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FORECASTING PENETRATION OF ELECTRIC TWO-WHEELERS IN INDIA

A BOTTOM-UP ANALYSIS

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TIFAC

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Acknowledgement

Driven by concerns over climate change, environmental pollution and energy security, the road transport sector is undergoing through a transformation with electric mobility promising to replace the conventional fossil fuel-based transport in near future. Thus, while determining the policy imperatives for the desired future, planning for infrastructure and ensuring an appropriate ecosystem, a prior estimate of possible level of penetration of electric two-wheelers is extremely useful. It is very important to have a bottom-up analysis of how various policies and economic, market and technological factors may influence consumer acceptance of electric vehicles. Keeping these issues in mind, NITI Aayog initiated the bottom up forecasting for electric two-wheelers in collaboration with TIFAC. Several models were deliberated, studied and discussed before finalizing an Agent Based tool for analyzing market penetration of electric vehicles on annual basis. Since in the Indian context two-wheelers have a very prominent role to play, this tool has been used for scenario analysis of electric two-wheelers penetration, resulting into the present report.

This work could be conceptualized because of the vision and inspiration of Mr. Amitabh Kant, CEO NITI Aayog, Mr. Sudhendu Sinha provided valuable guidance to the authors regarding the formulation of the Agent Based Model. Advices and comments received from other senior officials of NITI Aayog were instrumental in steering this activity to the right direction.

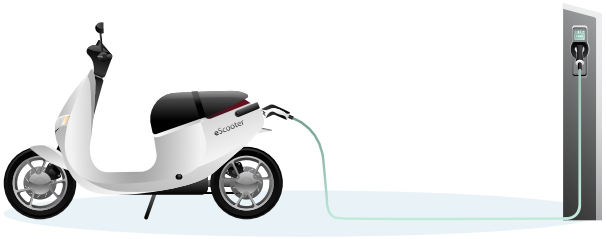
Valuable inputs were received from the automobile manufacturers, component manufacturers and Society of Indian Automobile Manufacturers (SIAM), either in response to specific query, or through discussions/brainstorming in various forums.

We would also like to thank our colleagues from TIFAC, NITI Aayog, various research institutions, educational institutions as well as others who participated in the consumer survey that enabled us to develop realistic data on Agent Attributes for use in the model.

We hope that this report will provide all relevant stakeholders with important insights and the Agent Based model, that can be easily customized for other categories of vehicles as well, will serve as a useful tool for the policy makers, industry, research community and other stakeholders.

Contents

EXECUTIVE SUMMARY



A shift towards electric mobility is essential for India considering high amount of petroleum imports, its adverse impact on the trade balance, valuable foreign exchange and environment. Since, two-wheelers dominate the Indian road transport sector this segment deserves an immediate attention. The electric two-wheeler technology has now matured to a significant level and a number of manufacturers have come out in the market with saleable products. In such context, a bottom-up estimation of future penetration of electric two-wheelers on yearly-basis will help to have important insights into the required infrastructure, manufacturing capability, policies and technology development priorities. Sensing this need TIFAC and NITI Aayog have jointly developed an Agent-based tool for analyzing the future penetration of electric two-wheelers in the country.

The tool was prepared based on the insights developed from extensive interactions of NITI Aayog and TIFAC team members with stakeholders in the electric mobility sector and detailed literature survey on various approaches adopted in other countries (e.g., USA, Germany and South Korea etc.) for forecasting the market penetration of electric vehicles. Surveys on available vehicle specifications, future plans of vehicle manufacturers for addition of manufacturing capacity of electric two-wheelers and consumer preference for various attributes of two-wheelers provided us the foundation for the development of this tool. It will help the governments, both central and states, to further frame their policies building upon the success of FAME-I and FAME-II schemes.

The basic underlying principle of this Agent-based model is to simulate the decision making of buyers. This is influenced by the attributes of the Agents, attributes of the vehicles available as options and combination of prevailing economic, technological, policy and market related factors. For an assessment of the distribution of consumer attributes, a survey was conducted. Specifications of available two-wheelers of both propulsion types – IC engine and electric were compiled and vehicles were classified into few categories. Based on announced plans of setting up vehicle manufacturing facilities and charging infrastructure an assessment of future production and availability of charging points was made. This process included a judicious estimate of appropriate values for the years for which no announced plans were available. Apart from the base level achieved this way,

two more levels of vehicle manufacturing and charging infrastructure were assumed and used in the scenario analysis. Assumption on overall two-wheelers market volume in future years was made based on the Compound Annual Growth Rate (CAGR) of the Indian two-wheelers market since 2015.

The tool has been used to create few possible scenarios that may unfold for the penetration of electric two-wheelers in the country depending on various driving forces like technology, economy, social and policy. A total of 8 quantitative scenarios were constructed on the basis of three major factors that may influence the market penetration of electric two-wheelers– demand incentives, cost of battery and vehicle performance in terms of range and power (Figure 1). Each of these factors have two possible levels: demand incentive can be either till FY 2024 or FY 2031; battery cost may reduce with CAGR of either 2% or 8%; and the range and power either improves by 5 % annually during FY 2024 to FY 2027 or remain same. However, for Technology Driven and Optimistic Scenarios, the improvement in FY 2027 is assumed to be 10% in anticipation of the introduction of better battery technology.

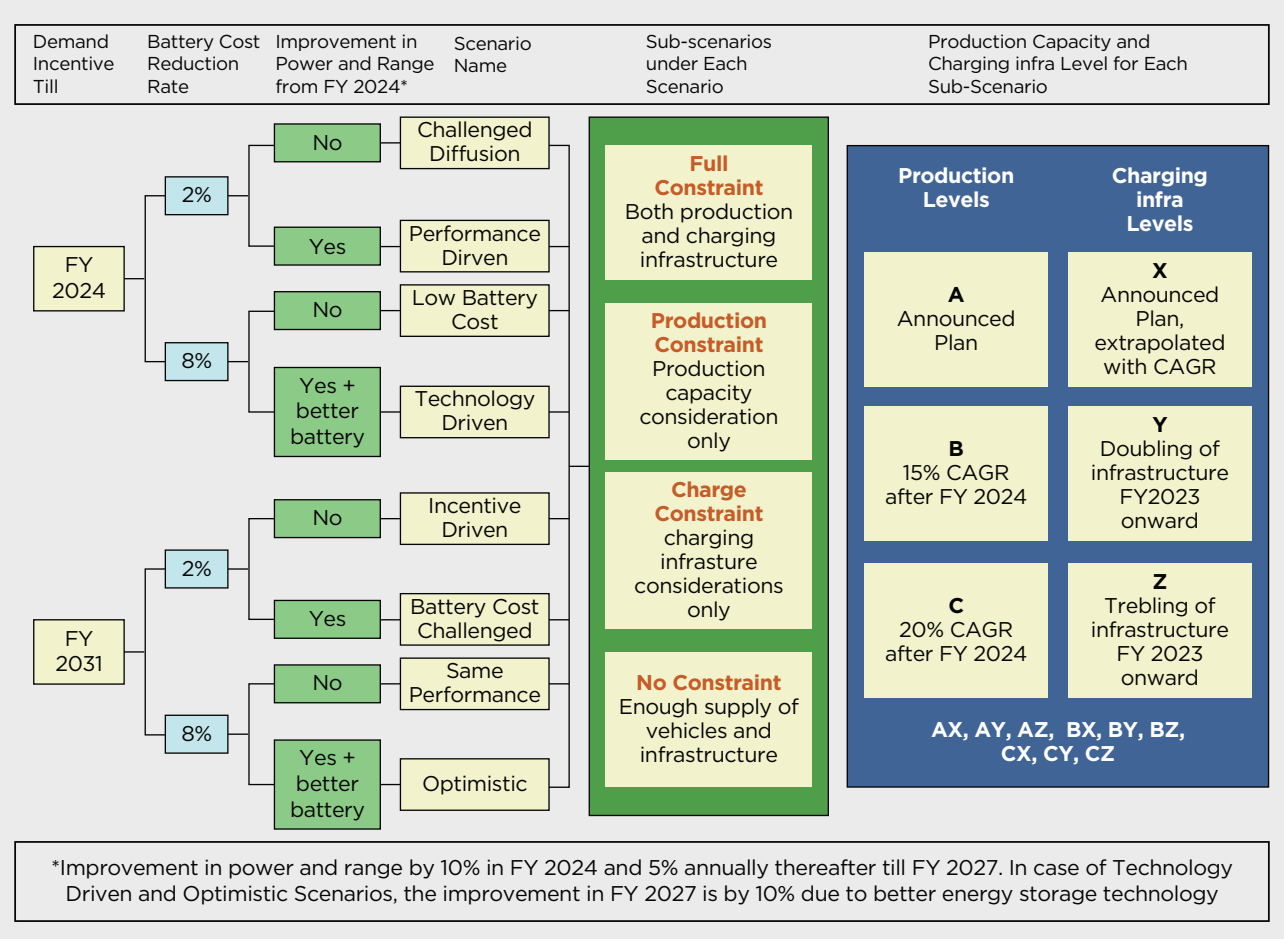


Figure 1: *Scenarios, sub-scenarios and constraint levels analysed using the tool*

For each of these 8 scenarios, four broad constraint levels were considered in terms of installed vehicle manufacturing capacity and available charging infrastructure – Full Constraint (both vehicle production and charging infrastructure are constraints), Production

Constraint (only vehicle production capacity is constraint), Charge Constraint (only charging infrastructure is constraint) and No Constraint. Three different levels were assumed both for vehicle manufacturing capacity and charging infrastructure, with the base level estimated on publicly made announcements and available information. For each scenario and constraint level, projections were made for annual electric vehicle market penetration, total sale, demand for charging points and annual battery demand for the electric two-wheelers. The Full Constraint condition can be considered as the reference for each scenario, with the sub-scenarios and other constraint conditions serving the purpose of getting insights into the latent demand of electric two-wheelers, battery and charging points.

From the scenario analysis, it was found that in the Full Constraint scenarios with base level of production capacity and charging infrastructure (Figure 2 and Table 1), it is possible to achieve 100% penetration of electric two-wheelers. However, there will be a need for enhancing the production capacity as sale of electric two-wheelers will otherwise be limited to the available numbers and thus their relative market share will go down.

Results obtained from the Full Constraint Sub-Scenarios (base level of production and infrastructure) under each of the eight Main Scenarios suggest that improvement in technology and reduction in battery cost are crucial for self-sustenance of electric mobility. With demand incentives withdrawn after FY 2024, maximum penetration is in Technology Driven Scenario, which is 71.54%. With no technological improvement and reduction in battery cost, penetration level of 21.86% only can be achieved even if incentives are continued till FY 2031. Combination of technological improvement and incentives can achieve 100% penetration.

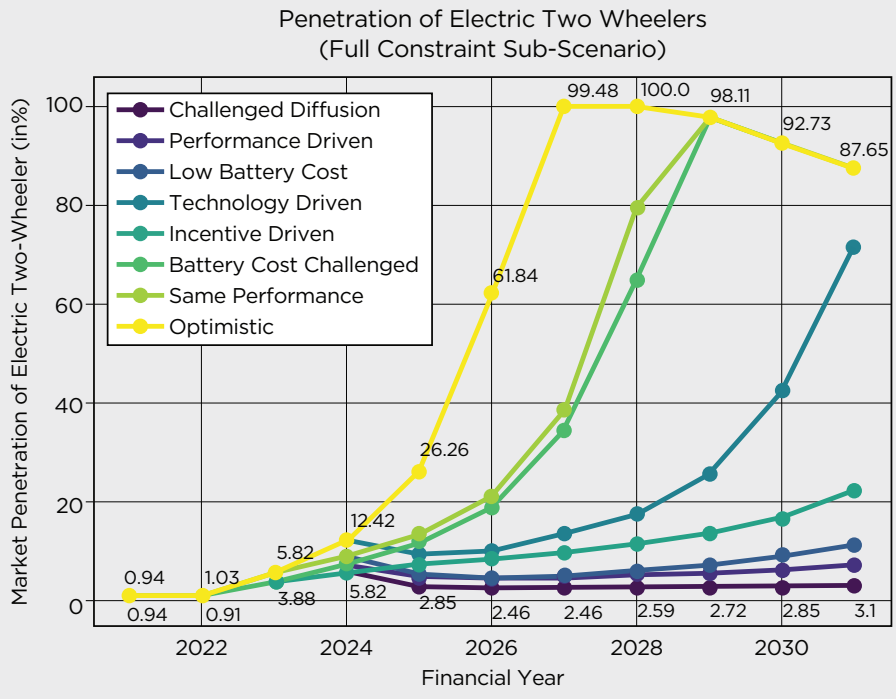


Figure 2: *Market penetration of electric two-wheelers in various scenarios*

Table 1: Market penetration (%) of electric two-wheeler under Full Constraint Sub-scenarios of various Main Scenarios

Financial Year	Incentive withdrawn after FY 2024				Incentive remain throughout			
	Battery cost reduces @2%		Battery cost reduces @8%		Battery cost reduces @2%		Battery cost reduces @8%	
	Power, Range Same	Power, Range Improved	Power, Range Same	Power, Range Improved	Power, Range Same	Power, Range Improved	Power, Range Same	Power, Range Improved
	Challenged Diffusion	Performance Driven	Low Battery Cost	Technology Driven	Incentive Driven	Battery Cost Challenged	Same Perfor-mance	Optimistic
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	1.03	1.03	0.91	0.91	1.03	1.03
2023	3.88	3.88	5.82	5.82	3.88	3.88	5.82	5.82
2024	5.82	7.50	9.06	12.42	5.82	7.50	9.06	12.42
2025	2.85	4.40	5.43	9.31	7.37	11.64	13.45	26.26
2026	2.46	4.27	4.27	9.96	8.41	18.89	20.83	61.84
2027	2.46	4.92	4.66	13.58	9.70	34.28	38.55	99.48
2028	2.59	5.30	6.08	17.59	11.51	64.81	79.17	100
2029	2.72	5.56	7.24	25.49	13.58	97.54	98.11	98.11
2030	2.85	5.82	8.93	42.04	16.69	92.73	92.73	92.73
2031	3.10	7.12	11.00	71.54	21.86	87.65	87.65	87.65

The Optimistic Scenario, as per definition, requires a combination of all critical factors. The battery cost should continue its downward trend with a CAGR of 8%, range and power of the vehicles should increase by 20% by FY 2024 (due to technological progress) and Demand Incentive should continue till FY 2031. Otherwise, there is a wide variation in projected market penetration of electric two-wheelers among various scenarios. In case of Challenged Diffusion Scenario, when most of conditions are assumed to be unfavorable, the maximum market penetration of only 5.82% is achieved in FY 2024, which is followed by a decline due to withdrawal of demand incentive and finally reaches 3.1% in FY 2031.

The projected sale of electric two-wheelers was found to be at a higher level in case of four scenarios – Technology Driven, Battery Cost Challenged, Same Performance and Optimistic (Figure 3). In the Optimistic Scenario, projected sale in FY 2031 is 220.15 lakh units. On the other hand, in the Challenged Diffusion Scenario the sale is 9.85 lakh units and 7.80 lakh units in financial years 2024 and 2031, respectively. In case of all the scenarios when demand incentive was discontinued after FY 2024, there is an obvious impact of the withdrawal on sale. The Incentive Driven Scenario, in which demand incentive is assumed to continue throughout but with only 2% reduction of battery cost annually and no improvement in range and performance, the electric two-wheelers sale achieved in FY 2031 will be 54.91 lakh units, at a market penetration of 21.86%.

Projected sale of electric two-wheelers reaches the announced production level in Optimistic, Same Performance and Battery Cost Challenged Scenarios even under Full-Constraint conditions with base level production and infrastructure

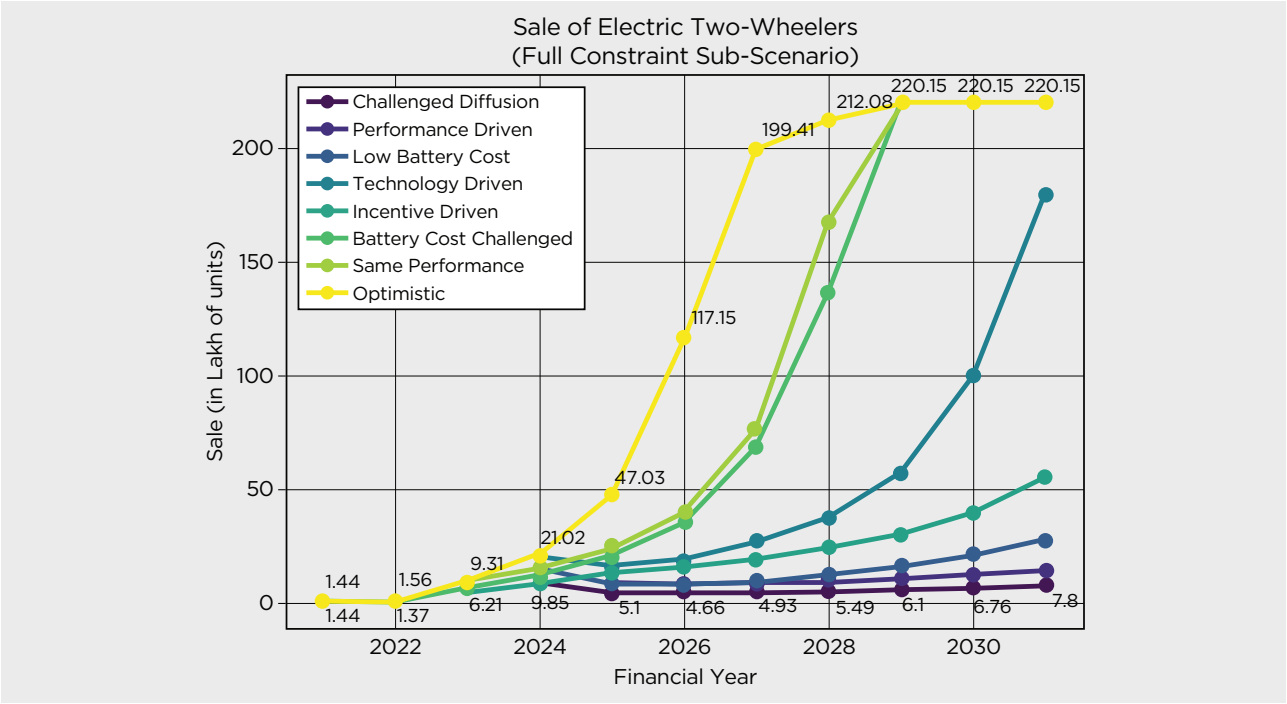


Figure 3: *Sale of electric two-wheelers in various scenarios*

The projected battery demand in FY 2031 varies from 1.28 GWh in Challenged Diffusion Scenario to 114.25 GWh in Optimistic Scenario (Figure 4).

Battery demand does not have a linear relationship with sale of electric two-wheelers. In scenarios with favourable conditions, some of the buyers opt for vehicles with bigger battery packs

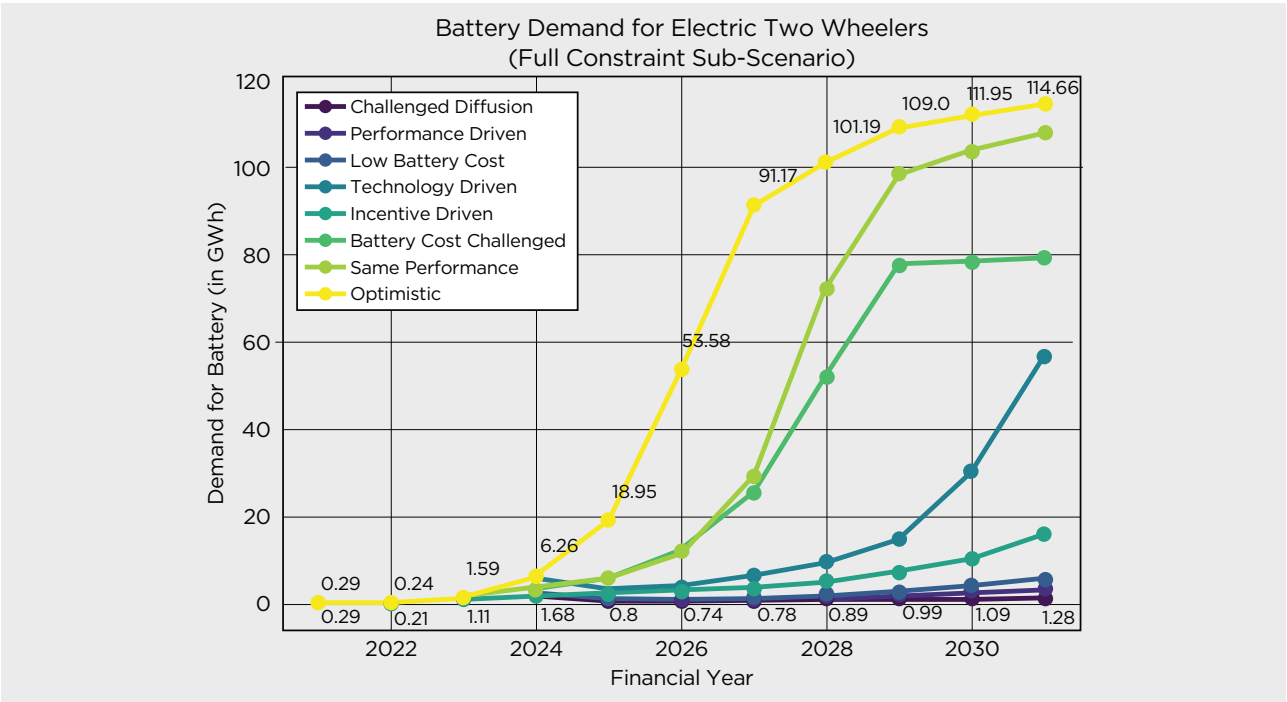


Figure 4: *Battery demand in various scenarios*

While analyzing market penetration of electric two-wheelers, it has been considered that all the charging points will not be dedicated to only two-wheelers only and utilization of charging points will also not be 100%. The utilization is expected to increase over the years. Considering these facts, the total requirement of charging points in FY 2031 is projected to vary from 29639 units in Challenged Diffusion Scenario to 774746 units in Optimistic Scenario (Figure 5). However, these are for Full Constraint condition, when available infrastructure and production capacity may restrict the sale.

Projection of charging infrastructure is cumulative and meant for all kind of light electric vehicles including electric two-wheelers. The utilization factor of charging infrastructure also increases with increasing penetration of electric vehicles. The shapes of demand curves for charging infrastructure, therefore, are different from sale curves

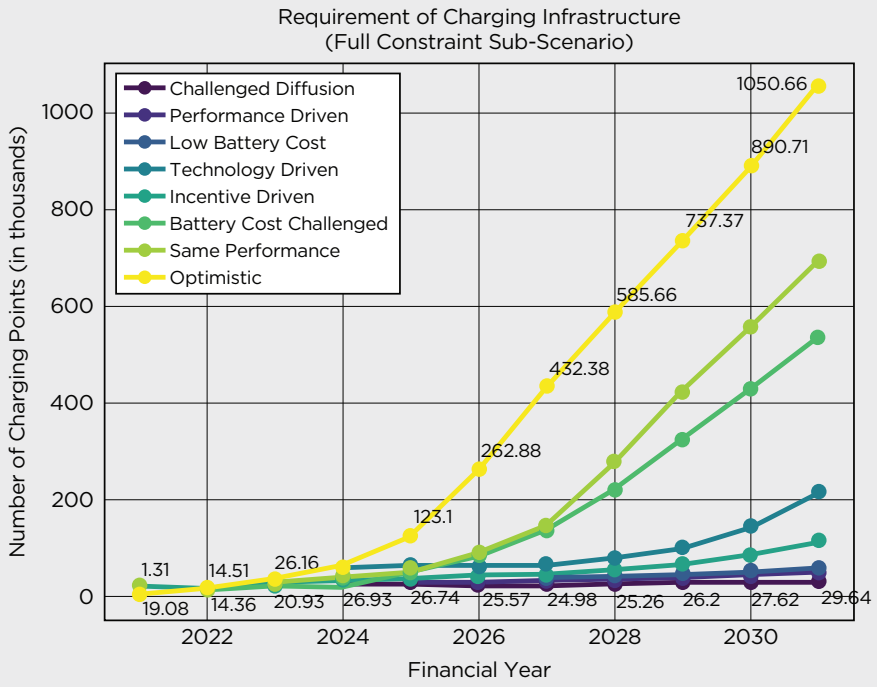


Figure 5: *Requirement of charging points in various scenarios*

Certain hypothetical conditions were also analyzed for each of these scenarios. They include – Production Constraint (no limitation of charging infrastructure and consumers do not consider this aspect in their purchase decision), Charge Constraint (enough vehicles are available) and No Constraint (neither vehicle production nor charging infrastructure pose any hurdle). The results of such sub-scenarios are also presented in the report.

It was observed that the demand for electric two-wheelers surpasses assumed base production under the No Constraint Sub-scenarios of Battery Cost Challenged, Same Performance and Optimistic Scenarios. Similar cross-over is observed in case of Charge Constraint Sub-scenarios of Battery Cost Challenged and Optimistic Scenarios.

One notable conclusion from this analysis is the significance of technology development initiatives to improve performance and reducing cost of the vehicles.

INTRODUCTION

1.1 High Level of Petroleum Imports

The road transport sector is heavily dependent on imported fossil fuels and procurement of crude oil has increased significantly over the years. As per the data available from the Petroleum Planning and Analysis Cell (PPAC), Ministry of Petroleum and Natural Gas (MoPNG), the amount of imported crude oil has increased 5.7 folds during a period of 22-years from 1998-99 to 2019.

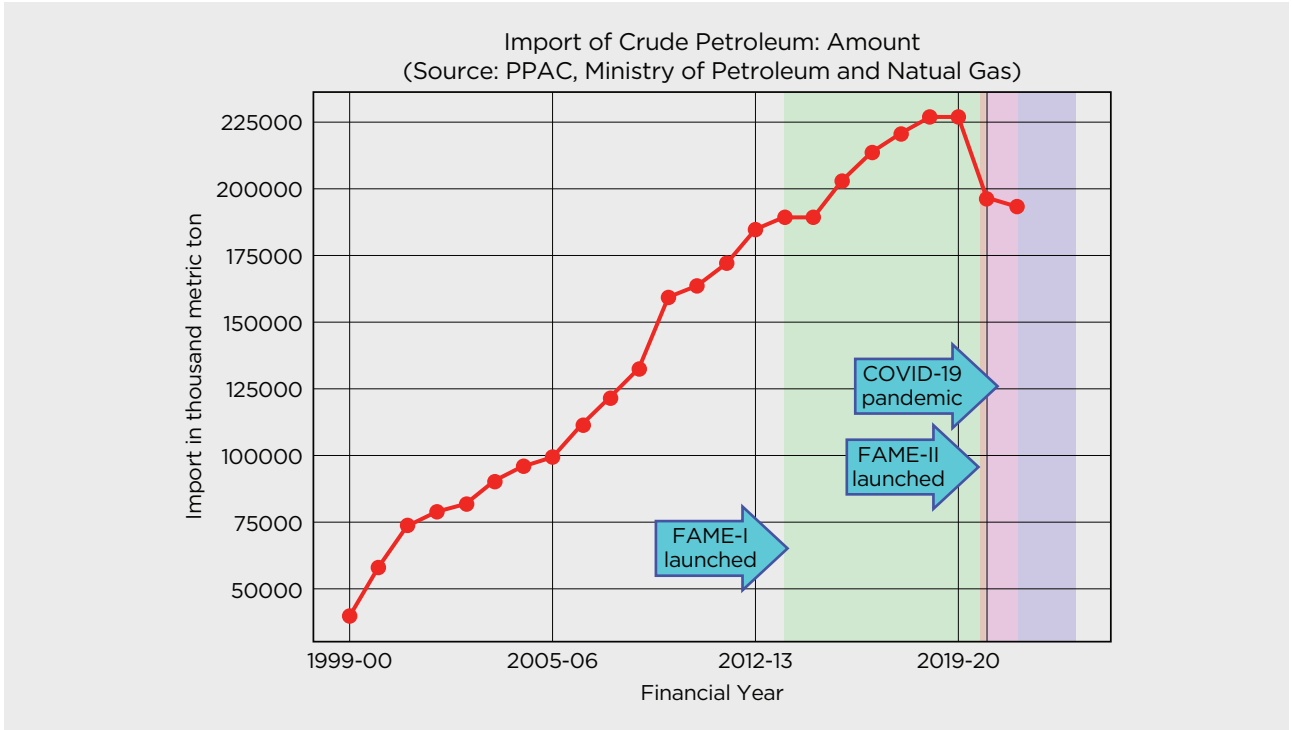


Figure 6: *Quantities of crude oil import*

In the economic terms, the value of total crude oil import was Rs.14917 crore during 1998-99 and reached to Rs.783193 crore during 2018-19. In the year 2019-20 it was Rs.717001 crore (Figure 6).

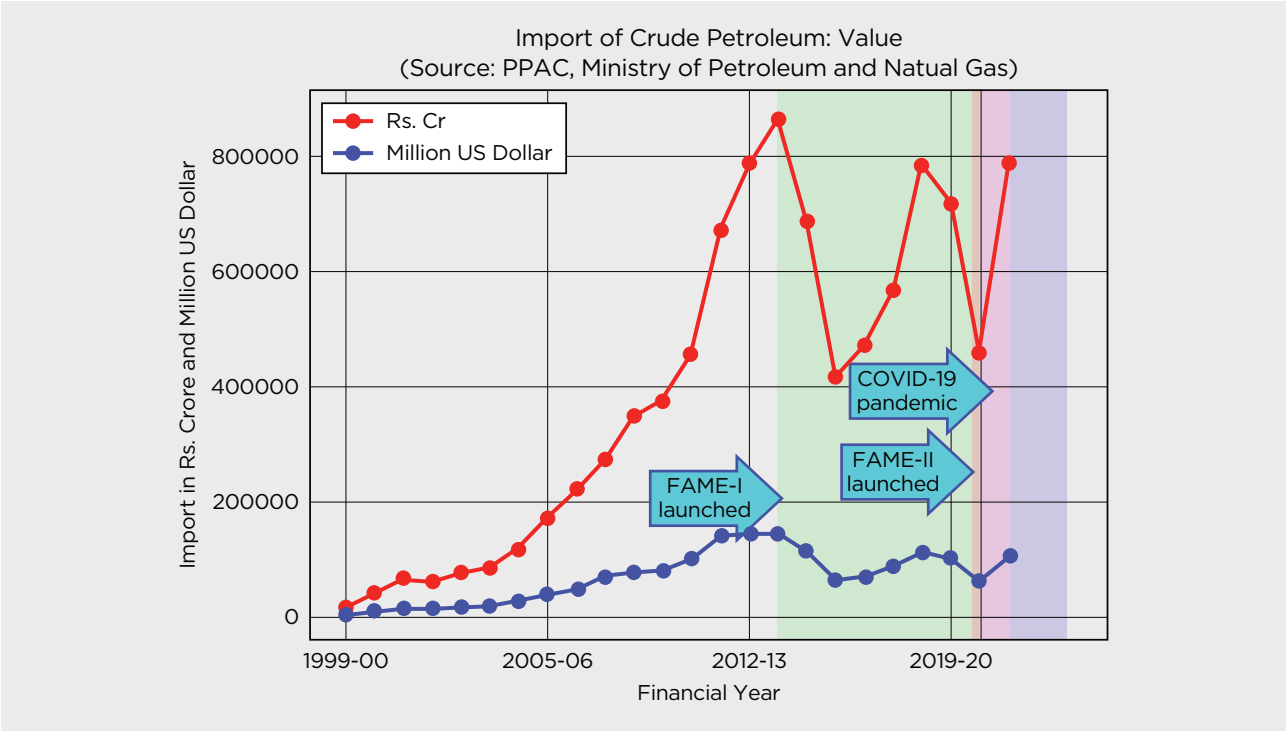


Figure 7: *Amount spent towards crude oil import*

The large amount spent towards petroleum import has significant impact on India's overall Balance of Trade. As per the World Integrated Trade Solutions (WITS) database, total imports by India in the year 2019 were worth over USD 478 billion, whereas total exports were worth USD 323 billion, implying a negative trade balance of over USD 153 billion.

The share of petroleum products in total imports since FY 2015 shown in the Figure 7, where it can be seen that petroleum products contributed significantly in overall import. During the FY 2021-22 (till February) India's total import bill was USD 551,155 million and contribution of petroleum was USD 128,930 million (23.39%). Further, the petroleum market is volatile and there has been significant increase in petroleum prices in recent times.

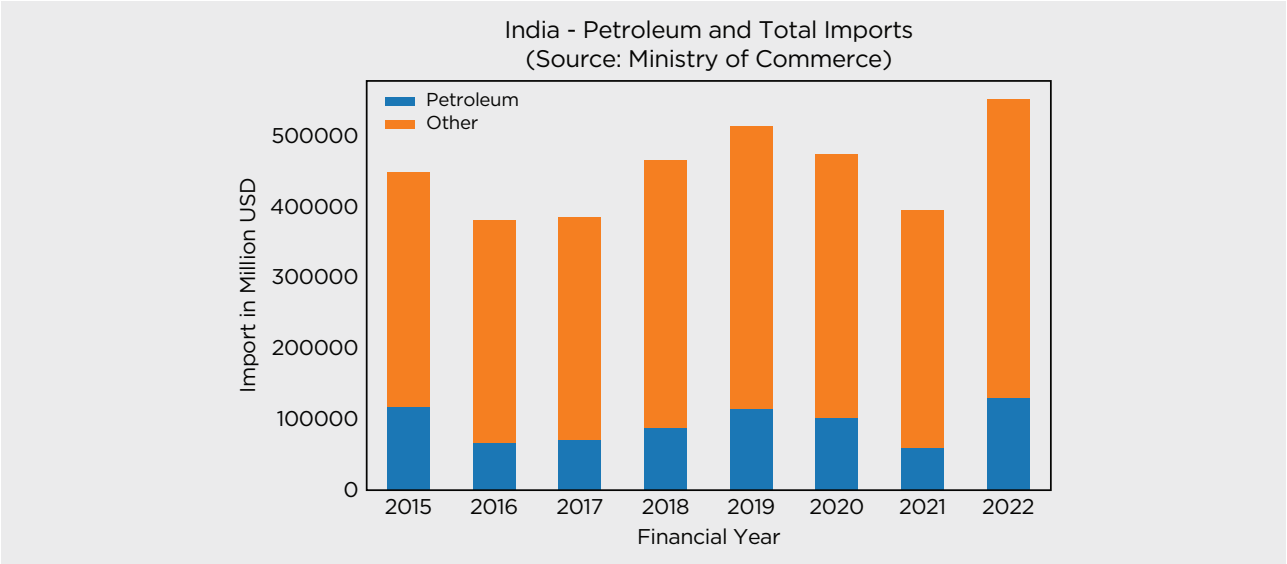


Figure 8: *Share of petroleum products in India's total import*

1.2 Fossil Fuel –Market Volatility, Future Uncertainties and Environmental Concerns

The fossil fuel market has been volatile in the recent past (Figure 8) and the crude prices have reached onerous heights several times during the last few decades, threatening economic progress of many countries. Since the price and availability of crude oil are dependent on many extraneous factors including geopolitical scenario, it is desirable to reduce dependence on them. Moreover, many studies indicate that the petroleum reserves are limited and in the long run all economies will have to shift to the alternative energy sources.

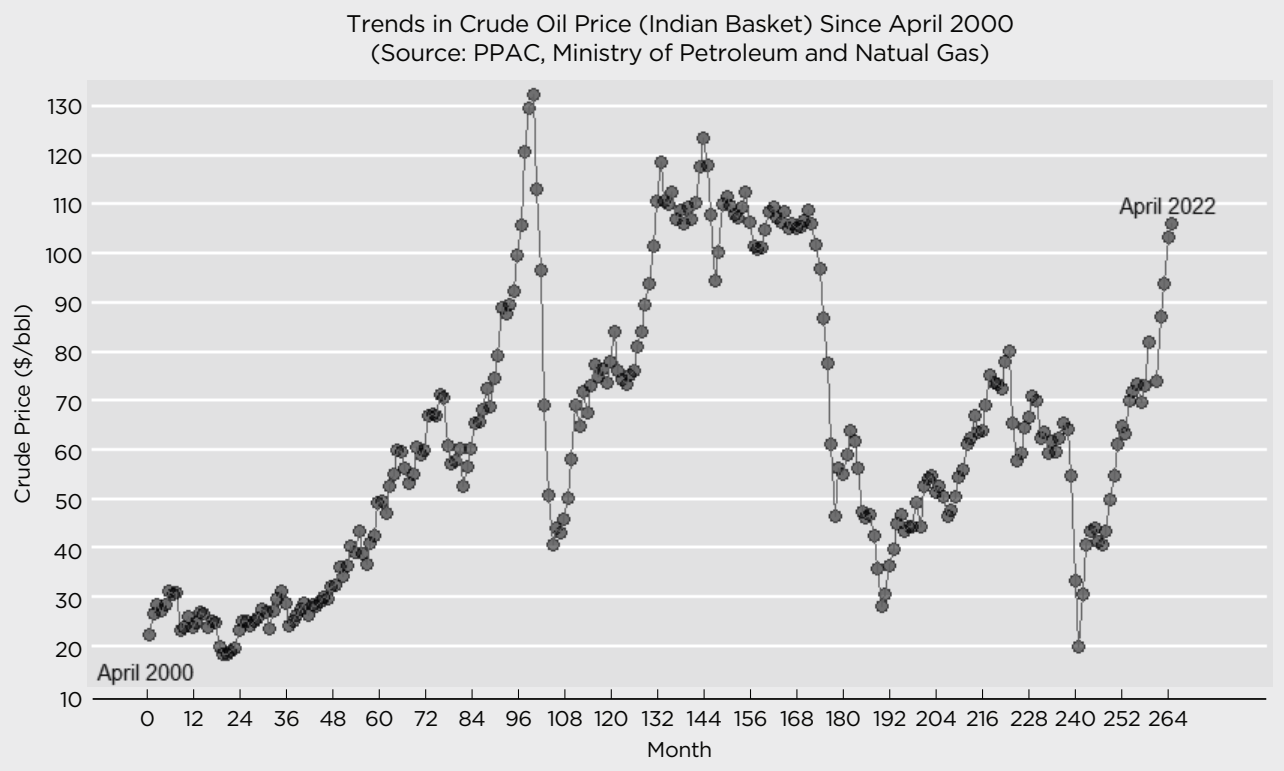


Figure 9: *Variation of international crude prices (Indian basket)*

Apart from price and availability, another compelling reason to move towards alternative fuels is the environmental concern. Emissions from the combustion of fossil fuels are the main reason behind the deterioration of local air quality and overall climate disbalance.

Globally, policy measures towards tackling the environmental problems in the road transport sector are mainly focused on effecting stringent emission norms and encouraging improvements in existing IC engine technologies. However, such improvements in IC engine technologies and fuel quality have become increasingly difficult and costly. Factors such as increase in vehicle numbers, weight of the vehicles, size of the engines, travel frequency and trip length etc. have further aggravated the problem and at the present situation, a radical shift is desirable than the just incremental technology improvements. Electric mobility can be an effective solution in such a situation.

India signed the Paris Agreement in 2015 and committed to reduce its carbon footprint by 33-35% below 2005 levels by 2030, along with increasing the share of non-fossil fuel-based electricity to 40%. This target of reducing carbon foot-print was further revised to 45% by 2030 in the COP26. During the conference the Prime Minister of India also announced that India will achieve net-zero emissions by 2070 through adopting 'Panchamrita', a five-fold strategy:

- India will get its non-fossil energy capacity to 500 giga-watt by 2030
- India will meet 50 per cent of its energy requirements till 2030 with renewable energy
- India will reduce its projected carbon emission by one billion tonnes by 2030
- India will reduce the carbon intensity of its economy by 45 per cent by 2030
- India will achieve net zero by 2070

1.3 Importance of Two-wheelers

The Indian vehicle market is primarily dominated by the two-wheelers with more than 70% of the registered vehicles currently falling under this category (Figure 9). Thus, any effort to address the problems associated with the fossil fuels in the transport sector needs to have a major focus on their use in these vehicles. Figure 9 shows the year-wise vehicle share data from 1951 onwards, indicating the continuous increasing share of two-wheelers.

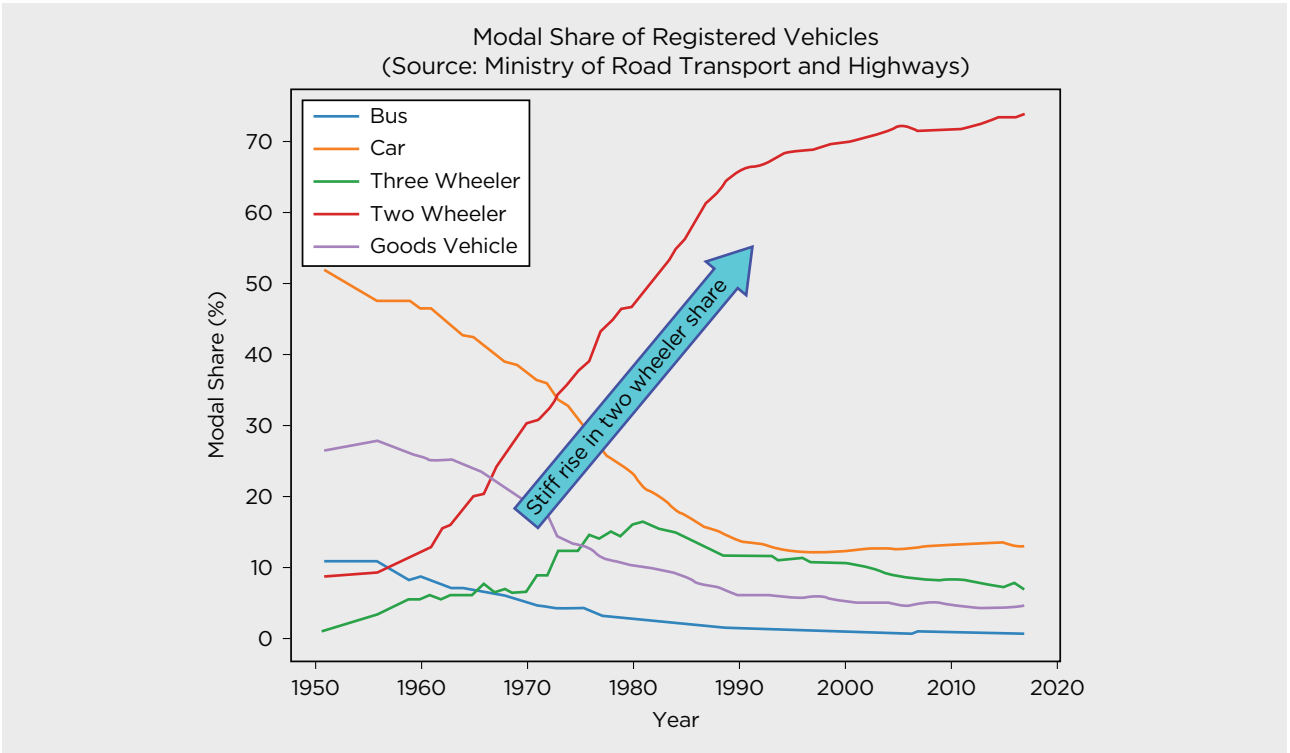


Figure 10: *Share of various categories of registered vehicles in India*

1.4 Government Initiatives on Electric Mobility

Government has decided to push forward the use of electric vehicles in the country. The National Mission on Electric Mobility was approved in 2011 and its plan, called the National Electric Mobility Mission Plan (NEMMP 2020), was released in 2013. In April 2015, the Faster Adoption of Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) was launched as a part of the mission. This scheme had three components – demand subsidy, infrastructure and R&D support. The first phase of FAME scheme continued till 31 March 2019 and the second phase, termed as FAME-II, was launched on 01 April 2019. FAME-II aims to strengthen the electric vehicle manufacturing ecosystem in the country through demand incentives, establishment of network of charging stations and administration of schemes including publicity and IEC (Information, Education and Communication) activities. Maximum number of electric two-wheelers to receive demand incentives will be 10,00000 and they need to have maximum ex-factory cost of Rs.1.5 lakh. The incentive applicable for electric two-wheelers is Rs.15,000 per kWh of battery capacity, maximum up to 40% of the vehicle cost.

Table 2: Incentives Applicable for Various Categories of Vehicles as per FAME-II

Sr. No.	Vehicle Segment	Maximum Number of vehicles to be supported	Approximate size of battery in KWH	Total Approximate Incentive @ 10000/KWH for all vehicles and 20000/KWh for Buses and Trucks	Maximum Ex-Factory price to avail incentive	Total Fund support from DHI
1.	Registered e-2 Wheelers	100000	2 KWH	Rs.20000/-	Rs.1.5 Lakhs	Rs.2000 Cr.
2.	Registered e-3 Wheelers (including eRikshaws	500000	5 KWH	Rs.50000/-	Rs.5 Lakh	Rs.2500 Cr.
3.	e-4 Wheelers	35000	15 KWH	Rs.150000/-	Rs.15 Lakh	Rs.525 Cr.
4.	4W Strong Hybrid Vehicle	20000	1.3 KWH	Rs.13000/-	Rs.15 Lakhs	Rs.26 Cr.
5.	e-Bus	7090	250 KWH	Rs.50 Lakhs	Rs.2 Cr.	Rs.3545 Cr.
Total Demand Incentive						Rs.8596 Cr.

Source: *FAME-II Gazette Notification*

In June 2017, the basic custom duty and GST were reduced and rationalized on electric vehicles, its assemblies/sub-assemblies and parts/sub-parts/inputs of the sub-assemblies. In January 2019, the government further reduced and rationalized the basic custom duty.

Subsequently, the National Mission on Transformative Mobility and Battery Storage was launched to recommend and devise strategies for transformative mobility and phased manufacturing programs for EVs, EV components and batteries.

A phased manufacturing roadmap for the electric vehicles and components/subsystems has been prepared keeping in view the present status of the ecosystem in the country.

This envisages promotion of indigenous manufacturing of (i) electric vehicles (ii) their assemblies/sub-assemblies and components etc. through a graded duty structure. The intention is to increase the value addition and capacity building within the country in a sustainable manner. The Phased Manufacturing Programme was notified in March 2019 and it will enable the manufacturers to plan their investments.

The government has recently also approved the Production Linked Incentive Scheme (PLI) for manufacturing of Advance Chemistry Cell (ACC) in the country. Further, 4 successful bidders have been selected for a total capacity of 50 GWh.

In addition to above initiatives, following actions have also been taken by the government to ensure the success of its electric mobility efforts:

- Amendments in Urban Regional Development Plans Formulation and Implementation Guidelines (URDPFI-2014) for Establishing Electric Vehicle Charging Infrastructure by Ministry of Housing and Urban Affairs.
- Amendments in Model Building Byelaws (MBBL-2016) for Electric Vehicle Charging Infrastructure by Ministry of Housing and Urban Affairs
- Guidelines and Standards for Charging Infrastructure for Electric Vehicle by Ministry of Power
- Development of Indian Standards for electrotechnical aspects of totally or partly electrically propelled road vehicles by the Bureau of Indian Standards (BIS) and Department of Science and Technology (DST).
- Exemption of electric vehicles from the payment of fees for issue or renewal of registration certificates

1.5 Importance and Prospects of EV Two-wheelers

In terms of various categories of vehicles, the two-wheeler segment is most promising for electrification because the prices of electric two-wheelers have become competitive with that of IC engine counterparts in recent times due to supporting policies of the Government of India. Such vehicles can also be served by relatively low power chargers and the growth trajectory of this industry appears to be promising.

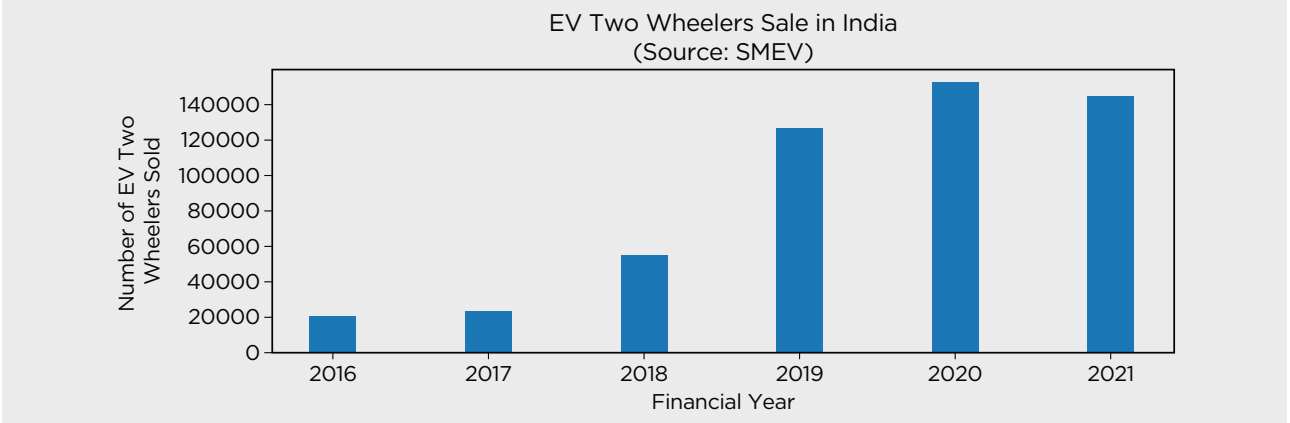


Figure 11: *EV Two-wheelers Sale in India*

1.6 Need for Analysis of EV Two-wheelers Penetration

Electrification of road transportation is not merely an incremental change towards a better technology but involves a paradigm shift in terms of the ecosystem, supply of energy, manufacturing and even behavioral changes in the society at large. For such a fundamental transition, there are many aspects of policies and planning that can be better understood with a prior knowledge on the likely scenarios of the penetration of electric vehicles.

Adoption of electric vehicles, to a large extent, will depend on the presence of appropriate ecosystem and policies. Such vehicles require adequate charging infrastructure, which is totally different from the infrastructure requirement of the existing IC engine vehicles. While availability of adequate charging infrastructure will have positive impact on adoption of electric vehicles, its underutilization at a low level of EV penetration may be a serious problem for the relevant stakeholders. Appropriate planning for rolling out the charging infrastructure can thus play an important role in this regard.

Since electric vehicles are charged from the power supplied by the electricity grid, they may have impact on its performance, particularly at the distribution level, in terms of additional power demand and power quality. Issues such as harmonics, powerline congestion, transformer overloading may affect the life of various grid assets. The power demand from the electric vehicles is not usually considered in the long-term plans of the utilities. To take this into consideration, the utilities will require probabilistic estimates of the future level of penetration of electric vehicles.

In such a scenario, it becomes important for all the stakeholders to understand the trajectory of electric vehicles penetration in the next few years, so that the industry may take suitable decisions to augment their manufacturing capabilities and government could take affirmative decisions to support the growth.

This is further important to simultaneously plan for the creation of necessary charging, delivery and servicing infrastructure for the vehicles and production of critical components like batteries.

Thus, various stakeholders such as policymakers, electric utilities, charging station planners and battery manufacturers can benefit from an agent-based tool that models the EV ecosystem and enables exploration of 'what-if' scenarios. Table 3 enlists some of the possible uses of this tool.

Table 3: Use of the present tool for various stakeholders

Stakeholders	Use of the Tool
Policy Makers	Estimating the impacts of different policies on the adoption of electric 2/3 wheelers.
Electric Utilities	Plan for strengthening the power distribution grid and estimating demands
Charging Station Planners	Estimating spatial and temporal changes in electrical loads resulting from different levels of EV adoption and different EV technologies
Battery Manufacturers	Determining how battery sizes will affect EV adoption and electrical load

TIFAC and NITI Aayog jointly took up the task of developing such an agent-based model for forecasting penetration of electric two-wheelers in India where the purchase decisions taken by the customers have been simulated based on their various attributes and relevant input conditions.

It is felt that availability of this model will help the stakeholders to do a scenario analysis of the sector for various combinations of technological, policy related and market related assumptions to make necessary changes in their decisions.

In the following sections, while at one end developmental schematics have been briefly discussed, on the other, analyses of a few plausible scenarios have also been presented.

ABOUT THE TOOL

2.1 Modeling Principles

Firstly, an Agent-based model has been developed to simulate the behavior of individual actors (so-called Agents) which can effectively capture their interactions and mutual influences among themselves and with the associated ecosystem. This enables an in-depth analysis of the complex adaptive system and the forces that set the trajectory of their evolution. For example, it can provide an idea of how the system could evolve in different institutional frameworks, policies on incentive structures and technology development scenarios. Effectively, this is a bottom-up system approach that enables one to understand the possible futures based on interactions between agents and environment.

In the context of electric mobility, the possible agents are consumers, government, vehicle manufacturers, charging system operators and fuel producers etc. Inclusion of agents other than consumers, however, gives the user less control on estimating the sensitivity of EV adoption towards the policies, plans or decisions adopted by such actors. Hence, the current model is designed to analyze the impacts of different policies, plans and EV technologies that are exogenous to the tool, whereas consumers represent the agents whose decisions are simulated.

Each agent (customer) is characterized by a set of attributes such as age, income and daily travel distance etc. The purchase decision of the agent is influenced by these attributes as well as the exogenous factors. The process of creating such agents with defined sets of attributes is described in Figure 12. Agent attributes are created as correlated random variables following the given statistical distributions, which can directly be given to the model as inputs for scenario analysis. However, for several attributes, a consumer survey helps to have a realistic idea about the possible distributions.

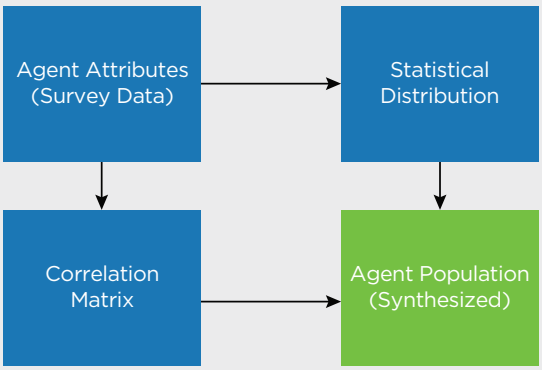


Figure 12: *Creation of agent population*

The correlation matrix for the agent attributes is derived from the data obtained from this consumer survey. Table 4 provides a brief description of the agent attributes used in the model.

Table 4: Agent attributes used in the model

Sl. No.	Agent Attribute	Description
1.	Income	Total annual income of the household
2.	Age	Age of the Agent
3.	Economic Weight	Relative weightage given by the buyer to the price of the vehicle
4.	Range Weight	Relative weightage given by the buyer to the maximum distance that the vehicle can travel with a single charge of the battery
5.	Fuel Economy Weight	Relative weightage given by the buyer to the energy consumption by the vehicle per km
6.	Power Weight	Relative weightage given by the buyer to the maximum power of the vehicle
7.	Easy Refueling Weight	Relative weightage given by the buyer to the convenience of recharging/refueling the battery/fuel tank of the vehicle
8.	Emission Weight	Relative weightage given by the buyers to the environmental performance of the vehicle in terms of exhaust emissions
9.	Popularity Weight	Relative weightage given by the buyer to a category of vehicle based on its market share
10.	Maximum Expenditure	Maximum amount the consumer is willing to spend to purchase a vehicle
11.	Willingness to Pay More	The additional amount in terms of percentage that the buyer is willing to pay for an environment-friendly vehicle
12.	Daily Travel Distance	Average distance that the buyer travels with the vehicle

Variables related to EV ecosystem can be used to create various scenarios which are listed in Table 5.

Table 5: Scenario defining variables

Sl. No.	Variable	Description	Default
1.	Gasoline Price	Gasoline price in terms of Rs.	A starting value of Rs.95.40/litre and CAGR of 3.48% are assumed for the duration 2021 to 2030
2.	Cost of Electricity	Electricity price per unit in terms of Rs.	A starting value of Rs.7/unit is assumed and the price is assumed to have a CAGR of 2.5% throughout the duration 2021 to 2030
3.	Discount Rate	Rate of return used to determine the time value of money	7.75%
4.	Battery Life	Service life of the battery for the electric vehicle application	8 years
5.	Battery Cost	Cost of battery in terms of Rs./kWh	Rs.10000/- kWh
6.	Battery Cost Reduction Rate (CAGR)	Rate at which the cost of the battery reduces over the years due to scale of manufacturing and technological improvements etc.	8% (reduction)

The following parameters (Table 6) were assumed to be constant throughout the simulation period.

Table 6: Constant parameters

Sl. No.	Parameter	Description	Value
1.	Charging Power	The amount of power delivered by the charging system to the electric vehicles battery. The power is assumed to remain constant during charging.	7 kW
2.	Hours of Charger Operation	Number of hours during which the public charging system offers its service during the day	14 hours
3.	Average Life of Charging Systems	Life of a 7.4 kW electric vehicle charging system	15 years

This work also uses a refueling effect variable to incorporate the utilization and acceptability of public charging stations that is assumed to increase with the market share of EVs.

Features of the model include:

- Projection of required charging infrastructure/effect of inadequate charging infrastructure
- Effect of subsidy withdrawal in a given year
- Effect of technological parameters such as battery life and battery specific energy
- Option for considering announced and anticipated production plans by OEMs/ demand-supply gap

2.2 Agent Decision Making

For each year during the simulation period, a set of Agents is generated, which represents the buyers of two-wheelers in that specific year. Each Agent takes a decision on which

vehicle to purchase based on his/her individual heterogeneous attributes and the specifications of the IC engine and electric vehicles available in the market. A set of utility functions are defined and the Agents evaluate these utility functions. The overall utility function is a weighted sum of all these utilities and the weights are also defined based on agent preferences. The overall process of Agent decision making is described schematically in Figure 13.

The Agents first shortlist the vehicles that they can afford to buy based on their prices in the year when decision is being taken. Prices of IC engine and electric vehicles in a given year are determined based on the assumed rate of change of their manufacturing prices and the applicable subsidies and taxes assumed for the given year. The price reduction of electric vehicles in the coming years is assumed to be mainly driven by the reduction in the battery prices.

Each Agent evaluates the shortlisted vehicles in terms of their utilities. The overall utility of a vehicle for an Agent is a function of a set of utilities and associated weights. These include Economic, Power, Environment, Popularity, Range and Refueling utilities. The evaluation of the overall utility varies depending on the assumed scenario. In the No Constraint or Production Constraint scenarios only the first four utilities are considered and the Refueling utility is only included in the Charge Constrained and Full Constrained sub-scenarios. Definitions of each of the utilities and their associated weights are provided in the next section.

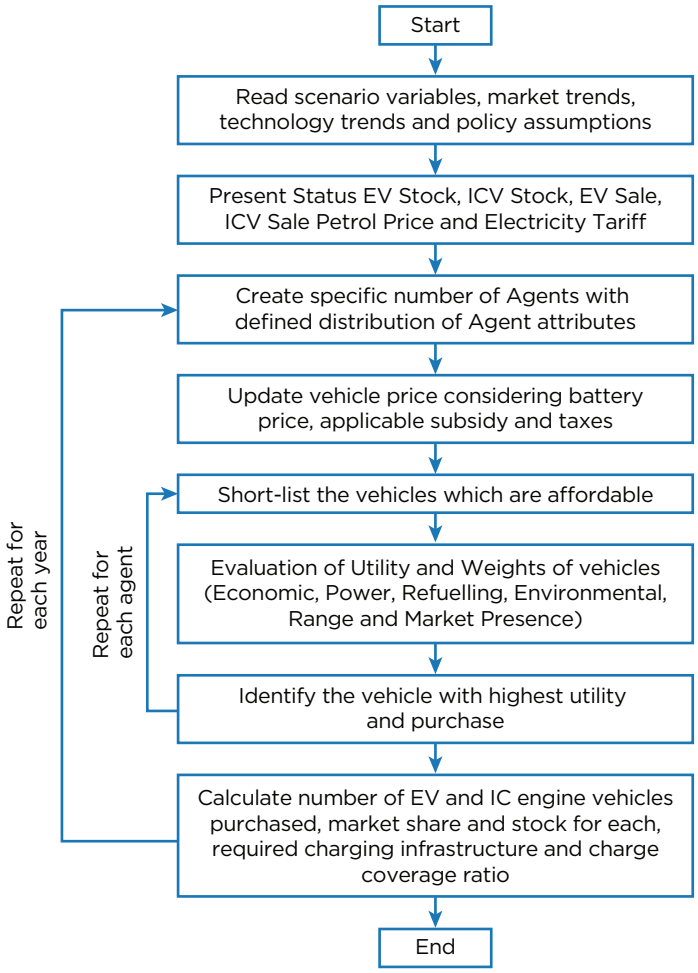


Figure 13: *Agent decision making process*

2.3 Equations for Agent Decision Making

It is assumed that the price of the internal combustion engine vehicle remains constant throughout the forecasting period. However, the price of the electric vehicle is expected to reduce in the coming years, with reduction in battery cost being the main contributor. On an average, the battery contributes 40% of the total vehicle cost and accordingly the rate at which the vehicle manufacturing cost will reduce can be assumed to be 40% of the rate of reduction of the battery cost.

The price of petroleum and electricity tariff are both assumed to increase in the coming years. However, the rate of increase of electricity price will be less than that of petroleum. Fuel price in a given year is estimated based on the present cost and the rate of its increase.

The total capital cost to the buyer is the sum of the price of the vehicle and the cost of infrastructure, if applicable. Infrastructure cost is applicable for a consumer only if she/he decides to install a home charger that is priced. Slow chargers are often provided by the vehicle manufacturers without any additional cost. If the user is dependent only on the public charging points, no infrastructure cost is applicable.

The total operational cost is the sum of fuel cost, maintenance cost and annual tax. Among these, the first two are derived from the corresponding per km values and the average annual distance travelled by the user.

In a specific year, the Annual Charging Energy Demand for electric vehicles is obtained by summing up the energy required for covering the annual travel distance by each individual electric vehicle that is on the road in that year (already existing and purchased during the year).

Based on the above discussions, the mathematical representation of various parameters used in the tool are given below.

The manufacturing price of the vehicle at present

$$C_{man0} = \frac{C_{vehicle0}}{1 + \frac{GST}{100}}$$

Where $C_{vehicle0}$ is the ex-showroom price of the vehicle at present, GST is the applicable GST in per cent.

Ex-showroom price of the vehicle after n years

$$C_{vehicle} = C_{man}\left(1 - \frac{r_{vp}}{100}\right)^{n} - C_{sub}x_{sub}$$

Where C_{man} is the manufacturing cost, r_{vp} is the rate of reduction of vehicle manufacturing cost, n is the number of years, C_{sub} is the amount of applicable subsidy and x_{sub} is a Boolean variable representing existence or absence of subsidy. If subsidy is offered, x_{sub} = 1 otherwise it is 0.

Price of fuel in a given year

$$C_{fuel,\,n} = C_{fuel0}\left(1+\frac{r_{fuel}}{100}\right)^{n}$$

Where C_{fuel0} is the fuel price in the start-year, r_{fuel} is the rate of increase of fuel price where n is the number of years.

Capital expenses for the vehicle

$$C_{cap} = C_{vehicle} + C_{infra}x_{infra}$$

Where C_{infra} is the cost of required infrastructure and x_{infra} is a Boolean variable indicating presence (1) or absence (0) of infrastructure.

Operating expenditure

$$C_{opex} = (C_{fuel}E_{fuel} + C_{maint})d_{annual} + C_{tax}$$

Where E_{fuel} is the amount of fuel/energy required per km, C_{maint} is the maintenance cost on per-km basis, d_{annual} is the annual distance travelled by the vehicle and C_{tax} is the annual tax on the vehicle.

The cost due to the replacement of battery during the lifetime of the vehicle is perceived by the buyer with respect to the battery cost at the time of the purchase of the vehicle and the number of times battery replacement may be required during the vehicle lifetime.

$$C_{batrep} = n_{batrep}p_{bat}\left[1-\left(\frac{r_{batred}}{100}\right)^{n}\right]$$

Where, n_{batrep} is the anticipated number of battery replacements, p_{bat} is the present price of the battery, r_{batred} is the CAGR of cost reduction of battery and n is the time in years till the time of purchase of the vehicle.

Net present value of total capital and operational costs as perceived by the buyer

$$C_{npv} = C_{opex}n_{l} + C_{cap} + C_{batrep}$$

Where C_{batrep} is the total cost of battery replacements throughout vehicle life (n_l) and r_d is the discount rate for time value of money.

Various Utility Functions are evaluated by Agents using above parameters for taking a vehicle purchase decision. These are defined below.

Economic Utility

$$U_{econ} = \frac{C_{npv,\,\min}}{C_{npv}} \quad \text{for IC engine vehicle}$$

$$U_{econ} = \frac{C_{npv,\,\min}}{\left(C_{npv} - \frac{C_{exsh}p_{wtpm}}{100}\right)} \quad \text{for electric vehicle}$$

Where $C_{npv,\,min}$ is the minimum net present value among all vehicle options considered by the Agent, C_{exsh} is the ex-showroom price of the vehicle and p_{wtpm} is the extra amount in

terms of per cent of vehicle cost that the Agent is willing to pay extra for environment-friendly vehicle.

In case of electric vehicles, the consumer willingness to pay more has been reflected. Otherwise, both the equations are same.

Power Utility

$$U_{power} = \frac{P_{vehicle}}{P_{vehicle,\ max}}$$

Where $P_{vehicle}$ is the power of the vehicle, $P_{vehicle,\ max}$ is the power of the vehicle that offers maximum power among all vehicles under consideration.

Range Utility

$$U_{range} = \min\left(\frac{d_{vehicle}}{d_{\max}}, 1\right)$$

Where $d_{vehicle}$ is the range of the vehicle, d_{max} is the maximum range among all the vehicles being considered by the Agent. It may be noted that the maximum value of Range Utility is 1, hence the minimum function is used in the equation.

Environmental Utility

U_{evn} = 1 for *EV*, 0 for *ICEV*

It is assumed that the environmental utility of IC engine vehicle is 0 and it is 1 for electric vehicles.

Recharge Utility

$U_{recharge}$ = 1 for IC engine vehicles

$U_{\text{recharge}} = \min\left(\frac{€_{ch} d_{vehicle}}{d_{daily}}, 1\right)$ for electric vehicles

Where, $€_{ch}$ is the Charge Coverage ratio in the previous year and d_{daily} is the average distance travelled in a day.

Popularity Utility

$$U_{pop} = \frac{f_{marketv}}{100}$$

Where $f_{marketev}$ is the market share of electric vehicles in percent in the previous year.

Weightage given to various Utilities by the Agent, used in the model have been calculated based on the consumer survey, in which respondents were asked to rate several parameters on a scale of 10 as per their preference. The relative weightages are then calculated as follows:

Weightage to economic utility

$$W_{econ} = \frac{R_{econ}}{(R_{econ} + R_{pop} + R_{range} + R_{power} + R_{easyrefuel} + R_{env})}$$

Weightage to popularity (market presence)

$$W_{pop} = \frac{R_{pop}}{(R_{econ} + R_{pop} + R_{range} + R_{power} + R_{easyrefuel} + R_{env})}$$

Weightage to range

$$W_{range} = \frac{R_{range}}{(R_{econ} + R_{pop} + R_{range} + R_{power} + R_{easyrefuel} + R_{env})}$$

Weightage to power

$$W_{power} = \frac{R_{power}}{(R_{econ} + R_{pop} + R_{range} + R_{power} + R_{easyrefuel} + R_{env})}$$

Weightage to easy refuel

$$W_{easyrefuel} = \frac{R_{easyrefuel}}{(R_{econ} + R_{pop} + R_{range} + R_{power} + R_{easyrefuel} + R_{env})}$$

Where, R_{econ}, R_{pop}, R_{range}, $R_{easyrefuel}$, and R_{env} are ratings given by the survey respondents to vehicle price, popularity (market presence), range, power, easy refueling and environment-friendliness, respectively. Since in the model there is one utility covering all economic aspects (net present value of sum of vehicle price, fuel costs and tax etc. during vehicle lifetime), it was felt reasonable to assume that the survey respondent's rating of vehicle price represents weightage given to the economic utility.

The total vehicle Utility in a particular scenario will thus finally be calculated by the Agent as under

No Constrained and Production Constrained conditions:

$$U_{total} = W_{econ}U_{econ} + W_{pop}U_{pop} + W_{power}U_{power} + W_{range}U_{range} + W_{env}U_{env}$$

In the Charge Constrained and Full Constrained conditions:

$$U_{total} = W_{price}U_{econ} + W_{pop}U_{pop} + W_{power}U_{power} + W_{range}U_{range} + W_{easyrefuel}U_{recharge} + W_{env}U_{env}$$

2.4 Aggregating Agent Decisions

Strategies adopted for aggregation of the decisions of the Agents to estimate overall market penetration of the electric two-wheelers depend on the scenarios considered. The tool developed provides four broad scenarios as mentioned below. These are further explained in detail later in section 4.

Full Constrained Condition: Under this condition both availability of charging infrastructure and production capacity of electric two-wheelers pose constraints to the maximum penetration level and total sale.

Production Constrained Condition: In this condition it is assumed that there are enough number of charging points always available to ensure that users do not face any inconvenience. Hence vehicle production level is the only constraint in this scenario.

Charge Constrained Condition: It is assumed that there is enough supply of vehicles in the market to meet the demand, irrespective of the installed production capacity. So, charging infrastructure is the only constraint in this case.

No Constraint Condition: It is assumed that there are enough supplies of both vehicles and charging points.

Demand for electric two-wheelers is given by:

$$N_{evdem} = \frac{n_{ev} N_{sale}}{N_{agent}}$$

Where n_{ev} is the total number of agents choosing electric two-wheeler during the year, N_{sale} and N_{agent} are the total number of two-wheelers sold during the year and the number of Agents in the simulation, respectively.

Average annual energy consumption of the batch of the electric vehicles chosen by the Agents during the year

$$E_{avev} = \frac{E_{vbatch}}{N_{agent}}$$

Where, E_{vbatch} is the total energy consumption by the electric two-wheelers purchased by the Agents

Energy that can be supplied by the planned charging installations

$$E_{chgplan} = 365 N_{chgplan} P_{chg} t_{chg} f_{chgut} x_{tw}$$

Where,

$N_{chgplan}$ is the number of charging points planned to be installed till the year

P_{chg} is the power output of each charging point,

t_{chg} is the time of operation of the charging points,

f_{chgut} is the utilization factor of the charging points and

x_{tw} is the fraction of the total energy supplied by charging points that is available for two-wheelers.

The total number of electric two-wheelers that can be supported by the charging infrastructure planned till the year *i* (total number of active charging points as per the plan)

$$N_{evchplan} = \frac{E_{chplan}}{x_{pub} E_{avev}} - \sum_{k=1}^{i-1} N_{ev,\,k}$$

Where, x_{pub} is the share of public charging points in the total energy demand for charging of all electric two-wheelers and x_{tw} is the share of two-wheelers in the energy required for charging of all electric vehicles.

The number of electric two-wheelers sold in a particular year (*i*)

$N_{ev,\,i}$ = min(N_{evdem} N_{evprod}, $N_{evchplan}$) in the Full Constrained condition

$N_{ev,\,i}$ = min(N_{evdem}, N_{evprod}) in the Production Constrained condition

$N_{ev,\ i}$ = min(N_{evdem}, $N_{evchplan}$) in the Charge Constrained condition

$N_{ev,\ i}$ = N_{evdem} in the No Constraint condition

Where N_{evprod} is the number of electric two-wheelers planned to be produced during the year under consideration.

2.5 Equations for Estimation of Charging Infrastructure and Battery Demands

Annual energy demand by all electric vehicles at present (N_{ev0}) in the market is estimated by assuming an average energy consumption of 0.017 kWh/km and average annual travel distance ($d_{annualav}$) estimated based on the consumer survey responses.

E_{ev0} = 0.017 $N_{ev0}d_{annualav}$

For subsequent years during the simulation, the total annual energy demand by the electric vehicles chosen by the agents is determined by

$$E_{evbatch} = \sum_{i=1}^{n_{ev}} e_i d_i$$

Where n_{ev} is the total number of agents choosing electric two-wheelers during the year and e_i and d_i are the per km energy consumption and annual travel distance, respectively, of the vehicle i.

This energy consumption value is then scaled up proportionately to estimate the annual energy demand by all the new electric vehicles sold during the year (N_{ev})

$$E_{ev} = \frac{E_{evbatch} N_{ev}}{n_{ev}}$$

The annual energy demand by the total stock of electric vehicles present during the year

$$E_{evstock,\ i} = \frac{E_{evbatch} N_{ev,\ i}}{n_{ev,\ i}} + E_{evstock,\ i-1}$$

Here the subscripts i corresponds to the year under consideration and i – 1 corresponds to the previous year. $E_{evstock}$ represents the total stock of electric two-wheelers.

The annual energy demand by the new electric vehicles considering latent demands

$$E_{evlat} = \frac{E_{evbatch} N_{evdem}}{n_{ev}}$$

The total annual energy demand by the stock of electric vehicles considering latent demands

$$E_{evlat,\ i} = \frac{E_{evbatch,\ i} N_{evdem,\ i}}{n_{ev,\ i}} + E_{evstock,\ i-1}$$

The subscripts i and i – 1 represent the year under consideration and the previous year, respectively.

The number of charge points required in the initial year

$$N_{chpt_0} = \frac{E_{ev0}}{365 x_{tw} f_{chgut} t_{chg} P_{chg}}$$

Total number of charging points needed in operation in year *i*

$$N_{chg,\,i} = \frac{E_{evstock,\,i}}{365 x_{tw} f_{chgut} P_{chg} t_{chg}}$$

Actual installed charging points for the Full Constraint or Charge Constraint conditions:

$N_{chginst,i} = N_{chgplan,i}$ if $N_{chg,i} > N_{chgplan,i}$

$N_{chginst,i} = \max(N_{chginst,i-1,}\ N_{chg})$ if $N_{chg} \leq N_{chgplan}$

In case of Production Constraint or No Constraint conditions:

$N_{chginst} = N_{chgplan}$ if $N_{chg} > N_{chgplan}$

$N_{chginst,i} = \max(N_{chginst,i-1,}\ N_{chg})$ if $N_{chg} \leq N_{chgplan}$

Energy supplied by the installed charging points

$E_{chg} = 365\ N_{chg} P_{chg} t_{chg}$

The variable, Charge Coverage Ratio, is defined as follows:

$$€_{ch} = \min\left(\frac{E_{chg}}{E_{ev}}, 1\right) \text{ in Full Constrained scenario}$$

$$€_{ch} = \min\left(\frac{E_{chgplan}}{E_{ev}}, 1\right) \text{ in Charge Constrained scenario}$$

$€_{ch}$ = 1 in Production Constrained or No Constrained scenario

Where, f_{ev} is the share of electric two-wheelers in total two-wheeler population, in fraction.

CONSUMER PREFERENCES

3.1 EV Two-Wheeler Consumer Survey

A consumer survey was conducted with the two main objectives: (i) to get the statistical distribution of the agent attributes and (ii) to get the correlation among these attributes. While it is possible for the users to define the statistical distributions of agent attributes on their own, thereby, creating a desired scenario, in this report the distributions obtained from the survey results have been followed. The correlation matrix obtained from the survey has been used in the model as a default. However, defining a new correlation matrix will also be possible. It needs to be noted that the projected level of penetration of the electric two-wheelers is not directly obtained from the response to any specific question.

Survey form was sent to about 2000 persons and about 260 responses were received. The respondents represent various income groups and age and are from various states of India. After cleaning up the data, 140 inputs have been used. There is, however, a scope for conducting a survey at a larger scale to generate necessary input data for this model.

3.2 Agent Attributes

From the statistical analysis of the consumer survey data, it was observed that all the 12 Agent attributes selected can be represented by 3-parameter lognormal distribution. Hence the model creates required number of agents either based on consumer survey data or based on parameters of the lognormal distribution for all the Agent attributes provided in the model as input.

Since some of the values obtained in responses to consumer survey were unrealistic, the data was cleaned by removing such values. Agent Attributes for which such criteria had to be applied are described in Table 7.

Table 7: Lower and upper limits of some Agent Attributes

Sl. No.	Agent Attribute	Minimum Value	Maximum Value
1.	Income	Rs. 50000 per annum	Rs.150 lakh per annum
2.	Age	18	65
3.	Maximum Expenditure	Rs.35,000	Rs. 8,00,000
4.	Willingness to Pay More (%)	0 (unwilling)	40
5.	Daily Travel Distance	1 km	100 km

By fitting the sample data to three-parameter lognormal distribution, the parameters of the distribution of all the Agent Attributes were obtained and these were used to create Attributes of the desired number of Agents. The Cumulative Density Functions (CDF) of the sample data and the fitted data are shown in Figure 14,.

Good fit between Cumulative Density Functions of the modelled and sample data in following graphs suggest that the distributions of Agent Attributes taken for analysis are representative of real-life situations

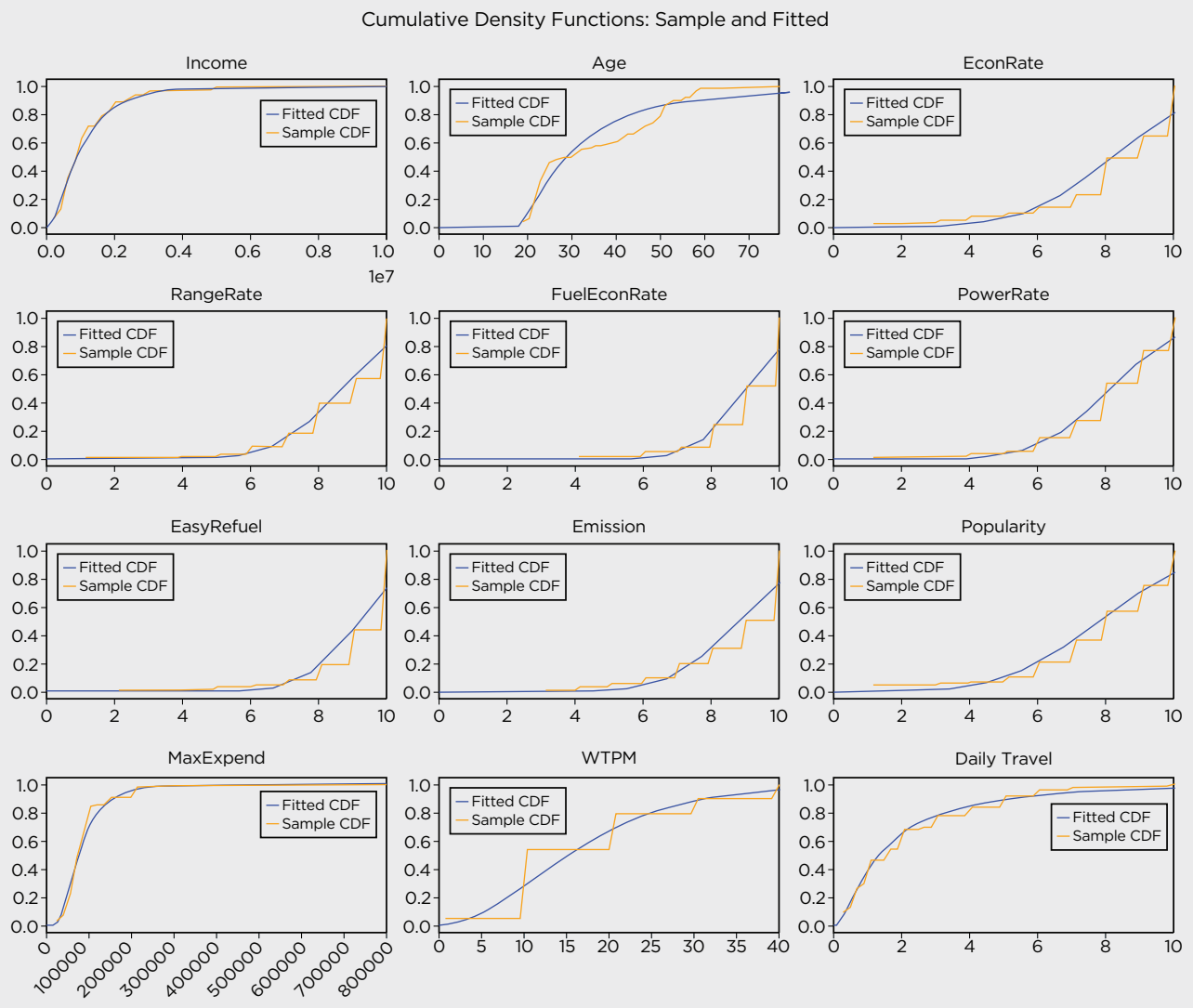


Figure 14: *CDF of Agent Attributes - sample and fitted*

3.3 Correlation Matrix

For representing a real-life scenario, there needs to be certain correlation among the various Agent Attributes, described by a correlation matrix. The correlation coefficients between the attributes were estimated from the survey results. The correlation matrix obtained is shown in Figure 15.

The correlation matrix is important to ensure that the synthesized Agent Attributes in the model have similar inter-relationships as in the real-life survey data

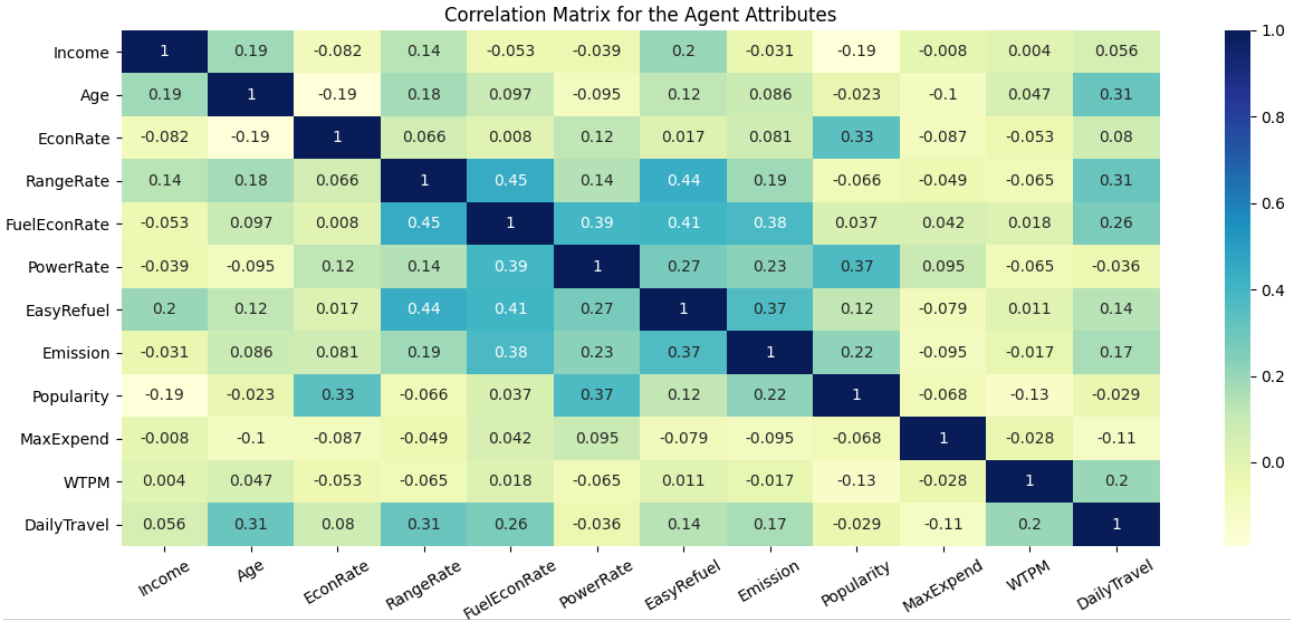


Figure 15: *Correlation matrix for Agent Attributes obtained from survey responses*

3.4 Created Agents

A total of 1000 Agents were created based on the correlation matrix among Agent Attributes and probability density functions of the Agent Attributes. Two different approaches are possible, first by using probability density functions from the survey results and second by defining the distribution parameters. However, since some of the created Agents had attributes whose values were not within the ranges as mentioned in Table 6, such Agents were screened out. Figures 16 and 17 show the histograms of created Agent Attributes.

The histograms for each of the Agent Attribute show the range of values (x-axis), and number of synthesized Agents against each value (y-axis)

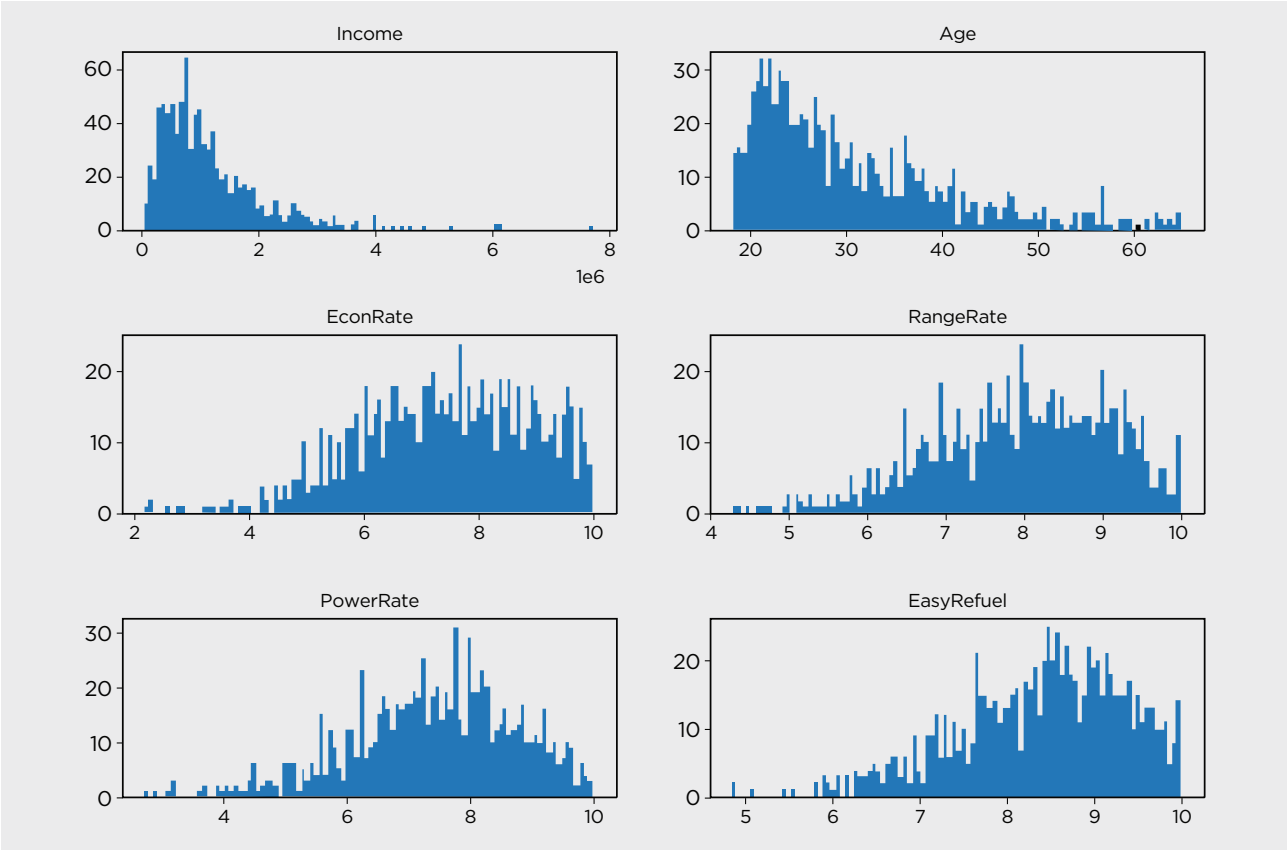


Figure 16: *Histogram of created Agent Attributes (Part A)*

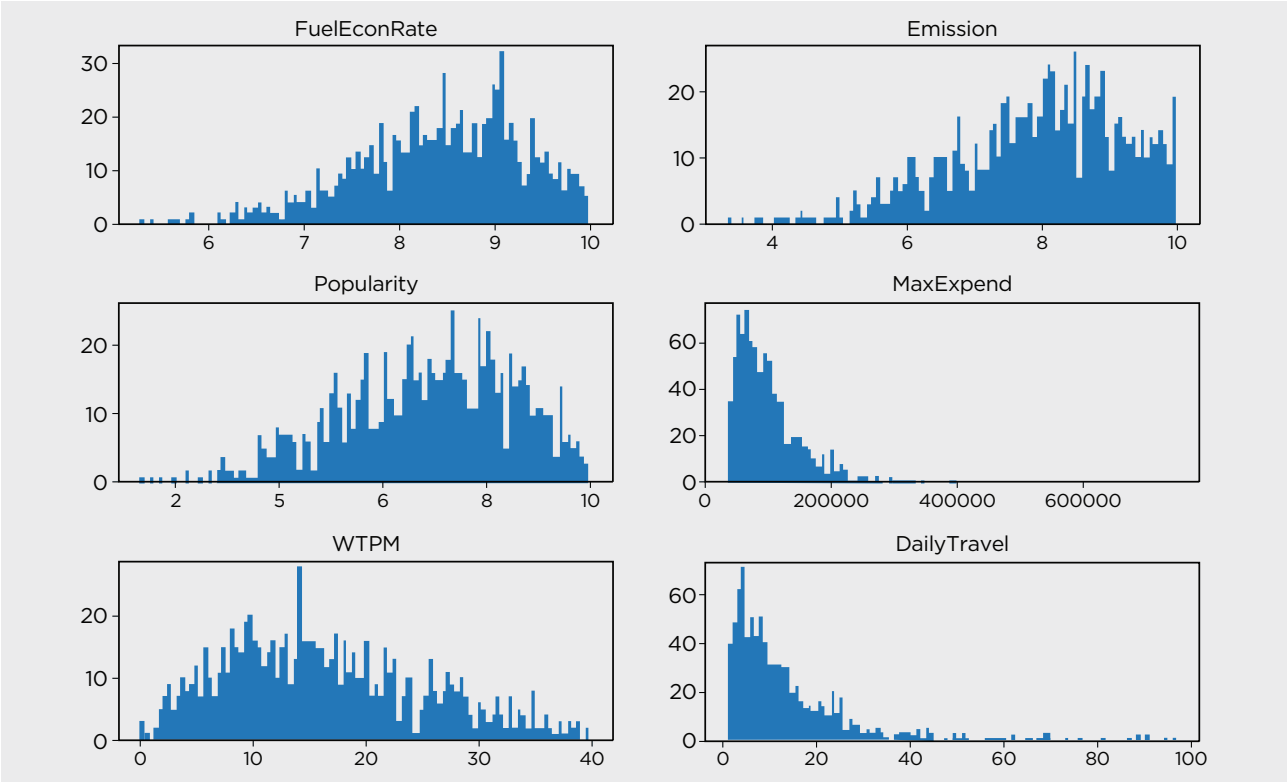


Figure 17: *Histogram of created Agent Attributes (Part B)*

3.5 Charging Behaviour

The electric two-wheelers typically have battery sizes between 1.2 kWh to 3.3 kWh and thus can be charged either at home or at public charging points. As per the survey, 63% of the respondents preferred public charging points over charging at home (Figure 18).

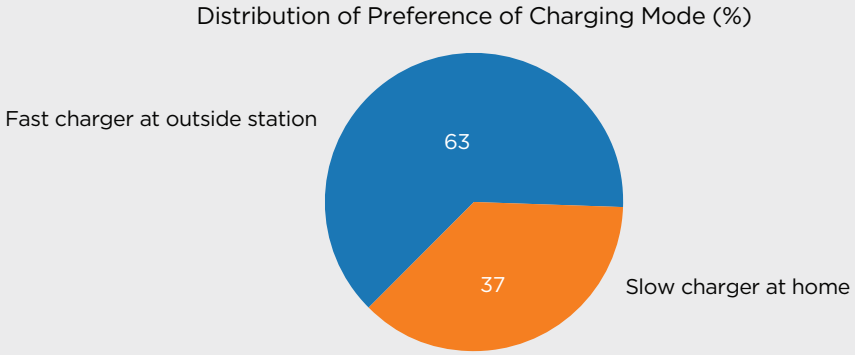


Figure 18: *Consumer preference of charging*

However, from the survey responses, it was found that the preference to home charging or charging at station is not strongly correlated to the daily travel distance. It was observed in both the cases that the daily travel distance varies through a wide range. Even the income distribution of the agents preferring public charging or home charging facilities were also similar, as shown in Figures 19 and 20. Hence 37% of the agents were randomly assigned the attribute of preference for home charging, whereas other 63% were randomly assigned the attribute of preference for public charging.

Figure 19 and Figure 20 demonstrate that preference for home charging or public station charging is not strongly related to the daily travel distance. It may be dependent on the personal attitudes.

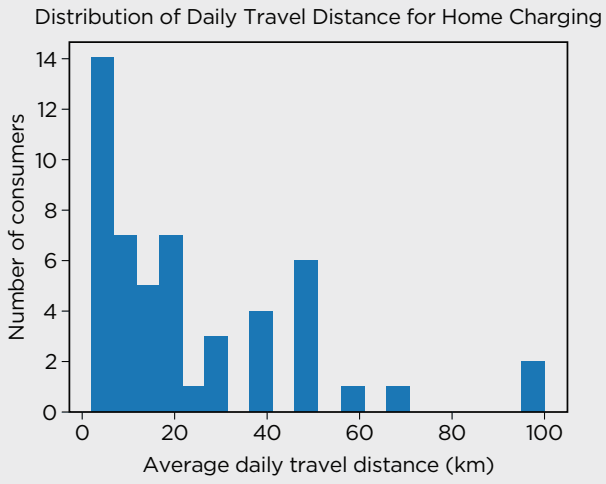


Figure 19: *Distribution of daily travel distance for Agents preferring home charging*

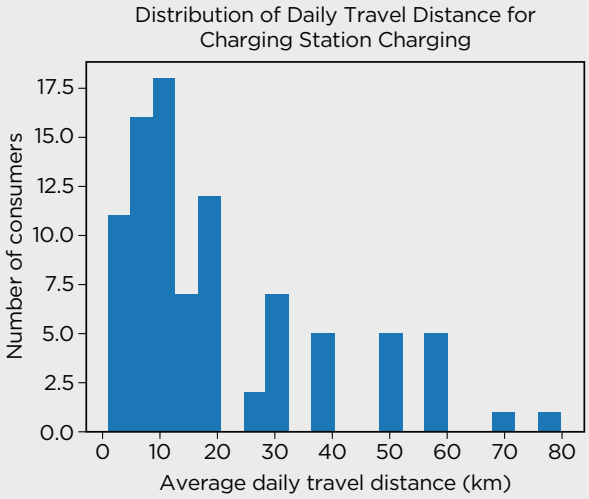


Figure 20: *Distribution of daily travel distance for Agents preferring public charging facilities*

TECHNOLOGY AND MARKET TRENDS

4.1 Survey of Available Electric Two-wheelers

A detailed study of the specifications of the IC engine and electric two-wheelers available in the market (as in August 2021) was made. The vehicles were categorized in terms of their power and type of propulsion. The obtained representative results are given below in Table 8.

Table 8: Specifications of available vehicles

Category Name	Vehicle Class	Ex-showroom Price (Rs.)	Traction Battery Kwh	Power (W)	Fuel Economy (kmpl)	Fuel Per km*	Range (km)
ICScooter87	Scooter	57000	-	4000	59.6	0.017	250
ICScooter110	Scooter	63000	-	6000	55.45	0.018	266
ICScooter125	Scooter	73000	-	6120	51.02	0.02	271
ICMotCycle100	MotorCycle	53000	-	5810	82.6	0.012	867
ICMotCycle110	MotorCycle	58000	-	6330	84.03	0.012	882
ICMotCycle125	MotorCycle	73000	-	8000	58.85	0.017	706
ICMotCycle150	MotorCycle	98000	-	10300	55.51	0.018	833
ICMotCycle160	MotorCycle	112000	-	11200	47.38	0.021	569
ICMotCycle180	MotorCycle	114000	-	12500	47.39	0.021	711
ICMotCycle200	MotorCycle	118000	-	13300	44.8	0.022	582
ICMotCycle220	MotorCycle	132000	-	13990	43.5	0.023	566
ICMotCycle250	MotorCycle	154000	-	19850	35	0.029	455
ICMotCycle300	MotorCycle	200000	-	20000	28.9	0.035	607
ICMotCycle310	MotorCycle	255000	-	25000	33.1	0.03	364

Category Name	Vehicle Class	Ex-showroom Price (Rs.)	Traction Battery Kwh	Power (W)	Fuel Economy (kmpl)	Fuel Per km*	Range (km)
ICMotCycle350	MotorCycle	166000	-	14249	40.8	0.025	551
ICMotCycle400	MotorCycle	212000	-	29400	28.57	0.035	371
ICMotCycle410	Motor Cycle	241000	-	17880	37.3	0.027	560
ICMotCycle650	Motor Cycle	323000	-	35062	25.7	0.039	352
ICMotCycle1000	Motor Cycle	1597000	-	73000	23.52	0.043	576
EVScooter1200	Scooter	60000	1.68	1200	NA	0.015	87
EVScooter1200a	Scooter	59000	1.54	1200	NA	0.01	122
EVScooter1300	Scooter	63000	1.54	1300	NA	0.007	165
EVScooter1500	Scooter	76000	1.44	1500	NA	0.016	70
EVScooter1800	Scooter	71440	1.87	1800	NA	0.014	108
EVScooter1900a	Scooter	89000	1.44	1900	NA	0.014	85
EVScooter1900b	Scooter	104000	2.8	1900	NA	0.013	170
EVScooter2020	Scooter	94500	2.09	2020	NA	0.014	120
EVScooter2200	Scooter	79000	2.5	2200	NA	0.017	120
EVScooter2500	Scooter	73000	2.4	2500	NA	0.016	120
EVScooter2500a	Scooter	99700	3.3	2500	NA	0.019	139
EVScooter5000	Scooter	90000	4.2	5000	NA	0.034	100
EVScooter5400	Scooter	113400	2.4	5400	NA	0.027	70
EVScooter6000	Scooter	132400	2.61	6000	NA	0.025	85
EVMotCycle1500	Motorcycle	95000	2.7	1500	NA	0.02	110
EVMotCycle3000	MotorCycle	90800	3.24	3000	NA	0.017	150
EVMotCycle4300	MotorCycle	157000	4.32	4300	NA	0.025	140
EVMotCycle5000	MotorCycle	229000	5.18	5000	NA	0.038	110
EVMotCycle5300	MotorCycle	130000	6.6	5300	NA	0.053	100
EVMotCycle6000	MotorCycle	112000	4	6000	NA	0.027	120
EVMotCycle8000	MotorCycle	136000	4.4	8000	NA	0.023	150
EVMotCycle12000	MotorCycle	142000	8.2	12000	NA	0.066	100
EVMotCycle25430	MotorCycle	289000	2.4	25430	NA	0.01	200

***Note:** Fuel per km values are in l/km in case of IC engine vehicles and kWh/kg in case of electric vehicles*

4.2 Charging of Electric Two-wheelers

Charging points that offer maximum power of 7.4 kW (230 V, 32 A) and are accessible by portable charging cables may be available at locations where vehicles are parked on a regular basis. The NITI Aayog-DST handbook on EV charging broadly categorizes EV charging infrastructure into three types: private, semi-public and public and a brief description about these is given in Table 9.

Table 9: Types of charging facilities for electric two-wheelers

Charging Infrastructure Type	Description
Private Charging	Dedicated charging for personal EV or EV fleet owners located at independent homes and dedicated parking spots in apartments/offices etc.
Semi-Public Charging	Shared charging for a restricted set of EV users located at apartment complexes, office campuses, gated communities, shopping malls, hospitals, universities and government buildings etc.
Public Charging	Open for all EV users, located at public parking lots, on-street parking, charging plazas, petrol pumps, highways and metro stations.

Thus, in terms of financial implications to the owners of the electric two-wheelers, two scenarios can be considered. The first is the private charging in which the owner needs to pay for the installation of charging facility at his/her premises and will need to pay electricity bill. The other is the use of public charging stations for which the user will have to pay to the owner/operator of the facility**. In both the cases, the power drawn by the battery is assumed to be 7 kW while using the tool.**

4.3 Status of EV Ecosystem and Electric Two-wheelers Production Plan

Efforts for introducing electric two-wheelers started in India in 1990s. Companies like Bajaj Auto, Scooters India Ltd. and Hero Motor Corporation etc. developed electric two-wheelers. The Ministry of New and Renewable Energy (MNRE) offered subsidy on electric vehicles during 2010-12. However, such efforts did not sustain and the sales of electric vehicles dropped significantly once subsidy was withdrawn.

After the launch of the FAME scheme, many new electric two-wheeler manufacturers have emerged and even the established ones have joined the race. Start-up companies such as Ather Energy, Okinawa, Pure EV and Ampere Vehicles etc. have established EV 2/3 wheeler manufacturing capacities and plan to expand them further. Ola has announced an ambitious plan for manufacturing and companies such as Hero Electric and Bajaj Auto etc. have also set up manufacturing facilities for the electric 2/3 wheelers.

An assessment of year-wise production capacity of electric 2/3 wheelers in the country was made based on the announcements made by the companies in the media and also based on direct inputs received from some of the manufacturers. Figure 21 gives a glimpse of such estimated capacity up to FY 2031.

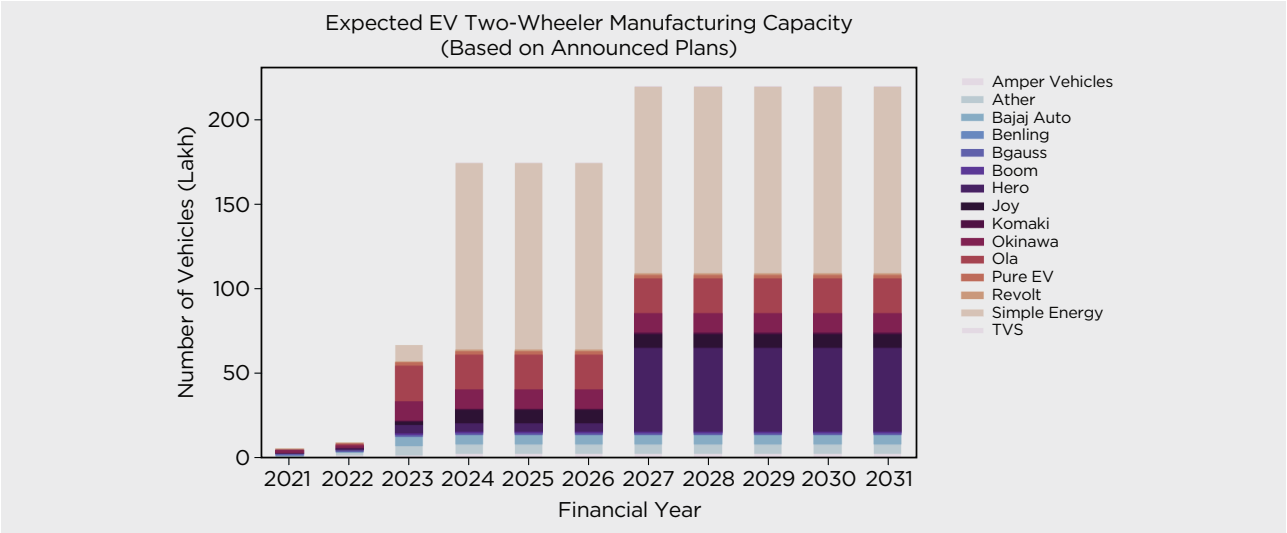


Figure 21: *Estimated production capacity of electric two-wheelers in India (scooters and motorcycles)*

In terms of infrastructure, in March 2021, there were about 1800 charging stations in India. Sanction has been given for installation of 3300 more charging stations under the FAME scheme. In the first phase of FAME, 520 charging stations were sanctioned and out of these, 429 have been commissioned. In the second phase, 2877 charging stations have been sanctioned. The public sector oil companies such as IOCL, HPCL and BPCL also plan to set up EV charging facilities at their 22000 fuel outlets. A host of private sector companies and start-ups have recently ventured into the business of electric vehicle charging. Based on the announcements on charging facility installation plans by the government as well as private sector entities and applying our judgement on likely year-wise phasing of their installations, a picture of future charging facility availability as depicted in the Figure 22 emerges.

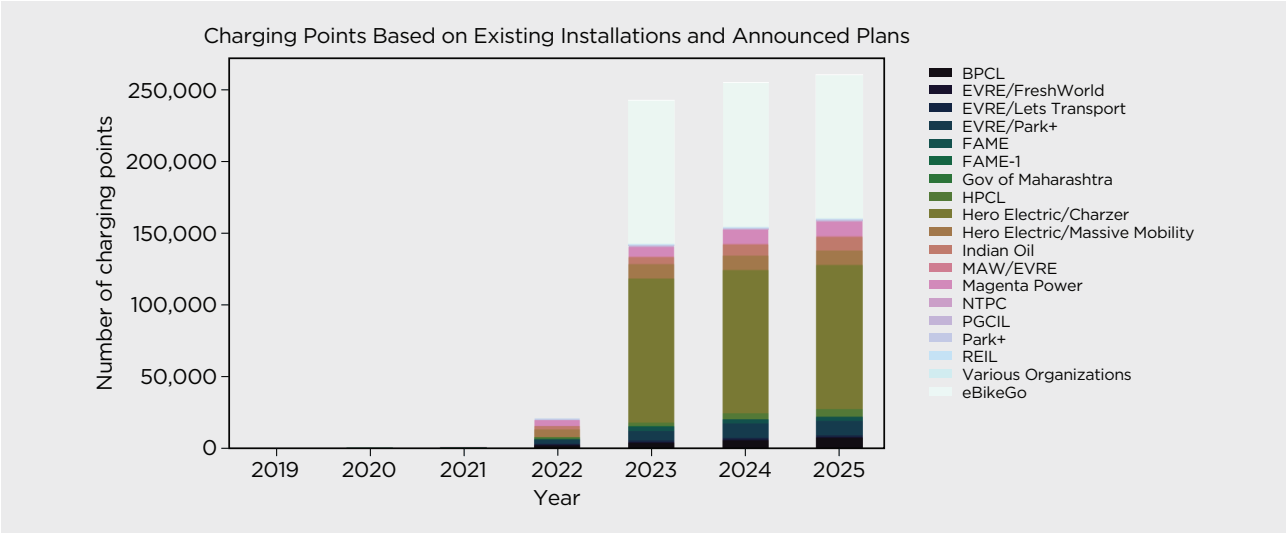


Figure 22: *Existing and announced plans for charging facility in India*

While this information provided an initial benchmark for constructing a few scenarios of possible roll out of charging facilities, it was also kept in mind that the announcements are mainly short-term onesand many more such plans may come up for the future years.

4.4 Trajectory of the Overall Two-Wheeler Market

From the data on registered motor vehicles in India since 1951 it can be seen that there has been phenomenal growth in their population in the country. The driving forces behind such growth have been population growth, economic growth and urbanization etc. Among various types of vehicles, two-wheelers have been in the lead except in the initial few years. Particularly, since 1980s there has been big strides in the two-wheelers market and the sales were only hit during 2019-20 and 2020-21 due to COVID-19 pandemic situation.

Figure 23 shows the growth pattern of various categories of vehicles over the years.

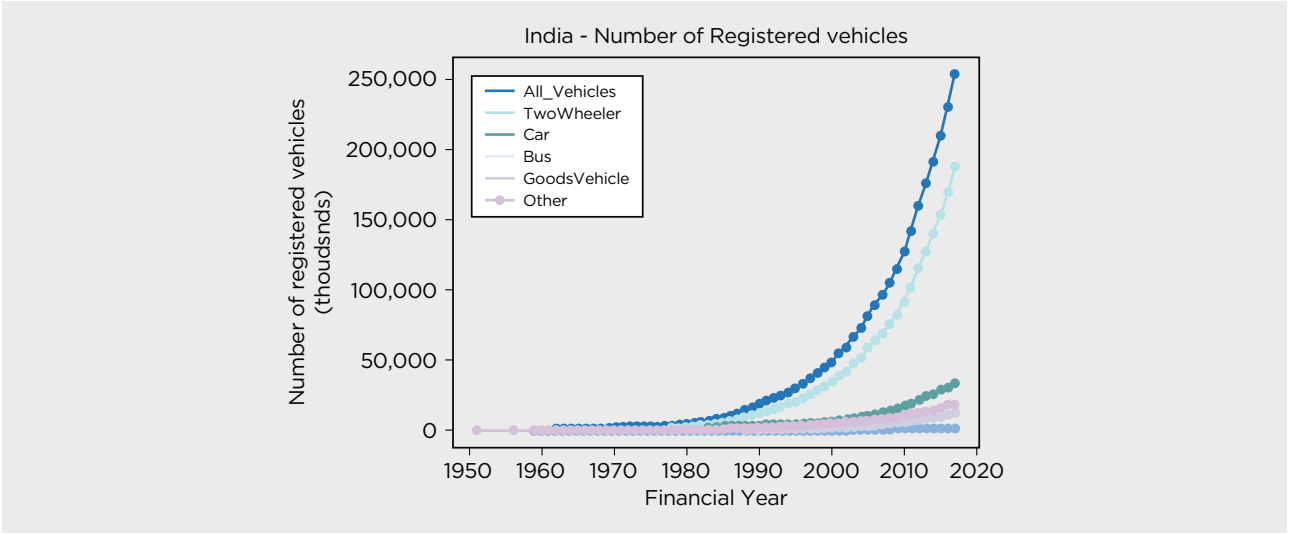


Figure 23: *Growth in number of registered vehicles in India*

Overall sales of two-wheelers in future years (FY2023 onwards) were estimated based on the CAGR between FY2015 and FY2019.

5 PROJECTED SCENARIOS OF EV TWO-WHEELERS PENETRATION

5.1 Definition of the Scenarios

A number of variables influence the projections of the annual level of market penetration of electric two-wheelers and it is possible to create many scenarios using the Agent-based model. However, in this report the focus is on those scenarios which provide important insights into the required measures by various stakeholders. Typically, such scenarios are defined based on the variables which are associated with high uncertainties and have high impact. Along with that, we also considered those scenarios which provide some policy insights.

As mentioned earlier, the crude oil prices have historically varied significantly. Although in the domestic market attempts have been made to stabilize the prices of petroleum fuels through measures like tax exemptions, they only impact moderately when crude prices reach very high in the international market. Thus, fuel price is one driving force for adoption of electric vehicles which is associated with high uncertainty and is likely to have a high impact.

Among all the components, battery contributes the most to the manufacturing cost of the electric vehicles. Thus, battery cost is expected to have high impact on the adoption of electric two-wheelers in India. Lithium ion battery cost has come down significantly in the last decade. However, very recently, with the availability of lithium being a concern the downward trajectory of the lithium ion battery has been arrested to some extent. Even there is slight increase in the cost also. However, in some studies it is projected that there will be some reduction in the cost of lithium ion battery, driven by solid state technology. In India, there is possibility of cost reduction due to local manufacturing. With the Production Linked Incentive scheme for Advanced Chemistry Cells, such a scenario is distinctly possible.

Incentives/subsidies directly impact purchase of electric vehicles by reducing the gap between the IC engine and electric vehicles in terms of sale price. Although in the longer term it is desirable that electric vehicles sustain in the market on their own without such incentives/subsidies, they are justified as short-term actions towards removing the initial inertia and apprehensions about electric mobility. The fact that environmental and social benefits are expected as a result of such support also justifies such actions.

Hence, subsidies/incentives are considered in the scenario analysis. Since there are FAME subsidies as well as subsidies provided by various state governments, we only focus on an equivalent of FAME subsidy. The scenarios have been constructed by varying the year till such subsidies are expected to continue.

Enhanced adoption of electric vehicles can also be driven by enhanced performance due to technological improvements. Higher specific energy battery may improve the range of the vehicle and improved electric motors may offer higher power and speed, removing the gap between electric vehicles and conventional IC engine vehicles.

There are also some factors which mainly influence the electric mobility adoption in terms of constraints.

Roll out of charging infrastructure is one such important factor for adoption of electric mobility, as it has a direct relevance to the so-called 'Range Anxiety' of the users. Although setting up charging infrastructure cannot be classified as something that involves 'high uncertainty', including it as a scenario defining variable offers an advantage for important policy insights. Broadly, two major states of this driving force are considered: one in which electric vehicle penetration is faced with the limitation of availability of charging infrastructure and the other in which enough number of charging facilities are always available. A third scenario, which assumes no constraint in terms of either supply of vehicles or availability of charging facilities, is an unlikely scenario, but gives an indication of the latent demand for the electric two-wheelers.

The readiness of the industry is another important influencing factor for market penetration of electric vehicles. In this analysis, it has been considered in terms of plan for production of electric two-wheelers by the vehicle manufacturers. The announcement of plans for establishing electric two-wheeler manufacturing facilities constitute the basis of the capacity estimates. However, as the electric mobility industry gains momentum in India, some more established vehicle manufacturers as well as the new entrants may come up with plans of further capacity addition. To consider such possibilities, three different production levels have been considered under each of the main scenarios. These are shown in Figure 24.

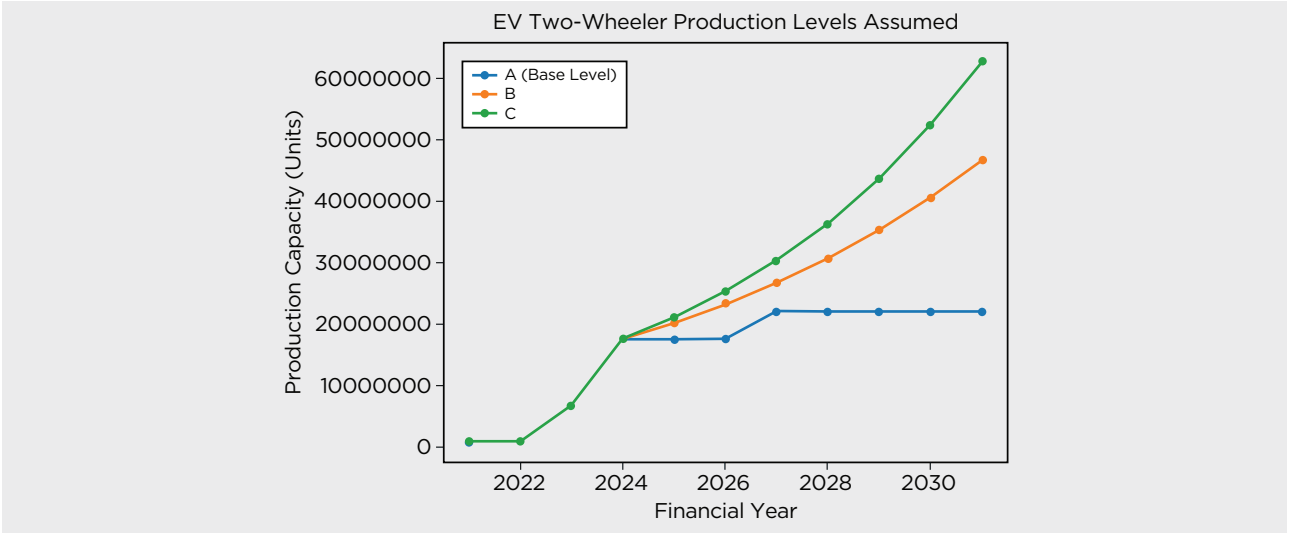


Figure 24: *Assumed production scenarios for EV two-wheelers*

Under sub-scenario A, the number of vehicles produced each year is solely derived from the announced plans of the vehicle manufacturers. Since information on the new capacity additions is not available beyond a certain period, it is assumed that capacity achieved till then will continue till the Financial Year 2031. Under production sub-scenario B, it is assumed that after FY 2024 the capacity will grow with a CAGR of 15%. Similarly, the production sub-scenario C assumes a CAGR of 20% for the production capacity growth after FY2024.

Just like sub-scenarios of production, three different sub-scenarios of availability of charging infrastructure have also been considered. Under the base sub-scenario X, the information of plans for setting up charging infrastructure has been compiled as shown in Figure 25. However, considering the fact that setting up charging facilities may be a more agile process as compared to setting up vehicle manufacturing facilities, certain annual capacity additions are expected. Hence, we have considered the CAGR between financial year 2022 and financial year 2025 (until such data is available), to estimate charging facilities up to financial year 2031 in the base level X. Doubling and tripling of charging infrastructure from FY 2023 onwards have been assumed in the charging infrastructure levels Y and Z, respectively.

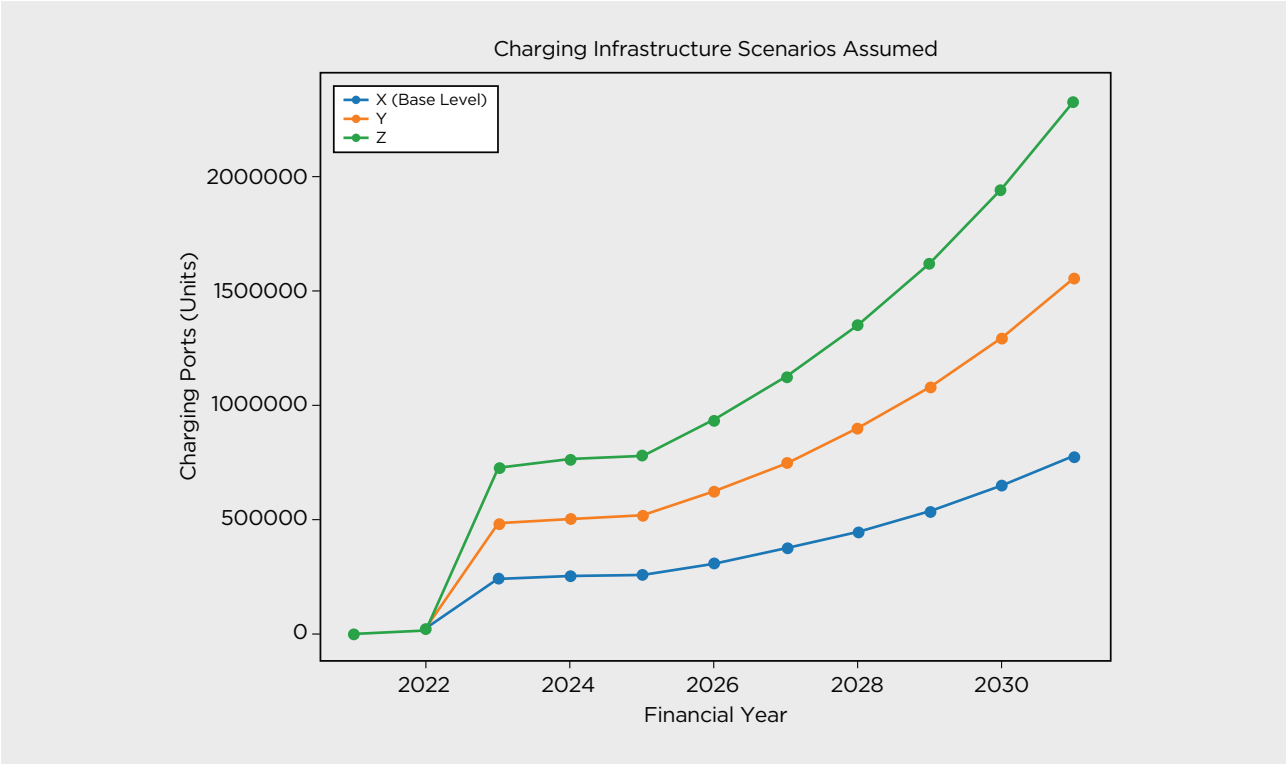


Figure 25: *Assumed charging infrastructure scenarios for EV two-wheelers*

Estimation of required charging infrastructure at any point of time depends on, apart from the stock of the electric vehicles, how the infrastructure is utilized. In general, the installed charging infrastructure is not fully utilized and the utilization is low at the low level of penetration of electric vehicles. To take this into account, a Capacity Utilization Factor (CUF) is considered, which is assumed to follow a logistic growth curve to grow from 10% in FY2021 to 70% in 2031 (Figure 26).

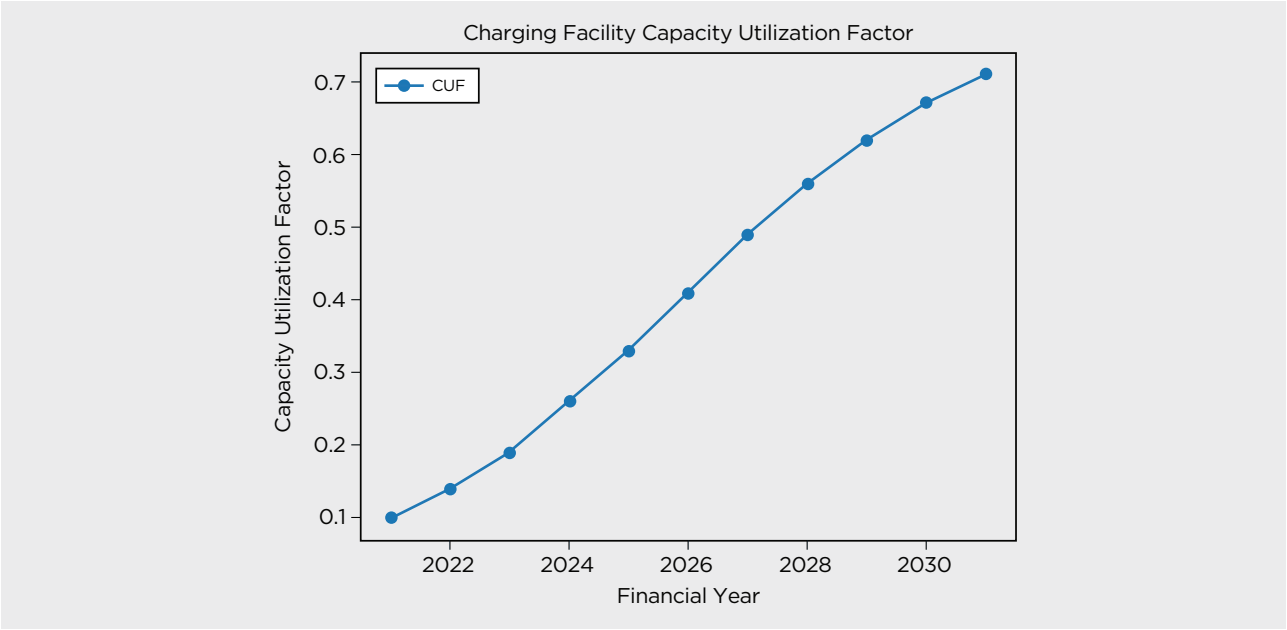


Figure 26: *Assumed Capacity Utilization Factor for the charging infrastructure*

Apart from the utilization factor, we also need to consider the fact that not all charging facilities are dedicated for electric two-wheelers. Hence, it is assumed that 70% of the charging power dispensed by the charging infrastructure during its operation is available for the two-wheelers. Though comprehensive assessment of required charging infrastructure can only be made if all types of vehicles are considered, we can have a reasonable assessment based on these assumptions.

As per the above discussion, all the scenarios analyzed in the present report are summarized in Table 10.

Table 10: Scenarios considered

Scenario Name	Demand Incentive	Battery Cost Reduction CAGR	Performance Improvement Due to Technological Progress
Challenged Diffusion	No after FY 2024	2%	No
Performance Driven	No after FY 2024	2%	Yes
Low Battery Cost	No after FY 2024	8%	No
Technology Driven	No after FY 2024	8%	Yes
Incentive Driven	Yes (till FY 2031)	2%	No
Battery Cost Challenged	Yes (till FY 2031)	2%	Yes
Same Performance	Yes (till FY 2031)	8%	No
Optimistic	Yes (till FY 2031)	8%	Yes

The forecasting results of EV two-wheelers penetration are also influenced by the constraints, mainly, in terms of production capacity of the electric two-wheelers and availability of charging infrastructure. The constraint levels analyzed for each of the scenarios are listed in Table 11.

Table 11: Sub-scenarios and constraint levels considered

Sub-scenarios based on constraints	Limited by Vehicle Production	Limited by Availability of Charging Infrastructure	Production Capacity Level	Charging Infrastructure Level	Constraint Sub Scenario
Full Constrained	Yes	Yes	A (Base Level)	X (Base Level)	FullConstr-AX
				Y (Doubled from third year)	FullConstr-AY
				Z (Tripled from third year)	FullConstr-AZ
			B (Doubled from third year)	X	FullConstr-BX
				Y	FullConstr-BY
				Z	FullConstr-BZ
			C (Tripled from third year)	X	FullConstr-CX
				Y	FullConstr-CY
				Z	FullConstr-CZ
Production Constrained	Yes	No	A	Any	ProdConstr-A
			B		ProdConstr-B
			C		ProdConstr-C
Charge Constrained	No	Yes	Any	X	ChgContr-X
				Y	Chg Constr-Y
				Z	ChgConstr-Z
No Constraints	No	No	Any	Any	NoConstr

However, it may be noted that the tool can be run with varying a number of input parameters and thus, it is possible to construct many more scenarios and sub-scenarios. For example, for the entire analysis, it is assumed that demand incentive will be available till 2024. However, the tool provides options to study other scenarios related to demand incentives as well.

In the following sections of this report all the above sub-scenarios have been analyzed for the penetration, production and sale of electric two-wheelers. The demand for charging points and battery demand have also been studied.

5.2 Challenged Diffusion Scenario

5.2.1 Challenged Diffusion Scenario with Full Constraint

The penetration level is low in this case. A peak of 5.82% is achieved in the FY 2024 after which withdrawal of demand incentives cause a fall in penetration of electric two-

wheelers. There is, however, a rise in penetration after this decline and for base level of production and charging infrastructure the penetration value in FY 2031 is 3.10%. Enhancing the charging infrastructure does not increase EV penetration. This is depicted in Figure 27.

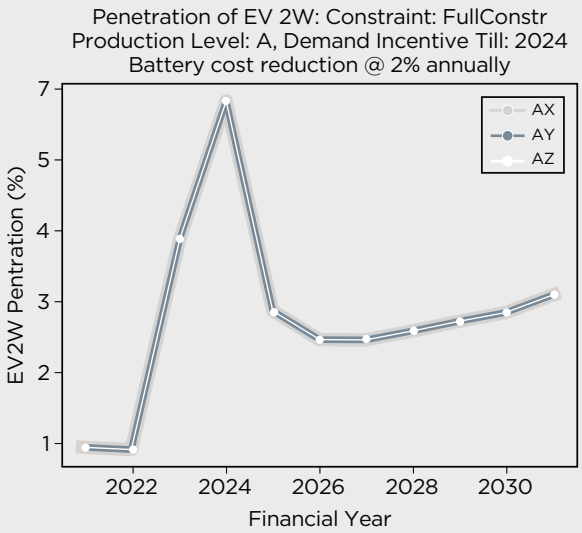


Figure 27: *Projected penetration of electric two-wheelers in Challenged Diffusion Scenario with Full Constraint, production level A*

The details of penetration values for all combinations of production capacity and charging infrastructure availability are presented in the Table 12.

Table 12: Projected Penetration of Electric Two Wheelers in Challenged Diffusion Scenario, with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2025	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2026	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2027	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2028	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
2029	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
2030	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2031	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1

Sale of electric two-wheelers always remain less than the installed production capacity (Figure 28).

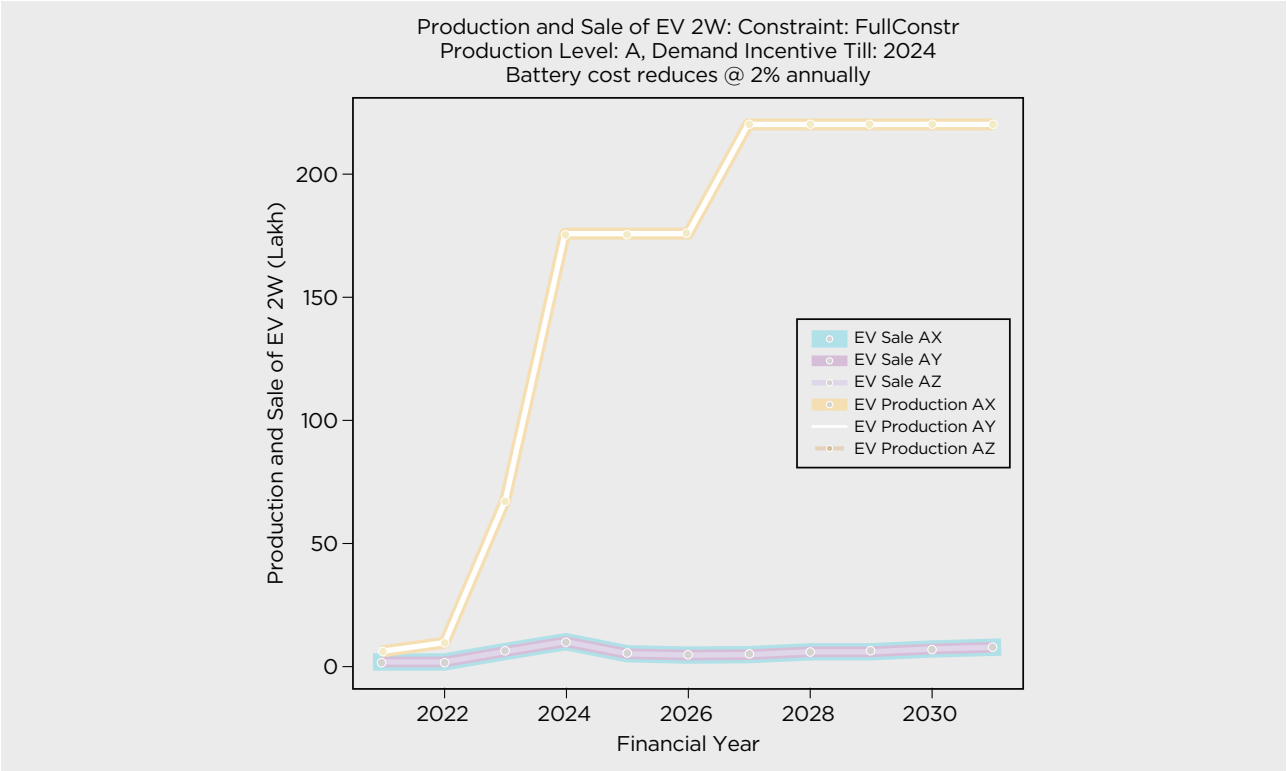


Figure 28: *Sale and production of electric two-wheeler in Challenged Diffusion Scenario with Full Constraint, production level A*

Details of sales volume of electric two-wheelers in all combinations of production capacity and charging infrastructure are shown in Table 13.

Table 13: Projected Sale of Electric Two-wheelers in Challenged Diffusion Scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2025	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
2026	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
2027	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93
2028	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
2029	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
2030	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76
2031	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80

The demand for charging infrastructure for the AX constraint level is shown in Fig 29.

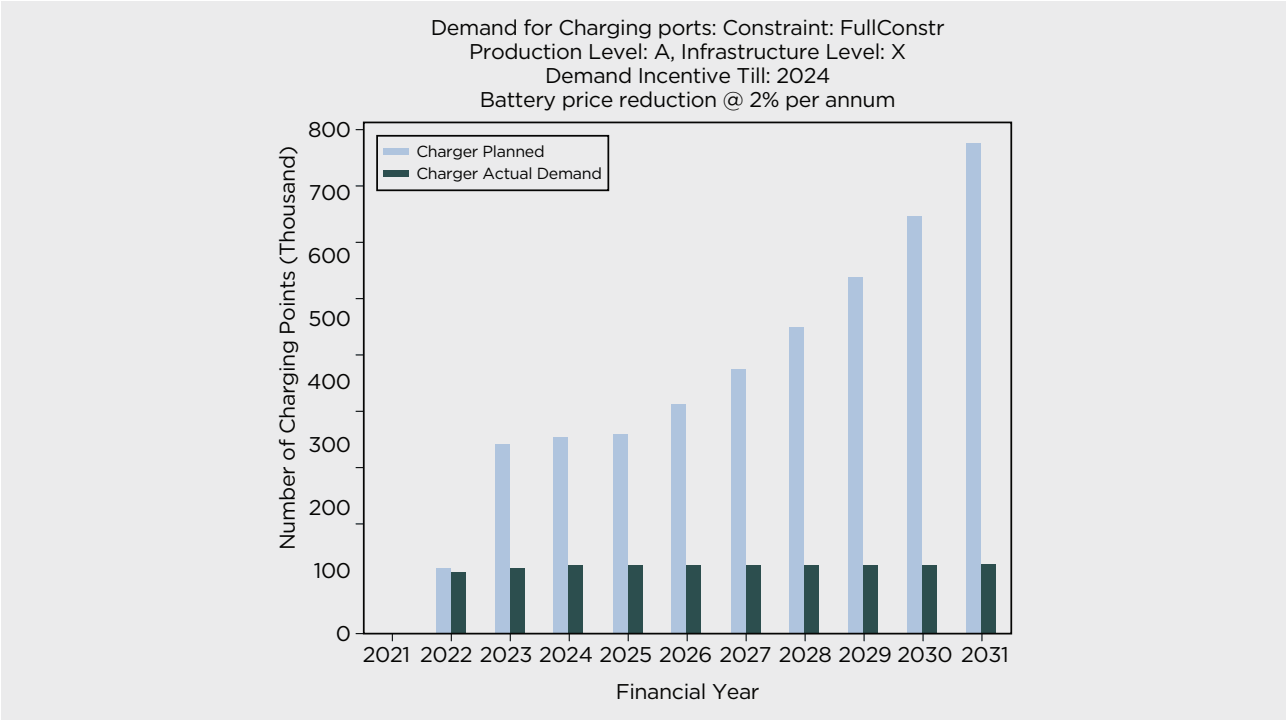


Figure 29: *Demand for charging infrastructure in Challenged Diffusion Scenario, constraint level AX*

The demand for battery reaches a 1.68 GWh in the FY 2024and then followed by a decline, rises to 1.28 GWh in the FY 2031 (Figure 30 and Table 14).

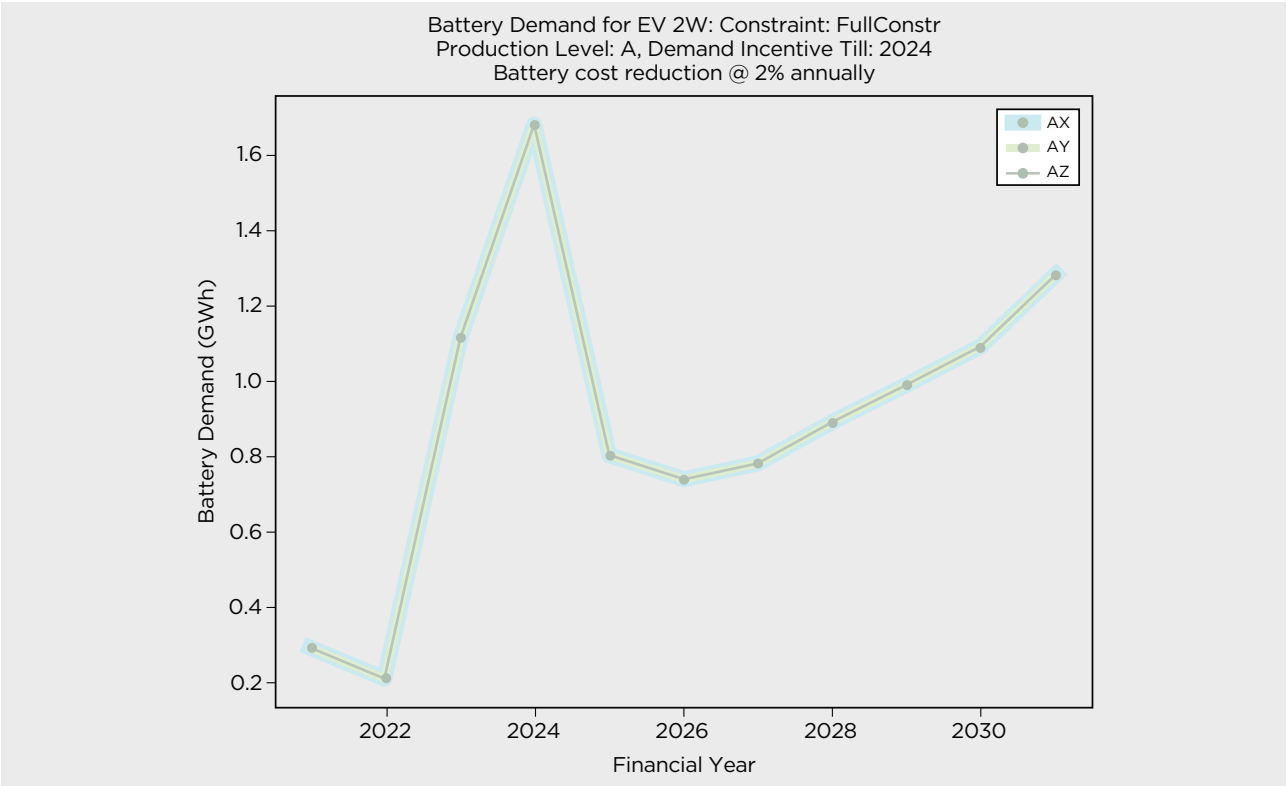


Figure 30: *Projected battery demand in Challenged Diffusion Scenario with Full Constraints, vehicle production level A*

Table 14: Projected battery demand in Challenged Scenario with Full Constraints

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
2025	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
2026	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
2027	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
2028	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
2029	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
2030	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
2031	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28

5.2.2 Challenged Diffusion Scenario with Production Constraint

Since the constraint of charging infrastructure is not considered, the penetration at all planned charging infrastructure levels increases to 6.86% in FY 2024, declines after withdrawal of subsidy and then again rises to reach 3.10% in FY 2031 (Figure 31).

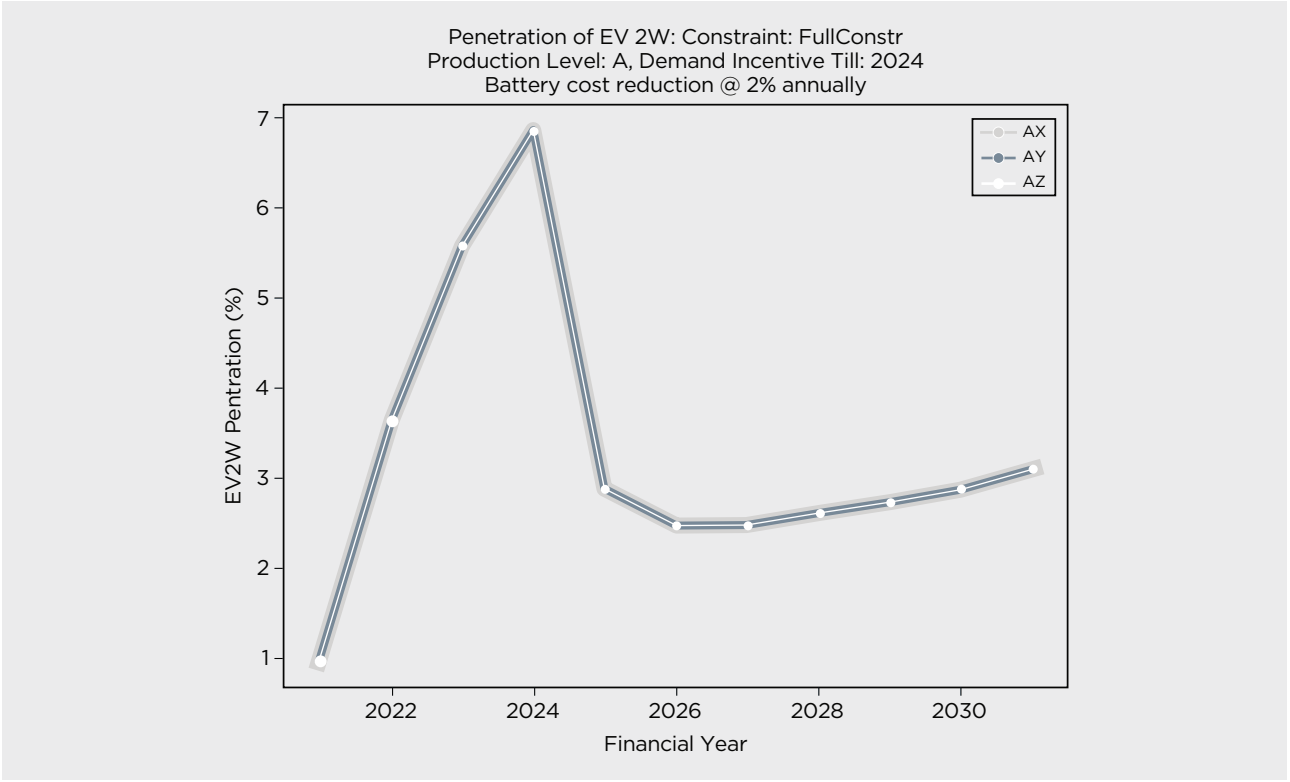


Figure 31: *Projected penetration of electric two-wheelers in Challenged Diffusion Scenario with Production Constraint, production level A*

The details of projected penetration values under this scenario for various combinations of production capacity and infrastructure capacity are in the Table 15.

Table 15: Projected Penetration of Electric Two-Wheelers in Challenged Diffusion Scenario with Production Constraint

Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86
2025	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2026	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2027	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2028	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
2029	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
2030	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2031	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1

Accordingly, the sale of electric two-wheelers is also same in all the combinations of production capacity and charging infrastructure (Figure 32).

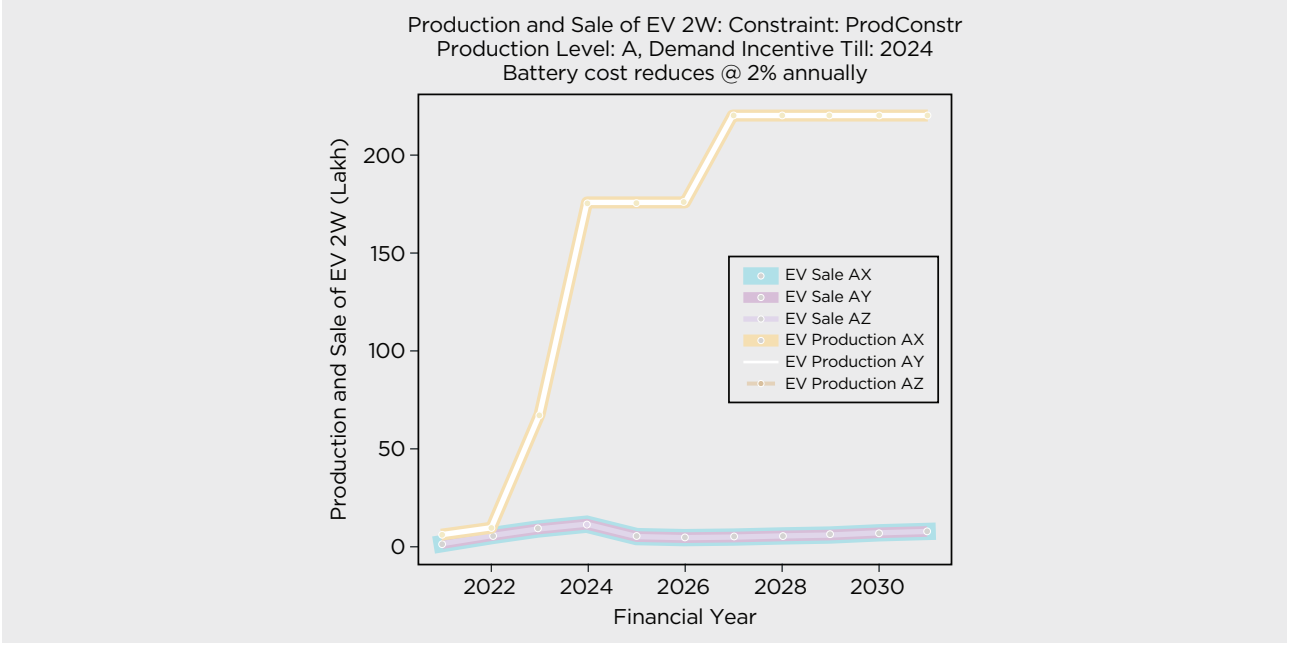


Figure 32: *Sale and production of electric two-wheelers in Challenged Diffusion Scenario with Production Constraint, production level A*

Details of sale volumes of electric two-wheelers in all the combinations of production level and charging infrastructure are shown in Table 16.

Table 16: Projected Sale of Electric Two-Wheelers in Challenged Diffusion Scenario with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
2024	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
2025	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
2026	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
2027	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93
2028	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
2029	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
2030	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76
2031	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8

The demand for charging points for the AX constraint level is shown in Figure 33. The demand was found to be same for all the combinations of above constraint levels.

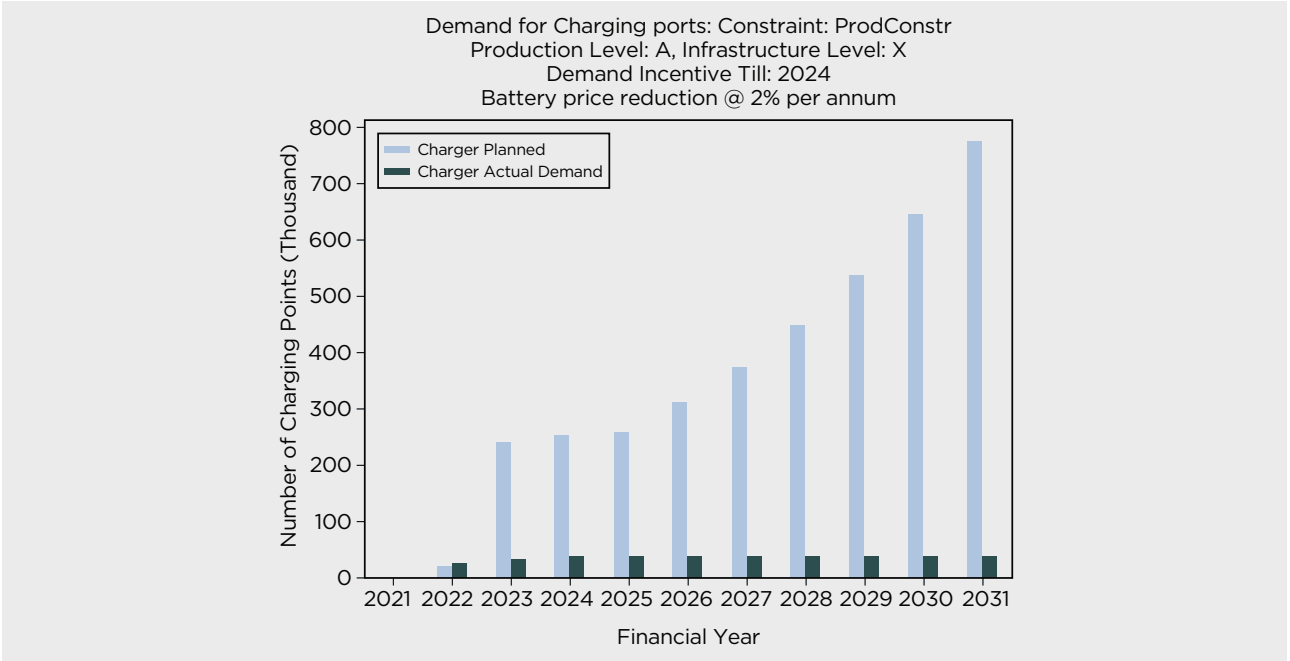


Figure 33: *Demand for charging points in Challenged Diffusion Scenario with Production Constraint (constraint level AX)*

The demand for battery for all the combinations of constraint levels reaches 2.12 GWh, which occurs in the FY 2024 and then, followed by a decline, again rises to 1.28 GWh in the FY 2031. Figure 34 describes the situation for Production Constraint A and Table 17 gives the detailed results for all the combinations.

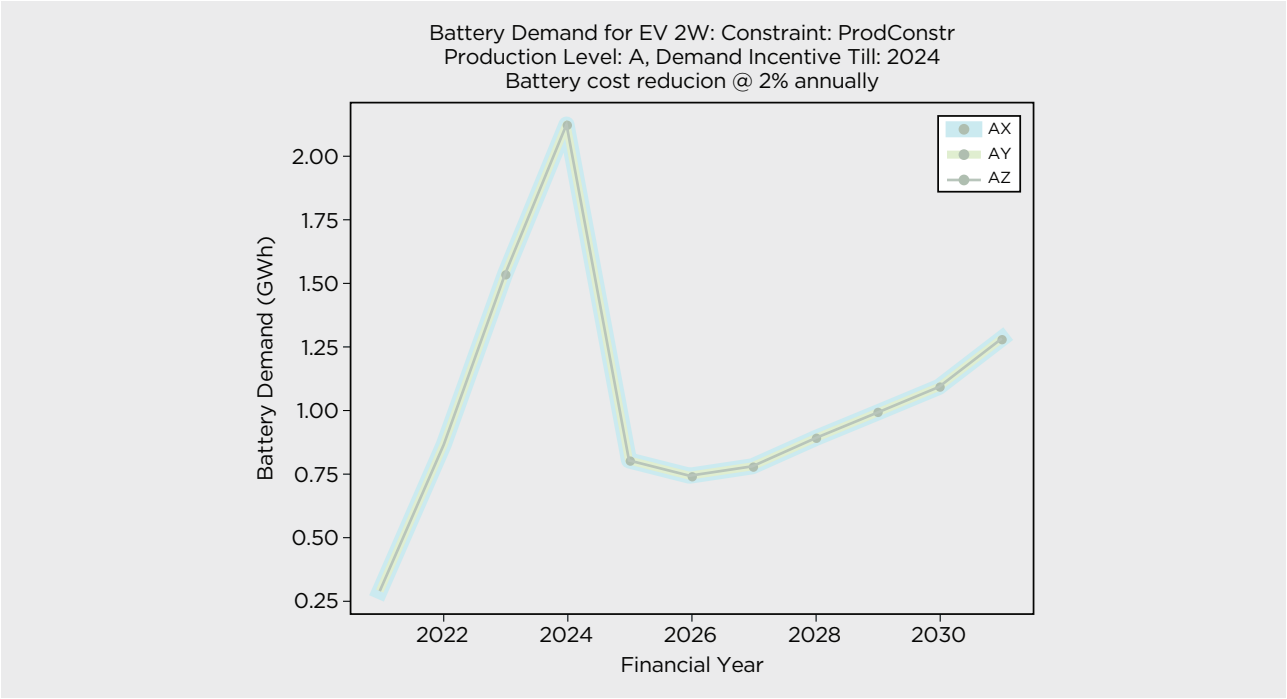


Figure 34: *Battery demand in Challenged Diffusion Scenario with production constrain, production level A*

Table 17: Battery Demand in the Challenged Diffusion Scenario with Production Constraint

Financial Year	Projected battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
2025	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
2026	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
2027	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
2028	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
2029	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
2030	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
2031	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28

5.2.3 Challenged Diffusion Scenario with Charge Constraint

The profile of penetration of electric two-wheelers in base infrastructure level X is shown in Figure 35 in this scenario. The maximum penetration of 5.82% is achieved in the FY 2024. Subsequently, penetration level follows a pattern based on available charging infrastructure and absence of demand incentives.

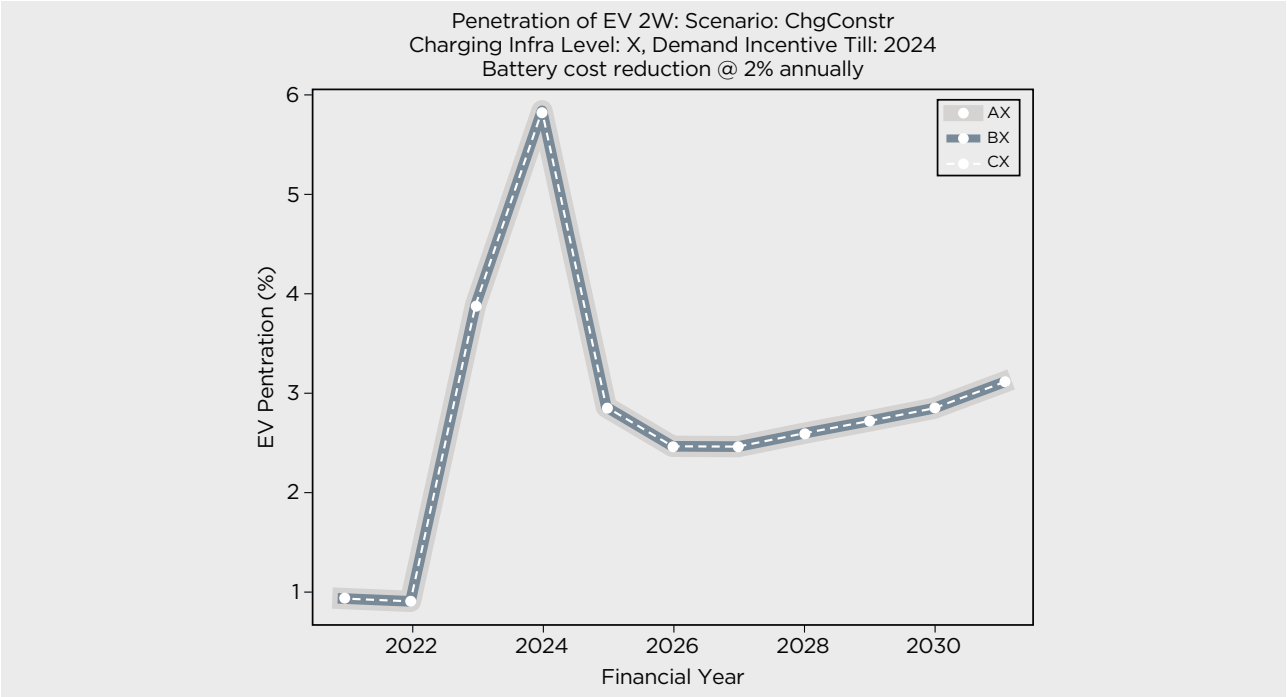


Figure 35: *Penetration of electric two-wheelers in Challenged Diffusion Scenario with Charge Constraint, infrastructure level X*

The penetration levels remain same for infrastructure levels Y and Z too, because the assumed infrastructure is same for first two years, during which a higher level of infrastructure would have made a difference (Table 18).

Table 18: Penetration of Electric Two-Wheelers in Challenged Diffusion Scenario with Charge Constraint, infrastructure level X

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2025	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2026	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2027	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2028	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
2029	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
2030	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2031	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1

Projected sale of electric two-wheelers shows that the maximum sale will be 9.85 lakh units in the FY 2024 and it will reach 7.8 lakh units in FY 2031 after a slump following withdrawal of demand incentives (Figure 36 and Table 19).

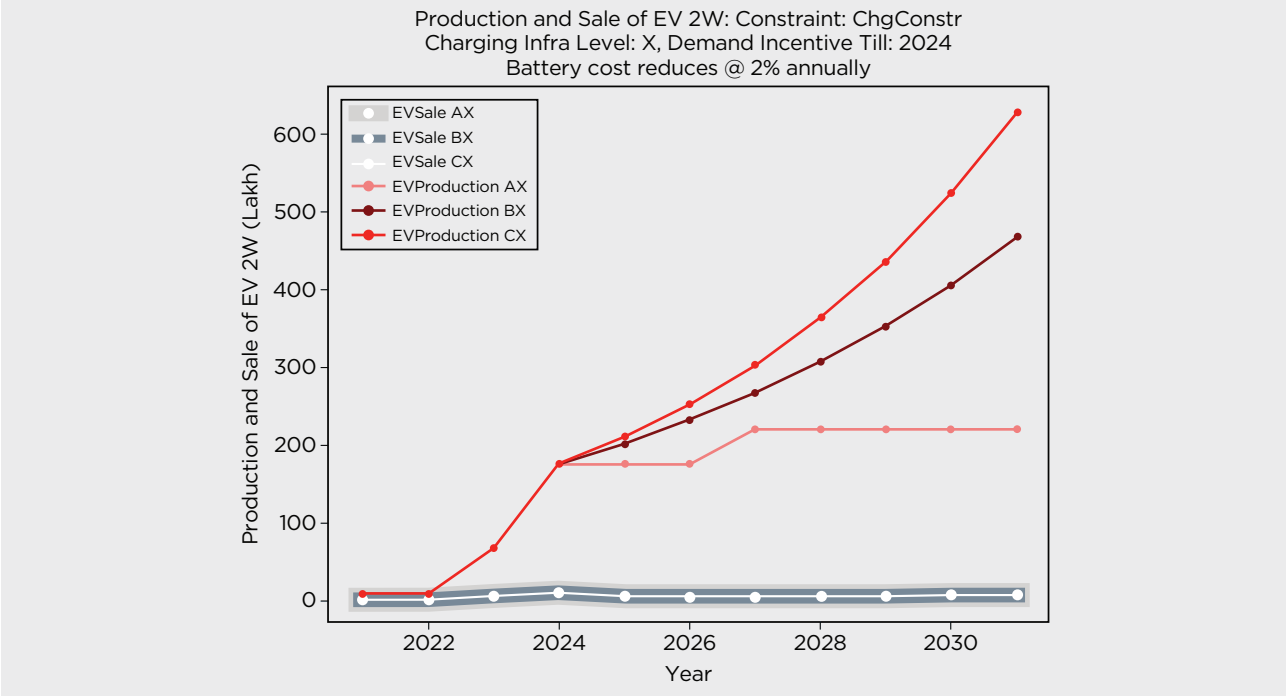


Figure 36: *Sale and production of electric two-wheelers in the Challenged Diffusion Scenario with Charge Constraint, infrastructure level X*

Table 19: Sale of electric two-wheelers in Challenged Diffusion Scenario with Charge Constraint

Financial Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2025	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
2026	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
2027	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93
2028	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
2029	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
2030	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76
2031	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8

Projected charging point demand at the AX constraint level is shown in Figure 37.

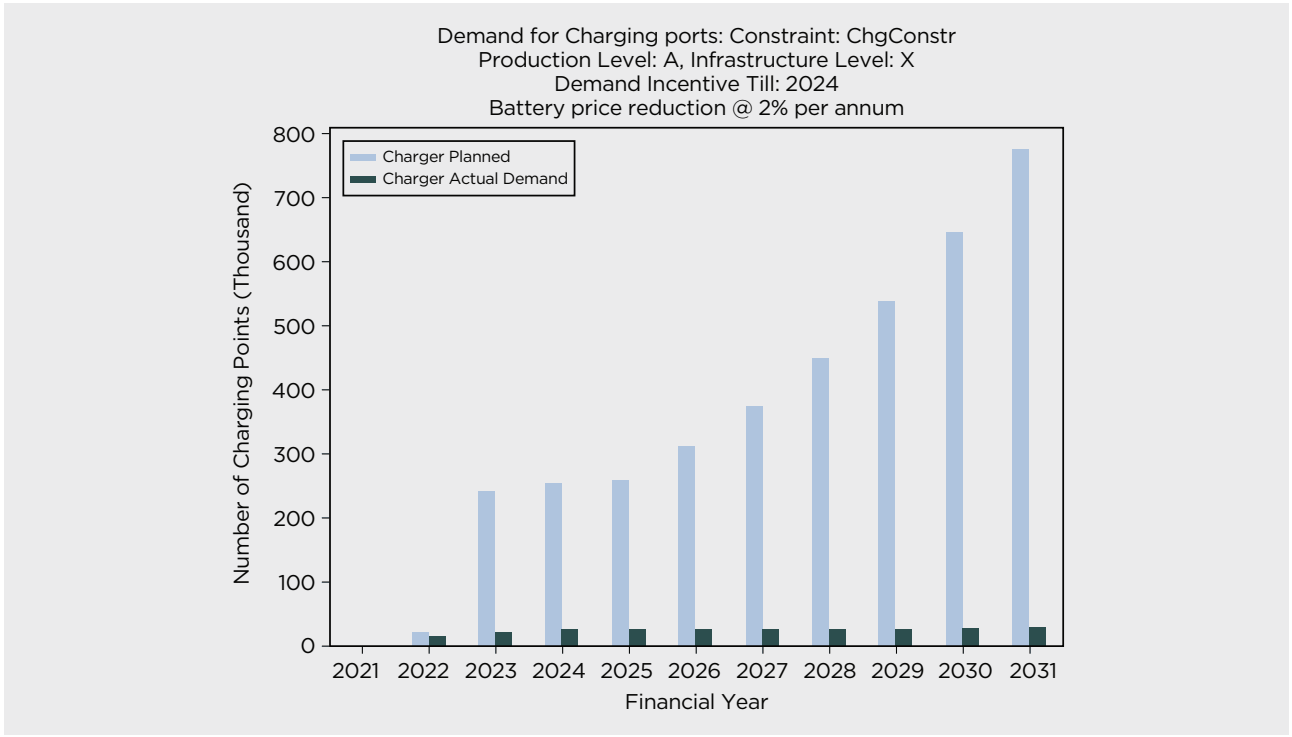


Figure 37: *Demand for charging points in Challenged Diffusion Scenario with Charge Constraint (constraint level AX)*

Projected battery demand has a maximum value of 1.68 GWh in FY 2024 and in FY 2031 this value reaches 1.28 GWh (Figure 38 and Table 20. As can be seen, there is no difference in results due to variation of vehicle production capacity or charging infrastructure.

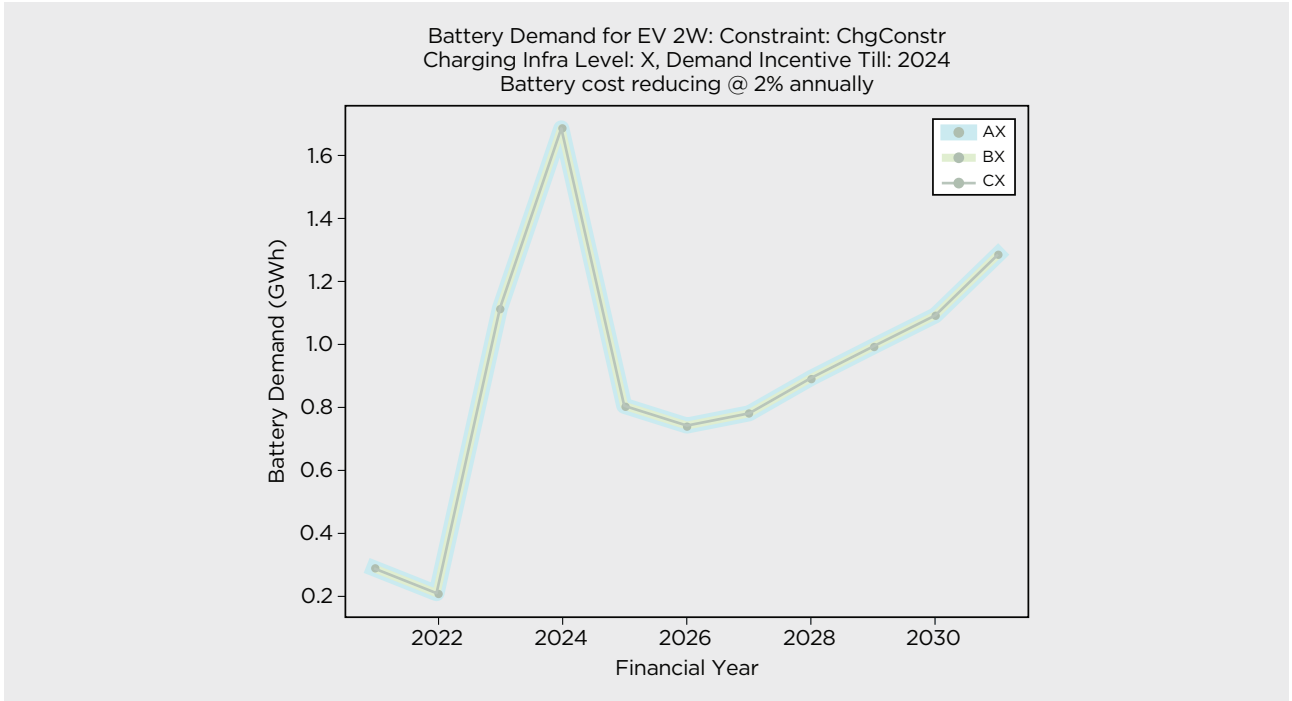


Figure 38: *Battery demand for charging points in Challenged Diffusion Scenario, with infrastructure constraint level X*

Table 20: Battery demand for charging points in Challenged Diffusion Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
2025	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
2026	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
2027	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
2028	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
2029	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
2030	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
2031	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28

5.2.4 Challenged Diffusion Scenario with No Constraint

This is a hypothetical scenario in which there is no limitation in terms of charging infrastructure or supply of vehicles. While purchasing the vehicles the buyers do not consider availability of adequate charging infrastructure as a factor

However, in the present case, absence of any constraint in terms of vehicle production capacity or installed charging infrastructure does not make any significant difference in the penetration of electric two-wheelers (Figure 38 and Table 21) in all the constraint levels assumed by us.

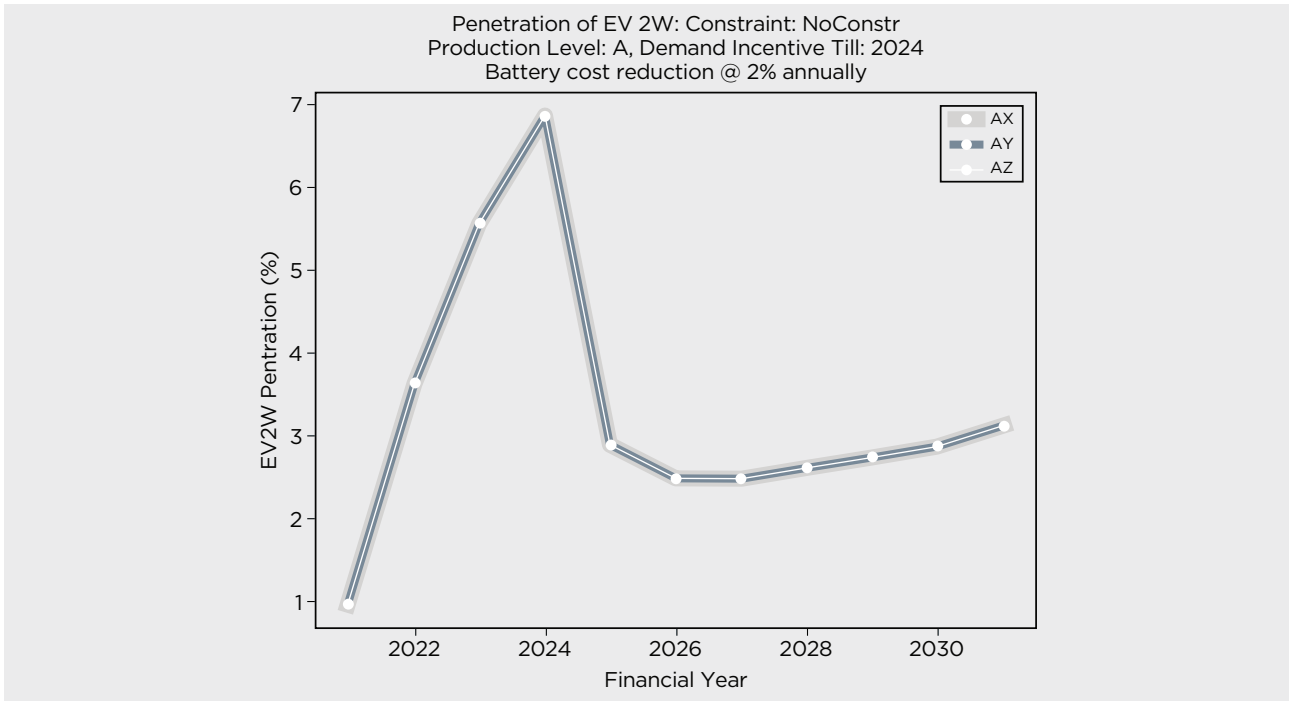


Figure 39: *Penetration of electric two-wheelers in Challenged Diffusion Scenario with No Constraint, production level A*

Table 21: Penetration of electric two-wheelers in Challenged Diffusion Scenario with no constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86
2025	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2026	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2027	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
2028	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
2029	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
2030	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
2031	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10

The sale of electric two-wheelers reaches a maximum of 11.6 lakh units in the FY 2024and then 7.8 lakh units in the FY 2031. These values when compared with other sub-scenarios of Challenged Diffusion Scenario, indicate that there will be some initial gains due to absence of constraints, but the maximum sale volume achieved will not be significantly higher (Figure 40 and Table 22).

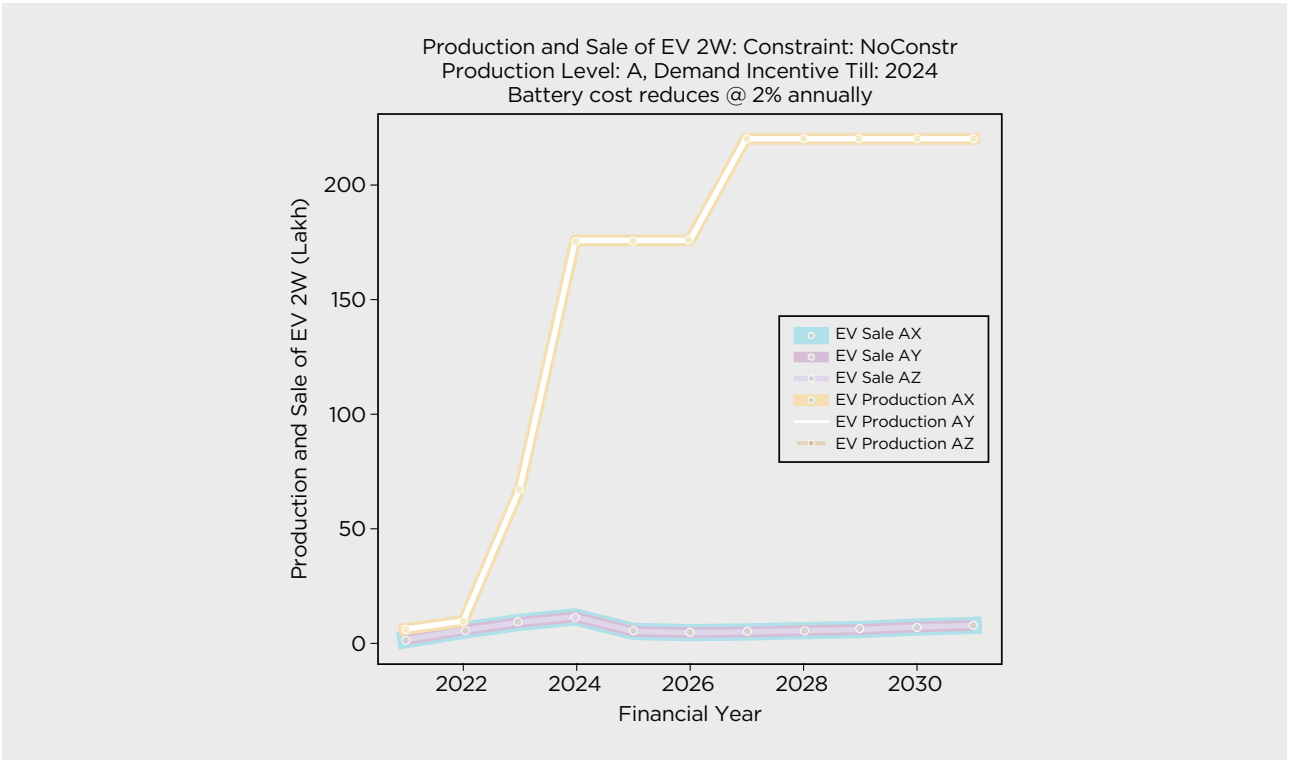


Figure 40: *Sale and production of electric two-wheelers in Challenged Diffusion Scenario with No Constraint*

Table 22: Sale of electric two-wheelers in Challenged Diffusion Scenario with no constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
2024	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
2025	5.10	5.10	5.10	5.10	5.10	5.10	5.1	5.1	5.1
2026	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
2027	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93	4.93
2028	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
2029	6.10	6.10	6.10	6.10	6.10	6.10	6.1	6.1	6.1
2030	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76	6.76
2031	7.80	7.80	7.80	7.80	7.80	7.80	7.8	7.8	7.8

The demands for charging points remain at a very low level like in other constraint sub-scenarios under the Challenged Diffusion Scenario. An example for the constraint level AX is shown in Figure 41 for this situation.

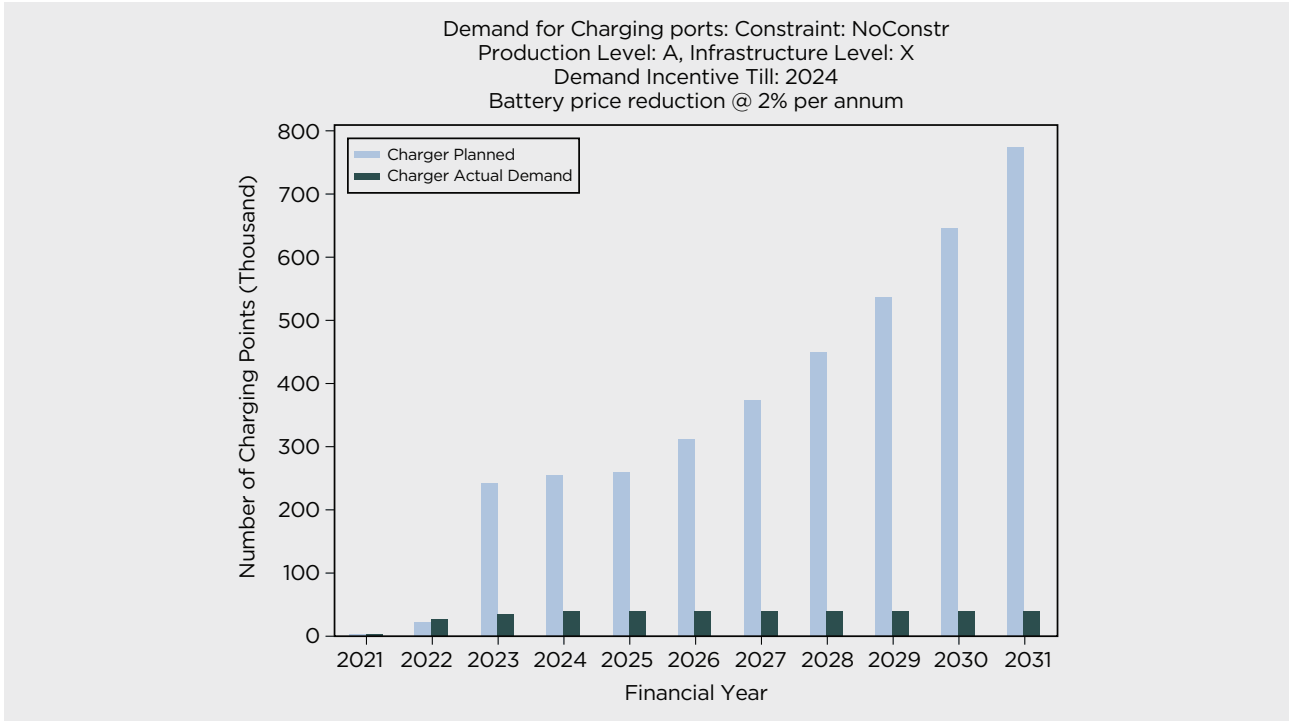


Figure 41: *Demand for charging points in the Challenged Diffusion Scenario with No Constraint (constraint level AX)*

The demand for battery also, reaches only a marginally higher level at 2.12 MWh in the FY 2024 and then 1.28 GWh in the FY 2031 (Figure 41 and Table 23).

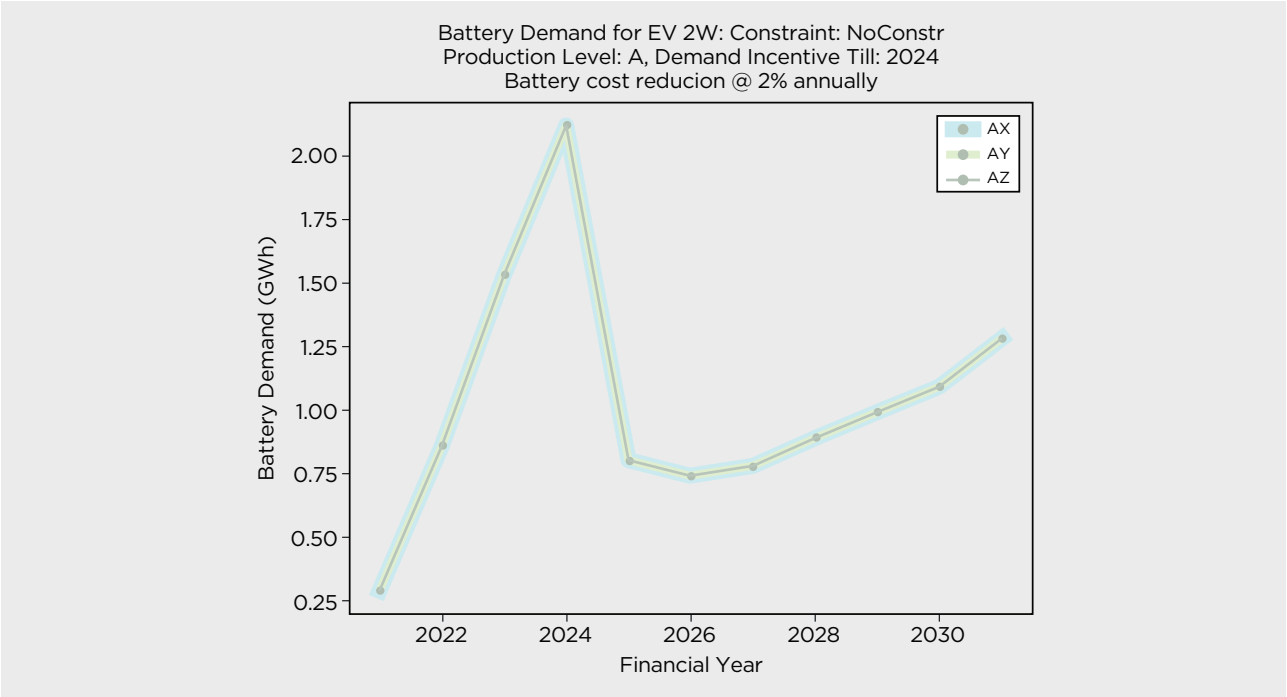


Figure 42: *Battery demand for electric two-wheelers in the Challenged Diffusion Scenario with no constraint, vehicle production level A*

Table 23: Battery demand for electric two-wheelers in the Challenged Diffusion Scenario with No Constraint (GWh)

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
2025	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
2026	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
2027	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
2028	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
2029	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
2030	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
2031	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28

5.3 Performance Driven Scenario

Under this scenario, the demand incentive is withdrawn after FY 2024, the battery cost reduction annually is at 2% and the only positive influence is improvement in the range and power of the electric two-wheelers by 5% annually during the period the FY 2024 to FY 2027.

5.3.1 Performance Driven Scenario with Full Constraint

The penetration level under this case is shown in Figure 43 and Table 24. There is significant growth of adoption of electric two-wheelers till FY 2024, when penetration level reaches 7.50%. After the expected decline followed by withdrawal of subsidy, penetration starts growing again, but finally reaches only 7.12% in the FY 2031. This is little higher as compared to similar conditions in the Challenged Diffusion Scenario.

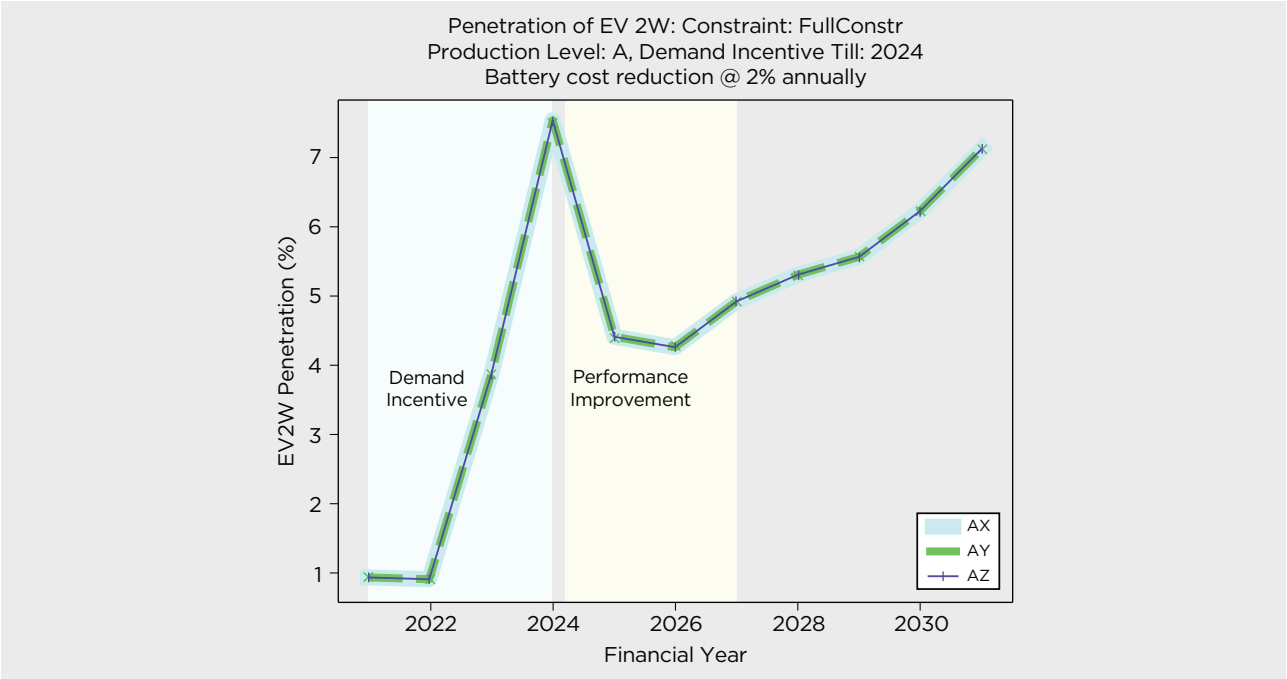


Figure 43: *Penetration of electric two-wheelers in Performance Driven Scenario with Full Constraint, production level A*

Here also, the production capacity enhancement does not have any influence on the penetration. The assumed charging infrastructure at levels X, Y and Z are same during the first two years, when it could have some impacts because we had assumed that doubling and tripling of this infrastructure may take place after third year. In the subsequent years, the base level of infrastructure itself will be much higher compared to the penetration level of electric two-wheelers.

Table 24: Penetration of electric two-wheelers in the Performance Driven Scenario with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
2025	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40
2026	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2027	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2028	5.30	5.30	5.30	5.3	5.3	5.3	5.3	5.3	5.3
2029	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2030	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2031	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12

A sale of 12.70 lakh units of electric two-wheelers will occur in the FY 2024 and it will reach 17.87 lakh units in FY 2031 (Figure 44 and Table 25).

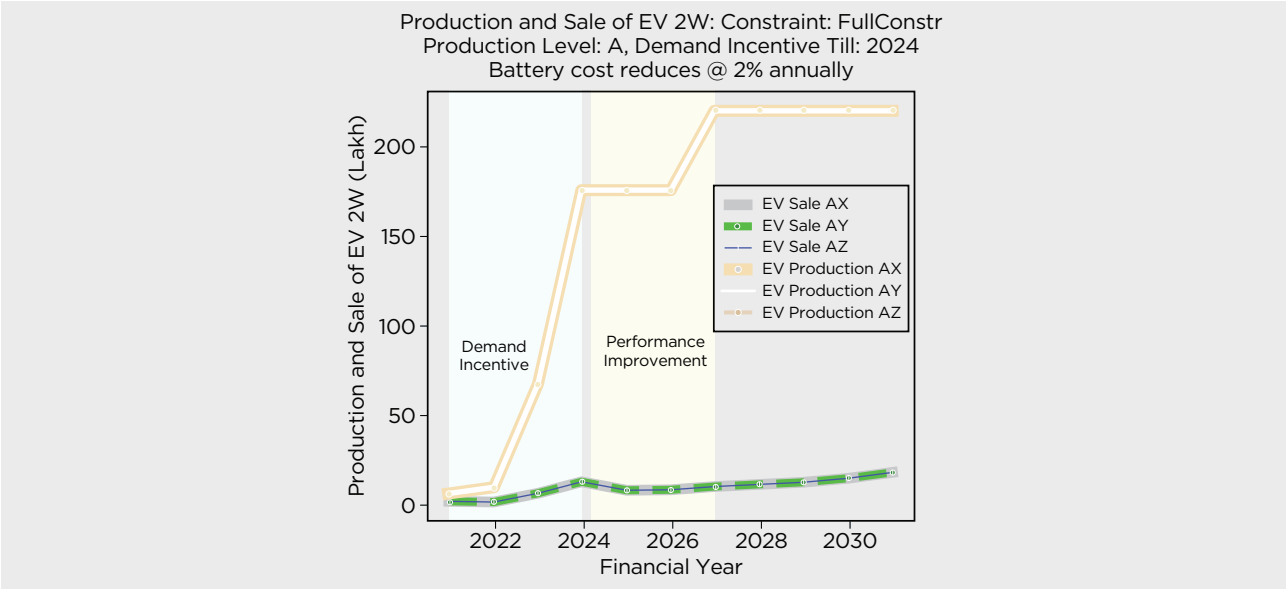


Figure 44: *Sale and production of electric two-wheelers in Performance Driven Scenario with Full Constraint, production level A*

Table 25: Sale of electric two-wheelers in Performance Driven Scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70
2025	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88
2026	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
2027	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2028	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25
2029	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48
2030	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74
2031	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87

Due to low penetration of electric two-wheelers, the projected demand for charging infrastructure is much less in this case as compared to the base level assumed as per announced plans. Demand for charging points at the constraint level AX is shown in Figure 45.

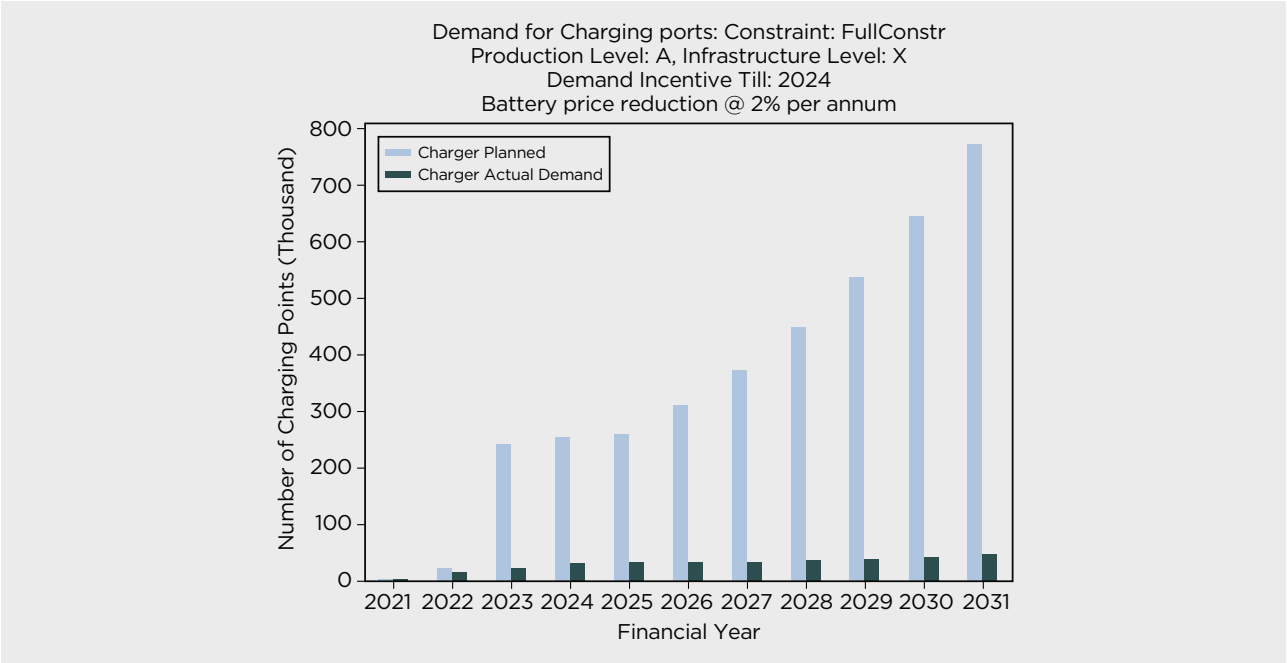


Figure 45: *Demand of charging points in the Performance Driven Scenario with Full Constraints (constraint level AX)*

The demand for battery reaches 2.45 GWh occurs in the FY 2024 and the final value in the FY 2031 is 3.35 GWh (Figure 45 and Table 26).

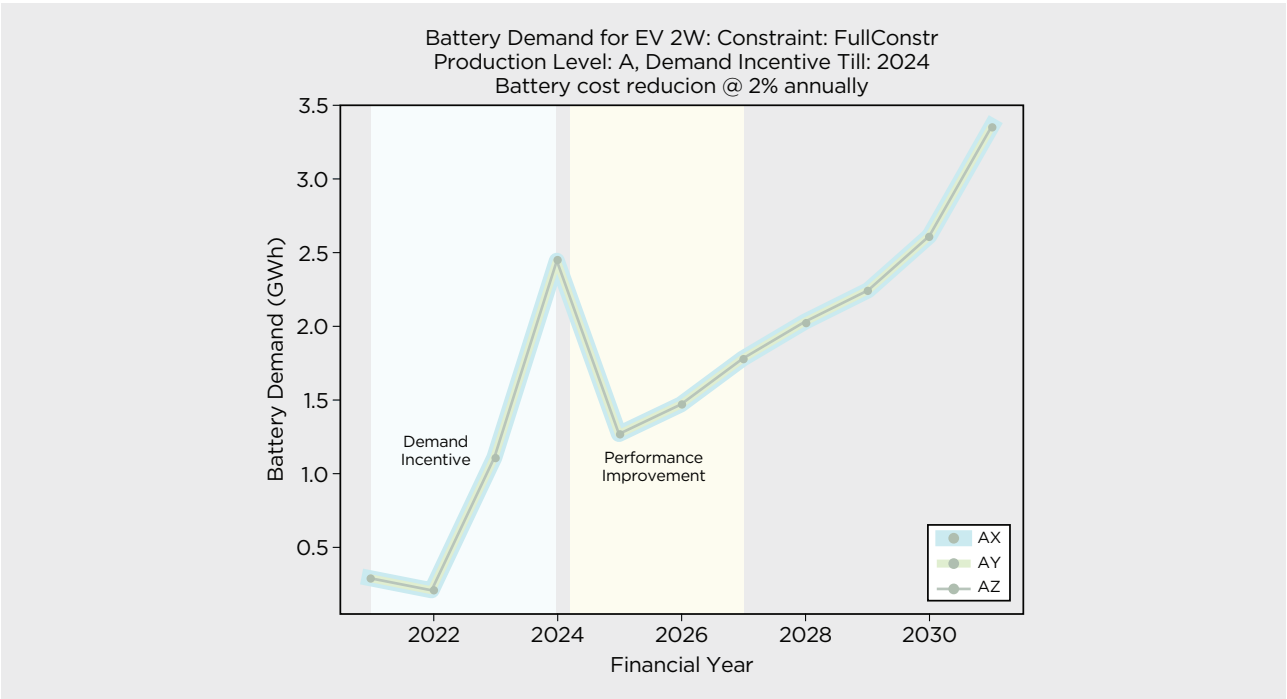


Figure 46: *Battery demand in the Performance Driven Scenario with Full Constraint, production level A*

Table 26: Battery demand in the Performance Driven Scenario with Full Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
2025	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
2026	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
2027	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
2028	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2029	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
2030	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
2031	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35

5.3.2 Performance Driven Scenario with Production Constraint

Some increased level of penetration in the FY 2022 and FY 2023 is seen in this case indicating that there is lack of adequate charging infrastructure at present. The peak level of electric two-wheelers penetration will be achieved in the FY 2024, which is 8.15%. Finally, market penetration will reach 7.12% (Figure 47 and Table 27).

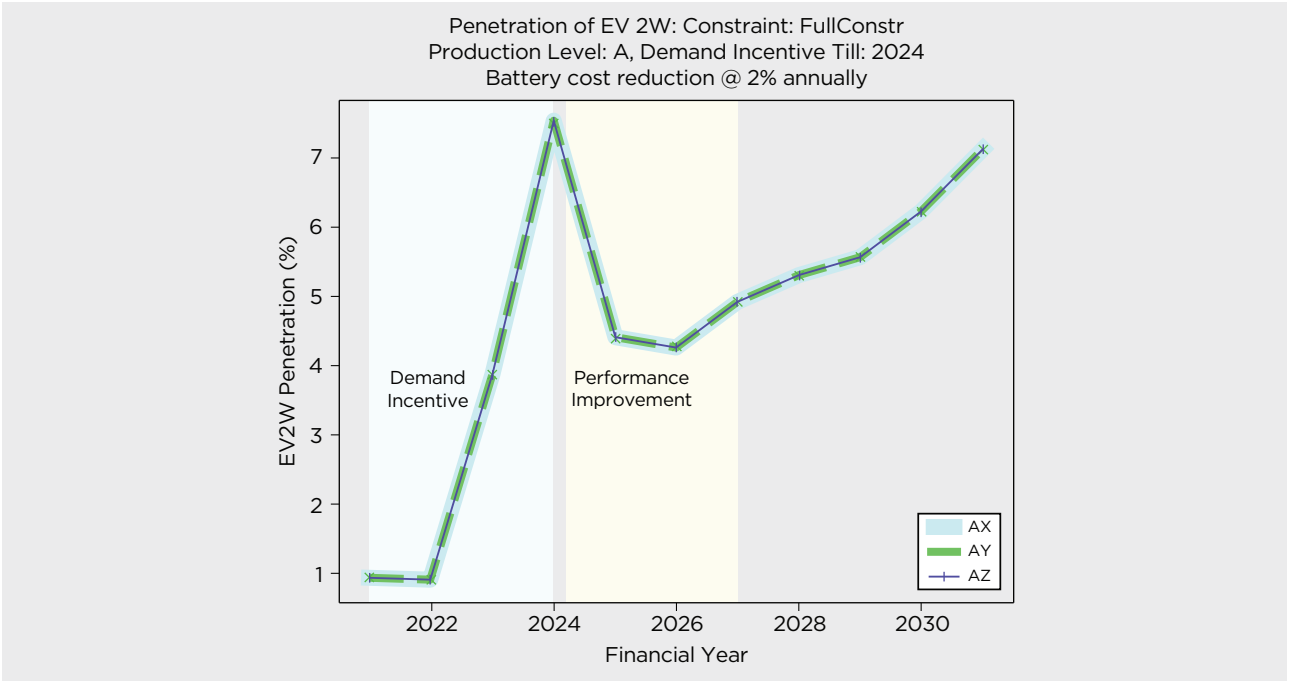


Figure 47: *Penetration of electric two-wheelers in the Performance Driven Scenario with Production Constraint, production level A*

Table 27: Penetration of electric two-wheelers in the Performance Driven Scenario with Production Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15
2025	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2026	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53
2027	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2028	5.30	5.30	5.30	5.3	5.3	5.3	5.3	5.3	5.3
2029	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2030	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2031	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12

Here, the sale achieved in the FY 2024 is 13.69 lakh units and in the FY 2031 it is 17.87 lakh units (Figure 48 and Table 28).

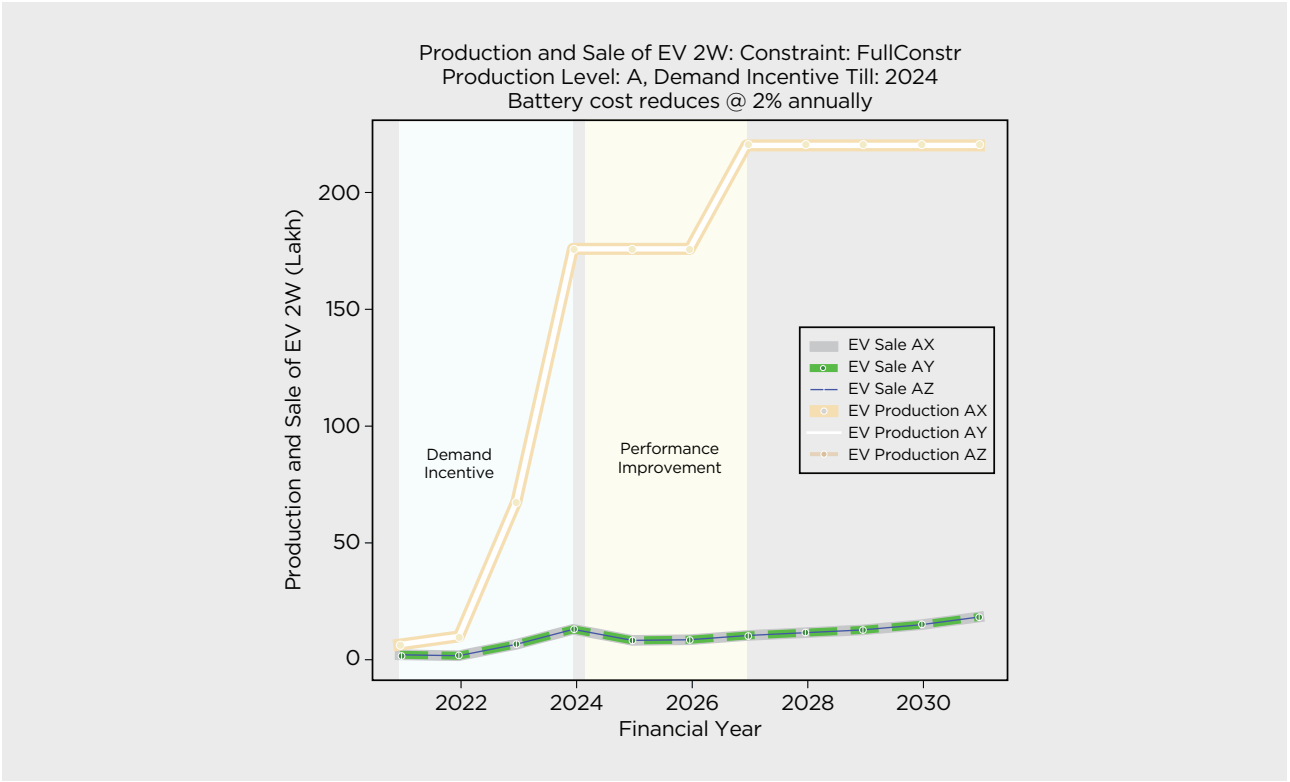


Figure 48: *Sale of electric two-wheelers in the Performance Driven Scenario with Production Constraint, production level A*

Table 28: Sale of electric two-wheelers in the Performance Driven Scenario with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90
2024	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79
2025	8.80	8.80	8.80	8.80	8.8	8.8	8.8	8.8	8.8
2026	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58
2027	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2028	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25
2029	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48
2030	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74
2031	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87

Demand for the charging points at constraint level AX is shown in the Figure 49.

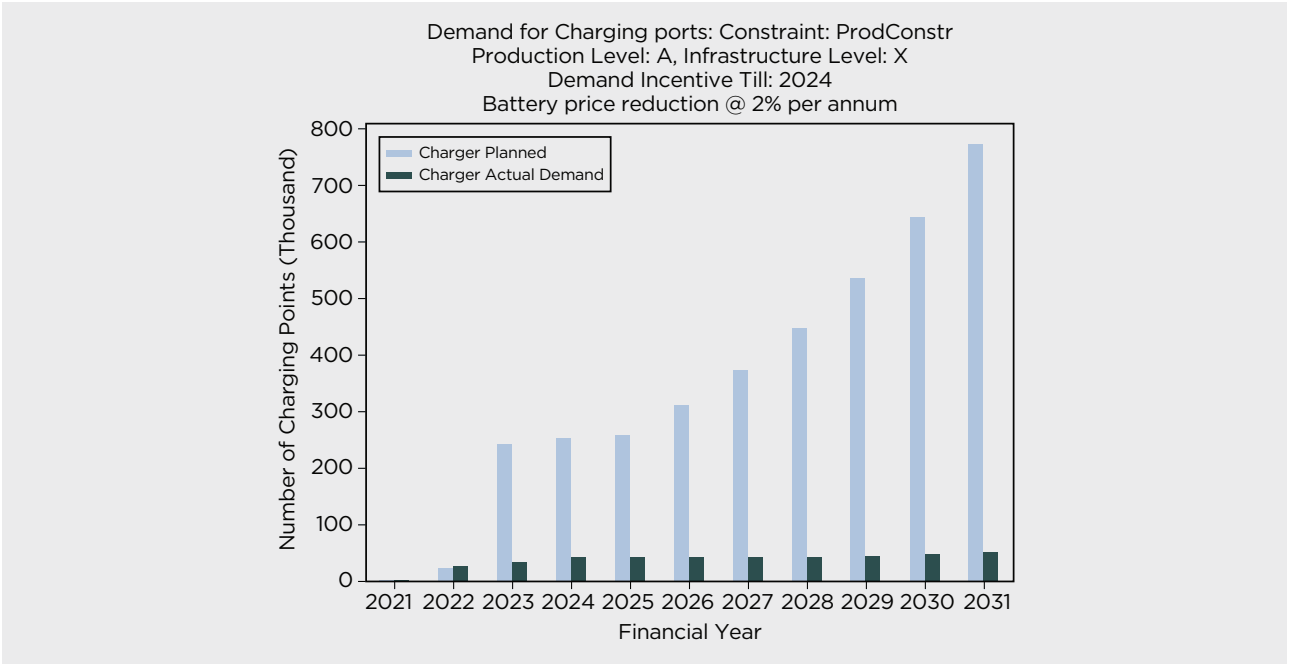


Figure 49: *Demand for charging points in the Performance Driven Scenario with Production Constraint (constraint level AX)*

The peak battery demand will be 2.93 GWh in the FY 2024 and the final demand will be 3.35 GWh in the FY 2031 (Figure 50 and Table 29).

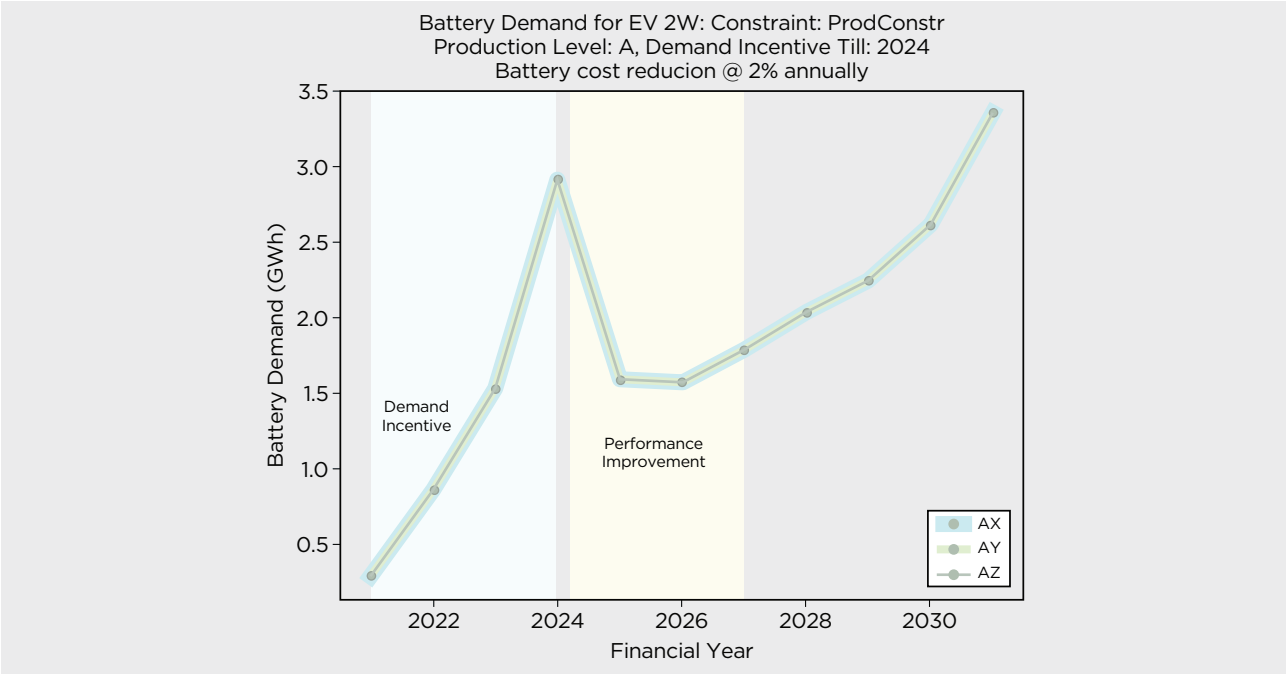


Figure 50: *Battery demand in the Performance Driven Scenario with Production Constraint, production level A*

Table 29: Battery demand in the Performance Driven Scenario with Production Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
2025	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2026	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
2027	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
2028	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2029	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
2030	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
2031	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35

5.3.3 Performance Driven Scenario with Charge Constraint

The penetration levels projected for the charging infrastructure level X are shown in Figure 51 for this case. A maximum penetration of 7.50% will be achieved in the FY 2024 and it will be 7.12% in FY 2031.

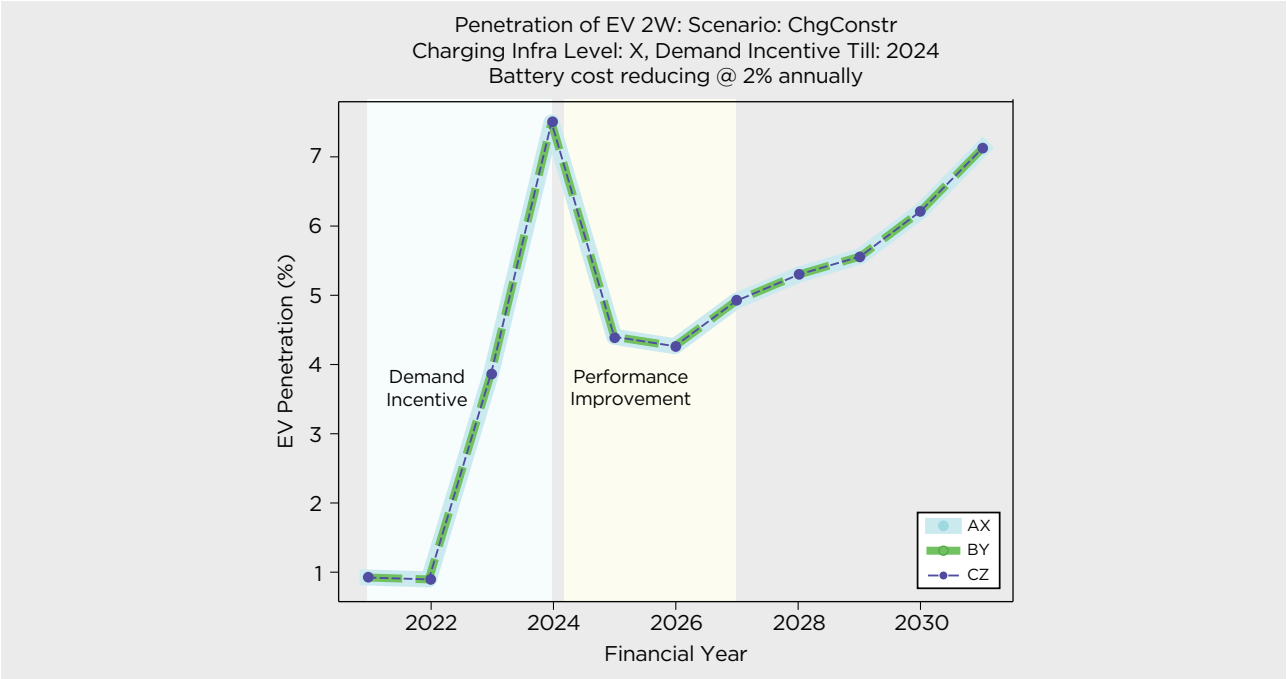


Figure 51: *Penetration of electric two-wheelers in the Performance Driven Scenario with Charge Constraint, infrastructure level X*

The penetration is same for all the combinations of constraint levels (Table 30). This is because till FY 2022 infrastructure levels X, Y and Z are assumed to be same and beyond that period even the assumed base level of infrastructure is sufficient for supporting the demand for electric two-wheelers.

Table 30: Penetration of electric two-wheelers in the Performance Driven Scenario with Charge Constraint

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
2025	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40
2026	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27
2027	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2028	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
2029	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2030	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2031	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12

Projected sale of electric two-wheelers is same for all the vehicle production capacity levels. Figure 52 shows this situation for infrastructure level X.

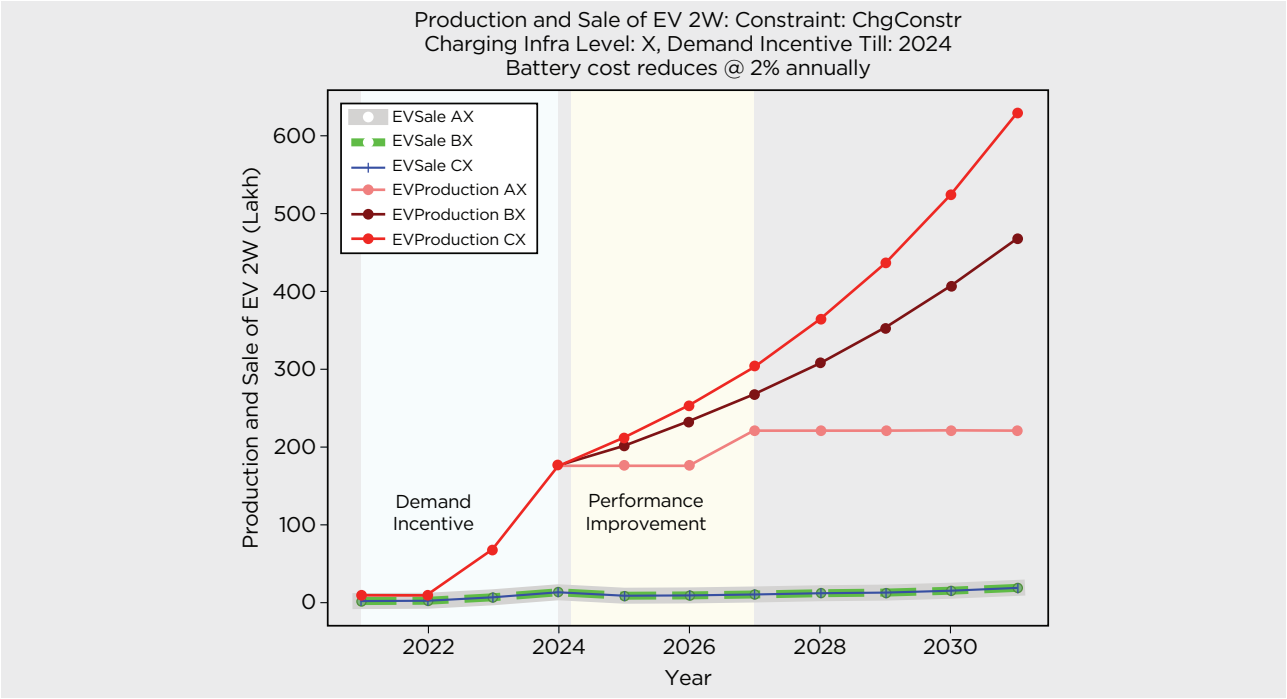


Figure 52: *Sale and production of electric two-wheelers in the Performance Driven Scenario with Charge Constraint, infrastructure level X*

Table 31 shows that the sales figures are same in all the possible combinations of vehicle production and charging infrastructure capacities. Sales volume is 12.70 lakh units in the FY 2024 and the sale reaches 17.87 lakh units in the FY 2031.

Table 31: Sale and production of electric two-wheelers in the Performance Driven Scenario with Charge Constraint

Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70
2025	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88	7.88
2026	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
2027	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2028	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25
2029	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48
2030	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74
2031	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87

Projected demand for charging points at the constraint level AX is shown in Figure 53.

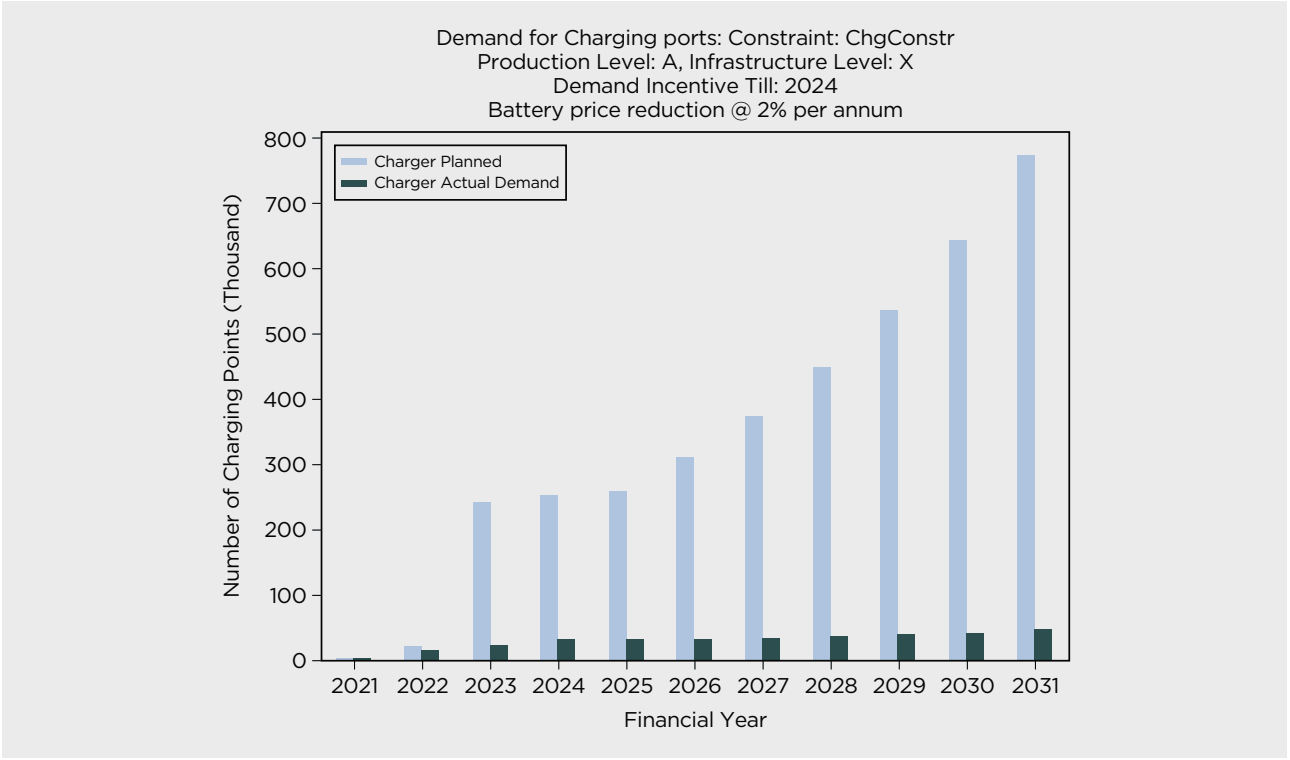


Figure 53: *Demand for charging points in the Performance Driven Scenario with Charge Constraint (constraint level AX).*

The battery demand will be 2.45 GWh in the FY 2024 and it will reach 3.35 GWh in the FY 2031 (Figure 54 and Table 32).

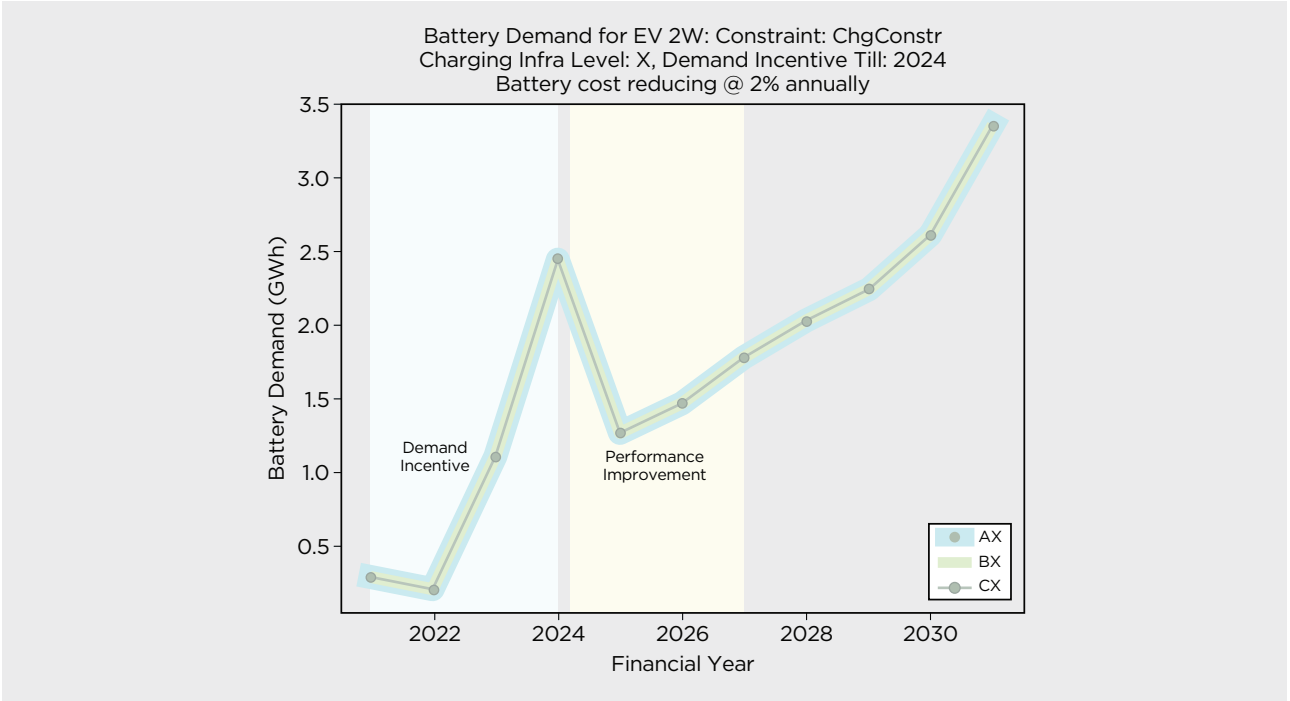


Figure 54: *Battery demand in the Performance Driven Scenario with Charge Constraint, infrastructure level X*

Table 32: Battery demand in the Performance Driven Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
2025	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
2026	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
2027	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
2028	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2029	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
2030	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
2031	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35

5.3.4 Performance Driven Scenario with No Constraint

When none of the constraints of the production capacity or charging infrastructure are considered, the penetration level of electric two-wheelers is higher as compared to other constraint sub-scenarios under this scenario. However, the peak penetration value in the FY 2024 is 8.15% and subsequently, with the withdrawal of demand incentives, the profile of penetration is similar to other constraint sub-scenarios. The situation is depicted in Figure 55 and Table 33.

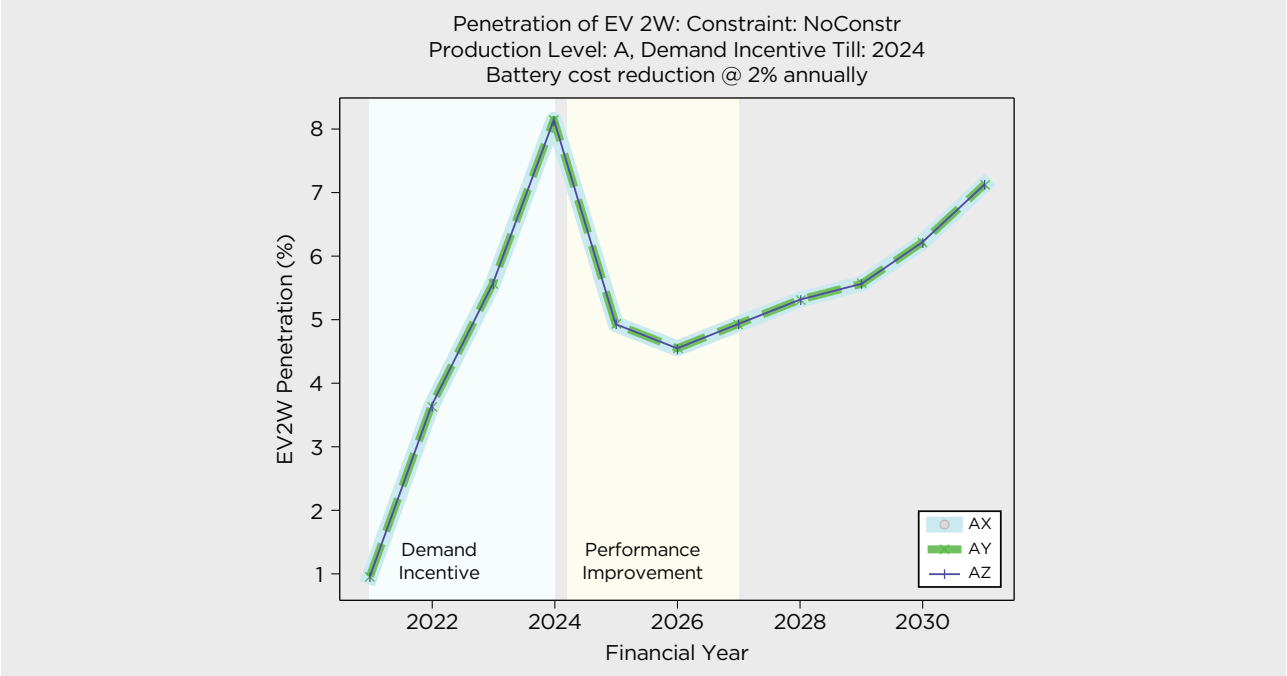


Figure 55: *Penetration of electric two-wheelers in the Performance Driven Scenario with No Constraint, production level A*

Table 33: Penetration of electric two-wheelers in the Performance Driven Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15
2025	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2026	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53
2027	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2028	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30	5.30
2029	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2030	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2031	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12	7.12

The sales volume in the FY 2024 is little higher in this case at 13.79 lakh units but the final sales volume in FY 2031 remains at 17.82 lakh units (Figure 56 and Table 34).

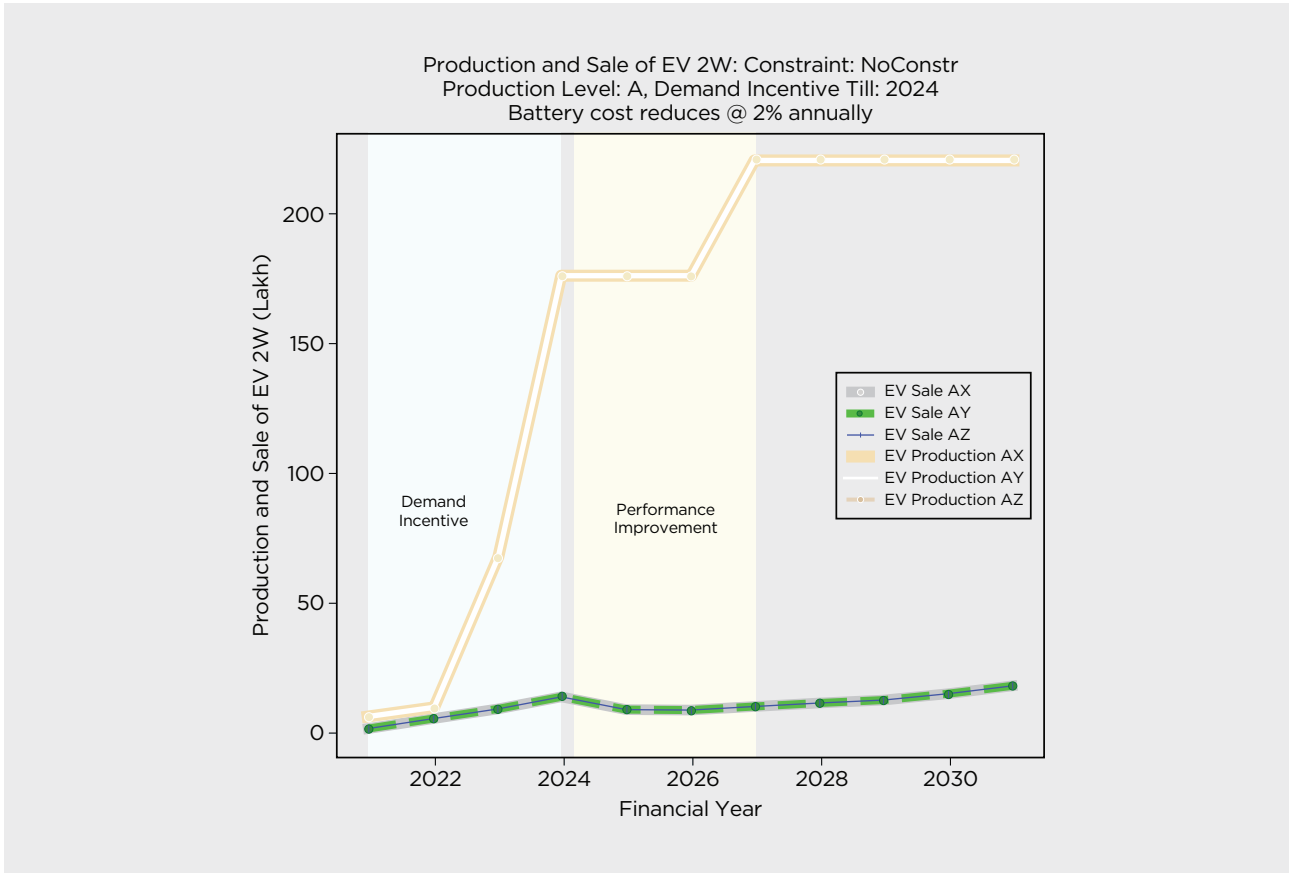


Figure 56: *Sale and assumed production of electric two-wheelers in Performance Driven Scenario with No Constraint, production level A*

Table 34: Sale of electric two-wheelers in Performance Driven Scenario with no constraint (Lakh)

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90
2024	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79
2025	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
2026	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58
2027	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2028	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25	11.25
2029	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48
2030	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74	14.74
2031	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87	17.87

Demand for charging points at the constraint level AX is show in Figure 57.

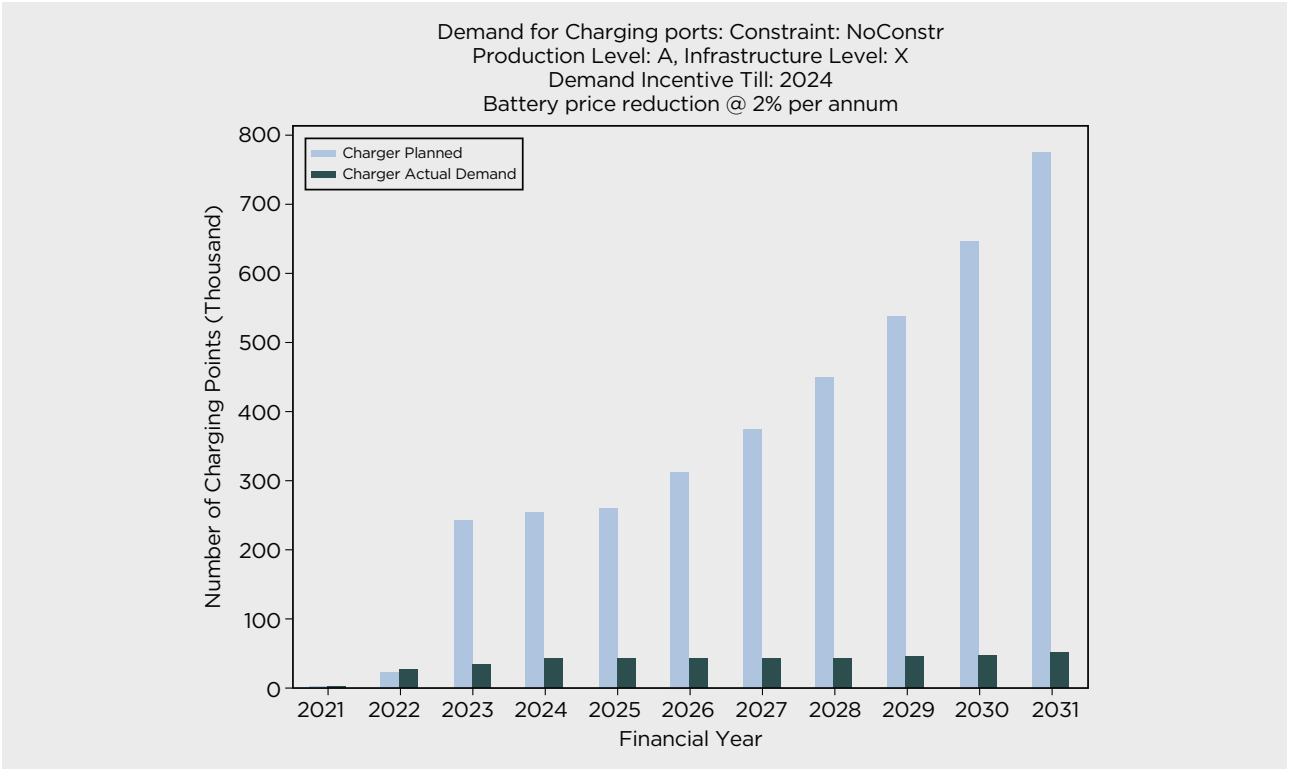


Figure 57: *Demand of charging infrastructure in the Performance Driven Scenario with No Constraint, constraint sub-scenario AX*

Demand for battery reaches 5.23 GWh in the FY 2024 and finally 2.64 GWh in FY 2031 (Figure 58 and Table 35).

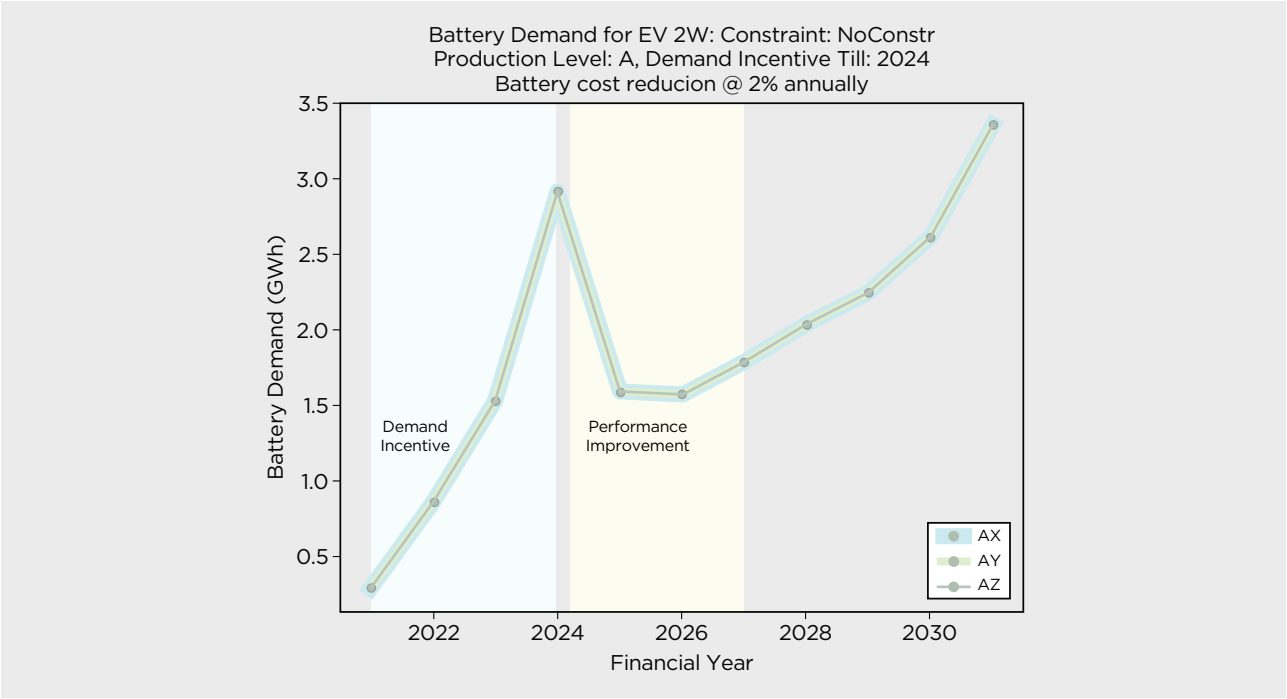


Figure 58: *Demand for battery in the Performance Driven Scenario with No Constraint, production level A*

Table 35: Demand for battery in the Performance Driven Scenario with No constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
2025	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2026	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57
2027	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78
2028	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2029	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24
2030	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
2031	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35	3.35

5.4 Low Battery Cost Scenario

Under this scenario the battery cost is assumed to reduce annually at a rate of 8%. However, the demand incentives are withdrawn after FY 2024 and the performance level of the electric two-wheelers is assumed to remain same.

5.4.1 Low Battery Cost Scenario with Full Constraint

The penetration levels here are higher as compared to Challenged Diffusion and Performance Driven scenarios discussed earlier. However, there is a slump after FY 2024 and the penetration levels do not increase by enhancing the production level or charging infrastructure. The situation is depicted in Figure 59 and Table 36.

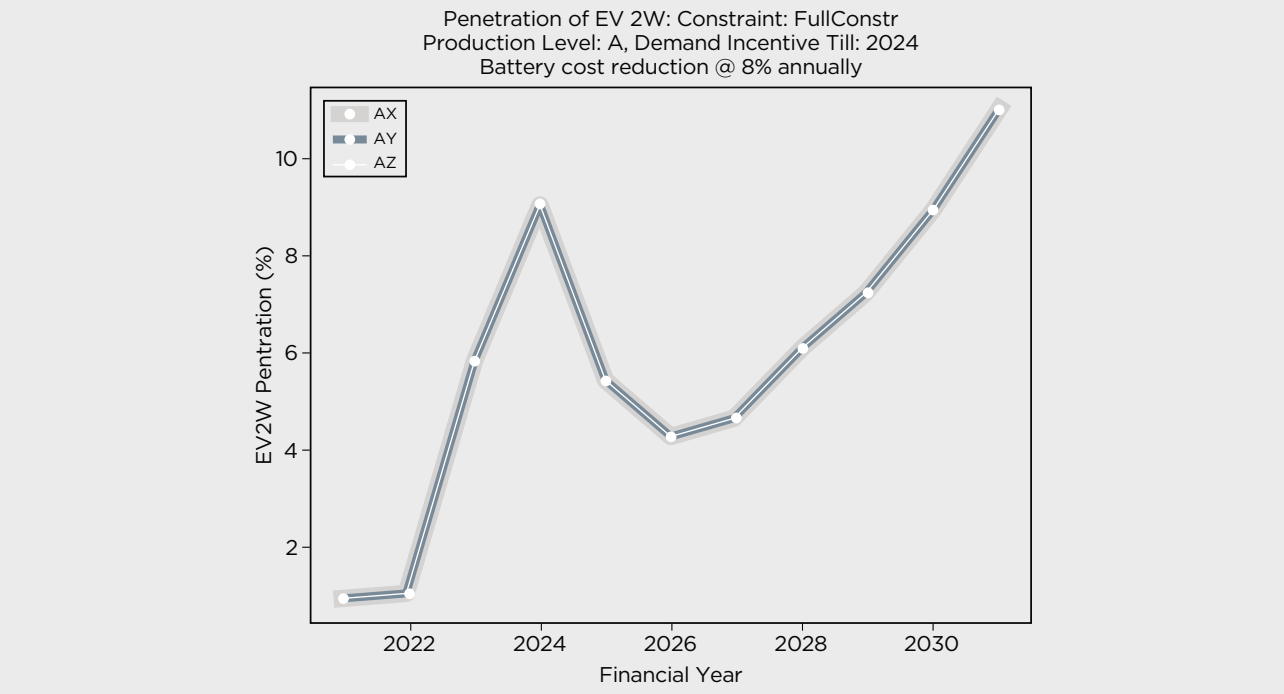


Figure 59: *Penetration of electric two-wheelers in the Low Battery Cost Scenario with Full Constraints, production level A*

Table 36: Penetration of electric two-wheelers in the Low Battery Cost Scenario with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06
2025	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43
2026	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27
2027	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
2028	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08
2029	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2030	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93
2031	11	11	11	11	11	11	11	11	11

The sales volume of electric two-wheelers reaches a maximum of 15.33 lakh units in the FY 2024 and subsequently at 27.62 lakh units in the FY 2031 (Figure 60 and Table 37).

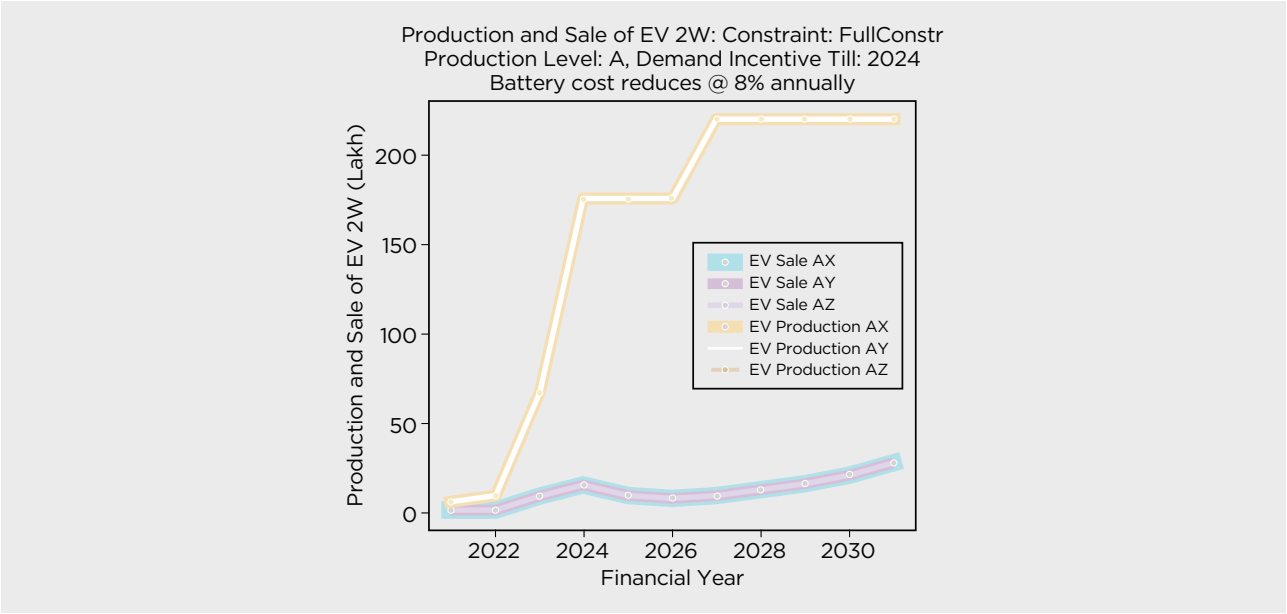


Figure 60: *Sale and assumed production of electric two-wheelers in the Low Battery Cost scenario with Full Constraint, production level A*

Table 37: Sale of electric two-wheelers in the Low Battery Cost scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33
2025	9.73	9.73	9.73	9.73	9.73	9.73	9.73	9.73	9.73
2026	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
2027	9.34	9.34	9.34	9.34	9.34	9.34	9.34	9.34	9.34
2028	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89
2029	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26
2030	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19
2031	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62

The demand for charging points increases continuously but the values are much less as compared to the assumed installations in the base level X (Figure 61).

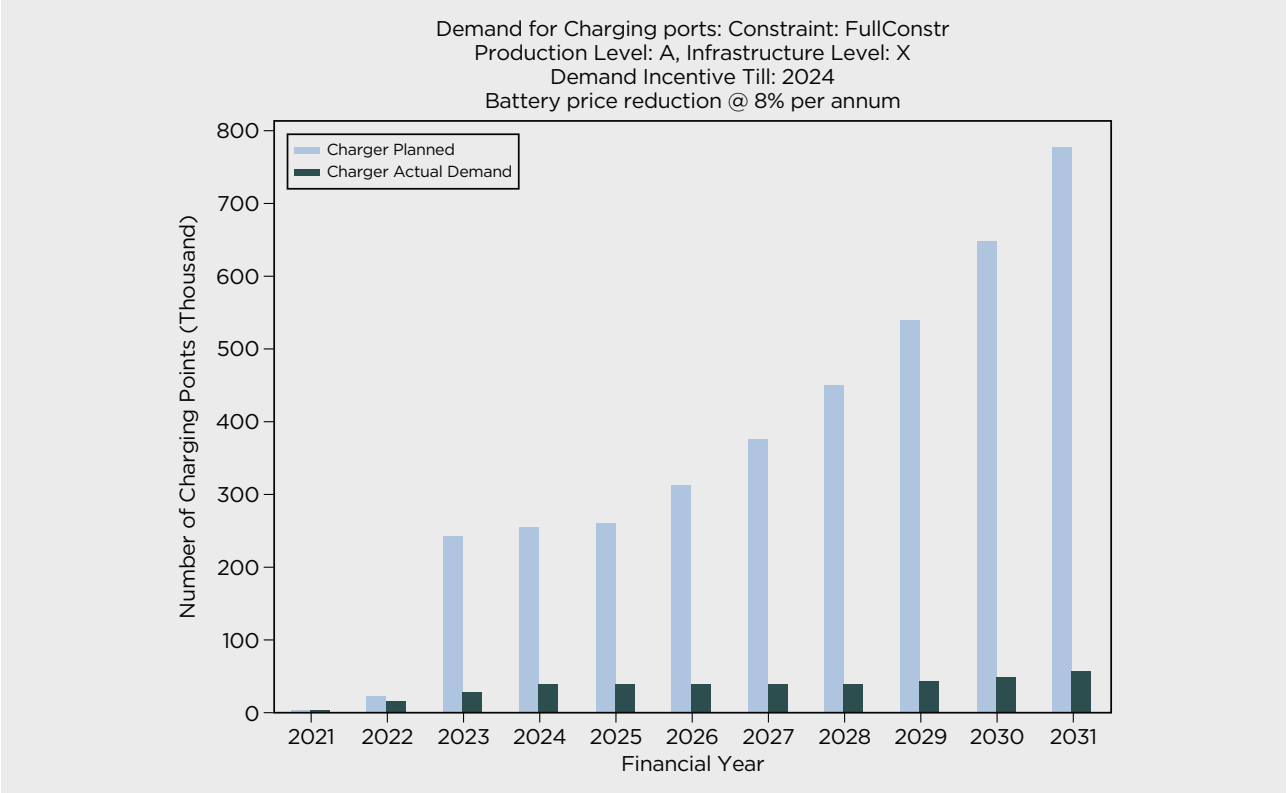


Figure 61: *Demand for charging points in the Low Battery Cost Scenario with Full Constraints (constraint level AX)*

The projected demand for battery is 3.08 GWh in the FY 2024 and 5.37 GWh in the FY 2031 (Figure 62 and Table 38).

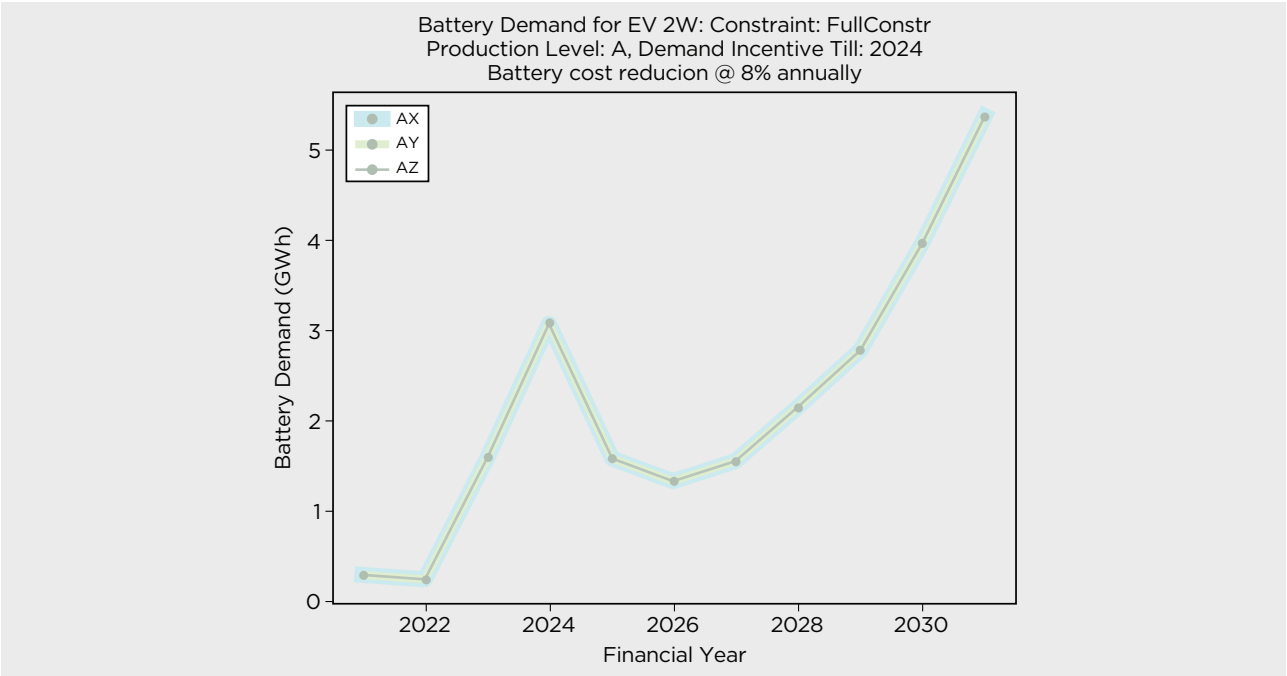


Figure 62: *Battery demand in the Low Battery Cost Scenario with Full Constraint, production level A*

Table 38: Battery demand in the Low Battery Cost Scenario with Full Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
2025	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58
2026	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
2027	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
2028	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
2029	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
2030	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
2031	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37

5.4.2 Low Battery Cost Scenario with Production Constraint

With charging infrastructure not being a concern in the purchase decision, there are some minor increments in the penetration levels in the initial years, until it reaches 10.22% in the FY 2024. After the decline due to immediate effect of withdrawal of incentives, the penetration level finally reaches 11% in the FY 2031 (Figure 63).

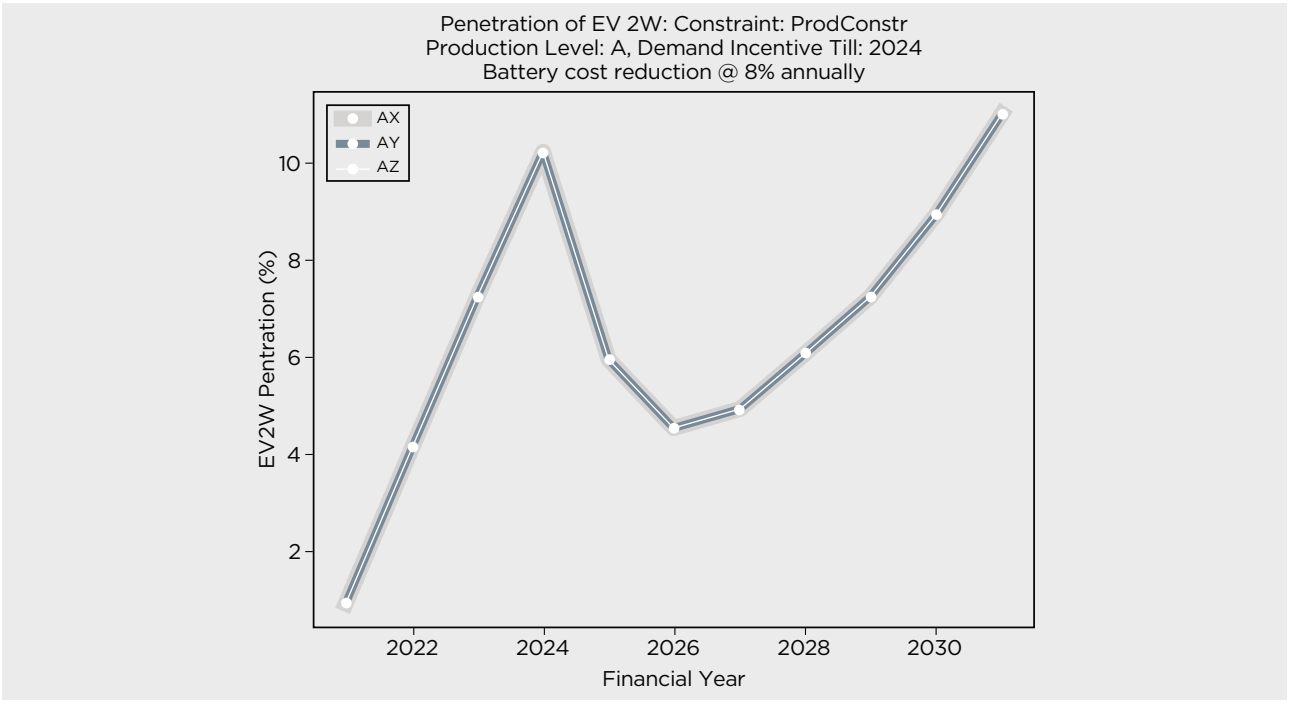


Figure 63: *Penetration of electric two-wheelers in the Low Battery Cost Scenario with Production Constraint, production level A*

Table 39: Penetration of electric two-wheelers in the Low Battery Cost Scenario with Production Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22
2025	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
2026	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53
2027	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2028	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08
2029	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2030	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93
2031	11	11	11	11	11	11	11	11	11

The sale of electric two-wheelers is projected to reach 17.30 lakh units in the FY 2024 and 27.62 lakh units in the FY 2031 (Figure 64 and Table 40).

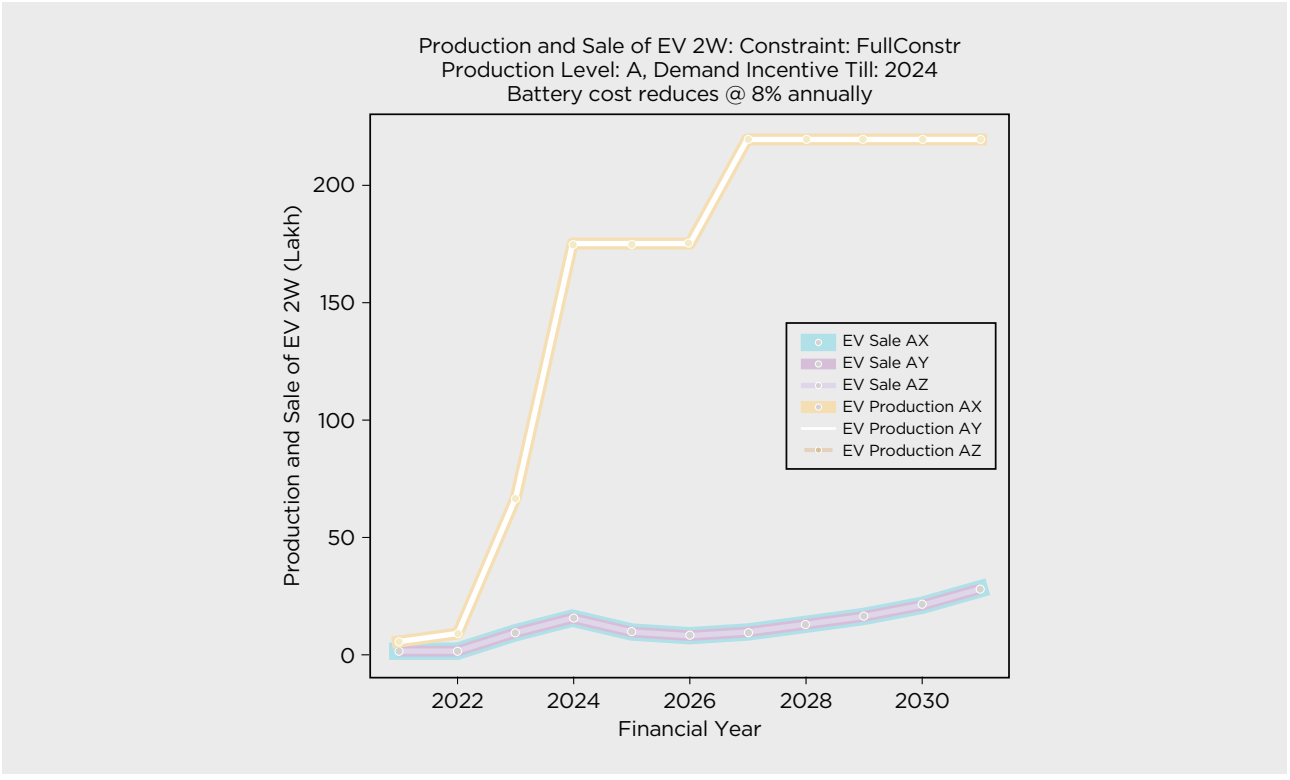


Figure 64: *Sale and production of electric two-wheelers in the Low Battery Cost Scenario with Production Constraint, production level A*

Table 40: Sale of electric two-wheelers in the Low Battery Cost Scenario with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
2025	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66
2026	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58
2027	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2028	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89
2029	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26
2030	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19
2031	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62

Demand for charging points remains much less as compared to planned infrastructure assumed in the base level. This situation for constraint level AX is depicted in Figure 65.

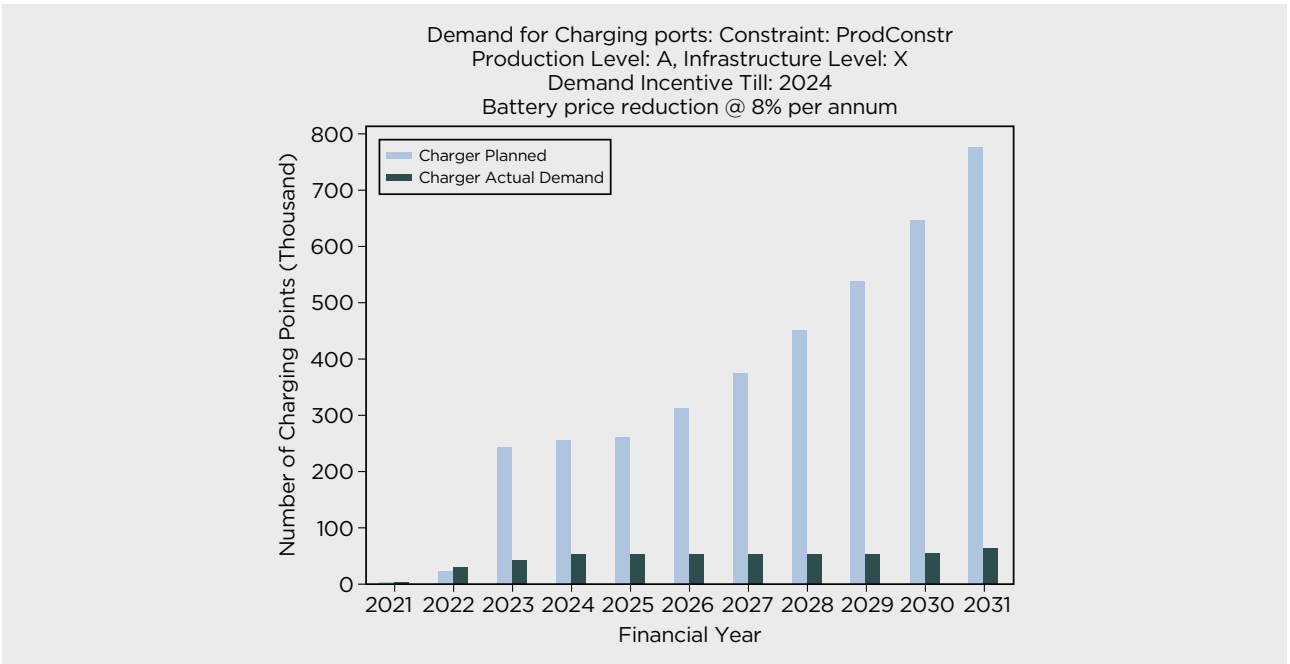


Figure 65: *Demand for charging points in the Low Battery Cost Scenario with Production Constraint, constraint level AX*

As can be seen, projected battery demand in the FY 2024 is 3.53 GWh and in the FY 2031 it is 5.37 GWh (Figure 66 and Table 41).

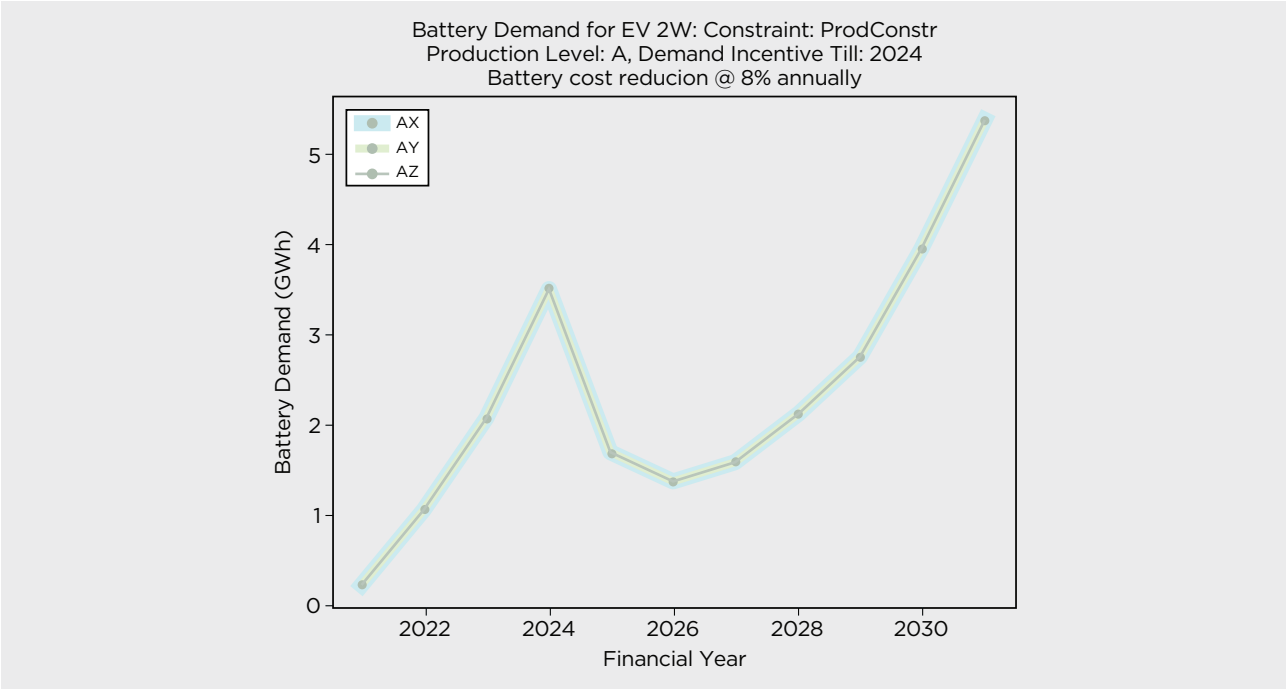


Figure 66: *Projected battery demand in the Low Battery Cost Scenario with Production Constraint, production level A*

Table 41: Projected battery demand in the Low Battery Cost Scenario with Production Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53
2025	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72
2026	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
2027	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
2028	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
2029	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
2030	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
2031	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37

5.4.3 Low Battery Cost Scenario with Charge Constraint

Penetration of electric two-wheelers in this case reaches 9.06% in FY 2024 and finally 11.00% in FY 2031 after going through a decline due to withdrawal of demand incentives (Figure 67 and Table 42).

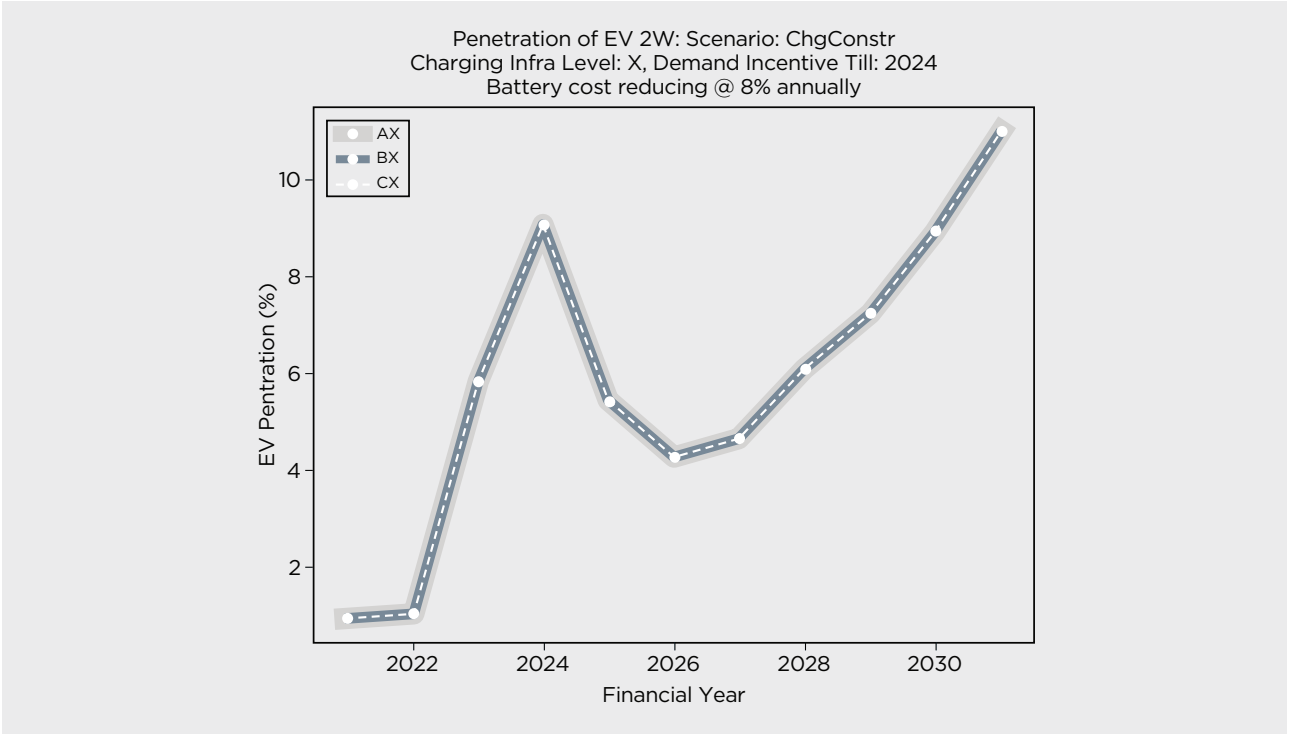


Figure 67: *Penetration of electric two-wheelers in the Low Battery Cost Scenario with Charge Constraint, infrastructure level X*

Table 42: Penetration of electric two-wheelers in the Low Battery Cost Scenario with Charge Constraint

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06
2025	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43	5.43
2026	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27	4.27
2027	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.66
2028	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08
2029	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2030	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93
2031	11	11	11	11	11	11	11	11	11

The projected sale of electric two-wheelers is same for all the combinations of vehicle production and infrastructure levels (Figure 68 and Table 43).

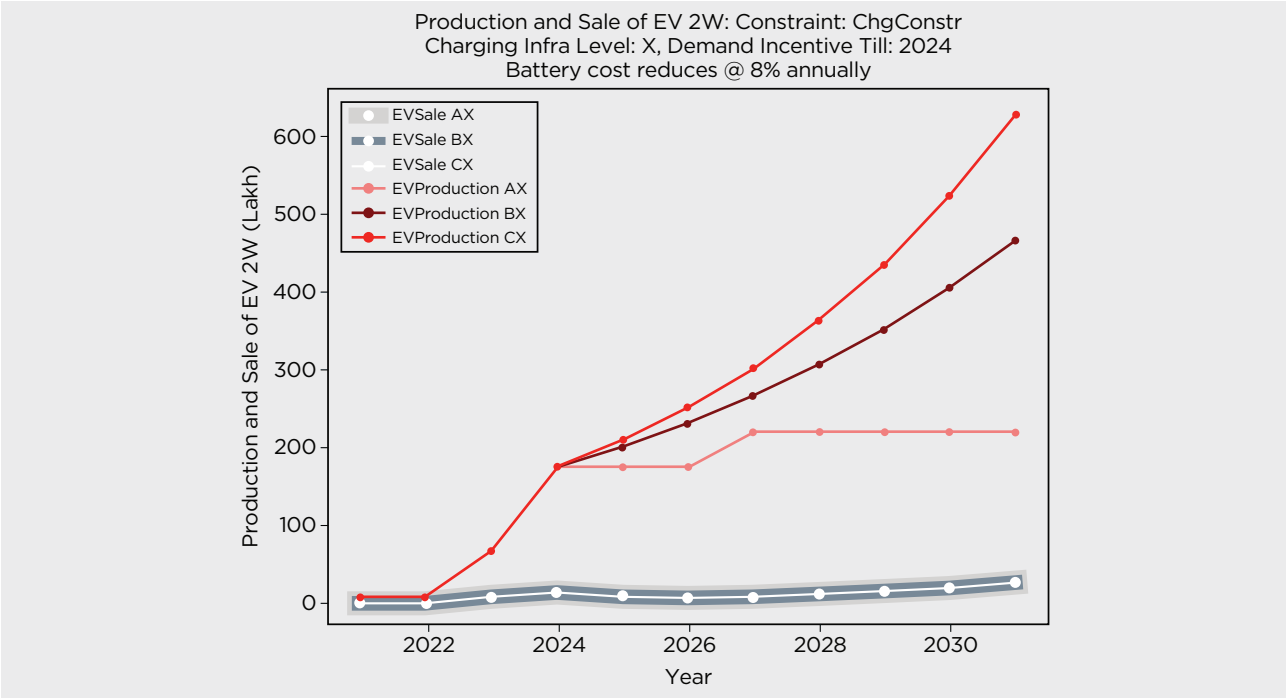


Figure 68: *Sale and production of electric two-wheelers in Low Battery Cost Scenario with Charge Constraint, infrastructure level X*

Table 43: Sale of electric two-wheelers in Low Battery Cost Scenario with Charge Constraint

Financial Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33
2025	9.73	9.73	9.73	9.73	9.73	9.73	9.73	9.73	9.73
2026	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09	8.09
2027	9.34	9.34	9.34	9.34	9.34	9.34	9.34	9.34	9.34
2028	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89
2029	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26
2030	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19
2031	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62

Demand for charging infrastructure remains at low level as compared to announced plans (Figure 69).

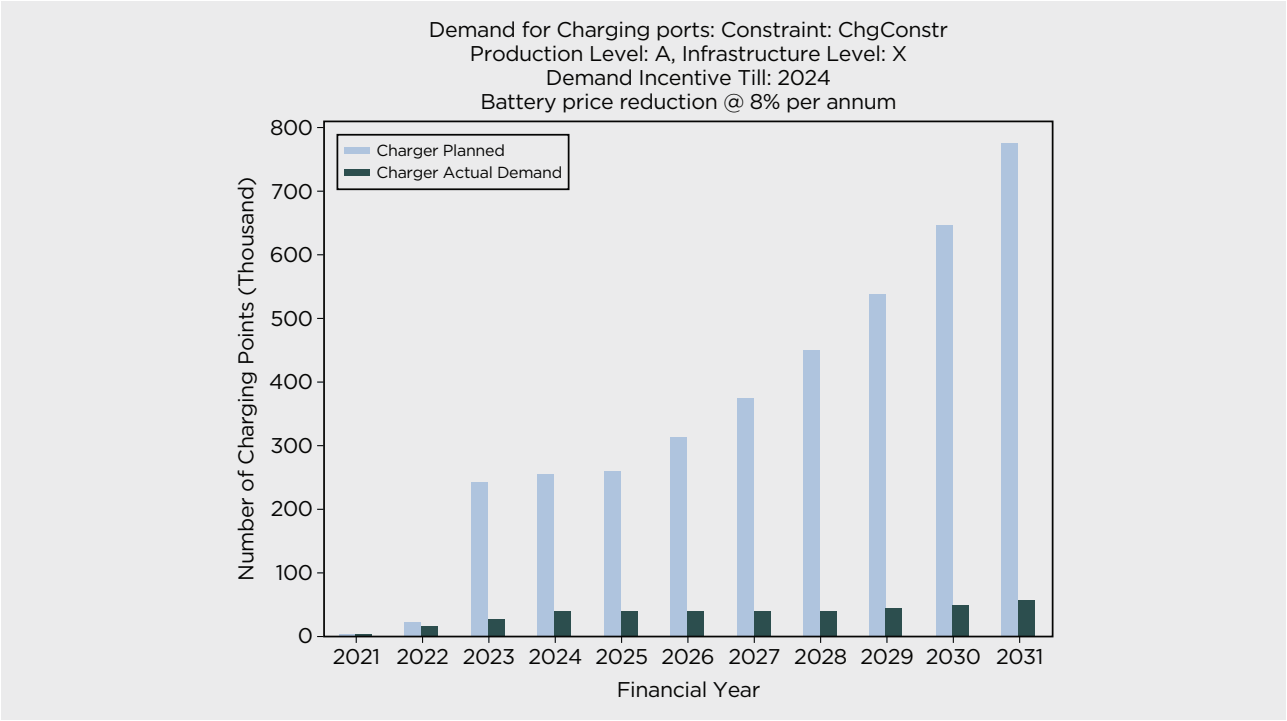


Figure 69: *Demand for charging points in the Low Battery Cost Scenario with Charge Constraint, infrastructure level X*

The projected battery demand for infrastructure level X is shown in the Figure 65 and Table 44. Projected demand for FY 2024 is 3.08 GWh and 5.37 GWh for FY 2031.

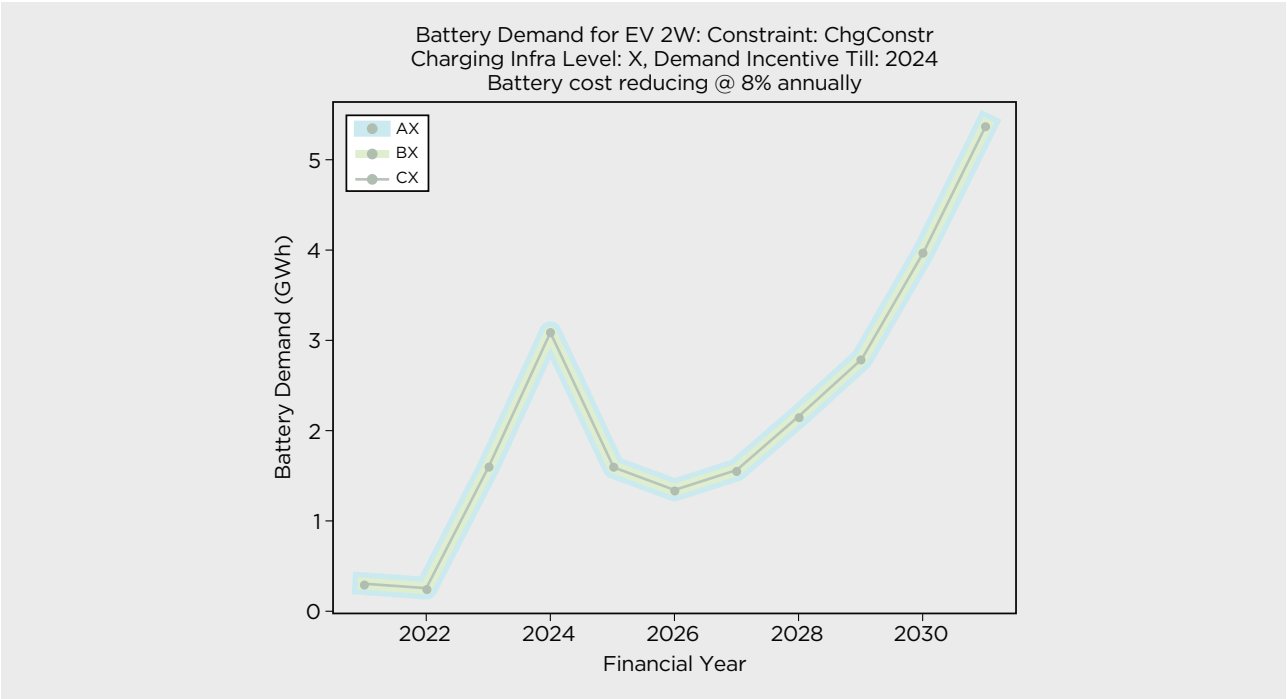


Figure 70: *Projected battery demand in the Low Battery Cost Scenario with Charge Constraints, infrastructure level X*

Table 44: Projected battery demand in the Low Battery Cost Scenario with Charge Constraint

Financial Year	Projected battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
2025	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58
2026	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
2027	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
2028	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
2029	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
2030	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
2031	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37

5.4.4 Low Battery Cost Scenario with No Constraint

With no constraint of production capacity and charging infrastructure considered, the penetration level is little higher for initial two years. However maximum penetration level of 11.00% is achieved in FY 2031 (Figure 71 and Table 45).

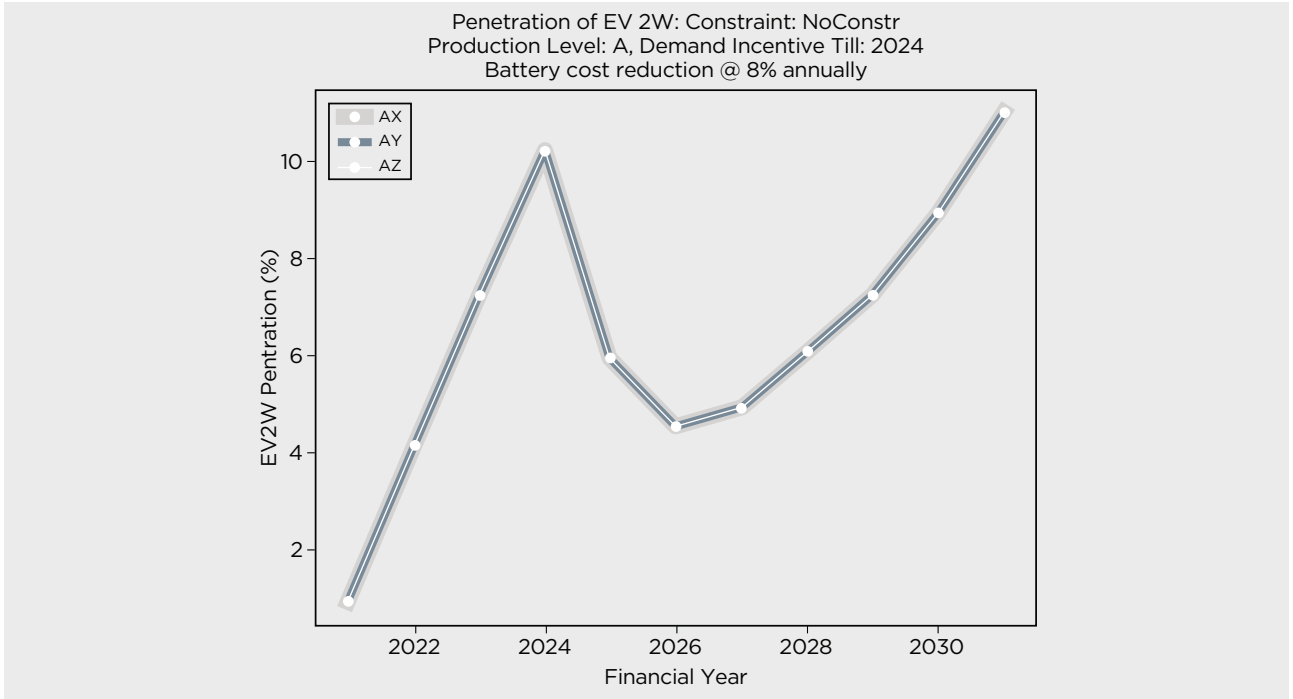


Figure 71: *Penetration of electric two-wheelers in the Low Battery Cost Scenario with No Constraint*

Table 45: Penetration of electric two-wheelers in the Low Battery Cost Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22
2025	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
2026	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53	4.53
2027	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92	4.92
2028	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08	6.08
2029	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2030	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93	8.93
2031	11	11	11	11	11	11	11	11	11

Projected sale of electric two-wheelers, as shown in Figure 72 and Table 46, is much below the assumed installed production capacity. Sale of electric two-wheelers reach 17.3 lakh units in FY 2024 and 27.62 lakh units in FY 2031.

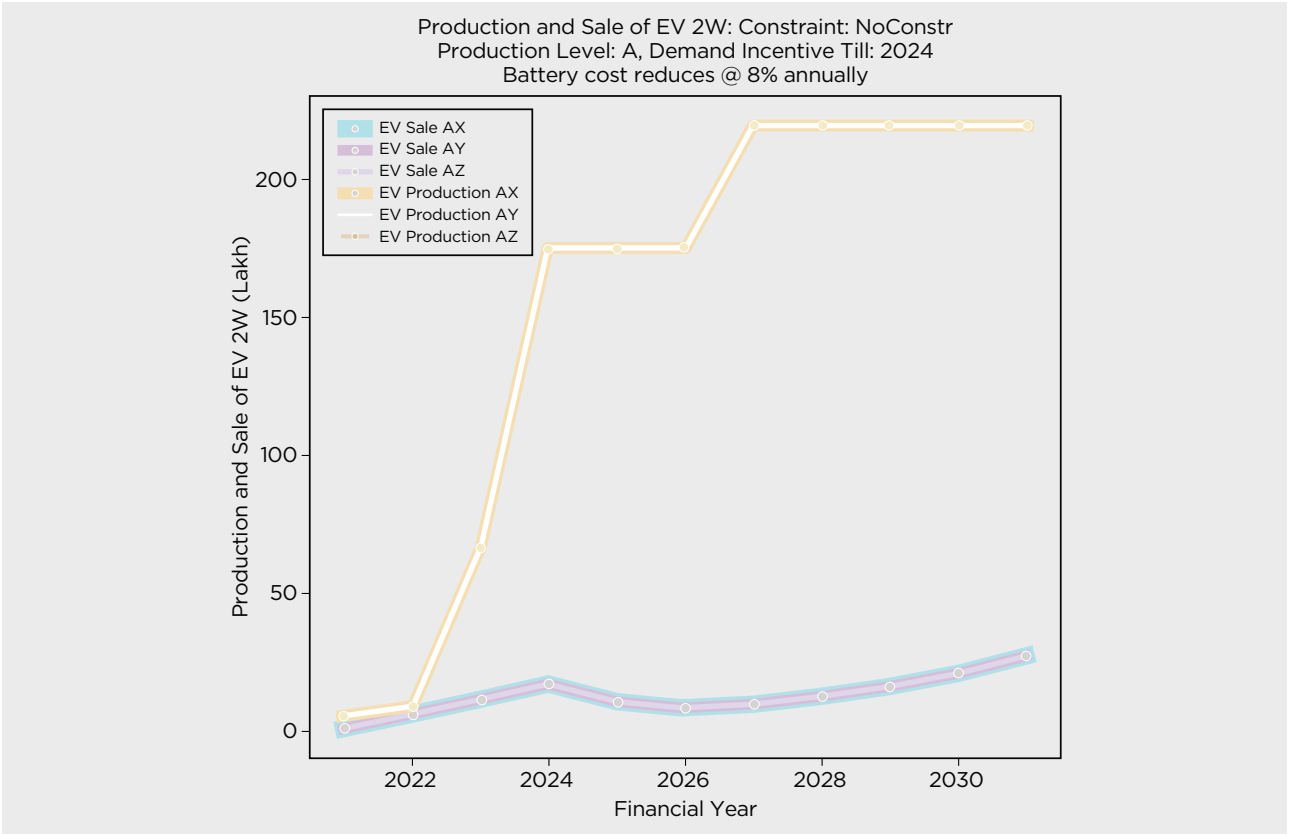


Figure 72: *Sale and production in the Low Battery Cost Scenario with No Constraint (production level A)*

Table 46: Sale in the Low Battery Cost Scenario with no constraint (Lakh)

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
2025	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66	10.66
2026	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58	8.58
2027	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2028	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89	12.89
2029	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26	16.26
2030	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19	21.19
2031	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62	27.62

The projected demand for charging infrastructure in the constraint level AX is shown in Figure 73.

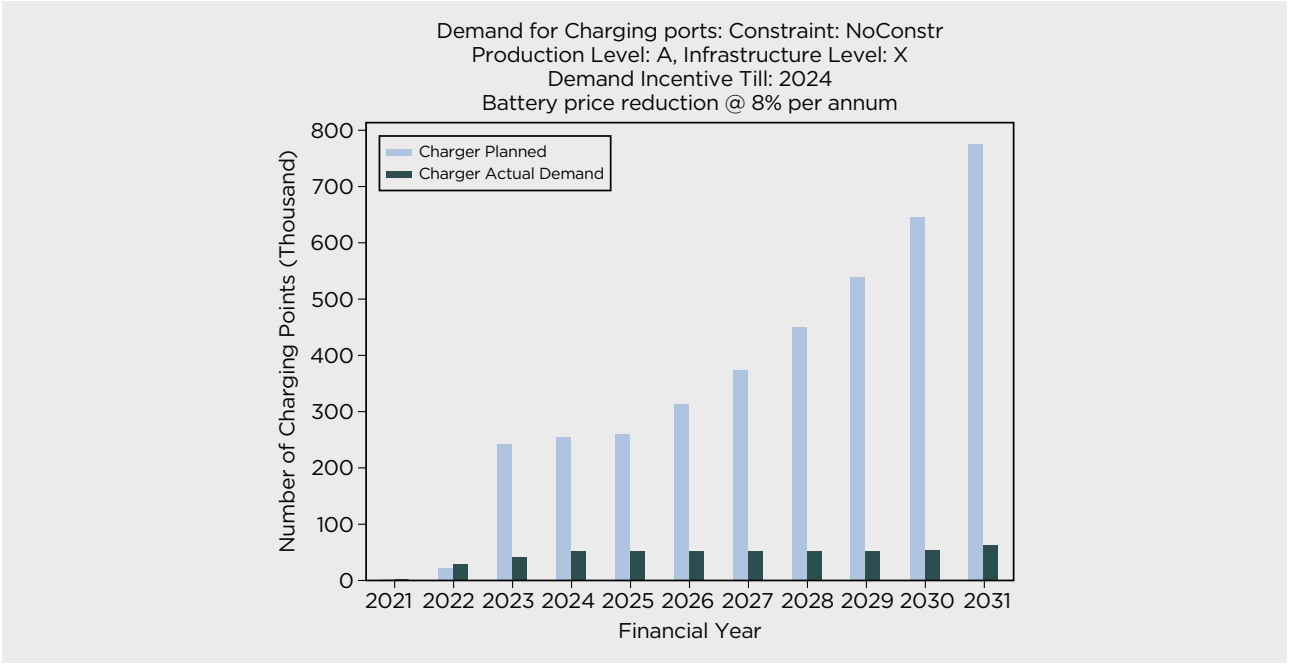


Figure 73: *Demand for charging points in the Low Battery Cost Scenario with No Constraint (constrain level AX)*

The battery demand, as shown in Figure 74 and Table 47, reaches 3.53 GWh in FY 2024 and 5.37 Gwh in FY 2031.

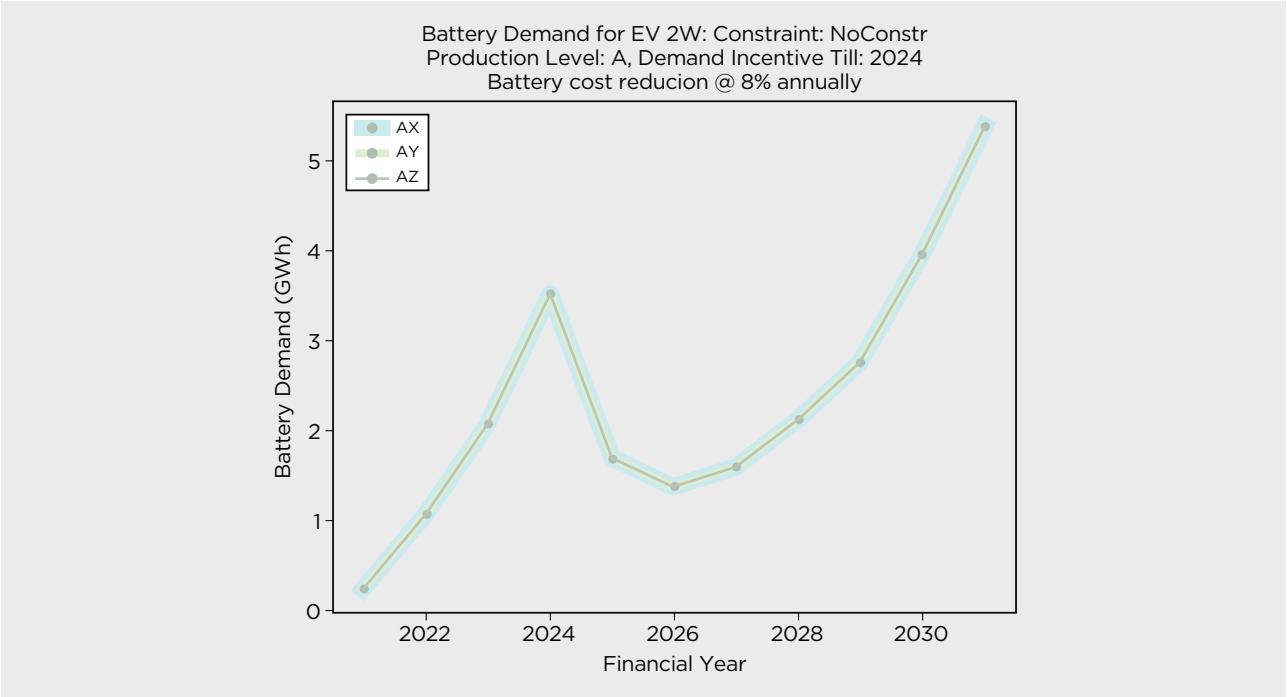


Figure 74: *Battery demand in the Low Battery Cost Scenario with No Constraint, production level A*

Table 47: Projected battery demand in the Low Battery Cost Scenario with No Constraint (GWh)

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53
2025	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72
2026	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.41
2027	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
2028	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
2029	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78	2.78
2030	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97	3.97
2031	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37	5.37

5.5 Technology Driven Scenario

Under this scenario the demand incentive is assumed to be withdrawn after FY 2024 and battery cost is assumed to reduce by 8% annually. The range and power of electric two-wheelers are both assumed to improve by 5% annually during the period FY 2024 to FY 2026 and by 10% in FY 2027 due to technological progress.

5.5.1 Technology Driven Scenario with Full Constraint

In this sub-scenario the Initial growth in penetration of electric two-wheelers is driven mainly by demand incentives and technological improvement in FY 2024, enabling it to reach 12.42% in FY 2024. The penetration level is adversely impacted with the withdrawal of demand incentives, but growth picks up again and finally reaches a value of 71.54% in the FY 2031 (Figure 75 and Table 48).

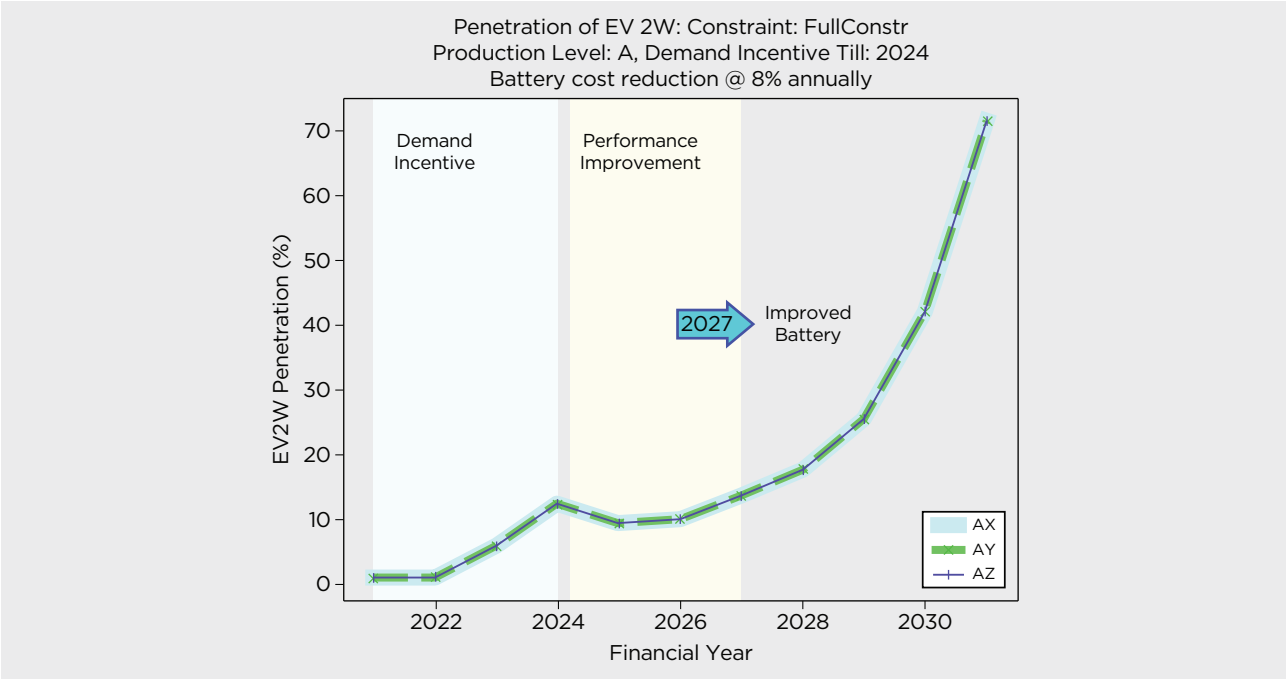


Figure 75: *Penetration of electric two-wheelers in the Technology Driven Scenario with Full Constraint, production level A*

Table 48: Penetration of electric two-wheelers in the Technology Driven Scenario with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42
2025	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2026	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96
2027	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
2028	17.59	17.59	17.59	17.59	17.59	17.59	17.59	17.59	17.59
2029	25.49	25.49	25.49	25.49	25.49	25.49	25.49	25.49	25.49
2030	42.04	42.04	42.04	42.04	42.04	42.04	42.04	42.04	42.04
2031	71.54	71.54	71.54	71.54	71.54	71.54	71.54	71.54	71.54

The sale volume of electric two-wheelers is expected to reach 21.02 lakh units in FY 2024 and 179.69 lakh units in FY 2031 (Figure 76 and Table 49).

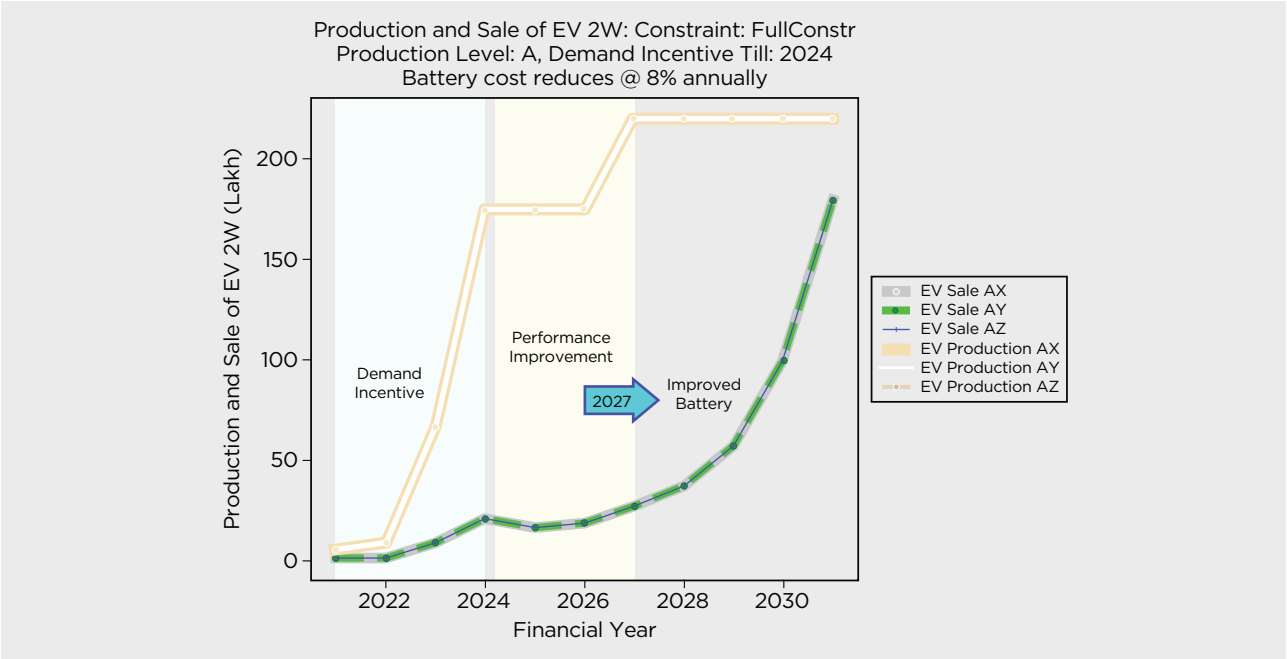


Figure 76: *Sale and production of electric two-wheelers in the Technology Driven Scenario with Full Constraint, production capacity level A*

Table 49: Sale of electric two-wheelers in the Technology Driven Scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02
2025	16.68	16.68	16.68	16.68	16.68	16.68	16.68	16.68	16.68
2026	18.87	18.87	18.87	18.87	18.87	18.87	18.87	18.87	18.87
2027	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23
2028	37.31	37.31	37.31	37.31	37.31	37.31	37.31	37.31	37.31
2029	57.18	57.18	57.18	57.18	57.18	57.18	57.18	57.18	57.18
2030	99.81	99.81	99.81	99.81	99.81	99.81	99.81	99.81	99.81
2031	179.69	179.69	179.69	179.69	179.69	179.69	179.69	179.69	179.69

The demand for charging points in this sub-scenario in the constraint level AX is shown in Figure 77.

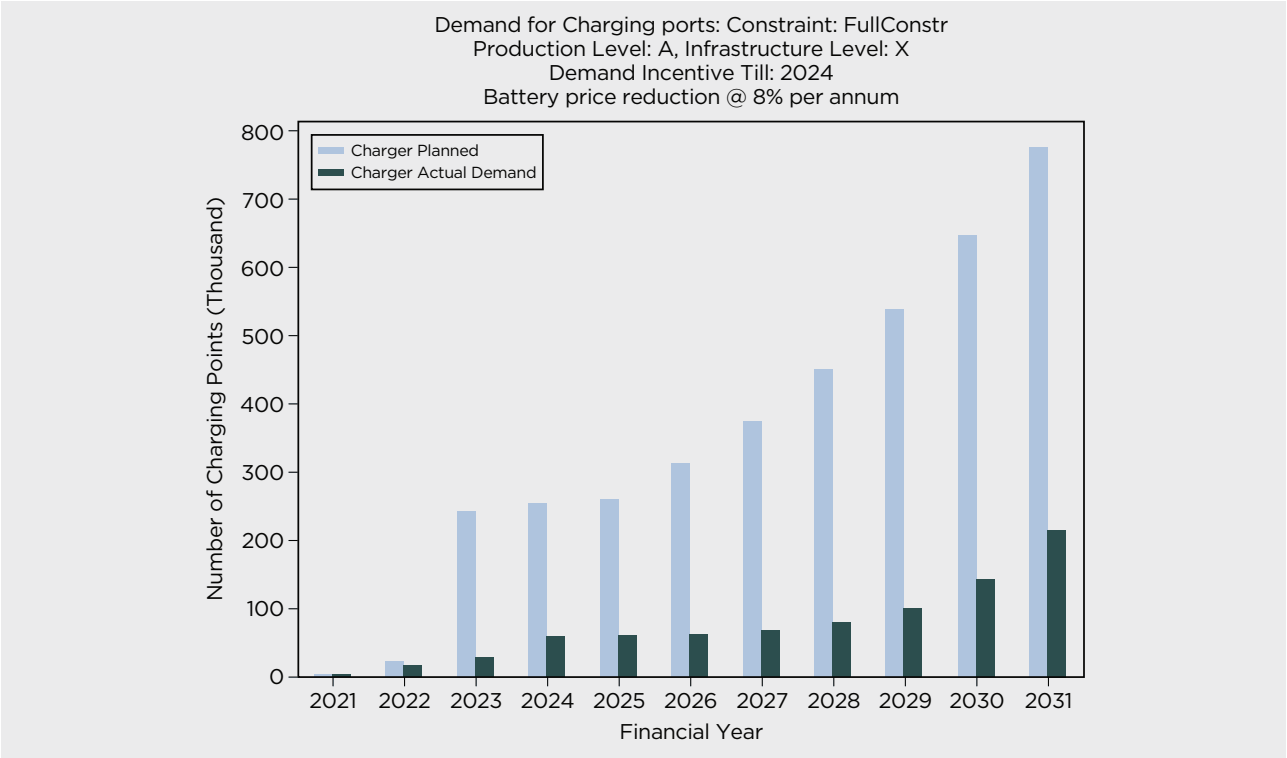


Figure 77: *Demand for charging infrastructure in the Technology Driven Scenario with Full Constraint, constraint level AX*

The battery demand rises to 6.26 GWh in the FY 2024, followed by a decline and then again rises to reach a maximum value of 56.79 GWh in the FY 2031 (Figure 78 and Table 50).

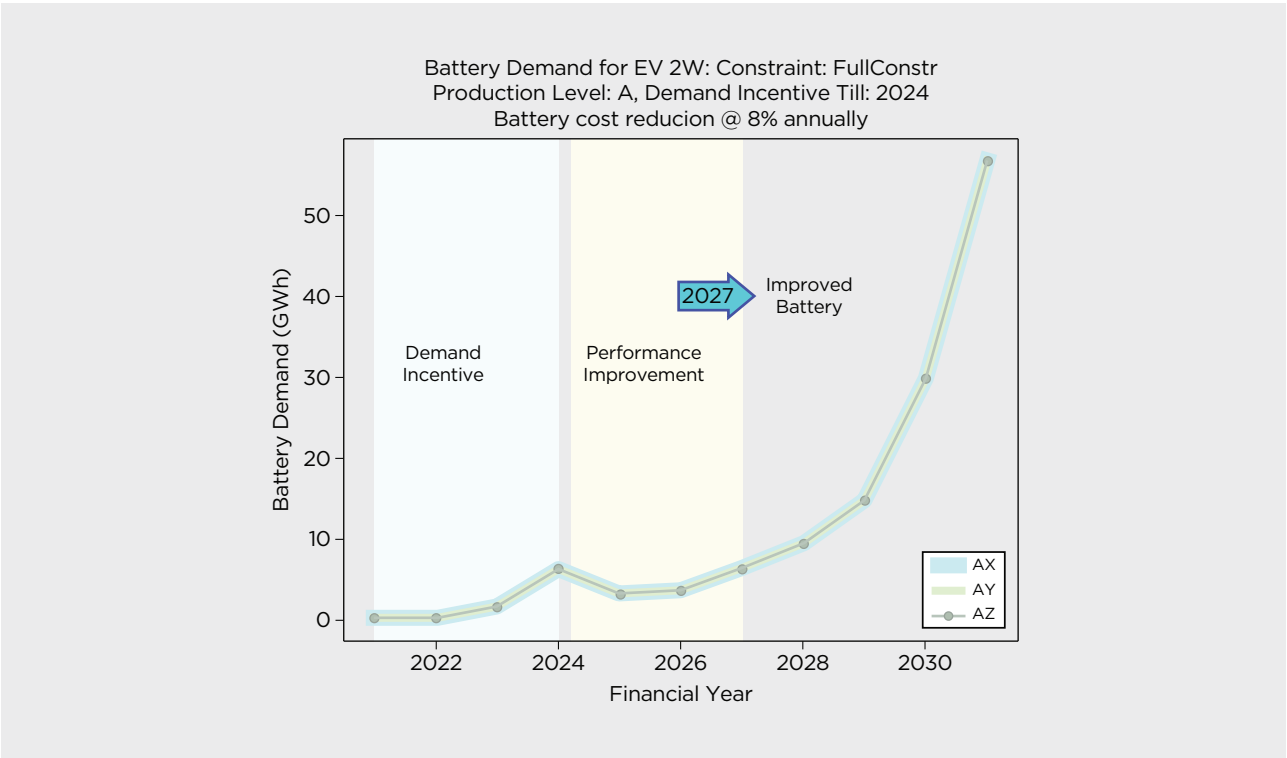


Figure 78: *Battery demand in the Technology Driven Scenario with Full Constraint, production level A*

Table 50: Battery demand in the Technology Driven Scenario with Full Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2025	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21
2026	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65
2027	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36
2028	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
2029	14.81	14.81	14.81	14.81	14.81	14.81	14.81	14.81	14.81
2030	29.91	29.91	29.91	29.91	29.91	29.91	29.91	29.91	29.91
2031	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79

5.5.2 Technology Driven Scenario with Production Constraint

In this sub-scenario, penetration of electric two-wheelers reaches 13.84% in the FY 2024, followed by a slump on withdrawal of demand incentive and then rises again to reach 75.03% in the FY 2031 (Figure 79 and Table 51).

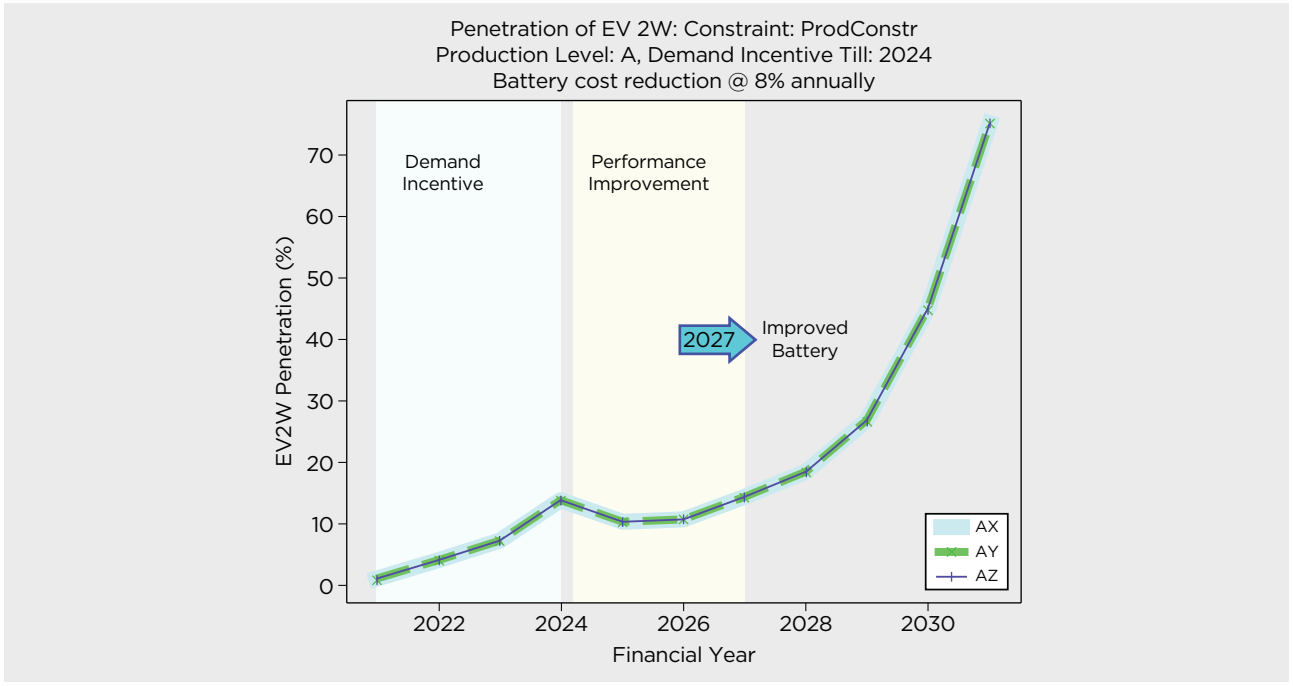


Figure 79: *Penetration of electric two-wheelers in the Technology Driven Scenario with Production Constraint, production level A*

Table 51: Penetration of electric two-wheelers in the Technology Driven Scenario with Production Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84
2025	10.35	10.35	10.35	10.35	10.35	10.35	10.35	10.35	10.35
2026	10.74	10.74	10.74	10.74	10.74	10.74	10.74	10.74	10.74
2027	14.36	14.36	14.36	14.36	14.36	14.36	14.36	14.36	14.36
2028	18.37	18.37	18.37	18.37	18.37	18.37	18.37	18.37	18.37
2029	26.78	26.78	26.78	26.78	26.78	26.78	26.78	26.78	26.78
2030	44.89	44.89	44.89	44.89	44.89	44.89	44.89	44.89	44.89
2031	75.03	75.03	75.03	75.03	75.03	75.03	75.03	75.03	75.03

Little higher level of sale is achieved in the initial years and the sales figure for the FY 2024 is 21.02 lakh units. But the final sales figure in the FY 2031 is 179.69 lakhs, same as in the case of Full Constraint sub-scenario (Figure 80 and Table 52).

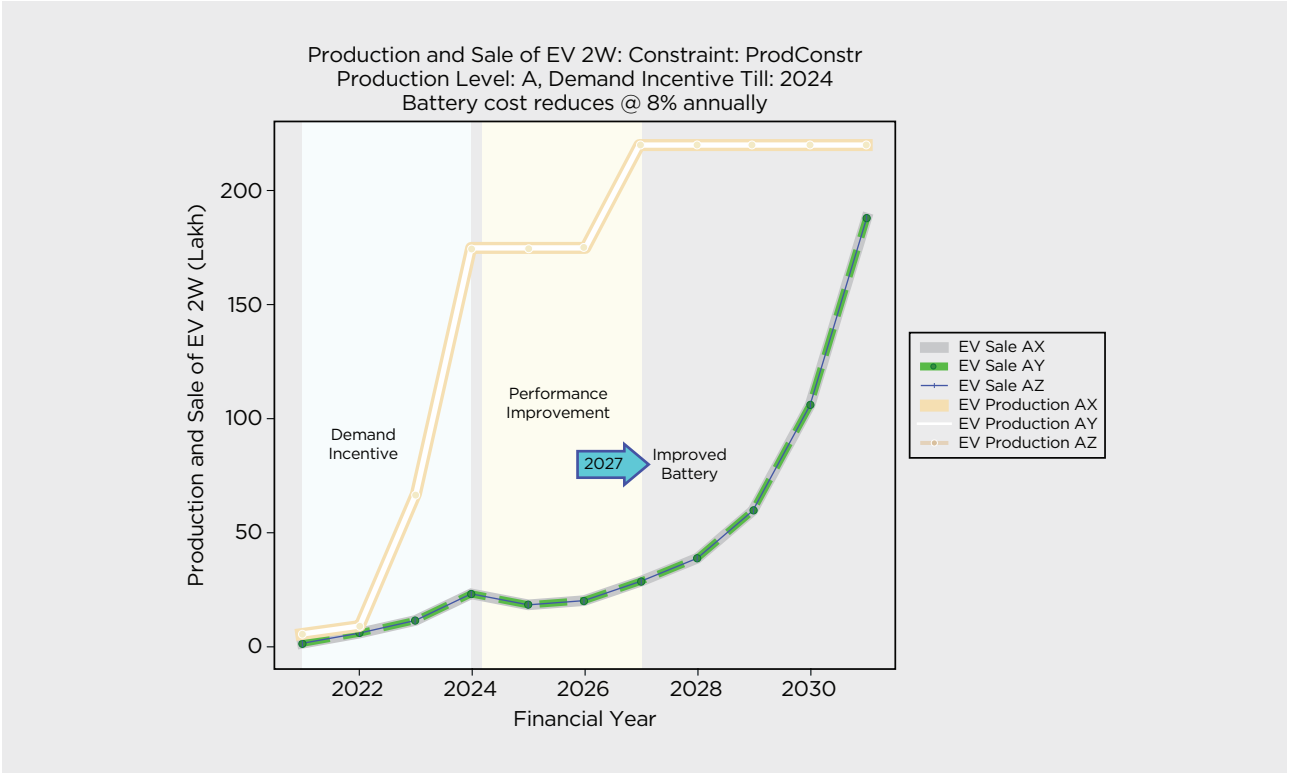


Figure 80: *Sale and production of electric two-wheelers in the Technology Driven Scenario with Production Constraint, production level A*

Table 52: Sale of electric two-wheelers in the Technology Driven Scenario with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02
2025	16.68	16.68	16.68	16.68	16.68	16.68	16.68	16.68	16.68
2026	18.87	18.87	18.87	18.87	18.87	18.87	18.87	18.87	18.87
2027	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23
2028	37.31	37.31	37.31	37.31	37.31	37.31	37.31	37.31	37.31
2029	57.18	57.18	57.18	57.18	57.18	57.18	57.18	57.18	57.18
2030	99.81	99.81	99.81	99.81	99.81	99.81	99.81	99.81	99.81
2031	179.69	179.69	179.69	179.69	179.69	179.69	179.69	179.69	179.69

Projected demand for charging infrastructure is shown in Figure 81.

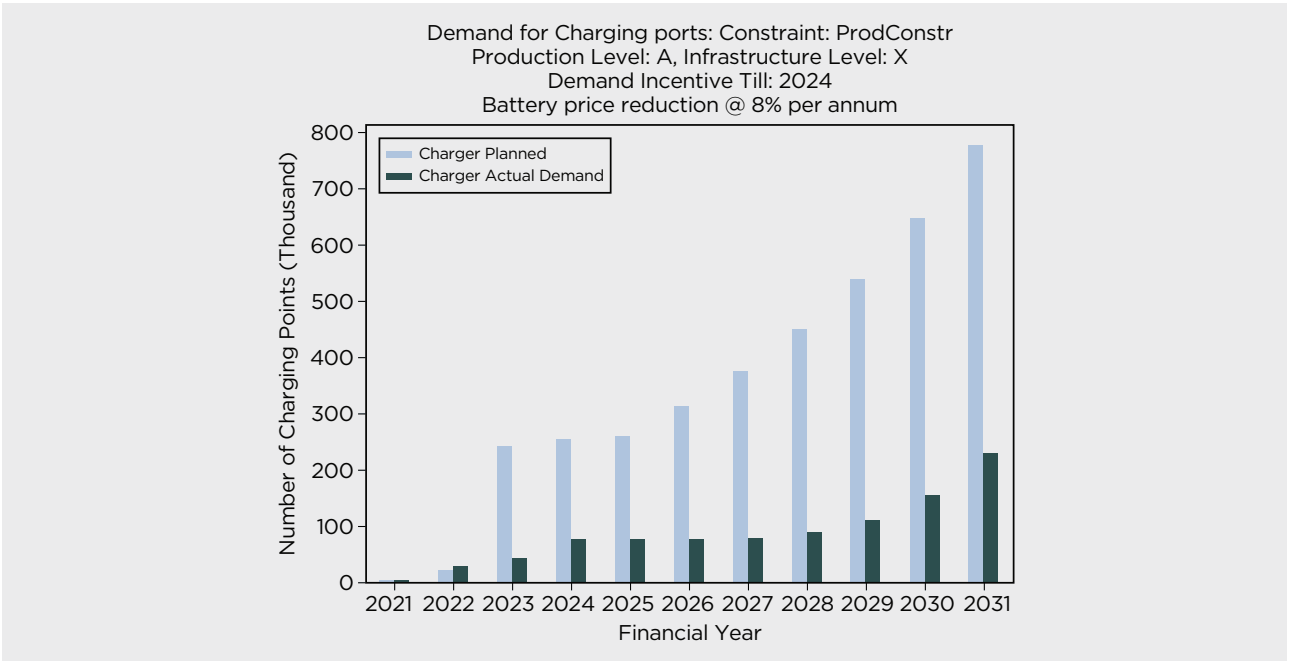


Figure 81: *Demand for charging points in the Technology Driven Scenario with Production Constraint (Constraint level AX)*

The demand for battery reaches 7.42 GWh in the FY 2024 and 59.17 GWh in the FY 2031 (Figure 82 and Table 53).

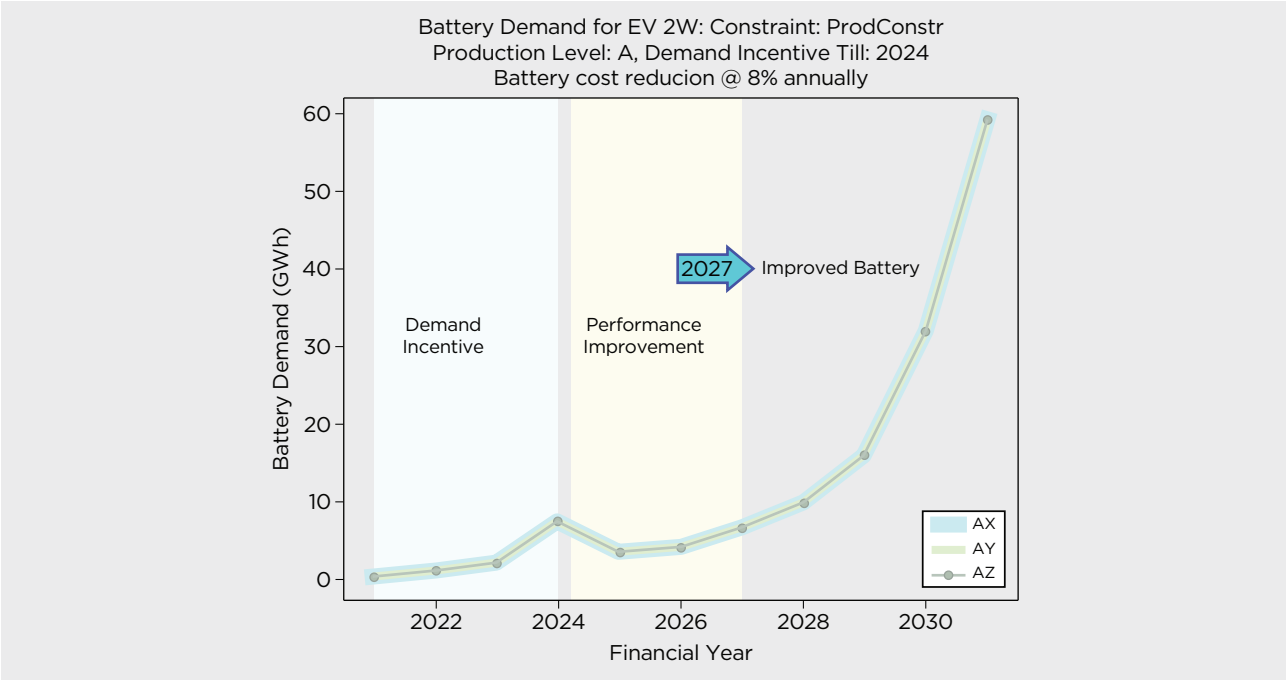


Figure 82: *Battery demand in the Technology Driven Scenario with Production Constraint, production level A*

Table 53 : Battery demand in the Technology Driven Scenario with Production Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42
2025	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
2026	4.08	4.08	4.08	4.08	4.08	4.08	4.08	4.08	4.08
2027	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62
2028	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87
2029	16.01	16.01	16.01	16.01	16.01	16.01	16.01	16.01	16.01
2030	32.01	32.01	32.01	32.01	32.01	32.01	32.01	32.01	32.01
2031	59.17	59.17	59.17	59.17	59.17	59.17	59.17	59.17	59.17

5.5.3 Technology Driven Scenario with Charge Constraint

The projected penetration level I this case is similar to the Full Constraint sub-scenario indicating that the charging infrastructure is the main constraint in the initial years. The penetration levels projected for FY 2024 and finally in FY 2031 are same as in case of Full Constraint sub-scenario (Figure 83 and Table 54).

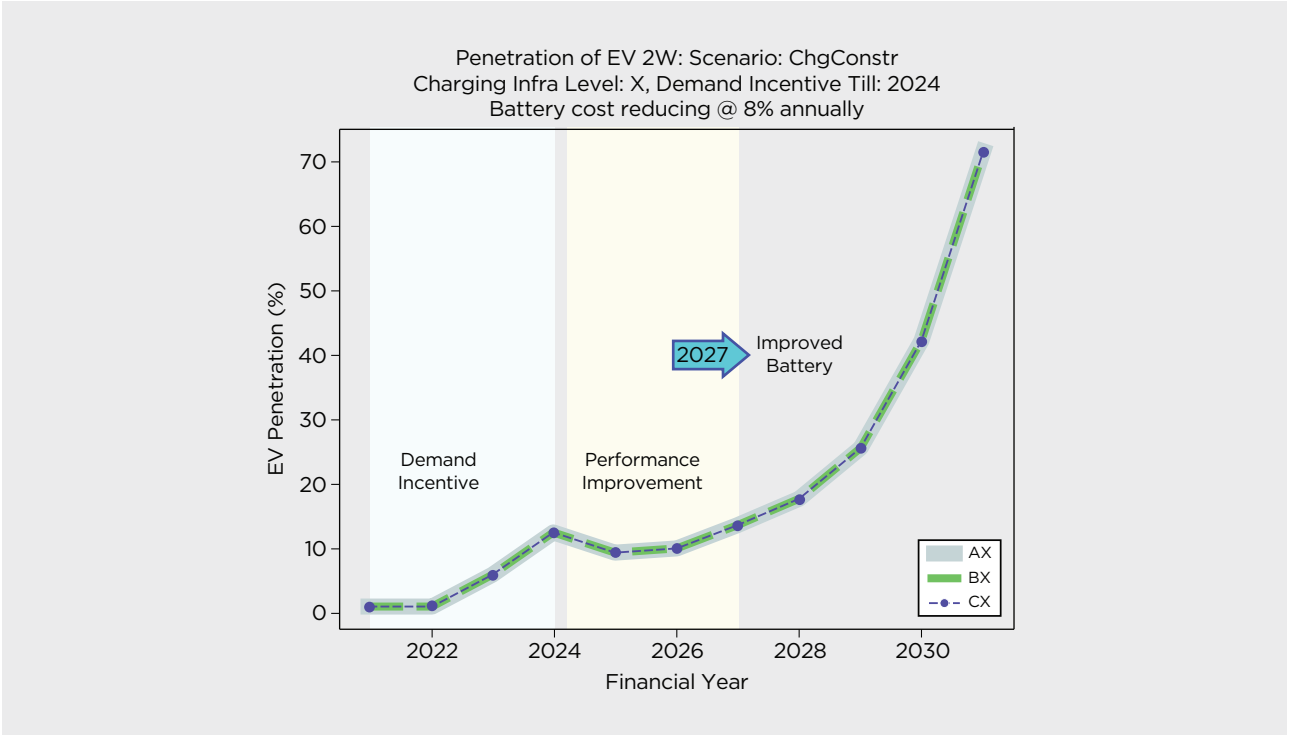


Figure 83: *Penetration of electric two-wheelers in the Technology Driven Scenario with Charge Constraint, infrastructure level X*

Table 54: Penetration of electric two-wheelers in the Technology Driven Scenario with Charge Constraint

Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42
2025	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2026	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96	9.96
2027	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
2028	17.59	17.59	17.59	17.59	17.59	17.59	17.59	17.59	17.59
2029	25.49	25.49	25.49	25.49	25.49	25.49	25.49	25.49	25.49
2030	42.04	42.04	42.04	42.04	42.04	42.04	42.04	42.04	42.04
2031	71.54	71.54	71.54	71.54	71.54	71.54	71.54	71.54	71.54

The projected total sale is shown in Figure 84 and Table 55. Sales projected for FY 2024 and FY 2031 are 21.02 lakh units and 179.69 lakh units respectively.

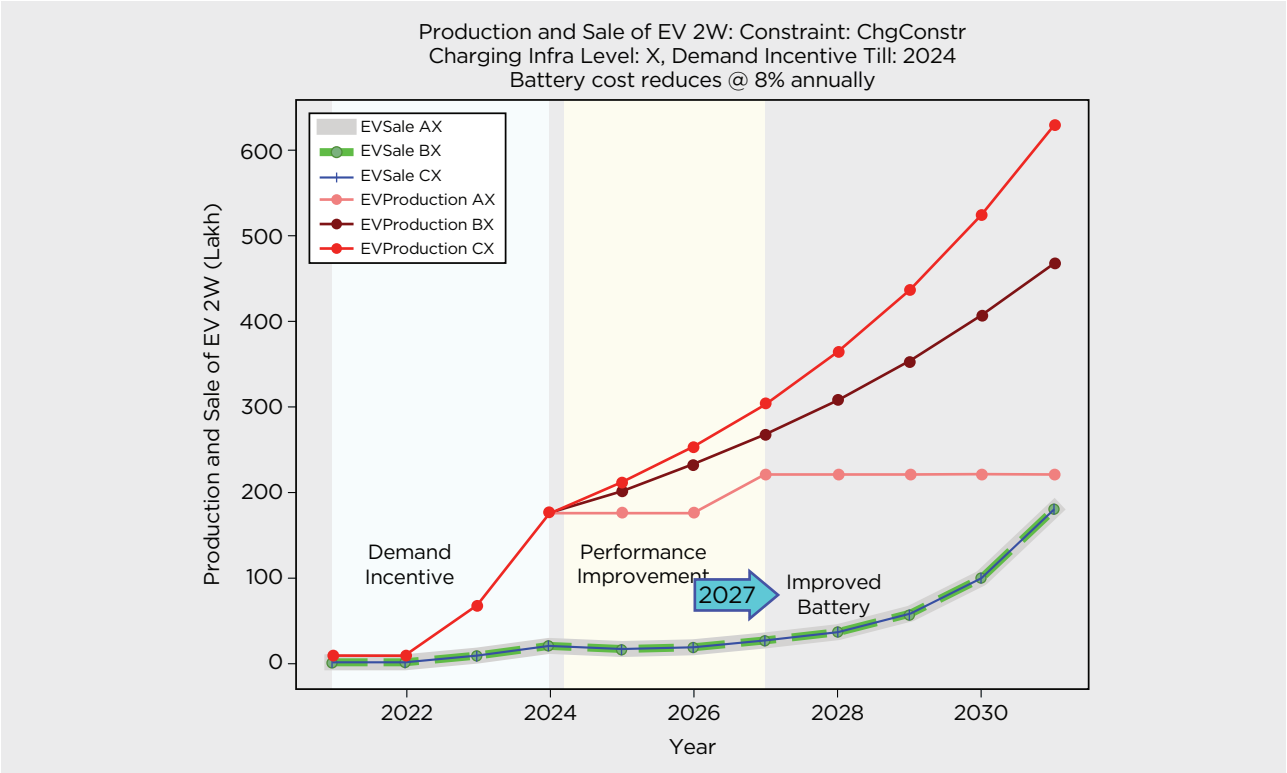


Figure 84: *Sale and production of electric two-wheelers in the Technology Driven Scenario with Charge Constraint, infrastructure level X*

Table 55: Sale of electric two-wheelers in the Technology Driven Scenario with Charge Constraint

Financial Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02
2025	16.68	16.68	16.68	16.68	16.68	16.68	16.68	16.68	16.68
2026	18.87	18.87	18.87	18.87	18.87	18.87	18.87	18.87	18.87
2027	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23	27.23
2028	37.31	37.31	37.31	37.31	37.31	37.31	37.31	37.31	37.31
2029	57.18	57.18	57.18	57.18	57.18	57.18	57.18	57.18	57.18
2030	99.81	99.81	99.81	99.81	99.81	99.81	99.81	99.81	99.81
2031	179.69	179.69	179.69	179.69	179.69	179.69	179.69	179.69	179.69

Figure 85 shows demand projected demand for charging infrastructure.

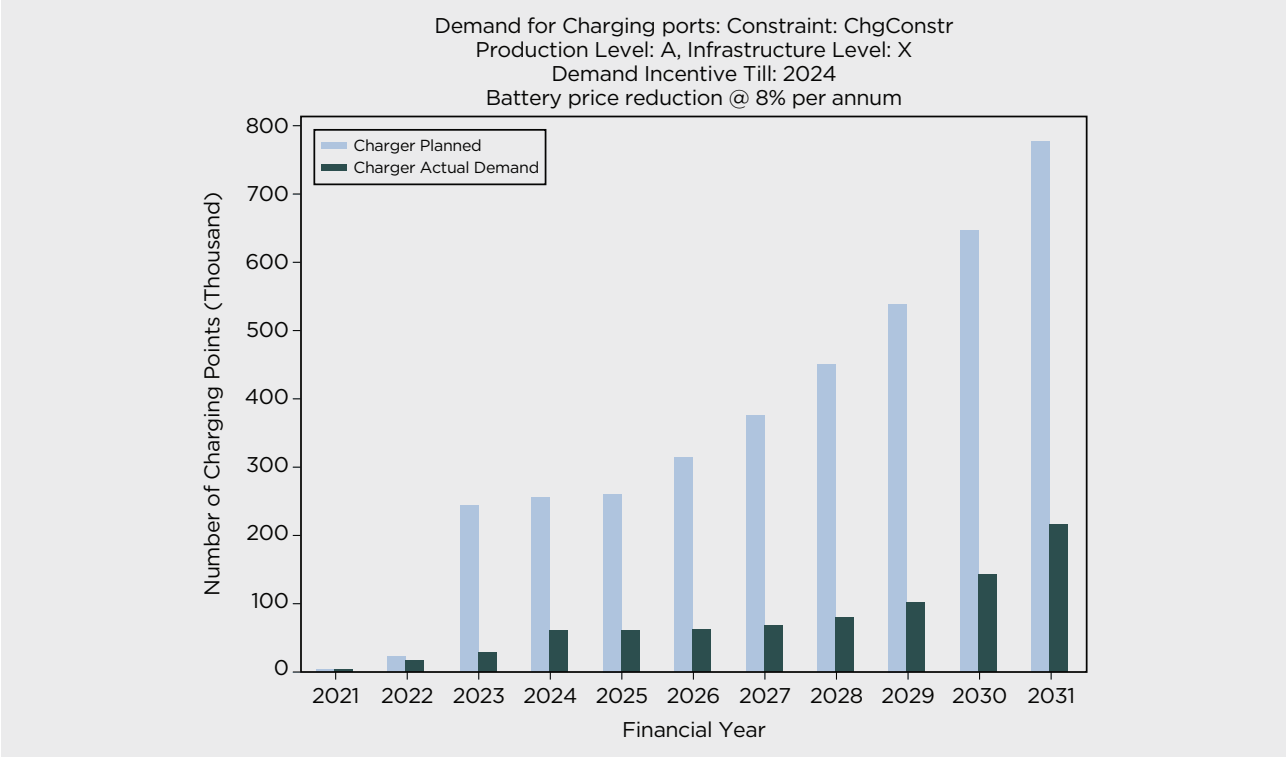


Figure 85: *Demand for charging points in the Technology Driven Scenario with Charge Constraint (constraint level AX)*

The battery demand is projected to reach 6.26 GWh in FY 2024 and then 56.79 GWh in FY 2031 (Figure 86 and Table 55).

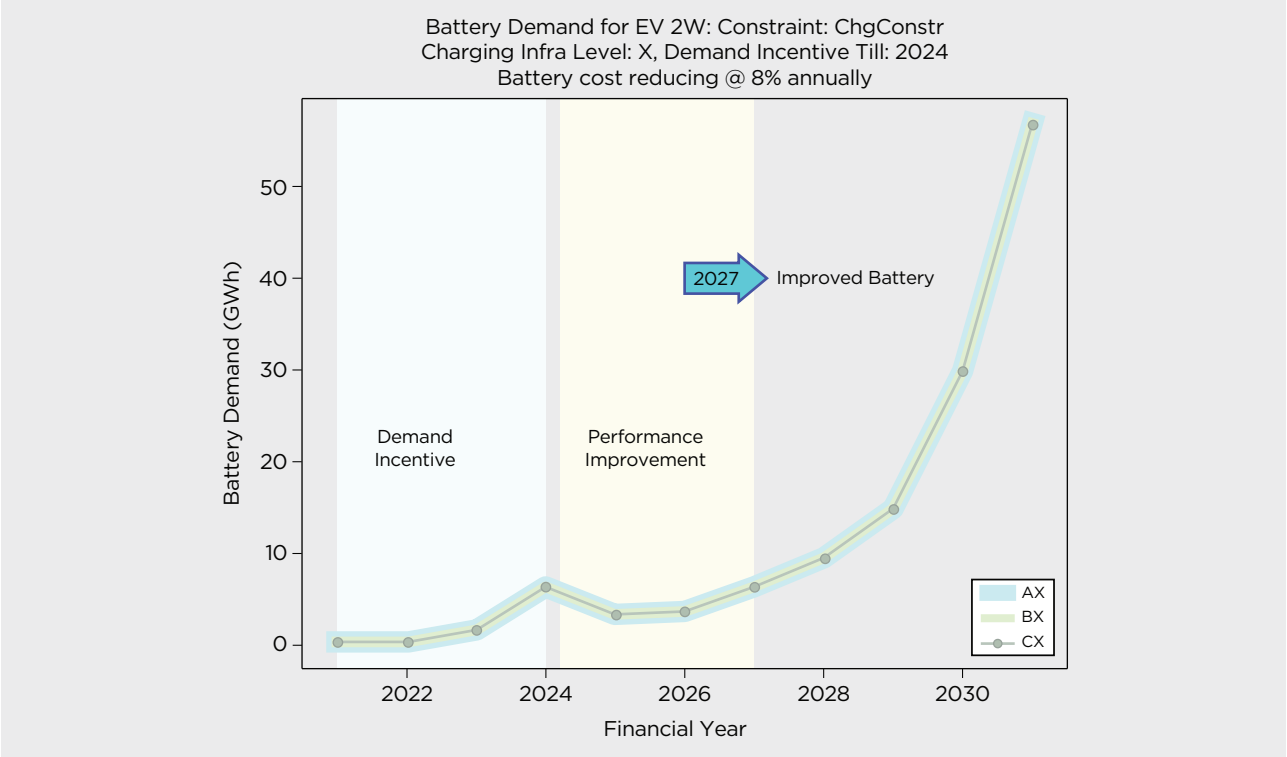


Figure 86: *Battery demand in the Technology Driven Scenario with Charge Constraint, infrastructure level X*

Table 56: Battery demand in the Technology Driven Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2025	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21	3.21
2026	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65	3.65
2027	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36	6.36
2028	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44	9.44
2029	14.81	14.81	14.81	14.81	14.81	14.81	14.81	14.81	14.81
2030	29.91	29.91	29.91	29.91	29.91	29.91	29.91	29.91	29.91
2031	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79	56.79

5.5.4 Technology Driven Scenario with No Constraint

Penetration levels projected here are similar to the Production Constraint sub-scenario again re-emphasizing the fact that availability of charging infrastructure is an important issue during the initial years (Figure 87 and Table 57).

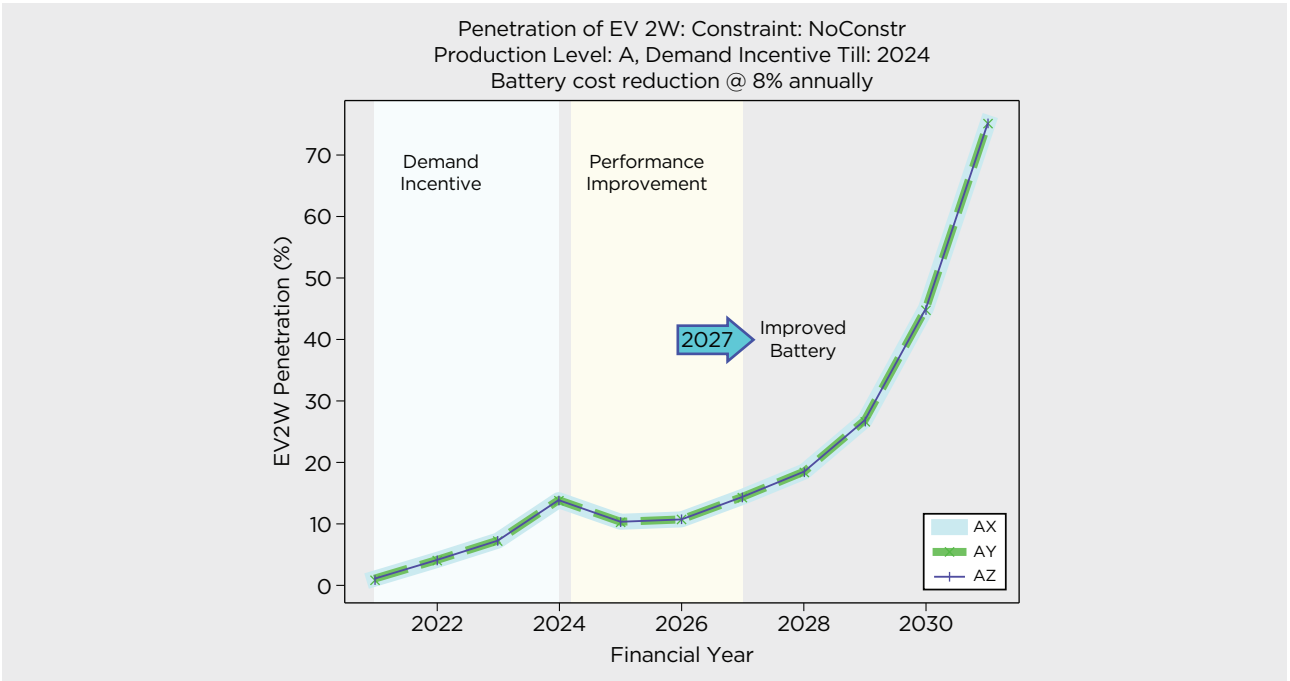


Figure 87: *Penetration of electric two-wheelers in the Technology Driven Scenario with No Constraint, production level A*

Table 57: Penetration of electric two-wheelers in the Technology Driven Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84
2025	10.35	10.35	10.35	10.35	10.35	10.35	10.35	10.35	10.35
2026	10.74	10.74	10.74	10.74	10.74	10.74	10.74	10.74	10.74
2027	14.36	14.36	14.36	14.36	14.36	14.36	14.36	14.36	14.36
2028	18.37	18.37	18.37	18.37	18.37	18.37	18.37	18.37	18.37
2029	26.78	26.78	26.78	26.78	26.78	26.78	26.78	26.78	26.78
2030	44.89	44.89	44.89	44.89	44.89	44.89	44.89	44.89	44.89
2031	75.03	75.03	75.03	75.03	75.03	75.03	75.03	75.03	75.03

Projected sale of electric two-wheelers is little higher than that in Production Constraint sub-scenario (Figure 88 and Table 58)

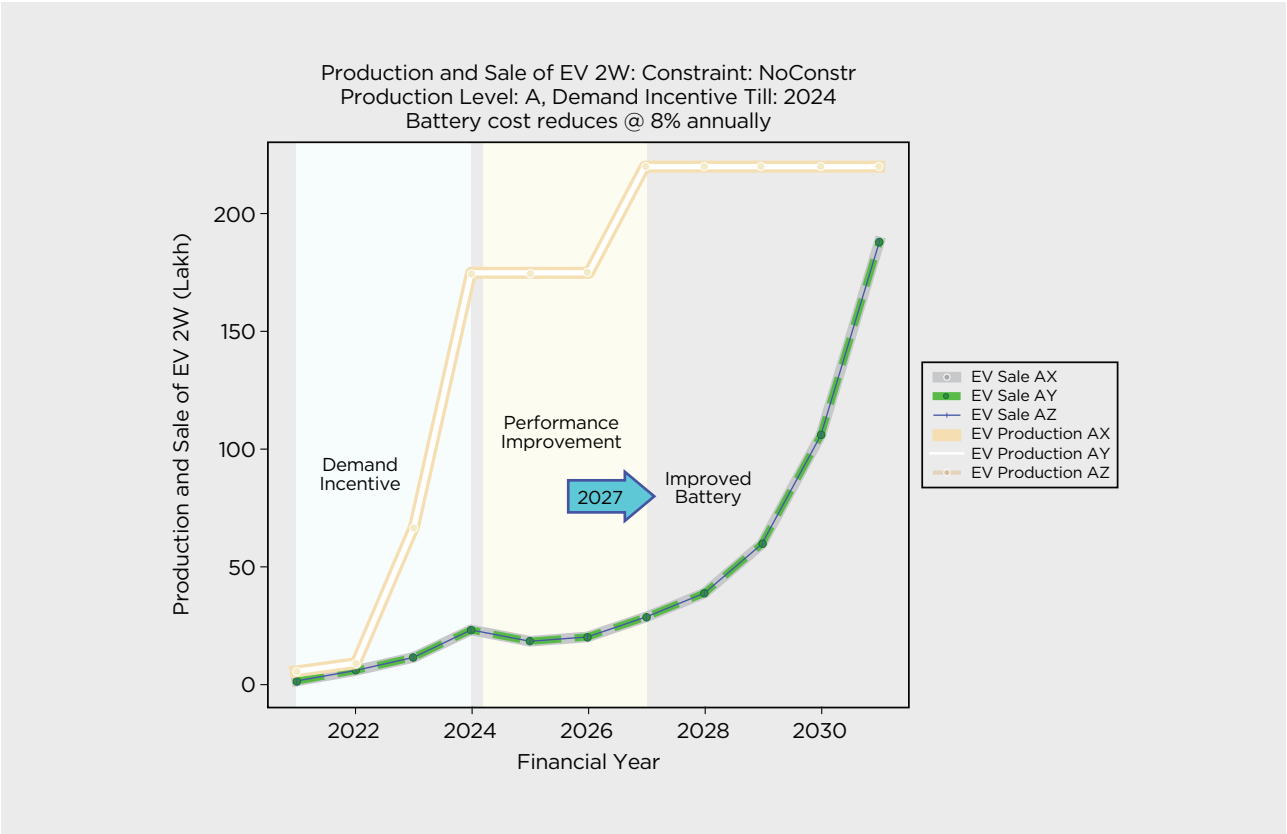


Figure 88: *Sale and production in the Technology Driven Scenario with No Constraint, production level A*

Table 58: Sale in the Technology Driven Scenario with No Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43
2025	18.53	18.53	18.53	18.53	18.53	18.53	18.53	18.53	18.53
2026	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34	20.34
2027	28.78	28.78	28.78	28.78	28.78	28.78	28.78	28.78	28.78
2028	38.96	38.96	38.96	38.96	38.96	38.96	38.96	38.96	38.96
2029	60.09	60.09	60.09	60.09	60.09	60.09	60.09	60.09	60.09
2030	106.57	106.57	106.57	106.57	106.57	106.57	106.57	106.57	106.57
2031	188.46	188.46	188.46	188.46	188.46	188.46	188.46	188.46	188.46

Projected demand for charging infrastructure for the infrastructure level X is shown in Figure 88.

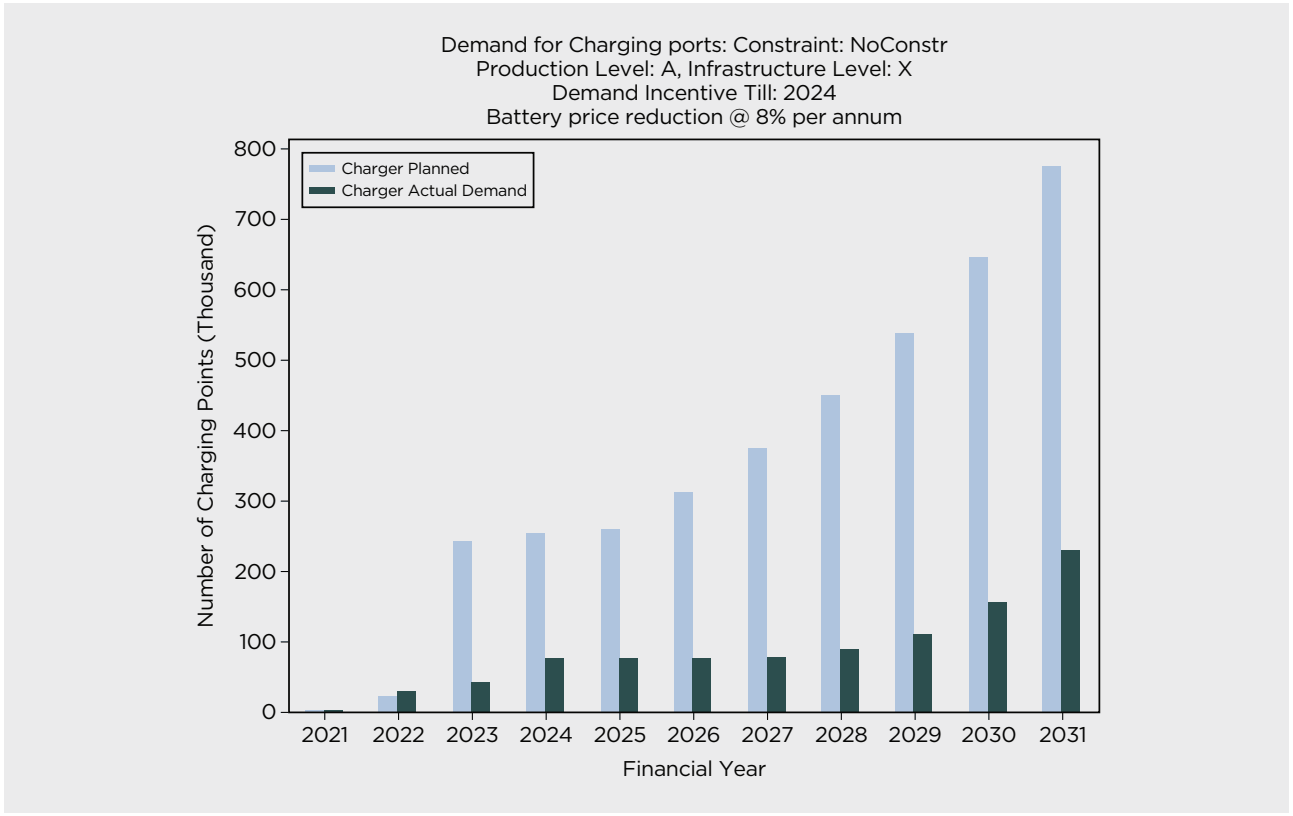


Figure 89: *Demand for charging points in the Technology Driven Scenario with No Constraint (constraint level AX)*

Battery demand, as shown in Figure 90 and Table 59, reaches 11.92 GWh in the FY 2024 and 27.14 GWh in the FY 2031.

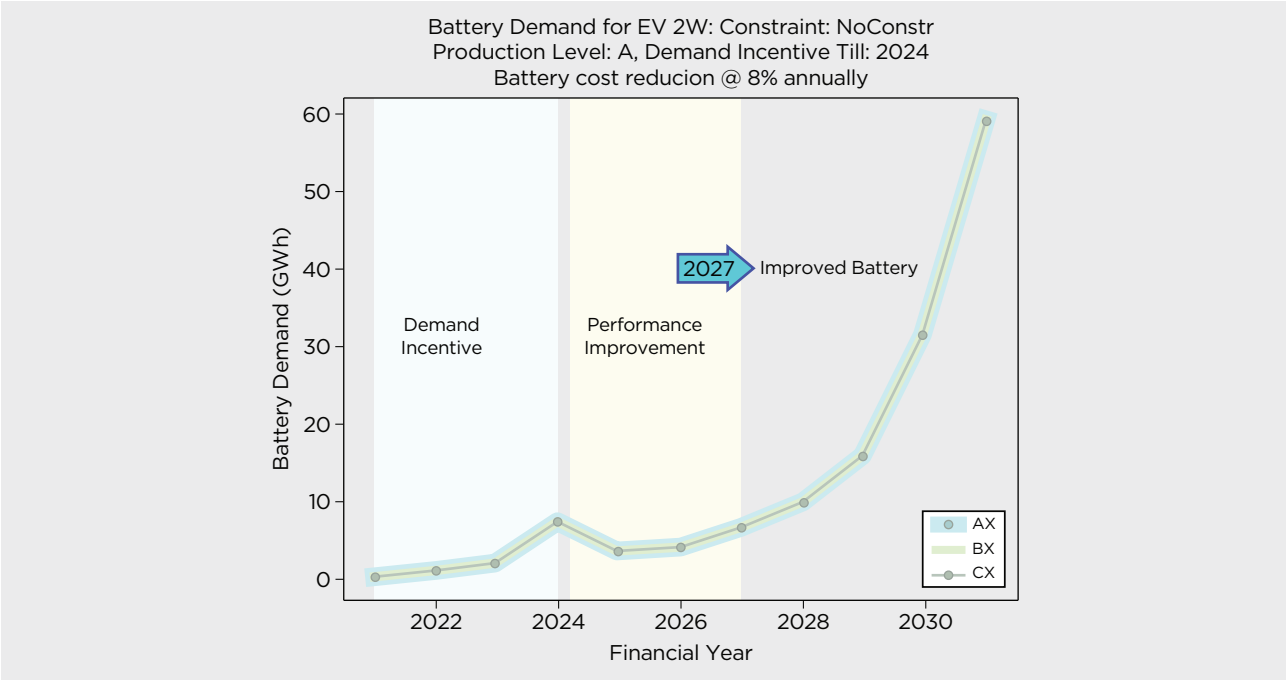


Figure 90: *Battery demand in the Technology Driven Scenario with No Constraint, production level A*

Table 59: Battery demand in the Technology Driven Scenario with No Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42
2025	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52	3.52
2026	4.08	4.08	4.08	4.08	4.08	4.08	4.08	4.08	4.08
2027	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62	6.62
2028	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87	9.87
2029	16.01	16.01	16.01	16.01	16.01	16.01	16.01	16.01	16.01
2030	32.01	32.01	32.01	32.01	32.01	32.01	32.01	32.01	32.01
2031	59.17	59.17	59.17	59.17	59.17	59.17	59.17	59.17	59.17

5.6 Incentive Driven Scenario

In this scenario the demand incentive is assumed to continue till FY 2031. Range and power of the electric two-wheelers are assumed to remain at the present level and battery cost reduces by 2% annually.

5.6.1 Incentive Driven Scenario with Full Constraint

In this case no impact of enhancing the vehicle production capacity or number of installed charging infrastructure is observed. The maximum level of penetration of electric two-wheelers that can be achieved is about 22%. This situation, for a production capacity of A, is depicted in Figure 91 and Table 60.

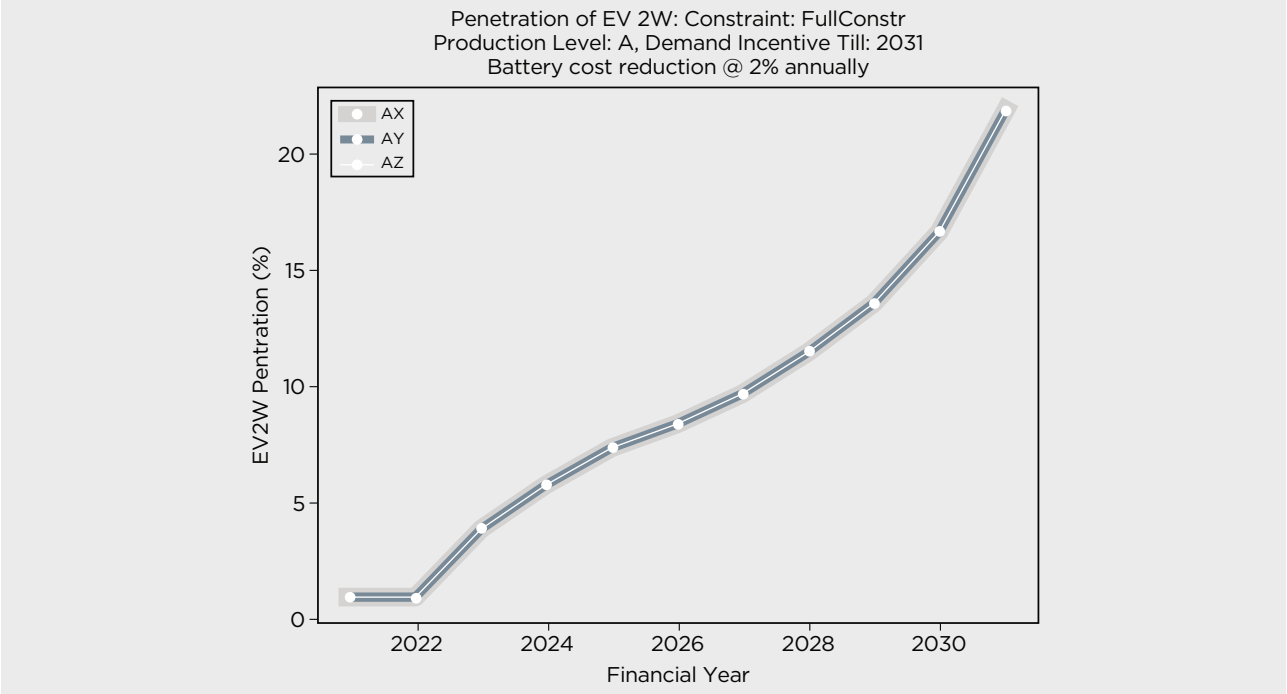


Figure 91: *Penetration of electric two-wheelers in Incentive Driven Scenario with Full Constraint, production level A*

Table 60: Penetration of electric two-wheelers in Incentive Driven scenario with Full Constraints

Financial Year	Penetration of Electric Two-wheelers (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2025	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
2026	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41
2027	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
2028	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51
2029	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
2030	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69
2031	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86

The total sale and production of electric two-wheelers, too, remain at the same level for all the constraint levels in the Full Constrained sub-scenario. The situation at production Level A is shown in Figure 92 and Table 61.

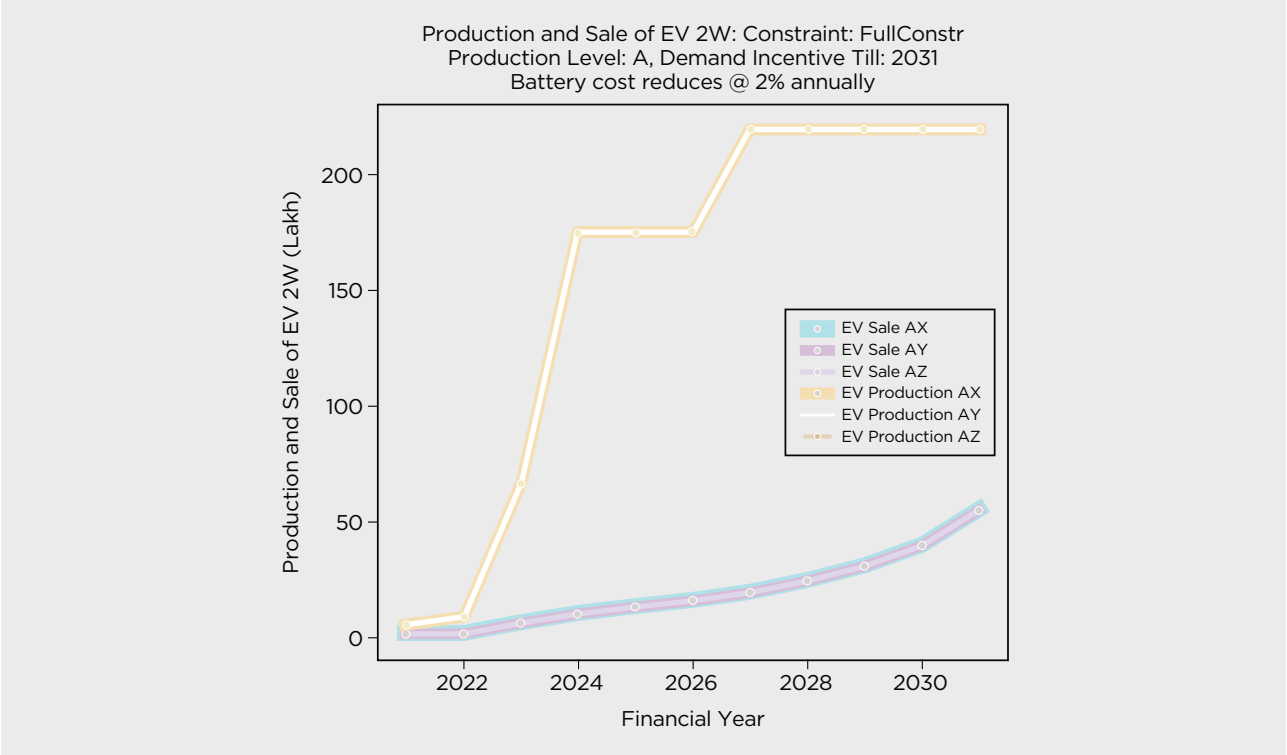


Figure 92: *Sale and production of electric two-wheelers in Incentive Driven Scenario with Full Constraint, production level A*

Table 61: Sale of electric two-wheelers in Incentive Driven scenario with Full Constraints

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2025	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2
2026	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93
2027	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45
2028	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42
2029	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48
2030	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62
2031	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91

The demand for charging infrastructure is shown in Figure 93.

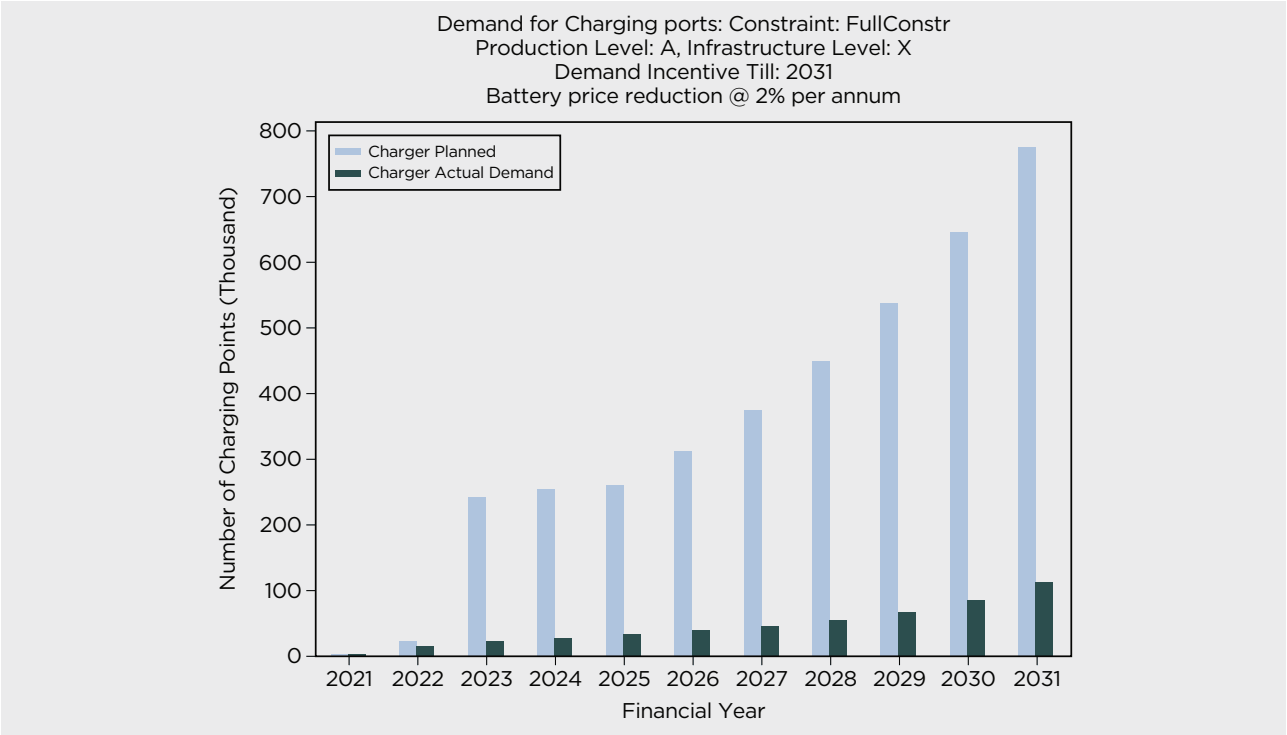


Figure 93: *Demand for charging points in Incentive Driven scenario with Full Constraint (constraint level AX)*

The projected battery demand for electric two-wheelers, as shown in Figure 94 and Table 62, has a similar trajectory as penetration and sale of vehicles. Demand value reaches 15.82 GWh in FY 2031.

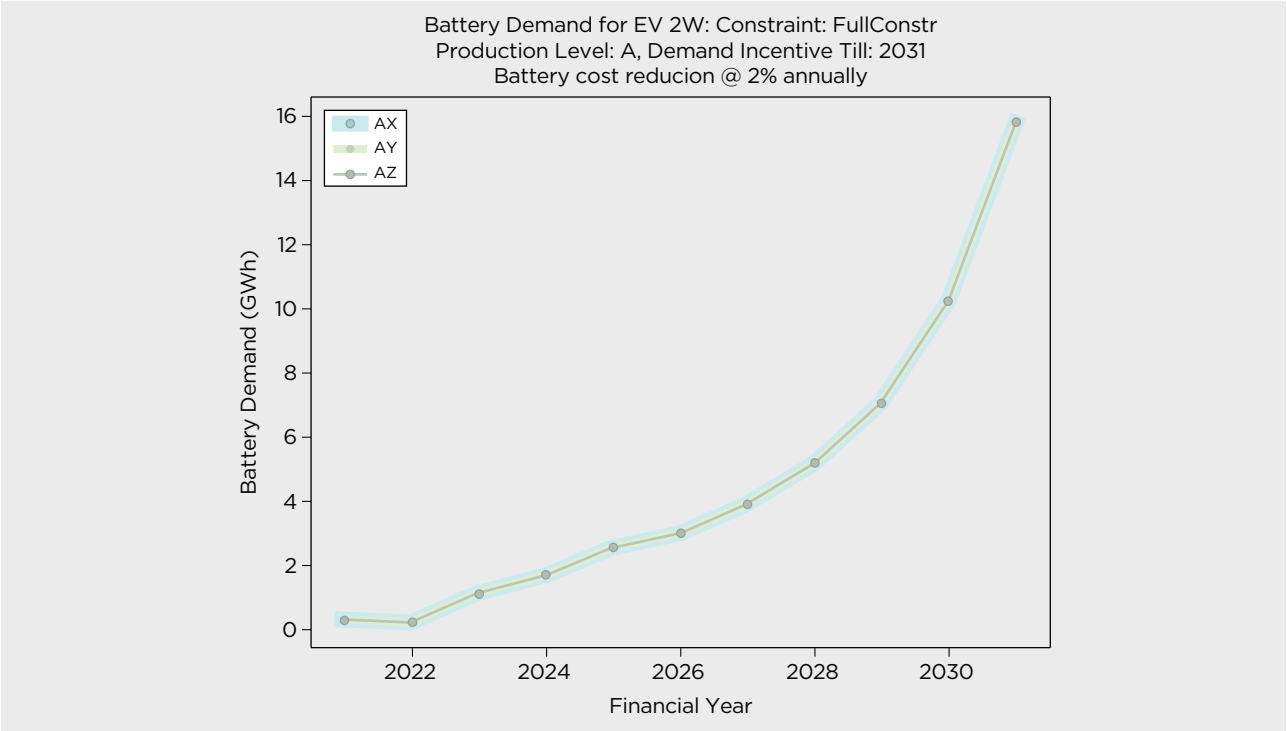


Figure 94: *Battery demand in Incentive Driven Scenario with Full Constraints, production level A*

Table 62: Battery demand in Incentive Driven Scenario with Full Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
2025	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2026	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99
2027	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
2028	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18
2029	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05
2030	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23
2031	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82

5.6.2 Incentive Driven Scenario with Production Constraint

The projected penetration of electric two-wheelers in this case is shown in Figure 95 and Table 63. It is 6.86% in FY 2024 and reaches 21.86% in FY 2031. Here, there is a difference in the penetration level in the initial years as compared to the Full Constraint sub-scenario. This is due to the fact that the constraint of charging infrastructure, which influences penetration in the initial years, is not considered in this case.

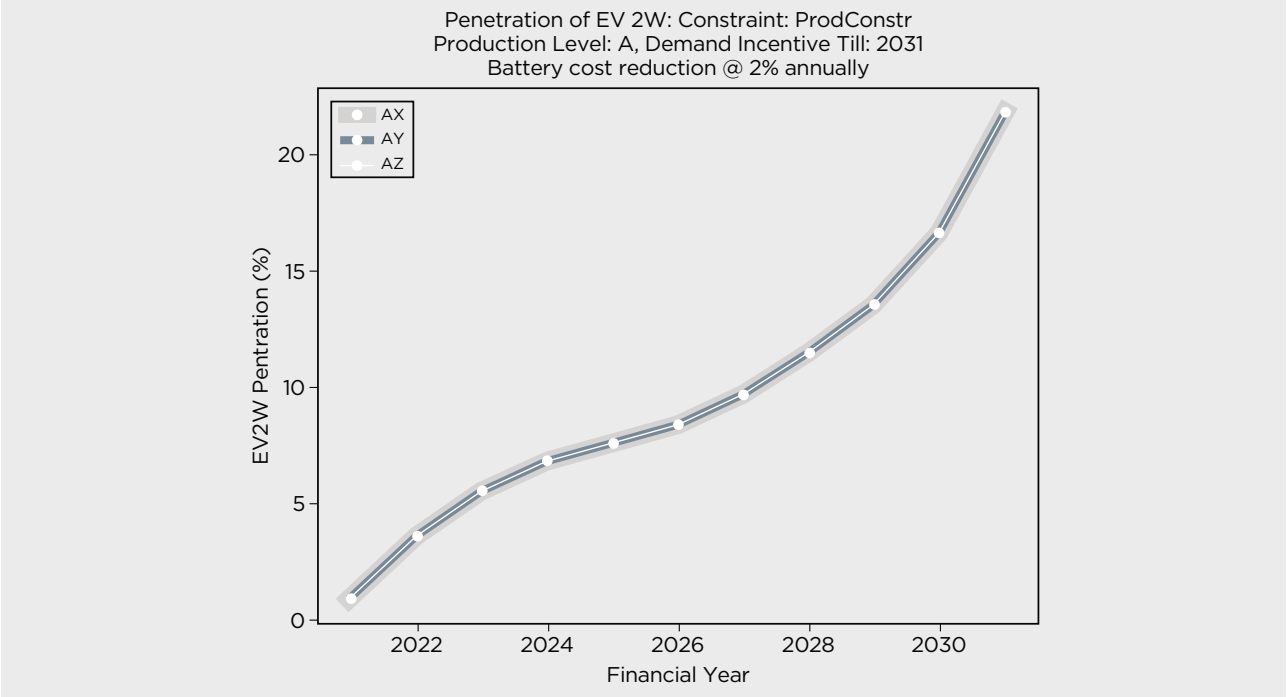


Figure 95: *Penetration of electric two-wheelers in Incentive Driven Scenario with Production Constraint, production level A*

Table 63: Penetration of electric two-wheeler in Incentive Driven scenario with Production Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86
2025	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63
2026	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41
2027	9.70	9.70	9.70	9.70	9.70	9.70	9.7	9.7	9.7
2028	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51
2029	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
2030	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69
2031	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86

Figure 96 and Table 64 that show the projections of electric two-wheelers sale along with installed manufacturing capacity further make this clear. Since the purchase decision is not influenced by the coverage of charging facilities there is some increase in the penetration level at the beginning. The sale of EV2W during this period is limited only by the installed vehicle manufacturing capacity. However, issues such as battery cost, range and power of vehicle etc. limit the sale of electric two-wheelers, which is much below the assumed production capacity. Sale volume of electric two-wheelers in the FY 2031 is 54.91 lakh units.

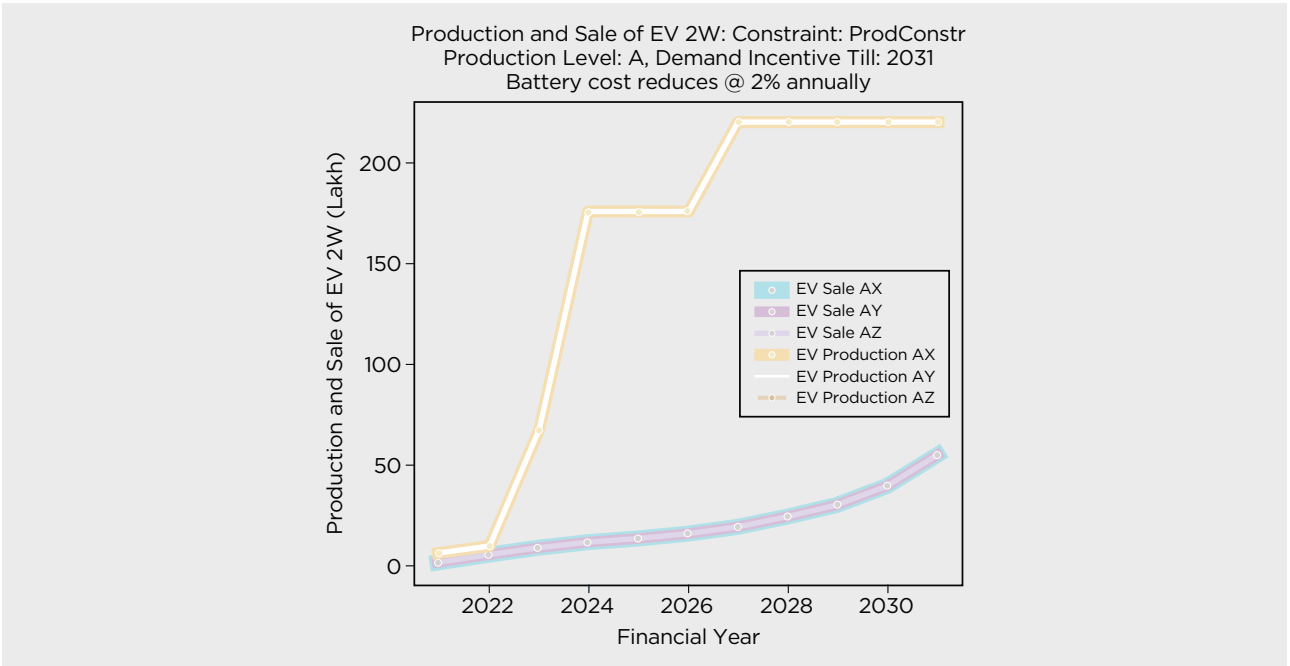


Figure 96: *Sale and production of electric two-wheelers in Incentive Driven Scenario with Production Constraint, production level A*

Table 64: Sale of electric two-wheelers in Incentive Driven Scenario with Production Constraint

Financial Year	Projected Sale of Electric Two-Wheeler (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.90	8.90	8.90	8.90	8.90	8.90	8.9	8.9	8.9
2024	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
2025	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67
2026	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93
2027	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45
2028	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42
2029	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48
2030	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62
2031	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91

The charging infrastructure demand here is much below the planned infrastructure except in the initial year. This is described in Figure 97.

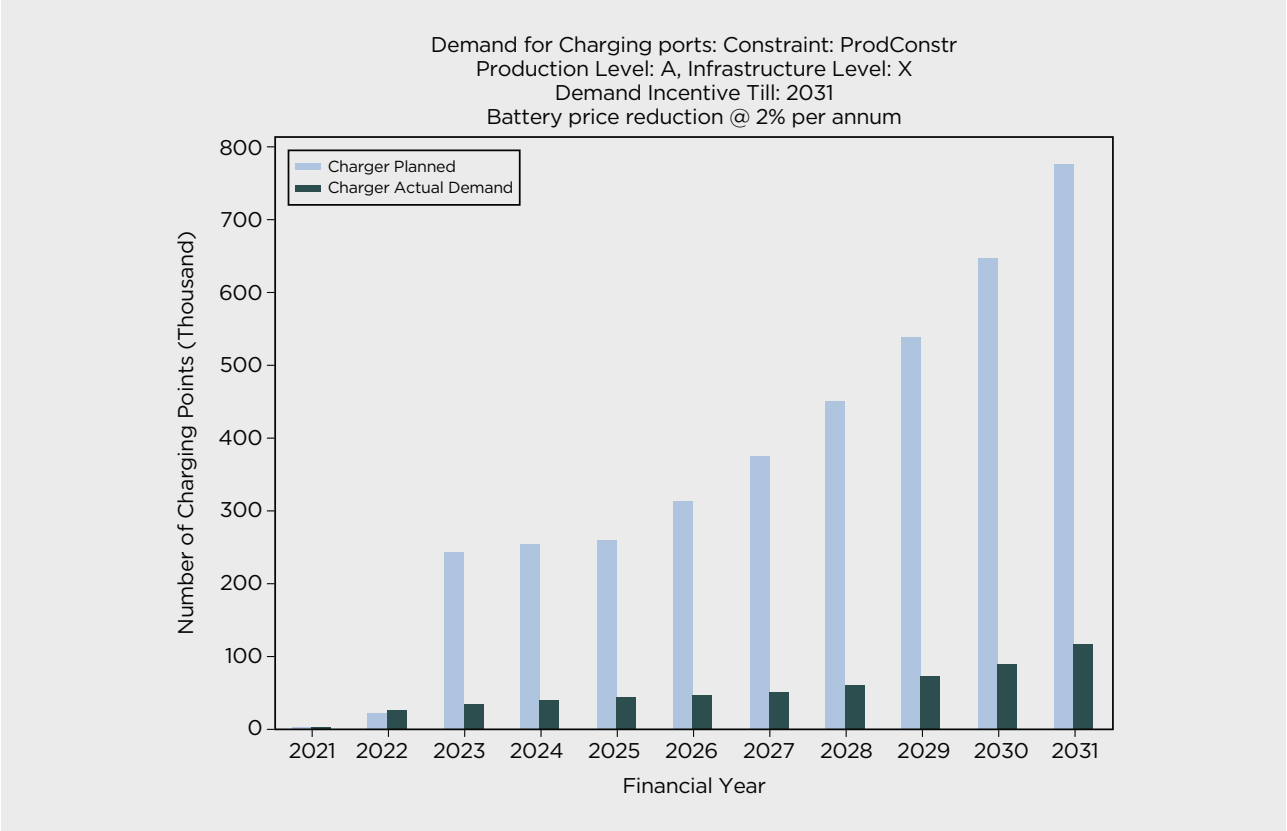


Figure 97: *Demand for charging points in Incentive Driven Scenario with Production Constraint (constraint level AX)*

The battery demand reaches 15.82 GWh in FY 2031 (Figure 98 and Table 65).

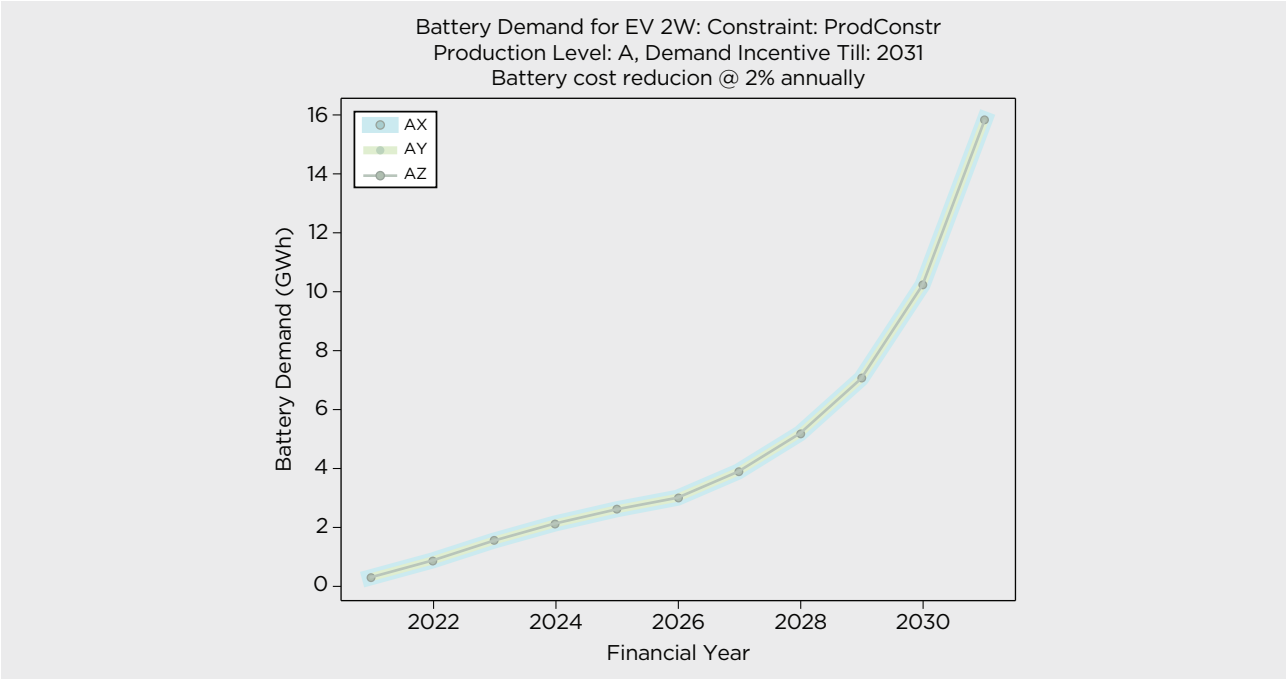


Figure 98: *Battery demand in Incentive Driven Scenario with Production Constraint, production level A*

Table 65: Battery demand in Incentive Driven Scenario with Production Constraint

Financial Year	Projected battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
2025	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
2026	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99
2027	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
2028	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18
2029	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05
2030	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23
2031	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82

5.6.3 Incentive Driven Scenario with Charge Constraint

Penetration level that can be achieved in Charge Constrained scenario with charging infrastructure level X is depicted in Figure 99 and Table 66. Production capacity of electric two-wheelers does not have any impact on its market penetration, as per the basic assumption under this scenario. It is assumed that there is supply of vehicles with same sets of attributes and prices to match the demand.

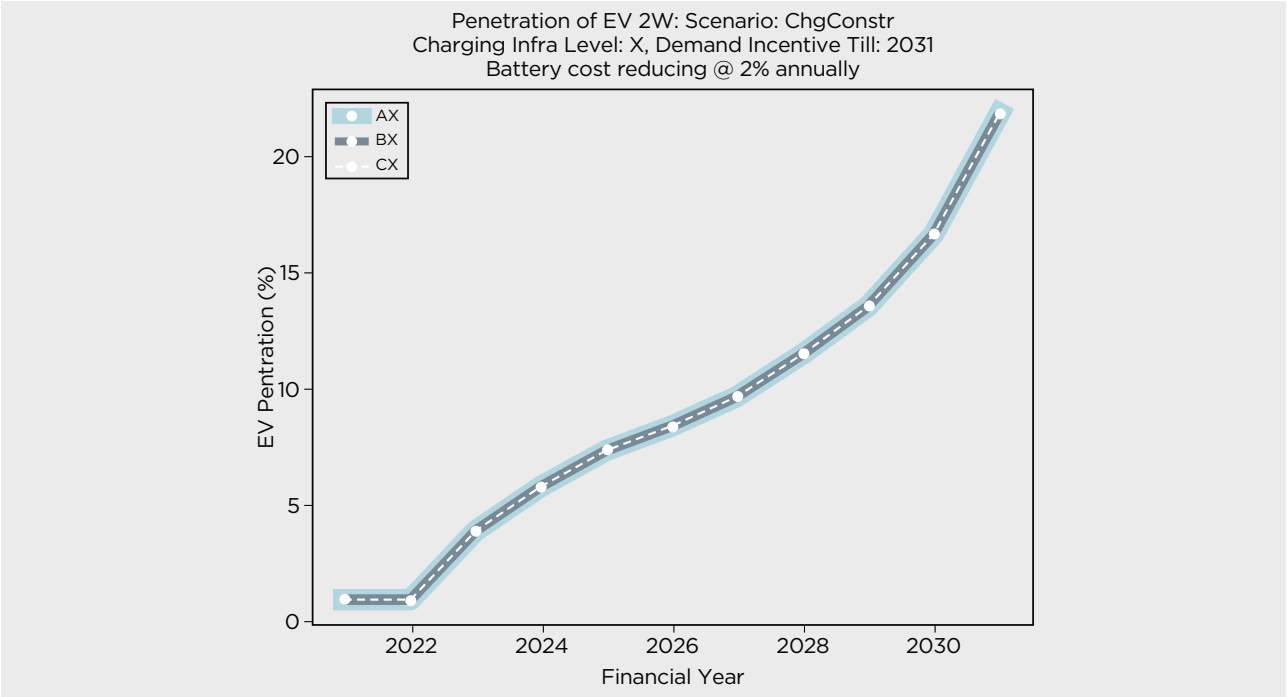


Figure 99: *Penetration of electric two-wheelers in Incentive Driven Scenario with Charge Constraint, infrastructure level X*

As can be seen, penetration of electric two-wheelers here is less than that in the case of Production Constraint sub-scenario during the initial years, as available charging infrastructure is not sufficient. Since, in all three assumed infrastructure capacity levels X, Y and Z, the installed charging points are assumed to be same in first two years, the penetration values are same across all constraint sub-scenarios. In subsequent years, the assumed charging infrastructure in the base level itself is higher than the latent demand and hence there is no effect of enhancing charging infrastructure.

Table 66: Penetration of electric two-wheelers in Incentive Drive Scenario with Charge Constraint

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2025	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37	7.37
2026	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41
2027	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
2028	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51
2029	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
2030	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69
2031	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86

Assumed production and projected sale of electric two-wheelers are shown in Figure 100 and Table 67.

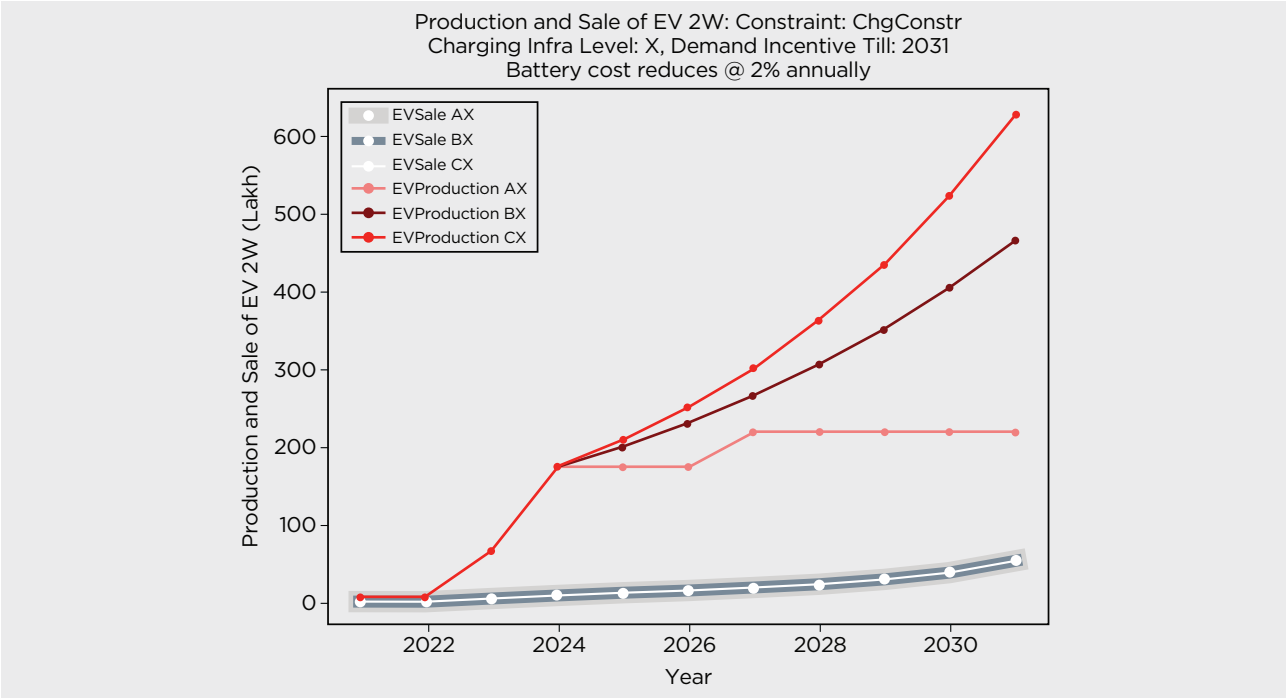


Figure 100: *Sale and production of electric two-wheelers in Incentive Driven Scenario with Charge Constraint, infrastructure level X*

Table 67: Sale of electric two-wheelers in Incentive Driven Scenario with Charge Constraint, infrastructure level X

Financial Year	Projected Sale of Electric Two-Wheelers (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
2025	13.20	13.20	13.20	13.20	13.20	13.20	13.20	13.20	13.20
2026	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93
2027	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45
2028	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42
2029	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48
2030	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62
2031	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91

The demand for charging infrastructure for constraint level AX is shown in Figure 101.

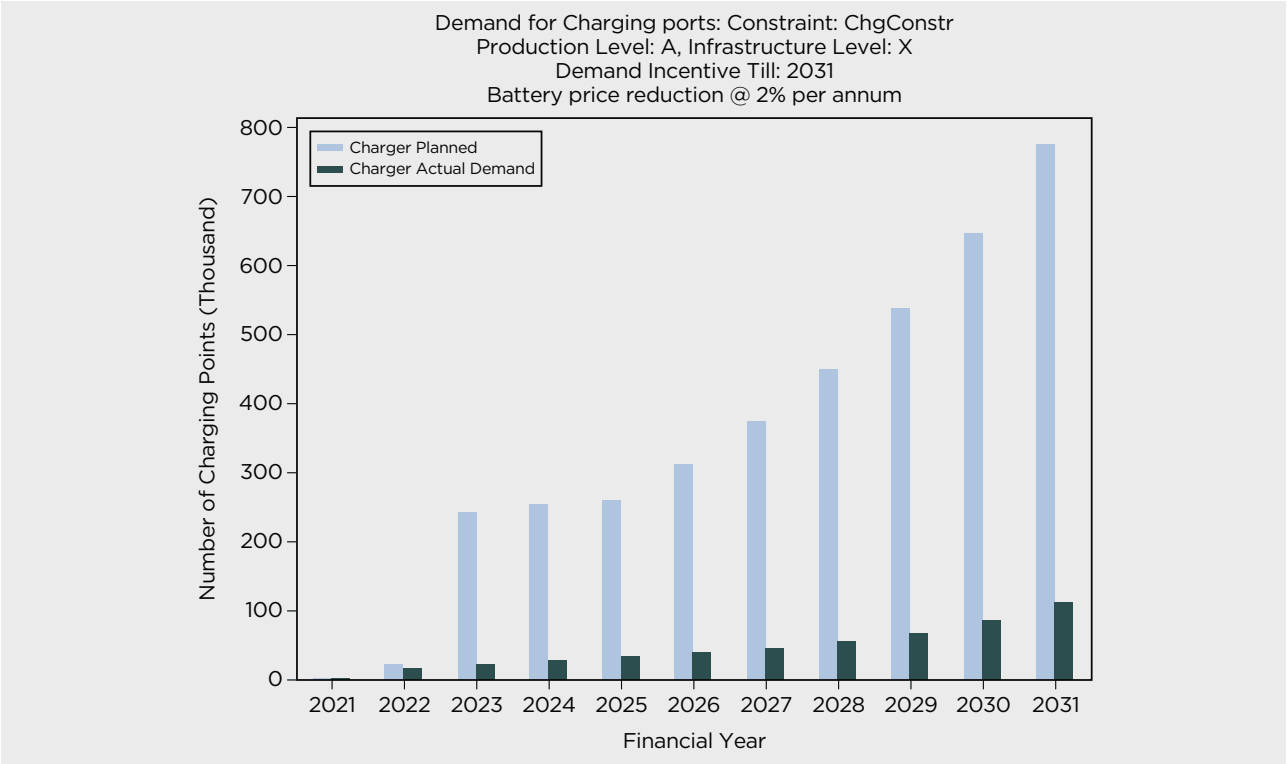


Figure 101: *Demand for charging points in Incentive Driven Scenario with Charge Constraint (constraint level AX)*

The demand for battery is shown in Figure 102 and Table 68.

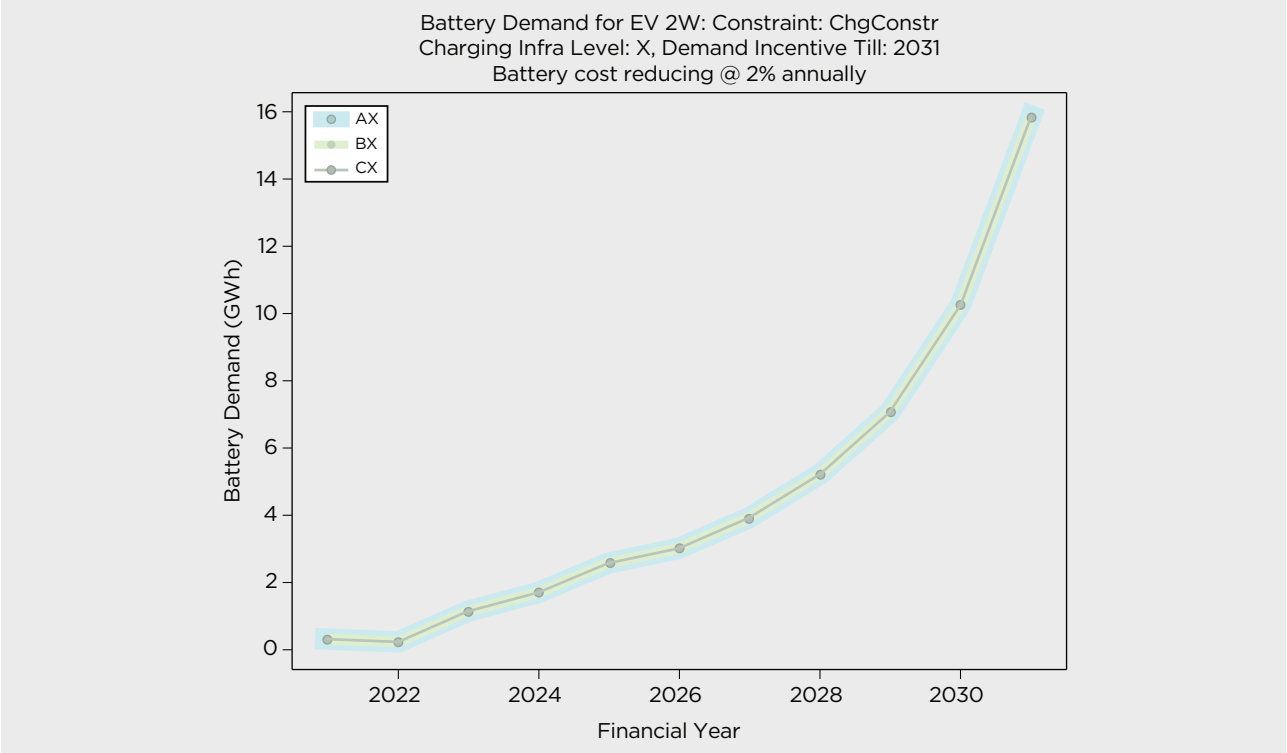


Figure 102: *Demand for battery in Incentive Driven Scenario with Charge Constraint, infrastructure level X*

Table 68: Demand for battery in Incentive Driven Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68	1.68
2025	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54	2.54
2026	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99
2027	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90	3.90
2028	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18
2029	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05
2030	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23
2031	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82

It can be seen that increased level of electric two-wheelers production does not increase their market penetration, which is same as in the case of infrastructure level X.

5.6.4 Incentive Driven Scenario with No Constraint

The penetration that can be achieved with no constraint in the Incentive Drive Scenario is presented in Figure 103 and Table 69.

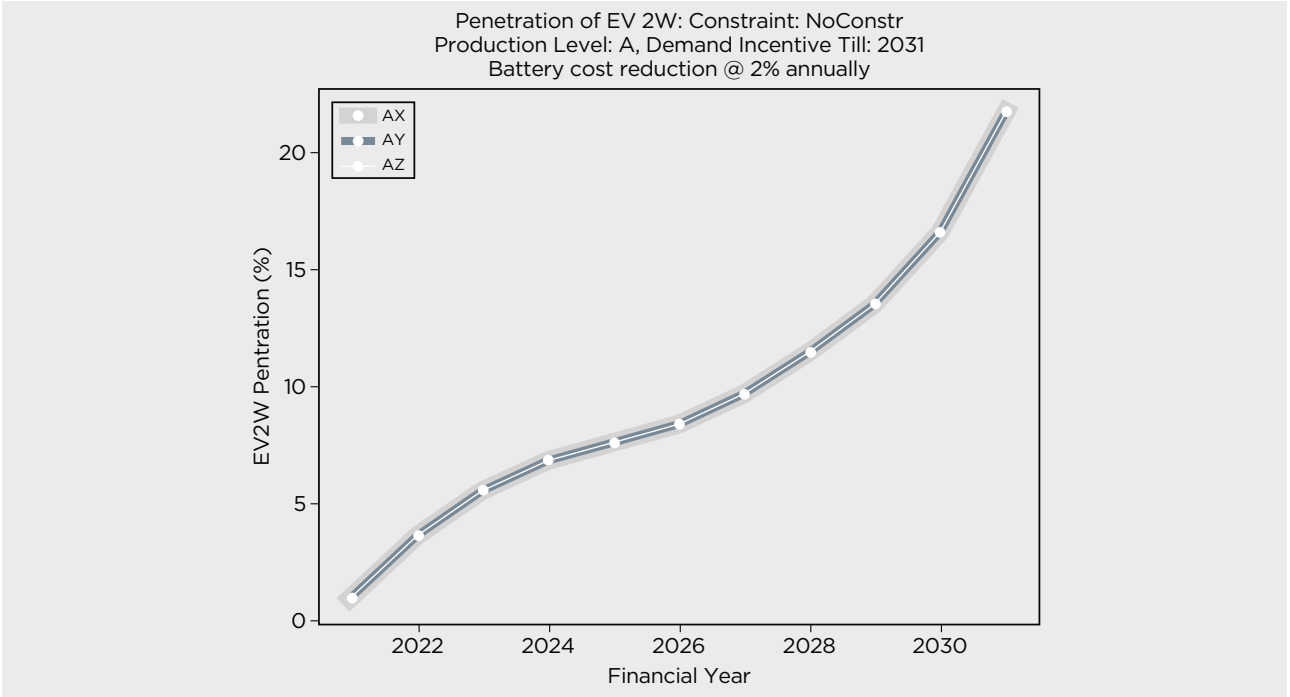


Figure 103: *Penetration of electric two-wheelers in Incentive Driven Scenario with No Constraint, production level A*

For several years, the penetration level is higher as compared to the same achieved in Full Constraint or Charge Constraint sub-scenarios due to insufficient charging infrastructure. However, subsequently, installed capacity of charging points increases and is more than enough with respect to the demand for electric two-wheelers for the given conditions.

Table 69: Penetration of electric two-wheelers in Incentive Driven Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86	6.86
2025	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63	7.63
2026	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41	8.41
2027	9.70	9.70	9.70	9.70	9.70	9.70	9.70	9.70	9.70
2028	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51	11.51
2029	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58	13.58
2030	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69	16.69
2031	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86	21.86

The total annual sale of electric two-wheelers is shown in Figure 104 and Table 70.

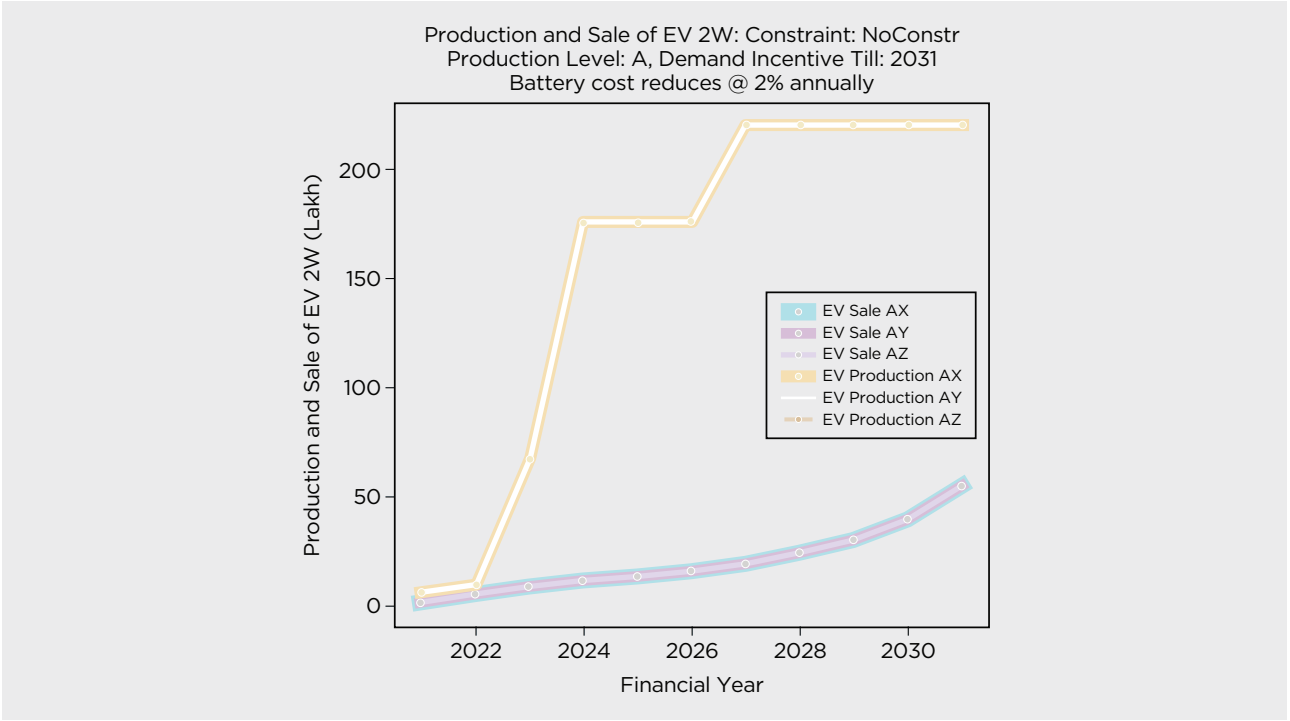


Figure 104: *Sale and production of electric two-wheelers in Incentive Driven Scenario with No Constraint, production level A*

Table 70: Sale of electric two-wheelers in Incentive Driven Scenario with No Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90
2024	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
2025	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67	13.67
2026	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93	15.93
2027	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45
2028	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42
2029	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48	30.48
2030	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62	39.62
2031	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91	54.91

Demand for charging facility is still much less than what is envisaged in the base case, as shown in Figure 105.

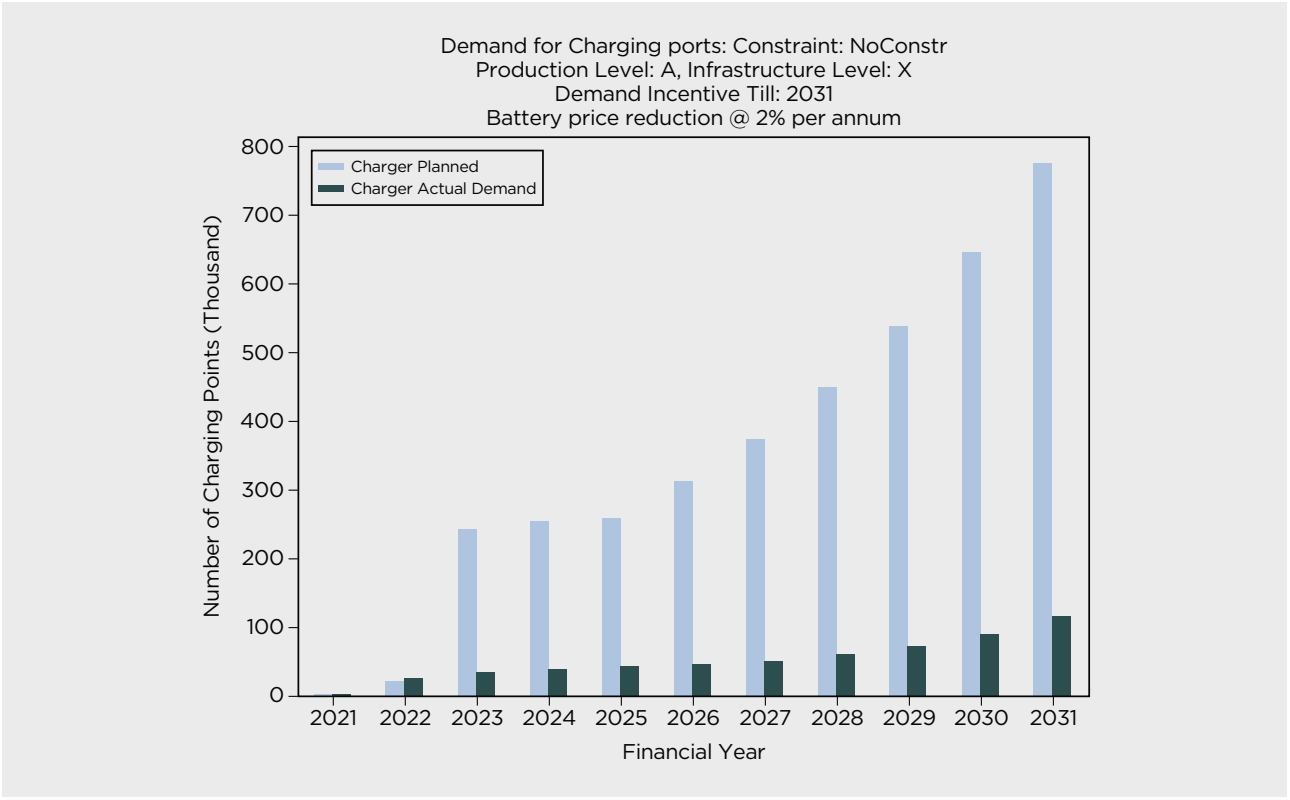


Figure 105: *Demand for charging points in Incentive Driven Scenario with No Constraint (constraint level AX)*

The projected annual demand of batteries for electric two-wheelers is shown in Figure 106 and Table 71.

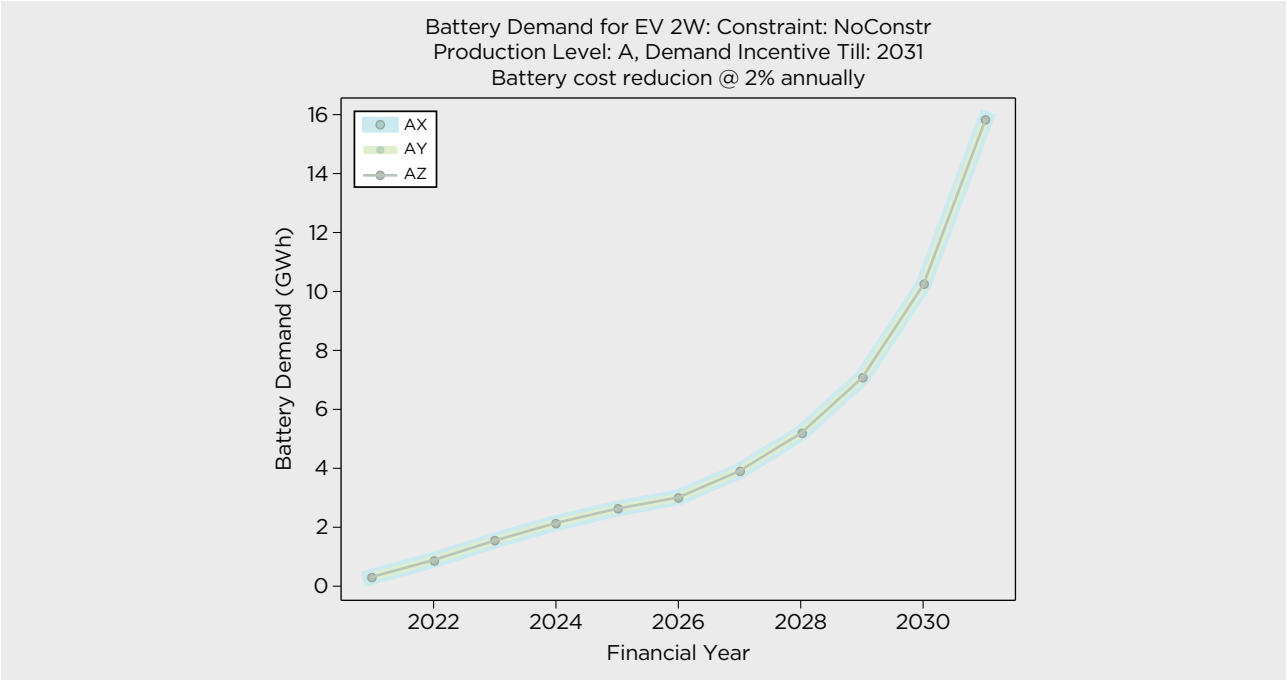


Figure 106: *Battery Demand in Incentive Driven Scenario with No Constraint, production level A*

Table 71: Battery demand in Incentive Driven Scenario with No Constraint

Financial Year	Projected Demand for Battery (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
2025	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61	2.61
2026	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99
2027	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
2028	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18
2029	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05
2030	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23	10.23
2031	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82	15.82

5.7 Battery Cost Challenged Scenario

Under this scenario the only major obstacle for larger penetration of electric mobility is the cost of the battery, which is assumed to reduce at a CAGR of 2% only. Demand incentive is present during all the period FY 2024 to FY 2031. Range and power improve by 5% annually during FY 2024 to FY 2027.

5.7.1 Battery Cost Challenged Scenario with Full Constraint

In this case, demand incentive is present throughout the period and vehicle range and power are also assumed to improve by 5% annually during FY2024 to FY 2027. The projected market penetration of electric two-wheelers in the base level of production reach a maximum value in the FY 2029 when the number of electric two-wheelers sold equals the number of electric two-wheelers produced. Subsequently, sale of EV cannot further increase and hence the relative market share of electric two-wheelers come down. This is shown in Figure 107.

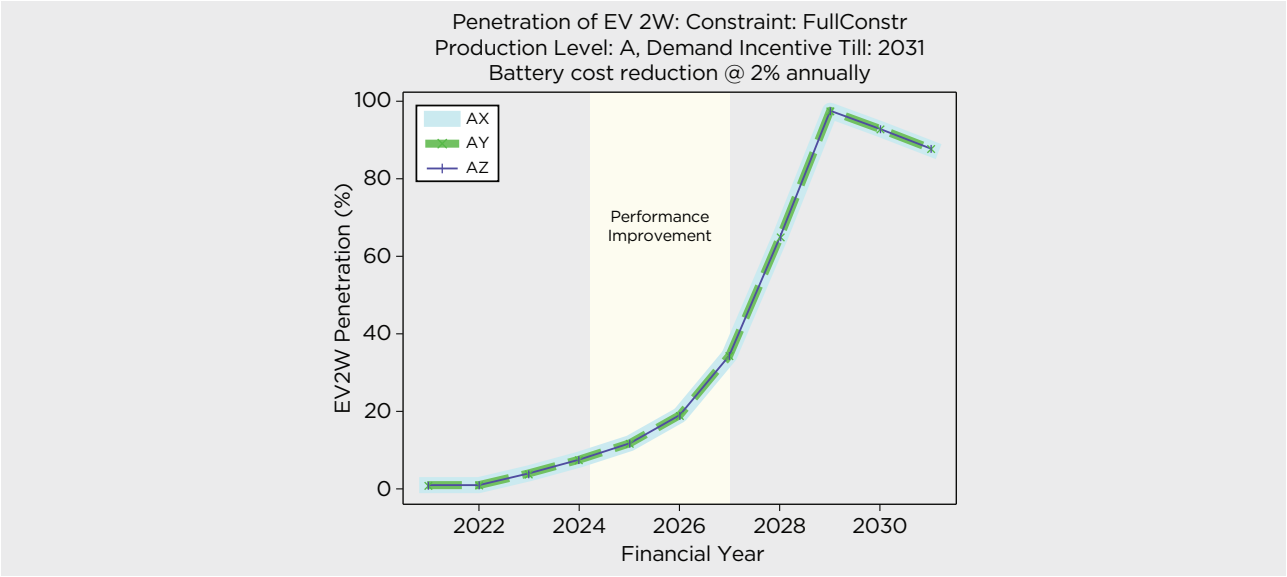


Figure 107: *Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with Full Constraints, production level A*

However, in case of higher electric two-wheeler production capacity, the penetration level is higher for the FY2030 and FY 2031, as shown in Figure 108.

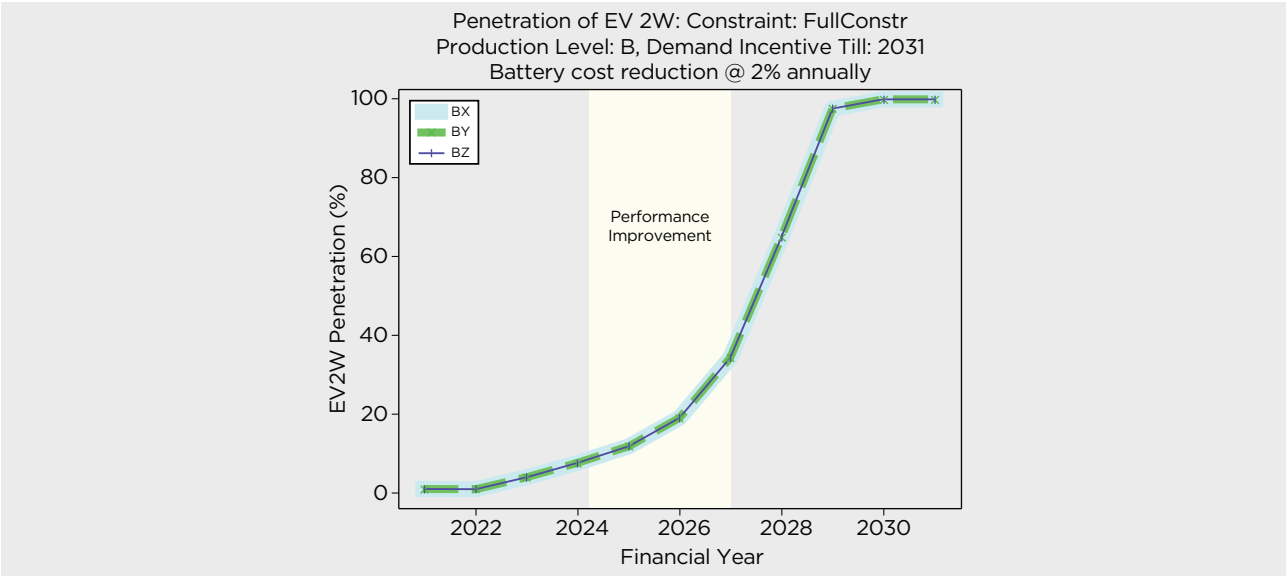


Figure 108: *Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with Full Constraints, production level B*

Details of market penetration of electric two-wheelers for various combinations of production and charging infrastructure levels in this case are presented in Table 72.

Table 72: Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
2025	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64
2026	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89
2027	34.28	34.28	34.28	34.28	34.28	34.28	34.28	34.28	34.28
2028	64.81	64.81	64.81	64.81	64.81	64.81	64.81	64.81	64.81
2029	97.54	97.54	97.54	97.54	97.54	97.54	97.54	97.54	97.54
2030	92.73	92.73	92.73	99.87	99.87	99.87	99.87	99.87	99.87
2031	87.65	87.65	87.65	100	100	100	100	100	100

Projected sale and production of electric two-wheelers are shown in Figure 109 and Table 73.

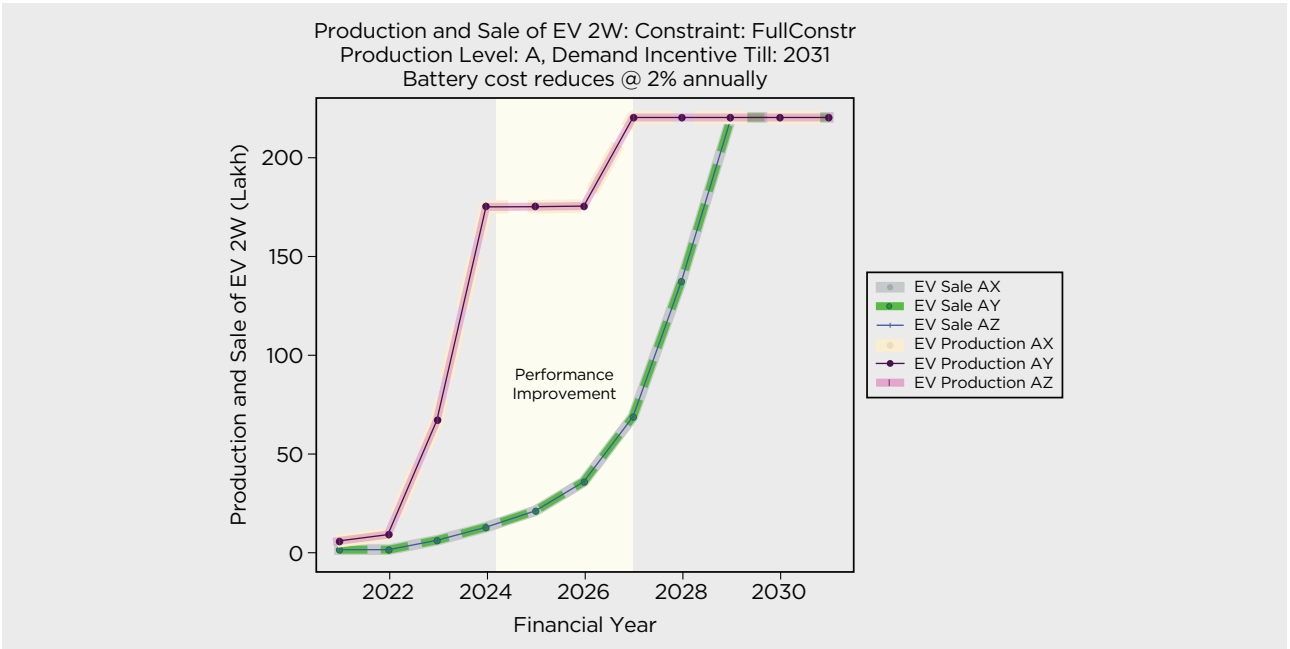


Figure 109: *Sale and production of electric two-wheelers in Battery Cost Challenged Scenario with Full Constraint, production level A*

At production level A, the maximum sale of electric two-wheelers is 220.15 lakh units. With increased vehicle production levels, annual sale of 251.17 lakh units is achieved in FY 2031.

Table 73: Sale of electric two-wheelers in Battery Cost Challenged Scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
2025	20.85	20.85	20.85	20.85	20.85	20.85	20.85	20.85	20.85
2026	35.78	35.78	35.78	35.78	35.78	35.78	35.78	35.78	35.78
2027	68.72	68.72	68.72	68.72	68.72	68.72	68.72	68.72	68.72
2028	137.45	137.45	137.45	137.45	137.45	137.45	137.45	137.45	137.45
2029	218.87	218.87	218.87	218.87	218.87	218.87	218.87	218.87	218.87
2030	220.15	220.15	220.15	237.09	237.09	237.09	237.09	237.09	237.09
2031	220.15	220.15	220.15	251.17	251.17	251.17	251.17	251.17	251.17

The demand for charging points is shown in Figure 110.

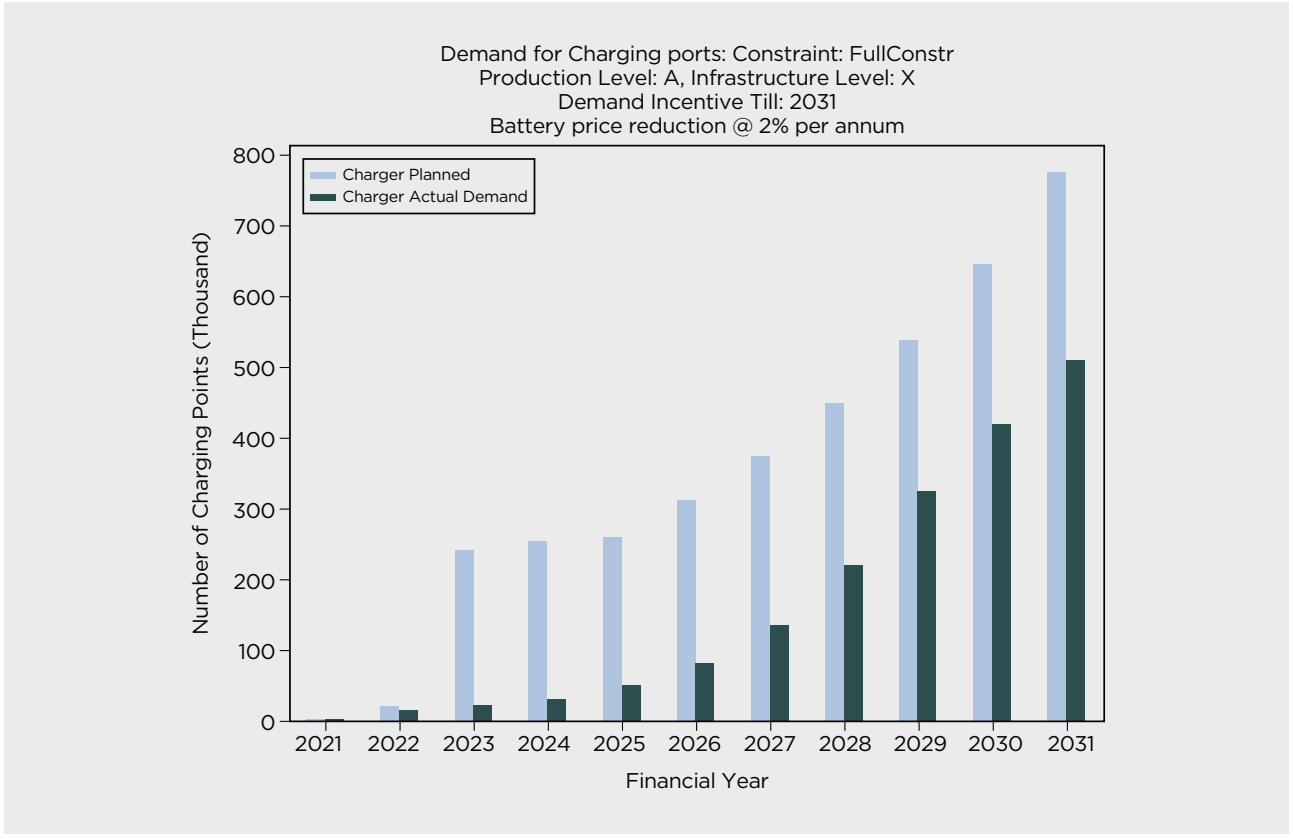


Figure 110: *Demand for charging points in Battery Cost Challenged Scenario with Full Constraint*

At base production level of electric two-wheelers, the projected battery demand shows that 79.39 GWh of battery will be required in FY 2031 (Figure 111 and Table 74).

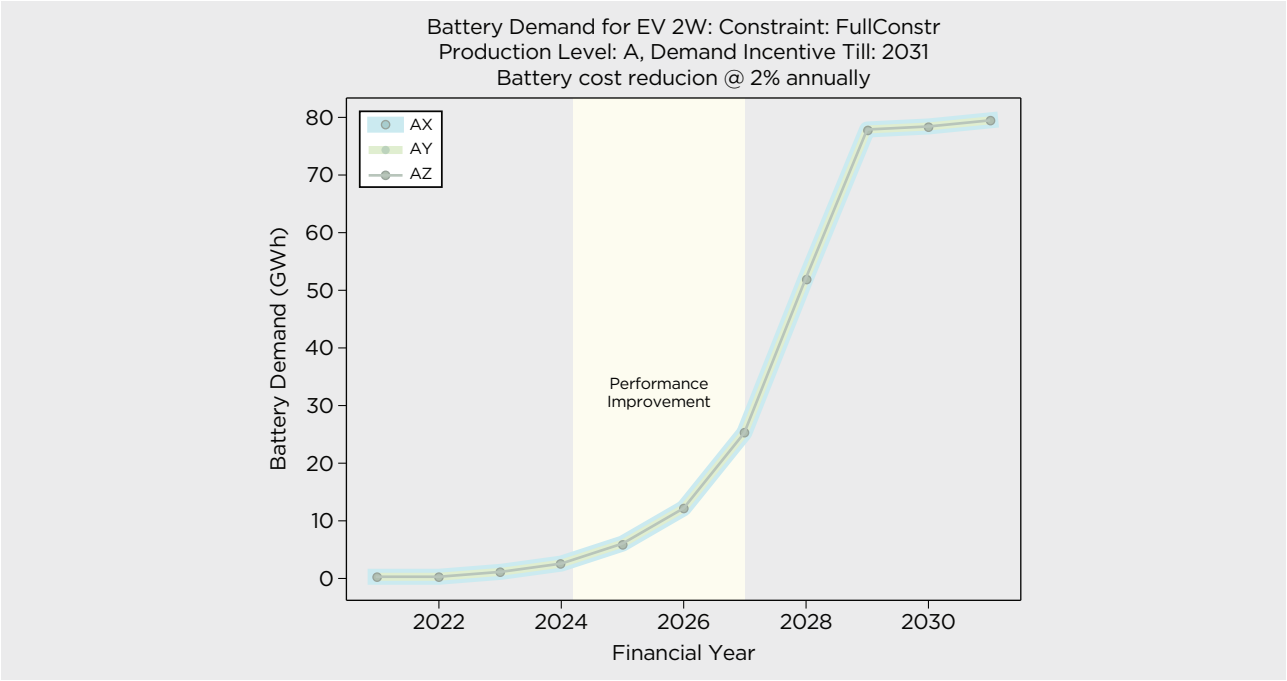


Figure 111: *Battery demand in the Battery Cost Challenged Scenario with Full Constraint, production level A*

Table 74: Battery demand in the Battery Cost Challenged Scenario with Full Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
2025	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
2026	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
2027	25.23	25.23	25.23	25.23	25.23	25.23	25.23	25.23	25.23
2028	51.84	51.84	51.84	51.84	51.84	51.84	51.84	51.84	51.84
2029	77.66	77.66	77.66	77.66	77.66	77.66	77.66	77.66	77.66
2030	78.32	78.32	78.32	84.35	84.35	84.35	84.35	84.35	84.35
2031	79.39	79.39	79.39	90.54	90.54	90.54	90.54	90.54	90.54

5.7.2 Battery Cost Challenged Scenario with Production Constraint

In this case, at the base level of production, penetration reaches a maximum value of 97.93% in FY 2029. The EV sale is limited by the installed vehicle production capacity from this point onwards and hence the relative market share of electric two-wheelers comes down in FY 2030 and FY 2031. This situation is shown in Figure 112.

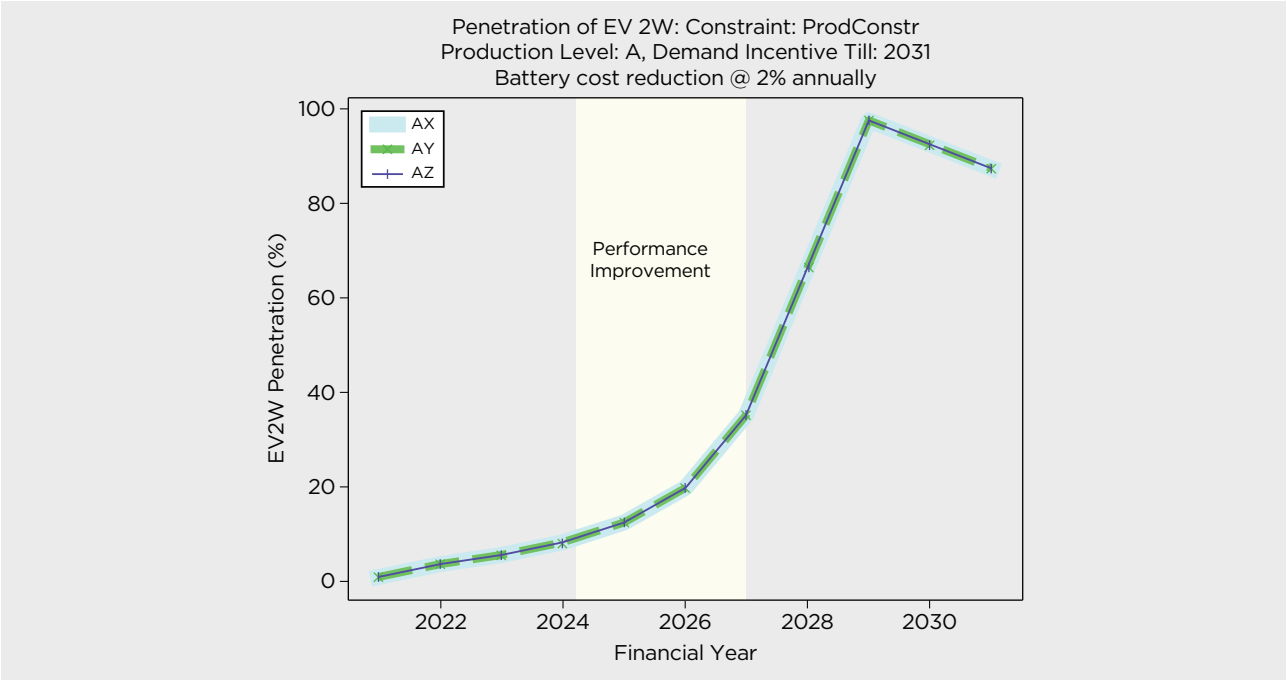


Figure 112: *Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with Production Constraint, production level A*

However, as can be seen in Table 75, the market penetration of electric two-wheelers is projected to reach 100% in the FY 2031 when there is higher installed manufacturing capacity.

Table 75: Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with Production Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15
2025	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42
2026	19.79	19.79	19.79	19.79	19.79	19.79	19.79	19.79	19.79
2027	35.45	35.45	35.45	35.45	35.45	35.45	35.45	35.45	35.45
2028	66.49	66.49	66.49	66.49	66.49	66.49	66.49	66.49	66.49
2029	97.93	97.93	97.93	97.93	97.93	97.93	97.93	97.93	97.93
2030	92.73	92.73	92.73	99.87	99.87	99.87	99.87	99.87	99.87
2031	87.65	87.65	87.65	100	100	100	100	100	100

Projected sale of electric two-wheelers reaches 220.15 lakh units in FY 2031 in the base level of production. Both For production levels B and C, it reaches 251.17 lakh units in the same year (Figure 113 and Table 76).

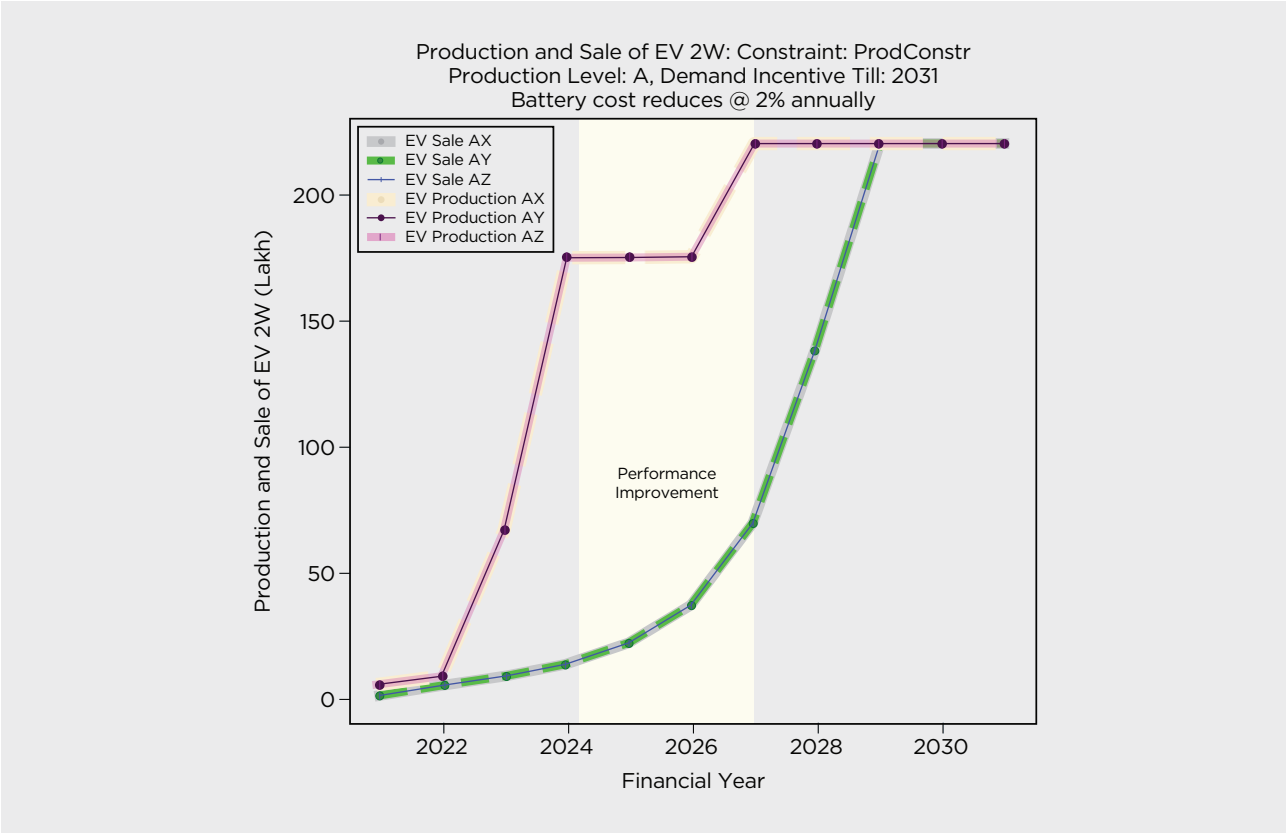


Figure 113: *Sale and production of electric two-wheelers in the Battery Cost Challenged with Production Constraint, production level A*

Table 76: Sale of electric two-wheelers in the Battery Cost Challenged with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
2024	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79
2025	22.24	22.24	22.24	22.24	22.24	22.24	22.24	22.24	22.24
2026	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5
2027	71.05	71.05	71.05	71.05	71.05	71.05	71.05	71.05	71.05
2028	141.02	141.02	141.02	141.02	141.02	141.02	141.02	141.02	141.02
2029	219.74	219.74	219.74	219.74	219.74	219.74	219.74	219.74	219.74
2030	220.15	220.15	220.15	237.09	237.09	237.09	237.09	237.09	237.09
2031	220.15	220.15	220.15	251.17	251.17	251.17	251.17	251.17	251.17

Demand for charging infrastructure is shown in Figure 114.

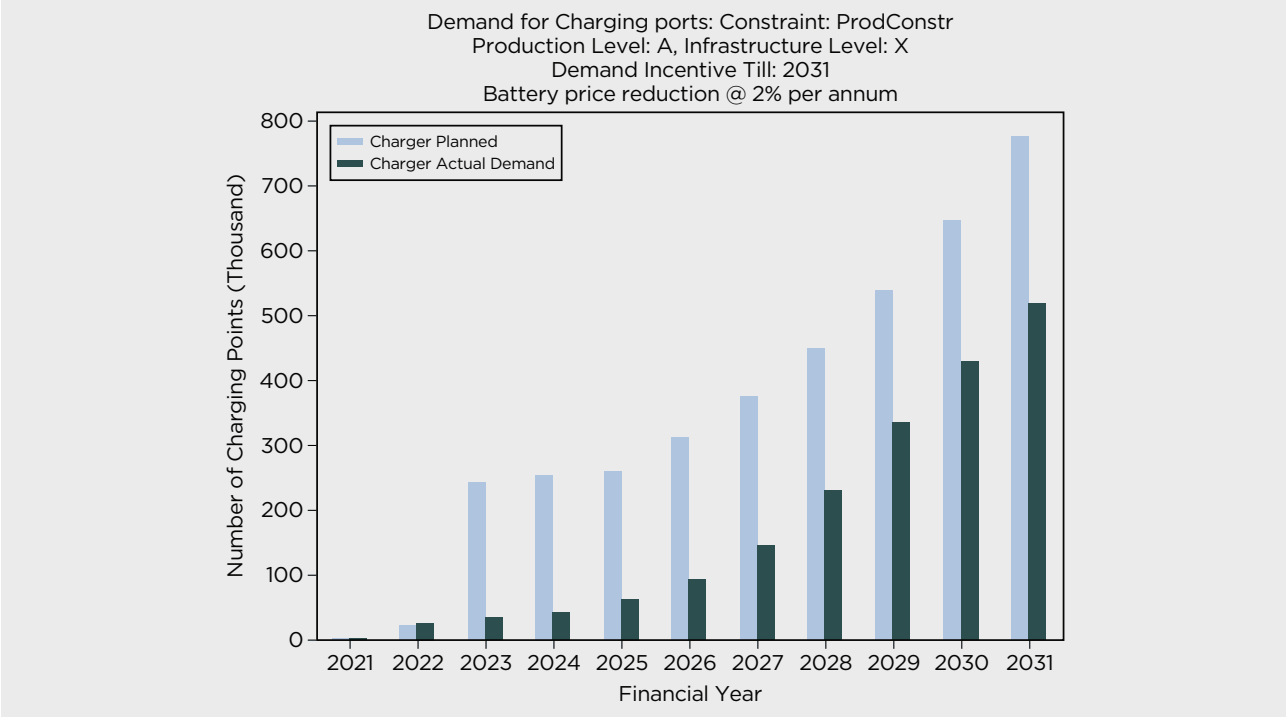


Figure 114: *Demand for charging points in the Battery Cost Challenged Scenario with Production Constraint (constraint level AX)*

Projected battery demand is also marginally higher as compared to Full Constraint sub-scenario in the initial years but finally reaches the same value of 79.39 GWh in the FY 2031 (Figure 115 and Table 77).

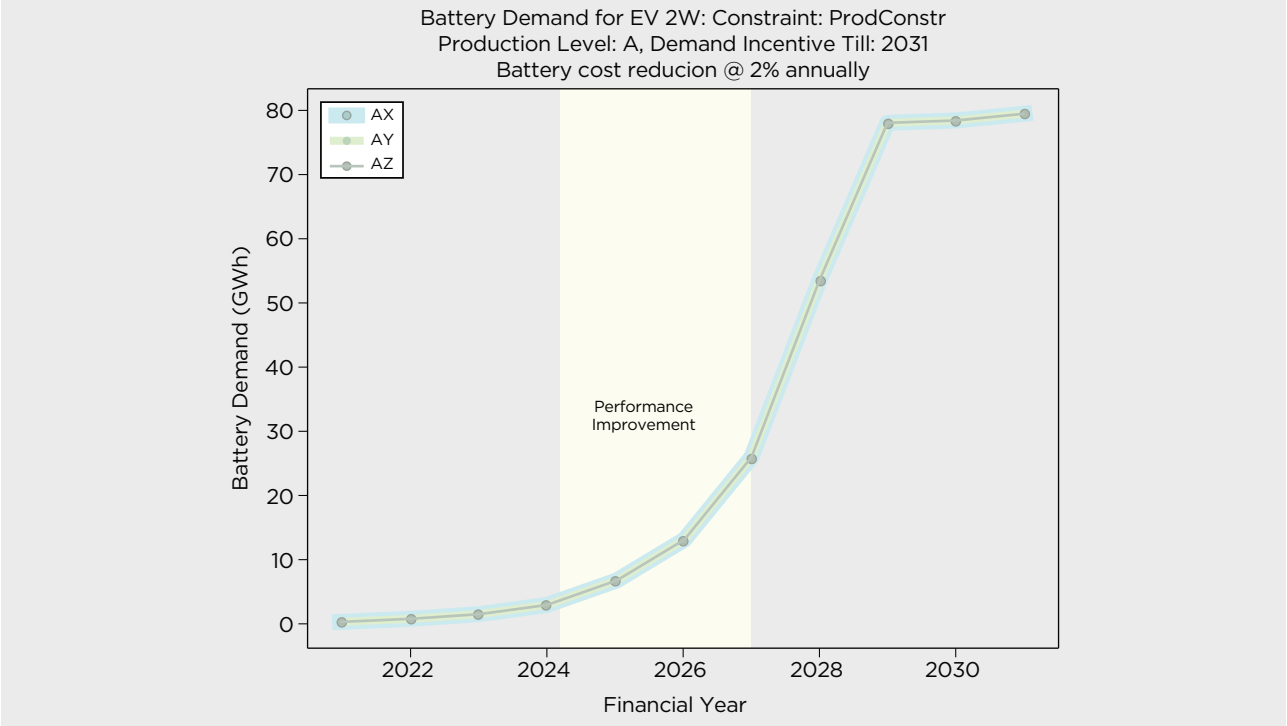


Figure 115: *Battery demand in the Battery Cost Challenged scenario with Production Constraint, production level A*

Table 77: Battery demand in the Battery Cost Challenged scenario with Production Constraint

Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
2025	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65
2026	12.85	12.85	12.85	12.85	12.85	12.85	12.85	12.85	12.85
2027	25.72	25.72	25.72	25.72	25.72	25.72	25.72	25.72	25.72
2028	53.31	53.31	53.31	53.31	53.31	53.31	53.31	53.31	53.31
2029	77.87	77.87	77.87	77.87	77.87	77.87	77.87	77.87	77.87
2030	78.32	78.32	78.32	84.35	84.35	84.35	84.35	84.35	84.35
2031	79.39	79.39	79.39	90.54	90.54	90.54	90.54	90.54	90.54

5.7.3 Battery Cost Challenged Scenario with Charge Constraint

In this case, the market penetration of electric two-wheelers reaches 100% in all production capacities (Figure 116 and Table 78).

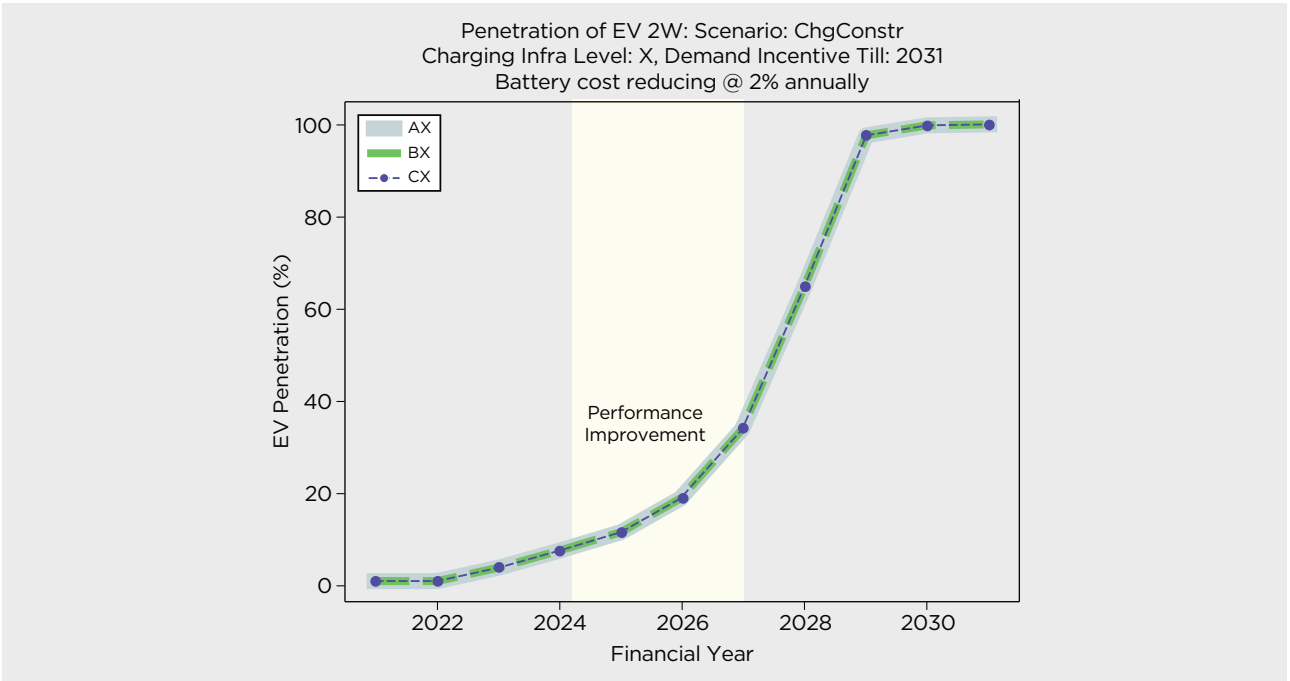


Figure 116: *Penetration of electric two-wheelers in Battery Cost Challenged Scenario with Charge Constraint, infrastructure level X*

Table 78: Penetration of electric two-wheelers in Battery Cost Challenged Scenario with Charge Constraint

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
2023	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
2024	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
2025	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64	11.64
2026	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89	18.89
2027	34.28	34.28	34.28	34.28	34.28	34.28	34.28	34.28	34.28
2028	64.81	64.81	64.81	64.81	64.81	64.81	64.81	64.81	64.81
2029	97.54	97.54	97.54	97.54	97.54	97.54	97.54	97.54	97.54
2030	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87
2031	100	100	100	100	100	100	100	100	100

The sale of electric two-wheelers reaches 251.17 lakh units in the FY 2031 (Figure 117 and Table 79).

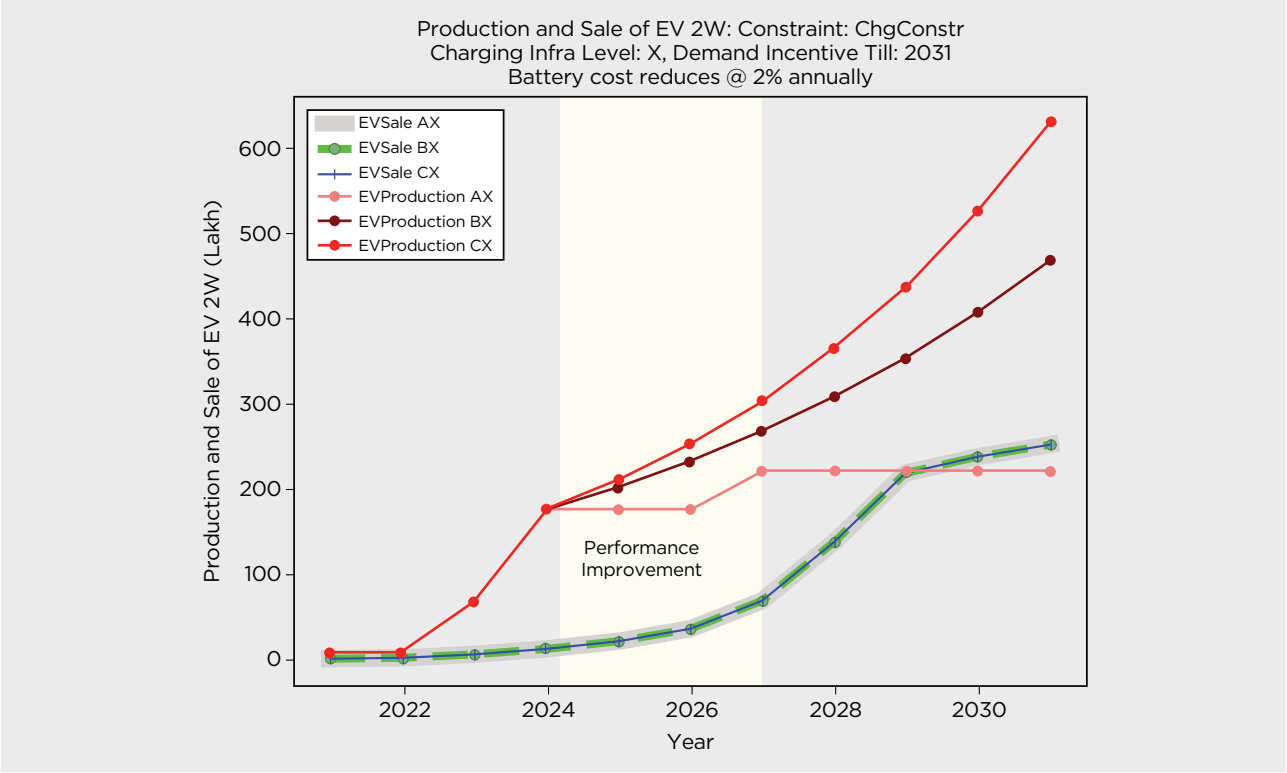


Figure 117: *Sale and production of electric two-wheelers in Battery Cost Challenged Scenario with Charge Constraint, infrastructure level X*

Table 79: Sale of electric two-wheelers in Battery Cost Challenged Scenario with Charge Constraint

Financial Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
2023	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21	6.21
2024	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7
2025	20.85	20.85	20.85	20.85	20.85	20.85	20.85	20.85	20.85
2026	35.78	35.78	35.78	35.78	35.78	35.78	35.78	35.78	35.78
2027	68.72	68.72	68.72	68.72	68.72	68.72	68.72	68.72	68.72
2028	137.45	137.45	137.45	137.45	137.45	137.45	137.45	137.45	137.45
2029	218.87	218.87	218.87	218.87	218.87	218.87	218.87	218.87	218.87
2030	237.09	237.09	237.09	237.09	237.09	237.09	237.09	237.09	237.09
2031	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17

Projected demand for charging infrastructure is shown in Figure 118.

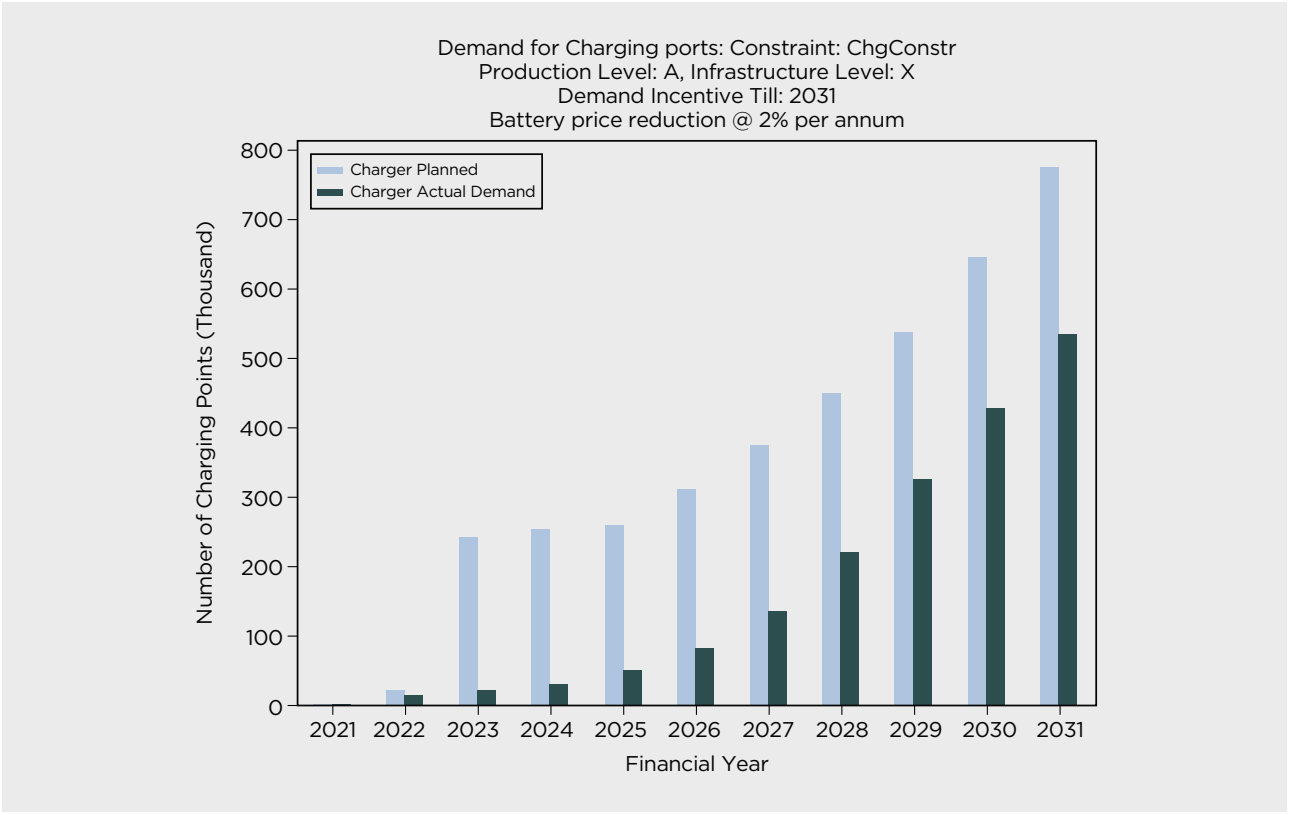


Figure 118: *Demand for charging points in the Battery Cost Challenged Scenario with Charge Constraint (constraint level AX)*

The projected battery demand, as shown in Figure 119 and Table 80, will reach 90.54 GWh in FY 2031.

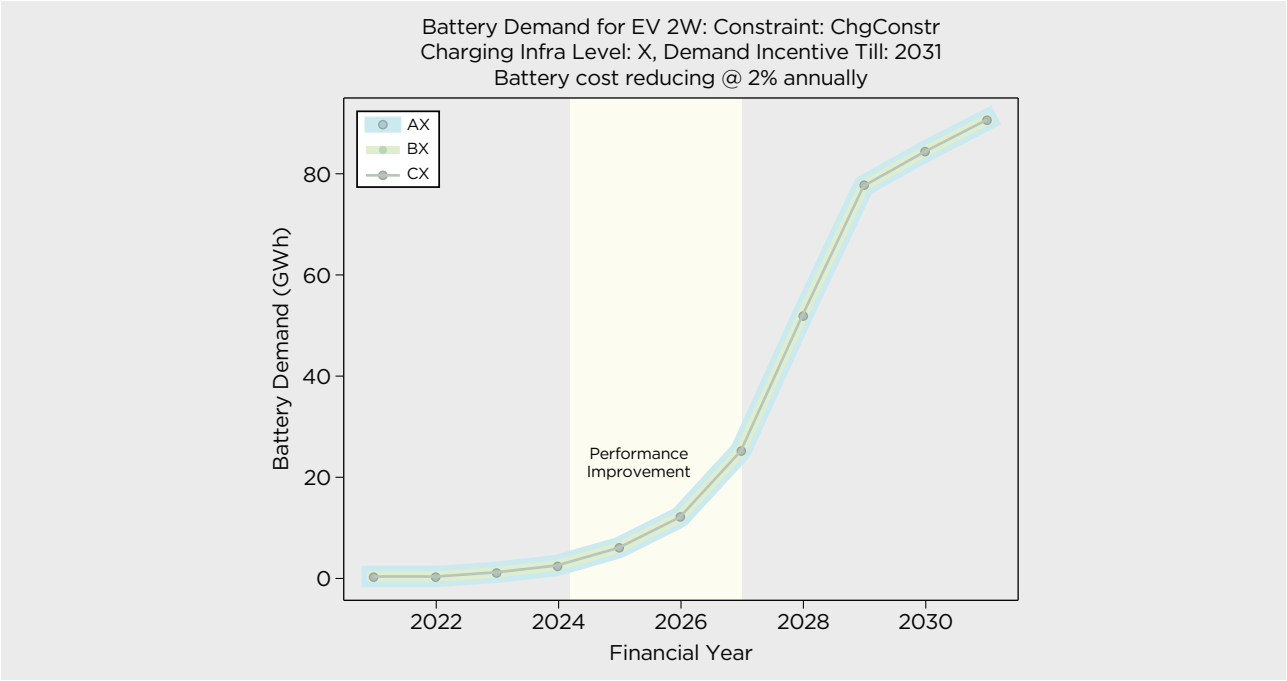


Figure 119: *Battery demand in the Battery Cost Challenged Scenario with Charge Constraint, infrastructure level X*

Table 80: Battery demand in the Battery Cost Challenged Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
2023	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2024	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45	2.45
2025	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
2026	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
2027	25.23	25.23	25.23	25.23	25.23	25.23	25.23	25.23	25.23
2028	51.84	51.84	51.84	51.84	51.84	51.84	51.84	51.84	51.84
2029	77.66	77.66	77.66	77.66	77.66	77.66	77.66	77.66	77.66
2030	84.35	84.35	84.35	84.35	84.35	84.35	84.35	84.35	84.35
2031	90.54	90.54	90.54	90.54	90.54	90.54	90.54	90.54	90.54

5.7.4 Battery Cost Challenged Scenario with No Constraint

When neither supply of the vehicles nor the charging infrastructure in place is a concern under the Battery Cost Challenged Scenario, the penetration level will reach 100% in the FY 2031. This can be seen in Figure 120 and Table 81.

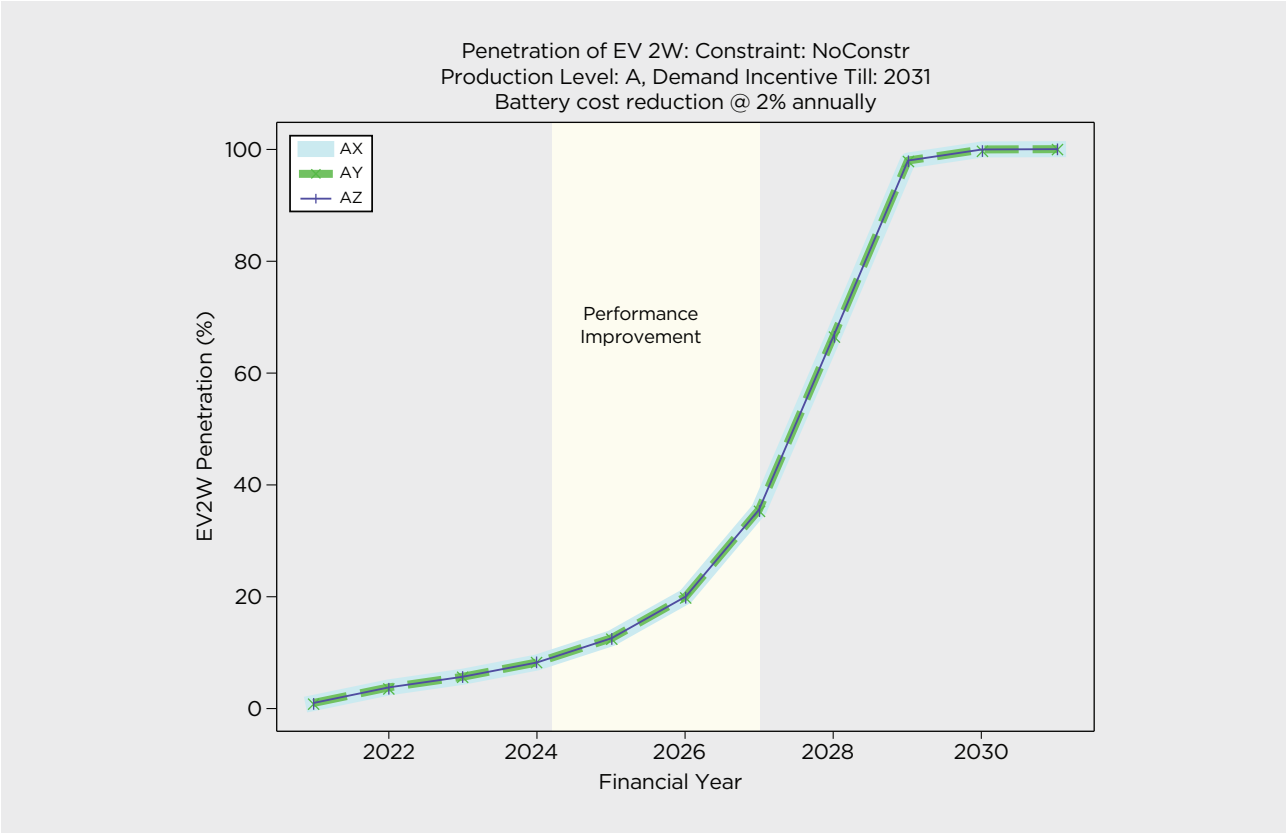


Figure 120: *Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with No Constraint, production level A*

Table 81: Penetration of electric two-wheelers in the Battery Cost Challenged Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62	3.62
2023	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56	5.56
2024	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15	8.15
2025	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42
2026	19.79	19.79	19.79	19.79	19.79	19.79	19.79	19.79	19.79
2027	35.45	35.45	35.45	35.45	35.45	35.45	35.45	35.45	35.45
2028	66.49	66.49	66.49	66.49	66.49	66.49	66.49	66.49	66.49
2029	97.93	97.93	97.93	97.93	97.93	97.93	97.93	97.93	97.93
2030	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87
2031	100	100	100	100	100	100	100	100	100

Figure 121 and Table 82 show that the sale of electric two-wheelers will gradually increase to reach 54.91 lakh units in the FY 2031.

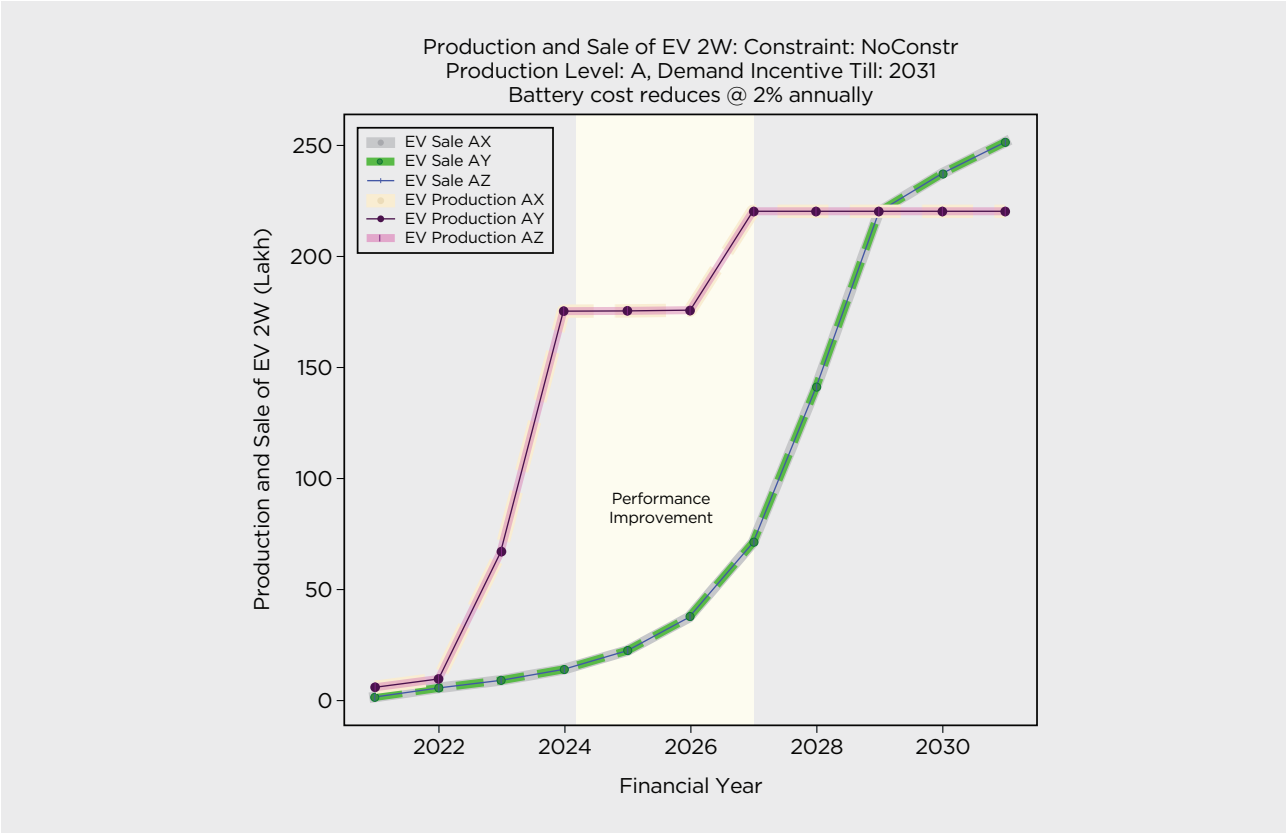


Figure 121: *Sale and production of electric two-wheelers in Battery Cost Challenged Scenario with No Constraint, production level A*

Table 82: Sale of electric two-wheelers in Battery Cost Challenged Scenario with No Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
2023	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90	8.90
2024	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79	13.79
2025	22.24	22.24	22.24	22.24	22.24	22.24	22.24	22.24	22.24
2026	37.50	37.50	37.50	37.50	37.50	37.50	37.50	37.50	37.50
2027	71.05	71.05	71.05	71.05	71.05	71.05	71.05	71.05	71.05
2028	141.02	141.02	141.02	141.02	141.02	141.02	141.02	141.02	141.02
2029	219.74	219.74	219.74	219.74	219.74	219.74	219.74	219.74	219.74
2030	237.09	237.09	237.09	237.09	237.09	237.09	237.09	237.09	237.09
2031	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17

Corresponding projections of the demand for charging points in the constraint level AX is shown in Figure 122.

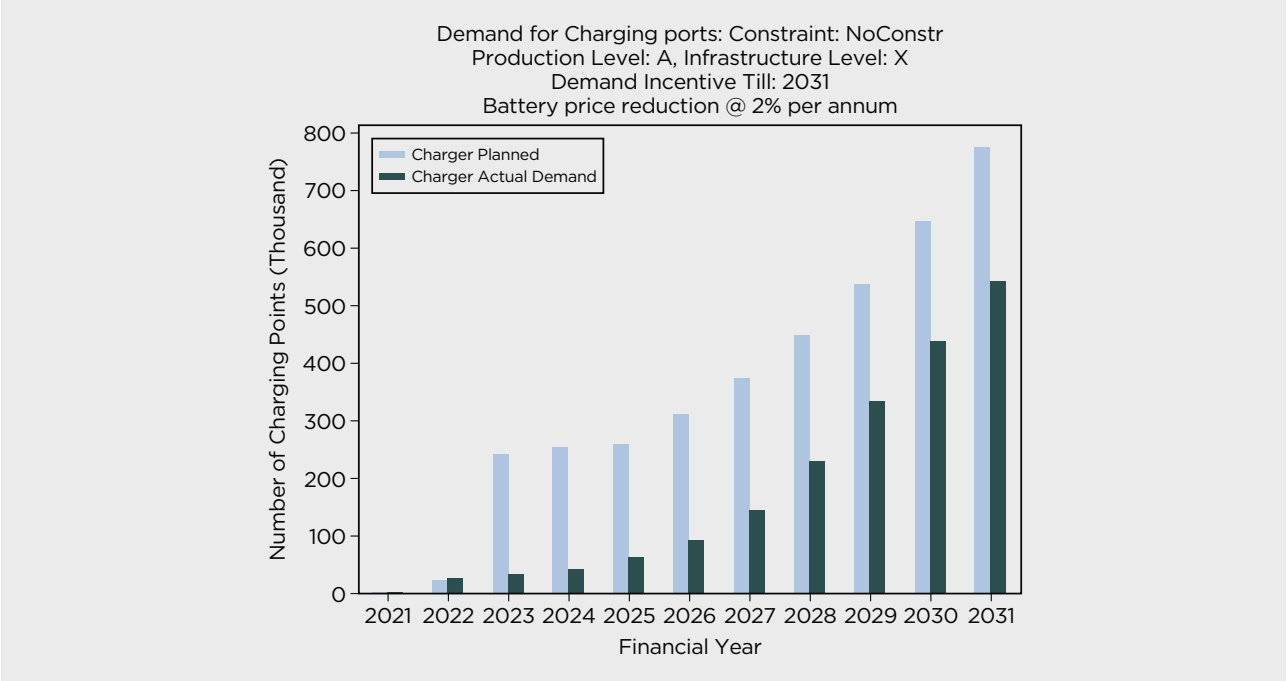


Figure 122: *Charging point demand in the Battery Cost Challenged Scenario with No Constraint (constraint level AX)*

The projected of battery demand, as shown in Figure 123 and Table 83, will reach 90.54 GWh in FY 2031.

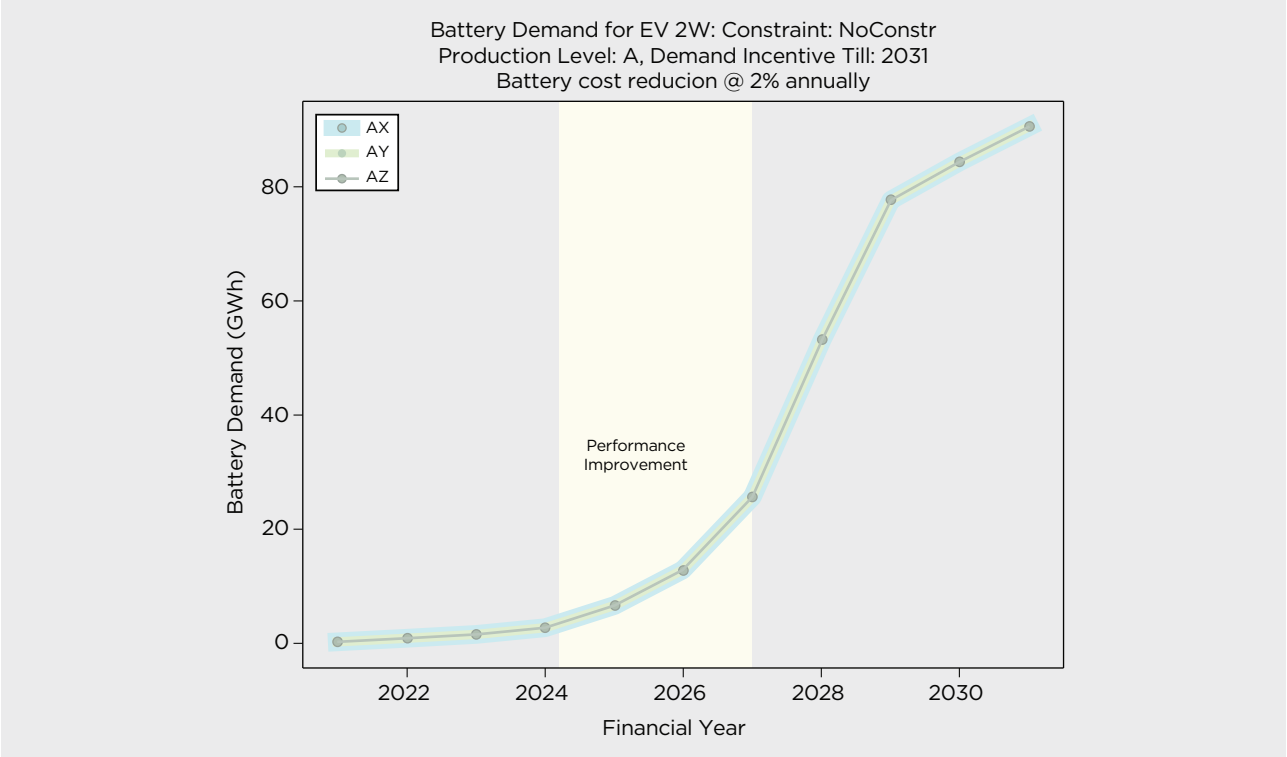


Figure 123: *Battery demand in the Battery Cost Challenged Scenario with No Constraint, production level A*

Table 83: Battery demand in the Battery Cost Challenged Scenario with No Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
2023	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53	1.53
2024	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
2025	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65
2026	12.85	12.85	12.85	12.85	12.85	12.85	12.85	12.85	12.85
2027	25.72	25.72	25.72	25.72	25.72	25.72	25.72	25.72	25.72
2028	53.31	53.31	53.31	53.31	53.31	53.31	53.31	53.31	53.31
2029	77.87	77.87	77.87	77.87	77.87	77.87	77.87	77.87	77.87
2030	84.35	84.35	84.35	84.35	84.35	84.35	84.35	84.35	84.35
2031	90.54	90.54	90.54	90.54	90.54	90.54	90.54	90.54	90.54

5.8 Same Performance Scenario

Under this scenario, all other favorable conditions are assumed to exist, except improvement in the range and power of the vehicles, which are assumed to remain at the present level. Thus, the demand incentive will remain in force and the battery cost will reduce by 8% annually.

5.8.1 Same Performance Scenario with Full Constraint

In this case the projected market penetration at the base production level A is shown in Figure 124.

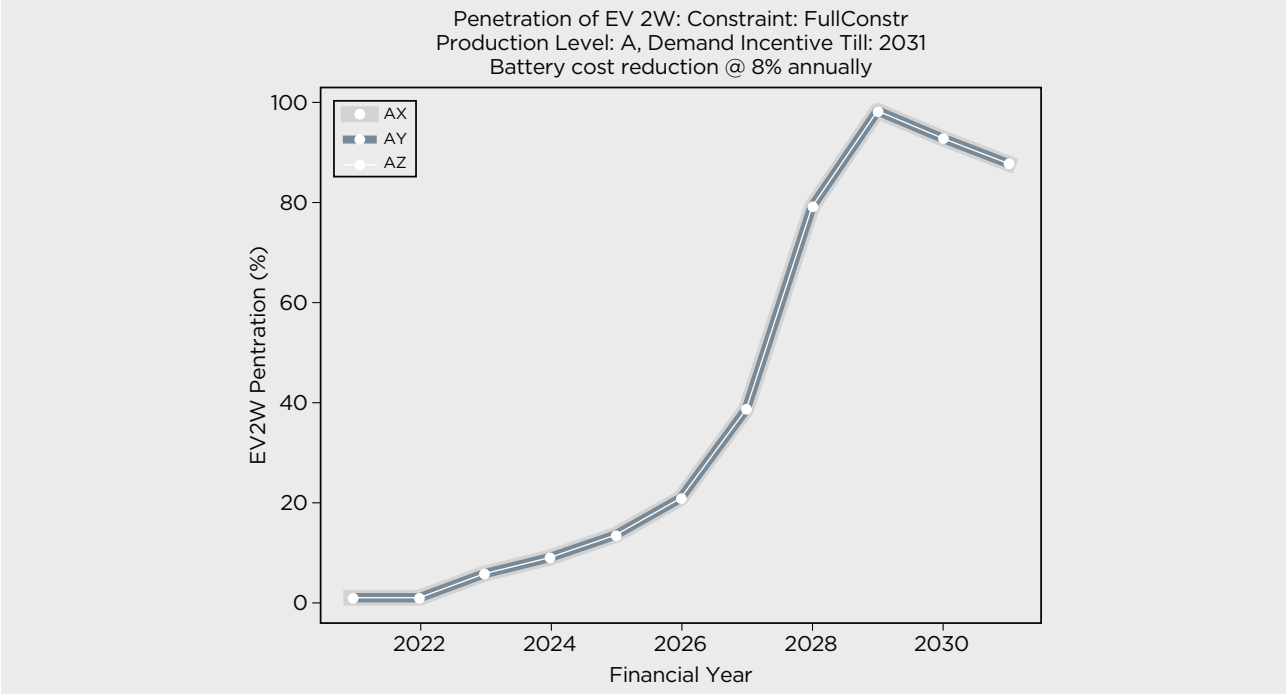


Figure 124: *Penetration of electric two-wheelers in the Same Performance Scenario with Full Constraint, production level A*

It is observed that the penetration reaches 98.11% in FY 2029, when the number of electric two-wheelers sold equals the installed production capacity in the base production level. Since the sale of electric two-wheelers does not increase anymore, their overall share in the market comes down to 92.73% and 87.65%, respectively in FY 2030 and FY 2031. However, if supply of vehicles is enhanced, as in level B and C, the penetration reaches 100%. Such a situation is depicted in the Figure 125.

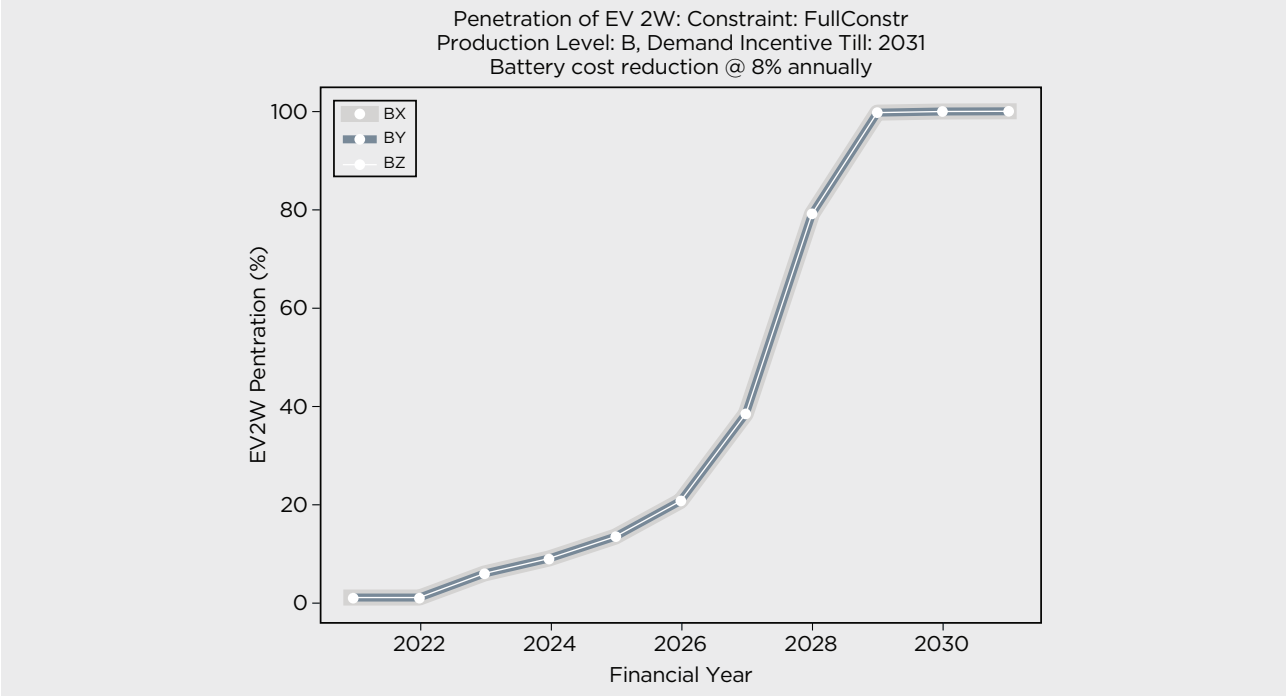


Figure 125: *Penetration of electric two-wheelers in the Same Performance Scenario with Full Constraint, production level B*

Details of the projected penetration of electric two-wheelers at various constraint levels are provided in the Table 84.

Table 84: Penetration of electric two-wheelers in the Same Performance Scenario with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06
2025	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45
2026	20.83	20.83	20.83	20.83	20.83	20.83	20.83	20.83	20.83
2027	38.55	38.55	38.55	38.55	38.55	38.55	38.55	38.55	38.55
2028	79.17	79.17	79.17	79.17	79.17	79.17	79.17	79.17	79.17
2029	98.11	98.11	98.11	99.87	99.87	99.87	99.87	99.87	99.87
2030	92.73	92.73	92.73	100	100	100	100	100	100
2031	87.65	87.65	87.65	100	100	100	100	100	100

Projected sale of electric two-wheelers in the base production level A is shown in Figure 126.

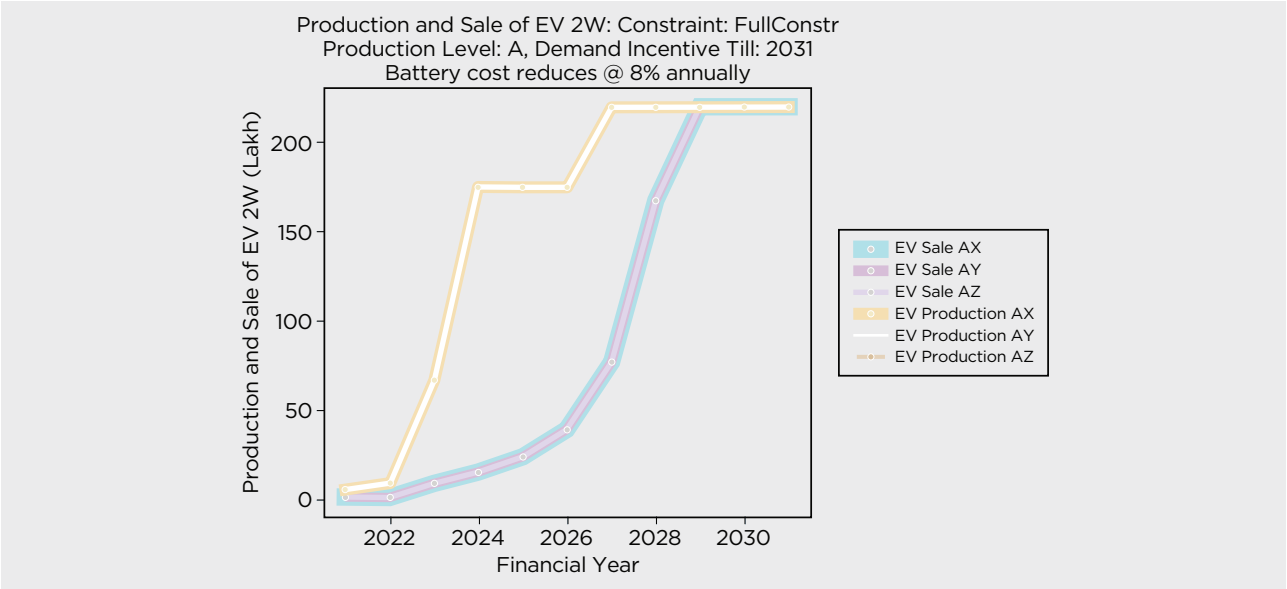


Figure 126: *Sale and production of electric two-wheelers in the Same Performance Scenario with Full Constraints, production level A*

From Table 85, it is observed that electric two-wheeler sale from FY 2029 onwards are higher for production levels B and C.

Table 85: Sale of electric two-wheelers in the Same Performance Scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33
2025	24.09	24.09	24.09	24.09	24.09	24.09	24.09	24.09	24.09
2026	39.46	39.46	39.46	39.46	39.46	39.46	39.46	39.46	39.46
2027	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27
2028	167.91	167.91	167.91	167.91	167.91	167.91	167.91	167.91	167.91
2029	220.15	220.15	220.15	224.09	224.09	224.09	224.09	224.09	224.09
2030	220.15	220.15	220.15	237.4	237.4	237.4	237.4	237.4	237.4
2031	220.15	220.15	220.15	251.17	251.17	251.17	251.17	251.17	251.17

The demand for charging points in this case, as shown in Figure 127, is significantly higher as compared to other cases discussed so far, as the penetration of electric two-wheelers is high.

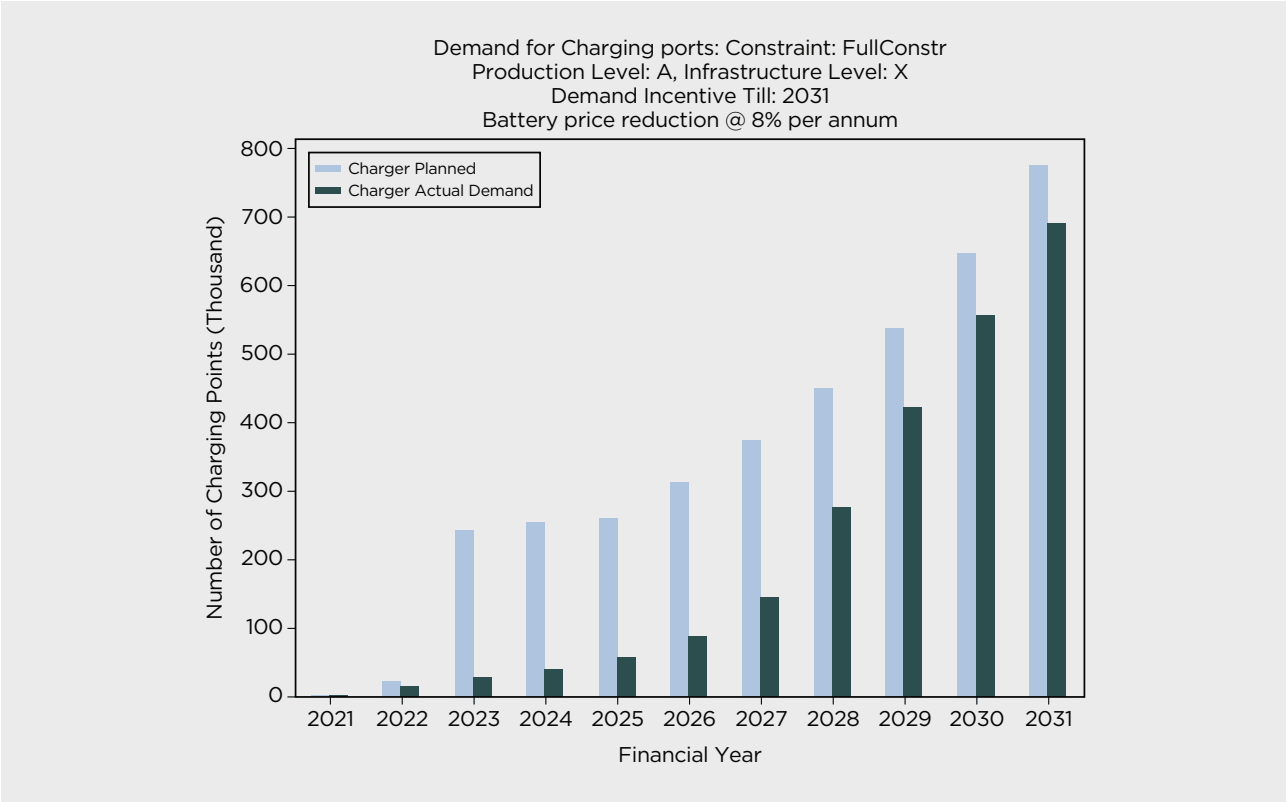


Figure 127: *Demand for charging points in the Same Performance Scenario with Full Constraints (constraint level AX)*

Projected battery demands are shown in Figure 128 and Table 86. For electric two-wheelers production level A, the maximum battery demand in FY 2031 is 107.57 GWh. However, in the electric two-wheelers production levels B and C, the battery demand reaches 122.73 GWh in the FY 2031.

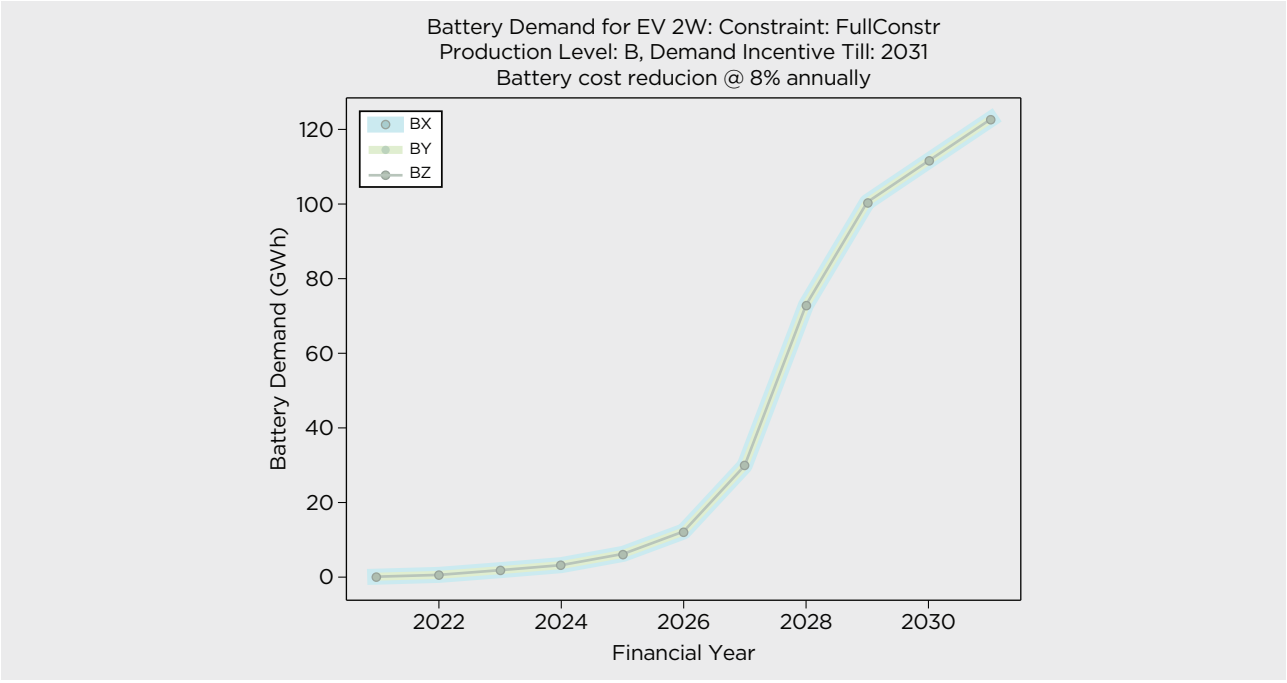


Figure 128: *Battery demand in Same Performance Scenario with Full Constraint, production level A*

Table 86: Battery demand in the Same Performance Scenario with Full Constraint

Financial Year	Projected Battery Demand (kWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
2025	5.86	5.86	5.86	5.86	5.86	5.86	5.86	5.86	5.86
2026	11.98	11.98	11.98	11.98	11.98	11.98	11.98	11.98	11.98
2027	29.26	29.26	29.26	29.26	29.26	29.26	29.26	29.26	29.26
2028	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8
2029	98.7	98.7	98.7	100.47	100.47	100.47	100.47	100.47	100.47
2030	103.43	103.43	103.43	111.53	111.53	111.53	111.53	111.53	111.53
2031	107.57	107.57	107.57	122.73	122.73	122.73	122.73	122.73	122.73

5.8.2 Same Performance Scenario with Production Constraint

Projected penetration of electric two-wheelers here is similar as in the case of Full Constraint sub-scenario, except in initial few years, when it is slightly higher. Penetration reaches maximum value supported by the base production level in FY 2029. The situation is depicted in Figure 129.

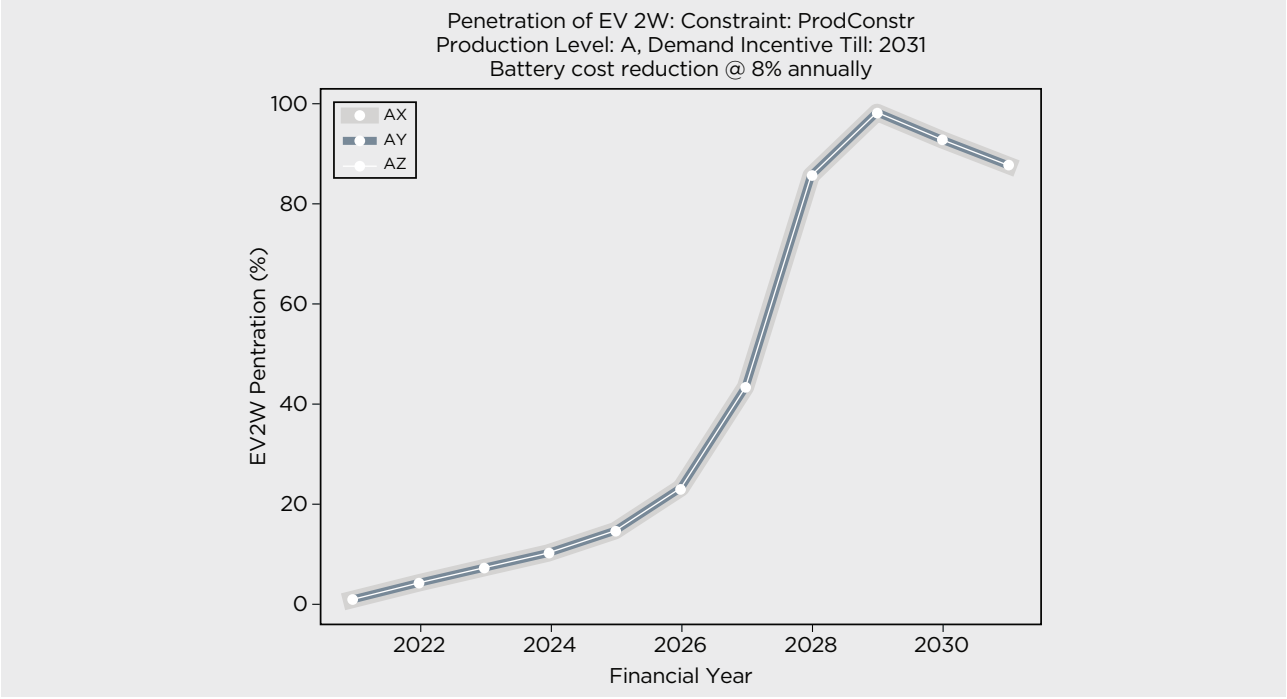


Figure 129: *Penetration of electric two-wheelers in the Same Performance Scenario with Production Constraint, production level A*

The details of the projected penetration levels for all constraint levels are in the Table 87. The penetration level is higher for level B and C since FY 2029 onwards.

Table 87: Penetration of electric two-wheelers in the Same Performance Scenario with Production Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22
2025	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49
2026	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03
2027	43.34	43.34	43.34	43.34	43.34	43.34	43.34	43.34	43.34
2028	85.64	85.64	85.64	85.64	85.64	85.64	85.64	85.64	85.64
2029	98.11	98.11	98.11	100	100	100	100	100	100
2030	92.73	92.73	92.73	100	100	100	100	100	100
2031	87.65	87.65	87.65	100	100	100	100	100	100

Projected sale of electric two-wheelers is shown in Figure 130 and Table 88. The sale of electric two-wheelers reaches 220.15 lakh units in the FY 2031 for production level A.

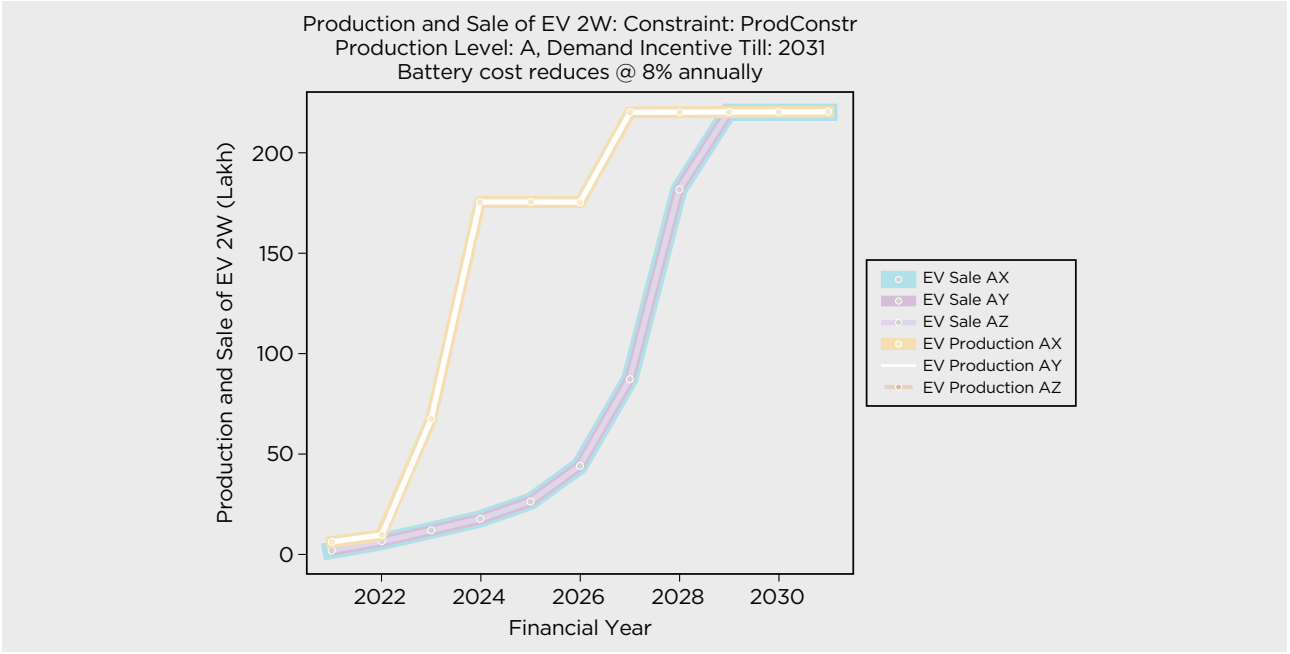


Figure 130: *Sale and production of electric two-wheelers in Same Performance Scenario with Production Constraint, production level A*

For production levels B and C, the sales volume in FY 2031 reaches 251.17 lakh units, as shown in Table 88.

Table 88: Sale of electric two-wheelers in Same Performance Scenario with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
2025	25.94	25.94	25.94	25.94	25.94	25.94	25.94	25.94	25.94
2026	43.63	43.63	43.63	43.63	43.63	43.63	43.63	43.63	43.63
2027	86.87	86.87	86.87	86.87	86.87	86.87	86.87	86.87	86.87
2028	181.62	181.62	181.62	181.62	181.62	181.62	181.62	181.62	181.62
2029	220.15	220.15	220.15	224.38	224.38	224.38	224.38	224.38	224.38
2030	220.15	220.15	220.15	237.4	237.4	237.4	237.4	237.4	237.4
2031	220.15	220.15	220.15	251.17	251.17	251.17	251.17	251.17	251.17

The projected demand for charging infrastructure in constraint level AX is shown in Figure 131. The latent demand is higher than the actual demand during the last two years.

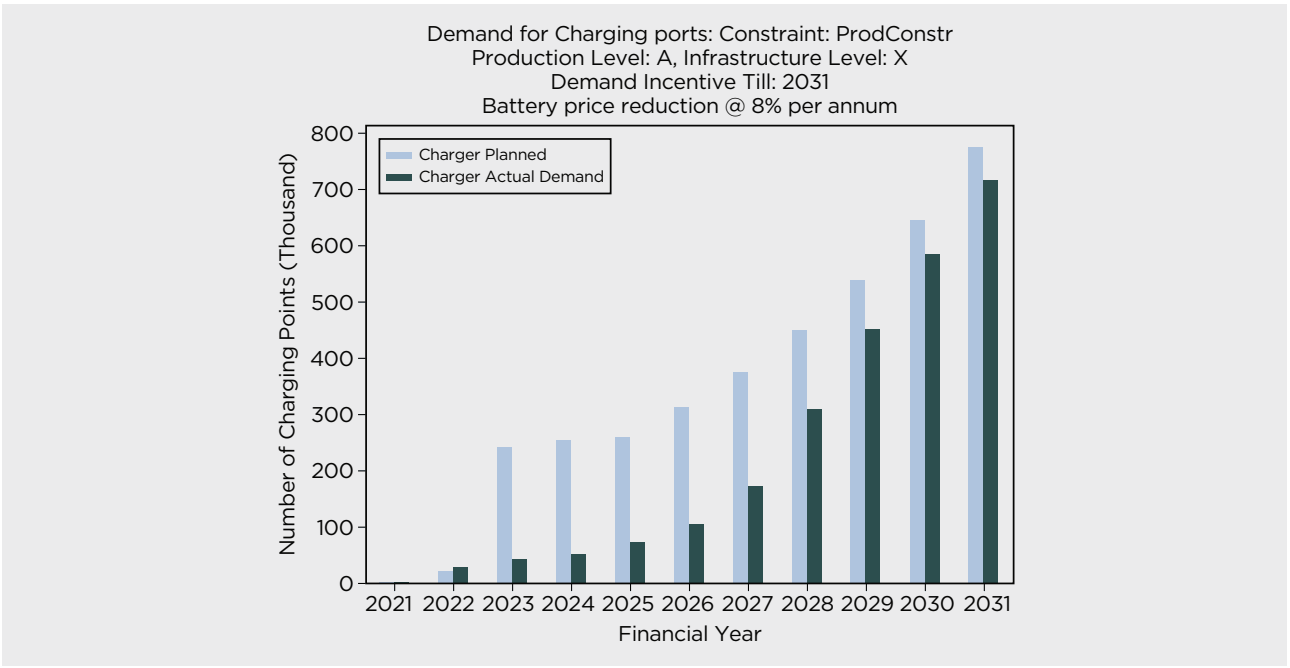


Figure 131: *Demand of charging points in the Same Performance Scenario with Production Constraint (constraint level AX)*

The projected battery demand reaches 107.57 GWh in FY 2031 at the production level A and 122.73 GWh at production levels B and C. These are shown in Figure 132 and Table 89.

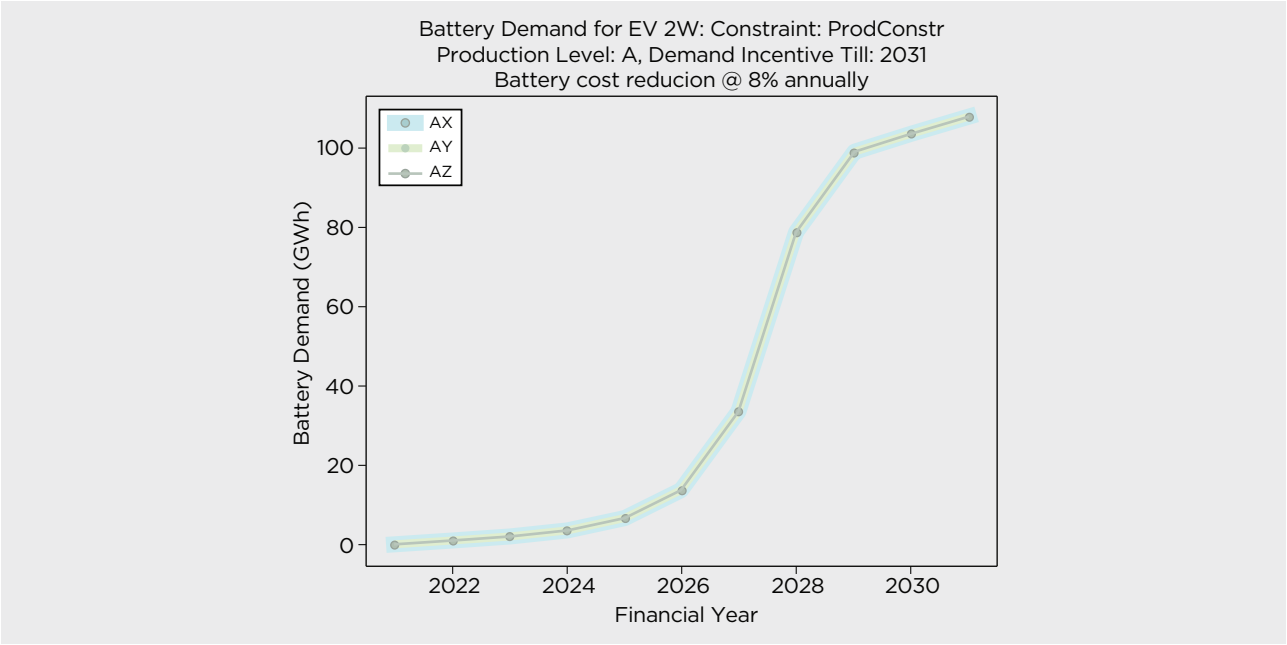


Figure 132: *Battery demand in the Same Performance Scenario with Production Constraint, production level A*

Table 89: Battery demand in the Same Performance Scenario with Production Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53
2025	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66
2026	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68
2027	33.62	33.62	33.62	33.62	33.62	33.62	33.62	33.62	33.62
2028	78.66	78.66	78.66	78.66	78.66	78.66	78.66	78.66	78.66
2029	98.69	98.69	98.69	100.59	100.59	100.59	100.59	100.59	100.59
2030	103.43	103.43	103.43	111.53	111.53	111.53	111.53	111.53	111.53
2031	107.57	107.57	107.57	122.73	122.73	122.73	122.73	122.73	122.73

5.8.3 Same Performance Scenario with Charge Constraint

Projected penetration of electric two-wheelers in this case is shown in Figure 133 and Table 90. In the initial years it is less as compared to that in the Full Constraint sub-scenario. However, the penetration reaches 100% in FY 2031 and stays at that level, since, supply of electric two-wheelers is not an issue.

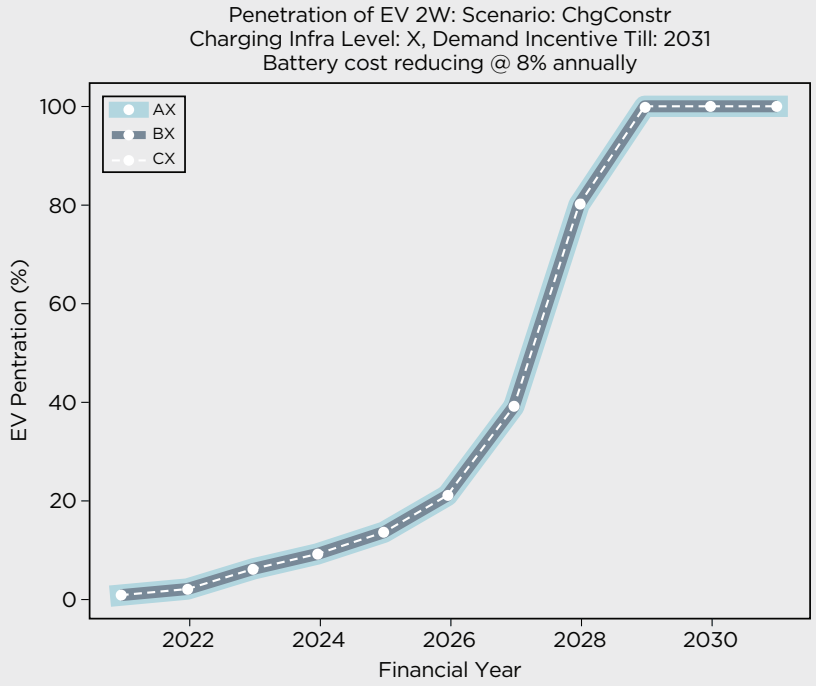


Figure 133: *Penetration of electric two-wheelers in the Same Performance Scenario with Charge Constraints, infrastructure level X*

Table 90: Penetration of electric two-wheelers in the Same Performance Scenario with Charge Constraint

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06	9.06
2025	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45	13.45
2026	20.83	20.83	20.83	20.83	20.83	20.83	20.83	20.83	20.83
2027	38.55	38.55	38.55	38.55	38.55	38.55	38.55	38.55	38.55
2028	79.17	79.17	79.17	79.17	79.17	79.17	79.17	79.17	79.17
2029	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87	99.87
2030	100	100	100	100	100	100	100	100	100
2031	100	100	100	100	100	100	100	100	100

Projected sale of electric two-wheelers is shown in Figure 134 and Table 91.

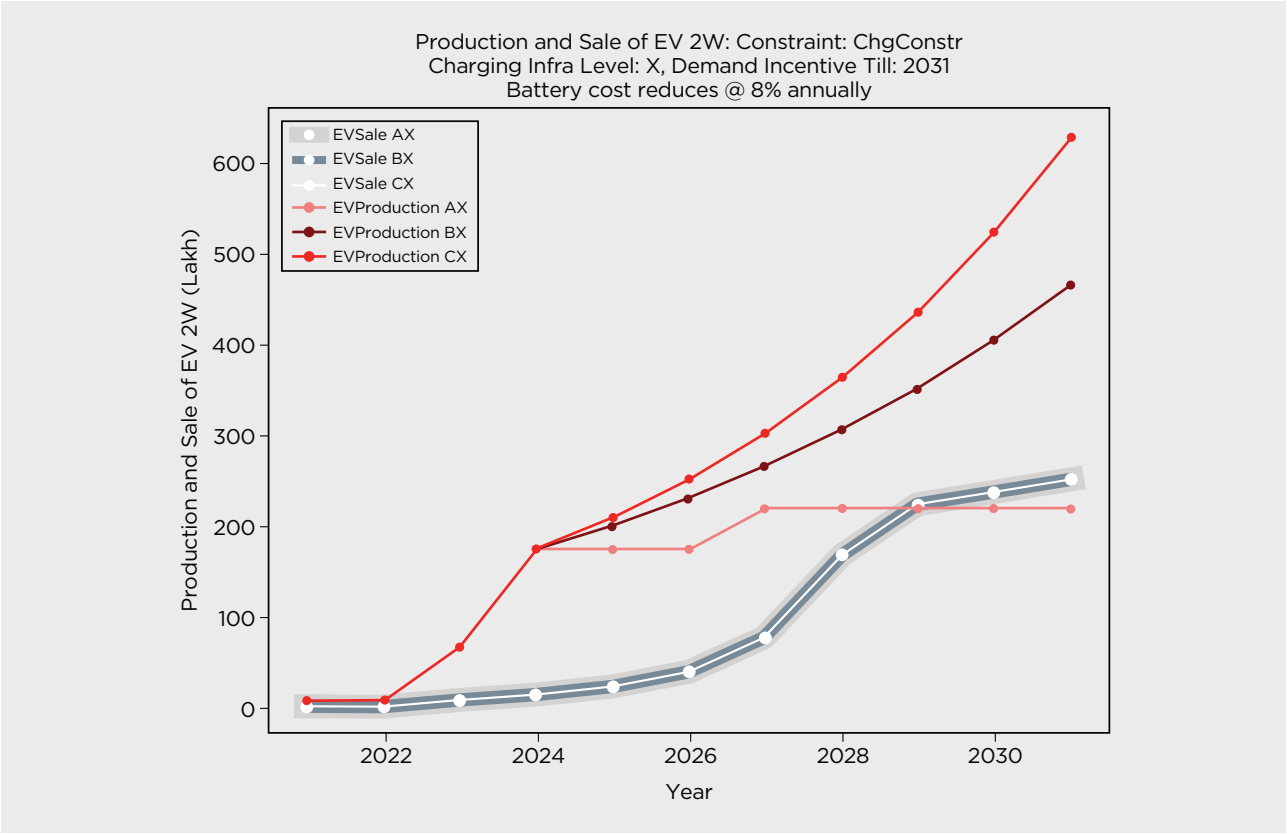


Figure 134: *Sale and production of electric two-wheelers in Same Performance Scenario with Charge Constraint, infrastructure level X*

Table 91: Sale of electric two-wheelers in Same Performance Scenario with Charge Constraint

Financial Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33	15.33
2025	24.09	24.09	24.09	24.09	24.09	24.09	24.09	24.09	24.09
2026	39.46	39.46	39.46	39.46	39.46	39.46	39.46	39.46	39.46
2027	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27	77.27
2028	167.91	167.91	167.91	167.91	167.91	167.91	167.91	167.91	167.91
2029	224.09	224.09	224.09	224.09	224.09	224.09	224.09	224.09	224.09
2030	237.4	237.4	237.4	237.4	237.4	237.4	237.4	237.4	237.4
2031	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17

The demand for charging infrastructure is shown in the Figure 135.

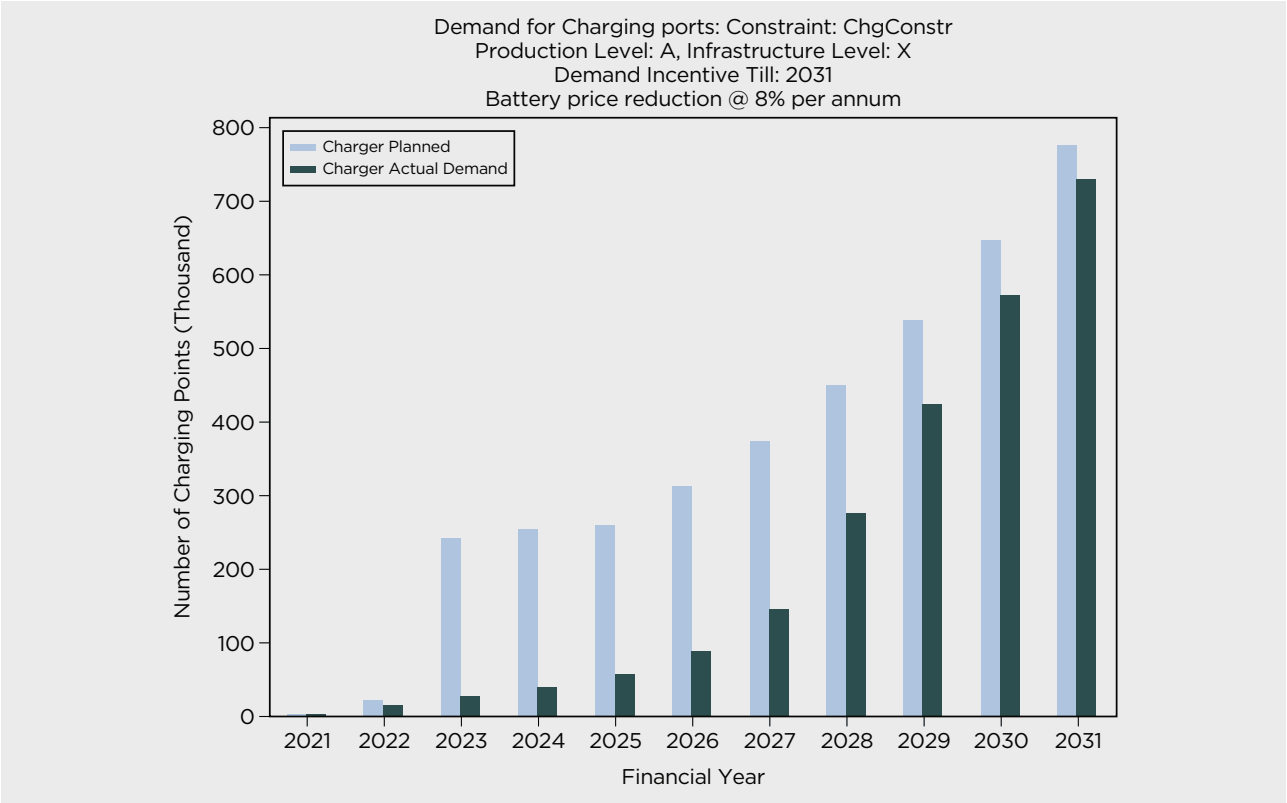


Figure 135: *Demand for charging points in the Same Performance Scenario with Charge Constraint (constraint level AX)*

The projected battery demand, as shown in Figure 136 and Table 92, reach 122.73 GWh in FY 2031.

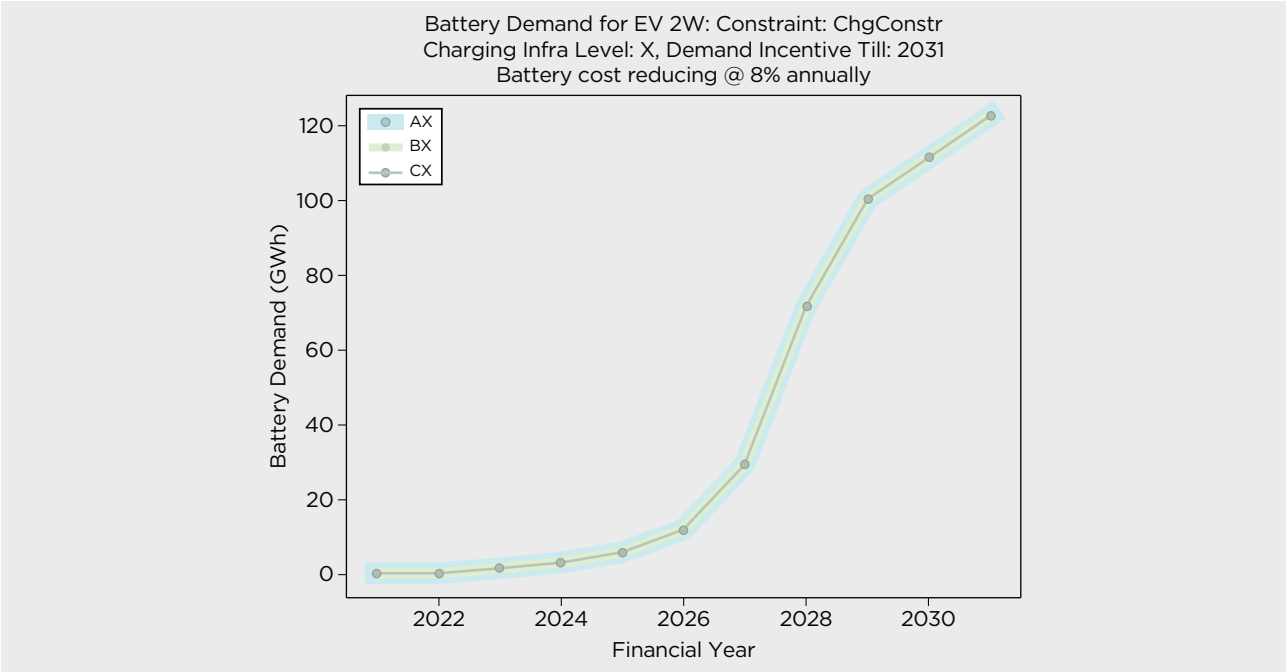


Figure 136: *Battery demand in the Same Performance Scenario with Charge Constraint, infrastructure level X*

Table 92: Battery demand in the Same Performance Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08	3.08
2025	5.86	5.86	5.86	5.86	5.86	5.86	5.86	5.86	5.86
2026	11.98	11.98	11.98	11.98	11.98	11.98	11.98	11.98	11.98
2027	29.26	29.26	29.26	29.26	29.26	29.26	29.26	29.26	29.26
2028	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8	71.8
2029	100.47	100.47	100.47	100.47	100.47	100.47	100.47	100.47	100.47
2030	111.53	111.53	111.53	111.53	111.53	111.53	111.53	111.53	111.53
2031	122.73	122.73	122.73	122.73	122.73	122.73	122.73	122.73	122.73

5.8.4 Same Performance Scenario with No Constraint

Projected penetration of electric two-wheelers for this case is shown in Figure 137 and Table 93.

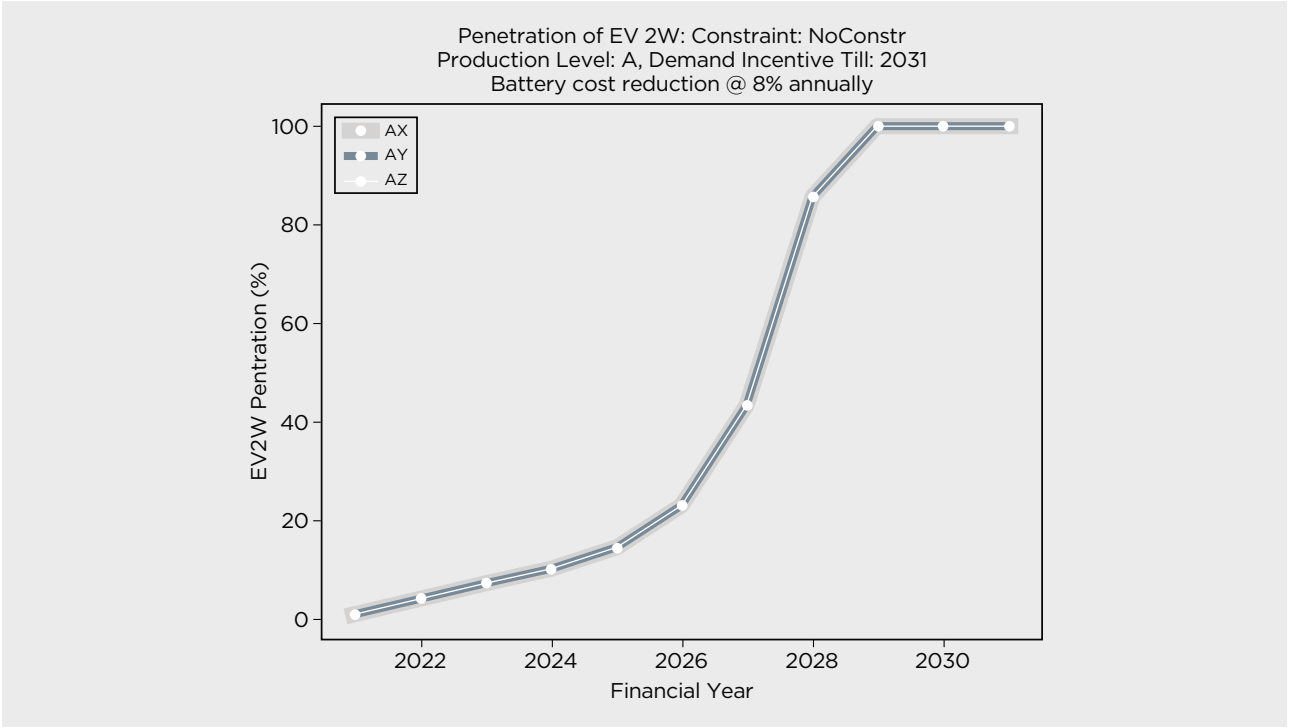


Figure 137: *Penetration of electric two-wheelers in the Same Performance Scenario with No Constraint, production level A*

Table 93: Penetration of electric two-wheelers in the Same Performance Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22	10.22
2025	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49	14.49
2026	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03	23.03
2027	43.34	43.34	43.34	43.34	43.34	43.34	43.34	43.34	43.34
2028	85.64	85.64	85.64	85.64	85.64	85.64	85.64	85.64	85.64
2029	100	100	100	100	100	100	100	100	100
2030	100	100	100	100	100	100	100	100	100
2031	100	100	100	100	100	100	100	100	100

At the base production level A, projected sale of electric two-wheelers will surpass the production capacity in the FY 2029, as shown in the Figure 138.

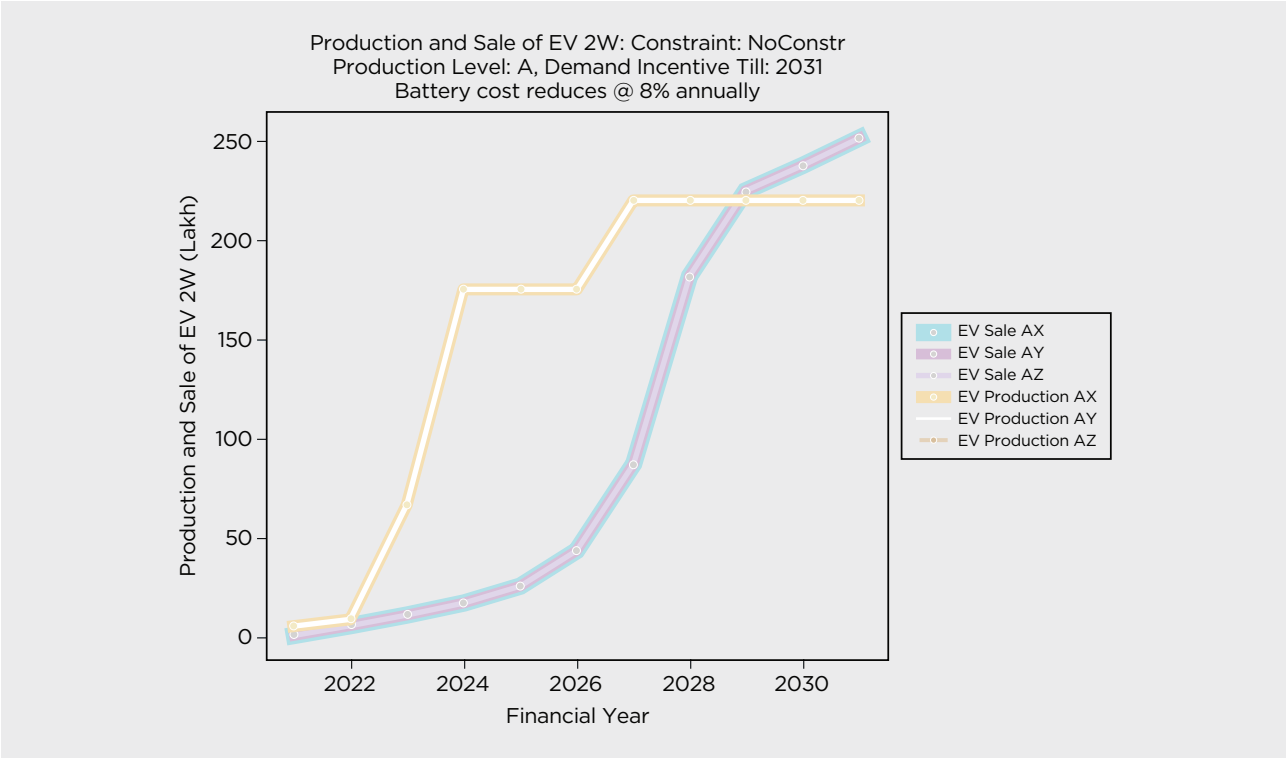


Figure 138: *Sale and production of electric two-wheelers in the Same Performance Scenario with No Constraint, production level A*

Projections of sale are same for all combinations of production and infrastructure constraints, as shown in Table 94.

Table 94: Sale of electric two-wheelers in the Same Performance Scenario with No Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3	17.3
2025	25.94	25.94	25.94	25.94	25.94	25.94	25.94	25.94	25.94
2026	43.63	43.63	43.63	43.63	43.63	43.63	43.63	43.63	43.63
2027	86.87	86.87	86.87	86.87	86.87	86.87	86.87	86.87	86.87
2028	181.62	181.62	181.62	181.62	181.62	181.62	181.62	181.62	181.62
2029	224.38	224.38	224.38	224.38	224.38	224.38	224.38	224.38	224.38
2030	237.4	237.4	237.4	237.4	237.4	237.4	237.4	237.4	237.4
2031	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17

Projected demand for charging points is shown in Figure 139.

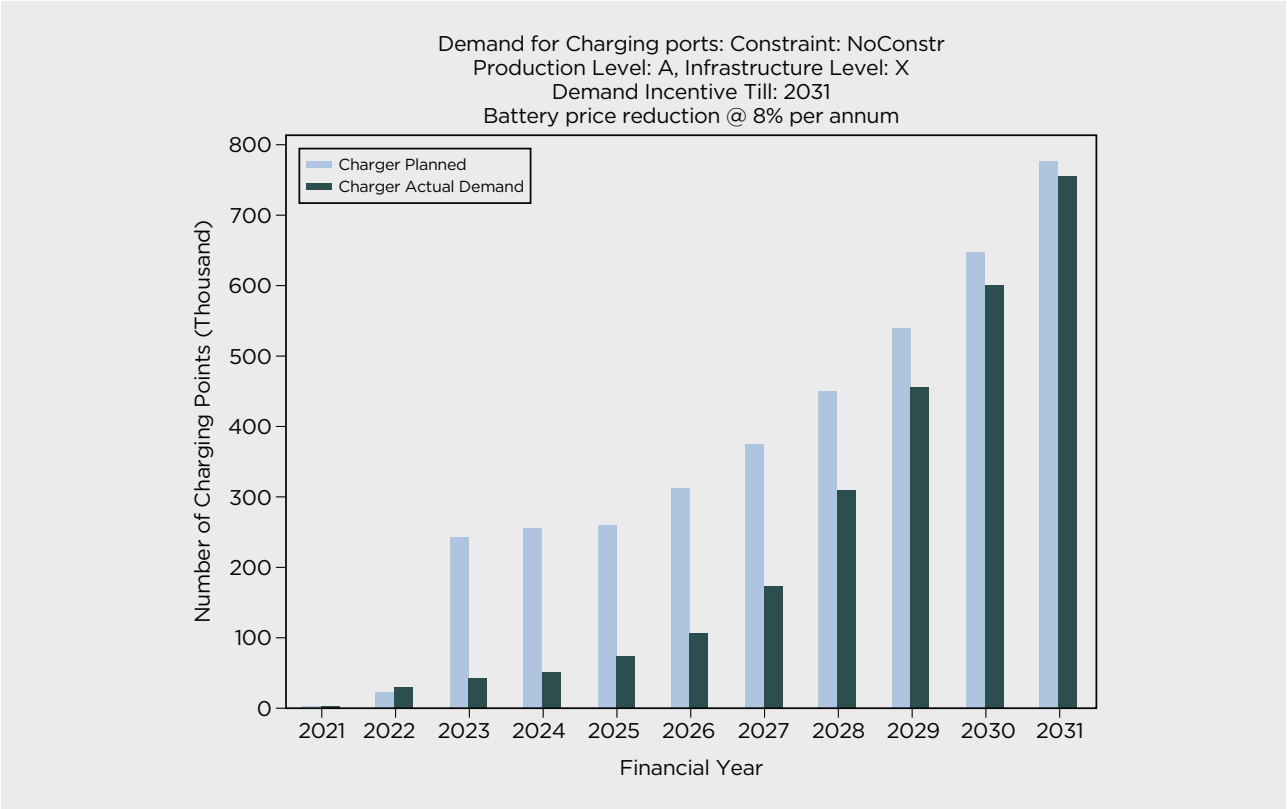


Figure 139: *Demand for charging points in the Same Performance Scenario with No Constraint (constraint level AX)*

The battery demand is projected to reach 122.73 GWh in FY 2031 (Figure 140 and Table 95).

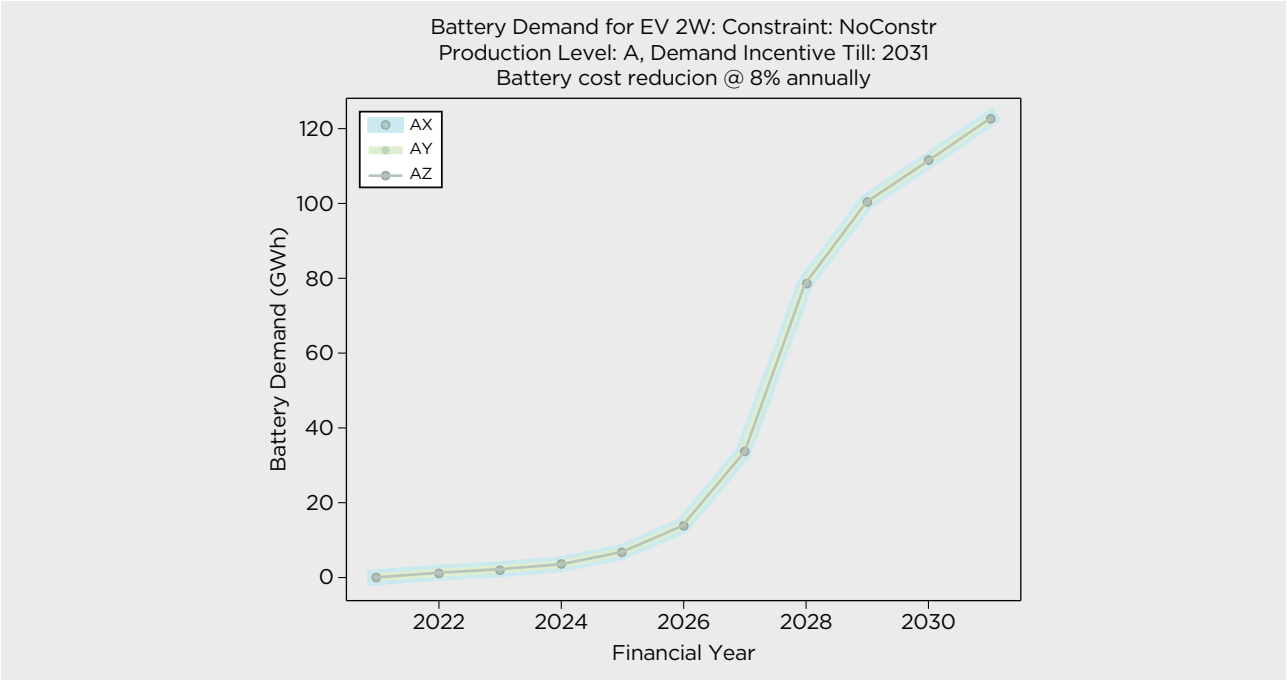


Figure 140: *Battery demand in the Same Performance Scenario with No Constraint, production level A*

Table 95: Battery demand in the Same Performance Scenario with No Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53	3.53
2025	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66
2026	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68	13.68
2027	33.62	33.62	33.62	33.62	33.62	33.62	33.62	33.62	33.62
2028	78.66	78.66	78.66	78.66	78.66	78.66	78.66	78.66	78.66
2029	100.59	100.59	100.59	100.59	100.59	100.59	100.59	100.59	100.59
2030	111.53	111.53	111.53	111.53	111.53	111.53	111.53	111.53	111.53
2031	122.73	122.73	122.73	122.73	122.73	122.73	122.73	122.73	122.73

5.9 Optimistic Scenario

Under this scenario, all factors that have positive influence on the adoption of electric two-wheelers are present. The demand incentive is assumed to be in place throughout the period and the battery cost is assumed to reduce by 8% annually. It is also assumed in addition that the range and power of the vehicle will improve by 5% during FY 2024 to FY 2026 and by 10% in the FY 2027.

5.9.1 Optimistic Scenario with Full Constraint

The penetration of electric two-wheelers reaches 100% in FY 2028 and subsequently due to due to supply-constraint in the base production level, relative share of electric two-wheelers come down. However, with increased production capacity, 100% share of electric two-wheelers can be maintained. This is apparent from Figure 141 and Table 96.

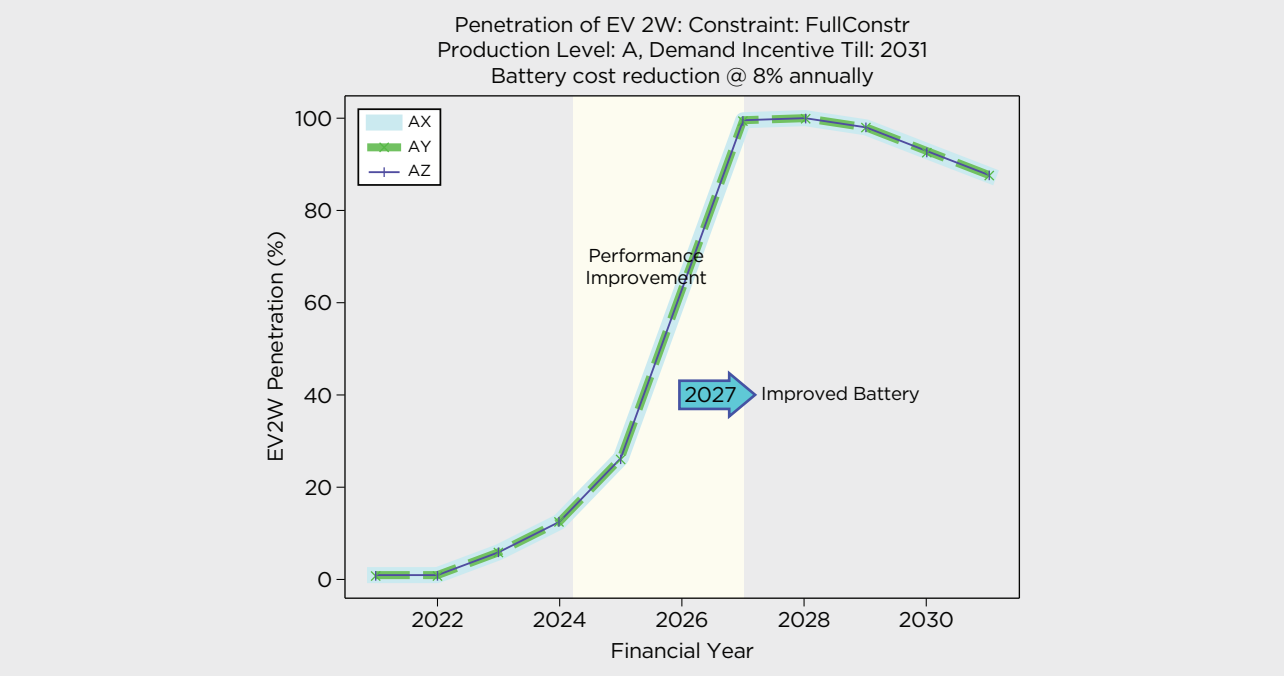


Figure 141: *Penetration of electric two-wheelers in the Optimistic Scenario with Full Constraint, production level A*

Table 96: Penetration of electric two-wheelers in the Optimistic Scenario with Full Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42
2025	26.26	26.26	26.26	26.26	26.26	26.26	26.26	26.26	26.26
2026	61.84	61.84	61.84	61.84	61.84	61.84	61.84	61.84	61.84
2027	99.48	99.48	99.48	99.48	99.48	99.48	99.48	99.48	99.48
2028	100	100	100	100	100	100	100	100	100
2029	98.11	98.11	98.11	100	100	100	100	100	100
2030	92.73	92.73	92.73	100	100	100	100	100	100
2031	87.65	87.65	87.65	100	100	100	100	100	100

There is a clear impact of technological improvements on the projected sale of electric two-wheelers in comparison to Same Performance Scenario with Full Constraints (Figure 142 and Table 97).

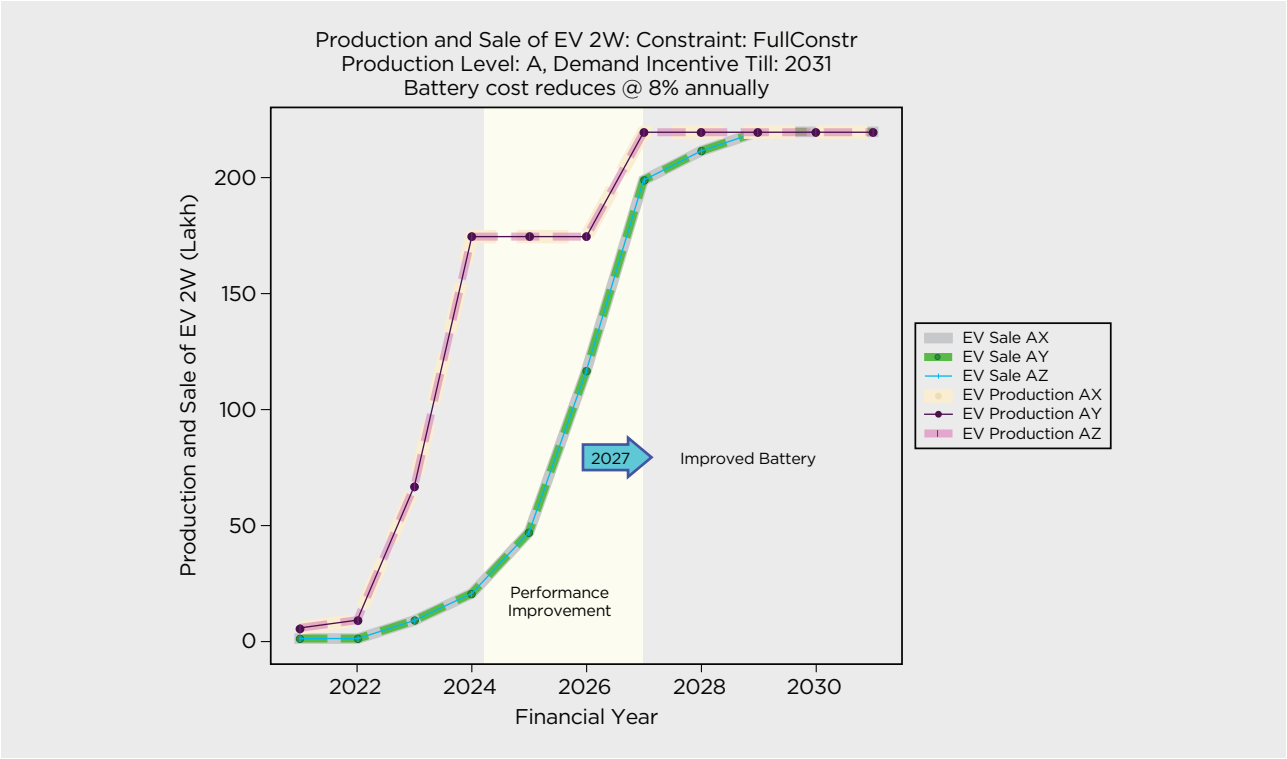


Figure 142: *Sale and production of electric two-wheelers in the Optimistic Scenario with Full Constraint, production level A*

Table 97: Sale of electric two-wheelers in the Optimistic Scenario with Full Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02
2025	47.03	47.03	47.03	47.03	47.03	47.03	47.03	47.03	47.03
2026	117.15	117.15	117.15	117.15	117.15	117.15	117.15	117.15	117.15
2027	199.41	199.41	199.41	199.41	199.41	199.41	199.41	199.41	199.41
2028	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08
2029	220.15	220.15	220.15	224.38	224.38	224.38	224.38	224.38	224.38
2030	220.15	220.15	220.15	237.4	237.4	237.4	237.4	237.4	237.4
2031	220.15	220.15	220.15	251.17	251.17	251.17	251.17	251.17	251.17

The projected demand for charging infrastructure in the AX constraint level is shown in Figure 143.

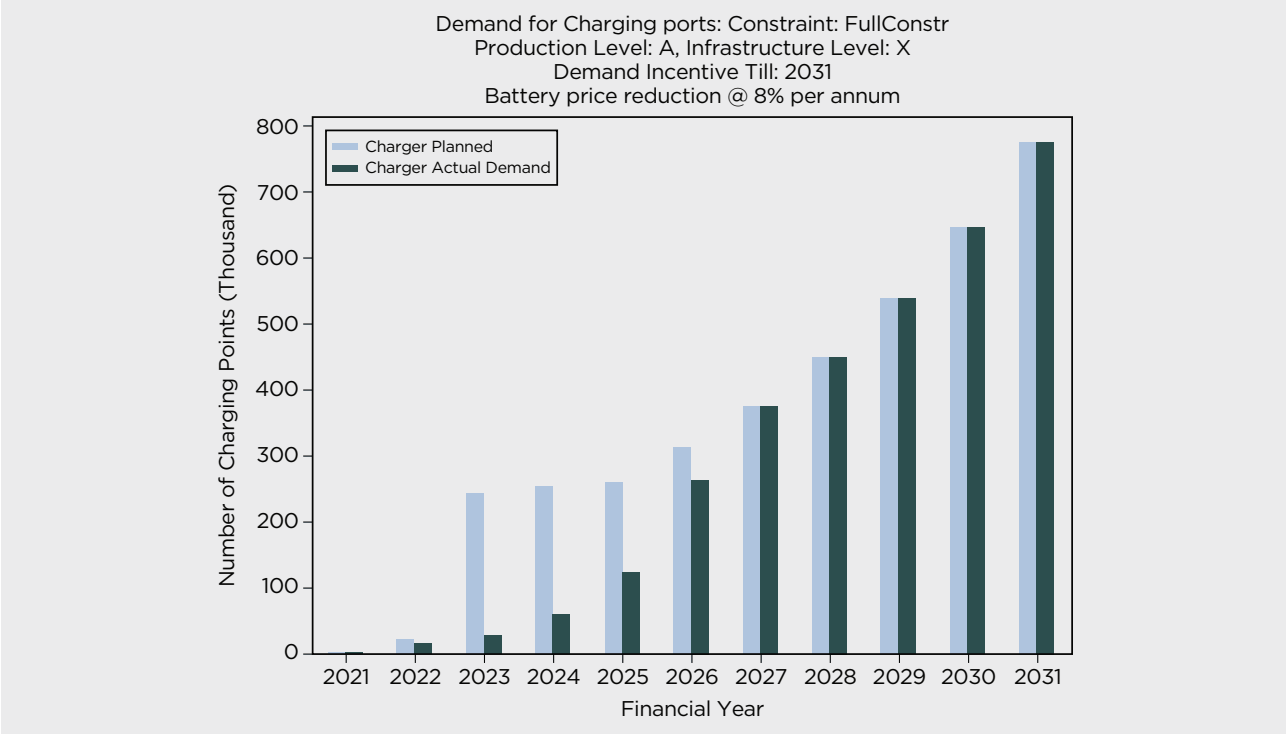


Figure 143: *Demand for charging points in the Optimistic Scenario with Full Constraints (constraint level AX)*

Projected battery demand reaches 114.66 GWh in FY 2031 at the production level A and 130.82 GWh in production levels B and C (Figure 144 and Table 98).

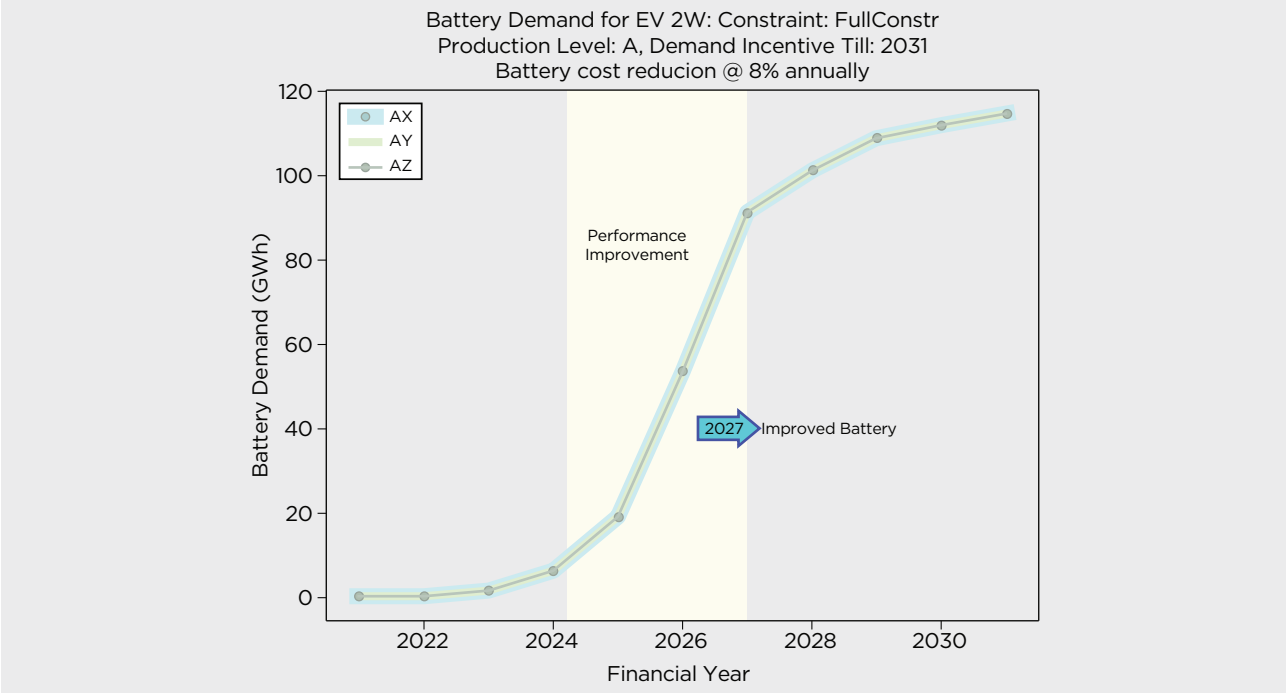


Figure 144: *Battery demand for electric two-wheelers in the Optimistic Scenario with Full Constraint, production level A*

Table 98: Battery demand for electric two-wheelers in the Optimistic Scenario with Full Constraint:

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2025	18.95	18.95	18.95	18.95	18.95	18.95	18.95	18.95	18.95
2026	53.58	53.58	53.58	53.58	53.58	53.58	53.58	53.58	53.58
2027	91.17	91.17	91.17	91.17	91.17	91.17	91.17	91.17	91.17
2028	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19
2029	109	109	109	111.09	111.09	111.09	111.09	111.09	111.09
2030	111.95	111.95	111.95	120.72	120.72	120.72	120.72	120.72	120.72
2031	114.66	114.66	114.66	130.82	130.82	130.82	130.82	130.82	130.82

5.9.2 Optimistic Scenario with Production Constraint

In this case the penetration level is increased during the initial years as compared to Full Constraint sub-scenario due to availability of adequate charging infrastructure. The effect of technological improvement is observed here also (Figure 145 and Table 99) when compared to Same Performance Scenario with Production Constraint.

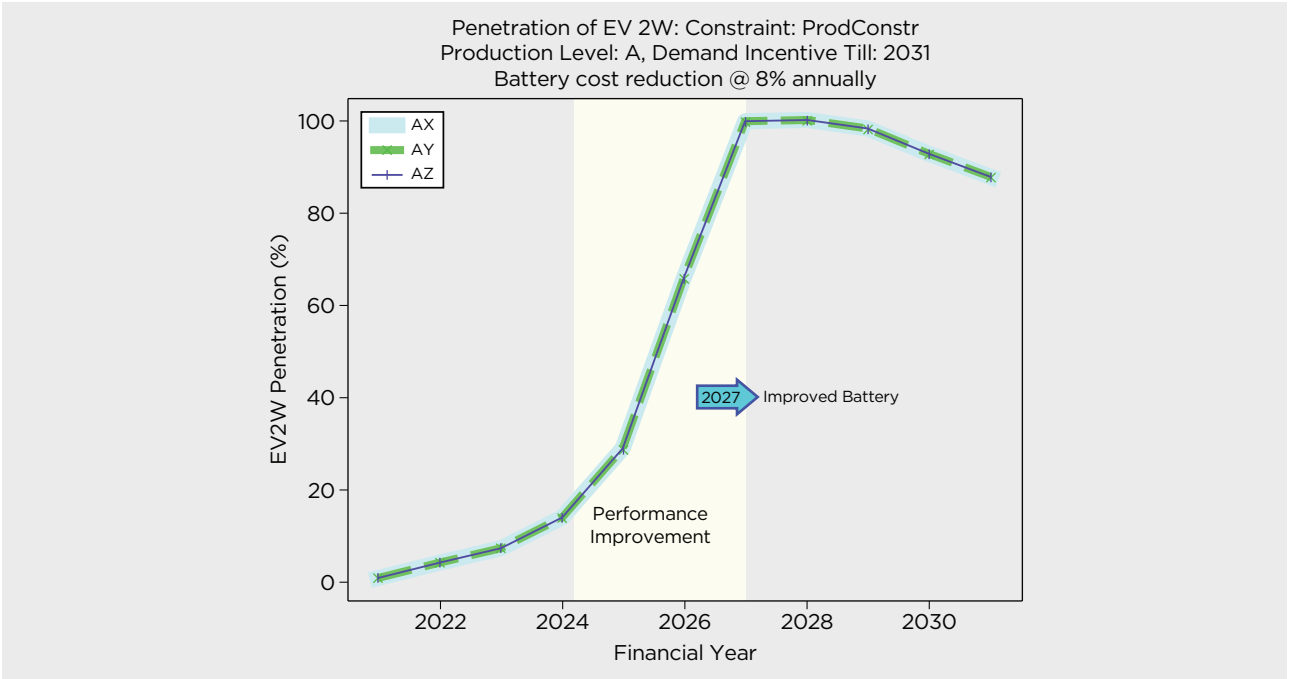


Figure 145: *Penetration of electric two-wheelers in the Optimistic Scenario with Production Constraint, production level A*

Table 99 Penetration of electric two-wheelers in the Optimistic Scenario with Production Constraint:

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84
2025	28.85	28.85	28.85	28.85	28.85	28.85	28.85	28.85	28.85
2026	65.85	65.85	65.85	65.85	65.85	65.85	65.85	65.85	65.85
2027	99.74	99.74	99.74	99.74	99.74	99.74	99.74	99.74	99.74
2028	100	100	100	100	100	100	100	100	100
2029	98.11	98.11	98.11	100	100	100	100	100	100
2030	92.73	92.73	92.73	100	100	100	100	100	100
2031	87.65	87.65	87.65	100	100	100	100	100	100

Projected electric two-wheeler sale is shown in Figure 146 and Table 100.

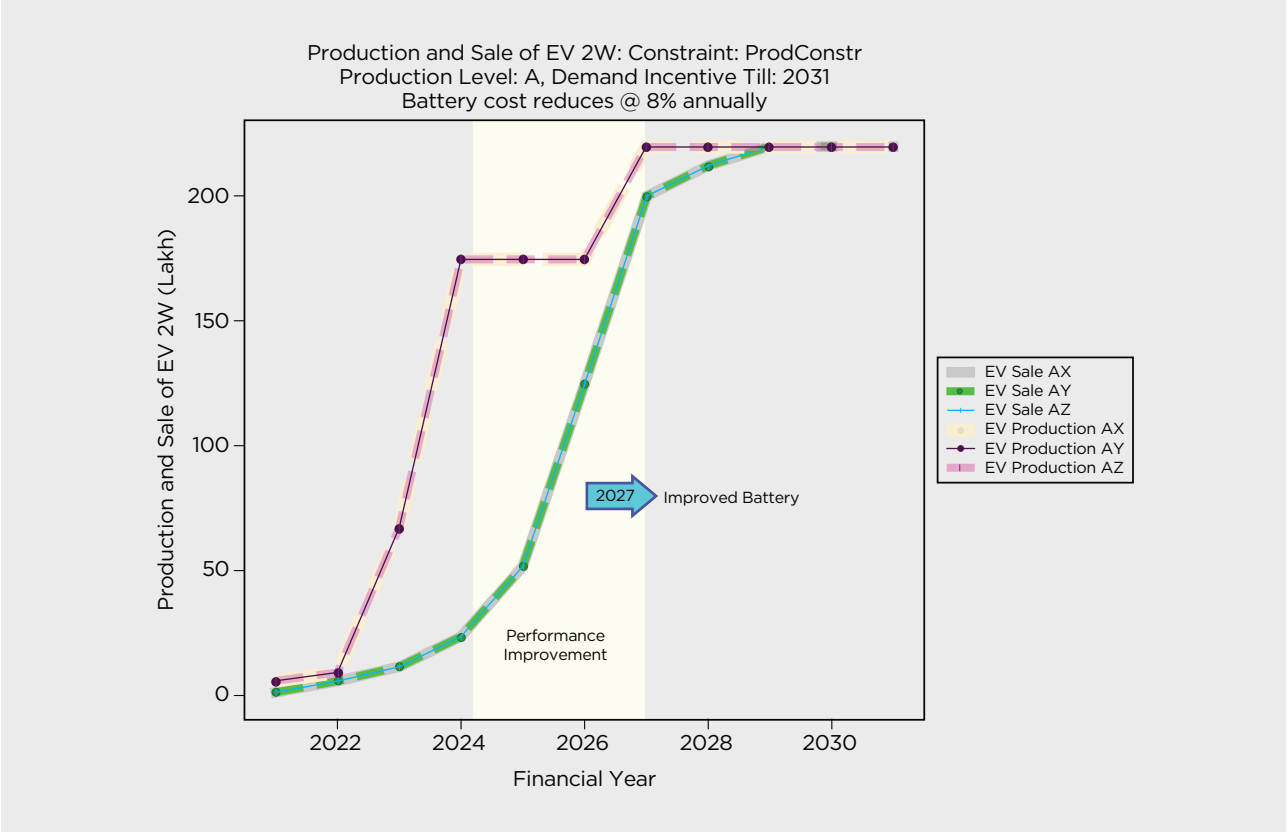


Figure 146: *Sale and production of electric two-wheelers in the Optimistic Scenario with Production Constraint, production level A*

Table 100: Sale of electric two-wheelers in the Optimistic Scenario with Production Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43
2025	51.66	51.66	51.66	51.66	51.66	51.66	51.66	51.66	51.66
2026	124.75	124.75	124.75	124.75	124.75	124.75	124.75	124.75	124.75
2027	199.93	199.93	199.93	199.93	199.93	199.93	199.93	199.93	199.93
2028	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08
2029	220.15	220.15	220.15	224.38	224.38	224.38	224.38	224.38	224.38
2030	220.15	220.15	220.15	237.40	237.40	237.40	237.40	237.40	237.40
2031	220.15	220.15	220.15	251.17	251.17	251.17	251.17	251.17	251.17

Figure 147 shows the projections of demand for charging points in the constraint level AX.

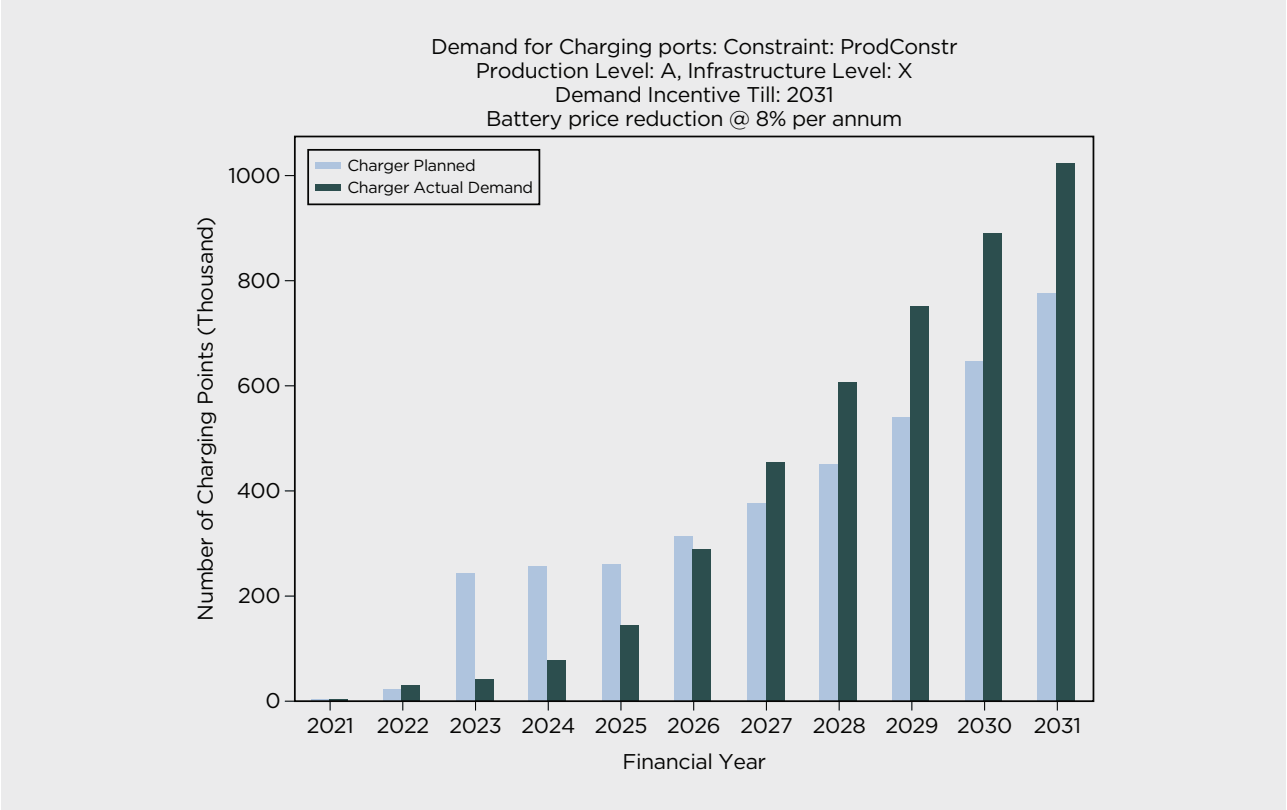


Figure 147: *Demand for charging points in the Optimistic Scenario with Production Constraint, (constraint level AX)*

The projected battery demand reaches 114.66 GWh at the production level A and 130.82 GWh at the production levels B and C (Figure 148 and Table 101).

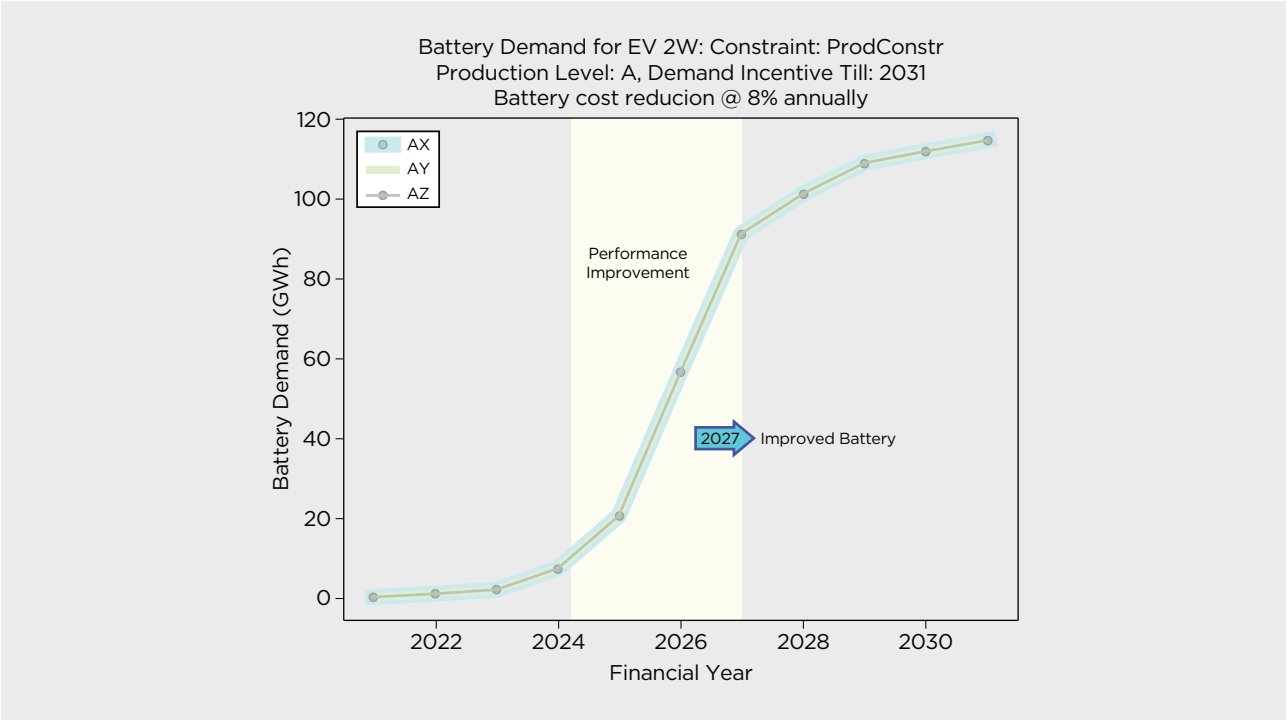


Figure 148: *Battery demand for electric two-wheelers in Optimistic Scenario with Production Constraint, production level A*

Table 101: Battery demand for electric two-wheelers in Optimistic Scenario with Production Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42
2025	20.71	20.71	20.71	20.71	20.71	20.71	20.71	20.71	20.71
2026	56.64	56.64	56.64	56.64	56.64	56.64	56.64	56.64	56.64
2027	91.35	91.35	91.35	91.35	91.35	91.35	91.35	91.35	91.35
2028	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19
2029	109.00	109.00	109.00	111.09	111.09	111.09	111.09	111.09	111.09
2030	111.95	111.95	111.95	120.72	120.72	120.72	120.72	120.72	120.72
2031	114.66	114.66	114.66	130.82	130.82	130.82	130.82	130.82	130.82

5.9.3 Optimistic Scenario with Charge Constraint

Penetration of electric two-wheelers reach 100% in FY 2028 itself and stays at that level (Figure 149 and Table 102).

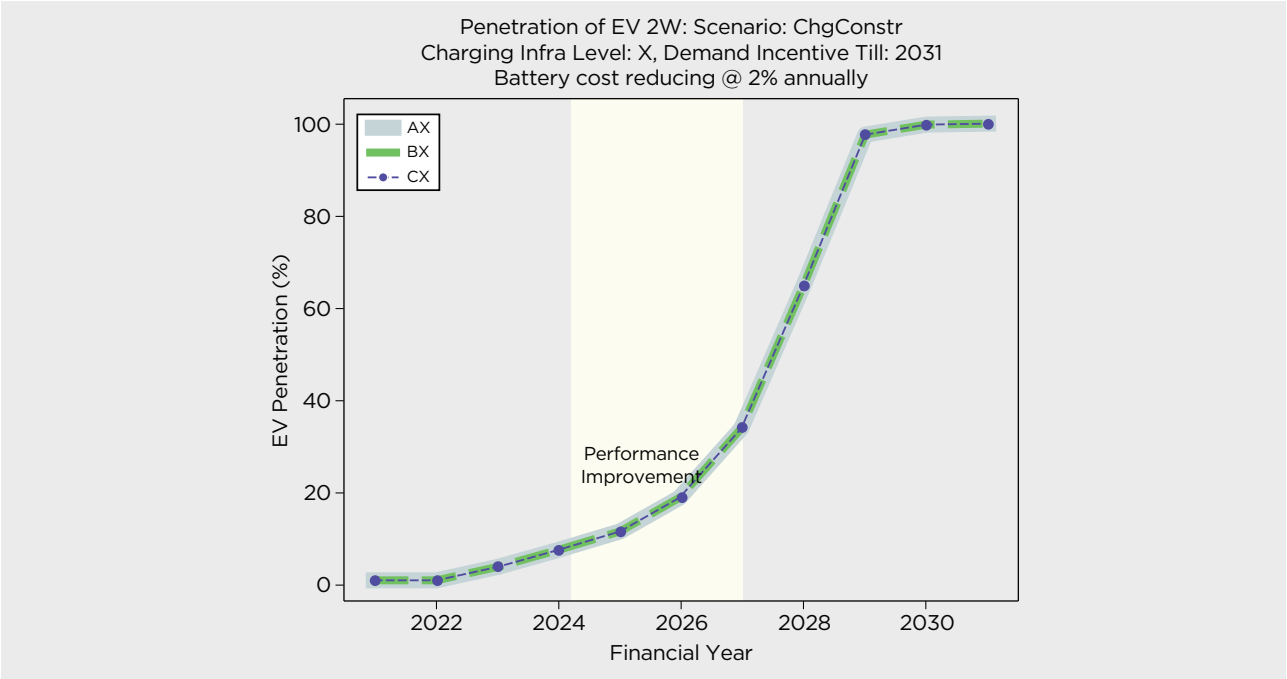


Figure 149: *Penetration of electric two-wheelers in the Optimistic Scenario with Charge Constraint, infrastructure level X*

Table 102: Projected penetration of electric two-wheelers in the Optimistic Scenario with Charge Constraint

Financial Year	Projected Penetration (%)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
2023	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82	5.82
2024	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42	12.42
2025	26.26	26.26	26.26	26.26	26.26	26.26	26.26	26.26	26.26
2026	61.84	61.84	61.84	61.84	61.84	61.84	61.84	61.84	61.84
2027	99.48	99.48	99.48	99.48	99.48	99.48	99.48	99.48	99.48
2028	100	100	100	100	100	100	100	100	100
2029	100	100	100	100	100	100	100	100	100
2030	100	100	100	100	100	100	100	100	100
2031	100	100	100	100	100	100	100	100	100

Projected sale of electric two-wheelers reaches 251.17 lakh units in FY 2031. However, impacts of technological improvement are observed in comparison to Same Performance Scenario with Charge Constraint (Figure 150 and Table 103).

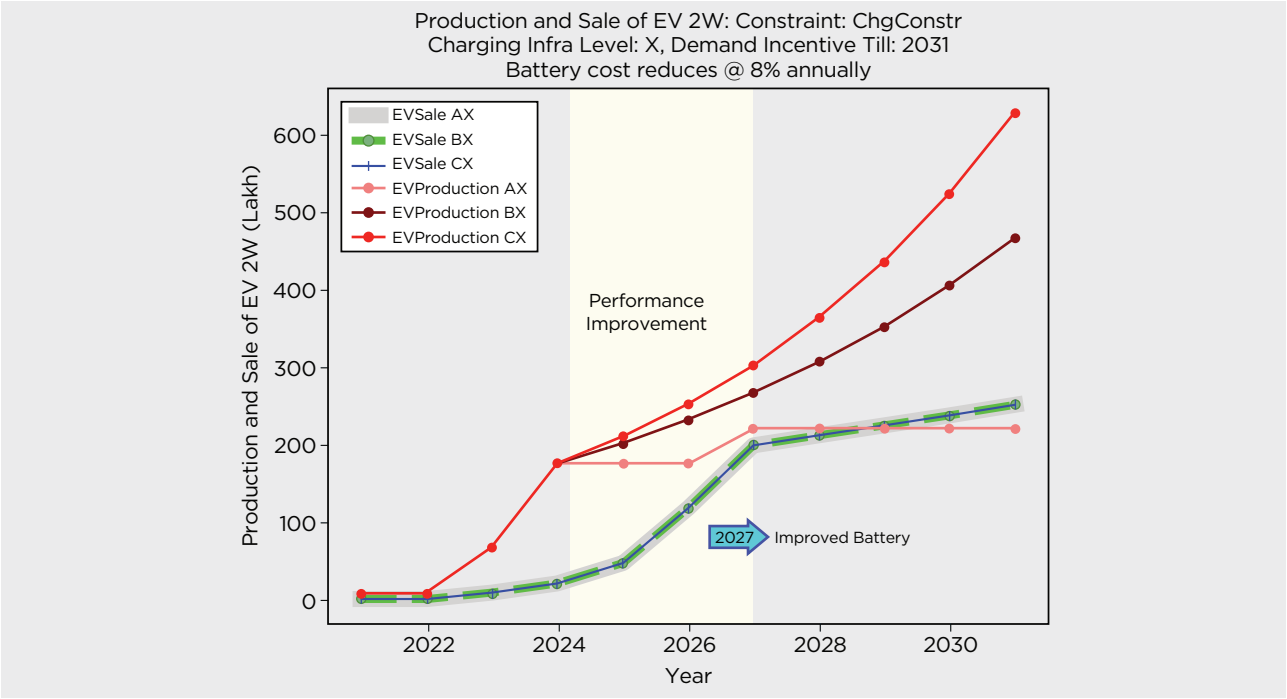


Figure 150: *Sale and production of electric two-wheelers in the Optimistic Scenario with Charge Constraint, infrastructure level X*

Table 103: Sale of electric two-wheelers in the Optimistic Scenario with Charge Constraint

Year	Projected Sale (Lakh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
2023	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.31
2024	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02	21.02
2025	47.03	47.03	47.03	47.03	47.03	47.03	47.03	47.03	47.03
2026	117.15	117.15	117.15	117.15	117.15	117.15	117.15	117.15	117.15
2027	199.41	199.41	199.41	199.41	199.41	199.41	199.41	199.41	199.41
2028	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08
2029	224.38	224.38	224.38	224.38	224.38	224.38	224.38	224.38	224.38
2030	237.40	237.40	237.40	237.40	237.40	237.40	237.40	237.40	237.40
2031	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17

The demand for charging infrastructure at constraint level AX is described in Figure 151. Since it is Charge Constraint scenario, the maximum demand for charging points is equal to the planned charging points starting from the FY 2026.

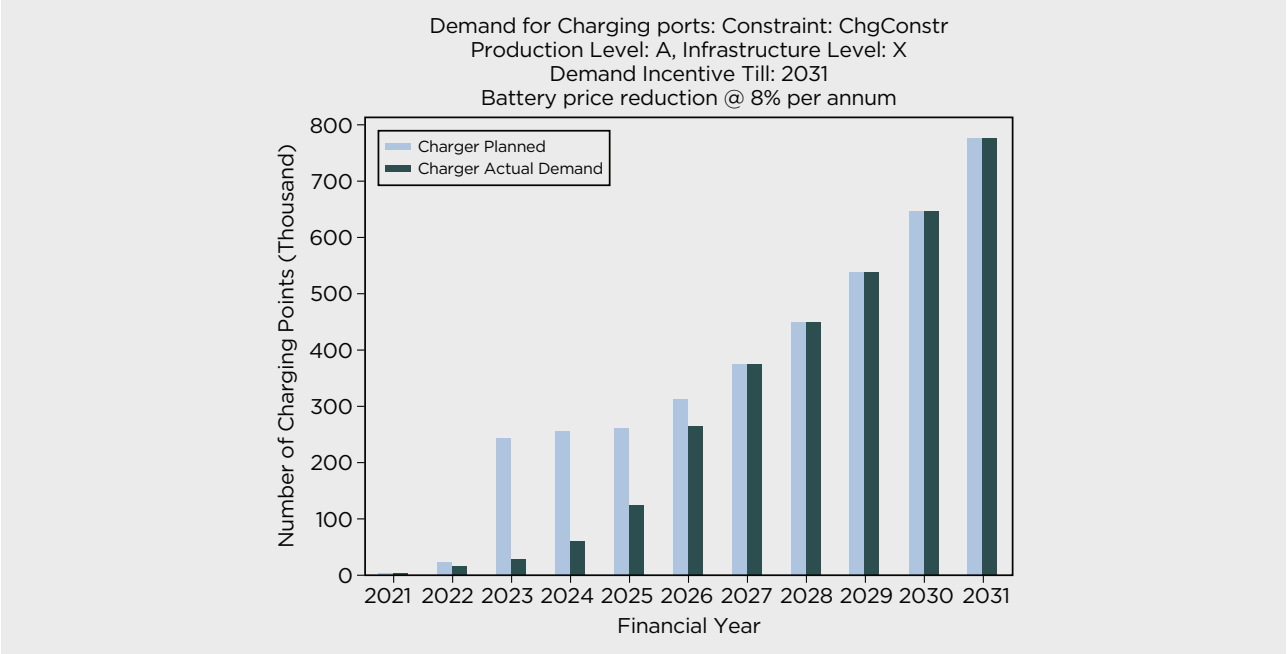


Figure 151: *Demand for charging points in the Optimistic Scenario with Charge Constraint (constraint level AX)*

Battery demand will reach 130.82 GWh in FY 2031 (Figure 152 and Table 104).

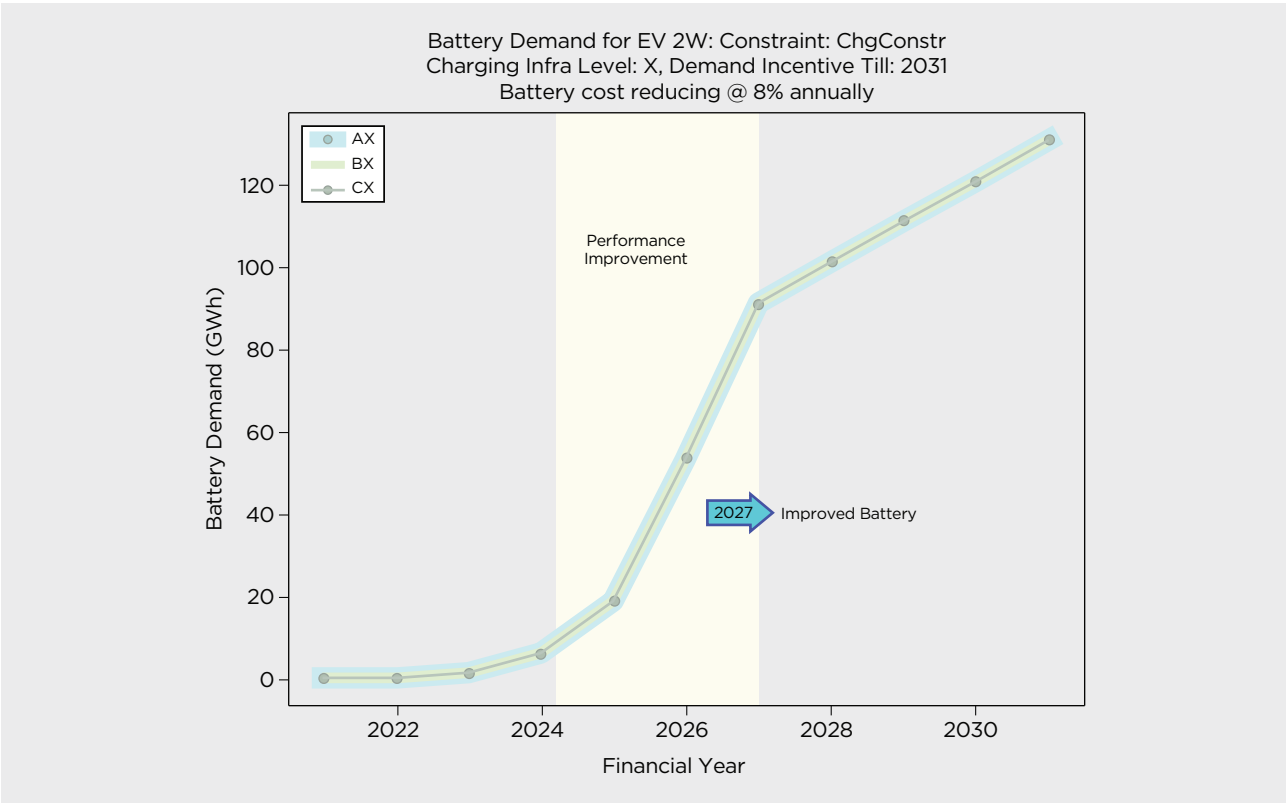


Figure 152: *Battery demand in the Optimistic Scenario with Charge Constraint, infrastructure level X*

Table 104: Battery demand in the Optimistic Scenario with Charge Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	BX	CX	AY	BY	CY	AZ	BZ	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
2023	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59
2024	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2025	18.95	18.95	18.95	18.95	18.95	18.95	18.95	18.95	18.95
2026	53.58	53.58	53.58	53.58	53.58	53.58	53.58	53.58	53.58
2027	91.17	91.17	91.17	91.17	91.17	91.17	91.17	91.17	91.17
2028	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19
2029	111.09	111.09	111.09	111.09	111.09	111.09	111.09	111.09	111.09
2030	120.72	120.72	120.72	120.72	120.72	120.72	120.72	120.72	120.72
2031	130.82	130.82	130.82	130.82	130.82	130.82	130.82	130.82	130.82

5.9.4 Optimistic Scenario with No Constraint

The projected penetration reaches 99.74% in FY2027 itself and subsequently remains at 100% (Figure 153 and Table 105).

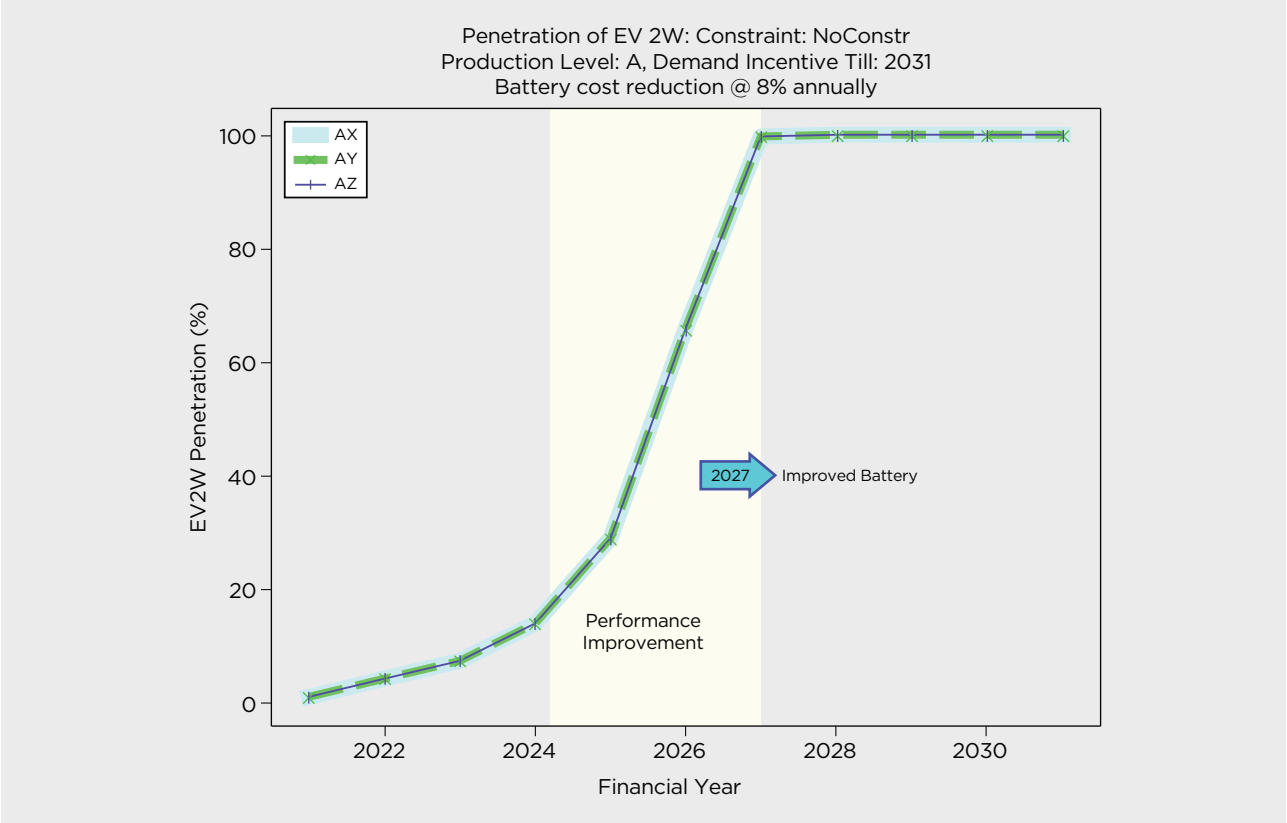


Figure 153: *Penetration of electric two-wheelers in the Optimistic Scenario with No Constraint, production level A*

Table 105: Penetration of electric two-wheelers in the Optimistic Scenario with No Constraint

Financial Year	Projected Penetration (%)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
2022	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14	4.14
2023	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24	7.24
2024	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84	13.84
2025	28.85	28.85	28.85	28.85	28.85	28.85	28.85	28.85	28.85
2026	65.85	65.85	65.85	65.85	65.85	65.85	65.85	65.85	65.85
2027	99.74	99.74	99.74	99.74	99.74	99.74	99.74	99.74	99.74
2028	100	100	100	100	100	100	100	100	100
2029	100	100	100	100	100	100	100	100	100
2030	100	100	100	100	100	100	100	100	100
2031	100	100	100	100	100	100	100	100	100

Projected sale exceeds the assumed production capacity from the FY 2028 onwards (Figure 154 and 106).

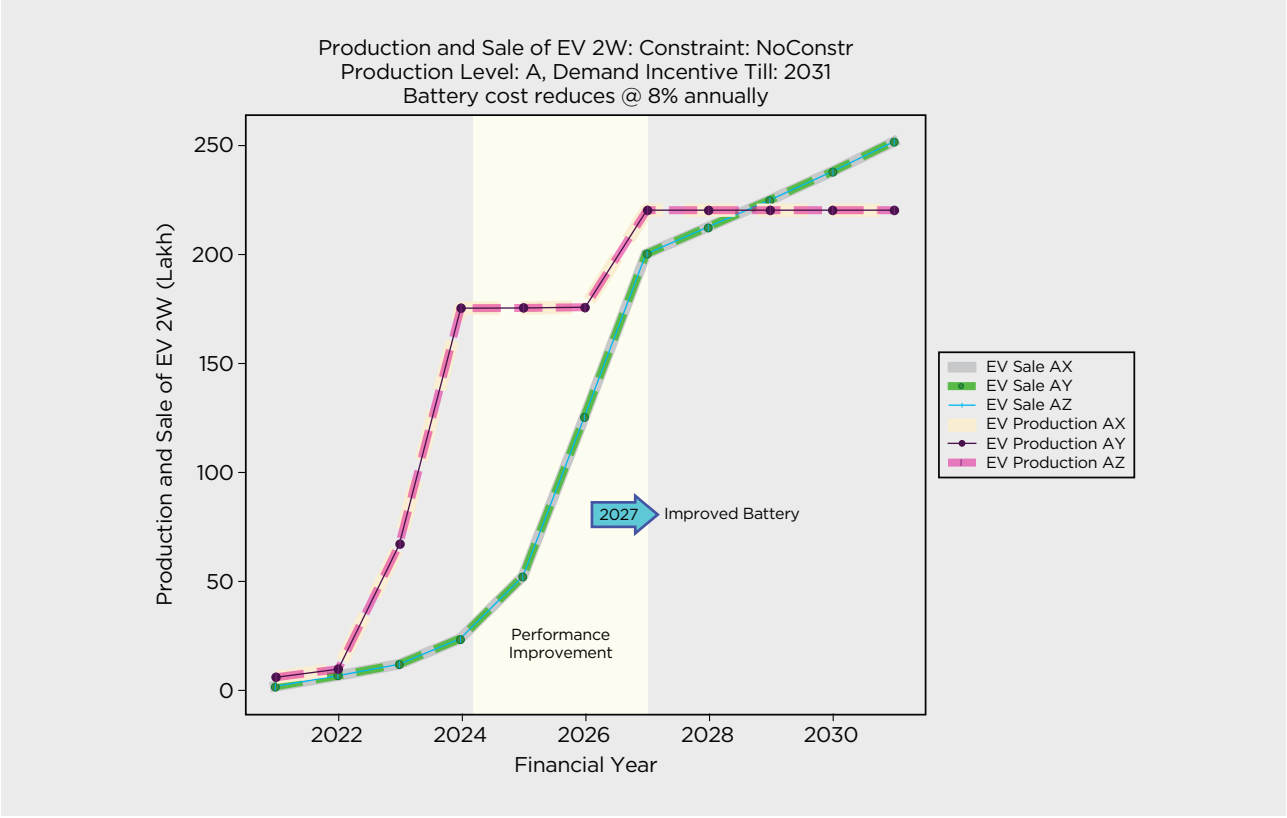


Figure 154: *Sale of electric two-wheelers in the Optimistic Scenario with No Constraint, production level A*

Table 106: Sale of electric two-wheelers in the Optimistic Scenario with No Constraint

Financial Year	Projected Sale (Lakh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1.44
2022	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26
2023	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
2024	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43	23.43
2025	51.66	51.66	51.66	51.66	51.66	51.66	51.66	51.66	51.66
2026	124.75	124.75	124.75	124.75	124.75	124.75	124.75	124.75	124.75
2027	199.93	199.93	199.93	199.93	199.93	199.93	199.93	199.93	199.93
2028	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08	212.08
2029	224.38	224.38	224.38	224.38	224.38	224.38	224.38	224.38	224.38
2030	237.4	237.4	237.4	237.4	237.4	237.4	237.4	237.4	237.4
2031	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17	251.17

The projected demand for charging points at constraint level AX is shown in Figure 155. Since no constraint of charging infrastructure is considered, the demand for charging points is more than the assumed installed capacity from FY 2026 onwards.

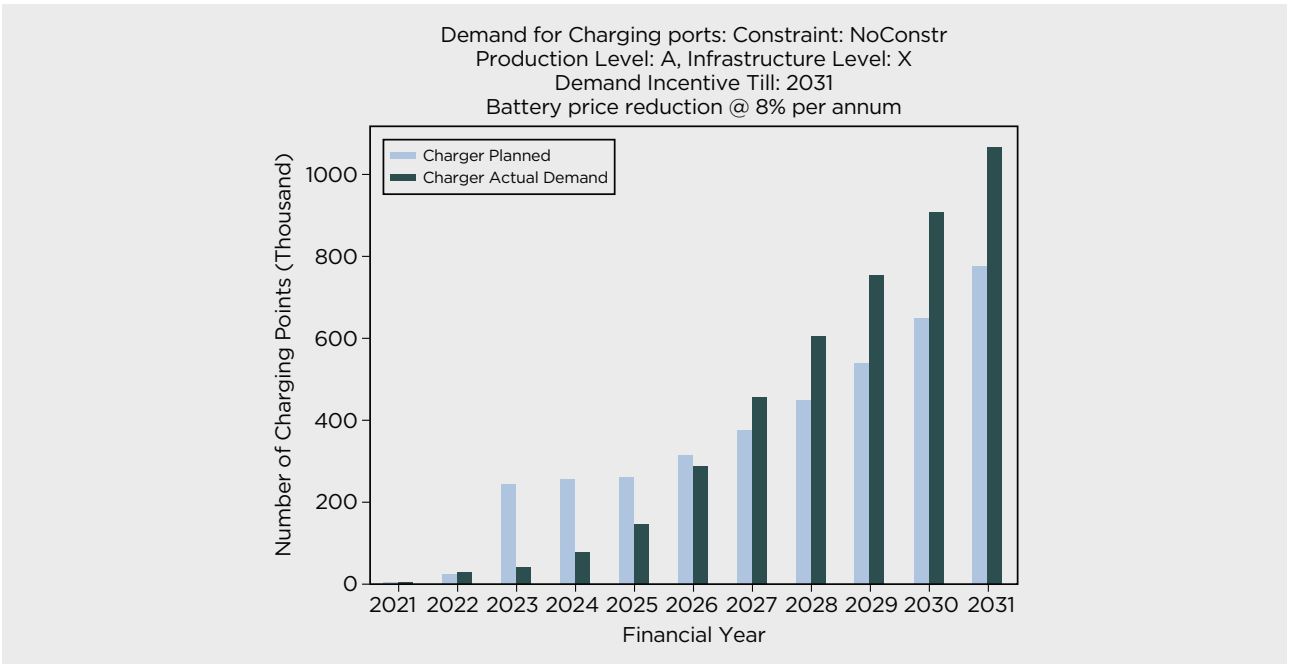


Figure 155: *Demand for charging points in the Optimistic Scenario with No Constraints, (constraint level AX)*

Projected battery demand, as shown in Figure 156 and Table 107, reaches 130.82 GWh in FY 2031.

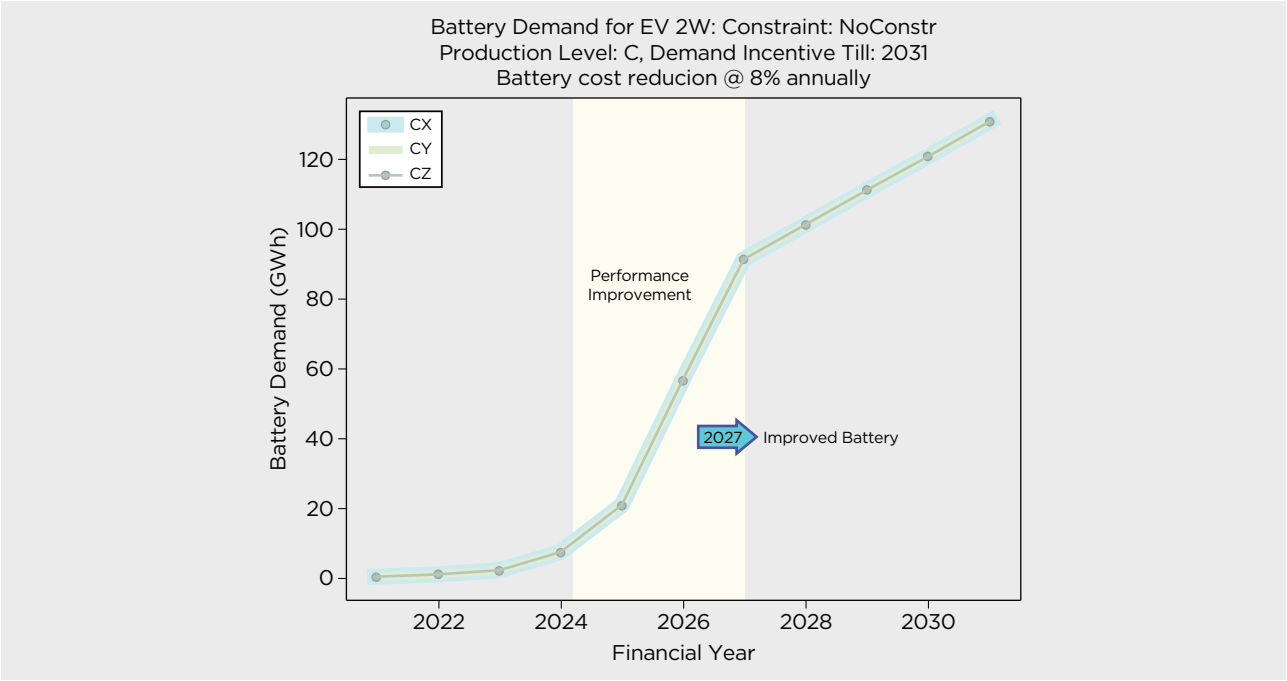


Figure 156: *Battery demand in the Optimistic Scenario with No Constraint, production level A*

Table 107: Battery demand in the Optimistic Scenario with No Constraint

Financial Year	Projected Battery Demand (GWh)								
	AX	AY	AZ	BX	BY	BZ	CX	CY	CZ
2021	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
2022	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11	1.11
2023	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
2024	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42	7.42
2025	20.71	20.71	20.71	20.71	20.71	20.71	20.71	20.71	20.71
2026	56.64	56.64	56.64	56.64	56.64	56.64	56.64	56.64	56.64
2027	91.35	91.35	91.35	91.35	91.35	91.35	91.35	91.35	91.35
2028	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19	101.19
2029	111.09	111.09	111.09	111.09	111.09	111.09	111.09	111.09	111.09
2030	120.72	120.72	120.72	120.72	120.72	120.72	120.72	120.72	120.72
2031	130.82	130.82	130.82	130.82	130.82	130.82	130.82	130.82	130.82

CONCLUSIONS

Based on this analysis, we can conclude that India is at the cross-roads and a shift to electric mobility, particularly, in the two-wheelers segment, may happen faster than anticipated. There is a positive mindset about electric mobility among the consumers and recent rise in the price of petroleum fuels has played a major role towards this shift. Public awareness about electric mobility has increased. Demand incentives increase the penetration level of electric two-wheelers. But more important issues appear to be the manufacturing cost of the vehicle which is mainly influenced by the cost of the battery. Reduced dependence on the import of electric vehicle components and sub-systems may be one of the crucial factors in enhancing domestic manufacturing capacity along with other policy related measures.

During the initial stage, due to low level of electric vehicle penetration, higher ratio of charging points to electric vehicles will be required to instill confidence in the minds of the customers. While at later stage the absolute number of charging points should increase, this ratio may even come down. Such a scenario in any case, is expected to happen.

Apart from the policy and infrastructure related issues, technology plays an important role in market penetration of electric vehicles. The results clearly demonstrate how improvement in the performance of the vehicle over a period of three years, along with improved battery can drastically increase penetration, overcoming the impacts of withdrawal of incentives. Battery cost is another important parameter and technology can play an important role in reducing cost of the battery and other components, many of which are presently imported.

Certain aspects which have not been discussed in this report, such as resource availability safety etc. may prove to be important issues for widespread adoption of electric mobility and technology has a key role in addressing these issues.

At certain point of time in future there may be an appropriate ecosystem for enforcement of a regulation towards electric mobility or other clean transport options. But as the present analysis shows, there are plenty of opportunities for accelerating adoption of electric vehicles through technological improvements other interventions.