE (Note: Rest of the incentive amount is reserved for administrative expenditure and transferred FAME I expenditure)

Unlike FAME I, the second phase has larger control over vehicle segments that qualify for incentives. It focuses on electrifying longer daily trips by prioritizing electric public transport fleets and commercial vehicles over private vehicles.

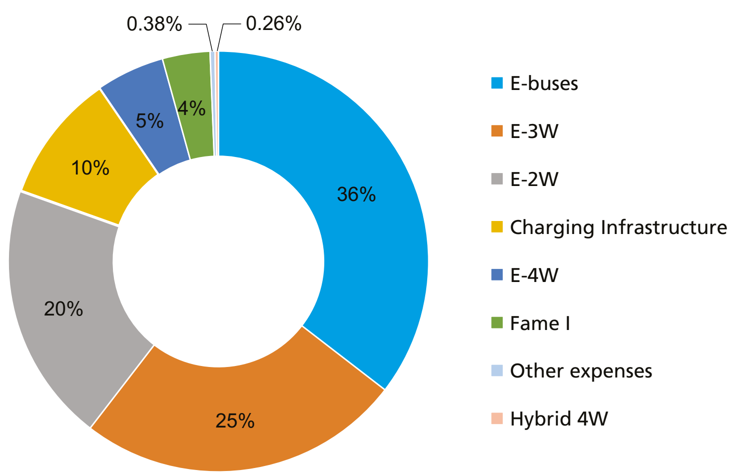
FAME I was not outcome based, while FAME II has set a clear target of the number of vehicles that are incentivized segment-wise.

The focus on prioritizing high performance vehicle models using a quality certification for incentives is a move in the right direction. The certification's demand for features such as battery size and technology has weeded out low performance models that use conventional technologies such as lead acid.

However, linking demand incentives with battery size (per kWh) runs the risk of reduced support for more efficient batteries. As battery technology develops, the batteries will shrink in size and improve in energy density, which effectively translates into higher range by as much as 20 per cent and higher lifespan but smaller in size. That runs the risk of deterring advancement in battery technology for future electric vehicles in India.

A segment-wise split of FAME II incentives allocated to electric vehicles till 2022 reveals that a lion's share (35 per cent or Rs 3,500 crore) will be spent on electric buses, followed by 25 per cent on E3Ws including e-rickshaws and 20 per cent on E2Ws. Thus, E2W and E3W account for nearly half of FAME subsidy package. Charging infrastructure and four-wheelers come fourth and fifth in the pecking order (see Gra*ph 14: Segment-wise incentive disbursal plan of Rs 10,000 crore under FAME II (2019-2022)*).

Graph 14: Segment-wise incentive disbursal plan of Rs 10,000 crore under FAME II (2019–2022)



Data source: NITI Aayog 2020, *Towards a cleaner energy economy*

According to the 2021 WBCSD study, 'two-thirds of the intended FAME II scheme duration has elapsed (as of March 2021), but a significant portion of the fund remains underutilized (as of April 2021)'.

FAME and buses: Given the fact that FAME has a special focus on e-buses, it is important to assess the learning from this strategy separately.

Evaluation of FAME I e-bus deployment strategy provides some interesting insights on why and where it has failed to give the desired push. There was a slow start after the commencement of FAME I on 01 April 2015 as an expression of interest (EOI) to avail the grant from FAME scheme was first issued on 03 November 2017, which is more than 2.5 years later.

There was limited coverage initially. EOI was issued with a plan to extend the grant to a minimum of five cities only, whereas the participation was restricted within million-plus cities, as per census 2011. However, later on, the grant was sanctioned to nine cities. Even so, the number is really small compared to India's scale.

Cities had little time to prepare. From issuance of EOI to proposal submission, cities had effectively less than a month's time to prepare such multi-modal transport proposals. The problems were compunded further with it being a completely new technology and there being low technical know-how on the electric eco-system. In the end, majority of the cities hurriedly prepared and submitted proposals which they themselves find difficult to implement.

E-bus purchase happened without direct focus on e-bus deployment. In FAME I, all the participating cities were asked to submit a multi-modal transport proposal including e-buses, commercial E4Ws, and E3Ws. Furthermore, allocation of grant was limited to only Rs 105 crores for each city for the entire composite basket of e-segments including e-buses.

There was also delay due to wrong technology selection. Initially, FAME I initiatives were more focused on deployment of hybrid e-buses (HEB) where a clear incentive structure was laid out for different variants of hybrid (i.e., mild or strong HEB) according to their fuel type (i.e., CNG and diesel). However, due to low demand for hybrid e-buses, an additional incentive mechanism for pure electric buses was introduced at a much later stage in September 2017.

There were more obstacles in the form of unreliability of available technology, high cost of buses (i.e., 3-4 times higher than conventional diesel buses of that time), rapidly changing technology scenario, limited market players, etc. The agencies which had shown an interest to procure e-buses had to face issues at the time of deciding technology specifications, choosing right e-bus operational model—outright purchase or gross cost contract— etc., as any mistake would have to be suffered for the next 10 to 12 years. It is important to mention here that Bangalore was unable to avail their FAME I incentives, even after selection, due to this dilemma.

Learning from FAME II e-bus programme: Although FAME II tried to address several limitations of FAME 1, including coverage, promotion of cleaner technology, setting up clear deployment targets along with dedicated fund allocation, etc., there is still a lot of space for improvement.

The focus of FAME II scheme to promote e-bus operations only under GCC models is forcing some public transit agencies to adopt a completely new bus operating model. Following which some may require substantial changes even in their organization structure to manage it. Secondly, as the incentive structure is linked to battery capacity only, it indirectly discourages the other technology options like battery swapping, flash charging, etc. which require small batteries.

Recently, the government has extended the FAME II scheme for another two years, which is a right move considering a lot of funds are still available due to non-utilization during the pandemic. However, going forward, the government may consider making the following amendments in FAME II itself:

1) **Flexibility in e-bus operation:** Preference for the GCC model comes from the fact that it helps reduce upfront costs while improving the efficiency of services. However, as many big STUs in India have the organizational strength to manage their services, an open FAME incentive structure may provide more flexibility to the STUs to choose the appropriate operational model for themselves.
2) **Reform in subsidy pattern to ensure better service delivery:** Currently, FAME II is providing capital incentive up to 40 per cent of total bus cost. The cost of the bus is calculated based on the prescribed formula and the maximum demand incentive is capped as per bus size (i.e., a maximum of Rs 55 lakh for >10m buses). Instead of paying the whole subsidy amount within a few months of bus operation (i.e., 6 to 7 months), if the government provides the same support for a longer duration—let's say for seven years, considering battery replacement requirement—it will be equal to a subsidy of Rs 12 per km (considering an average of daily operation of 180 km per bus). This can make the cost of operations almost equal to low floor diesel (at par with Tata/Volvo) services. It will also ensure longer operation of e-buses. Additionally, when capex subsidy is provided, operators do not have control over price and OEMs tend to quote high prices. Without capex subsidy, private operators will be in a position to negotiate the price through bulk purchase.
3) **Create opportunity for diverse technology with different charging options:** Design incentives to create more ways to combine technology with different charging options. In addition to the battery-operated electric buses with only conduction charging facilities that dominates the market today, promote charging options for pentagraph charging or battery swapping or any other approach. Incentives should be more flexibly provided based on technical and financial viability of the projects. Transit agencies should have the right to strategize e-bus deployment according to their local planning and strength. It is possible to adopt the battery lease model (in which responsibility of batteries and setting up charging infrastructure is given to a private partner). This can reduce the high upfront cost and allow STUs or other public transport agencies to hold significant control over the system.

4.1 Fuel efficiency benchmark to drive EV market

Yet another accelerator for electrification is the fuel efficiency regulation for vehicles. This regulation controls energy guzzling in ICE vehicles but a strong benchmark can also accelerate electrification of the vehicle fleet. This strategy is regulated globally as fuel economy standards in terms of litre per 100 km (l/100 km) or as gram of carbon dioxide emissions per kilometre (gCO_2/km). CO_2 emissions are linked to the carbon content of the fuel and the amount of fuel burnt. Further, vehicles are tested for CO_2 emissions that are converted to fuel economy or mileage numbers. Other countries have leveraged these regulations to fast pace electrification.

In India, fuel efficiency standards are crafted by the Bureau of Energy Efficiency (BEE) under the Energy Conservation Act that is administered by Ministry of Power (MoP) and is also notified under Central Motor Vehicle Act and Central Motor Vehicle Rules by MoRTH for implementation.

India has implemented fuel efficiency standards only for passenger cars so far and not for other vehicle segments including heavy duty vehicles, two-wheelers and other commercial vehicles. The standards for the passenger cars are also too lenient to make a difference and represent a lost opportunity.

The first ever fuel efficiency standards for passenger cars—termed as Corporate Average Fuel Consumption Standards (CAFCS)—were implemented in 2017–18. The stage 2 standards are scheduled for implementation in 2022–23. The gazette notification (S.O.1072 (E) dated 23 April 2015) outlines these standards. CAFC standards are linked with the average weight of the cars. For instance, the stage 1 standard of 5.49 l/100 km or 129.8 gCO_2/km was linked with the average weight of 1037 kg. The stage 2 standard of 4.77 l/100 km or 113 gCO_2/km to be enforced from 2022 onward is linked with average weight of 1145 kg (weight of the vehicle is a critical parameter that has bearing on fuel efficiency performance of vehicles).

BEE estimates that the current standards can lead to a reduction of 22.97 million tonnes of fuel consumption by 2025. The EV policy roadmap needs to be linked more strongly with a fuel efficiency regime in order to promote electrification.

India is approaching the deadline for the stage 2 standards for passenger cars in 2022–23. But there is strong pushback from the automobile industry for its deferment on the grounds that big investments have been made to upgrade to BS VI emissions standards in 2020 and COVID-19 pandemic has slowed down the economy. Reportedly, the government has not yet officially approved any delay.

The opportunity for electrification depends on the stringency of the fleet-wide and industry-wide fuel efficiency target and the super credits that are allowed to be earned by individual manufacturers based on their technology innovation and level of electrification.

The devil is in the method of compliance that is monitored at corporate fleet wide level. For each manufacturer, the average fuel consumption (in terms of petrol equivalent litre per one hundred kilometre) is computed and weighted against the sales of each make and model during the fiscal year. The compliance is assessed annually for each car maker based on the sale of each and every make and model and certified CO_2 emission value provided by vehicle certification agencies like ARAI and the average emissions levels are weighted against sales. Then, sales weighted average of all manufacturers is taken to compute the industry-wide compliance. At the end of each year, the status of industry-wide compliance is established and reported. This is calculated based on a formula given in the notification that require specific parameters like fuel efficiency levels and kerb weight of the vehicle (weight of the vehicle that takes into account the weight of all the standard equipment and consumable items fitted on the vehicle while measuring weight of the vehicle).

This compliance mechanism is based on self-reported data on certified emissions levels and sales data for each model and make of vehicle for the fiscal year that is submitted by all manufacturers every year to MoRTH. Therefore, transparency and accountability in the reporting systems are critical for effective implementation. This will have to be ensured in the future.

Different manufacturers produce widely different cars—mix of small and big, petrol, diesel, CNG and electric—and their individual fleet-wide targets vary accordingly; this is represented in a mathematical slope that has been notified as a regulation. Irrespective of this variation, the industry-wide collective average has to stay within the industry-wide limit.

Assessment of stage 1 standards underway shows that not only have all car companies met the 2017–18 standards but have also exceeded them by a margin. According to an independent evaluation by IEA, average fuel consumption of new light duty vehicles sold in 2018 had overreached the target by 9 per cent that year. Thus, the industry has comfortably achieved the target.

Moreover, as the estimates of ICCT show, the fleet is only 7 per cent away from meeting the next target in 2023 without even considering flexibility mechanisms. This implies that targets are very weak (see *Table 5: Indian manufacturer's average fuel efficiency compliance* *in 2017–18 and 2018–19*). 'Small scale manufacturers' such as Volvo, Mitsubishi, Isuzu and Force Motors have been provided even more lenient targets.

The bigger challenge is that lenient targets do not require fleet electrification to reduce fleet average emissions. Clearly, emission targets will have to be more stringent to enable increased share of electric vehicle production.

Table 5: Indian manufacturer's average fuel efficiency compliance in 2017–18 and 2018–19

	Current standards (130 g/km)		FY 2022–23 standards (113 g/km)	
	Without flexibility mechanism	With flexibility mechanism	Without flexibility mechanism	With flexibility mechanism
2017–18	+8.9%	+9.2%	-8.0%	-7.5%
2018–19	+7.6%	+8.0%	-10.3%	-9.8%

Note: + stands for ahead of the target; - stands for away from the target

Data source: ICCT 2018, *Compliance with India's first fuel-consumption standards for new passenger cars;* ICCT 2020, *Fuel consumption of new passenger cars in India*; compiled by CSE

India has not only set weak targets that the industry can meet easily, but it has further weakened the targets by giving away super credits or extra points for ineffectual technological approaches like six speed transmission that normally all big and luxury cars use or tyre pressure monitoring that depends on driver's behaviour. The biggest giveaway initially was the mild diesel hybrids that resulted in only nominal improvement; they were removed subsequently from the eligibility list. But weaker targets and super credit for ineffectual technology have impeded movement towards more substantial technology transformation like electrification.

A well-designed super credit system combined with stringent fuel efficiency norms can help speed up technology transformation and, more importantly, electrification of the fleet, as is evident in Europe. Despite having heavier vehicles—compared to low powered smaller cars of India—Europe has set CO_2 standards at 95 gmCO_2/km in 2020–21 as opposed to 113 gmCO_2/km in India. The average weight of car fleet in Europe is about 1400 kgs, which is higher than India. Even with heavier cars, Europe has set a target that is 20 per cent tighter than India. This has accelerated electrification of the fleet in Europe despite the pandemic led economic downturn. Europe is now aiming to meet 60 gCO_2/km for cars in 2030, which is equivalent to what most two-wheelers meet in India (see *Table 6: Global fuel efficiency standards compared to India's CAFE*). India has to catch up quickly.

Table 6: Global fuel efficiency standards compared to India's CAFE

Country	Target year	Fuel efficiency standard	in gCO_2/km *
India	2022	113 gCO_2/km	*113*
EU	2021	95 gCO_2/km	*95*
China	2020	5 l/100km	*116*
USA	2020	54 mpg	*100*

Note: *conversion based on ICCT unit conversion table

Source: CSE analysis

Without deviating from the target to be met in 2022–23, India will have to set the next targets for 2026 and 2030. This needs to be done both ambitiously and strategically to accelerate electrification. This should account for phasing out of super credits post-2023 and provide for improved testing methods for certification (like adoption of Worldwide Harmonised Light Vehicle Test Procedure (WLTP) based on the new driving cycles or Worldwide Harmonised Light-duty Vehicles Test Cycles (WLTC)) to reduce the gap between lab-based emissions and on-road emissions and related fuel efficiency performance to ensure real world performance. Industry is also hoping to work out a carbon credit scheme but its design and evaluation is critical for it to be effective.

Other vehicle segments: Even though India took the initiative to craft the fuel consumption standard for heavy duty vehicles in 2016–17, its implementation has been kept on hold. Fuel consumption norms for heavy and light commercial vehicles were crafted but the MoRTH has not notified this for implementation. The fuel efficiency standards for light commercial vehicles were also notified in 2019 but these have not been implemented effectively yet.

Though very nascent, there is also growing interest in the electrification of heavy-duty truck fleet. This stems from the global trend that is picking up pace for zero emissions trucks. It is said that logistics firms like GATI and Blue Dart can be early movers in this direction. If supported by highway-based charging infrastructure, especially on key corridors like Delhi-Mumbai corridor or Mumbai-Pune corridor, considerable change is possible. Global experience shows that a targeted policy can also allow a reduction in total cost of ownership compared to ICE trucks. Electric vehicle policy needs to evaluate the strategies to build a roadmap.

Similarly, BEE has started the discussion on developing fuel efficiency standards for two-wheelers. Even though these ICE vehicles have the smallest carbon and energy footprint, given their sheer numbers and gradual migration to bigger and more powerful engines, benefits of the lower powered vehicles on Indian roads may soon be eroded. However, unlike the four-wheelers, more effective strategy for electrification of two-wheeler fleet will be to set mandate for targeted electrification with strong incentive support. This market has the potential to achieve 100 per cent electrification.

4.2 Localization and scale

As the market plummeted following the pandemic shock, the Government of India rolled out a PLI programme to rebuild and support manufacturing. This is an opportunity for a green recovery that, while expanding manufacturing and generating new jobs, can also decarbonize the vehicle sector.

The Indian EV market relies heavily on imports to meet its requirement of components, especially battery cells. To increase local manufacturing, NITI Aayog has initiated the National Programme on Advance Chemistry Cell (ACC) Battery Storage to support and promote domestic manufacturing of 50 GWh of battery storage over the next 5 years. This initiative is linked with the National Mission on Transformative Mobility and Battery Storage announced in 2019.

This policy focuses on promoting advanced storage technologies that can store electric energy as chemical energy and convert it back to electric energy when needed. As part of the economic recovery package, PLI of Rs 18,000 crore has been earmarked for 50 GWh of battery capacity and for manufacturers to set up production units with a capacity of at least 5 GWh. PLI programme provides incentives between 2–12 per cent on the incremental sales revenue and 4–7 per cent on the incremental exports revenue.

Private entities are expected to set-up manufacturing facilities for committed capacity to produce advance chemistry cells. The scheme offers larger incentives to manufacturers producing higher value batteries with increased specific energy density and cycles. NITI Aayog and Department of Heavy Industry, Ministry of Heavy Industries & Public Enterprises are spearheading planning for developing giga-scale advanced cell manufacturing.

To further support the PLI scheme that is designed to curb imports by incentivizing localization of battery production, it has been proposed that the import tax on battery cells be increased from 5 to 15 per cent after 2022. Localization of the value chain for the EVs and their components is expected to address raw material requirements, electrochemistry, and end-of-life treatment of cells, modules, and battery packs.

The government expects the PLI scheme to attract direct investment of around Rs 45,000 crore and offers a roadmap to incentivize domestic value addition from 25 to 60 per cent over the next five years. While the roadmap can trigger manufacturing of cell components such as electrodes, electrolytes, and separators, it also has the potential to drive skill development initiatives among component and sub-component manufacturers aimed at higher value capture in the years to follow.

ICCT has estimated the expected growth in EV fleet by 2035 and how that translates into battery storage capacity. Accordingly, India will need about 3,400 GWh to 4,100 GWh of batteries by 2035. In the next decade, India's annual requirement could be 17 per cent to 26 per cent of annual global production. Therefore, localized giga factories can bring economy of scale and lower the prices.

Already, several companies have announced plans to set up battery cell manufacturing facilities in India. These include joint investments by Toshiba Corporation, Denso Corporation, and Suzuki Motor Corporation in Gujarat. TDK Corporation owned Amperex Technology Limited will invest in Haryana. Tata Chemicals is planning a 10 GWh lithium-ion cell manufacturing plant in Gujarat. The PLI incentive can be catalytic.

The premium on improved technology and larger capacity is also aimed at enhancing the sector's export performance. India enjoys the largest export numbers in the two- and three-wheeler segments which could become potential candidates for high volume electric vehicle exports. According to SIAM, India exports four-wheelers to 175 countries. India is the largest three-wheeler exporter in the world. India ranks fourth in two-wheeler exports.

The scheme's particulars throw up two broad issues that could impact its take-off. First, a time frame of five years is too short to drive adequate commitment from manufacturers. Given the size of the investment required for batteries (the PLI scheme defines Rs 225 crore for a 5 GWh plant), in an area of uncertain scale economies, evolving battery chemistries and high uncertainty about the short and medium-term volumes, it is too large a risk if the support structures are likely to fade away in a span of five years. Besides, the failure or slippage of such an investment could easily have an impact on the financial health or even existence of a manufacturer.

For PLI strategy to be successful, the larger programme has to catalyse a much larger EV market to build demand for batteries. Otherwise, investment in battery cell manufacturing will remain rigid and slow. This will require more strategic incentives for a wider genre of vehicle segments, particularly cars, commercial vehicles and trucks, to build demand and scale. According to an estimate of ICCT, the FAME scheme aims to incentivize the purchase of 1 million electric two-wheelers, which is equivalent to creating demand for about 2.3 GWh of battery cells. The same can be created with a sale of only 55,000 to 115,000 electric four-wheelers as the battery capacity in electric four-wheelers is about 10 to 20 times larger than that needed for electric two-wheelers. Currently, about 6 per cent of the FAME demand incentives are for electric four-wheelers.

Second, the PLI incentives will be disbursed only on the basis of incremental sales from products manufactured in domestic units. Which means that a lack of matching demand from the EV sector for the planned production volumes of batteries could result in the manufacturer missing out on the promised incentives and hurting profitability. Thus, EV market with long term incentives and mandate is critical.

4.3 Battery ecosystem to drive electrification

Building battery ecosystem to support ambitious electrification target presents a challenge and requires well-defined strategies addressing each aspect of the ecosystem—battery production and raw material sourcing, battery assembly and management, etc.

Sourcing battery minerals: A large part of the uncertainty for manufacturers rises from issues related to battery raw material security as access to mined materials for batteries has emerged as one of the biggest challenges to localization of battery cells in India and the industry continues to be dependent on imports. The programme has also highlighted India's vulnerability to geopolitical complexities and uncertainties in the global supply of material and minerals and battery technology. Indian manufacturers are almost entirely dependent on global supplies of resources and technology for batteries. Self-reliance and localization are high on national priority but this needs firmer strategies.

It is believed that 60–70 per cent of the materials can be sourced locally. Given the uncertainties in the battery material supply chain caused by delays in the raw material supply chain, the assurance of material security is of huge significance to manufacturers. Lithium-ion batteries use lithium nickel manganese cobalt oxide (NMC), lithium nickel cobalt aluminum oxide (NCA), lithium iron phosphate (LFP), or, to a limited extent, lithium manganese oxide (LMO) at the cathode; at the anode, graphite is used.

Securing supply chain for cobalt, lithium, nickel, and graphite will be a challenge as geopolitics and price volatility add to the uncertainty. The race towards cobalt substitution has led to development of nickel-rich cathode chemistries. But this requires sustainable and economically viable methods to produce class 1 grade nickel in large quantities. Lithium reserves and production are concentrated in Australia and the salt lakes of Chile, Argentina and Bolivia. Supply chain of graphite is dominated by China. There are talks of synthetic graphite. The cell chemistry will be determined by the energy density requirement, availability and price volatility.

India does not have any meaningful reserves of key battery raw materials such as lithium and cobalt. Two-thirds of the minerals required for battery cells are already available in the country. For the rest, the government has signed battery mineral sourcing agreements with Latin American countries and Australia. The government has created a battery sourcing entity, Khanij Bidesh India Ltd, a joint venture between National Aluminium Co., Hindustan Copper Ltd and Mineral Exploration Corp, for the purpose. This has led to a strategic partnership in Argentina for the exploration and production of lithium and a similar initiative in Bolivia. By promoting and incentivizing cell chemistries with less cobalt and other sensitive materials, it is possible to reduce reliance on mineral imports while developing critical technological capabilities. Policies should be able to promote diverse battery chemistry to reduce reliance on a limited set of raw materials.

More unconventional areas in the developing regions are opening up to supply these minerals and rare earth. A lot of the mineral rich regions are in the developing world. The United States Geological Survey (USGS) stated in 2020 that majority of the lithium in the global trade flow comes from Australia, Chile, Argentina, and China. Currently, only eight countries produce lithium. According to the 2020 World Bank report, out of the total lithium produced in 2020, about 49 per cent came from Australia, 22 per cent from Chile and 17 per cent from China.

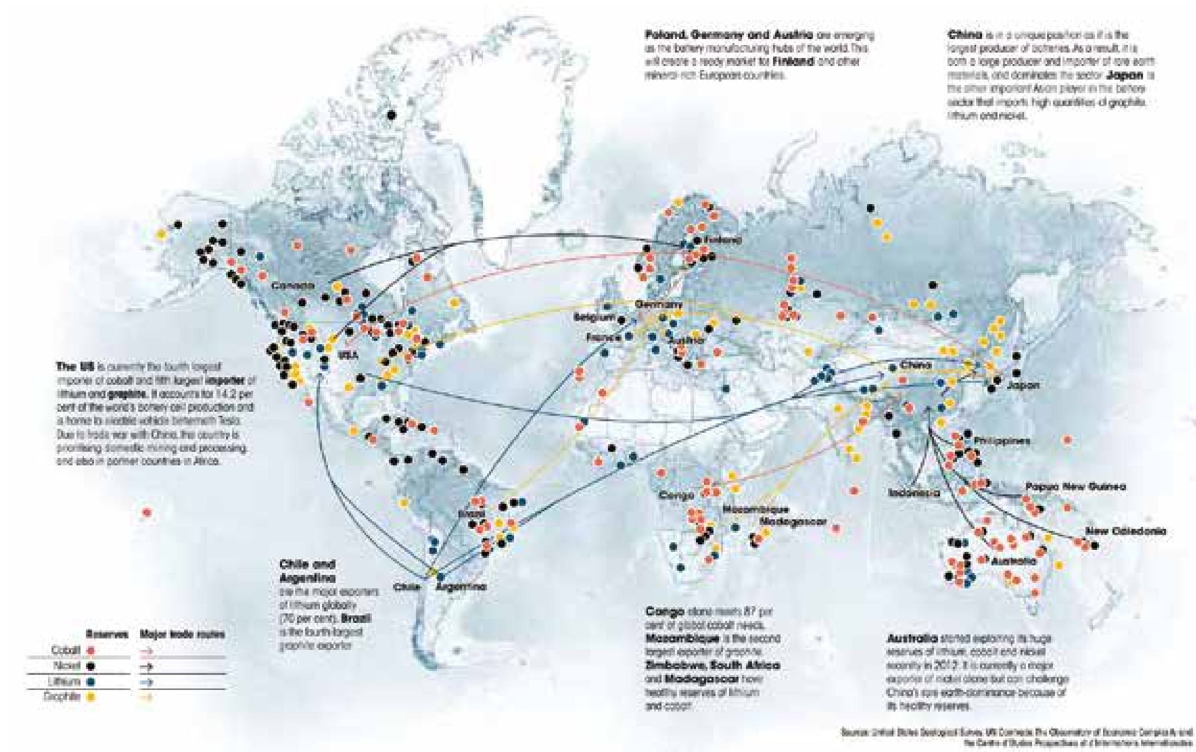
Processing is also expensive and complex. For instance, lithium is extracted as lithium carbonate from brines and as lithium hydroxides from hard rock. Hydroxides are preferred to improve range of batteries in electric vehicles. But the process of converting carbonates to hydroxides and vice versa can be very expensive. Therefore, these salts are mostly traded without processing near mining sites. Increasingly, there is an interest to retain economic value of this activity within their economy. Prices of materials are contingent on the way the original metal ore is mined (see *Map 1: Trade flow of battery materials across the globe*) and the distance it needs to travel before being processed into battery grade materials.

Build manufacturing capacity: The crucial issue for the future battery and electric vehicle industry in India is the scale this industry will have to reach to be viable. The high cost and R&D intensive nature of cell development makes scale an imperative in battery manufacturing. For success in localization and to get that equation right, the sector will require large amounts of capital and a plan to work at incremental growth that leads to scale in battery cell manufacturing and battery pack assembly.

Moves on import substitution are already under way. Under the National Mission on Transformative Mobility and Battery Storage, Amara Raja Batteries has recently announced a lithium-ion battery cell manufacturing facility in Tirupati. The Rs 20 crore plant will work with Indian Space Research Organisation (ISRO) to develop the product.

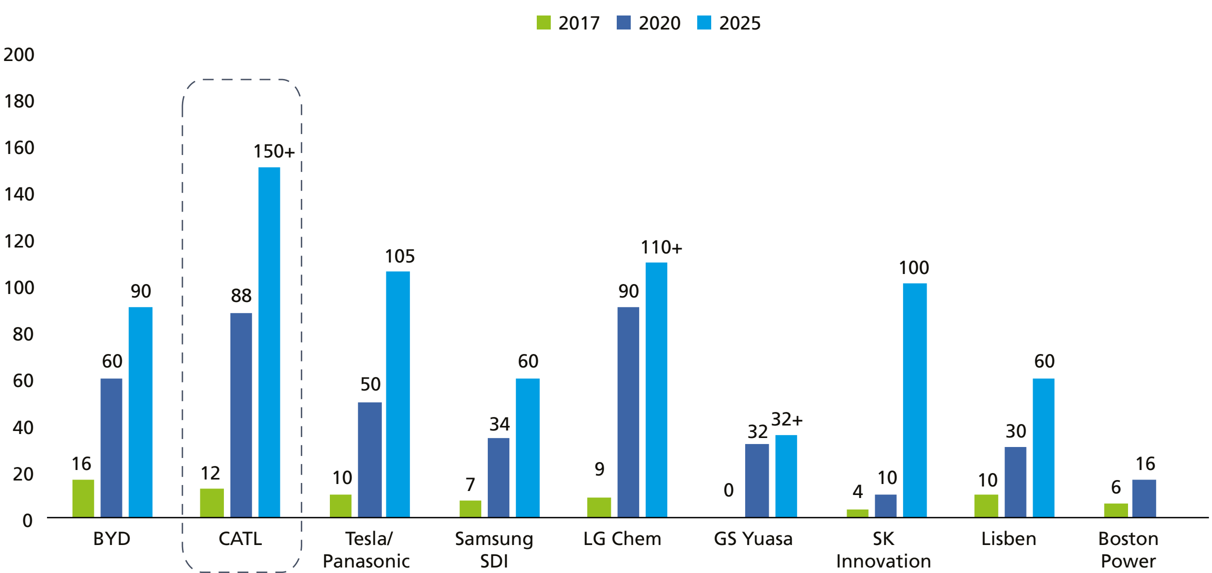
Amara Raja was one of the 10 companies selected by ISRO in 2019 for technology transfer and facilitation with setting up manufacturing units. A second company from the chosen

Map 1: Trade flow of battery materials across the globe



Source: CSE analysis

Graph 15: Global battery production companies and their capacities (2017–2025)



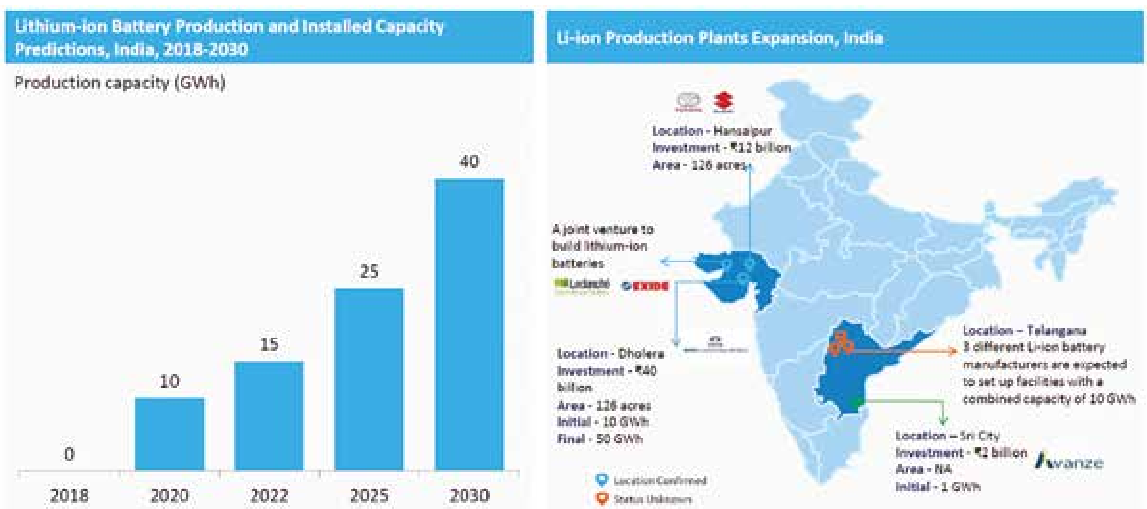
Source: Frost and Sullivan, 2020

10, Tata Chemicals is expected to start manufacturing lithium-ion cells at a facility in Dholera, Gujarat. Reliance is now planning massive manufacturing of batteries. How much this will serve the EV industry is yet to be seen.

However, under the 30@30 scenario, battery capacity is expected to increase substantially by 2030. As mentioned earlier, an ICCT estimate shows that for the total cumulative battery capacity needed in 2030 to support the 30@30 target, India will need annual addition of 246.9 GWh and cumulative addition of 824.7 GWh in 2030, and about 3,400 GWh to 4,100 GWh of batteries by 2035. In the next decade, India's annual requirement could be 17 per cent to 26 per cent of annual global production. This takes into account the growing number of vehicles, changing battery size, etc.

The battery capacity will be dominated by cars at 31 per cent, followed by two- and three-wheelers at 28 per cent, trucks at 18 per cent, buses at 7 per cent and MPV at 16 per cent. More ecosystem support, tax waivers, non-fiscal preferential incentives, reliable charging network and facilities and initial support for a targeted fleet can help to build the e-car market. Currently, lack of competition and a low fleet volume have dampened the e-car market as well as the import substitution efforts. Even though the sale of battery production in India is still unpredictable, some nascent forecasts have been made (see *Graph 16: EV battery production in India*).

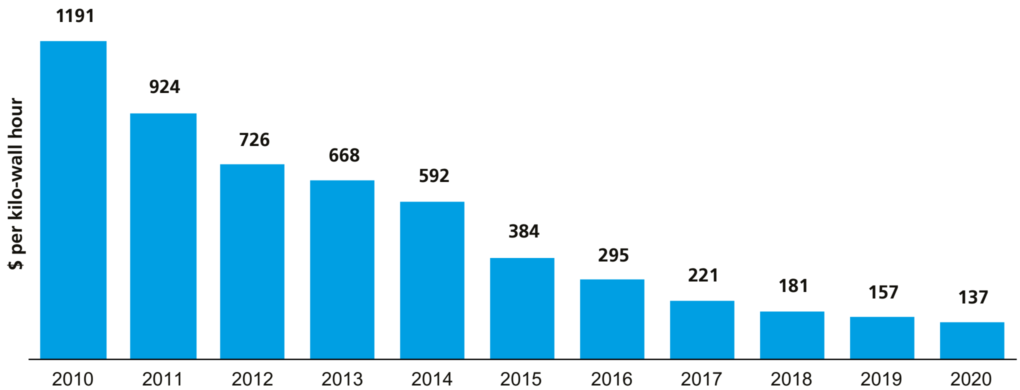
Graph 16: EV battery production in India



Source: Frost and Sullivan, Industry Reports, 2020

Battery costs: Indian efforts at manufacturing batteries will benefit from the enormous gains in cost reduction achieved globally. In the last decade, battery price has reduced by over 85 per cent from around $1,200 per kWh in 2009 to $137 per kWh in 2020 (see *Graph 17: Lithium-ion battery price, volume weighted average, all sectors*). Bloomberg estimates that if this trend of battery development continues and prices keep falling, the cost parity between EVs and ICEs will likely be achieved within just three to four more years when the battery costs fall below $100 per kWh.

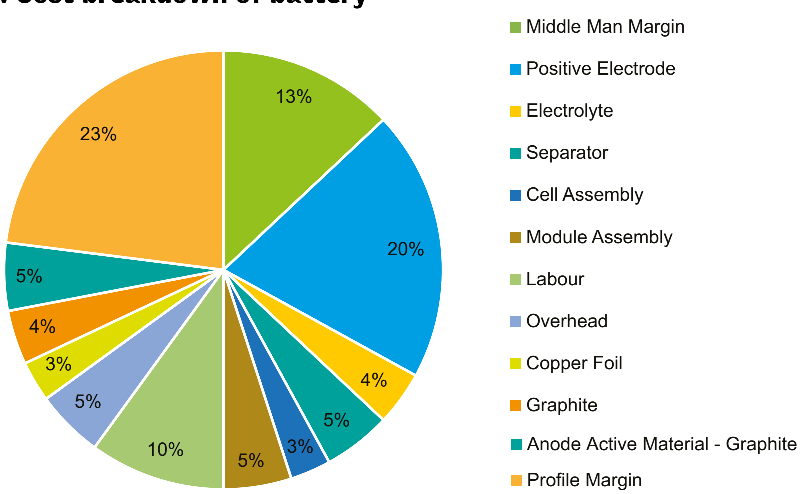
Graph 17: Lithium-ion battery price, volume weighted average, all sectors



Source: BloombergNEF 2020

A large part of the cost of the battery pack comes from the cell and its components. The cost of electrodes (cathode and anode), electrolyte, separator, cell assembly, module assembly and other materials, makes up for more than 50 per cent of the total cost of the battery (see *Graph 18: Cost breakdown of battery*).

Graph 18: Cost breakdown of battery



Source: Gert Berckmans et al, MDPI

Battery development for different vehicular segments: The battery costs, however, vary significantly depending on the application—buses, cars and other light duty vehicles. In the EV sector, a bus has a lower battery cost (about $105 per kWh) compared to passenger vehicles (around $126 per kWh for BEV, and up to $359 per kWh for PHEV). They also vary across sectors. For example, a battery pack manufactured for cars will cost less than those made for the power grid or home solar arrays.

A study conducted by SIAM identifies the difference in cost of vehicles based on the battery requirement during the lifetime of a vehicle. It was found that in all categories of vehicles, the increase in capital cost was significant. However, the study also recognized that economies of scale will likely be achieved with indigenization and adoption of EVs in the future, reducing the cost gap (see *Table 7: Difference in cost of vehicles based on battery requirements*).

Table 7: Difference in cost of vehicles based on battery requirements

Type of vehicle	Cost increase of EV counterpart
Passenger car, vans and utility vehicles	70 per cent more than ICE due to incremental EV cost component of battery, traction motor, control unit and charging point
3W	At current cost levels, any E3W with near equal performance to ICE will be at least twice in price
Buses	Buses will need a larger battery pack leading to increase in initial cost price to 1.7 to 2.5 times that of diesel bus

Source SIAM, 2017

Globally, batteries continue to get enhanced, and it is clear batteries with high nickel content such as Nickel Manganese Cobalt (in 622 and 811 ratios) and Nickel Cobalt Aluminium could service passenger EVs in D-F segment high-end vehicles, while low-cost and high-cycle life options such as lithium iron phosphate cells will find deployment in mass market vehicles. Batteries can be custom-built and aligned with applications that are India specific (see *Table 8: Battery cost by manufacturers for state transport units*).

Battery recycling and reuse: Battery ages with use and the electrode materials, the number of charge and discharge cycles, charging speed, and temperature of operation, etc. determine the ageing of batteries. Usually, once the battery capacity is reduced to about 70–80 per cent of the initial stated capacity, these are then either downgraded for further use or otherwise recycled. This will require proper collection, dismantling and disposal facilities. More importantly, recycling can help recover lithium, cobalt or nickel. The rate of recovery will improve with appropriate technologies. This requires a regulatory mandate to ensure collection of spent batteries and adequate scale for recycling.

Table 8: Battery cost by manufacturers for state transport units

City	Supplier	Battery capacity	Bid cost of vehicle (INR lakhs)	Bus specifications
Kolkata	TATA	125 KWH	74.9	AC/Non-AC Length 9m; Range: 150 km; Floor height: 900 mm; Seating capacity: 31
Mumbai	Goldstone	162 KWH	169.8 – AC 161.8 – non AC	AC/Non-AC Length 9m; Range: 200 km; Floor height: 650 mm; Seating capacity: 31
Bangalore	Goldstone	320 KWH	240	AC/Non-AC Length 12m; Range: 300 km; Floor height: 400 mm; Seating capacity: 40
Jaipur	TATA	125 KWH	74.9	AC/Non-AC Length 9m; Range: 150 km; Floor height: 900 mm; Seating capacity: 31
Indore	TATA	125 KWH	74.9	AC/Non-AC Length 9m; Range: 150 km; Floor height: 900 mm; Seating capacity: 31
Jammu	TATA	125 KWH	74.9	AC/Non-AC Length 9m; Range: 150 km; Floor height: 900 mm; Seating capacity: 31
Guwahati	TATA	125 KWH	74.9	Length 9m; Range: 150 km; Floor height: 900 mm; Seating capacity: 31
Lucknow	TATA	125 KWH	74.9	AC/Non-AC Length 9m; Range: 150 km; Floor height: 900 mm; Seating capacity: 31
Hyderabad	Goldstone	320 KWH	240	AC/Non-AC Length 12m; Range: 300 km; Floor height: 400 mm; Seating capacity: 40

Source: Recommendation committee report Benchmark Price document 2018

One of the key areas for mining battery metals could be old batteries. This, however, requires standardized battery products with information on the chemistry used and streamlined networks for battery collection to be put into place. Recycling batteries holds the potential to recover expensive materials while avoiding the environmental cost of disposing of hazardous materials.

Other governments have started to craft such EV oriented regulations. Policy strategies that could aid this process can focus on incentivizing end-of-life battery recycling. Incentives can take the form of investment subsidies or be based on the remaining capacity of end-of-life batteries purchased for recycling.

The European Commission requires that all retired EV batteries in their jurisdiction are collected for end-of-life processing. It is also setting up targets for increasing the efficiency of recycling processes, along with establishing a specific target for lithium-based batteries. According to ICCT, by 01 January 2027, EV batteries will have to declare the content of recycled cobalt, lead, lithium, and nickel contained therein. From 01 January 2030 onwards, these batteries will have to contain minimum levels of recycled content (12 per cent cobalt, 85 per cent lead, 4 per cent lithium, and 4 per cent nickel). From 01 January 2035 onward, these levels will be further increased (20 per cent cobalt, 10 per cent lithium, and 12 per cent nickel). Managing the second life of battery until they deteriorate to 60 per cent of their initial capacity is also important.

Shenzhen in China subsidizes electric vehicle manufacturers or their wholly owned subsidiaries for every battery recycled with 10 yuan ($1.45) per kWh of battery capacity.

Besides, used batteries can be repurposed and reused in stationary storage applications. The reuse of batteries helps to reduce the lifecycle cost of batteries, lowering the cost of electric vehicles and making them more cost-competitive. It is also said that second-life applications of EV batteries are appropriate for grid-scale renewable energy storage. India's renewable energy policy should leverage this to build energy banks.

India's Battery Waste Management Rules 2001, with directives for battery waste management and recycling, provide for Extended Producer Responsibility (EPR) norms. This requires the battery manufacturer to create their collection centres, have buy-back or exchange schemes, and make agreements with registered dismantlers or registered recyclers either individually or collectively or through a producer responsibility organization. This requires policy measures for adequate supply of retired EV batteries for energy storage applications. Directives on scalable recycling technologies and regulations on recovery rates for strategic resources such as lithium, cobalt, manganese, nickel and graphite are also essential.

In addition, automakers and battery manufacturers could collaborate in developing pilot projects for second-life commercialization and financial incentives offered to projects offering gainful returns. Among global parallels of a similar initiative, California supported a second-life commercialization pilot project by EVgo, a private charging station network, and automobile manufacturer BMW. The project demonstrated a grid-tied public fast-charging system using second-life batteries that helps in insulating the grid from sudden spikes in demand and ensures affordability in fast charging.

4.4 Scrappage policy as an EV stimulus

Post-COVID, there was strong expectation that the scrappage policy would be leveraged in India in the same way that global governments have deployed it to expand electrification. But India lost that opportunity. Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules announced in March 2021 have not made that connection.

The potential offered by the scrappage policy to be used as an EV stimulus was not taken into consideration. In its current form, the policy is an instrument directed at material recovery and the sourcing value chain closing the loop with recycling and safe disposal. This includes concession in motor vehicle tax that can be availed against submission of 'certificate of vehicle scrapping'. The concession is up to 25 per cent, in case of non-transport vehicles; and up to 15 per cent, in case of transport vehicles. It will be available up to eight years, in case of transport vehicles, and up to 15 years, in case of non-transport vehicles—from the date of first registration. Both the notifications outline the criteria for defining end-of-life vehicles and scrapping them. It also makes provision for scrapping facilities for safe disposal of waste and material recovery.

This is an important step towards building infrastructure for organized and scientific scrapping of old vehicles. But the policy has missed the opportunity of being an effective stimulus programme for green recovery in the sector to achieve deeper and quicker air quality benefits and electrification.

The government expects the policy to affect around 51[19] lakh aging vehicles (20-year-old) and their removal to build demand for new vehicles. According to market information reported in the media, the new policy is expected to boost the Indian automotive industry's turnover by 30 per cent to Rs 10 lakh crore in the coming years. It could also create up to 50,000 jobs and generate investments of around Rs 10,000 crore. This regulation will have to be designed for accelerating electrification, as is the global good practice.

5. State level policy driving electrification

Fifteen states in India have either notified or drafted EV policies that support the national electric mobility agenda aimed at addressing barriers to electrification on the demand and supply side as well as market enablers such as charging. The states with approved EV policies include Andhra Pradesh, Karnataka, Kerala, Maharashtra, New Delhi, Tamil Nadu, Telangana and Uttar Pradesh. The states with draft policies include Bihar and Punjab.

The framed policies reveal that electrification in India will be a two- and three-wheeler narrative, at least in the first phase of market development. A number of them underline the significance of electrifying two- and three-wheelers (both passenger vehicles and goods carriers) along with public transport.

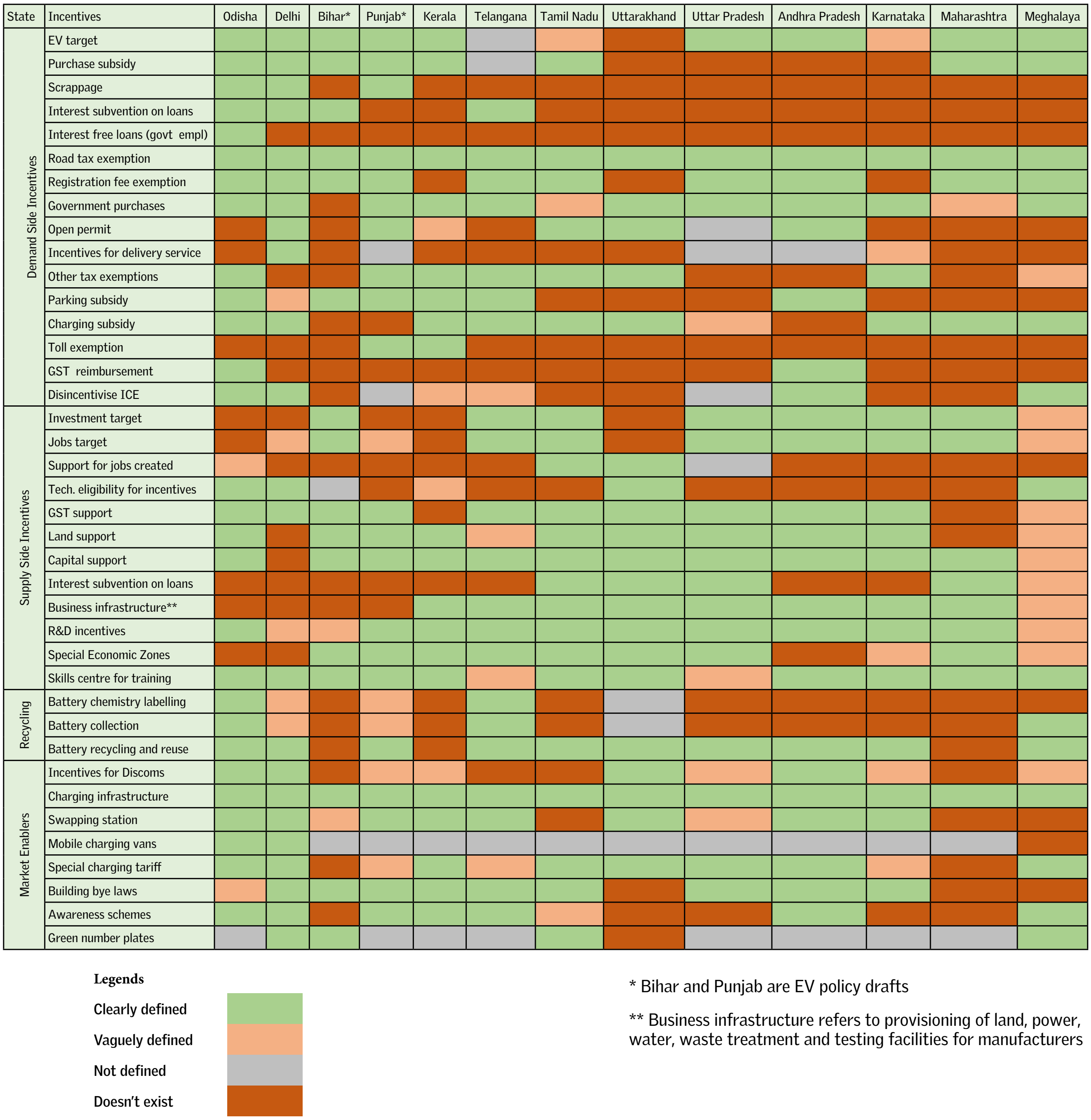
Most state policies chart out a multi-phased roadmap to electrification focused on facilitating EV and EV component manufacturing and consumer adoption. Seven states—Andhra Pradesh, Bihar, Karnataka, Maharashtra, Tamil Nadu, Telangana and Uttar Pradesh—have defined investment and job targets and designed packages according to the size of manufacturing capacity. Though most states have set segment-wise targets for 100 per cent conversion for two- and three-wheelers by 2030, three of these states (Andhra Pradesh, Karnataka and Uttar Pradesh) offer only road and registration tax exemption for EV adoption on the demand side and skip purchase incentives completely.

A few segment targets are much closer. Bihar, for instance, has a 2022 target to convert all paddle rickshaws to electric. Karnataka aims to attain complete conversion to electric in auto-rickshaws, cab aggregators, corporate fleets, and school buses/vans by 2030.

While some states focus on generating opportunities for technological collaboration and skill development, some provide incentives on the basis on socio-economic status (Bihar) and management of used batteries (Delhi and Punjab) (see *Table 9: Key elements of state level policies*).

CSE created a comprehensive matrix of electric vehicle policies in Indian states using colour codes to cross reference them with global electric vehicle incentives in the US, Europe and Asia and found a number of parallels.

Table 9: Key elements of state level policies



* Bihar and Punjab are EV policy drafts

** Business infrastructure refers to provisioning of land, power, water, waste treatment and testing facilities for manufacturers

Source: Electric Vehicle policies of Indian states; compiled by CSE

Uttarakhand, for instance, prioritizes permits and routes for electric vehicles, specifically buses, reminiscent of 'high occupancy vehicle' lane access followed by the 'Section 177' states in the US. Among policies formulated by other hill states, Meghalaya clearly defines incentives for expanding demand and supply, with a clear roadmap for funding incentives.

Meghalaya and Uttarakhand are among eleven states in India that have notified EV policies that support the national electric mobility agenda aimed at addressing barriers to electrification on the demand and supply side as well as market enablers such as charging facilities and awareness programmes. The states with approved EV policies include Andhra Pradesh, Delhi, Karnataka, Kerala, Maharashtra, Meghalaya, Odisha, Tamil Nadu, Telangana, Uttarakhand and Uttar Pradesh. The states with draft policies include Bihar and Punjab.

The states with clearly defined EV targets are Andhra Pradesh, Bihar, Delhi, Maharashtra, Meghalaya, Kerala, Odisha, Punjab and Uttar Pradesh. Though most states have set vehicle segment-wise targets of 100 per cent conversion for two- and three-wheelers by 2030, three of these states (Andhra Pradesh, Karnataka and Uttar Pradesh) offer only road and registration tax exemption for EV adoption on the demand side and skip purchase incentives completely.

Among all the incentive parameters studied, Odisha scores the highest number of greens, followed by Andhra Pradesh and Tamil Nadu. However, a more comprehensive analysis of the EV policies would require an examination of regulations under the larger categories—demand side, supply side, market enablers and recycling.

Among the 16 parameters listed under demand side incentives, Odisha scores the highest at 13, followed by Delhi (11) and Punjab (10). Regarding the twelve parameters listed under supply-side incentives, Tamil Nadu scores the highest (11), followed by Uttarakhand (10) and Uttar Pradesh (9).

While some policies focussed on manufacturing offer incentives such as interest free loans and reimbursement of goods and service tax for companies aiming to set up factories, others offer facilitation of business infrastructure with subsidies on capital, and support schemes related to land, water, electricity, waste disposal and testing facilities during the policy tenure of five years, barring Delhi where the policy tenure is three years.

Odisha and Andhra Pradesh score 6 out of 8 under market enablers; while under recycling parameters, Odisha and Telangana have the best-defined policies.

The state policies also reflect specific priorities of each state. Kerala focuses on retrofitting ICE vehicles, while only three (Odisha, Delhi and Punjab) provision for scrappage incentives. Only two states (Odisha and Delhi) define technical eligibility for availing incentives, thus pointing at a disconnect with the national level policy ambition.

Only four states (Odisha, Delhi, Bihar and Telangana) offer incentives on loans for driving adoption of vehicles. Odisha, in fact, has gone a step ahead with interest free loans to government employees who want to buy electric vehicles. For a technology struggling to find a foothold in the market, larger visibility of EVs on the road could push the agenda further.

On the topic of recycling and reuse of old batteries, Meghalaya suggests deployment of old batteries at charging stations, where EV owners will be encouraged to deposit vehicle batteries that have reached their end of life.

While all the state policies appear to have been based on mapping of their own priorities, they will have to be tweaked and redesigned on the basis of the market's response and to better align with the national agenda.

5.1 Charging infrastructure target: Chicken and egg syndrome

The Indian government has been strategizing for strengthening the country's charging infrastructure network since NEMMP was first launched in 2012–13, however no real action was taken towards achieving this goal until 2018, when Ministry of Power released a notification titled 'Clarification on charging infrastructure for Electric Vehicles with reference to the provision of Electricity Act 2003'. The notification states that electricity consumed for charging a vehicle is a simple conversion of electrical energy to chemical energy, and therefore should not be considered as transmission or distribution or trading of electricity. All these activities need a license under the provision of the Electricity Act, 2003, and therefore charging a vehicle does not need one. Ministry of Power has further recognized battery swapping as a mode of charging.

Ministry of Housing and Urban Affairs came up with the revised set of Model Building Byelaws in 2019 which now included the provision for exclusive parking areas for electric vehicles within the premises of various building types. Further, building premises can now have an additional power load equivalent to power required for all charging infrastructure within. The notification also gave technical details of charger requirements in plotted and other buildings.

Direct incentives for charging infrastructure started with FAME I but only about 4.8 per cent of the scheme was dedicated to charging infrastructure. During this period, 500 stations were sanctioned under the scheme for Rs 43 crores in the entire country. According to the DHI Dashboard for FAME progress, 425 stations were established under FAME till 31 March 2019.

Under FAME II, support for charging infrastructure was increased to 10 per cent of the Rs 10,000 crores total outlay. Besides direct financial incentives for setting up charging facilities, the government has also reduced the GST on charging stations from 18 per cent to 5 per cent. This change in the incentive system was envisaged to bring about a revolution in the charging infrastructure landscape in India.

Soon after FAME II was launched, MoP released guidelines and standards for charging infrastructure, outlining the roles and responsibilities of various central and state stakeholders. According to the notification, public charging stations (PCS) do not require a license to setup, provided they meet the technical and performance standards of MoP and the Central Energy Authority (CEA). The DISCOMs shall consider all applications for power connection in the PCS area as priority connections. The notification also gave guidelines for the infrastructure required at every PCS with exemptions to some players such as fleet operators, two- or three-wheeler PCS, etc.

Now that India had guidelines to setup infrastructure and standards for the equipment, DHI released a list of 62 cities in 24 states in early 2020 with the number of sanctioned charging stations in each city. A total of 2,636 stations were sanctioned, which amounted to approximately half the budget allocated to charging infrastructure under FAME II. Later the same year, 241 additional stations were sanctioned under FAME in seven cities.

CEA has to maintain a database of all the charging stations installed in the country, based on the communication from DISCOMs. According to this database, 933 charging stations are currently active in the country under the jurisdiction of DISCOMs, licensee or PSUs including six set up by the Power Grid Corporation of India.

State DISCOMs are the nodal agencies at the state level to set up charging infrastructure and service operations, unless the state government deems in favour of local bodies or public sector units. Energy Efficiency Services Limited (EESL) is a joint venture under the Ministry of Power, between NTPC, PowerGrid, REC Limited and Power Finance Corporation, which is actively installing public charging stations in Delhi. Even urban local bodies, among other public agencies, are expected to support the establishment of charging infrastructure. Networks are emerging in cities and also along highways.

Several states in India are now coming up with their own strategies for establishing a network of charging stations to induce electric vehicle adoption in their markets. Some states are also offering incentives to the service providers who are willing to invest in setting up infrastructure. Other provisions are also offered by the states such as base minimum lease for setting up infrastructure, SGST reimbursements, investment subsidy for manufacturing of chargers and other equipment, amendment in zonal regulations and city codes to incorporate charging, and so on. Many states in India have also established special tariffs for electric vehicle charging. This tariff is a subsidized amount of the standard commercial tariff applicable in the state, which is enjoyed by both the service operator and the EV owner for charging.

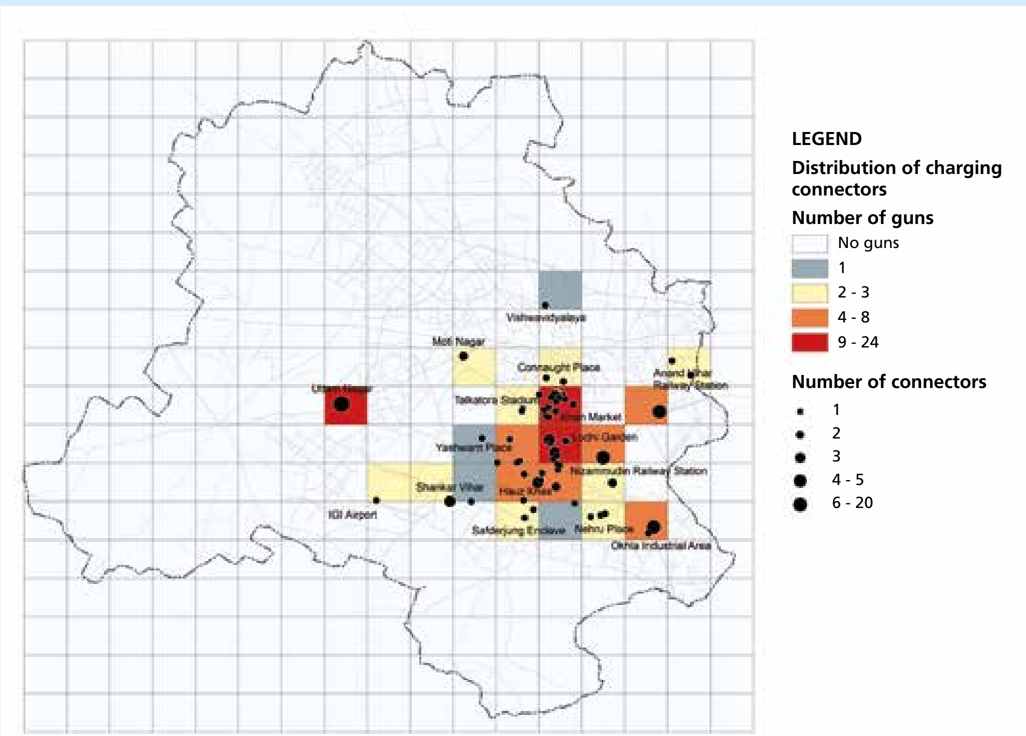
Case study of charging infrastructure network in Delhi

According to Grant Thornton-FICCI, India needs 4,00,000 chargers to power 20,00,000 vehicles on its roads, or 1 charger for every 5 vehicles. Applying the 5 vehicles per charger argument, Delhi will need 34,500 chargers in the state to power its 25 per cent market share of EVs. CSE‘s projection for number of EVs that Delhi needs to register in 2024 for achieving its 25 per cent electrification target is 1.72 lakh vehicles.

Currently, Delhi has 72 public charging stations, which will have to expand manifold to be able to meet demand. In comparison, global EV cities such as Shenzhen, Oslo and Amsterdam have more than 2500 public charging stations per million. The Delhi state government has promised to install an additional 500 PCS for now.

As per Delhi’s EV policy notified in August 2020, the city should have at least one charging station in every 3x3 grid in the city. A quick spatial analysis suggests that this policy statement translates to atleast 200 stations across the state.

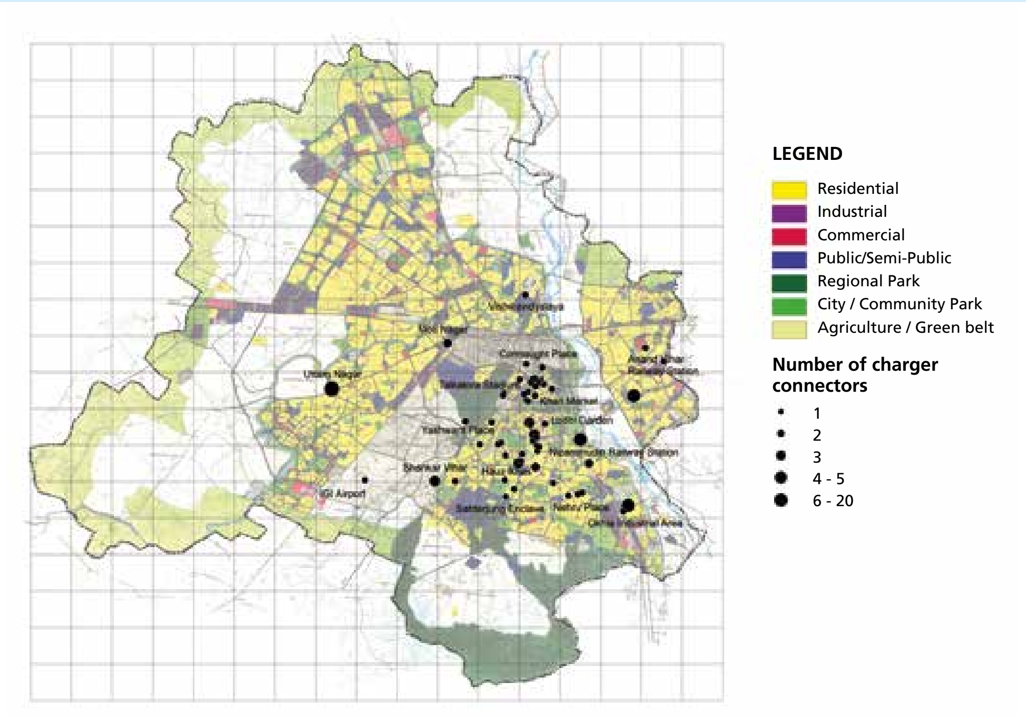
Distribution of charging stations in Delhi on a 3 km x 3 km grid



Source: CSE analysis

Most stations are closely located, and 61 out of the 72 have only one charger connector at the station. 89 per cent of the chargers, or 64 of them, are located within 500 meters of a metro station, paving the path for last mile connectivity using electric vehicles around metro stations. All chargers are located within 500 meters of the major arterial and sub arterial roads in Delhi, making them accessible to both highway and city commuters.

Distribution of charging stations and its comparison with the land use as per MPD 2021



Source: CSE analysis

Other than stations at the IGI airport and Talkatora Garden, all stations are located in either residential areas or commercial/mixed-use land. This siting strategy makes sense especially during the early stages of the EV market. Commuters would look for charging infrastructure around residential colonies and recreational areas and market places to charge their vehicle when they are busy with day-to-day activities.

Further expansion of the grid is needed. Also, athe problem of which type of chargers to adopt will require a separate review.

Though FAME II pays close attention to charging infrastructure with an allocation of Rs 1,000 crores to set up infrastructure for charging, the numbers are too small to inspire confidence for EV adoption. Global EV adoption trends provide evidence of a directly proportional relationship between demand for electric vehicles and the availability of publicly accessible charging infrastructure. In 2019, India's ratio of charging points to electric vehicles was 1:41. In Norway, the ratio was 1:20 while in China, every charging point had only eight vehicles associated with it.

According to a Deloitte global automotive consumer survey in 2018, approximately 36 per cent Indians felt that a lack of charging infrastructure and charging anxiety is a primary deterrent to adoption of EVs rather than the cost or range of the vehicle.

India has a notified guideline for charging infrastructure development which recommends the installation of at least one charging station in a grid of 3*3 km or at every 25 km on both sides in case of highways/roads. Further, for long range EVs (like SUVs) and heavy duty EVs (like buses/trucks), at least one fast charging station is required every 100 km on each side.

Battery swapping: Along with charging, battery swapping stations could also be used to address concerns about battery range. Though FAME II did not initially recognize battery swapping technology as an opportunity for the Indian market, an amendment dated 08 June 2020 to 'Charging Infrastructure for Electric Vehicles—Guidelines and Standards' covered that end by including vehicles sold without batteries for incentives. Batteries sold separately for vehicles will reduce the upfront cost of vehicles and the need for a dense recharging network.

Swapping will also enhance battery durability, as charging the batteries separately can be done under a more conditioned and temperature-controlled environment. Besides, swapping requires a standardized system of battery cavities, batteries, and chargers to enable interoperability, a system that will work well for the commercial segment and thus needs to be developed.

Though it is believed that increased EV adoption requires robust infrastructure to support ownership and use, real-time data reveals opposing trends. Examples exist wherein countries have succeeded in increasing the penetration of EVs both with and without extensive public charging infrastructure in place. UK, which has 1 EV per 12,600 people, has an extensive public charging infrastructure. On the other hand, Norway, which has 1 EV per 238 people, has minimal public charging facilities.

Widely available charging network is seen as key to EV adoption. Visibility is crucial to give the consumer more confidence for buying an EV. Therefore, both the chicken and the egg have to continue to move on their separate development curves to be able to resolve the problem.

Charging infrastructure in India—understanding the segment use cases: It is also important to select the right kind of charging technology to scale it up for creating a citywide network that would expedite EV adoption. Varying usage patterns and charging requirements according to vehicle types makes the decision even more complex.

The design for public charging infrastructure would depend on the Indian city's characteristics; cities with plotted development may find it easier to promote charging at home while those with dense and high-rise residential units may have to retrofit parking areas to provide for charging points. Infrastructure for EVs in public spaces like commercial centres, institutional and office areas would also be required.

The typical locations for installation of public charging infrastructure are highway exits, parking lots, curb sides, and fuelling stations. There are other factors that also govern successful and efficient deployment of the infrastructure. These include: cost effective establishment and operation of the infrastructure; accessibility to the charging facility; cost recovery by the service providers or operators of the facility; and capacity utilization of the facilities.

Each vehicle segment has different charging needs and the charging sectors for each segment are therefore developing differently as well (see *Table 10: Suitability of and charging models for each segment and their characteristics in the Indian context*).

Charging two-wheelers and three-wheelers: These two micro-mobility segments in India dominantly depend on two types of charging solutions: network charging and battery swapping. Network charging includes public charging infrastructure, and home or office charging facilities. In India, no two-wheeler manufacturer currently provides public charging solutions to their buyers except Ather Energy.

Ather's business model is to provide a complete ecosystem for their consumers, to inhibit their apprehensions towards the newer electric vehicle technology, especially towards the charging requirements of the vehicle. Therefore, Ather provides their consumers both personal home and office AC charging solutions called the Ather Dot, and a public DC charging network called the Ather Grid. The availability of their public charging solutions is very limited though, currently only in Bengaluru and Chennai, but they are in the process of expanding to other cities.

Table 10: Suitability of charging models for each segment and their characteristics in the Indian context

<table>
<tr><th colspan="2" rowspan="2">Type of charging solution - Private/ Passenger</th><th colspan="2">2W</th><th colspan="2">3W</th><th colspan="3">4W</th><th rowspan="2">Bus</th></tr>
<tr><th>Logistics</th><th>Passenger</th><th>Logistics</th><th>On-demand cab</th><th>Staff transport</th><th>Logistics</th><th></th></tr>
<tr><td rowspan="3">Network charging</td><td>En-route public charging</td><td colspan="4">Moderately preferred by 2Ws; Smaller power requirement for connection that can be provided by any commercial establishment</td><td colspan="3">Moderately preferred by 4Ws; Can cater to both private and commercial vehicles</td><td rowspan="3">Most preferred at captive charging facility for fleet operators</td></tr>
<tr><td>Charging at public parking spaces</td><td colspan="4">Least preferred by 2Ws; new electric connection required to set up a multiple charging facility</td><td colspan="3">Least preferred by 4Ws</td></tr>
<tr><td>Other destination charging options</td><td>Most preferred at captive charging facility or home/office charging</td><td>Most preferred at logistics hub facility</td><td>Most preferred at captive charging facility for fleet operators</td><td>Most preferred at logistics hub facility</td><td>Most preferred at captive charging facility for cabs</td><td>Most preferred at office facility</td><td>Most preferred at logistics hub facility</td></tr>
<tr><td colspan="2">Battery swapping</td><td colspan="4">Most preferred by fleet operators; Tie ups with kirana stores for individual swapping or captive facilities set up by fleet operators for both individual and stack swapping</td><td colspan="3">Limited commercial deployment for 4Ws</td><td>Few cases; Expensive but reduces battery recharging time significantly</td></tr>
<tr><td colspan="2">Inductive charging</td><td colspan="4">No use cases for 2W and 3W</td><td colspan="3">Lower financial viability for 4Ws</td><td>No cases in India; Expensive but minimal area requirement and good for range extension</td></tr>
</table>

Source: AEEE, expert interviews

India's market is currently very limited when it comes to charging equipment for two-wheelers, and therefore a similar ecosystem approach is the only option left for manufacturers who want to gain momentum in the country. Moreover, many two-wheeler models in India can also be charged on 5/15 A sockets available in every household that are used to power all common electrical appliances, which means they are not completely dependent on public chargers.

Fleet operators have also developed their own captive AC charging solutions to power their electric vehicle service. DOT, a logistics fleet operator, is one such example. The company is operational in more than 25 urban areas including Delhi, Mumbai, Bengaluru, Hyderabad and so on. eFleet Logix is another example from Jaipur and Gurugram that has set up facilities which can charge up to 15 vehicles at a time, and its fleet only requires charging twice a day to run both morning and evening shifts.

Battery swapping for two- and three-wheelers works in different ways depending on the nature of vehicle utilization. Among the personal and passenger segment, kirana store battery swapping solution is the most common in India. Companies such as Bounce in Bengaluru are providing swapping facilities in partnership with local kirana shop owners, complete with a mobile application that can locate nearest swapping stations. Fleet operators on the other hand prefer captive swapping stations set up by the operators. Dabadingo rental in Kolkata is a good example that has detachable batteries, which are swapped and charged twice a day, without the need for overnight charging, in a 100 sqft area for 10 batteries.

Charging four-wheelers: With more and more emerging use cases for four-wheelers in the e-mobility domain, different kinds of charging models are being preferred by each use case. Four wheelers are most commonly charged via the public charging facilities or destination charging facilities, available at home or office, logistics hub, etc. depending on the vehicle usage.

Battery swapping has seen very limited applicability in India, mostly because the standards for swapping systems are not commonly used in India, and, therefore, products using these standards are very rare in India. However, some states such as Delhi have allowed purchase incentives for vehicles sold without batteries, to support swapping for four-wheelers as well. Similarly, wireless charging or inductive charging standards are not followed by vehicles in India currently and therefore this charging technology is not used.

In India, different use cases for four-wheelers have emerged over the last few years. These are private use, on-demand cab fleets, logistics fleet, and staff transport fleet. Naturally, vehicles used in each use case would prefer destination charging the most, where the vehicle can be charged at either the home charging facility, captive charging facility for cab fleets, the logistics hub charging facility, or the office premises charging facility.

En-route charging is preferred only if the destination charging facility available to the drivers is not adequately reliable, or if the trips are longer than the range of the vehicle. En-route chargers are the public charging infrastructure usually located along the roads, or even at fuelling stations. These stations are open to both the private and the commercial segment to use, depending on the number of connectors available at the station.

Apart from these, there are charging facilities also located at on-street and off-street parking locations. They may be present in and around shopping complexes, business districts, hospitals, etc. run by either the municipal corporations or private operators. These are the least preferred charging solutions for a four-wheeler driver, due to their limited and situational accessibility.

Charging buses: Public transport, especially the bus sector, has seen a lot of experimentation on the e-mobility front. Public transport routes are fixed routes and thus proper route rationalization techniques and charging infrastructure siting strategies can help reduce issues of range anxiety.

Buses prefer plug-in charging at the trip nodes or the starting and end points of the trip. Separate start and end nodes for the route length would mean buses can have more operational kilometres each trip. Intermediate charging points may also be provided in case the range of the bus is small. According to AEEE, intra-city buses in India cover a root-mean-square (RMS) distance of 33 kms in a single trip. This distance is well below the maximum range of many e-bus models available for intra-city travel in India.

In several parts of the world and even in India, there have been experimentations with swapping and inductive charging as well. Inductive charging or wireless charging uses static or dynamic induction to charge the vehicles. This technology is very costly to install. However, it requires minimal area of installation since most of the power delivery system is underground. Inductive charging is prone to electromagnetic interference due to its wireless energy transfer technology, and in most cases is only used for range extension of an e-bus. Some examples of this technology are the On-line Electric vehicle (OLEV) systems in Gumi and Sejong, South Korea.

Swapping technology is also uncommon for buses. However, it is more financially viable than inductive charging due to the significant reduction in charging times, from hours of required charging to just minutes required for swapping, eventually improving bus operations. Swapping requires special equipment such as the battery swapping arms and battery moving systems to swap the depleted battery in an e-bus. Ahmedabad saw India's first battery swapping pilot run on its 31 km BRTS route, resulting from a partnership between Ashok Leyland (bus manufacturers) and Sun Mobility (charging service providers). Swappable batteries were installed in 18 out of 50 e-buses.

Working principle behind setting up chargers in India: India's current state of charging infrastructure standardization is very limited. The India specific standards cannot charge all the vehicle segments available in India, which is why there are plug-in chargers in the country with specifications borrowed from the international market. It becomes pertinent to understand the specifications of the charging standards India has adopted and developed to charge its vehicles, before reaching a best-case scenario for setting up chargers anywhere.

There are two plug-in charging options for any vehicle: slow charging (AC charging) and fast charging (DC charging). The grid electricity supply is AC, which is why AC chargers are more common in India. However, the battery uses DC supply, and therefore AC must be converted into DC by an AC-DC convertor present either on board the EV (in case of AC charging) or as part of the EVSE (in case of DC charging). This is also why DC chargers are more expensive because, apart from the high output connection required for them, they also need the AC-DC convertor as part of their EVSE in addition to other auxiliary equipment.

DC chargers are fast because the only restriction to their power output is the safe power limit the battery will accept. In the case of AC chargers, the vehicle is charged through an on-board charger and therefore has limited power output.

Table 11: Technical specifications of AC and DC chargers applicable worldwide which are also applicable in India

	International standards adopted by India			India specific standards
AC charging	**AC II**		**AC III**	**Bharat AC 001**
	(A)	**(B)**		
Input voltage (V)	230	230	>415	415
Output power (kW)	1.4–3.3	3.3–7.4	11–43	3.3
Charging mode	Mode 1 or 2	Mode 2 or 3	Mode 3	Mode 3
Supported segment	2W, 3W, 4W	3W, 4W	n/a currently	2W, 3W, 4W
Indian use case	Lithium Urban	Magenta Power	n/a currently	Lithium Urban
DC charging	**DC I**	**DC II**	**DC III**	**Bharat DC 001**
Input voltage (V)	415	>415	>415	415
Output power (kW)	<50	>50	>150	3.3/10/15
Charging mode	Mode 4	Mode 4	Mode 4	Mode 4
Supported segment	4W	4W	n/a currently	4W
Indian use case	Fortum India	Fortum India	n/a currently	EESL

Source: AEEE

Moreover, each charging standard uses a different charging 'mode'. There are four charging modes based on the output power levels and charging rates, which give information about the type of installation required for the charger. Mode 1 uses a standard household socket in which the charger can be plugged to charge the vehicle. Mode 2 also uses a household socket to charge, but it has inbuilt shock protection against DC currents, and a control device. Mode 3 uses a fixed outlet, such as wall mount (less than 0.2 sqm of area required), and a tethered cable to communicate with the vehicle while charging. Mode 4 technology is for DC fast charging and is used for public fast chargers (see *Table 11: Technical specifications of AC and DC chargers applicable worldwide which are also applicable in India*).

Technical specifications of available charger options in India: The most commonly used standards in India are the AC II (or Level II AC), Bharat AC 001 and Bharat DC 001 chargers. AC II chargers provide single phase charging and work on the most common service voltage in India, i.e., 230V, which is universally available. AC II (A) chargers are used by vehicles with on-board chargers between 1 to 3 kW, whereas AC II (B) is used for newer car models with on-board chargers rated at higher power levels. AC II (A) can charge two-wheelers and three-wheelers that use the standard three-pin which can be plugged into the 15 A household sockets.

AC III provides three-phase charging, therefore it is only applicable for vehicles with three-phase on-board chargers. Indian four-wheelers currently do not have such vehicle models available in the market, but these chargers are possible in India once supported vehicle models are launched.

DC charger standards most commonly used in India are DC I and DC II. DC I chargers are wall mounted while DC II are floor mounted chargers. DC II chargers need additional equipment such as high-tension and low-tension switchgears, protection systems, step down transformers, etc., whereas DC I chargers only need cables and circuit breakers. DC III chargers have very high output capacities, and are new and uncommon in the market. DC chargers are used for charging four-wheelers.

Bharat AC 001 and Bharat DC 001 are specially designed charger standards for the Indian context. Bharat AC 001 or BAC requires a three-phase input connection, and gives a single-phase output. A 10 kW input can charge three vehicles at a time at 3.3 kW power output each. This charging technology is the most commonly used for charging two-wheelers and three-wheelers in India.

Bharat DC 001 can give out a much higher power output range than Bharat AC 001 chargers, although for two-wheelers and three-wheelers only the 3.3 kW output is suitable. Bharat DC 001 chargers are currently not being used for two-wheelers or three-wheelers since the connectors required by the DC standard to charge the vehicle have not been developed for these two segments. This charging standard is most commonly used by four-wheelers in India at output power levels of 10 kW or 15 kW.

For setting up charging infrastructure, the cost of ancillary equipment will be higher for high tension (HT) line electric connection, which is used only in the case of DC II chargers. These chargers would need a distribution transformer, HT/LT switchgears and HT/LT cables. All other chargers have a low electricity connection requirement and can work on low tension (LT) lines. DC II chargers will also be floor mounted chargers, unlike the rest that can be wall mounted chargers, with a much lower area requirement. Moreover, in terms of drawing power from the distribution network, installation of AC II, Bharat DC 001 and DC I are moderately difficult, whereas DC II can be very difficult. This difficulty arises from either the absence of adequate sanctioned load (if sanctioned load requirement comes under HT line in a state) or if the charger cannot charge without a 11, 22 or 33 kV connection (if it does not, a new connection is needed).

Several challenges: The 2021 WBCSD report states that the sector still faces unclear rules on grid upgradation strategies; land availability for private investments in charging; absence of subsidy support to battery swapping; double taxation levied on charging services; and operational difficulties related to the open-access regulation threshold. It therefore underscores the importance of allocating affordable and accessible land for private investors, permit battery swapping to avail of FAME subsidy and reduce GST on charging and battery swapping services.

High cost of installation: Setting up public charging stations with fast charger or combination of fast and slow chargers is still a costly affair. The cost of charging equipment, land and grid connectivity requires initial capital, but the prospect of return on investment continues to be grim with low deployment of EVs and charging demand expanding the gestation period to break even. Therefore, major developments in this area continue to depend on FAME subsidy support (see *Table 12: Cost of EV chargers in India*).

Limited financial support for development: As the sector is new and the sector's risk profile is not yet mapped comprehensively, access to capital continues to be a challenge with banks as well as non-banking financial companies (NBFCs). In interviews with industry leaders such as Volttic, it was revealed that due to the nascent nature of the market, and lack of proven records and experience in India, it is difficult for newer companies to enter this capital-intensive business. Government needs to do more than just incentivize support for infrastructure and equipment.

Table 12: Cost of EV chargers in India

All costs in INR ( )	International standards adopted by India			India specific standards
AC charging	**AC II**		**AC III**	**Bharat AC 001**
	(A)	**(B)**		
Charging equipment cost	Up to 24,000	38,000–65,000	80,000–1,20,000	40,000–50,000
Ancillary equipment cost	1,400–1,900	1,600–2,500	4,000–11,000	1,800–2,500
Total cost	**1,400–25,900**	**39,600–67,500**	**79,000–1,41,000**	**41,800–52,500**
DC charging	**DC I**	**DC II**		**Bharat DC 001**
Charging equipment cost	6,00,000–8,00,000	12,00,000–13,00,000		2,40,000–2,60,000
Ancillary equipment cost	8,000–15,000	6,25,000–8,25,000		2.800–3.500
Total cost	**1,80,000–2,60,000**	**18,25,000–21,25,000**		**2,02,800–2,63,500**

Source: AEEE

Limited standards for charging technology: Indian manufacturers use the Bharat DC 001 and AC 001 connectors as the only two defined standards tailored specifically for India. All other standards have been adopted from the international market. Even the two Bharat AC and DC standards are inspired from the Chinese GB/T connector standard. Since charging equipment child parts are imported from China, aligning with the Chinese connector standard is required. Indian car and bus manufacturers use GB/T port on vehicles for DC fast charging. The central government has set up charging stations: with Type-2 AC, and the Indian Bharat AC and DC connectors. Two global charger types CHAdeMO and CCS have also been adopted in India. Both follow the technical standards of DC II chargers (see *Table 11: Technical specifications of AC and DC chargers applicable worldwide which are also applicable in India*).

Since Bharat AC and DC chargers cannot charge all types of vehicles, new charging standards are required. Bureau of Indian Standards (BIS) and Department of Science and Technology (DST) are currently working on indigenous charging standards for India. An innovative low-cost AC charger (LAC) is supposed to be released soon at a price less than Rs. 3500 that can charge two-wheelers and three-wheelers up to 3 kW power output. The input required by the charger in a household is a 220 V 15 A single phase socket.

There are challenges of interoperability, maximizing utilization of all charging stations and identifying potential revenue opportunities for the charging station operator. Faced with a similar conundrum, China has adopted GB/T chargers nationwide. Similarly, a majority of European nations use CCS and Type-2 connectors whereas North America subscribes to the CCS connector. Therefore, following and adapting to international standards that are applicable in the Indian context can be good for the country.

5.2 Challenges of financing the EV market

The 2021 NITI Aayog report has estimated the total capital and financing requirements for an ambitious EV adoption scenario based on the cumulative capital cost of vehicles. It assumes that EV sales penetration has the potential to be about 70 per cent in 2030 across segments and this will have a bearing on electric vehicle supply equipment like hardware and batteries, including replacements between 2020 and 2030. Accordingly, the estimated cumulative capital cost of India's EV transition is expected to be Rs 19.7 lakh crore by 2030 while the estimated size of the organized EV finance market is around Rs 3.7 lakh crore. This requires strategies to mobilize capital and financing.

EV technology is nascent in India, which creates uncertainties about the currently high financing costs and long-term economics such as resale value. Therefore, to offset risks associated with the sector, problems such as high interest rates, low loan-to-value ratios to recover costs in case of default, high insurance rates, and even limited financing options have emerged.

Even though central and state governments are providing a range of incentives, this has not affected the financial market yet. However, at the state level, some efforts are being made to work with the financial institutions. For example, Delhi EV Policy provides an interest rate subvention of 5 per cent on loans for buying e-autos and e-carriers. Delhi Finance Corporation (DFC) and its empanelled Scheduled Banks and NBFCs are developing a scheme on interest rate subvention. The Kerala Finance Corporation (KFC) has created a programme to provide low-cost loans for EVs in the state. But a lot more is needed.

Given the impact of the COVID-19 pandemic and the associated economic slowdown, EV growth has stymied and industry investment has also become rigid, especially after the investment to meet BS VI emissions standards for the ICE engines. Confidence in the finance sector is low due to high financing cost, uncertainty around the nascent small market along with fuzzy long-term targets, and concerns around the performance and resale value of these products. This has led to the problem of high interest and insurance rates, low loan-to-value ratio, and limited financing options for retail customers. This results in unsecured borrowing from the unorganized sector at even higher rates.

The 2021 NITI Aayog report has comprehensively outlined the risks and barriers associated with the financing of EVs in India. A financing strategy that ensures adequate financial flow into the sector is critical to build ambition and target. According to this report, the share of finance flow from the organized finance institutions—banks and non-banking financial institutions together, is about 50 per cent to four-wheeler passenger vehicles, 40 per cent to commercial vehicles and only 10 per cent to tractors and two-wheelers. The less expensive the segment and use case, the lower is the finance penetration to those segments. E-rickshaws have minimal organized sector financing due to the unregulated nature of the segment and the high-risk nature of borrowers.

The EV market in India is diverse, with multiple vehicle segments and each segment having multiple usage patterns. The economics for each use pattern will be different. For example, the total cost of ownership and its parity with the ICE segment for a rental electric two-wheeler model will be different from a private electric two-wheeler. Similarly, two-wheelers and buses will have very different parameters for financing. In addition, the charging infrastructure has its own funding demand.

Two/three-wheeler fleet operators need high daily vehicle usage to justify their business model viability to financial institutions. This in turn needs a robust charging infrastructure network to support operations and better model availability in the market. And since these two aspects lack in the Indian market currently, operators find it difficult to access financing.

However, there is some traction now. For instance, the e-rickshaw market has seen dedicated, collateral free loan initiatives through partnerships between financial institutions and OEMs, such as the IndusInd Bank-Lohia Auto partnership in 2017 and Ujjain Small Financing Bank-Green Shuttle Technology partnership in 2019. Other agencies such as Bank of India and Punjab National Bank have also started giving e-rickshaw dedicated financing. However, these options require the drivers to provide credit scores and income tax returns, which is difficult for them.

Similarly, purchasing buses is not easy for operators due to the debt finance requirements involved such as bank guarantee, collateral and the debt issuance fees, which can be up to 1.5 per cent. As a result, bus operators may typically have to raise up to 25 per cent of the capital costs as equity, which is not ideal.

The Indian landscape for EV financing has seen some initiatives emerging to improve owner and investor confidence in EVs, but a lot more is needed.

Addressing the risks: The 2021 NITI Aayog report has identified a range of risks associated with financing of EV ecosystem that will have to be addressed:

- There is business model risk associated with the level of utilization of the commercial vehicles and their associated viability. Viability of commercial vehicle operations depends on high utilization rates to ensure cash flow during operations. This requires reliable access to charging infrastructure.

- Individual customers in the commercial vehicle segments need formal financing to meet the high upfront cost of EVs. But they often lack the experience of borrowing from the organized sector and are unable to provide guarantees to pay back loans. This inhibits the process.
- EV owners are still not well adapted to the operational parameters and maintenance risk that include battery replacement, voltage fluctuations, or technical requirements of charging infrastructure, etc. Without adequate knowledge of maintenance requirements, battery ageing or uncertainty around the resale value of EVs, bankability can be adversely affected.
- The finance industry will have to develop the logistical capability to process loans for EVs and penetrate deep across geographies. Financial institutions will have to reorient and change their financing products and procedures. Moreover, non-banking financial corporations are facing a liquidity crunch that has tightened financing of vehicle financiers. There is a trend towards new fintech-based EV lending models such as Delhi-based RevFin and Bengaluru-based Three Wheels United (TWU) that deal with high-risk customers. But they may also require access to low-cost finance from larger banks.
- Interest rates for EV loans tend to be higher than ICE vehicles. For a personal electric car in Delhi, banks charge a marginally higher interest rate than an ICE vehicle but a commercially operated electric car can be charged up to 14 to 15 per cent, compared to 12 per cent for a diesel car. For E2Ws, interest rates are as high as 20 per cent or more. This increases the equated monthly instalment adding to ownership costs.
- Banks also provide loans for EVs through partial financing at a low loan to value ratio to recover substantial costs in case of default, as the resale value of EVs is low. Small operators or drivers may not possess the equity to accommodate the low loan to value ratio. They will be forced to seek unsecured high-interest supplementary loans from the unorganized sector.
- There are very limited financing options for EVs. Only SBI has Green Car Loan scheme. Globally, in Norway, China, the UK, Australia, and other countries, banks offer specialized products.
- High interest rates, low loan to value ratio, and shorter repayment periods plague the sector. Owners also have to pay higher insurance than conventional models as the upfront cost is high.
- Such rigidity in the financial market is due to poor understanding and lack of information about the performance of EVs, in terms of range, asset life, maintenance requirements, load capacity, etc. Insurance products are limited as the EV technology is considered unproven. Even manufacturers do not offer guarantees or warranties, which further aggravates the issue. Financial institutions are not clear about the obsolescence of the technology. Moreover, there is a lot of uncertainty around resale

value and secondary market of these products. Further, bankability of e-commercial vehicles depends on cash flow from high utilization during the operational phase. This can be constrained if reliable charging infrastructure is not available.

- Lack of long-term policy visibility further brings uncertainty in the sector. Policy certainty is critical for this and to bring price parity.
- Manufactures will have to play a role to improve information and data on product performance and reliability of the technologies. Also, there are several new entrants who are yet to get on board for formal lending. It is also said that OEMs selling these expensive products at lower or negative margins also create risk associated with their balance sheets.

Financing roadmap: The central government and the state governments have come up with solutions to improve the situation, such as interest subventions to banks, and subsidies for capex and opex. However, financial penetration is still low. Therefore, more efforts are needed to ensure that government, industry and financial institution collaborations come with a set of tailored solutions for the Indian context.

The 2021 NITI Aayog report has recommended that both central and state governments need to increase access to low-cost financing. RBI can include public sector lending mandates for EVs to increase finance available for them. The central government or NDBs can capitalize risk-sharing facilities to provide longer-tenure and lower risk financing. Lowering of interest rate for EV buyers can be mandated to lower the cost of financing for end-users.

More states should come up with interest rate subvention in their respective state EV policies. Delhi's EV policy cuts down interest by up to 5 per cent for e-rickshaw and e-auto buyers through subventions to the bank.

Ensuring product guarantees for the long-term on products in the market can mean that more OEMs can partner with financing bodies due to assured vehicle performance and increased resale values. OEMs can also offer maintenance and repair services free of cost for specific time periods after the purchase.

Risk sharing mechanisms created by government and multilateral organizations can cover loan repayment risks for the financial institutions, making them more proactively send out loans. They can lower the cost of financing by capitalizing risk-sharing facilities. They can also offer low-interest loans and other financing products to start-ups, fintech companies, and more.

Banks are beginning to change their products. SBI started the Green Car Loan, the only specialized product for electric cars, in April 2019. This provides a discount. On average, the SBI Green Loan would charge an interest rate closer to 9 per cent, marginally less compared to other cars. To reduce costs, the processing fees for the first six months of the scheme is waived. The maximum repayment period has been increased. A loan to value ratio as high as 90 per cent is offered. The focus of business model innovation and procurement schemes is on reducing upfront costs and technological risk by leveraging leasing, battery separation and economies of scale.

Fleet operators can offer similar risk sharing mechanisms with the financial institutions by providing guarantees for their driver partners, including partial credit guarantees for full-time driver partners. They can also offer utilization guarantees to driver partners to help achieve TCO parity while improving fleet economics, innovating the business model and setting fleet electrification targets.

Moreover, even if the upfront capital cost of buying a vehicle is subsidized, the subsequent replacement of batteries—that can be 3–4 times until the vehicle reaches end of life—are not subsidized. Sometimes, the cost of replacing a battery can be nearly equal to buying a new petrol two-wheeler. That can stymie consumer interest. Further, while a battery in a new vehicle draws 5 per cent GST, the replacement battery attracts 28 per cent GST. This will have to be rationalized. This is needed particularly as MoRTH has now allowed sale of vehicles without battery.

Start-ups and fintech are part of the EV financing ecosystem. Venture capital funding is catalysing this sector with innovative business models and manufacturing. This can make for a bigger role in two- and three-wheeler markets where financing penetration is low and can support the first time EV buyers without credit history.

5.3 Building industry support

NITI Aayog released its transformative mobility report in 2017 with an ambitious roadmap for pure electric vehicles aiming at 100 per cent public transport vehicles and 40 per cent private vehicles by 2030. Following which, the Society of Indian Automobile Manufacturers, the apex national body representing all major vehicle and vehicular engine manufacturers in India, had issued a white paper providing the preferred industry roadmap. The paper expected all new vehicle sales for intra-city public transport fleets to be pure electric vehicles by 2030; 40 per cent of new vehicle sales to be pure electric vehicles by 2030; and 60 per cent of new vehicle sales to employ greener technologies like hybrids & other alternate fuels by 2030. Finally, all new vehicle sales have to be pure electric vehicles by 2047.

The SIAM roadmap had proposed enablers to achieve these targets. It sought bridging the viability gap, enabling charging infrastructure buildout, domestic manufacturing, creating public awareness, among others. The industry is however weary of a legal mandate for zero emissions targets. SIAM feels the most plausible way of inducing electric vehicle adoption in India without disrupting the Indian automotive industry is to plan out a practical roadmap for the industry. The general sense in the industry is that short-term ICE phase out targets will adversely affect the industry as there is little consumer demand currently for pure electric vehicles.

Further, SIAM points out that most of the stakeholders involved in creating the EV roadmap in the country, from government officials to the automotive industry to suppliers, have little experience in the field of electric vehicles, and, therefore, a high percentage shift to EVs is unlikely in a few years. SIAM suggests that the roadmap in question shall first address the infrastructure gap across the country to make India EV ready.

Society of Manufacturers of Electric Vehicles (SMEV), on the other hand, has articulated its position on several platforms and through conversations. This 60 member body is the core industry group that is expected to drive electric mobility and build a supply chain. SMEV is asking 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.

The industry is discussing quality of vehicles and EV design and that there is need for a grounds up approach to designing and developing EV products. It cannot be simply adapting and modifying the model of diesel buses into EV buses.

For instance, the industry holds that the development of new products could take years. The entire FAME programme hinges on the assumption that in four years the cost of batteries will reduce significantly and the bridge support from the government for that period will be sufficient to stimulate the market. But the industry is sceptical of this assumption.

It may be noted that the cost of products varies according to the performance of products. In the two-wheeler segment, the range can vary between Rs 75,000–160,000. Even after the subsidy, the cost of the product can be two and half times higher than the comparable ICE vehicle. This either requires higher subsidy from the government or compromises on the performance of the products to reduce costs to the consumer.

There is still no clarity on how additional resources can be mobilized to increase not only the share of subsidy but also to provide longer term support. SMEV has proposed green tax on IC engines to offset the cost of subsidy for EVs. This needs to be done urgently.

Even today, 75 per cent of the two-wheeler market is below 125 cc engine category. SMEV seeks modification of the FAME scheme to make it more effective as the current phase of FAME II has just about met 10 per cent of its target in two years.

Industry reaction to the localization agenda is mixed. Uncertainties in the market related to sales volumes continue to be a concern. Industry insiders feel that the import restrictions to promote localization need a more phased approach, as in the initial stages it will likely increase costs of key vehicle components such as batteries and motors. In comparison, imported components are cheaper and there is the danger that localization could get stymied if it is not planned well. Besides, access to capital continues to be a challenge. Low volumes and concerns around resale value have hardened the financing side. The sector requires priority lending.

5.4 Towards zero emissions mandate in India

India's intent to promote electric vehicles would do well to complement its voluntary electrification programme which focuses on incentivization with a mandatory programme that uses credits and penalties to ensure compliance. A combination of mandatory numbers on the supply side and incentives on the demand side is likely to have larger impact than the status quo at the moment.

With such a programme, companies can diversify their product portfolios 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. Currently, the percentage of EVs in the total sale of individual manufacturers is miniscule—less than 1 per cent. If the current market trends continue, the possibility to build ambition and maintain a robust and desired growth rate to achieve 30@30 target seems bleak (see *Table 13: Share of electric vehicles in total sales of selected manufacturers*).

Table 13: Share of electric vehicles in total sales of selected manufacturers (2018–19)

Manufacturer	Electric/strong hybrid	EV sales volume in FY 2018–19	Total sales volume in FY 2018–19	EV/hybrid %
Mahindra	EV	1,623	2,52,486	0.6%
Tata	EV	343	2,29,892	0.1%
Toyota	Strong hybrid	439	1,50,558	0.3%
Volvo	Strong hybrid	21	2.596	0.8%

Source: Fuel consumption of new passenger cars in India: Manufacturers' performance in fiscal year 2018–19; ICCT Working Paper 2020

Lessons from Tesla

The structure and architecture of the EV industry will change with new players, much like Tesla in the US and elsewhere. California-based automaker Tesla's entry into India could be a reality. Tesla's strategy is an interesting case study for electrification strategies deployed across the world.

The Tesla EV strategy was born out of an understanding of the electric vehicle as a product for which buyers have to be found. The automaker paid attention to building two major assets—a large customer base and a large and dense network of multi-stall rapid-charging stations. The role of the network is to provide confidence to customers about the availability of charging stations in order to address their range anxiety even if they were not buying Tesla vehicles.

The attractiveness of Tesla cars is based on the promise that they can be driven for hours over long distances with the confidence that the drivers have easy access to charging locations. Once the core vehicle needs are met, consumers can focus on deciding on the car to buy based on its features instead of the features of its charging network.

Globally, traditional automakers that have not found Tesla-like traction in sales volumes typically waited for others to set up charging stations. Nissan had won an early lead in sales in the US in 2011–2014 as the manufacturer of the best-selling LEAF, an advantage that the automaker could not win benefits from beyond 2014 as owners were left to depend on very few third party stations available to all brands.

One of the biggest lessons Tesla offers is a tunnel-vision focus on the product, but only after working on the customer's confidence. Investment in designing feature-rich EVs, for instance, may not bring in expected returns unless automakers are building charging infrastructure in parallel, either by themselves, or, in partnership with the government or private charging station players. Indian automaker Tata Motors has already started out on this path. So has Ather, which offers its own charging facilities, even though E2Ws typically charge at home and do not require public charging most of the time.

A Tesla syndrome in the Indian automotive industry will likely be segmented. Omega Seiki Mobility, for instance, wants to become the Tesla of the 3W space in India, while Okinawa looks set to become an E2W Tesla. In the four-wheeler space, Tata is working on building its own charging network.

Globally as well, credit programmes have been developed that are linked to sale of electric vehicles. The mandatory programme could draw a leaf out of such programmes in the US and China and tailor it to the Indian market. A ZEV mandate will define a fuel economy standard that needs to be stringent enough to drive automakers to build larger numbers of electric vehicles.

While global ZEV policies segregate manufacturers for eligibility on the basis of their size of sales, a size-wise eligibility package could only work in India if it is combined with industrial level incentives that are designed to push small manufacturers into building ambition.

The policy could define compliance for small, medium and large manufacturers with the production of a predefined percentage of their portfolio, depending of their total annual unit sales. Non-compliance could attract a penalty in terms of the numbers of ICE vehicles that can be sold by the manufacturer (see *Table 14: Comparison of manufacturer eligibility for ZEV mandate in global electrified markets*).

The target percentage share can be outlined for every model year, along with a minimum ZEV floor that can only be met using pure electric vehicles and not hybrids. These targets have to be aligned with the NEMMP target of 30 per cent electric vehicles on the roads by 2030.

Table 14: Comparison of manufacturer eligibility for ZEV mandate in global electrified markets

	California	China	EU
Manufacturer eligibility	Must produce and sell (in California) > 4,500 units	Must produce or import > 20,000 units	All manufacturers under GHG program qualify
Manufacturer categories	> 20,000: large 20,000–4,500: intermediate <4,500: small	<20,000: small	No categories

Source: California Air Resources Board; Ministry of Industry and Information Technology, China; European Commission; CSE compilation

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.

Besides, they were the largest volume grossers with the FAME II incentives scheme. Under the programme, over 77 per cent incentives were utilized by two-wheelers and over 20 per cent by three-wheelers till July 2021.

For a cost sensitive market like India, these segments offer huge potential to be early adopters of electric vehicles and industry targets for these segments will accelerate this process.

How the ZEV programme works – credit scheme: Manufacturers can qualify for ZEV programme 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.

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.

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 the proceeds being channelized for EV awareness programmes.

How can a ZEV mandate help over the existing EV policy in India? India's EV plan, formulated under NEMMP as FAME I and then FAME II, is focused on consumer adoption, while emphasizing on developing technology and creating local manufacturing capability. A ZEV mandate could ensure a robust supply side with larger model availability guided by market economics that could lead to greater adoption. Its impact on the market could be amplified much like the effect it has had in Europe.

PART 2:

STATE OF ELECTRIC VEHICLES GLOBALLY

6. Global learning curve

Global electric vehicle landscape is changing rapidly. IEA, in its May 2021 report, *Net Zero by 2050: A Roadmap for the Global Energy Sector*, states that the number of countries announcing pledges to achieve net-zero emissions over the coming decades has continued to grow.

But the pledges by governments to date, even if fully achieved, ‘fall well short of what is required to bring global energy-related carbon dioxide emissions to net zero by 2050 and to limit the global temperature rise to 1.5 °C’. Staying on course will require massive deployment of all available clean energy technologies in all sectors between now and 2030 and electric vehicles will be a critical part of this transition.

Within this framework, the EV trajectory is expected to play a big role and electric vehicles need to go from around 5 per cent of global car sales to more than 60 per cent by 2030. It further states that annual battery production for EVs needs to leap from 160 GWh today to 6,600 GWh in 2030—this is equivalent to adding almost 20 gigafactories each year for the next ten years—and, simultaneously, the public charging points for EVs need to increase from around 1 million today to 40 million in 2030. The change during the coming two decades is expected to be very rapid.

This scale of change and the policy instruments needed to accelerate this change are critical to move forward.

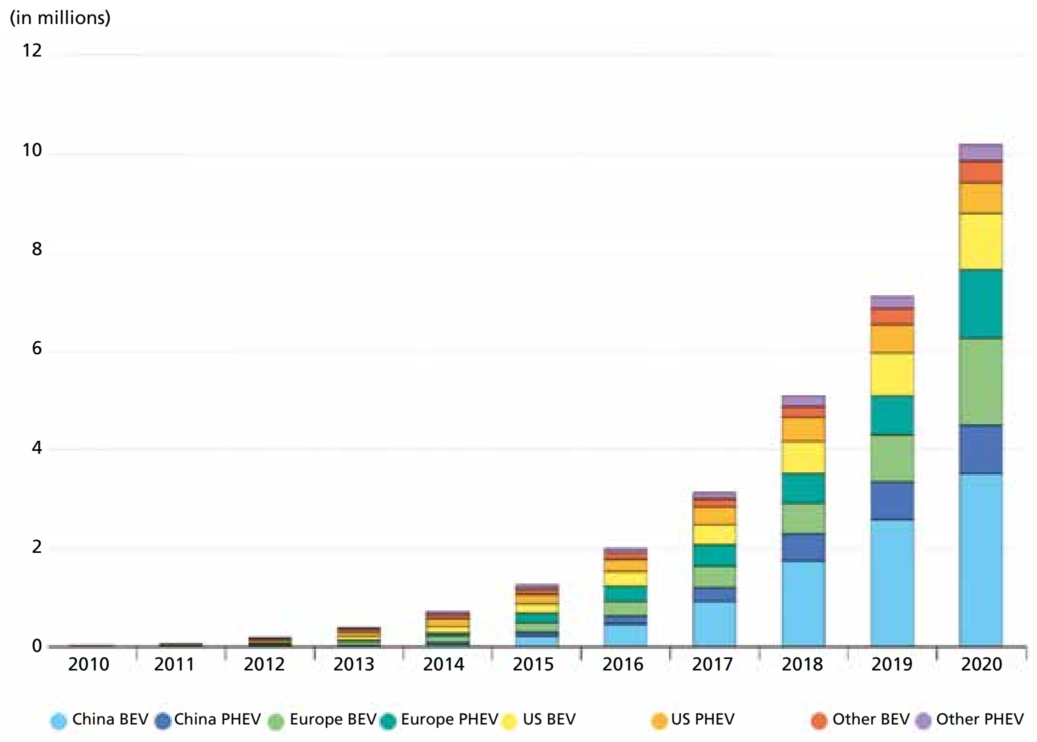
6.1 Changing global market

The most recent and comprehensive trend in global EV sales in different regions of the world is available from IEA's global EV outlook 2021. The total global electric car stock reached the 10 million mark in 2020. This is about a 43 per cent increase over the 2019 level and is 1 per cent of the total car stock. IEA has counted both BEVs and PHEVs, and states that BEVs were two-thirds of new electric car registrations and two-thirds of the stock in 2020.

The year 2020 was also a difficult year due to the pandemic, which deeply affected the market. IEA highlights that even though the overall car registration dropped by about 16 per cent overall compared to the previous year, global electric car sales share rose by 70 per cent to a record 4.6 per cent in 2020. Globally, 3 million new electric cars were registered in 2020. Europe witnessed the largest annual increase to reach 3.2 million electric cars, followed by China and the US. In the total global stock, China has the highest share at 4.5 million electric cars (see *Graph 18: Global electric passenger car stock, 2010–2020*).

Within this broader context, the vehicle segment-wise trend varied across the regions and it is important to understand this granularity.

Graph 18: Global electric passenger car stock, 2010-2020

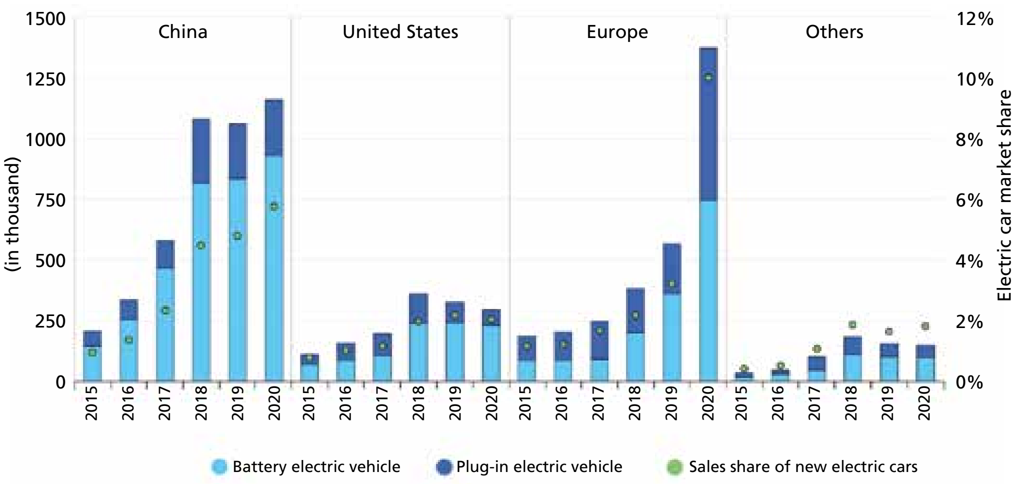


Source: IEA Global EV Outlook 2021

Electric cars: It is the car segment that is driving electrification globally. This trend has played out differently across different countries (see *Graph 19: Global electric car registrations and market share, 2015–2020*).

The IEA's Global EV Outlook 2021 shows that Europe has remained the front runner despite the car market slow down. New electric car registrations have more than doubled in Europe and are 10 per cent of the sales. Germany is the largest market with 3,95,000 new electric cars followed by France with 1,85,000 cars. Even in the UK, registrations have more than doubled. Norway has reached a record high sales share of 75 per cent, up by about 19 per cent since 2019. Sales shares of electric cars have exceeded 50 per cent in Iceland, 30 per cent in Sweden and have reached 25 per cent in the Netherlands.

Graph 19: Global electric car registrations and market share, 2015–2020



Source: IEA, Global EV Outlook 2021

This has been possible because of the 2020 target for EU's CO_2 emissions standards and the increased subsidy scheme of several European governments for EVs as part of the economic recovery or the fiscal stimulus package.

This trend also indicates that out of total electric car registrations, 54 per cent were fully BEVs in 2020, and the rest were PHEVs. BEV registration was particularly high in the Netherlands (82 per cent of all electric car registrations), Norway (73 per cent), United Kingdom (62 per cent) and France (60 per cent).

China, on the other hand, faced shrinking of overall car registration by 9 per cent due to the pandemic, but the sales share that dropped initially picked up again to 4.8 per cent more than the 2019 level. BEVs were 80 per cent of all EVs. In China, the subsidies for EVs were due to end in 2020, but the plummeting automotive sales as a result of the economic slowdown forced the government to extend subsidies till 2022. Several Chinese cities have relaxed rules for licencing policy to allow more IC engines.

It is evident that the US car market has also declined by 23 per cent in 2020 but the decline in EVs was lesser. Of the total EV cars sold in 2020 (about 295,000 new electric cars), 78 per cent were BEVs. During this time the federal incentives had also reduced.

Other countries have shown a mixed trend with both ups and downs. Some remained resilient and some didn't. In Japan, for example, the electric car market contracted more than the overall car market.

The evidence of resilient electric car sales in 2020 also reflects higher consumer spending than 2019 and this happened despite the increase of 6 per cent in average prices. This is particularly noticeable in Europe. According to the IEA, governments across the world have spent $14 billion on direct purchase incentives and tax deductions for electric cars in 2020, which is a 25 per cent increase from 2019. But the share of government incentives in total spending on EVs is declining and has reduced from 20 per cent in 2015 to 10 per cent in 2020.

Europe saw the maximum increase in government spending where economic recovery was linked with the incentives for electric vehicles. In China, government spending decreased as the criteria for incentives were tightened. Both Europe and China have applied price caps and no subsidy was given for vehicles with prices above a certain threshold. This also kept the prices low. In fact, BEV cars sold in China were 3 per cent cheaper in 2020 than in 2019, while PHEV cars in Europe were 8 per cent cheaper.

With this change in the market, the electric car models also diversified to 370 in number in 2020, which was a 40 per cent increase from 2019. Highest number of models are available in China, though Europe witnessed the highest year-on-year increase.

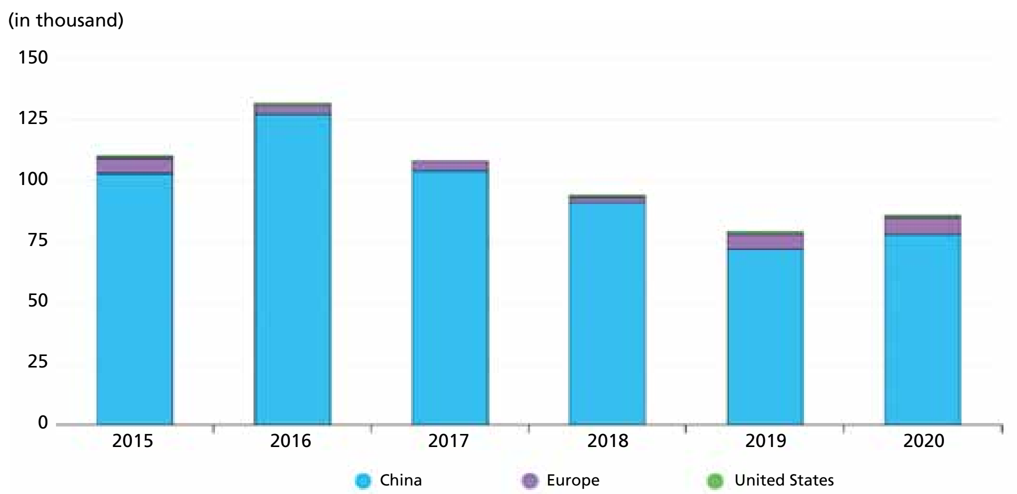
IEA notes that the average driving range of new electric cars is also increasing steadily—from a weighted average range of 200 km in 2015 to 350 km in 2020. The US saw a higher increase than China. Moreover, SUVs and pick-ups constitute more than 55 per cent of the announced models worldwide. These are more popular and have higher profit margins as the cost of powertrain in EVs is smaller. Electrification of bigger cars helps to meet the targets. Europe's ZLEV scheme will provide stronger incentive for electric SUVs from 2025 as their emissions standards are lax compared to their potential to reduce specific CO_2 emissions. In addition, electric LCV registrations have also increased by almost 40 per cent in 2020.

Electric bus: Rapidly growing markets like China have shown deeper interest in linking of electrification with low carbon mass mobility and have targeted expansion of bus transport. IEA review of global bus market shows that China continues to dominate this market with registrations of 78,000 new vehicles in 2020, which is 9 per cent higher than the previous year. Local policies to reduce air pollution have contributed to this trend. Europe has registered 2,100 electric buses in 2020, that is an increase of around 7 per cent, which is double that of 2019. Electric buses are 4 per cent of all new bus registrations in Europe. This is largely driven by municipal level policies. In the US, California is leading this market. Though the stock is small—580 buses—it is still a 15 per cent increase over last year. In South America, Chile leads with 400 electric buses registered in 2020. India increased electric bus registrations by 34 per cent to 600 in 2020.

Electric heavy-duty truck: The trend to be watched is the electrification of the heavy-duty sector. HDV models (that include everything from long-haul freight to garbage collection trucks) have started to increase in leading global markets—buses have progressed more than trucks. IEA's EV Outlook 2021 has outlined the changes in the global market for the heavy-duty trucks. With the overall registration of 7400 in 2020, it has seen an increase of over 10 per cent from the previous year. The total global stock of electric HDTs is 31,000. China had 6,700 new registrations in 2020, an increase of 10 per cent, though it is down from fourfold increase in 2019. Electric HDT registrations in Europe have increased by 23 per cent to about 450 vehicles and in the US they have increased to 240 vehicles (see *Graph 20: Registration trend registration of heavy-duty vehicles*).

Graph 20: Registration trend of heavy-duty vehicles

Electric bus registrations by region, 2015–2020



Electric truck registrations by region, 2015–2020

Source: IEA Energy Outlook 2021

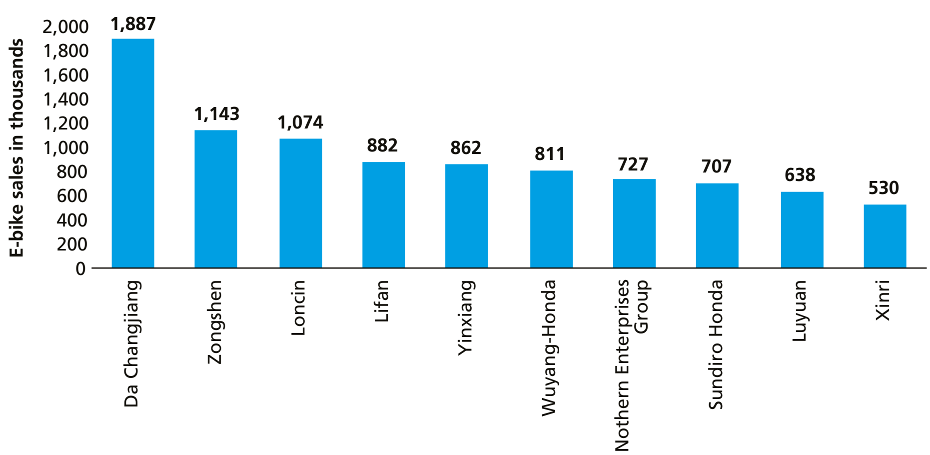
Heavy duty truck manufacturers like Daimler, Man, Renault, Scania and Volvo have adopted a corporate strategy for an electric roadmap. The China and US markets have seen comparatively more diversity. IEA explains that fewer total models may mean higher reliability and broader applicability of the existing designs and more diverse models may mean more customization to meet the requirements of different markets and operations.

Two-wheelers: It is challenging to assess the global trend in electric two-wheelers as this is a unique imperative of Asia. IEA projections do not include two-wheelers. This segment is dominated by China and India and several other Asian countries. There is also an emerging market in Africa.

Therefore, data available from China and India is indicative of the trend. The largest E2W market in the world is China. According to the Chinese Ministry of Industry and Information Technology (MIIT), e-bike output totalled almost 23 million units in the first nine months of 2020, jumping over 30 per cent from 2019. The country's annual electric bicycle sales have reportedly crossed 30 million units in the last few years and the total production in 2020 is expected to cross 36 million units of which around 25 per cent are to run on lithium-ion batteries.

The Chinese e-bike market is dominated by three manufacturers who sold over a million units. Over 60 per cent of the market was captured by five e-bike manufacturers, led by Da Changjiang which sold almost 1.9 million units in 2020 (see *Graph 21: Chinese e-bike sales in 2020*).

Graph 21: Chinese e-bike sales in 2020



Source: Statista

The e-bike boom in China traces its roots to 1996 when the Chinese government had banned petrol-driven motorcycles from city centres to avoid air pollution. The trend received additional boost during the SARS outbreak in 2005, when the Chinese distanced themselves from public transport. Further, in 1999, the Chinese government changed its definition of electric two-wheelers with low speed and weight. They were labelled bicycles, a move that made them eligible for use in bicycle lanes and won them exemption from registration requirements—factors that contributed to increased sales volumes.

Electric two-wheelers are popular mostly in Asia, China and India. The economics of the two-wheeler category offers easy scale-up opportunities, making it a more workable option for conversion to electric in a market with low electrification. E-bikes typically cover short distances and have low energy requirements per km. For this, they need small batteries that are easy and quick to charge, ruling out the need for an elaborate charging infrastructure. It has also been argued that they offer a strong case for personal mobility in Europe and US as almost half of passenger kilometres are trips under 8 km.

6.1.1 Industry shake-up

As the world is moving away from ICE vehicles and adopting electrification of vehicle fleet, a new economy and ecosystem is growing around the EVs globally and this has a bearing on industry restructuring.

A big shake up is expected as the ICE industry is deeply entrenched. As stated by the International Labour Organisation in its 2020 report, based on the estimates of the World Trade Organization (WTO), motor vehicles and automotive parts accounted for 9 per cent of world merchandise exports and 12 per cent of world exports of manufactured goods in 2017. The top five producers of motor vehicles in 2018 were China, US, Japan, India and Germany where the GDP share of the automotive industry varied from 10–14 per cent. There are fears that replacing this can disrupt jobs and the economy around it.

Several estimates are emerging in different markets regarding the job potential and also potential job losses. Large-scale EV transition is expected to affect the jobs and skilling requirements of the industry significantly. At a global level, the ILO has estimated employment implications of introducing a voluntary or mandated target of 50 per cent electrification of vehicle fleet across all member states of the UNECE by 2030. This shows net employment increase in the automotive industry and sectors related to green transport. Net job creation worldwide would be close to 10 million jobs, which is 0.2 per cent greater than the jobs that would be created in a business-as-usual scenario. There are several such estimates emerging now that provide either positive or more conservative possibilities.

According to Transport and Environment (T&E), a think tank in Germany, a study by German IFO institute for the car manufacturer association VDA in 2017 estimated that 600,000 jobs will be directly or indirectly impacted in Germany. But this loss will also be compensated by new job creation across the supply chain as the older supply system will have to shift from parts such as gearbox, exhaust pipes, or injectors to delivering battery materials, electric motors, regenerative braking systems, etc. New suppliers such as battery manufacturers, light-weighting and mining companies, etc. will take the place of old suppliers. This will change incrementally.

This will require re-skilling of engineers and workers. The increased integration of the energy, telecommunication, and transport sectors will create new opportunities and should not be seen narrowly as bad for the traditional OEMs and their suppliers. But it has also been emphasized that with localization a lot of the new value chain can be retained within Europe. T&E estimates that if EU OEMs neglect local EV production in Europe and rely on import and only 10 per cent of EV manufacturing happens in Europe, then jobs in the automotive sectors can be only 72 per cent of the current employment levels. But if 90 per cent of vehicles are manufactured and supplied in Europe, job loss will only be 6 per cent compared to current level by 2030. Export market can also create additional jobs. This has created strong interest in localizing EV manufacturing.

Similar concerns have emerged in the US. The US market is picking up but is slower than Europe. ICCT has estimated that about 15 per cent of the global automaker electric vehicle investments are destined for the United States. Based on the company announcements through 2020, about 5 per cent of this global total is actively being invested in specific U.S. assembly plants to increase electric vehicle production. Many automakers have developed limited capacity for some electric vehicle production and are making investments to further expand their electric vehicle capacity.

China is hogging the lion's share of investments, which is benefitting its overall economy by creating jobs. For almost a decade, the global electric vehicle market has been China focused. To help build the domestic industry, China's strategy requires foreign automakers to enter joint ventures with Chinese firms to share profits and technology. Several global vehicle brands have entered into joint ventures with Chinese companies to access markets and secure supplies of battery materials. Some of these joint ventures are: Toyota Motor Corp and BYD Co. Ltd; Renault SA and Jiangling Motors Corporation Group; Volkswagen, FAW Group Corporation, JAC Motors and Star Charge for charging infrastructure; Ford and Zotye Auto, BMW and Great Wall Motor; and Nissan Motor with Dongfeng Motor Group. Japanese automakers also buy batteries from China's Contemporary Amperex Technology Co Ltd.

Tesla is the only exception that has not entered into a joint venture but has set up a factory in Shanghai to manufacture and export to the global market. China has become an export hub for EVs to make inroads into advanced markets. The net result is China has met its policy goal of 5 million EVs by 2020, and also cornered nearly half of the world's electric car production and 90 per cent of heavy-duty EV production. Chinese companies—BYD, BAIC Motor Corporation Ltd, Geely, and SAIC Motor Corporation Ltd—have achieved economies of scale with global sales. As of 2019, China owns the most technology patents in fast charging and wireless charging. This reflects its ecosystem approach to the new programme. China's strategy on vehicle production is clear—since it could not beat the West with internal combustion engine technology, it has taken the lead in electro-mobility.

European nations have for long viewed China's strong lead in electric vehicle battery technology as a threat to their car industry and have placed vehicle electrification among their topmost priorities in future plans. Germany has taken the lead in the EV market in 2020 and announced plans to make large investments in battery development projects. The labour-intensive vehicle manufacturing sector is a significant source of revenues and jobs in Germany and is an important focus area for the government as the industry moves towards electrification.

Positioning of car companies: The go-electric trend has been driven by stronger regulations that have evolved in the last decade. The automotive value chain has become larger. More car companies have come forward to commit to a EV makeover. Based on these announcements, IEA estimates that the cumulative sales of cars can possibly be 55–72 million by 2025.

A quick review of the media and company announcements globally shows that as the regulations are getting tighter for ICE engine phase out and net zero goals are getting stronger, the vehicle industry is voluntarily committing to an ambitious target for electrification within the next two decades. In fact, this trend is stronger in Europe with more stringent regulatory targets for decarbonization.

While this phase out relates more to passenger cars and buses, even truck manufacturers, including Volvo, DAF, Daimler, Ford, Iveco, MAN and Scania, have committed to stop diesel truck sales by 2040. To illustrate, General Motors plans to be carbon neutral by 2040; Ford-Europe aims for 100 per cent electrification of passenger cars and to make two-third of its light commercial vehicles fully electric or even hydrogen fuel-cell operated by 2040; Honda is targeting 100 per cent battery electric or hydrogen fuel-cell electric vehicles by 2040; Volvo will start phasing out ICE and hybrid vehicles to be fully electric by 2030; Volkswagen wants to be fully electric soon; and Daimler aims to make its entire passenger car fleet carbon neutral before 2040. There are more including Nissan, Renault, etc. that have made similar announcements.

This trend also shows the power of regulations to shape markets. The big automotive manufacturers in the US have set higher ambition for the European market than the US market. For instance, while Ford is planning an all-electric strategy for Europe, it has not expressed similar scale of change in the US market as of now.

Industry in China is benefitting the most from government regulations and the target of 25 per cent set for new energy vehicles out of the total car registrations by 2025. Perhaps Tesla's biggest story in 2020 was its popularity in China. Tesla sold 148,000 units of the Made-in-China Model 3, inching fairly close to sales numbers registered by domestic Chinese companies. BYD and SAIC-GM-Wuling (a joint venture between GM and SAIC and Wuling), which have benefitted from government funded EV subsidy before 2019. Similarly, companies like the Shanghai-based Nio, are funded by state-run companies in Hefei City (China) and have used innovative marketing strategies such as a battery subscription and swapping to gain popularity.

In response to rising competition in the EV segment, traditional automakers have been forced to prioritize large investments in electric mobility and in customer focused innovation, even while battling reducing margins amidst a slowing economy. Volkswagen, in its 2020 plan for the next five years, has allocated almost half of its investment war chest to electric mobility, hybrid cars, software-based vehicle operating system and self-driving technologies. Daimler and BMW have pledged investments while, across the Pacific, Ford and General Motors have made plans to set investment targets by 2022 and 2025 on vehicle electrification. Fiat Chrysler-Peugeot (FCA-PSA) and General Motors-Honda have tied up with historical rivals to address the new trend. FCA and PSA merged to form Stellantis. Honda has tied up with GM to gain access to the latter's new Ultium lithium-ion batteries and to develop a native vehicle platform for EVs.

Ford has tied up with Volkswagen to gain access to the Modularer E-Antriebs-Baukasten (MEB) platform or the modular electric-drive toolkit for electric cars to avail the benefits of scale that a common vehicle platform offers. A rapid drop in prices of electric vehicle batteries combined with regulatory pressure and financial incentives will likely move larger numbers of vehicles towards electrification.

In yet another trend, relatively low technology barriers for entry into electric vehicle manufacturing are attracting investments from new and unconventional actors such as UK's vacuum cleaner manufacturer Dyson and China's real estate giant Evergrande About 500 manufacturers have registered to make EVs in China, a number of them are Tesla clones.

New business model: The business model around EVs is changing rapidly. The car manufacturer's relationship with the customer continues long after the product leaves the assembly line, extending to its entire lifetime, right till its recycling. New entrants, such as Nio, Faraday and Byton, which are well-funded, have begun flooding the EV manufacturing space.

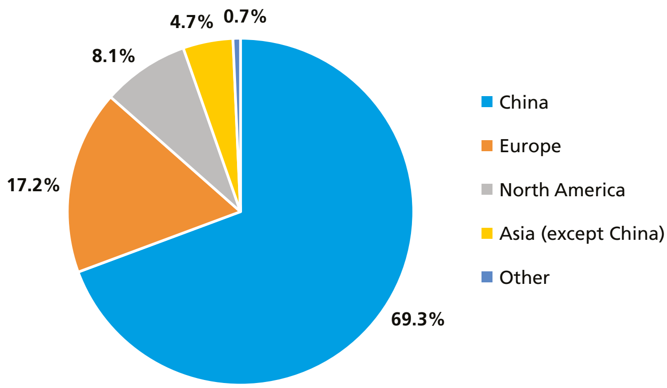
In fact, a massive shift towards electrification is expected to lead to substantial restructuring of the industry and efforts to retain the value chain within the industry. The electro-economy has triggered another unique trend of automakers investing in mining projects to secure and control raw material sources.

As per reports, Europe's first lithium mine is looking for auto industry investors and automakers in Germany are considering the possibility of owning stakes in mining projects in Finland that can deliver lithium to comprise 25 gigawatt hours of battery cell supply starting at the end of 2021. Reports also say Toyota's trading arm Tshusho has acquired a 15 per cent stake in Australia-based miner Orocobre to secure rights and help fund a lithium brine project in Argentina. This can take the form of a fixed supply deal where an automaker agrees to take a bulk of the production while ensuring sustainable mining. Global players in battery manufacturing like Panasonic have already partnered with Tesla to build a giga-battery factory in Nevada. Livent, a Philadelphia-based company, operates one of the lowest-cost lithium mineral deposits in Argentina and is entering into a joint venture to buy Canada's lithium mining projects. This move is to secure supplies of battery grade lithium.

A growing EV market has also expanded opportunities for EV battery makers. Western EV manufacturers source batteries from Japan, Korea and increasingly from China, which has the largest installed battery capacity in the world (see *Graph 22: Global Lithium-ion battery capacity in 2019*). According to London-based Benchmark Mineral Intelligence (BMI), which specializes in battery supply chain analysis, China had almost 70 per cent of the proposed battery manufacturing pipeline capacity by 2019 and at least 10 Chinese battery companies plan to achieve a minimum of 50 GWh capacity by 2025.

Faced with the prospect of dependence on China for EV batteries, Europe has expanded its agenda for battery factories, with new planned capacity of 348 GWh by 2028. By the end of 2028, the world would have more than 2000 GWh (2 TWh) of installed capacity, which can run 40 million EVs, assuming an average of 50 kWh per vehicle, BMI said in its report.

Graph 22: Global lithium-ion battery capacity in 2019



Source: Lithium Ion Battery Megafactory Assessment, December 2019, Benchmark Minerals Intelligence

7. Towards building scale: Policy levers to drive EV transition

The challenge of mass deployment of EVs by 2030 is enormous. According to IEA this amounts to putting 230 million EVs on roads globally by 2030. This is possible only with effective policy design that can reduce the initial uptake cost spurring both vehicle and battery manufacturing. An effective policy design translates to capital and purchase subsidies, tax rebates and non-fiscal measures. This also requires strategic support for charging infrastructure that includes installation of public chargers and home charging facilities. Even building codes will be needed for new construction or retrofitment.

It is not only a dedicated EV policy that will drive this change but also tightening of benchmarks for the IC engines. More stringent CO_2 emissions standards or fuel economy standards combined with stronger requirements of real-world emissions regulations will give impetus to EVs. This is evident in Europe where stringent CO_2 standards have accelerated electric car sales.

Ban on internal combustion engine powered car sales: As a starting point, several countries have set targets to ban ICE propulsion vehicles by 2030–2040. More than 20 countries have announced the full phase-out of ICE car sales over the next 10–30 years. While most of these countries are in the advanced North, even emerging economies such as Cabo Verde, Costa Rica and Sri Lanka have joined this club. Moreover, according to the IEA Energy Outlook, 2021, more than 120 countries (that is 85 per cent of the global road vehicle fleet, excluding two/three-wheelers) have announced economy-wide net-zero emissions pledges to reach net zero in the upcoming decades (see *Table 15: Country-wise full ICE phaseout and 100 per cent electric target years*).

More than 14 countries and over 20 cities around the world proposed banning the sale of passenger vehicles (primarily cars and buses) powered by fossil fuels such as petrol, LPG and diesel at a definite date in the future. The announcements underscore the commitment and ambition countries have set to mitigate climate change risk. The targets serve a major purpose. They are the governments' means of communicating to the automotive industry that they need to develop the technology and get prepared to help meet climate goals.

Table 15: Country-wise full ICE phaseout and 100 per cent electric target years

Country	Full ICE phaseout / 100% EV target	Year
India	30% EV sales	2030
Norway	100% EV sales	2025
Iceland	No new registration of ICE	2030
Ireland	No new registration of ICE	2030
Netherlands	100% EV sales	2030
Slovenia	100% EV sales	2030
Israel	100% EV sales	2030
Sweden	No new registration of ICE	2030
Denmark	No sales of new diesel / petrol car	2030
	100% EV sales	2035
UK	No new registration of ICE	2035
Cabo Verde	100% EV sales	2035
Sri Lanka	100% EV sales	2040
France	No new registration of ICE	2040
Spain	100% EV sales	2040
Canada	100% EV sales	2040
Japan	100% EV sales	2050
Germany	All passenger cars to be electric	2050
USA (10 states)	All passenger vehicles to be electric	2050
Costa Rica	100% EV sales	2050

Note: Though the Indian government has not officially stated a target, NITI Aayog has suggested a 30 per cent penetration for private cars, 70 per cent for commercial cars, 40 per cent for buses, and 80 per cent for two- and three-wheelers by 2030.

Source: International Energy Agency 2020; Global Electric Vehicle Outlook 2020

7.1 Incentives for electrification

Governments around the world have adopted a broad mix of strategies at federal and regional levels aimed at overcoming impediments to electric vehicle adoption in areas such as affordability and ease of operation.

CSE's review of incentive programmes for electric vehicles in key countries brings out the variability in design and its impact on the market. This shows that most markets with high electric vehicle uptake values have adopted policies directed at prevailing barriers to demand growth. Among the countries studied, Germany has the maximum number of policy actions at 19 (among the 23 policy parameters studied), followed by Norway (18) and UK (17). Germany registered the highest sales numbers globally in 2020 with almost 400,000 units, of which battery electric vehicles comprised about 50 per cent. Norway boasts of 54 per cent market share in 2020.

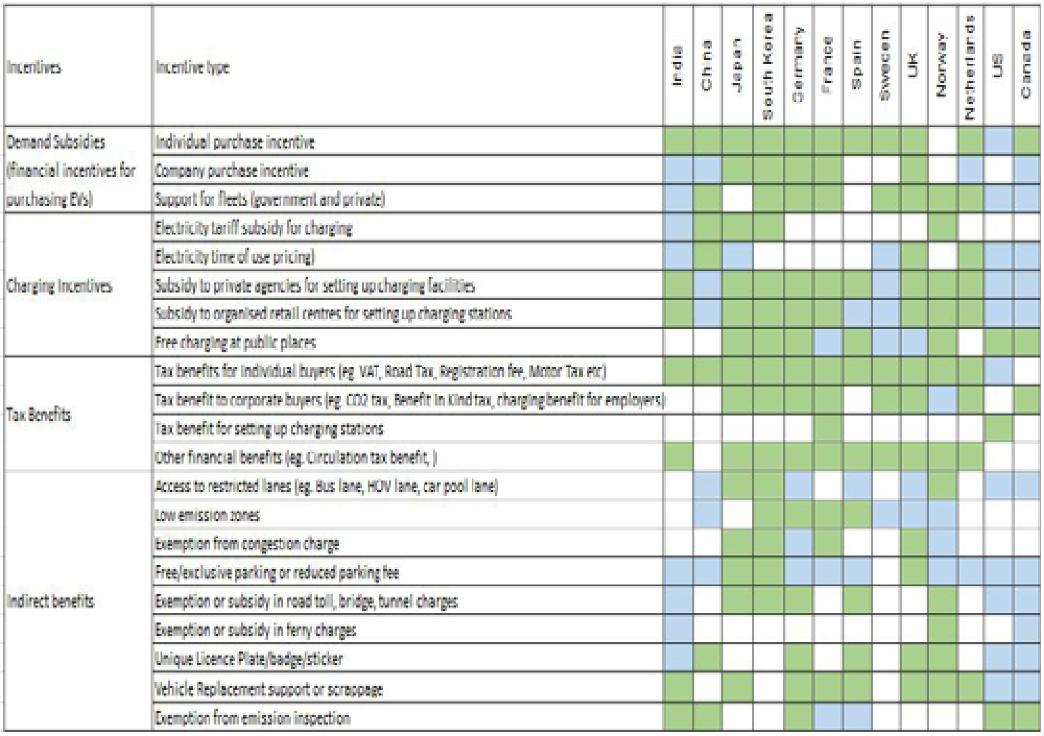
This review lists electric vehicle incentives under two broad categories—fiscal and non-fiscal incentives. Fiscal benefits cover three major categories—demand subsidies, tax benefits and charging incentives—while non fiscal incentives include indirect benefits. Within these categories, demand subsidies are further divided into purchase incentives offered to individuals, businesses and fleet owning government and private entities. Tax benefits are further divided into those offered to individual electric vehicle drivers (ranging from motor vehicle tax and road tax to registration tax), to businesses (CO_2 emissions, Benefit in Kind (BIK) tax and benefits offered to employers for charging), and to entities setting up charging stations.

A BIK is any non-cash benefit of monetary value that businesses provide to employees. These benefits are also referred to as notional pay, fringe benefits or perks. The benefits have monetary value, so they are treated as taxable income. UK offers exemption from BIK to employers. More than half of all cars in UK are registered to businesses and the cost savings with BIK have helped businesses rethink their vehicle acquisition strategies. Tax benefits covered in India also include interest subvention to individuals and to businesses for loans undertaken for acquisition of electric vehicles.

The study juxtaposes the grid listing of national incentives (marked in green) and regional incentives (marked in blue) with electric vehicle sales in corresponding markets to arrive at two key inferences. Countries that have witnessed significant gains in electric vehicle volumes share two commonalities. One, they have combined substantial financial incentives with market relevant convenience parameters. Two, they maintained fiscal and policy support over a long period of time driving the market towards inflexion points (see *Table 16: Global electric vehicle incentives map*).

To make electric cars affordable and to achieve parity with conventional ICE vehicles, governments offering high demand subsidies for purchase of electric vehicles have witnessed dramatic growth in Europe and China in the last five years since 2015. Tax regulation tools directed at shaving off cost from the total cost of ownership of an electric vehicle show an impact in the US market, though experts believe the tax credits offered a year after purchase would have seen larger gains in automotive market share if the incentives were disbursed at the point of sale.

Table 16: Global electric vehicle incentives map



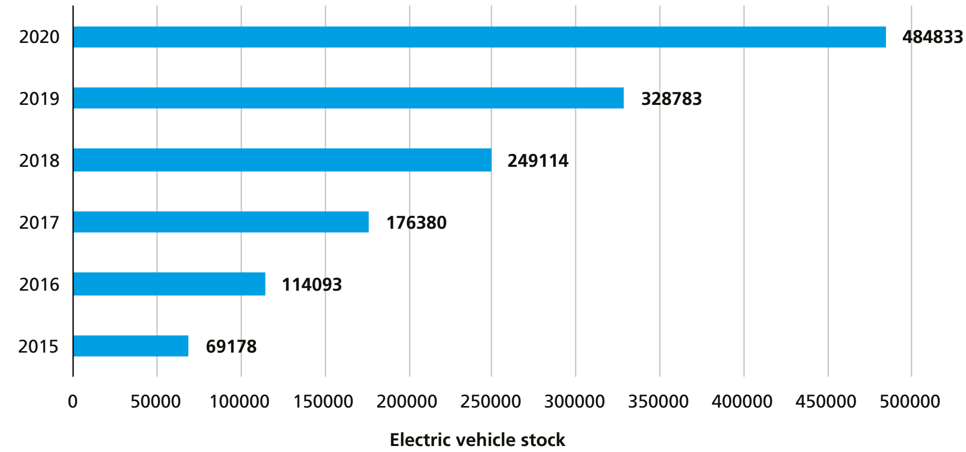
National level incentives

Regional level incentives

Source: CSE research; compiled from various sources

Charging incentives span the entire value spectrum ranging from support provided to individuals (and businesses) for charging station equipment and installation to discounts offered on the electricity tariff used by drivers. Indirect incentives are often offered at the regional level. Indirect benefits such as discounts and exemption from parking fees, road and ferry tolls or access to restricted lanes offered at the municipal level that have supplemented the cost advantage and save commuting time for electric vehicle drivers have been game changers in markets such as Norway (see *Graph 23: Electric vehicle stock in Norway from 2015 to 2020*).

Graph 23: Electric vehicle stock in Norway from 2015 to 2020



Source: Data from IEA includes BEV, PHEV and FCEV sales, Global EV Outlook 2021; graph drawn by CSE

7.1.1 Europe

Incentives and regulatory support programmes in Europe are gathering momentum to achieve a 100 per cent ZEV fleet by 2050. A policy support study for the European Commission Directorate General Mobility & Transport, carried out as part of the EAFO project to define the 2050 pathway, states that such a target will require all new car sales to be ZEV by 2035. According to this study, this will require substantially faster deployment of ZEVs than the current and future policies are able to achieve. This will have to be driven by a pathway for 100 per cent ZEV sales.

The key objective of incentives and regulatory support is to achieve economy of scale and purchase cost parity within this decade (during 2022–2026) for an electric vehicle compared to ICE vehicle. The electric vehicles can be comparatively lower in cost after that. This study for European Commission Directorate General Mobility & Transport has estimated that parity of total cost of ownership can be achieved two to four years before the purchase cost parity is achieved. This study expects the average TCO for a ZEV to be €0.04 to €0.06 per kilometre less than an ICEV by 2030. It is now accepted that ZEV fleet is a very cost-effective solution.

However, the trajectory in European countries so far has been varied and has several lessons.

Nordic countries (Denmark, Finland, Sweden and Norway) and the Netherlands

This section will look at leaders of electric vehicle policies which have dominated the alternative propulsion narrative for over a decade—the Nordic countries of Denmark, Norway, Sweden and Finland, and also the Netherlands, by virtue of it being located in the same geography. The transport characteristics of this set of countries differ from those of the central and southern European countries because of their relatively low population, large surface area in relation to the population, and cold climate conditions during winter.

As EV policy designers, this set of countries have three common factors that helped them achieve their targets—they all made an early start; they used heavy incentive tools to push the EV market; and all of them witnessed early gains in EV numbers.

The earliest move by far was made by Norway in 1990 when the government abolished purchase and import tax for EVs. Norway was followed by Denmark in 2008 and Sweden in 2011 with financial support schemes for EV buyers. Denmark exempted battery EVs and fuel cell vehicles from registration taxes that were very high—180 per cent—of the value of the car until the end of 2015. Copenhagen has slashed the registration tax to 40 per cent on electric vehicles from 150 per cent on conventional vehicles.

Stiff taxation continues to be a significant part of the narrative among EV leaders in the region. Norwegians do not buy so many electric vehicles (60 per cent market share in 2020) because they are an overly environmentally conscious population. They buy EVs because it makes more economic sense to buy electric instead of petrol or diesel vehicles. Instead of making electric vehicles cheaper with heavy subsidization, Norway has made petrol and diesel powered cars far more expensive than they are in other countries (see *Table 17: Price break-up for VW Golf and VW e-Golf*)

Norway's 'polluters pay' principle is directed at a net-zero revenue-loss strategy for the government as the ICE vehicle taxes are used to finance incentives for zero-emission cars.

Table 17: Price break-up for VW Golf and VW e-Golf

	VW Golf (€)	VW e-Golf (€)
Import price	22510	33730
Registration tax - CO_2 (113 g/km)	4440	-
Registration tax - NO_x	210	-
Registration tax - Weight	1750	-
Scrapping fee	250	250
25% VAT	5630	-
Retail price	34,780	33,980

Source: Norskelbilforening

Disincentives for fossil fuel vehicles, which have been a part of EV policy design in Netherlands as well, exempt EV owners from value-added tax (which comprises 25 per cent of the gas and diesel vehicle cost), registration tax on used car sales, annual ownership tax, and fuel tax. ZEV buyers are either fully or partially exempted from paying road tolls and ferry fares are discounted; bus lanes are mostly open to ZEVs, there are no public parking fees and charging is most often free for BEVs.

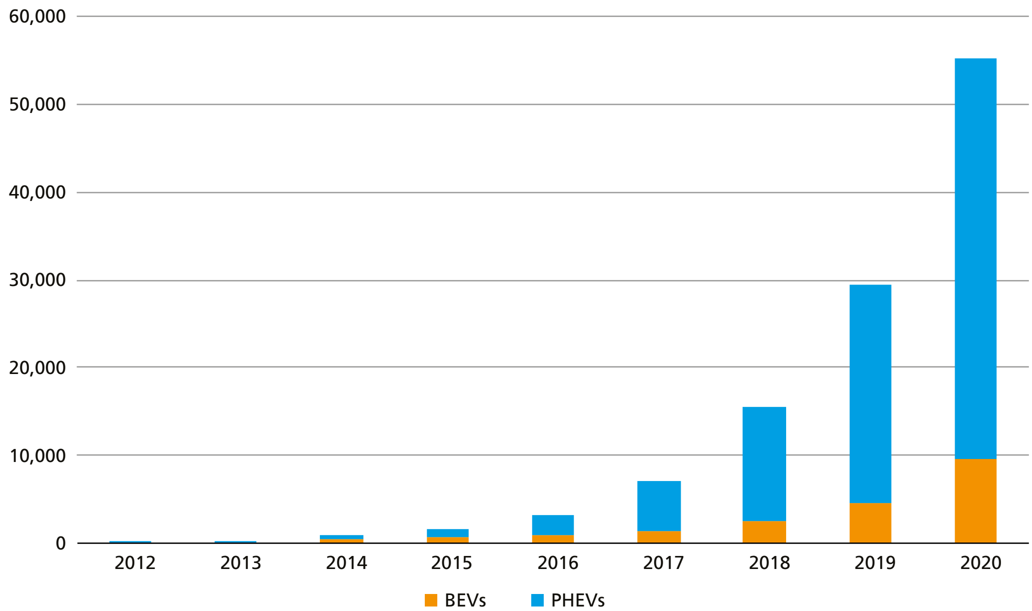
However, it was not only the size of the incentives that made EVs a popular mode of transport in Norway. It was also timing. Though Norwegians could import EVs free of cost from 1990 and did not have to pay value added tax since 2001, EV sales did not take off until 2010. There were no models available before that. The Norwegian EV policy finally paid off when the Mitsubishi i-MiEV in 2010 and the Nissan LEAF in 2011 were visibly enjoying privileges such as access to bus lanes. After that, the EV market simply took off. From 5.5 per cent market share in 2013, it gained considerable traction and by 2018 was at 31 per cent and at 60 per cent by 2020.

While Norway has clearly moved from the early adopter stage to the early mass market stage, Finland's journey with the EV program was eclipsed by the country's bio-fuels program. Finland began its EV program on a slightly conservative note in policy building in 2010, as there was no need to do so until then. As part of a European Commission Directive (2009/28/EC) in 2009, the EC had set a minimum requirement of 10 per cent of renewable energy (biofuels and renewable electricity) in transport by 2020. But Finland had already created a mandate in 2008 regarding biofuels in the market with national targets of 2 per cent biofuels for all vehicle fuels by 2008, growing to 4 per cent in 2009 and 2010. With the biofuels law, Finland did not push for electric vehicles to meet the 2020 requirement for renewable energy in transport (see *Graph 24: Electric car sales in Finland from 2008–2020*).

By 2017, there were a little over 1,000 electric cars in Finland, while Sweden had more than 10 times that figure and Norway had a 100 times more. They continued to be low even though Finland charges considerably lower taxes for EVs. Finland's focus on bio-fuels diluted the focus on EVs. Besides, the high costs of EVs and low availability of public charging stations did not help either.

All of that changed by 2020, courtesy a course correction in policy design in 2018. Finland had 877 charging stations in 2017, compared with Norway's 10,200 and Sweden's 3,300. By 2020, however, Finland's charging network increased multiple times to over 3,700, according to EAFO.

Graph 24: Electric car sales in Finland from 2008–2020



Source: European Alternative Fuels Observatory

The new growth accelerating policies introduced in 2018 included a new purchase incentive and three kinds of incentives for charging infrastructure—30–35 per cent support towards cost of setting charging stations; tenders for setting up at commercial, municipal and community levels with a project amount of EUR 3 million, and subsidies for housing companies for building infrastructure with a 2018 budget allocation of EUR 1 million for a year.

Though the purchase incentive was not very high—EUR 2000 for vehicles priced up to EUR 50,000—combined with the push for a charging network, it had an impact on the market, which expanded over four times from 2018 onwards to reach almost 10,000 BEVs in 2020. Finland aims to have 250,000 EVs by 2030.

Although Finland is not a very large BEV market yet, the country is a historical heavyweight in EV and EV component manufacturing since 2008. In 2010, the electric mobility turnover of the Finnish companies came from heavy duty machinery and buses. Electric bus manufacturer Linkker produces full-electric buses for the municipal transport companies of Helsinki, Espoo and Turku. European Batteries was manufacturing lithium-ion batteries for automotive use in its Varkaus facility in 2010, while manufacturing service provider Valmet Automotive was building the Think City in 2009 and the iconic Fisker Karma in 2010.

Norway's capital Oslo has mandated electric vehicle purchases for the city fleet under a procurement strategy that serves as a steering document for vehicle acquisitions. Additionally, the city signed a framework agreement to transform its fleet by acquiring ZEVs. Oslo also provides free street parking as well as exemptions from road tolls for electric vehicles. Otherwise, for ICE vehicles the municipal parking charges could be as much as $7 per hour and road tolls can be as much as $6.30.

The course correction undertaken by Finland is symptomatic of most EV policies around the world when policies do not deliver intended outcomes.

In the Netherlands, plug-in hybrid vehicles dominated the market until 2016, after which there was a dramatic drop with a change in tax rules. The changes were put into effect after it became apparent that many users rarely used the electric motors and only bought the cars for their tax advantage. The withdrawal of the tax incentive had a massive impact on the nascent EV market, registering a 64 per cent drop in new registrations in the first half of 2017, though it recovered later by the end of the year. Sales plummeted from 4,700 in 2015 to 1,400 in 2016 and 913 in 2017. One of the indirect incentives offered till 2016 which aided EV market movement was an exemption from bridge tolls, which ceased to exist when incentives were phased out.

Electric vehicle policies in Netherlands have had their ups and downs that were also dictated by market trends. Thinking of the future, the country is planning zero emission zones by 2025. To achieve this goal, fourteen city municipalities and participants from the transport sector signed an urban logistics implementation agenda in February 2021 that envisions emission free deliveries in 2025. Under the agenda, the government will provide grants to help businesses switch to clean delivery vans.

In many ways, Scandinavian countries provide ample examples of what works and what does not work in EV policy design. While Norway has been a trailblazer, Denmark witnessed a roller coaster rise after the country chose to remove incentives and had to review the decision in a few years. Sweden offered a subsidy on the purchase of vehicles, which was not always available due to insufficient funds. In addition, rebate was not offered at the point of sale. Owners would have to submit paperwork with the Swedish Transport Agency before they could avail of the incentive. The combination of inadequate funds and the waiting period between the purchase of an EV and accessibility of the government rebate did not go down well with buyers.

The issue with Sweden was not flawed policy design, it was flawed implementation that had an impact on the EV market and an unintended impact on trade flows in the region. Swedish buyers unwilling to wait for six months to avail subsidy took advantage of incentives offered at the point of sale in Norway and exported their cars. While on the one hand, the cross-border movement of EVs has become an avenue for quick cash for car dealers, on the other hand, it has begun to have a larger impact on the electrification goals of neighbouring countries like Germany, Netherlands, Sweden and UK.

Used EV imports into Norway rose by almost 30 per cent from 2017 to 2018. The trend, however, is not likely to last. Either a withdrawal of subsidies in Norway or increased EV demand in other parts of Europe could well turn the tide in the opposite direction. A subsidy phase-out will likely be the ultimate test for the Norwegian EV market. In any case, the country has achieved its target market share for EVs and is looking at phasing out incentives at the end of 2022.

One EV adoption incentive that has gained popularity is the vehicle lease program. Norway and the Netherlands offer incentives to not only new vehicles, but also leased vehicles. The financing or car rental company receives the incentive or vehicle tax reduction for new electric vehicles and then passes those savings to the lessee by lowering monthly, daily, or hourly payments.

Company-owned vehicles are common in Europe. Employers pay for the vehicles in full, and vehicle user employees have to pay a special company car tax. Drivers of company-owned electric vehicles are often eligible for some level of incentive that reduces the company's vehicle tax. Countries that offer significant vehicle tax reduction incentives to drivers of company-owned electric vehicles include Norway, the Netherlands, France, and Sweden.

UK, Germany, France: Lessons learnt

The European narrative with electric vehicle policies is as much about extremely favourable purchase incentives as it is about financing support provided to the EV industry and market.

Europe has deployed an emission tax regime to discourage sales of ICE vehicles and as a revenue generating tool for governments to sustain EV incentives. Its implementation, however, varies across countries. While France levies a CO_2 tax of as much as €10,000 as part of annual registration fees, Germany's tax is charged where the emission trail begins—at the petrol station.

Taxes on transportation fuels are seen as a way to reduce pollution and conserve energy. Levying higher taxes on fossil fuels makes petrol or diesel just as expensive as other fuels such as natural gas, biodiesel or even electric vehicle batteries.

Germany charges €25 ($30) per tonne of CO_2 emission released by the transport and heating sectors, which translates into a price increase of around 7 cents per litre of petrol and 8 cents per litre of diesel, according to the country's environment agency Umweltbundesamt (UBA). The fixed price will gradually increase to €55 by 2025. From 2026 onwards, the price will be determined with auctions that are expected to be set within the price range of €55–65.

Unlike Germany, UK's future fuel tax regulation has hit a bump with the COVID-19 pandemic. The UK government has decided against increasing taxes on fossil fuels during the pandemic as citizens prefer to use cars as a safe transport measure that helps adhere to social distancing norms. The decision means it has been frozen for 10 years at 58p (58 pence) a litre. It is estimated to cost the UK Treasury more than £50 billion in lost revenue. Though it is believed that UK will eventually start increasing fuel tax, as the switch to electric cars expands, the UK treasury's revenues will likely shrink unless the government decides to increase the fuel duty.

Beyond taxing transportation fuels, vehicles themselves are taxed on the basis of their CO_2 emissions. Since 01 January 2019, France charges SUVs, big sedans and other large cars penalties of €50 to €10,500 depending on pollution levels. Even before 2019, vehicles with emissions of 138 gCO_2/km (tested under the WLTP system) were penalized up to €12,500. Mercedes customers spent almost €27.7 million in the first six months of 2018 in CO_2 taxes, followed by Audi drivers at €21.3 million, Volkswagen at €19.7 million and BMW at €18.5 million. In comparison, Renault owners received €19.6 million in incentives, mostly on account of the Zoe. The maximum rate of CO_2 taxes is expected to be increased to €50,000 in 2022.

Germany has set an ambition of reducing CO_2 emissions in the transport sector by 40–42 per cent by 2030 (from 1990 levels). Under its 2030 climate protection programme, the government has decided to couple the motor vehicle tax more closely with CO_2 emissions and to extend the tax exemption for electric cars registered from 2021 to 2025. Vehicle tax on cars will now not only be on displacement of their engines, but also on the air conditioner component as part of a move to include a climate component in the taxes.

The annual motor vehicle tax, which had a fixed rate of €2 for every gCO_2/km, has been made flexible. It will increase in six stages to €4 per gCO_2/km. The German Association of the Automotive Industry (VDA) estimates that a car consuming 7.5 litres of petrol would approximately emit 175 gCO_2/km. This would result in an additional CO_2 tax of up to €350 per year and new electric cars registered between 2020 and 2025 would be exempted from motor vehicle taxes.

In addition, Germany offers companies carbon certificates or 'pollution rights' to run emission spewing vehicles, a provision that could build a revenue pipeline of €56.2 billion over the next four years.

The electric vehicle purchase incentives in the three countries studied in this section—Germany, France and UK—were accordingly designed to be the most favourable across the globe in 2020 as part of their Green Recovery stimulus program.

France provides a purchase subsidy of €7000 directed at vehicles with emissions of less than 20 gCO_2/km, while Germany's subsidy of €9000 specifies a maximum emission value of 50 gCO_2/km or an electric range of at least 40 km. The plan is to increase the range requirement to 60 km in 2022–2024 and 80 km in 2025.

Eligibility for purchase incentives offered in France specify a cap of 27 per cent of the vehicle cost and are offered on vehicles with market price of less than €45,000. Vehicles that cost more, between €45,000 and €60,000, can avail subsidy of up to €3000. Plug-in hybrids with emissions of 21 to 50 grams of CO_2/km and an electric range of up to 50 km, and a price of less than €50,000, are eligible for a subsidy of €2000.

Where the German subsidy scheme differs from that of France is its incentive financing strategy. The cost of the EV subsidy in Germany is borne by the government (66 per cent) and the vehicle manufacturer (33 per cent). A common approach used by both the countries is the use of tax regulation with corporates to expand EV ownership.

In Germany, the private use of a company car is treated as taxable income and is measured at a flat monthly rate of 1 per cent of the vehicle's gross list price. As part of the financial incentives offered to EV owners, private owners of plug-in electric vehicles that charge their cars in their employer's premises are exempted from declaring this perk as a cash benefit in their income tax returns. Employers who provide this perk are allowed to discount from their income tax a 25 per cent of the lump sum value of the cash benefits. The tax exemption for free charging of electric vehicles and plug-in hybrids in the employer's company has also been extended to 2030.

France offers a special subsidy of €5000 to companies that purchase electric cars, with a defined roadmap to reduce the subsidy value to €4000 in July 2021 and €3000 in 2022. The vehicle tax levied on companies is based on two components—the first is based on CO_2 emissions and is exempted for vehicles with emissions of <60g CO_2/km. The second component is based on environmental impact and is much higher for (older) diesel vehicles. New EVs pay €20 per year. In addition, the subsidy is provided at the point of sale; the dealer advances the amount of the bonus, which is automatically deducted from the total cost—tax included—of the bill.

In the UK, company car drivers and fleet operators are exempted from tax on benefit-in-kind during 2020–21. This zero rate also applies to hybrid vehicles with emissions from 1–50 g/km and a pure electric range of over 130 miles. However, the electric car tax on benefit-in-kind rate is planned to increase to 1 per cent in 2021–22 and 2 per cent in 2022–23.

Non-fiscal benefits: Gains in EV adoption have as much to do with purchase incentives as non-fiscal incentives such as access to bus lanes and low emission zones (LEZ) and free or discounted parking, paying attention to challenges in user experiences with motor driving.

Oslo has one of the highest parking rates in Europe with short term rates at NOK 30 (Rs 260) for 20 minutes or NOK 650 (Rs 5,650) per day. EV drivers get a 50 per cent discount on parking charges as well as road and ferry tolls. London's low emission zones charge diesel powered vehicles, including commercial vehicles, of over 3.5 tonnes. The current charge for vehicles that are not EURO VI compliant (increased from EURO IV in March 2021) can be as high as £100.

In Germany, EVs have special identification with a special number plate and the electromobility law allows municipalities to choose how they want to promote the use of electric cars with tools such as free parking or special transit rights to certain kinds of vehicles on roads with restricted access such as bus lanes.

That effort has not been without its share of challenges. When the new electric mobility laws that included access to bus lanes were announced in Germany in 2014, many local governments were opposed to it. Cities including Hamburg, Berlin, Munich and Stuttgart were not keen on sharing the bus lane with EVs. Berlin believed the idea was 'counterproductive' while Stuttgart did not believe it could be an option. Frankfurt's traffic department used the ruse of 'very few bus lanes', according to a Spiegel report.

Paris has a clear roadmap with regard to the phase out of diesel and petrol vehicles. Vehicles require Crit'Air stickers for entry into LEZs. Diesel heavy duty vehicles require a Euro 5 standard sticker, while petrol or gas heavy duty vehicles can be Euro 3. Flouting the LEZ rule can attract a penalty of €68 for cars and vans and €135 for heavy goods vehicles and buses.

The air quality certification on the sticker will get even more stringent from 2022–2024 with a Euro 6 sticker on diesel heavy duty vehicles and Euro 5 on their petrol versions. Post 2024, diesel vehicles will be barred and from 2030 onwards, both petrol and diesel vehicles will not be allowed to enter LEZs, while petrol vehicles with Euro 5 and motorbikes and mopeds with Euro 4 will be allowed.

Vehicle scrappage as a stimulus: Europe's electrification trajectory received a boost from leveraging a scrappage policy in 2020, especially in Germany. Almost 50 per cent of the vehicles running on the autobahn are over a decade old. The COVID-19 stimulus programme offered up to €2500 for old vehicles in addition to the €6000 purchase incentives on EVs. To capitalize on the trend, automakers are expected to introduce more electric models that move away from the high-end cars available now and span a larger price range.

Volkswagen has already started on this path with the launch of the ID3 compact hatchback, the first of a new generation of mass-market battery-powered cars. The automaker plans to launch 70 fully electric models globally by 2028, which according to one estimate, accounts for 22 million battery powered vehicles. BMW is planning 13 battery electric models by 2023 even though the car maker has decided against renewing the i3, its primary electric car.

In France, the incentive to convert to EV by scrapping a petrol vehicle is €5000. The eligibility for the conversion incentive is on low-income groups (based on taxable income), heavy drivers (who travel more than 12,000 km per year to and from work or have a commute of more than 30 km), as well as buyers of electric utility vehicles weighing less than 3.5 tonnes. When purchasing a new or second hand electric or rechargeable hybrid car, buyers may qualify for an additional bonus of €2000 if they live or work in a low emission zone.

The scrappage plan in Europe presents a huge lesson for India. Though India launched a scrappage policy during the pandemic, the country failed to avail the opportunity of using it as a fiscal stimulus to drive electric vehicles.

7.1.2 Incentives in the US and California

The United States has a variety of national policies and promotion actions in place that have supported the development of the market for electric vehicles. These programmes include federal tax credits for the purchase of new electric vehicles, vehicle efficiency standards through 2025 with explicit incentives for electric vehicles, funding for public charging infrastructure, and a programme to encourage workplace charging infrastructure deployment.

Since 2008, the US has made available electric vehicle tax credits of \$2,500 to \$7,500 per vehicle based on battery capacity. The US is reviewing the EV tax credits as part of a bill that is awaiting Senate approval. The 'Clean Energy for America' bill will boost tax credits to as much as \$12,500 for EVs. When approved, the new law would boost the \$7,500 tax credit by \$2,500 for vehicles assembled in the US and another \$2,500 for cars built at facilities whose production workers are members of, or represented by, a labour union.

That would mean smaller credits to automakers such as Tesla and Volkswagen, who do not have US union workers, and companies building EVs outside the United States. The EV incentives are estimated to cost $31.6 billion through 2031, according to a congressional estimate.

Vehicles that were eligible under the tax credit earlier had a 200,000 units cap. Two automakers in the US—Tesla and General Motors—have already reached the 200,000-vehicle threshold in 2018. This cap is being removed as part of the new bill.

Critics have argued that this cap hamstrings the market and that the credits would be more effective if they had an expiry date instead. The importance of handing out incentives at the point of sale was brought out in Colorado, New York and Vermont where dealers effectively lowered the price of the vehicles for larger traction with EV sales. Though there have been several initiatives at the federal level to convert the tax credit into a cash rebate, they have all been unsuccessful.

In addition to purchase incentives and non-financial support schemes such as access to high occupancy bus lanes and exemptions from emissions testing, the US government made aggressive moves in developing the electric vehicle industry.

In 2010, President Barack Obama pledged $2.4 billion in federal grants under the American Recovery and Reinvestment Act to support the development of next-generation electric vehicles and batteries; $1.5 billion in grants to US based manufacturers to produce highly efficient batteries and their components; up to $500 million to produce other components needed for electric vehicles, such as electric motors and other components; and up to $400 million to demonstrate and evaluate plug-in hybrids and other electric infrastructure concepts such as truck stop charging stations, electric rail, and training for technicians to build and repair electric vehicles.

The new bill builds on this further with a 30 per cent tax credit for manufacturers to retool or build new facilities to produce advanced energy technologies including batteries and also offers new incentives to purchase commercial electric vehicles.

The push for electrification in several countries often resorts to foregoing tax revenue from road tolls, bridges and tunnels, a feature that has begun to be reviewed in the US. Since 2017, 17 states, including West Virginia, Michigan, Minnesota, Indiana, Oklahoma, Tennessee and California, charge fees from EV drivers in a broader push to shore up road repairs, an expenditure which has traditionally been supplied by a gas tax. Ironically, California which hands out money over and above the federal tax credit to EV buyers, began taking some back each year that EV owners drove them. Beginning in

2016, California has also started to offer increased electric vehicle rebates for low- and moderate-income consumers.

Initially, the Corporate Average Fuel Economy Standards defined by the US National Highway Traffic Safety Administration (NHTSA) for cars, light trucks, and SUVs were not exacting enough. However, for passenger cars, the CAFE standard increased from the initial 18 mpg in 1978 to the current 27.5 mpg and the goal is to increase it to 54.5 mpg in 2025 fleet wide for cars, light trucks and SUVs. Failure to meet these standards results in a penalty of 5.5 to 14 USD per tenth of mile per gallon below the standard. But this needs to get tighter to drive electrification.

In the meantime, California's power to set tailpipe emissions standards that are stricter than the federal government has created bottom-up pressure. California and allied states have supported stricter fuel-efficiency standards for cars and trucks sold within their borders. California Air Resources Board and major automakers have worked out bilateral agreements to cut vehicle emissions in the state and other states that follow California's standards (representing about 40 per cent of the US auto market) joined to support the agreement. All these levers are required to accelerate the change.

7.1.3 China: More holistic strategy

China's electrification strategy is designed around an ambition to be carbon-neutral by 2060 and to become an automotive manufacturing powerhouse that could command a compelling presence in the global political and industrial landscape. To that end, the country has set a target for phasing out conventional ICE vehicles by 2035 and has created a new vehicle roadmap. According to the roadmap, 50 per cent of the vehicle registrations in 2035 will be new energy vehicles—electric, plug-in hybrid or fuel cell-powered—and the rest will be hybrids. Of the NEVs, 95 per cent will be EVs.

Technology mandate and performance-based incentives: The new energy vehicle mandate policy, released in February 2021, expands on the NEV credit mandate, which was introduced in 2017. The 2017 mandate set annual NEV credit targets for manufacturers as a percentage of their annual vehicle sales. The new policy has extended the targets from 2021 to 2023, increasing them to 18 per cent by 2023. An EV can receive between 1 and 3.4 credits depending on its technical specifications (see *Table 17: NEV credits for two example models using the new NEV mandate policy*). The path to achieve these targets for a manufacturer is by selling BEVs, PHEVs and FCEVs in various proportions, and by trading credits with other manufacturers.

The new policy offers manufacturers an additional compliance pathway towards achieving annual NEV credit percentage targets with the inclusion of fuel-efficient conventional fuel vehicles in the calculation. Though, points that can be won from conventional vehicles are set to reduce progressively. For instance, a vehicle model with fuel consumption lower than 3.2 l/100 km is counted as 1.4, but it reduces to 1.0 in 2025.

Table 17: NEV credits for two example models using the new NEV mandate policy

Type	2017 policy		2020 policy	
	BEV (BYD Song Max)	PHEV (Byd Tang)	BEV (BYD Song Max)	PHEV (Byd Tang)
Base credit	5	2	2.65	1.6
Energy consumption multiplier	1.2	1	1.15	1
Range multiplier	NA	NA	1	NA
Battery energy density multiplier	NA	NA	1	NA
Final per vehicle NEV credit	6	2	3.05	1.6

Source: ICCT

The policy also reduces the maximum NEV credit that could be received by a vehicle as technical requirements for determining the credit value are tightened further. In addition, electric range plays a role in determining NEV credits that can be won by a vehicle (see *Table 18: Qualification requirements for the 2020 subsidy* and *Table 19: Range-wise subsidies in 2019 and 2020*). Further, as part of the new mandate, automakers are expected to change their pricing strategy so as to persuade enough buyers to purchase EVs to reach their required credit percentage.

Table 18: Qualification requirements for the 2020 subsidy

<table>
<tr><th>Vehicle type</th><th>Technology</th><th>Year</th><th>Electric range (km)</th><th>Fuel saving (%)</th><th>Max speed (km/hr)</th><th>Battery density (Wh/kg)</th><th>Pre-subsidy vehicle price with tax included (CNY)</th></tr>
<tr><td rowspan="4">Passenger car</td><td rowspan="2">BEV</td><td>2019</td><td>≥250</td><td></td><td rowspan="2">≥100</td><td rowspan="2">≥125</td><td rowspan="2">300,000</td></tr>
<tr><td>2020</td><td>≥300</td><td></td></tr>
<tr><td rowspan="2">PHEV</td><td>2019</td><td rowspan="2">≥50</td><td rowspan="2">>40[b]</td><td></td><td></td><td rowspan="2">300,000</td></tr>
<tr><td>2020</td><td></td><td></td></tr>
</table>

Source: ICCT

The eligibility for availing subsidies specifies certain electric range criteria: BEVs with a range of over 300 km are eligible for a maximum CNY 18,000 whereas PHEVs are eligible for up to CNY 10,000. The subsidies, which were originally planned to be phased out by 2020 with a 20 per cent cut each in 2017 and 2019, have now been extended to 2022, however with gradual reductions in subsidies over that period. The subsidy programme has pushed for vehicles with long driving ranges, improved fuel economy and high-density batteries.

Table 19: Range-wise subsidies in 2019 and 2020

Range (km)	Subsidy 2019 (CNY)	Subsidy 2020 (CNY)
300–400	18,000	16,200
over 400	25,000	22,500

Source: ICCT

New energy vehicle policy and fuel economy regulations leveraged to drive electrification: Besides NEV credits, China's NEV mandate also regulates corporate average fuel consumption (CAFC) credits and how both are calculated and traded. Chinese fuel economy mandate has been progressively tightened since 2015 (see *Table 20: Fuel economy specifications in China*) to encourage automotive manufacturers to produce electric vehicles and reduce production of fossil fuel driven vehicles.

Average fuel consumption of new passenger cars is expected to be limited to 4 litres/100 km by 2025, down from 5.5 litres/100 km in 2019, helping automakers expand their credit scores. Automakers that do not comply will be unable to obtain approvals for new models that are less efficient than the fuel economy standard. While EV and efficient ICE vehicles will receive favourable treatment when calculating each manufacturer's fuel economy, a separate standard of EV efficiency sets a voluntary target on energy consumption based on weight classes. Also, the credit scheme favours FCEVs over BEVs and PHEVs with larger credit allocated to the hydrogen-based vehicles.

For manufacturers, compliance pathways available to meet a CAFC or NEV credit deficit is with previously banked credits or by purchasing them from other companies. However, under the 2017 policy, a number of long-range BEVs won high credits leading to surpluses. In 2019, manufacturer surpluses amounted to 4.17 million NEV credits and deficits were only 0.86 million NEV credits. The new policy has lowered the credits that can be won with long range BEVs, underscoring the significance of energy efficiency in vehicles.

Table 20: Fuel economy specifications in China

Year	Fuel consumption (litres/100 km)	Emissions conversion (gram of CO_2/km)
2015	6.9	160
2020	5.0	116
2025	4.0	92.8

Source: CSE research

China also offers vehicle tax reduction benefits including exemption from the one-time acquisition tax and discounted excise duties, which are partially based on engine displacement. In addition, NEVs have been fully exempt from the annual vehicle and vessel tax since 2015. Further, incentives are offered by provincial governments such as Beijing, Shenzhen, Shanghai, Hefei, and Hangzhou that match the central government subsidy for limited time periods. In addition, Chinese cities offer charging discounts to new ZEV drivers and have expanded traffic restriction waivers for ZEVs.

Purchase incentives for consumers and non-fiscal strategy: Apart from fiscal incentives discussed above, Chinese EV policy design supports new energy vehicle adoption with non-fiscal incentives ranging from parking fee exemptions to restrictions on conventional vehicles in low emission zones.

While on the one hand, the flexibility to use conventional vehicles to calculate NEV credits is intended to incentivize energy-efficient vehicles even as it continues to allow the production of less energy-efficient gasoline vehicles, on the other hand, city municipalities have imposed restrictions on certain ICE vehicles during peak hours in congested areas.

Cities such as Shanghai, Beijing, Shenzhen and Hangzhou have imposed traffic restrictions on conventional vehicles in a policy that resonates with the low emission zones and congestion pricing prevalent in Europe that exclude certain kinds of fossil fuel vehicles. Shanghai bars cars with two to nine seats during peak hours (7 am to 9 pm and 5 pm to 7 pm on workdays). Non-compliance with the law that was initiated in May 2021 can attract a penalty of CNY 200 (USD 30) and a deduction of three points from the driver's licence.

Designed to complement the NEV credit mandate policy, non-fiscal support schemes such as the licence plate strategy, which is focussed on consumer convenience, has proven to be one of the most powerful consumer incentives rolled out in China. In fact, according to a 2019 study published by Springer, it has been more influential than purchasing subsidy with Chinese consumers.

Several large cities in China have a cap on the number of new vehicle license plates issued every year. New license plates are regulated with a lottery system using a competitive bidding process and they cost about $13,000. In comparison, the licence plate for NEV buyers comes free, is exempted from the lottery system, and is handed out on a first-come-first-serve basis.

The licence plate strategy also helped curb sales of imported vehicles. Though licence plates could be availed for imported EVs, their high costs, which includes a 25 per cent tariff, ensures that their market share stays low. Besides, they could not avail either the subsidies or sales tax exemption.

In addition, NEVs are exempt from traffic restrictions aimed at controlling congestion and some cities even offer dedicated parking spaces for them.

Localization—support for manufacturers and debt capital: China's ambition to build the largest EV industry in the world required control over EV battery manufacturing and its supply chain. In a bid to promote localization, China had a two-decade long restriction on 100 per cent ownership in new vehicle manufacturing plants which was lifted only in 2018. The new rule created under the Special Administrative Measures for Admittance of Foreign Investment 2018, better known as the Negative List was issued by the National Development Reform Commission (NDRC) and the Ministry of Commerce (MOFCOM) on 28 June 2018 to become effective in June 2020.

Before the caps were removed, foreign automakers could set up plants in the country only in collaboration with local players, a provision that was directed at providing access for Chinese manufacturers to technologies developed by their foreign partners.

The restriction did not deter global automakers such as GM, Ford and BMW, among others, from investing in China, considering the access it offered to the largest vehicle market in the world.

In addition, automotive manufacturers in China could avail subsidies for their vehicles only if they sourced their batteries from a list of Chinese manufacturers approved by the Ministry of Industry and Information Technology (MIIT). The ministry published the list, often referred to as the 'White List' in the automotive industry, starting 2015 and ending in June 2019, a year after the country began phasing out the subsidy regime.

In addition, China has been aggressively pushing for the formation of industrial clusters that nurture domestic EV manufacturers. At least 20 EV towns worth around USD 30 billion are under construction as the country drives technology investments in the industry chain. So, if an EV manufacturer plans to sell his products in a new city, the company will have to invest and build a plant there first.

Additional support actions towards localization have been directed at building an EV battery manufacturing ecosystem in the country with aid to battery metal miners such as Tianqi and Ganfeng to acquire mining assets in Latin America and Australia and to companies setting up processing plants for supply-constrained EV battery metals such as cobalt.

Chinese companies Tianqi and Ganfeng are now among the world's largest lithium miners; Tianqi owns 51 per cent stake in Greenbushes, the world's largest hard-rock lithium mine and the Kwinana lithium processing plant, both in Australia; and Ganfeng counts among its assets a controlling stake in the substantial Cauchari-Olaroz lithium salt lake project in Argentina which has an annual design capacity of 40,000 tonnes of lithium. And in the area of cobalt processing, the country's capacity could exceed 20,000 tonnes in 2020, according to government-backed metals research firm Antaike.

Most of the cobalt used in EV batteries globally is mined in the Democratic Republic of Congo; China imports about 70 per cent of the unprocessed mine output from Congo and processes it in addition to other battery metals to produce EV batteries, which are consumed by the domestic industry and also exported to US, Europe and Japan.

Sustainability of subsidies: With the EV industry in China growing to be one of the largest in the world, the government has begun phasing out the subsidy programme to rein in firms that the government believes have become over reliant on its support. Going forward, Chinese incentives that are likely to aid the EV market include a 'dual credit policy' for manufacturers and growth in charging infrastructure to drive demand. China quadrupled its EV charging stations in 2019 to over 1.17 million, growing 61.2 per cent year on year.

Lessons learnt and course corrections: China's EV subsidy policy design has undergone multiple course corrections to align with the market's response to the qualifications required to avail incentives.

In 2018, when Beijing started phasing out purchase incentives, EV battery range ceased to be the only deciding factor to avail them. The subsidy calculation factored in two additional values—energy density and fuel consumption—in a move that was directed at improving innovation in the manufacturing sector. Automakers could no longer boost range by adding more battery cells to qualify for subsidies. With the changed rule, carmakers had to either alter vehicle designs or rope in an advanced technology battery supplier who offered higher energy density technology.

The stress on innovation was motivated by a need for distance from EVs manufactured with low quality technology that had begun flooding the Chinese market mid-decade. According to a 2016 note released by the Chinese Ministry of Finance, micro EVs accounted for 66 per cent of EV market share in China. Inevitably, the market segmented sales of EVs in China followed a bunching pattern around the 150 km range vehicle category where the subsidies started. High level technology electric vehicles comprised 20 per cent, the government note said, leaving a wide opportunity for domestic players to raise the bar on their products.

In addition, there was a subsidy fraud in 2016 which forced China to overhaul its subsidy programme and build more transparency into the process. A government disclosure document released in 2016 revealed manufacturers who submitted magnified and fake sales numbers of electric buses to avail subsidies.

The data released regarding the USD 150 million subsidy scam also revealed the story of how China had helped a small company like BYD become one of the biggest rechargeable mobile phone battery and electric vehicle manufacturers. The document divulged information about BYD's subsidy gains which was to the tune of about USD 1 billion in 2016. That was more than the profit the automaker earned that year (USD 750 million). China's strategy to become an electric vehicle power clearly also included supporting companies to become global winners in the field.

7.2 Anatomy of a ZEV mandate

A ZEV mandate is an electrification goal set for the automotive industry to accelerate the adoption of electric vehicles to meet climate goals for reducing carbon emissions. It typically works with a pre-defined scope and is implemented using three primary tools—ZEV production percentage, ZEV credits and fuel economy.

Global actors such as US, Europe and China have successfully implemented the ZEV mandate in various forms to achieve higher levels of EV adoption using tools such as ZEV production credits and a fuel efficiency target which can be achieved only by eschewing tailpipe emissions and including electrification in the overall technology mix in every automaker's portfolio. Vehicle technologies that can be deployed to achieve this end include full battery-electric, hydrogen fuel cell, and plug-in hybrid-electric vehicles.

Documented experience with the global deployment of ZEV mandates reveals varied narratives of how the regulation evolved over the last couple of decades.

7.2.1 The California ZEV experience

In California the regulations leading to electrification of vehicle fleet are the most evolved. It was way back in 1990 that the first Low Emission Vehicle (LEV) Standards came into being. Technically, that is when ZEV norms first appeared in the US. Launched by the California Air Resources Board (CARB), the first LEV regulation, called LEV I in its original form, required a car manufacturer in California to have 10 per cent of its fleet as zero-emission vehicles by 2003 to continue operating in the state. To achieve that end, the regulation offered a roadmap stating that car makers had to have 2 per cent of ZEVs in their fleet by 1998 and 5 per cent by 2001, requirements that were eliminated in 1998.

In response to the LEV I mandate, General Motors developed the EV1 by mid-decade in 1995. The EV1 was leased out to consumers in California and later throughout the country and it became quite popular despite its short range and minimal options to get charged. However, it offered a very low profit margin when compared to ICE vehicles.

California's first generation policy action in the 1990s, however, never arrived at its planned conclusion. The regulation was contested by the automobile and oil industries in public and in the courts. General Motors decided to scrap the EV1 and joined other US automakers to have the law repealed. It was much later, with successive efforts at reinventing the LEV regulations that the mandate gained traction.

The first LEV standards ran from model year 1994 through 2003 and were amended in November 1998 to create the LEV II Standards focused on criteria pollutant emission reductions. One of the primary motives behind LEV II was to expand the coverage of the light-duty truck category to include most SUVs, mini vans and pickup trucks in the same vehicle standards as passenger vehicles.

The criteria were introduced in response to the popularity of SUVs that were built on light duty truck platforms but were sold as passenger cars. Since light trucks were used for hauling goods rather than passengers, they represented a much smaller share of the automobile market and were guided by more lenient emissions standards compared to passenger vehicles. The gap in emission norms for that segment led to an influx of SUVs and, over the last decade, SUVs have witnessed a dramatic surge in their share of the new automobile market.

LEV II also strengthened the nitrogen oxide (NO_x) standard and established more stringent requirements for model year (MY) 2004 and MY 2010 vehicles in passenger cars, light duty trucks and medium duty vehicles. The program evolved into LEV III Standards with amendments in 2012 bringing for the first-time GHG emissions from motor vehicles (from MY 2009 through MY 2016) into the ambit of air quality regulation.

The 2012 amendment also brought smog-causing pollutants such as particulate matter, GHG regulations and a technology forcing regulation for ZEVs that contributes to both types of emission reductions under a single umbrella set of regulations collectively called the Advanced Clean Cars (ACC) programme. The LEV III GHG component was developed in coordination with the US EPA and National Highway Traffic Safety Administration (NHTSA) for One National Program to harmonize GHG and fuel economy standards.

According to CARB estimates, these GHG regulations can reduce greenhouse gas emissions from new vehicles by approximately 40 per cent (from 2012 model year vehicles) in 2025. The idea behind these regulations was their technological feasibility and their ability to save consumers money over the life of the vehicle because of lower fuel use and reduction in GHG emissions. Technologies that could achieve the new standards include engine and emission control advancements, wider application of advanced hybrid technology, and greater use of stronger and lighter materials.

The breadth and depth of the California ZEV programme is best understood by the recognition it received from 14 other states in the US that have adopted the regulations. The ZEV programme offers a 'travel provision' that allows automakers to earn credits in the other states with ZEV mandates for vehicles sold in California (see *Table 21: List of US states that have adopted California's vehicle standards*).

Table 21: List of US states that have adopted California's vehicle standards

State	Beginning model year			
	LEV regulations		ZEV regulations	% share of light duty vehicles in the US
	Criteria pollutant	GHG		
California	1992	2009	1990	11.7%
New York	1993	2009	1993	6.0%
Massachusetts	1995	2009	1995	2.1%
Vermont	2000	2009	2000	0.3%
Maine	2001	2009	2001	0.4%
Pennsylvania	2001	2009		3.9%
Connecticut	2008	2009	2008	1.0%
Rhode Island	2008	2009	2008	0.3%
Washington	2009	2009		1.8%
Oregon	2009	2009	2009	1.0%
New Jersey	2009	2009	2009	3.5%
Maryland	2011	2011	2011	2.0%
Delaware	2014	2014		0.3%
Colorado*	2022	2022	2023	1.6%

Source: *California Air Resources Board 2019, States under Section 177 of the Federal Clean Air Act;* *Colorado has plans to implement these regulations in the future and therefore was included in the list.

According to CARB, 8 per cent of new vehicle sales in California will need to be ZEVs and plug-in hybrids by 2025 to achieve compliance.

The LEV regulations in the US are implemented at the state level. At the national level, the US works with demand creation incentives (tax breaks ranging from $2,500 to $7,500) and supply side support such as the $25 billion low interest Advanced Technology Vehicle Manufacturing (ATVM) loan program.

How does the California ZEV mandate work? The California ZEV programme assigns each automaker 'ZEV credits'. Automakers are required to maintain ZEV credits equal to a set percentage of non-electric vehicle production. Each manufacturer has a target percentage for a model year (see *Table 22: ZEV credit percentage requirement for respective model years in California*). Each car produced earns a number of credits based on the type of ZEV and its battery range.

Table 22: ZEV credit percentage requirement for respective model years in California

Model year	Total ZEV % requirement	ZEVs (or ZEV Floor)	TZEVs*
2018	4.5%	2.0%	2.5%
2019	7.0%	4.0%	3.0%
2020	9.5%	6.0%	3.5%
2021	12.0%	8.0%	4.0%
2022	14.5%	10.0%	4.5%
2023	17.0%	12.0%	5.0%
2024	19.5%	14.0%	5.5%
2025	22.0%	16.0%	6.0%

Source: California Air Resources Board 2020. *Zero-Emission Vehicle Standards for 2018 and Subsequent Model Years* (*TZEV stands for Transitional ZEV, which consists of plug-in hybrid vehicles)

The credit requirement for 2025 is 22 per cent, which will likely require less than 8 per cent of sales to be ZEVs. Credits could also be won from Transitional Zero Emission Vehicles (TZEVs) or plug-in hybrid vehicles, but the mandate has restrictions on the amount of credits that can be won, with a cap of 6 per cent. The total production volume of ZEVs for a model year is calculated using a three-year average. For example, the total production volume for 2020 was based on the average for years 2017, 2018 and 2019. This volume was then used to calculate ZEV volume target based on the credit percentage mandate.

Manufacturers can apply for a base calculation of ZEV per cent target for the same model year (should they wish to opt out of the three-year average calculation system), if the production volume has dropped by at least 30 per cent since the previous year due to unforeseen circumstances such as the global pandemic. However, this provision can be availed only twice between 2018 and 2025.

For instance, a manufacturer producing 100,000 cars in 2021 will need at least 16,000 credits, with at least 12,000 coming from zero emission vehicles. However, they do not need 12,000 vehicles to win those credits as each ZEV accounts for more than one credit depending on the size of the manufacturer, the drivetrain installed and the electric range of the vehicles.

Trading credits

Manufacturers can bank excess credits for a model year to meet requirements in the subsequent year. Similarly, credits can be transferred and traded within or between states under the 'travel' and 'pooling' provision. The travel provision, which allowed credits earned in one state to be counted as earned in all ZEV states, is no longer in effect. The pooling provision allows automakers to over-comply in one eastern ZEV state and transfer the extra credits to another eastern ZEV state. Unlike the travel provision, pooling avoids the double-counting issue, and still requires that an actual vehicle is produced and sold before credit is rewarded and transferred. However, transferring or trading between region pools incurs a premium of 30 per cent of their credit value. In comparison, transactions within a region pool are free.

For example, if a manufacturer wishes to trade or transfer 100 credits from State A to State B, both states in the West Region Pool, it will only cost them the required 100 credits for the transfer. However, if State A is in the East Region Pool and State B is in the West Region Pool, it will cost them 130 credits for the trade or transfer.

Credit over-compliance

A flexibility mechanism, implemented from MY 2018, offsets ZEV credit requirements by over-complying with the GHG emission targets, enabling larger manufacturer commitment to the cause.

The over compliance mechanism makes a manufacturer eligible for GHG over compliance credits provided they have no outstanding debits from previous years (till 2017) under both the GHG and ZEV programs. To avail this scheme, the manufacturer had to state their commitment for over compliance with the GHG program by at least 2 gCO_2/mile for the entire period starting 2018 through 2021.

California—Who wins how many ZEV credits?

- **Large volume manufacturers** (>20,000 units) are required to meet a portion of the total ZEV credit percentage called the 'minimum ZEV floor' for each model year, which is awarded only with the production of pure ZEVs. The rest of the percentage can be fulfilled by producing TZEVs. As a result, large volume manufacturers cannot use TZEVs to fulfil more than the maximum per cent slab. For example, in 2020, at least 6 per cent of their total production volume had to be ZEVs and the rest had to be TZEVs to fulfil their ZEV target.
- **Intermediate volume manufacturers** may use TZEVs to meet the entire credit percentage target. For example, in 2020, even 9.5 per cent TZEVs and no ZEVs in their total output could help them achieve their ZEV target.
- **Small volume manufacturers** (<4,500 units) are not required to meet ZEV targets. However, they can earn ZEV credits with ZEVs and TZEVs if they wish to create a credit market for themselves.

Credit eligibility: Credits are allocated based on the vehicle segment type—pure ZEVs (BEVs and FCEVs), TZEVs (primarily PHEVs), NEVs, hydrogen combustion engine—and the all-electric range (AER) of the vehicle.

For pure ZEVs using the US EPA mandated dynamometer test called the urban dynamometer driving schedule or UDDS test cycle range, which represents city driving conditions and is used for light duty vehicle testing,

- If AER range is less than 50 miles, no credits are awarded
- If range is more than 350 miles, a credit cap at 4 credits per vehicle is awarded
- If range is anywhere between 50 and 350 miles, the ZEV credit is calculated thus:
  ZEV credit = (0.01) * Range + 0.05. **A vehicle with a range of 250 will earn 2.55 credits.**

For TZEVs using UDDS test cycle range,

- if AER is less than 10 miles, no credits are awarded
- if AER is more than 80 miles, a credit cap at 1.1 credits per vehicle is awarded
- If AER is anywhere between 10 and 80 miles, the ZEV credit is calculated thus:
  TZEV credit = (0.01) * AER + 0.30. A vehicle with a range of 60 will earn 0.9 credits.

If US06 test cycle range (which is a much stricter test cycle than the UDDS test cycle) is at least 10 miles for a TZEV, vehicles earn an extra 0.2 credits, bringing the total cap (for 80 miles range) allowed for TZEVs to 1.3.

Neighbourhood Energy Vehicles are eligible for 0.15 credits if they have a minimum 25-mile range when running at constant top speed (minimum 20 mph at a 50 per cent state of charge or SoC). Hydrogen electric internal combustion engines can earn an additional 0.75 credits if they have a range of at least 250 UDDS miles and have an overall credit cap of 1.25 credits. Both these vehicle technologies are technically included in TZEVs.

Conditions to use GHG credits for the ZEV programme:

- GHG credits can only be used in the same model year
- If the manufacturer is granted the use of their over-compliance GHG credits but fails to comply with at least 2 gCO_2/mile for any model year, it can no longer use the GHG credits for that year and subsequent years in the ZEV programme
- The over compliance GHG credits used for ZEV programme should be removed from the GHG bank
- Over compliance credits cannot be banked under the ZEV programme for future compliance
- In 2018 and 2019, GHG credits could be used only for a maximum of 50 per cent of the ZEV credit requirement; for 2020, only 40 per cent could be used and 30 per cent for 2021

Penalties

A manufacturer failing to comply with the ZEV regulation credit requirements for a model year must make up for the deficit by the next model year. Intermediate manufacturers can request for up to three consecutive model years to make up for the deficit, although they will have to back it up by submitting a plan on how to make up for the deficit during this period.

Manufacturers failing to make up for the required credit deficit during the time allowed attract a civil penalty of up to $5,000 for each credit deficit using the following calculation.

Calculation: ZEV credits required to be generated for the year—ZEV credits submitted for compliance (resulting number is rounded off to the nearest 1/100th)

Penalties do not write off credit deficits and these are carried over to the next compliance years.

Changes made for compliance years 2018–25: In 2012, California ZEV regulations were made much stricter for model years 2018–25 and credit eligibility was reviewed to expand coverage in the automotive industry.

Until 2017, credits were awarded to Partial Zero Emission Vehicle (PZEVs) and Advanced Technology PZEVs (AT-PZEVs); it was later discontinued as manufacturers availed a majority of the credits with gasoline-based hybrids. Although the system allowed credits earned before 2018 on PZEVs and AT-PZEVs to be banked, it was at a heavily discounted rate—only 25 per cent—under TZEVs and had an expiry date—after 2025.

The pure ZEV credit percentage requirement targets were much more lenient before 2018. In 2017, the total ZEV percentage required was 14 per cent, out of which only 3 per cent had to be pure ZEVs (minimum ZEV floor). Starting 2018, the number of credits that could be earned was reduced substantially (only 4 credits for pure ZEVs as compared to 9 credits before 2018).

The manufacturer categories were changed to include more players in the large-scale manufacturers group. Before 2018, manufacturers with production volume of more than 60,000 units only could be classified as large volume manufacturers, making only big players such as Chrysler, Ford, General Motors and Honda eligible. After 2018, the eligibility criterion was reduced to 20,000 units allowing smaller players such as Mazda, Subaru, Kia and Hyundai to qualify. Similarly, for intermediate volume manufacturers, the criterion was changed from 10,000–60,000 units till 2017 to 4,500–20,000 units starting 2018.

The changes for 2018–2025 also introduced the GHG over-compliance flexibility option, which was not available earlier.

More regulatory action: In California an executive order by the governor has established several electric vehicle goals for the state. That has led to the Zero Emission Vehicle Action Plan to define specific strategies for meeting the milestones established by the executive order. The Zero Emission Vehicle Action Plan has been revised twice since 2013 to align with changes in the market and new opportunities therein and to help the state's ambition of getting 1.5 million electric vehicles on the road.

California has also set targets for the transit agencies and requires them to submit zero emission bus rollout plans that demonstrate purchase and infrastructure buildout programmes. This has to include financial planning, and workforce training. California has also proposed the Clean Miles Standard and Incentive Program to enable state agencies to implement regulations for transportation network companies to electrify fleets and reduce emissions per passenger mile.

7.2.2 The European ZEV programme

Unlike California's production-based ZEV credit regulation, Europe follows an alternate compliance pathway built into the CO_2 emission standards for light passenger and commercial vehicles, under which, from 2025 onwards, the manufacturer will have a discount ratio on their specific emission targets, if they are producing electric vehicles.

Europe's CO_2 emission standards were till 2009 based on a voluntary commitment by the auto industry to reduce emissions. Since that failed to produce adequate results, the EU set a mandatory fleet average CO_2 emission target of 130 g/km for 2015 for every car maker. The 2009 regulation was followed by a similar regulation in 2011 for light commercial vehicles (also known as vans), setting a mandatory target of 175 g/km for 2017. Both targets were achieved by vehicle manufacturers long before they were due in 2013 (see *Table 23: CO_2 emission targets for light passenger and commercial vehicle manufacturers in EU*).

Periodic reviews of the emission regulation led to a new set of standards in 2014 that set average CO_2 emission target for new cars at 95 g/km by 2021 and for vans at 147 g/km by 2020. In a bid to increase stringency of the CO_2 emission standards, new post-2021 EU fleet-wide emission reduction targets were set in 2019 under Regulation (EU) 2019/631 for 2025 and 2030 which are specific for every manufacturer. These reduction targets use 2021 emission levels for each manufacturer as the baseline and are based on the New European Driving Cycle (NEDC) emission test procedure. From 2021 onwards, the emission targets for manufacturers will be based on the new WLTP guidelines.

Table 23: CO_2 emission targets for light passenger and commercial vehicle manufacturers in EU

	Light passenger vehicles	Light commercial vehicles
Target before 2020	*130 gCO_2/km*	*175 gCO_2/km*
Compliance 2019*	*122.4 gCO_2/km*	*158.4 gCO_2/km*
Target for 2020–21	*95 gCO_2/km*	*147 gCO_2/km*
Target for 2025 onwards	*15% reduction from 2021 levels*	*15% reduction from 2021 levels*
Target for 2030 onwards	*37.5% reduction from 2021 levels*	*31% reduction from 2021 levels*

Source: European Commission 2020, *CO_2 emission performance standards for cars and vans (2020 onwards)*;
* For EU 28, Norway and Iceland

How's the situation today? According to data published by the European Environment Agency, the average CO_2 emissions of new passenger cars registered in the EU, Iceland, Norway and the UK in 2019—the most recent year for which data is currently available—was 122.4 gCO_2/km for cars and 158.4 gCO_2/km for vans on the NEDC. Passenger cars and vans are responsible for around 12 per cent and 2.5 per cent of total CO_2 emissions in the EU. Under the EU regulations, CO_2 targets for individual manufacturers are adjusted for the average vehicle weight of their fleet. The heavier the average weight of the cars sold by a manufacturer, the higher the CO_2 level allowed. In addition, manufacturers are allowed to form pools with other manufacturers in order to jointly meet CO_2 targets.

Though the 2019 average CO_2 emissions value was well below the EU fleet-wide target of 130 gCO_2/km set for the period 2015–2019, it was above the 2021 target of 95 gCO_2/km phased-in in 2020. This was a cause for concern even though most car manufacturers met their individual binding CO_2 emission targets for fleets of newly registered passenger cars in 2019. It was a cause of concern because the average CO_2 emission figure which was on a decline between 2000 and 2016, began increasing from 2017. In 2019, the emission value increased by 1.6 gCO_2/km compared to 2018. Meanwhile, average emissions for new vans remained stable at 158 gCO_2/km, below the target of 175 gCO_2/km that applied until 2019.

The increase in average CO_2 emission values for cars from 2017 is attributed to the market shift from diesel to petrol cars and, also, the growth of the petrol-powered SUV segment which led to an increased average mass of vehicles. Between 2018 and 2019, the market share of SUVs increased from 35 per cent up to 38 per cent.

With the stricter EU fleet-wide targets of 95 gCO_2/km for cars and 147 gCO_2/km for vans that apply since 2020, manufacturers have had to improve the fuel efficiency of their fleet and accelerate the deployment of zero- and low-emission vehicles. It was imperative for car makers to meet those targets considering the volumes they operate with. Passenger cars account for 88 per cent of all new light-duty vehicle registrations in the EU with vans accounting for the remaining 12 per cent.

How does the European CO_2 emissions credit programme work? The EU CO_2 standards recognize all vehicles with emissions of less than 50 g/km as ZEVs. This led to a non-trivial impact on certain segments of the market with an influx of relatively low-range and heavier plug-in hybrid electric vehicles in the market. This anomaly was addressed with the 2021 CO_2 standards with market share credits, as part of which full electric vehicles receive full market share credits based on zero emissions while plug-in hybrid electric vehicles earn partial market share credits based on their tail pipe emissions.

Exceeding these targets in ZEV market share can win manufacturers the eligibility to receive certain levels of relaxation on their standards as part of a compliance flexibility mechanism. Only vehicles with tank-to-wheel CO_2 emissions less than 50 gCO_2/km can avail this relaxation on target. While BEVs and FCEVs are awarded full relaxation (capped at 5 per cent) on the emission targets under the provision, vehicles with emissions between 0 and 50 gCO_2/km can get relaxation between 0 and 5 per cent (based on their ZLEV factor).

Eligibility for relaxation

Manufacturers can avail the CO_2 emissions target relaxation on the basis of their share of ZLEVs:

- Manufacturers of passenger vehicles—15 per cent 2025 onwards and 35 per cent 2030 onwards
- Manufacturers of commercial vehicles—15 per cent 2025 onwards and 30 per cent 2030 onwards

Note: ZLEV factor is defined as the percentage to which a manufacturer's emission target can be relaxed. At the moment, this is capped at 5 per cent.

Calculation

Manufacturer's relaxed target = specific emission target x ZLEV factor

The ZLEV factor can be between 1.05 (5 per cent relaxation) and 1 (0 per cent relaxation).

ZLEV factor = (1 + A – B), where A and B are expressed as follows:

Table 24: Component values to calculate ZLEV factor for a manufacturer in EU

		A (weighted share of ZLEVs in manufacturer's total vehicle fleet) *	B =
Passenger vehicles	2025 onwards	Weight of each vehicle towards share of ZLEVs calculated based on equation: *1 – (CO_2 emissions x 0.7)/50*	0.15
	2030 onwards		0.35
Commercial vehicles	2025 onwards	Weight of each vehicle towards share of ZLEVs calculated based on equation: *1 – (CO_2 emissions)/50*	0.15
	2030 onwards		0.30

Note: These equations do not calculate the absolute value of A, they are the basis for the calculation. The absolute value of A is the weighted percentage share of ZLEVs, and the equations determine the weight of each ZLEV for counting towards that share. For example, a light commercial vehicle with tank-to-wheel emission of 40 gCO_2/km will be counted as 1 – (40/50) = 0.2 vehicles when calculating ZLEV share. Let's say the result of all ZLEVs counted as such provides a final ZLEV share as 17 per cent, then for 2025, ZLEV factor for the manufacturer = 1 + 0.17 - 0.15 = 1.02, which translates into 2 per cent relaxation for 2025.

Source: European Commission 2019, *Setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles*

Penalties: The ZLEV clause is designed to encourage manufacturers to produce more electric vehicles to earn relaxation in their emission target. Non-compliance does not include penalties. However, non-compliance with the vehicle emission target does invite a penalty.

Penalty calculation

Penalty premium = Excess emissions (gCO_2 over target) x *EUR 95* x number of newly registered vehicles

In addition, the European ZEV policy framework has built in a super credits system incentive that is operational from 2020 to 2022. It applies to passenger cars with emissions of less than 50 gCO_2/km (NEDC). These vehicles are counted multiple times for the calculation of the average specific emissions of a manufacturer. In 2020, they counted as two vehicles, as 1.67 vehicles in 2021 and 1.33 vehicles in 2022. The super credits are capped at 7.5 g/km per car manufacturer over the three years. There is no super credit system for vans.

7.2.3 China's NEV mandate with dual credits

China followed a modified version of the Californian ZEV mandate starting in 2017 with the New Energy Vehicle Mandate policy titled 'Measures for the Parallel Management of Average Fuel Consumption of Passenger Car Companies and New Energy Vehicle Credits'.

The policy has set annual NEV credit targets at 10 per cent of the passenger vehicle market in 2019 going up to 18 per cent in 2023 (see *Table 25: Summary of NEV credit percentage targets and maximum credits allowed under the two phases 2019–20 and 2021–23 in China*).

Similar to California's ZEV mandate, the annual percentage targets are based on NEV credits, not NEV sales. Where the policy differs from the California version is in its definition of the credit system that focuses on the relationship between NEV credits and CAFC, which is also why it is called a dual credit policy. Surplus credits earned under the NEV mandate can be used to offset deficits in CAFC compliance.

Table 25: Summary of NEV credit percentage targets and maximum credits allowed under the two phases 2019–20 and 2021–23 in China

<table>
<tr><th colspan="2"></th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024 and beyond</th></tr>
<tr><td colspan="2">NEV % target*</td><td>10%</td><td>12%</td><td>14%</td><td>16%</td><td>18%</td><td>TBD</td></tr>
<tr><td rowspan="3">Max. credits</td><td>BEV</td><td colspan="2">6 credits</td><td colspan="3">3.4 credits</td><td>TBD</td></tr>
<tr><td>PHEV</td><td colspan="2">2 credits</td><td colspan="3">1.6 credits</td><td>TBD</td></tr>
<tr><td>FCEV</td><td colspan="2">5 credits</td><td colspan="3">6 credits</td><td>TBD</td></tr>
</table>

*The percentages are for the number of NEV credits and not the number of vehicles. For example, if the production volume is 1 lakh, the manufacturers had to generate at least 10,000 NEV credits in 2019.

Source: Ministry of Industry and Information Technology 2020; International Energy Agency 2020; International Council on Clean Transportation 2018; compiled by CSE;

Each NEV is assigned credits ranging from one to six based on factors including electric range, energy efficiency and rated power of fuel cell systems. Aimed at controlling average fuel consumption of new passenger cars at 4 litres/100km by 2025, vehicles with higher performance get more credits, capped at six credits per vehicle. The credit targets apply to all auto companies with annual production or import volume of at least 30,000 conventional passenger cars. Manufacturers with production volumes less than 30,000 units are not eligible for incentives listed under the NEV mandate but are obliged to fulfil their CAFC credit targets.

Credit eligibility: Vehicles awarded NEV credits are bunched into three broad categories:

BEVs:

- 2019–20: Eligibility for credits start at 100 km range. Credits are awarded based on the linear equation: BEV Credits = (0.012 x range + 0.8) x conversion factor. This conversion factor (CF) can be either 0.5, 1 or 1.2 based on the curb weight (kg) of the vehicle and the energy consumption (kWh/100km). If CF = 0.5, maximum 2.5 credits per vehicle (if CF = 0.5, the credits earned by this vehicle cannot be sold to other companies); if CF = 1, maximum credits 5 and if CF = 1.2 maximum credits 6.
- 2021–23: The cap for BEVs to earn credits becomes slightly more complex with range above 100 km, battery energy density over 90 Wh/kg or maximum speed over 100 km/h. The maximum number of credits that can be earned has been reduced to 3.8 per vehicle. BEV credits = (0.0056 x Range + 0.04) x range coefficient x energy density coefficient x power consumption coefficient

Table 26: Coefficient values for BEV credit allocation to vehicles during 2021-23

Range coefficient	0.7, if range between 100 and 150 km
	0.8, if range between 150 and 200 km
	0.9, if range between 200 and 300 km
	1, if range more than or equal to 300 km
Energy density coefficient	0.8, if energy density between 90 and 105 Wh/kg
	0.9, if energy density between 105 and 125 Wh/kg
	1, if energy density more than 125 Wh/kg
Power consumption coefficient	= Energy consumption target / actual energy consumption (Energy consumption target is calculated based on the curb weight of the vehicle)
	Can be between 1 and 1.5
	0.5, If the vehicle does not come under the calculated energy consumption target, and then the credits from this vehicle cannot be sold to other companies

Source: Ministry of Industry and Information Technology 2020, *Annex 2 to "Measures for the Parallel Management of Average Fuel Consumption of Passenger Car Companies and New Energy Vehicle Credits"*

PHEVs

- 2019–20: Eligibility for credits starts at 50 km and PHEVs can earn a maximum of 2 credits per vehicle. PHEV credits = 2 x conversion factor. CF can either be 1 or 0.5 based on the range, curb weight of the vehicle (kg) and energy consumption (kWh/100km). If CF = 0.5, the credits earned by this vehicle cannot be sold to other companies.
- 2021–23: The credit allocation for PHEVs was made much simpler under the new rule, and the maximum credit earned by a PHEV can be up to 1.6 credits. Range will

not be a factor any more to determine the credits earned by the vehicle. Instead, if the vehicle's power consumption is more than 70 per cent of current fuel consumption limits, the credits awarded to the PHEV will be halved, and these credits cannot be sold to other companies.

FCEVs:

- 2019–20: Eligibility for credits starts at 300 km and the credit amount is capped at 5 credits per FCEV. FCEV Credits = 0.16 x rated power of fuel cell system. If the rated power of the fuel cell system (kW) is less than 30 per cent of the rated power of the driving motor or 10kW, whichever is higher, the credits awarded to the FCEV will be halved, and these credits can also not be sold to other companies.
- 2021–23: FCEV credits can be earned above 300 km and the maximum number of credits was increased to 6 per vehicle. FCEV Credits = 0.08 x rated power of fuel cell system. If the rated power of the fuel cell system (kW) is less than 30 per cent of the rated power of the driving motor or 10kW, whichever is higher, the credits awarded to the FCEV will be halved, and these credits can also not be sold to other companies.

Trading credits

In China, NEV regulation uses the market for credits as a flexibility tool for manufacturers to make up for credit deficits. If the actual credit value is higher than the target, a manufacturer generates positive credits, and for lower values, the manufacturer is awarded negative credits (credit deficit).

Manufacturers can bank positive credits for not more than three years, but the following conditions apply:

- Positive credits in 2019 for NEVs can be carried forward to 2020 without a discount rate
- Positive credits in 2020 for NEVs can be carried forward at a rate of 50 per cent for each consecutive year (for not more than three years)
- For positive credits in 2021–23, if the CAFC target is not exceeded by 123 per cent, the extra NEV credits can be carried over at a discounted rate of 50 per cent for each consecutive year. If the manufacturer only produces ICEs, the credits can be carried over at a discounted rate of 50 per cent

Trading or selling positive NEV credits to offset negative NEV/CAFC credits have to abide by the following conditions:

- Positive NEV credits can be used to compensate negative CAFC credits but not vice versa
- In case of credit deficit, positive NEV credits from other companies can be bought to compensate

- Positive NEV credits generated in the year 2020 can also be used to offset negative NEV credits of 2019, and this cannot be done for any other combination of years

Positive NEV credits generated by any manufacturer can only be used in the current year and cannot be traded again in case of carry-overs.

Penalties: Manufacturers are expected to submit their performance reports on NEV (and CAFC) credits every year to the MIIT, along with a credit commitment letter to hold them accountable in the case of non-compliance with targets. MIIT is responsible for checking and verifying credit calculations done by manufacturers. Severe violations by a manufacturer may get them labelled as 'untrustworthy passenger car manufacturers' by MIIT and this list will be released to the public.

If the negative NEV credits of a model year have not been compensated to zero, the manufacturers may be subjected to punitive action under the provisions of the Automotive Industry Development Policy and the Compulsory Product Certification Management Regulations.

In case of negative NEV/CAFC credits, the manufacturer will have to submit a plan for production volume or import adjustment to make up for their credit deficit. This could lead to MIIT denial of 'type' approval for all new vehicle models of the manufacturer that do not meet the specific fuel consumption criteria until the negative credits are compensated.

7.2.4 Designing a ZEV mandate in India

A ZEV mandate in India will have to be designed on the principle that a comprehensive policy framework is the only means to achieve the country's ambition related to emissions and climate change goals.

Globally, there are four primary strategies deployed to implement ZEV mandates and increase percentage share of zero emission vehicles on the road.

Production based criteria: California uses an annual percentage share system that wins automakers ZEV credits. Credits are assigned to particular automakers as a set percentage of the manufacturer's production of conventional vehicles. Each car produced earns a number of credits based on the type of ZEV and its battery range.

Production plus fuel consumption criteria: China defines annual percentage targets for automakers in the country based on NEV credits and, most importantly, surplus credits earned as part of the NEV mandate can be used to offset deficits in the automaker's fuel consumption compliance values.

Credit trading and flexibility mechanism: Automakers that have not built electric vehicles could buy surplus ZEV credits from those who have in order to avoid penalties. Automakers have the opportunity to offset credit requirements by overreaching GHG emission targets or winning over-compliance credits. This is aimed at boosting manufacturer commitment.

CO_2 emission-based targets: In Europe, each automaker has a specific 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.

Table 27: Summary of design elements of ZEV mandates and additional incentives that support EV adoption

			USA (California)	China	EU
Applicability to manufacturers	Manufacturer eligibility		Must produce and sell in California > 4,500 units	Must produce or import > 20,000 units	All manufacturers under GHG program qualify
	Manufacturer categories		> 20,000: large 20,000-4,500: intermediate <4,500: small	<20,000: small	No provision
Credit allocation	BEV	Eligibility criteria	Range > 50 miles	Range > 100 km, maximum speed > 100 kmph	All BEVs qualify
		Basis of credit allocation	Range	Range, Battery energy density, power consumption	All BEVs get full credits towards market share
	FCEV	Eligibility criteria	Range > 50 miles	Range > 300 km	CO_2 emission < 50 g CO_2/km
		Basis of credit allocation	Range	Power of fuel cell of FCEV	CO_2 emission of PHEVs
	PHEV	Eligibility criteria	Range > 10 miles	No provision	All FCEVs qualify
		Basis of credit allocation	Range	Power consumption of PHEV	All FCEVs get full credits towards market share
Credit surplus			Banking allowed; trading allowed	Banking allowed at a discount rate of 50%; Selling credits allowed	No provision

		USA (California)	China	EU
GHG-ZEV integration	Target compensation	Extra GHG credits can compensate ZEV credit deficits	Extra ZEV credits can compensate GHG credit deficits	Extra ZEV market share can lead to relaxed GHG targets
	Condition for compensation	If GHG target exceeded by manufacturer by at least 2 g CO_2/km	No condition	Capped at 5% relation of GHG target
Penalties		$5,000 per credit deficit	Denial of type approval of new models	No provision
Additional incentives	Fiscal incentives related to Vehicle Segments	No direct purchase subsidy Federal income tax exemptions of upto $7500 based on battery capacity (with phase out policy after 2,00,000-unit sales of manufacturer)	NEV incentives based on battery size and range (with a phase out policy for 2020-22) Exemption from purchase tax Reduced license plate fee	Country specific*: Norway: No direct purchase incentives Netherlands: Incentive based on vehicle cost Denmark: Incentive based on vehicle cost Common for countries: Reduced road tax Reduced registration tax Reduced VAT
Additional incentives	Fiscal incentives related to charging infrastructure	Tax credits can account for up to 30% of installation cost based on power output of EVSE	National and regional charging network layout for 2015-20 for 800 fast charging stations along Locally funded subsidies for installing chargers based on power output	Country specific*: Norway: State funded subsidies Netherlands: No purchase subsidy Denmark: Incentive based on power output
	Non-fiscal incentives	Free municipal parking Priority lane access Exempt from toll on high occupancy toll lanes Exemption from emission inspections	No restrictions on EV license plates but restrictions on ICE plates Reserved parking Reduced parking fees Exemption from road traffic restriction Exempted road toll	Common for countries: Reduced tolls on roads Access to bus lanes Reduced parking fee and reserved parking Designated environment zones for eco-friendly vehicles

Source: CSE compilation; *Norway, Denmark and Netherlands have some of the highest EV shares in EU

Global ZEV mandates studied by CSE revealed that they can be powerful tools to build volumes in electric vehicles. What works in favour of a ZEV mandate is that it provides certainty around the outcome and encourages investors by providing strong signals. In addition, it offers flexibility to 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. A low target does not provide an incentive for companies to exceed it.

A mandatory annual requirement for credits, expressed as a percentage of overall production or sales, which rises over time, could become a platform to push for larger ZEV sales as manufacturers sell an increasing proportion of ZEVs each year to meet a rising requirement for ZEV credits.

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.

Setting up a ZEV credit trading mechanism—as part of which if a manufacturer does not produce ZEVs, they can purchase excess ZEV credits from a competitor—could go a long way in inspiring larger numbers of conventional manufacturers to come forward to be counted. It could also encourage the entry of new specialist ZEV manufacturers, who can sell credits to other manufacturers.

7.3 Post-pandemic economic recovery to promote EVs

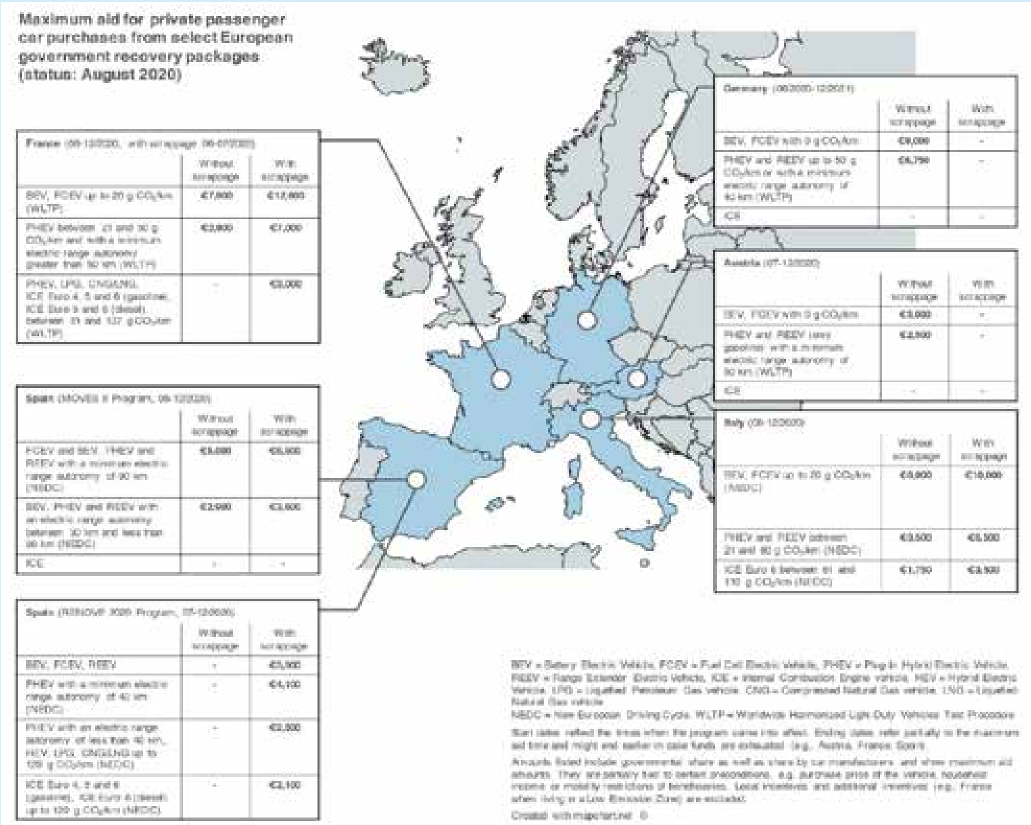
While incentive programmes have evolved rapidly and in varying combinations with different results, the market shock of the COVID-19 pandemic has catalysed another trend in which several governments have linked their economic recovery packages with fiscal stimuli for EVs.

Leveraging economic recovery has been important not only to survive the pandemic but also to ensure green recovery. According to the UNEP's Emission Gap Report in 2020, global fiscal action on economic recovery last year amounted to USD 12 trillion, or 12 per cent of global GDP. Several governments have framed conditional and preferential measures in the bailout packages to support green measures. They have provided direct support for zero-emissions energy technologies and clean energy infrastructure.

According to IEA, the nature and focus of stimulus measures this time is different from the earlier measures designed during the 2008–09 financial crisis. This time there has been a more specific focus on promoting uptake of electric and hybrid vehicles and countries have additionally adopted a more integrated approach for the transport sector by supporting charging infrastructure, public transport and nonmotorized mobility. Governments have increased purchase incentives or have delayed phase-out of subsidies and adopted vehicle scrappage policy to encourage EV purchase. At the same time, countries like Germany have not provided any subsidies to conventional cars.

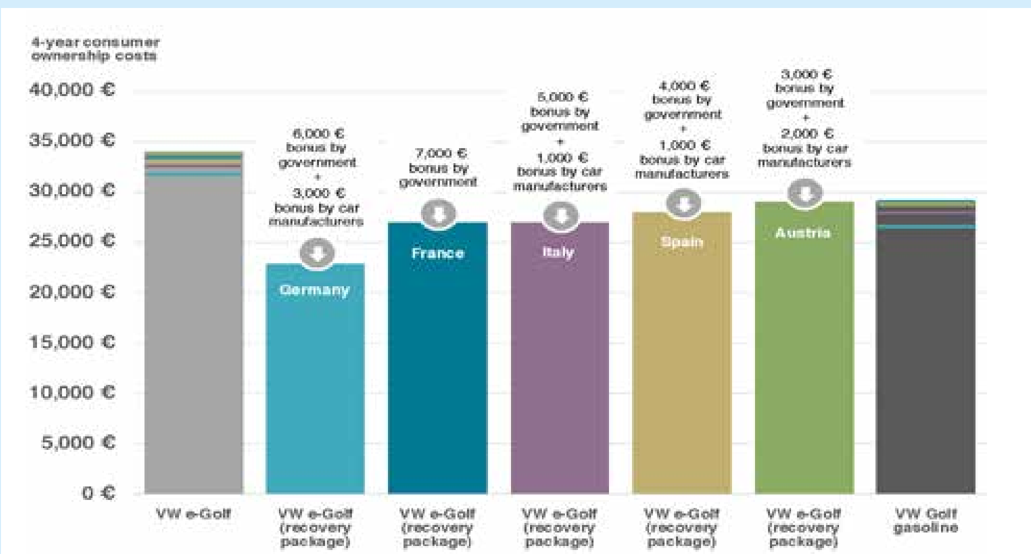
Overview of subsidies and incentives during pandemic in Europe

Map of Europe indicating EV subsidies



Source: ICCT

Impact of subsidy on e-car prices



Source: ICCT

Despite the drop in sale of IC engines during the pandemic, EV sales have remained robust in Europe as the government support for electrification combined with tougher CO_2 standards have continued. Electric cars are now 10 per cent of the new car sales. China has continued with a subsidy policy for NEVs. Governments have backed loans to vehicle manufacturers with environmental conditions among others.

Signs related to the economic impact of the COVID-19 pandemic show that many segments in the global automotive market have been significantly impacted by reduced demand, as well as by challenges along the complex automotive supply chain. Countries that implemented the COVID-19 economic stimulus package had the option to focus on the entire automotive industry, considering its value as a large driver of the economic machine. But they did not.

Instead, they chose to use the stimulus package as an opportunity to promote electric vehicles (see *Box: Overview of subsidies and incentives during pandemic in Europe*). The pandemic had already established a case for an environmentally sensitive economic package, as it demonstrated how widespread economic destabilization is possible if development plans do not pay attention to health and environmental concerns. In response, Europe used its stimulus programme to build a dominating role for climate change activities and pushed aggressively for an acceleration in the transition towards electric vehicles.

The public transport centred e-mobility programme is greatly relevant to India's decarbonization goal, as the majority in Indian cities are public transport users, especially buses. The electric bus therefore presents a unique opportunity to decarbonize a sizeable share of daily commute in cities and also reduce toxic exposures. While the current incentive programmes for electric vehicles have a priority focus on buses, and rightly so, there is considerable scope of further improvement in designing incentives for effective deployment. Future reforms will have to enable a new ecosystem for e-buses that has a bearing on the strategies for procurement, deployment, service conditions, charging options, and monitoring of service level to maximize gains.

8. Conclusion and way forward

There is a strong global learning curve to inform the next steps in India. The reforms during this decade require clear focus on strategies and policy design that will help to accelerate the change. India not only needs to be on track for the conservative target of at least 30@30 and but also build ambition to meet NITI Aayog's professed target of 70 per cent electrification by 2030.

This requires clear milestones and enablers to increase the one per cent market share that EVs currently have. Policy action has to get stronger both at the central and state government levels.

Reform FAME: This short-term programme requires longer term policy visibility. Currently, the four-year scheme has been extended until 2024 to fully utilize unspent funds. More time will be spent to roll out the originally planned vehicle stock and not catalyse bigger changes. Post FAME II strategy needs to be framed immediately to provide longer term market signals and bring certainty in the roadmap.

While framing the new strategy and amending the current programme, attention has to be paid to current flaws in the incentive design. For instance, incentives are currently linked with battery size and thus inhibit the innovation of smaller batteries with higher energy density and life. Well designed long-term incentive programmes can help to contribute towards the more ambitious target of 70 per cent set by NITI Aayog. Further reform will have to be appropriate for each vehicle segment.

In the case of e-buses, bus procurement strategy has to be leveraged for more holistic planning and service delivery. This has already begun with the reform of the tendering process that has shifted focus from only bus specifications to stating service and operational requirements including identification of bus routes, depot infrastructure, quality of power supply, tariff, etc. E-bus procurement has made the tender process more service oriented as STUs now prefer to specify their service needs instead of only specifying details of the vehicles. This needs to be strengthened further.

Bus funding should not be restricted to only GCC based operational model as this is forcing some public transit agencies to adopt a completely new bus operating model that may require substantial changes in their organizational structure. While there is merit in this approach as this helps to reduce upfront costs while improving the efficiency of services, more flexible operational models can enable more capable STUs with better ecosystem support to organize their operations as per their needs, local planning and strength.

FAME II should be linked with service guarantee. Currently, FAME II is providing capital incentive up to 40 per cent of total bus cost and the whole subsidy amount is supposed to be paid within six to seven months of bus operations. This does not allow much scope for service guarantee. This can be further reformed to provide the same support for longer operation period of at least seven years, considering battery replacement requirement.

The demand aggregation method for e-bus and autorickshaws is an opportunity to lower costs and engage in collective planning. This needs to be designed well for the model cities to build learning curve for others.

The larger bus augmentation plan under the current Union Budget, which states that it will support 20,000 buses, needs to be linked with targeted electrification with adequate support. This strategic support can expand economies of scale and lower total cost of ownership.

The 2030 target will also require cars to be on board. Both central and state governments will have to provide more ecosystem support, tax waivers, non-fiscal preferential incentives, reliable charging network and facilities, and initial support for a targeted e-car fleet. While strengthening the incentive programmes, it is important to pay attention to bridging the gap between certified level of driving range of vehicles and the on-road performance to build consumer confidence. This will require improvement in test procedures and adoption of WLTC to bridge the gap between certification and real-world range performance of EVs.

FAME II subsidy should also be designed to create more options for a combination of charging technologies. Currently, e-buses with only conduction charging facilities dominate the market. Charging options for pentagraph charging or battery swapping or any other approach need to be promoted. It is possible to adopt battery lease model (in which a private partner will be repsonsible for battery and setting up charging infrastructure) to reduce upfront cost.

FAME II incentives also need to acknowledge that e-bus deployment requires detailed planning before deployment and city level comprehensive fleet planning for routes and charging. City level e-bus deployment plans are needed to provide for e-bus oriented transit infrastructure like depots, terminals, bus stops, etc. The state should also proactively assist the power sector in improving grid capacity by providing benefits.

As part of an intermediate public transport strategy in cities, a targeted mandate for fleet electrification could be useful.

Incentives for E2W and E3W need to be linked with a mandate for targeted electrification within a specified timeline. Similarly, e-cargo fleet and fleet aggregators (ride hailing, delivery fleet, feeder services) need agreement with the service providers to commit to targeted electrification.

While direct fiscal incentives can be a powerful tool to make vehicle acquisition affordable, the key to scale will clearly be a combination of OEM price, government support, product diversity and model availability, and charging infrastructure.

Need zero emissions mandate in India: The only way to address the challenges of low model availability, inadequate charging facilities and insufficient promotion of the new technology, apart from a skewed cost-to-benefit ratio and low volumes, is to notify zero emissions mandate and targets. Electric vehicle production deficit can be addressed with a target and mandate programme.

This can help to build supply with larger model availability leading to larger adoption. Once the target has been formally defined, this can inform a roadmap to include a zero emission vehicle production mandate combined with a credit system and effective emission target standards that will provide a push for the production of zero emission vehicles. In addition, 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.

A ZEV credit trading mechanism can even bring into the fold those manufacturers that do not produce EVs; 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 targets and mandate and incentive based strategies. 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.

The government can therefore play the role of a facilitator by setting targets and timelines for electric vehicle production and fuel efficiency, that are both ambitious and achievable. 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.

Besides, a mandate is also a revenue neutral strategy for the government as it harnesses 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.

Incentive-based strategies that can help producers and consumers overcome cost barriers are already in place to an extent, but they require further tweaking to generate investor interest. 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.

Manufacturers can qualify for ZEV programme 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.

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.

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 programmes.

This strategy of mandate and target is needed urgently to drive scale. There is already a lesson from the legal mandate for large scale CNG programme in Delhi that was driven by the Supreme Court directive in July 1998. This had asked for the entire public transport and para transit to move to CNG within a well-defined period and accordingly the mandate for its refuelling infrastructure was defined. That has catalysed one of the largest CNG programmes in Delhi. Once the mandate was in place, that stimulated CNG bus manufacturing and other ancillary development. Mandates become necessary to enable penetration of new technology in the face of strong competition from the well-entrenched mainstream technologies like petrol and diesel.

Need disincentives for internal combustion engines: Review of the global good practices have borne out that while designing aggressive and longer term effective incentive programme to catalyse demand and supply of EVs, it is equally important to disincentivize internal combustion engines (petrol and diesel) with tax measures, pricing policy, non-fiscal measures or specific segment oriented phase out plans to improve competitive position and opportunities for EVs. This has been widely practiced in Nordic and Scandinavian countries, elsewhere in Europe, and in China. India needs to design such a programme.

Leverage fuel efficiency regulations to accelerate EV market: Yet another accelerator for electrification is the fuel efficiency regulation for vehicles. A strong benchmark can accelerate electrification of the vehicle fleet. Other countries have leveraged these regulations to fast-pace electrification. India needs to take immediate steps to further tighten efficiency standards not only for passenger cars but also for heavy duty vehicles and two-wheelers.

Accelerating localization: The Government of India has rolled out the PLI programme to rebuild and support giga-scale advanced cell manufacturing of upto 50 GWh batteries and generate new jobs. The scheme has earmarked Rs 18,000 crore for manufacturers to set up production units of at least 5 GWh. It is also proposed to increase the import tax on battery cells from 5 per cent to 15 per cent after 2022. PLI provides incentives between 2–12 per cent of the incremental sales revenue and 4–7 per cent of incremental exports revenue. This is linked to the National Mission on Transformative Mobility and Battery Storage, 2019, to promote local manufacturing of the entire value chain related to raw materials, electrochemistry, modules, battery packs and end-of-life treatment of cells.

However, there are still broad concerns that could impact its take-off. First, a timeframe of five years is too short to drive adequate commitment from manufacturers. Given the size of the investment required for batteries (the PLI scheme defines Rs 225 crore for a 5 GWh plant) in an area of uncertain scale economies, evolving battery chemistries and high uncertainty about the short and medium-term volumes, it is too large a risk if the support structures and roadmap are not clear after five years.

For PLI strategy to be successful, the market has to reach critical numbers to catalyse a much larger EV market to build demand for batteries. Otherwise, investment in battery cell manufacturing will remain rigid and slow. This will require more strategic incentives for a wider genre of vehicle segments to build demand and scale. The FAME II incentive for 1.5 lakh vehicles can create demand for small battery capacity cells. The 30@30 target will require much larger battery capacity. ICCT has estimated the expected growth in EV fleet by 2030 and shows that India will need annual addition of 246.9 GWh and cumulative addition of 824.7 GWh in 2030. Clearly, a much stronger staretgy is needed to address this.

Second, the PLI scheme incentives will be disbursed only on the basis of incremental sales from products manufactured in domestic units. Which means, a lack of matching demand from the EV sector for the planned production volumes of batteries could result in the manufacturer missing out on the promised incentives and hurting profitability. Thus EV market with long term incentives and mandate is critical.

Building battery ecosystem: Building a battery ecosystem to support an ambitious electrification target presents a challenge and requires well-defined strategies addressing each aspect of the ecosystem—battery production and raw material sourcing, battery assembly and management, among others.

The battery and electric vehicle industry needs scale economies to be viable. The sector will require large capital infusion to scale up battery cell manufacturing and battery pack assembly. Indian efforts at manufacturing battery cells will benefit from the gains in cost reduction achieved globally that may fall below $100 per kWh. Policies should be able to promote diverse battery chemistry to reduce reliance to only a limited set of raw materials.

Once the battery performance is reduced, these would need to be downgraded for further use or otherwise recycled. This will require proper collection, dismantling and disposal facilities. Recycling can help to recover lithium, cobalt, or nickel and require appropriate technologies to improve the rate of recovery. This requires regulatory mandate to ensure collection of spent batteries and to have adequate scale for recycling. This requires standardized battery products with information on the chemistry used and streamlined networks for battery collection to be put into place before old batteries can be harvested for the expensive metals used in them. While recovering expensive materials, the environmental cost of disposing off hazardous materials can be avoided. Used batteries can be repurposed and reused in stationary storage applications and thus reduce the lifecycle cost of batteries, lowering the cost of electric vehicles and making them more cost-competitive. This requires policy measures for adequate supply of retired EV batteries for energy storage applications. Directives on scalable recycling technologies and regulations on recovery rates for strategic resources such as lithium, cobalt, manganese, nickel, and graphite are also essential.

Accelerating charging infrastructure: Several policy reforms have been initiated by Ministry of Power to enable use of electricity for EVs. Direct support is also available for charging under FAME. Several states in India are now coming up with their own strategy for establishing a network of charging stations to induce electric vehicle adoption in their markets. But this is not adequate. Immediate steps are needed to address the investment deficit in charging infrastructure. The cost of charging equipment, land and grid connectivity requires initial capital. Access to capital continues to be a challenge with banks as well as non-banking financial companies.

It is time to develop robust EV charging standards. Indian manufacturers use the Bharat DC 001 and AC 001 connectors which are based on the Chinese GB/T connector standard. Since Bharat AC and DC chargers cannot charge all types of vehicles, new charging standards are required. Bureau of Indian Standards and Department of Science and Technology are currently working on indigenous charging standards for India. An innovative low cost AC charger is supposed to be released soon.

The rules related to the grid upgradation strategies, land availability for private investments in charging, absence of subsidy support to battery swapping, double taxation levied on charging services, and operational difficulties related to the open-access regulation threshold—as indicated in the WBSCD study—need to be addressed quickly. Allocation of affordable and accessible land for private investors will have to be addressed. There is a need to permit battery swapping to avail of FAME subsidy and reduce GST on charging and battery swapping services. Swapping requires a standardized system of battery cavities, interoperability of batteries and chargers. This is a system that will work well for the commercial segment and needs to be developed.

Locally appropriate charging infrastructure will have to be developed quickly. Infrastructure for EVs in public spaces like commercial centres, and institutional and office areas would also be required. It is also important to select the right kind of charging technology to scale it up for creating a citywide network. Varying usage patterns and charging requirements according to vehicle types makes the decision even more complex.

State level EV policy to drive electrification: About 15 states in India have either notified or drafted EV policies that support the national electric mobility agenda aimed at addressing barriers to electrification on the demand and supply side as well as market enablers such as charging. Most state policies chart out a multi-phase roadmap to electrification focussed on facilitating EV and EV component manufacturing and consumer adoption. Seven states (Andhra Pradesh, Bihar, Karnataka, Maharashtra, Odisha, Tamil Nadu, Telangana and Uttar Pradesh) have defined investment and job targets and designed packages according to the size of manufacturing capacity. Though most states have set segment-wise targets for 100 per cent conversion for two- and three-wheelers by 2030, three of these states (Andhra Pradesh, Karnataka and Uttar Pradesh) offer only road and registration tax exemption for EV adoption on the demand side and skip purchase incentives completely.

The state level policies need to be shaped for ambition and targeted transformation. The current policies have varying scope. While some policies focussed on manufacturing offer incentives such as interest free loans and reimbursement of GST for companies aiming to set up factories, others offer facilitation of business infrastructure with subsidies on capital, and support schemes related to land, water, electricity, waste disposal and testing facilities during the policy tenure of five years, barring Delhi where the policy tenure is three years. The state policies also reflect specific priorities of each state. Kerala focuses on retrofitting ICE vehicles, while only three (Odisha, Delhi and Punjab) provision for scrappage incentives. And only two states (Odisha and Delhi) define technical eligibility for availing incentives pointing at a disconnect with the national level policy ambition.

State policies also require alignment to create equal opportunities across states and prevent fragmentation of the market, across all states. Therefore effectiveness of the currently designed policies requires an evaluation. The Government of India has already carried out an evaluation of some of them including that of Karnataka to suggest modifications.

Address challenges of financing the EV market: The 2021 NITI Aayog report has estimated that with EV sales penetration across segments at about 70 per cent in 2030, the cumulative capital cost of India's EV transition is expected to be Rs 19.7 lakh crore between 2020 and 2030. And the estimated size of the organized EV finance market is around Rs 3.7 lakh crore. Therefore, strategies to mobilize capital and financing are required.

But this has not excited the financial market yet. However, at the state level some efforts are being made to work with financial institutions. But a lot more is needed. High financing cost and uncertainty around the nascent small market, fuzzy long term targets and concerns around the performance and resale value of these products have failed to build confidence in the financing sector. This has led to the problem of high interest and insurance rates, low loan-to-value ratio, and limited financing options for retail customers. This results in unsecured borrowing from the unorganized sector at even higher rates.

Different vehicle segments have different challenges and the economics for each use pattern will be different. The 2021 NITI Aayog report has recommended that both central and state governments need to increase access to low-cost financing. RBI can include Priority Sector Lending (PSL) mandates for EVs to increase finance available for them. The central government or multilateral organizations can capitalize risk-sharing facilities to provide longer-tenure, lower risk financing. Lowering of interest rate for EV buyers can be mandated to lower the cost of financing for end-users. More states should come up with interest rate subvention in their respective state EV policies.

Ensuring product guarantees for the long term on products in the market can mean that more OEMs can partner with financing bodies due to assured vehicle performance and increased resale values. OEMs can also offer maintenance and repair services free of cost for specific time periods after the purchase.

Risk sharing mechanisms created by government and multilateral organizations can cover loan repayment risks for the financial institutions, making them more proactively send out loans. They can lower the cost of financing by capitalizing risk-sharing facilities. They can also offer low-interest loans and other financing products to start-ups, fintech companies, and more.

Banks are beginning to change their products. SBI has started the Green Car Loan, the only specialized product for electric cars, in April 2019. Fleet operators can offer risk sharing mechanisms with financial institutions by providing guarantees for their driver partners including partial credit guarantees for full-time driver partners to share default risk with FIs. They can also offer utilization guarantees to driver partners to help achieve TCO parity while improving fleet economics, innovate business model and set target for fleet electrification targets.

Start-ups and fintech are part of the EV financing ecosystem. Venture capital funding is catalysing this sector with innovative business models and manufacturing. This can play a bigger role in two/three-wheeler markets where financing penetration is low and can support the first time EV buyers without credit history.

Scrappage policy as an EV stimulus : Yet another lost opportunity in India is the failure to leverage the vehicle scrappage policy to accelerate electrification. Post-COVID, there was strong expectation that the scrappage policy would be leveraged the way global governments have deployed it to expand electrification. But Motor Vehicles (Registration and Functions of Vehicle Scrapping Facility) Rules, 2021 announced in March 2021 have not made that connection. In its current form, the policy is an instrument directed at material recovery and the sourcing value chain closing the loop with recycling and safe disposal.

The government expects the policy to affect around 51 lakh aging vehicles (20 year old) and their removal to build demand for new vehicles. But this regulation could have been designed for accelerating electrification, as is the global good practice.

References and endnotes

1 The United Nation's statement in November 2020

2 Anon 2020. Global EV Outlook. IEA. Accessed at https://www.iea.org/reports/global-ev-outlook-2020

3 Anon 2021. *Net Zero by 2050, A Roadmap for the Global Energy Sector*, *Flagship report — May 2021.* IEA. Accessed at https://www.iea.org/reports/net-zero-by-2050

4 Anon. *FAME India scheme phase II,* National Automotive Board. Accessed at https://fame2.heavyindustry.gov.in/ on 28 July 2020

5 David Stringer et al 2020. *The Electric Car Battery Boom Has Screeched to a Halt*. Bloomberg. Acessed at https://www.bloomberg.com/news/articles/2020-06-17/the-electric-car-battery-boom-has-screeched-to-a-halt-for-now

6 Manish Mathur, Rahul Mishra, Bhaskar Rakshit and Harneet Singh 2020. *Electric mobility 2.0: tracking the next wave in India*. Kearney. Accessed at https://www.kearney.in/article/?/a/electric-mobility-2-0-tracking-the-next-wave-in-india

7 Aditi Shah 2019. *Exclusive: India plans to order taxi aggregators like Uber, Ola to go electric - documents.* Reuters. Accessed at https://www.reuters.com/article/india-electric-autos-idINKCN1T805J

8 Anon. *Fuel Efficiency*. Bureau of Energy Efficiency, Government of India, Ministry of Power. Accessed at https://beeindia.gov.in/content/fuel-efficiency

9 Anon 2014. *Report of the Expert Committee on Auto Fuel Vision & Policy 2025*. Government of India. Accessed at http://petroleum.nic.in/sites/default/files/autopol.pdf

10 Leonardo Paoli et al 2020, *Fuel Consumption of Cars and Vans, Tracking report — June 2020.* IEA. Accessed at https://www.iea.org/reports/fuel-consumption-of-cars-and-vans

11 Pramoda Gode, Georg Bieker, and Anup Bandivadekar 2021. *Battery capacity needed to power electric vehicles in India from 2020 to 2035*. ICCT WORKING PAPER 2021-07

12 Dr Hao Wu et al 2019. *New Market. New Entrants. New Challenges. Battery Electric Vehicles*. Deloitte. Accessed at https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf

13 Anon 2019. *GST on electric vehicles, chargers slashed*. The Hindu Business Line. Accessed at https://www.thehindubusinessline.com/economy/gst-council-meet-tax-on-electric-vehicles-slashed/article28730571.ece

14 Anon 2021. *Policies for India's global leadership on EV adoption: Accelerating commercial fleet electrification and attracting private investments in charging.* WBCSD. Accessed at https://www.wbcsd.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Mobility-Decarbonization/Coalitions/Resources/Policies-for-India-s-global-leadership-on-EV-adoption

15 Anon 2021. *Mobilising finance for EVs in India: A toolkit of solutions to mitigate risks and address market barriers*. NITI Aayog and Rocky Mountain Institute. Accessed at https://rmi.org/insight/mobilizing-finance-for-evs-in-india/

16 Ibid.

17 Ibid.

18 Ibid.

19 Parth Charan 2021. *Budget 2021: What the vehicle scrappage policy means for private car owners, explained*. MoneyControl.com. Accessed at https://www.moneycontrol.com/news/business/budget-2021-what-the-vehicle-scrappage-policy-means-for-private-car-owners-explained-6429231.html

20 Pramoda Gode, Georg Bieker and Anup Bandivadekar 2021. *Battery capacity needed to power electric vehicles in India from 2020 to 2035.* ICCT. Accessed at https://theicct.org/publications/battery-capacity-ev-india-feb2021

21 To understand India's 30@30 target, the study followed a three step process to arrive at findings.
First, a regression model was used to estimate total annual vehicle registrations segment wise to 2030 using 2011 vehicle registrations data as the base to arrive at a value for projected EVs.
Second, an evaluation of compounded annual growth rate for EV market share from 2021 to 2030 was done to arrive at insights on the required pace of growth.
Third, a standalone projection for electric vehicles (segment wise) based on EV registrations since FY 2012 when EVs began appearing in the Indian market was done to tally results achieved in the first two steps. Assumptions used in the study were:
All EVs by 2030 will be battery electric and based on lithium-ion batteries

Buses, four-wheelers, two-wheelers, three-wheelers and light goods vehicles will form a majority of EV sales in 2030 E-rickshaws and <25 kmph E2Ws will likely form a part of the EV stock in 2030 when they get recognized by government criteria and therefore need to be studied, although separately.
The vehicle segments used in study are – electric two-wheelers, electric three-wheelers, electric four-wheelers, electric buses and electric goods vehicles.

22 Vahan Dashboard. Accessed at https://vahan.parivahan.gov.in/vahan4dashboard/ on 24 June 2020

23 Seric et al 2020. *Managing COVID-19: How the pandemic disrupts global value chains*. World Economic Forum. Accessed at https://www.weforum.org/agenda/2020/04/covid-19-pandemic-disrupts-global-value-chains/

24 Kishan Singh Bhorde 2020. *Pandemic, China conflict delay induction of e-bus to NWKSRTC*. Times of India. Accessed at https://timesofindia.indiatimes.com/city/hubballi/covid-strained-ties-with-china-delay-induction-of-electric-buses-to-nwkrtc/articleshow/78879458.cms

25 Statista Research Department 2021. *Market share of bus sales in India FY 2020, by manufacturer.* Statista. Accessed at https://www.statista.com/statistics/1094600/india-bus-market-share-by-manufacturer/

26 Aparna Vijaykumar, Dr Parveen Kumar et al 2021. *Procurement of Electric Buses: Insights from Total Cost of Ownership (TCO) Analysis*. WRI India – Ross Center. Accessed at https://wri-india.org/sites/default/files/WRI_EBus_Procurement_Commentary_FINAL.pdf

27 Anal Sheth and Debasis Sarkar 2019. *Life Cycle cost analysis for electric vs diesel bus transit in an Indian scenario*. International Journal of Technology

28 Sangeetha Chengappa 2019. *Grofers goes green for last-mile delivery; hopes to cut costs, too*. The Hindu Business Line. Accessed at https://www.thehindubusinessline.com/info-tech/grofers-goes-green-for-last-mile-delivery-hopes-to-cut-costs-too/article28658234.ece

29 Manish Mathur, Rahul Mishra, Bhaskar Rakshit and Harneet Singh 2020. *Electric mobility 2.0: tracking the next wave in India*. Kearney. Accessed at https://www.kearney.in/article/?/a/electric-mobility-2-0-tracking-the-next-wave-in-india

30 Anon 2021. *Policies for India's global leadership on EV adoption: Accelerating commercial fleet electrification and attracting private investments in charging*. WBCSD. Accessed at https://www.wbcsd.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Mobility-Decarbonization/Coalitions/Resources/Policies-for-India-s-global-leadership-on-EV-adoption

31 Anon 2020. *Online Taxi Services Market in India: Profiles of Leading Market Players Including ANI Technologies, Carzonrent and Uber India - ResearchAndMarkets.com*. Business Wire. Accessed at https://www.businesswire.com/news/home/20200515005415/en/Online-Taxi-Services-Market-in-India-Profiles-of-Leading-Market-Players-Including-ANI-Technologies-Carzonrent-and-Uber-India---ResearchAndMarkets.com

32 Anon 2020. *Uber vs Ola: Battle for dominance has restarted*. Economic Times. Accessed at https://economictimes.indiatimes.com/small-biz/startups/newsbuzz/uber-vs-ola-battle-for-dominance-has-restarted/articleshow/74055006.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

33 Anon 2021. *Policies for India's global leadership on EV adoption: Accelerating commercial fleet electrification and attracting private investments in charging*. WBCSD. Accessed at https://www.wbcsd.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Mobility-Decarbonization/Coalitions/Resources/Policies-for-India-s-global-leadership-on-EV-adoption

34 Ibid.

35 Ola Electric. Accessed at https://olaelectric.com/#design-intro

36 Anon 2020. *How the pandemic has hit Ola, Uber hard in India*. Economic Times. Accessed at https://economictimes.indiatimes.com/mobile/how-the-pandemic-has-hit-ola-uber-hard-in-india/articleshow/76956369.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

37 Anon. *Zero emissions for home deliveries*. Ikea. Accessed at https://about.ikea.com/en/sustainability/becoming-climate-positive/zero-emissions-for-home-deliveries

38 Tarush Bhalla 2021. *Amazon India partners with Mahindra Electric to expand EV fleet*. Livemint. Accessed at https://www.livemint.com/companies/news/amazon-india-partners-with-mahindra-electric-to-expand-ev-fleet-11614059054461.html

39 Aditi Shah 2019. *Exclusive: India plans to order taxi aggregators like Uber, Ola to go electric - documents.* Reuters. Accessed at https://www.reuters.com/article/india-electric-autos-idINKCN1T805J

40 Anon 2021. *Policies for India's global leadership on EV adoption: Accelerating commercial fleet electrification and attracting private investments in charging*. WBCSD. Accessed at https://www.wbcsd.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Mobility-Decarbonization/Coalitions/Resources/Policies-for-India-s-global-leadership-on-EV-adoption

41 Ibid.

42 Nibedita Dash, Sandra Wappelhorst and Anup Bandivadekar 2021. *Updated analysis of incentives for electrifying India's four-wheeler ride-hailing fleet, Working paper.* ICCT. Accessed at https://theicct.org/publications/update-electrifying-india-ride-hailing-fleet-apr2021

43 Ibid.

44 Anon 2021. *Mobilising finance for EVs in India: A toolkit of solutions to mitigate risks and address market barriers*. NITI Aayog and Rocky Mountain Institute. Accessed at https://rmi.org/insight/mobilizing-finance-for-evs-in-india/

45 Vaibhav Asher 2020. *Market share of two-wheelers India FY 2020, by leading manufacturer*. Statista. Accessed at https://www.statista.com/statistics/610445/two-wheeler-market-share-by-manufacturer-india/#:~:text=At%20 the%20end%20of%20fiscal,to%20the%20previous%20fiscal%20year

46 Nilesh Wadhwa 2021. *Hero Electric retains top spot on two-wheeler EV sales chart in 2020*. Autocar India. Accessed at https://www.autocarindia.com/bike-news/hero-electric-retains-top-spot-on-two-wheeler-ev-sales-chart-in-2020-419825

47 Anon 2021. *Lithium Urban Technologies acquires SmartCommute*. Live Mint. Accessed at https://www.livemint.com/companies/start-ups/lithium-urban-technologies-acquires-smartcommute-11622029586348.html

48 Nitish Arora et al 2019. *Beyond Nagpur: The promise of electric mobility*. Ola Mobility Institute. Accessed at https://olawebcdn.com/ola-institute/nagpur-report.pdf

49 Aditi Shah 2018. *Insight: Ola's sputtering India electric vehicle trial a red flag for Modi plan*. Reuters. Accessed at https://www.reuters.com/article/india-autos-electric-idINKCN1GL0CU

50 xEVs include all types of electromotive vehicles – Battery electric (BEV), Hybrid (HEV), Plug-in Hybrid (PHEV) and Fuel-cell electric (FCEV)

51 Anon 2020. *FAME India Scheme*. MoHIPE. Accessed at https://pib.gov.in/newsite/PrintRelease.aspx?relid=191377

52 *FAME India scheme phase II.* National Automotive Board. Accessed at https://fame2.heavyindustry.gov.in/ on 28 July 2020

53 David Stringer et al 2020. *The Electric Car Battery Boom Has Screeched to a Halt*. Bloomberg. Accessed at https://www.bloomberg.com/news/articles/2020-06-17/the-electric-car-battery-boom-has-screeched-to-a-halt-for-now

54 Ibid.

55 Anon 2017. *Expression of Interest for inviting proposal for availing incentives under FAME India scheme of Government of India form State Government Departments/ Undertakings/ Municipal Corporations for million plus*. Department of Heavy Industry. MoHIPE

56 Anon. *Fuel Efficiency*. Bureau of Energy Efficiency, Government of India, Ministry of Power. Accessed at https://beeindia.gov.in/content/fuel-efficiency

57 Anon 2014. *Report of the Expert Committee on Auto Fuel Vision & Policy 2025*. Government of India. Accessed at http://petroleum.nic.in/sites/default/files/autopol.pdf

58 Leonardo Paoli et al 2020, *Fuel Consumption of Cars and Vans, Tracking report — June 2020*. IEA. Accessed at https://www.iea.org/reports/fuel-consumption-of-cars-and-vans

59 Zifiei Yang 2019. *Looking back to look ahead: India's fuel consumption standards*, ICCT. Accessed at https://theicct.org/blog/staff/looking-back-look-ahead-india-fuel-consumption-standards

60 Anon 2016. *Chart library: Passenger vehicle fuel economy*. ICCT. Accessed at https://theicct.org/chart-library-passenger-vehicle-fuel-economy

61 Anon 2021. *Govt clears Rs 18,100-cr PLI scheme for battery manufacturing*. Business Today. Accessed at https://www.businesstoday.in/latest/economy-politics/story/govt-clears-rs-18100-cr-pli-scheme-for-battery-manufacturing-295747-2021-05-13

62 Pramoda Gode, Georg Bieker, and Anup Bandivadekar 2021. *Battery capacity needed to power electric vehicles in India from 2020 to 2035*. ICCT WORKING PAPER 2021-07

63 Anon 2020. *Automobile export trends*. SIAM. Accessed at https://www.siam.in/statistics.aspx?mpgid=8&pgidtrail=15

64 Pramoda Gode, Georg Bieker, and Anup Bandivadekar 2021. *Battery capacity needed to power electric vehicles in India from 2020 to 2035*. ICCT WORKING PAPER 2021-07

65 Frost and Sullivan 2020. *Post Covid Future of Electric Vehicles in India*. Accessed via Economic Times Webinar on 21 April 2020

66 Gert Berckmans et al 2017. *Cost Projection of State of the Art Lithium-Ion Batteries for Electric Vehicles Up to 2030*. Energies, MDPI. Available at https://www.mdpi.com/1996-1073/10/9/1314/pdf

67 Nathaniel Bullard 2020. *This Is the Dawning of the Age of the Battery.* Bloomberg Green. Accessed at https://www.bloomberg.com/news/articles/2020-12-17/this-is-the-dawning-of-the-age-of-the-battery

68 Anon 2017. *Adopting Pure Electric Vehicles: Key Policy Enablers*. SIAM. Accessed at https://www.siam.in/uploads/filemanager/114SIAMWhitePaperonElectricVehicles.pdf
69 Frost and Sullivan 2020. *Post Covid Future of Electric Vehicles in India*. Accessed via Economic Times Webinar on 21 April 2020
70 Among the colour codes used in the matrix, green stands for 'clearly defined' regulations, peach stands for 'vaguely defined', grey for 'not defined' and brick for 'doesn't exist'.
71 Press Information Bureau. Government of India.
72 Anon. EV CHARGING STATIONS SANCTIONED / INSTALLED UNDER FAME INDIA. FAME India Scheme-II. Ministry of Heavy Industries, Government of India. Accessed at https://dash.heavyindustry.gov.in/dhics
73 Anon 2019. *GST on electric vehicles, chargers slashed*. The Hindu Business Line. Accessed at https://www.thehindubusinessline.com/economy/gst-council-meet-tax-on-electric-vehicles-slashed/article28730571.ece
74 Press Information Bureau. Government of India.
75 Anon. *Details of EVCS/ PCI as on 30th June 2020 under the jurisdiction of discoms/ licensee/ PSUs.* Government of India, Ministry of Power, Central Electricity Authority, R&D Division. Accessed at https://cea.nic.in/wp-content/uploads/ev_charging_rep/2020/07/ev-06.pdf
76 N. Mohan 2020. 'India's emerging Electric Vehicles Charging Infrastructure Outlook- Striding towards economies of scale'. *Innovating energy: Charging India's e-mobility revolution*, EESL. Accessed at https://www.eeslindia.org/content/dam/doitassets/eesl/pdf/newsletters/Newsletter2020/EESL_May_Newsletter.pdf on 24 June 2020.
77 Anon 2019. *Towards e-mobility: putting the consumer at the wheel*. PwC. Accessed at https://www.pwc.in/assets/pdfs/industries/capital-projects-and-infrastructure-publications/towards-emobility.pdf
78 Dr Hao Wu et al 2019. *New Market. New Entrants. New Challenges. Battery Electric Vehicles*. Deloitte. Accessed at https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/manufacturing/deloitte-uk-battery-electric-vehicles.pdf
79 Anon 2013. *Pathways to high penetration of electric vehicles*. Committee on Climate Change, Element Energy Ltd, University of Aberdeen. Accessed at https://www.theccc.org.uk/wp-content/uploads/2013/12/CCC-EV-pathways_FINAL-REPORT_17-12-13-Final.pdf
80 Anon 2021. *Policies for India's global leadership on EV adoption: Accelerating commercial fleet electrification and attracting private investments in charging*. WBCSD. Accessed at https://www.wbcsd.org/Programs/Cities-and-Mobility/Transforming-Urban-Mobility/Mobility-Decarbonization/Coalitions/Resources/Policies-for-India-s-global-leadership-on-EV-adoption
81 Press Information Bureau. Government of India.
82 Anon 2021. *Mobilising finance for EVs in India: A toolkit of solutions to mitigate risks and address market barriers*. NITI Aayog and Rocky Mountain Institute. Accessed at https://rmi.org/insight/mobilizing-finance-for-evs-in-india/
83 Ibid.
84 PTI 2021. *Budget 2021: Society of Manufacturers of Electric Vehicles calls for rejig of FAME II*. Indian Express. Accessed at https://www.newindianexpress.com/business/2021/jan/25/budget-2021-society-of-manufacturers-of-electric-vehicles-calls-for-rejig-of-fame-ii-2254865.html
85 Sohinder Gill, Director General, Society of Manufacturers of Electric Vehicles
86 Lecture organized by SIAM titled *Hybrid and Electric Vehicles in India: Development, Testing & Homologation*, in April 2021. Senior industry executives spoke about the significance of a dedicated EV platform to be able to build efficient vehicles. Nitin Seth, COO, Switch Mobility, Ashok Leyland,
87 Sohinder Gill 2019. *The rational roadmap to electric mobility*. 2019 Two-wheeler Industry Conclave, Autocar. Accessed at https://www.autocarpro.in/video/sohinder-gill--the-rational-roadmap-to-electric-mobility--2019-twowheeler-industry-conclave-55865
88 Delhi Electric Vehicle Policy 2020. Government of National Capital Territory of Delhi (GNCTD).
89 Ibid.
90 Ibid.
91 Ibid.
92 Ibid.
93 Ibid.
94 Ibid.
95 Anon 2020. *Demand for lithium batteries from e-bikes to increase more than 70% in 2021*. SMM News. Accessed at https://news.metal.com/newscontent/101327471/demand-for-lithium-batteries-from-e-bikes-to-increase-more-than-70-in-2021-/ in January 2021
96 Anon 2021. *Leading motorcycle manufacturers in China in 2020, by sales volume*. Statista. Accessed at https://www.statista.com/statistics/314722/china-monthly-leading-motorcycle-manufacturers-by-sales-volume/

97 Jonathan Weinert, Chaktan Ma and Christopher Cherry 2006. *The Transition To Electric Bikes In China: History And Key Reasons For Rapid Growth*. Institute of Transportation Studies, UC Davis, Working Paper Series. Accessed at https://www.researchgate.net/publication/46439985_The_Transition_To_Electric_Bikes_In_China_History_And_Key_Reasons_For_Rapid_Growth

98 Christopher Cherry 2010. *Electric Two-Wheelers in China: Promise, Progress and Potential*. Accessed at https://www.accessmagazine.org/fall-2010/electric-two-wheelers-china-promise-progress-potential/

99 Kersten Heineke, Benedikt Kloss, Darius Scurtu and Florian Weig 2019. *Micromobility's 15,000-mile checkup*. McKinsey. Accessed at https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/micromobilitys-15000-mile-checkup

100 International Labour Organisation 2020. *The future of work in the automotive industry: The need to invest in people's capabilities and decent and sustainable work.* Issues paper for the Technical Meeting on the Future of Work in the Automotive Industry (Geneva, 15–19 February 2021)

101 Ibid.

102 Anon 2017, *How will electric vehicle transition impact EU jobs?* Transport and Europe, Germany. Accessed at https://www.transportenvironment.org/sites/te/files/publications/Briefing%20-%20How%20will%20electric%20vehicle%20transition%20impact%20EU%20jobs.pdf

103 Ibid.

104 Anh Bui, Peter Slowik and Nic Lutsey 2021. *Power play: Evaluating the U.S. position in the global electric vehicle transition*. ICCT. Accessed at https://theicct.org/publications/us-position-global-ev-jun2021

105 Joe Miller 2020. *Berlin insists German carmakers can fend off China battery threat*. Financial Times. Accessed at https://www.ft.com/content/7131f586-499c-11ea-aeb3-955839e06441

106 Anon 2020. *Germany Amps Up Domestic Battery Production With Massive State Subsidies*. Germany Trade & Invest. Accessed at https://www.prnewswire.com/news-releases/germany-amps-up-domestic-battery-production-with-massive-state-subsidies-301086012.html

107 International Energy Agency, 2021, Global EV Outlook 2021, Technology Report

108 Anon 2021. FORD EUROPE GOES ALL-IN ON EVS ON ROAD TO SUSTAINABLE PROFITABILITY; COLOGNE SITE BEGINS $1 BILLION TRANSFORMATION. Ford Media Center. Accessed at https://media.ford.com/content/fordmedia/feu/en/news/2021/02/17/ford-europe-goes-all-in-on-evs-on-road-to-sustainable-profitabil.html

109 Anon 2019. *China wants new energy vehicle sales in 2025 to be 25% of all car sales*. Reuters. Accessed at https://www.reuters.com/article/us-china-autos-electric-idUSKBN1Y70BN

110 Kirsten Korosec 2020. *EV startup Nio secures $1 billion investment from China entities*. TechCrunch. Accessed at https://techcrunch.com/2020/04/29/ev-startup-nio-secures-1-billion-investment-from-china-entities/

111 Anon 2020. *VW boosts investment in electric and autonomous car technology to $86 billon*. Reuters. Accessed at https://www.reuters.com/article/volkswagen-strategy-idUSKBN27T24O

112 Fred Lambert 2020. *Daimler announces $85 billion investment, mostly toward accelerating electrification*. Electrec. Accessed at https://electrek.co/2020/12/03/daimler-investment-mostly-toward-accelerating-electrification/

113 Stephen Edelstein 2020. *BMW re-ups electric-vehicle commitment—and hydrogen fuel-cell investment*. Green Car Reports. Accessed at https://www.greencarreports.com/news/1128075_bmw-re-ups-electric-vehicle-commitment-and-hydrogen-fuel-cell-investment

114 Colin Beresford 2020. *Ford, GM Production Plans Are Full of SUVs, Not Electric Vehicles*. Car and Driver. Accessed at https://www.caranddriver.com/news/a31944369/ford-gm-production-plans-suvs-pickups/

115 Anon 2019. *China's Electric Vehicle Market: A Storm of Competition Is Coming*. Knowledge@Wharton, University of Pensylvania. Accessed at https://knowledge.wharton.upenn.edu/article/chinas-ev-market/

116 Anon 2015. *Attack of the Chinese Tesla Clones*. Wired Magazine. Accessed at https://www.wired.com/2015/10/attack-of-the-tesla-clones-from-china/

117 Mark Kane 2020. *10 Chinese EV Battery Makers Plan To Pass 50 GWh Capacity By 2025*. Inside EVs. Accessed at https://insideevs.com/news/397955/10-chinese-battery-makers-50-gwh-2025/

118 Roland Zenn 2021. Li-on Battery Gigafactories in Europe (January 2021). Orovel. Accessed at https://www.orovel.net/insights/li-on-battery-gigafactories-in-europe-january-2021

119 Victoria Klesty 2021. *Electric cars rise to record 54% market share in Norway in 2020*. Reuters. Accessed at https://www.reuters.com/article/us-autos-electric-norway-idUSKBN29A0ZT

120 Benjamin Myklebust 2013. *EVs in bus lanes – controversial incentive*. EVS27 Barcelona, Spain, November 17-20, 2013. Accessed at http://e-mobility-nsr.eu/fileadmin/user_upload/downloads/info-pool/EVs_in_bus_lane_Benjamin_Myklebust_ZERO_EVS27.pdf

121 A policy support study for the European Commission Directorate General Mobility & Transport, 2021, carried out as part of the EAFO project, The transition to a Zero Emission Vehicles fleet for cars in the EU by 2050 Pathways and impacts: An evaluation of forecasts and backcasting the COP21 commitments
122 Robert Duffer 2021. *Why Norway leads the world in world electric vehicle adoption*. Green Car Reports. Accessed at https://www.greencarreports.com/news/1123160_why-norway-leads-the-world-in-electric-vehicle-adoption
123 http://www.ieahev.org/by-country/denmark-policy-and-legislation/
124 Anon 2011. *Sweden Follows Suit with Electric Car Subsidy*. The Global herald. Accessed at https://web.archive.org/web/20111017103803/http://theglobalherald.com/sweden-follows-suit-with-electric-car-subsidy/24444/
125 http://www.ieahev.org/by-country/denmark-policy-and-legislation/
126 Aparna Menon, Zifei Yang, Anup Bandivadekar 2019. *Electric vehicle guidebook for Indian states*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/India_EV_State_Guidebook_20191007.pdf
127 Sveinung Kvalø 2020. Volkswagen Golf in Norway – from diesel to electric. Norsk elbilforening. Accessed at https://elbil.no/volkswagen-golf-in-norway-from-diesel-to-electric/
128 Robert Duffer 2021. *Why Norway leads the world in world electric vehicle adoption*. Green Car Reports. Accessed at https://www.greencarreports.com/news/1123160_why-norway-leads-the-world-in-electric-vehicle-adoption
129 European Alternative Fuels Observatory - Finland. Accessed at https://www.eafo.eu/countries/finland/1732/vehicles-and-fleet
130 Anon. Technology Collaboration Programme by IEA. Finland - EV Adoption by Year. Accessed at https://ieahev.org/countries/finland/
131 Michael Kujawa 2021. *Linkker e-bus production on hold*. Urban Transport Magazine. Accessed at https://www.urban-transport-magazine.com/en/linkker-e-bus-production-on-hold/
132 Anon 2016. EVE - Electric Vehicle Systems 2011-2015. Accessed at https://www.businessfinland.fi/globalassets/julkaisut/eve_final_report.pdf?_t_
133 Ibid.
134 Ibid.
135 Aparna Menon, Zifei Yang, Anup Bandivadekar 2019. *Electric vehicle guidebook for Indian states*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/India_EV_State_Guidebook_20191007.pdf
136 Anon 2016. *EU-voertuigregistraties alternatieve brandstoffen*. Koninklijke RAI Vereniging. Accessed at https://www.raivereniging.nl/artikel/nieuwsberichten/2016-q3/0908-europese-voertuigregistraties-alternatieve-brandstoffen.html
137 Steve Hanley 2018. *Denmark Rethinks EV Incentives After Market Collapses*. Clean Technica. Accessed at https://cleantechnica.com/2018/05/01/denmark-rethinks-ev-incentives-after-market-collapses/
138 Alister Doyle 2019. *From California to Oslo: foreign subsidies fuel Norway's e-car boom, for now*. Reuters. Accessed at https://in.reuters.com/article/autos-norway/from-california-to-oslo-foreign-subsidies-fuel-norways-e-car-boom-for-now-idINKCN1R20H6
139 Sören Amelang 2021. Germany enters 2021 with price on transport and heating emissions. Clean Energy Wire. Accessed at https://www.cleanenergywire.org/news/germany-enters-2021-price-transport-and-heating-emissions
140 Jessica Elgot 2021. *Rishi Sunak freezes fuel duty over reliance on cars in pandemic.* The Guardian. Accessed at https://www.theguardian.com/politics/2021/feb/24/rishi-sunak-freezes-fuel-duty-over-reliance-on-cars-in-pandemic
141 Anon 2020. *Ending fuel duty freeze could treble NHS budget*. Government Business. Accessed at https://governmentbusiness.co.uk/news/10032020/ending-fuel-duty-freeze-could-treble-nhs-budget
142 The Worldwide Harmonised Light Vehicle Test Procedure (WLTP) laboratory test, which came into force in 2017 and is based on real driving data, is used to measure fuel consumption and CO_2 emissions from passenger cars, as well as their pollutant emissions.
143 Anon 2018. *France tightens grip on polluting cars by ramping up eco taxes*. The Local. Accessed at https://www.thelocal.fr/20180720/france-tightens-grip-on-polluting-cars-with-stricter-eco-tax
144 Ibid.
145 Ibid.
146 Ibid.
147 Anon. Website of Federal Government of Germany. Change in vehicle tax. Accessed at https://www.bundesregierung.de/breg-de/aktuelles/kfz-steuer-1759368
148 Ibid.
149 Anon 2021. *Germany rings in 2021 with CO_2 tax, coal phase-out*. Economic Times. Accessed at https://energy.economictimes.indiatimes.com/news/coal/germany-rings-in-2021-with-co2-tax-coal-phase-out/80055509

150 Elisa Miebach and Stefan Nicola 2020. *Electric-Car Subsidies Make Renaults Free in Germany*. Bloomberg Green. Accessed at https://www.bloomberg.com/news/articles/2020-07-15/electric-car-subsidies-have-rendered-renaults-free-in-germany

151 Anon. European Alternative Fuels Observatory - France. Accessed at https://www.eafo.eu/countries/france/1733/incentives

152 Anon. *Company car tax on electric cars*. EDF Energy. Accessed at https://www.edfenergy.com/electric-cars/tax-road-company

153 Anon 2014. *Großstädte lehnen Privilegien für Elektroautos ab*. Der Spiegel. Accessed at https://www.spiegel.de/auto/aktuell/elektroautos-auf-busspuren-grossstaedte-lehnen-dobrindts-plan-ab-a-986467.html

154 Anon. Urban Access Regulations in Europe - Paris. Accessed at https://urbanaccessregulations.eu/countries-mainmenu-147/france/paris

155 Anon 2009. Internal Revenue Bulletin: 2009-48. United States Government. Acessed at https://www.irs.gov/irb/2009-48_IRB

156 David Shepardson 2021. *U.S. Senate panel advances EV tax credit of up to $12,500*. Reuters. Accessed at https://www.reuters.com/world/us/us-senate-panel-advances-ev-tax-credit-up-12500-2021-05-27/

157 Sean O'Kane 2019. *GM will be the second automaker to lose the EV tax credit, while Bolt sales stumble*. The Verge. Accessed at https://www.theverge.com/2019/1/3/18166619/gm-ev-tax-credit-bolt-sales

158 Letter (Sub: Section 30D Electric Vehicle Credit) from coalition of energy providers to Reps. Paul Ryan (R-WI), Nancy Pelosi (D-CA), Kevin Brady (R-TX) and Richard E. Neal (D-MA), and Sens. Mitch McConnell (R-KY), Chuck Schumer (D-NY), Orrin G. Hatch (R-UT) and Ron Wyden (D-OR), 13 March 2018. Accessed at http://consideringthegrid.com/wp-content/uploads/2018/03/FINAL-EV-Tax-Credit-Letter-3-13-18.pdf

159 Sharon Silke Carty 2010. *Obama pushes electric cars, battery power this week*. USA Today: DriveOn. Accessed at http://content.usatoday.com/communities/driveon/post/2010/07/obama-pushes-electric-cars-battery-power-this-week-/1#.YMs-zagzbIU

160 Aparna Menon, Zifei Yang, Anup Bandivadekar 2019. *Electric vehicle guidebook for Indian states*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/India_EV_State_Guidebook_20191007.pdf

161 US CAFE Final Rule, NHTSA

162 S hunsuke Tabeta and Nikkei Asia 2020. *China plans to phase out conventional gas-burning cars by 2035*. Nikkei Asia. Accessed at https://asia.nikkei.com/Business/Automobiles/China-plans-to-phase-out-conventional-gas-burning-cars-by-2035

163 Anon 2019. *CHINA: LIGHT-DUTY: FUEL CONSUMPTION*. TransportPolicy.net. Accessed at https://www.transportpolicy.net/standard/china-light-duty-fuel-consumption/

164 Zhinan Chen and Hui He 2021. *The second phase of China's new energy vehicle mandate policy for passenger cars*. ICCT. Accessed at https://theicct.org/publications/china-new-energy-vehicle-mandate-phase2-may2021

165 Nancy W. Stauffer 2021. China's transition to electric vehicles. MIT News. Accessed at https://news.mit.edu/2021/chinas-transition-electric-vehicles-0429

166 Anon 2020. *ICCT Policy Update: China announced 2020–2022 subsidies for new energy vehicles*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/China%20NEV-policyupdate-jul2020.pdf

167 Anon. Government of China. Notice on Improving the Financial Subsidy Policy for the Promotion and Application of New Energy Vehicles. Accessed at http://www.gov.cn/zhengce/zhengceku/2020-04/23/content_5505502.htm

168 Anon 2020. *ICCT Policy Update: China announced 2020–2022 subsidies for new energy vehicles*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/China%20NEV-policyupdate-jul2020.pdf

169 Anon. China Association of Automobile Manufacturers. Announcement on the average fuel consumption and new energy vehicle points of Chinese passenger car companies in 2019. Accessed at http://www.caam.org.cn/chn/1/cate_2/con_5230951.html

170 Anon 2019. *CHINA: LIGHT-DUTY: FUEL CONSUMPTION*. TransportPolicy.net. Accessed at https://www.transportpolicy.net/standard/china-light-duty-fuel-consumption/

171 Chen Huizhi 2021. *New car plate restrictions come into force from May 6*. Shine. Accessed at https://www.shine.cn/news/metro/2104257963/

172 Danhua Ouyang, Xunmin Ou, Qian Zhang and Changgui Dong 2019. 'Factors influencing purchase of electric vehicles in China'. *Mitigation and Adaptation Strategies for Global Change* Vol. *25*, pp 413–440. https://doi.org/10.1007/s11027-019-09895-0

173 Bloomberg 2018. *Huge Break for Auto Companies as China Removes Ownership Caps*. Industry Week. Accessed at https://www.industryweek.com/the-economy/article/22025492/huge-break-for-auto-companies-as-china-removes-ownership-caps

174 NDRC, 2018. Negative list, accessed at https://www.ndrc.gov.cn/xxgk/zcfb/fzggwl/202006/P020200624549035288187.pdf

175 Ibid.

176 Min Zhang and Pratima Desai 2020. *China aiming to add to its cobalt stockpile - sources*. Reuters. Accessed at https://www.reuters.com/article/china-cobalt-stockpiling-idUKL4N2G82DV

177 Liu Yuanyuan 2020. *China installed more than 1000 EV charging stations per day in 2019*. Renewable Energy World. Accessed at https://www.renewableenergyworld.com/2020/01/13/china-installed-more-than-1000-ev-charging-stations-per-day-in-2019/#gref

178 Yue Zhang 2016. *Why the government should not keep subsidizing the New Energy Vehicles*. Ministry of Finance of PRC. Accessed at http://www.mof.gov.cn/zhengwuxinxi/caizhengxinwen/201603/t20160302_1828176.html

179 Echo Huang 2019. *Beijing gave its biggest electric-vehicle maker $1 billion in help toward a single year of sales*. Quartz. Accessed at https://qz.com/1579568/how-much-financial-help-does-china-give-ev-maker-byd/

180 Anon 2020. *Zero-Emission Vehicle Program.* CARB. Accessed at https://ww2.arb.ca.gov/our-work/programs/zero-emission-vehicle-program/about

181 Corey Singleton 2019. *The Fascinating History of Tesla and the General Motors EV1*. Medium. Accessed at https://medium.com/pushtostart/the-fascinating-history-of-tesla-and-the-general-motors-ev1-f00e4af62f78#:~:text=The%20story%20of%20Tesla%20begins,could%20reach%20these%20strict%20standard.

182 Anon. *CALIFORNIA: LIGHT-DUTY: EMISSIONS*. TransportPolicy.net. Accessed at https://www.transportpolicy.net/standard/california-light-duty-emissions/

183 Anon 2020. *Low-Emission Vehicle (LEV II) Program.* California Air Resources Board. Accessed at https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/lev-program/low-emission-vehicle-lev-ii-program

184 Anon 2020. *Advanced Clean Cars Program.* CARB. Accessed at https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program

185 Ibid.

186 Jihu Zheng, Rujie Yu, Yong Liu, Yuhong Zou and Dongchang Zhao 2019. *The Technological Progress of the Fuel Consumption Rate for Passenger Vehicles in China: 2009–2016*. China Automotive Technology and Research Center. Accessed at https://www.mdpi.com/1996-1073/12/12/2384/pdf#:~:text=To%20reduce%20the%20fuel%20consumption,and%20regulations%20for%20passenger%20vehicles.&text=China%20also%20set%20the%20FCR,L%2F100%20km%20in%202025.

187 Anon. *Zero emission vehicle (ZEV) regulation*. ICCT. Available at https://www.theicct.org/sites/default/files/5c_ARB_ZEV.pdf

188 Aparna Menon, Zifei Yang, Anup Bandivadekar 2019. *Electric vehicle guidebook for Indian states*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/India_EV_State_Guidebook_20191007.pdf

189 Ibid.

190 Ibid.

191 Anon 2019. *CO_2 EMISSION STANDARDS FOR PASSENGER CARS AND LIGHT-COMMERCIAL VEHICLES IN THE EUROPEAN UNION*. ICCT Policy Update. Accessed at https://theicct.org/sites/default/files/publications/EU-LCV-CO2-2030_ICCTupdate_20190123.pdf

192 2025 onwards and 2030 onwards mean that the phased implementation (phased means only some portion of vehicles counted towards emission targets) starts in 2021, and by 2025 and 2030 all vehicles should meet these targets.

193 Anon. *CO_2 emission performance standards for cars and vans*. European union. Accessed at https://ec.europa.eu/clima/policies/transport/vehicles/regulation_en

194 Anon 2021. *Average CO_2 emissions from new cars increased in 2019 ahead of stricter 2020 targets.* European Union. Accessed at https://ec.europa.eu/clima/news/average-co2-emissions-new-light-duty-vehicles-registered-europe-2019_en

195 Anon 2019. *CO_2 EMISSION STANDARDS FOR PASSENGER CARS AND LIGHT-COMMERCIAL VEHICLES IN THE EUROPEAN UNION*. ICCT Policy Update. Accessed at https://theicct.org/sites/default/files/publications/EU-LCV-CO2-2030_ICCTupdate_20190123.pdf

196 Anon 2020. *Measures for the Parallel Management of Average Fuel Consumption of Passenger Car Companies and New Energy Vehicle Credits*. MIIT. Accessed at http://www.miit.gov.cn/n1146295/n1652858/n7280902/c7988463/content.html

197 Anon 2020. Global EV Outlook. IEA. Accessed at https://www.iea.org/reports/global-ev-outlook-2020

198 Hongyang Cui 2018. *China's New Energy Vehicle mandate policy*. ICCT. Accessed at https://theicct.org/sites/default/files/publications/China_NEV_mandate_PolicyUpdate%20_20180525.pdf

199 A Neighbourhood Electric Vehicle (NEV) is a U.S. category for battery electric vehicles that are usually built to have a top speed of 25 miles per hour (40 km/h), and have a maximum loaded weight of 3,000 lb (1,400 kg). Depending on the particular laws of the state, they are legally limited to roads with posted speed limits of 35 miles per hour (56 km/h) or less (in some states 45 mph or less). NEVs fall under the United States Department of Transportation classification for low-speed vehicles. Source: https://one.nhtsa.gov/cars/rules/rulings/lsv/lsv.html

200 Sandra Wappelhorst 2020. *Economic recovery packages in response to COVID-19: Another push for electric vehicles in Europe?*" ICCT. Accessed at https://theicct.org/blog/staff/economic-recovery-covid-19-ev-europe-aug2020

201 Ibid.

202 Pramoda Gode, Georg Bieker, and Anup Bandivadekar 2021. *Battery capacity needed to power electric vehicles in India from 2020 to 2035*. ICCT WORKING PAPER 2021-07

203 Anon 2021. *Mobilising finance for EVs in India: A toolkit of solutions to mitigate risks and address market barriers*. NITI Aayog and Rocky Mountain Institute. Accessed at https://rmi.org/insight/mobilizing-finance-for-evs-in-india/

204 Ibid.

205 Parth Charan 2021. *Budget 2021: What the vehicle scrappage policy means for private car owners, explained*. MoneyControl.com. Accessed at https://www.moneycontrol.com/news/business/budget-2021-what-the-vehicle-scrappage-policy-means-for-private-car-owners-explained-6429231.html

Sources used in *Table 16: Global electric vehicle incentives map*

India

https://dhi.nic.in/writereaddata/UploadFile/publicationNotificationFAME%20II%208March2019.pdf

https://transport.delhi.gov.in/sites/default/files/All-PDF/Delhi_Electric_Vehicles_Policy_2020.pdf

https://www.acma.in/uploads/doc/EV-policy-Uttarakhand.pdf

https://www.acma.in/uploads/doc/EV-policy-Telangana.pdf

https://www.acma.in/uploads/doc/EV-policy_Maharashtra.pdf

https://www.acma.in/uploads/doc/EV-policy-Kerala.pdf

https://www.acma.in/uploads/Tamil%20Nadu%20eV%20Policy%202019.pdf

Sweden

https://www.eafo.eu/countries/sweden/1755/incentives

https://blog.wallbox.com/en/sweden-ev-incentives/

https://www.government.se/press-releases/2018/04/government-makes-announcement-on-low-emission-zones

Annual circulation tax exemption

France

https://theicct.org/blog/staff/actions-speak-louder-words-french-commitment-electric-vehicles

https://www.eafo.eu/countries/france/1733/incentives

https://www.electrive.com/2021/02/15/france-to-fund-fast-charging-sites-with-e100mn/

https://easyelectriclife.groupe.renault.com/en/day-to-day/charging/understanding-the-electric-car-charging-cost/

https://easyelectriclife.groupe.renault.com/en/day-to-day/charging/electric-car-charging-points-the-possibilities/

UK

https://www.rac.co.uk/drive/news/motoring-news/Electric-car-given-green-plates-use-bus-lane-park-for-free/

https://www.fleetnews.co.uk/news/fleet-industry-news/2019/07/09/no-company-car-tax-on-electric-vehicles-says-government#:~:text=The%20Government%20says%20that%20company,)%20tax%20in%20 2020%2F21.&text=Pure%20electric%20company%20cars%20registered,%2F22%20and%202022%2F23.

https://www.driving.co.uk/news/roads/budget-2021-chancellor-rishi-sunak-plan-roads-cars/

Spain

https://urbanaccessregulations.eu/countries-mainmenu-147/spain

https://www.eafo.eu/countries/spain/1754/incentives

Norway

https://elbil.no/english/norwegian-ev-policy/

https://www.eafo.eu/countries/norway/1747/incentives

https://urbanaccessregulations.eu/countries-mainmenu-147/norway-mainmenu-197/oslo-charging-scheme

Netherlands

https://www.eafo.eu/countries/netherlands/1746/summary

https://theicct.org/blog/staff/netherlands-ev-leader-feb2021

https://www.government.nl/latest/news/2021/02/11/new-agreements-on-urban-deliveries-without-co2-emission

https://blog.wallbox.com/en/netherlands-ev-incentives/

https://autodelen.info/greendeal-autodelen

China

https://theicct.org/sites/default/files/publications/EV-costs-benefits-china-EN-apr2021.pdf

https://www.electrive.com/2020/04/23/chine-extends-ev-sales-tax-exemption-til-2022/#:~:text=The%20 Chinese%20government%20has%20now,tax%20in%202021%20and%202022.&text=According%20to%2-0reports%2C%20government%20subsidies,until%20the%20end%20of%202022.

https://www.sciencedirect.com/science/article/pii/S1364032119304149

https://www.forbes.com/sites/jackperkowski/2018/07/13/china-shifts-subsidies-for-electric-vehicles/?sh=b-b0e76f57032

https://news.bloombergtax.com/daily-tax-report-international/china-extends-rebates-for-electric-car-purchases-to-revive-sales

US

https://afdc.energy.gov/fuels/electricity_charging_home.html

https://www.chargepoint.com/incentives/federal-charging-incentives/

https://theicct.org/sites/default/files/publications/EV-cities-update-aug2020.pdf

https://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx

https://evcharging.enelx.com/resources/federal-and-state-electric-vehicle-incentives

Canada

https://www.caa.ca/sustainability/electric-vehicles/government-incentives/#:~:text=The%20Government%20of%20Canada%20offers,buy%20or%20lease%20an%20EV.

https://blog.fossnational.com/ev-fleet-benefits

https://theicct.org/sites/default/files/publications/Canada-Power-Play-ZEV-04012020.pdf

https://www.plugndrive.ca/public-charging/

https://montreal.ctvnews.ca/free-tolls-for-electric-vehicle-owners-in-quebec-continue-into-2021-1.5237253

https://www.tesla.com/en_CA/support/incentives

Japan

http://www.cev-pc.or.jp/english/cev-subsidy.html

https://www.electrive.com/2020/12/16/japan-doubles-electric-vehicle-subsidies/

https://www.japantimes.co.jp/news/2020/11/25/business/subsidies-electric-vehicles/

Rakuten Insight; https://www.statista.com/statistics/1027974/japan-electric-car-purchase-incentives/

https://www.researchgate.net/publication/24049709_Second-Best_Congestion_Pricing_in_Urban_Space_Cordon_Pricing_and_Its_Alternatives

https://smapenergy.com/time-energy-change-deep-dive-japans-first-smart-meter-enabled-tou-tariff/

South Korea

http://www.businesskorea.co.kr/news/articleView.html?idxno=60769

A global shift is underway from petro-economy to electro-economy. Electric vehicles play a big role in this change. This report by CSE assesses the action that has been taken so far, both in India and globally, to promote the use of electric vehicles. Based on what has been done, CSE makes recommendations about what can be done to make electric vehicles a reality for the masses in the future.

Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
Phones: 91-11-40616000 Fax: 91-11-29955879
Website: www.cseindia.org