National Bus Resource Requirement

Road Map for Overcoming the Gaps

June 2021

SHAKTI
SUSTAINABLE ENERGY
FOUNDATION

SGA sustainable mobility solutions

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Glossary of Terms

Buses/1K population	Buses per 1000 population: Factor used to assess and estimate the number of buses required for a given population of a city or region.
Contract carriage	As per section 2 of motor vehicle act “contract carriage” means a motor vehicle which carries a passenger or passengers for hire or reward and is engaged under a contract, whether expressed or implied, for the use of such vehicle as a whole for the carriage of passengers mentioned therein and entered into by a person with a holder of a permit in relation to such vehicle or any person authorised by him in this behalf on a fixed or an agreed rate or sum either on a time to basis or between a defined origin and destination
CPK	Cost per kilometre: Value used to explain the operational cost of a bus or bus system. It is derived as a ratio of the total operational expenditure (excluding any capital expenditure) to the total kilometres operated in a given time period.
EPK	Earnings per kilometre: Value used to explain the operational earnings for a bus or bus system. It is derived as a ratio of the total revenue (including both fare box and non-fare box revenue) to the total kilometres operated in a given time period.
Fare Box Revenue	Revenue earned through bus ticket sales.
Fleet Utilisation	A factor that denotes the percentage of the total fleet utilised or operationalised per day.
GCC	Gross Cost Contract: Contracting mechanism for bus operations where a vendor/contractor provides buses, drivers, and associated services (such as bus maintenance and replacement) at a per kilometre service fee, borne by the city or a public bus operator/STU. Such buses are not owned by the operator.
GOI	Government of India
HA	High Ambition (Scenario)
ICE Bus	Bus based on internal combustion engine technology.

LA	Low Ambition (Scenario)
Load Factor	A factor explaining the occupancy of a bus, usually averaged over a day. It is derived as a ratio of the number of passengers in a bus to the bus's capacity (usually seating capacity).
$mtCO_2e$	Million metric tons of CO_2 equivalent
Non-Fare Box Revenue	All revenue from revenue sources in bus operations other than ticket sales. These usually include rental revenue, advertisement revenue, etc.
Non-Urban Operations	Bus operations with one or more stops, the origin, or destination outside the city limits.
Outright Purchase Model	A model of bus operations where the operator owns and operates the buses.
PCTR	Per Capita Trip Rate: Factor defined as a ratio of the total number of passenger trips in a defined region to the population of that region.
STU	State Transport Undertaking: Public bus company, owned and operated by a state government.
Stage Carriage Buses	Buses operated under licences from a regional transport office (RTO), operating on a fixed route with defined stops.
Urban Operations	Bus operations limited to urban areas, with an average station spacing of 400-800 metres.
Vehicle Utilisation	Factor derived as a ratio of the total bus kilometres actually operated in a day to the bus kilometres scheduled or planned to be operated in a day.

1 Background

Cities across the world are investing in urban transit systems to ensure mobility security, as well as counter increasing pollution, accidents, and congestion due to increasing private vehicle use. Bus-based public transport offers great potential to achieve these objectives, thanks to its low cost and high flexibility. Public bus companies form the backbone of bus-based mobility in India. Public bus companies operate the majority of urban bus services but are in the minority in the non-urban space. Nevertheless, even in non-urban services, they play the essential role of providing connectivity to remote areas and hinterland on routes that would be unprofitable for private operators. Public bus companies are under the control of State Transport Departments, with an objective to serve the mobility needs of the residents of that state and are known as State Transport Undertakings (STUs). However, the current state of affairs is that bus services (both public and private) are currently only serving a small fraction of passenger trips in the country. Of the overall passenger trips in India, it is estimated that currently only 6% are covered by bus transport. India is thus sitting on a large untapped demand for bus trips in general and public bus trips in particular, along with an untapped potential to significantly improve bus operations and services. Not tapping into this demand not only poses a serious risk today but will have more severe repercussions in the future. If bus operators are unable to provide affordable bus service to this huge potential commuter base, they will not only hamper the access to opportunities and essential services for a large segment of the population, thereby stunting economic growth, but also risk the capture of new mobility trips by inefficient modes of transport such as motorcycles and cars, leading to higher emissions, an increased carbon footprint, more accidents, and greater congestion.

1.1 The need

To overcome this problem, an assessment of the fleet requirement and other resources (such as land and capital) based on demand projections needs to be undertaken for the next 30 to 40 years. Shakti has been contributing to this effort, with the objective of promoting bus-based public transport to counter the rising carbon footprint of Indian mobility. SGA has developed a long-range planning tool for STUs known as the FLEET Tool. This tool was developed as part of a study funded by Shakti Sustainable Energy Foundation entitled “Building a Long-Range Planning Toolkit for State Transport Undertakings (STUs).” However, this tool is limited to providing resource estimates for an operator or a STU or for a defined region. This tool does not generate estimates of bus resource requirement at a national or a state level in a defined scenario.

Aggregated annual resource requirement at national and state level is required to influence policy direction, investments, and actions towards achieving an enhanced level of public transport use (especially buses) as well contribute in transitioning to cleaner energy modes in the country. These requirements need to include details of annual viability gap funding (VGF) required (over short, medium, and long term), land requirements, manpower requirement, etc. in multiple scenarios. Since current government policies promote electrification of mobility including buses, it is imperative that these scenarios take in to

account the impact of electrification of the current internal combustion engine (ICE) fleet along with increased bus trips.

There is thus a need to develop a model which can generate national level aggregated annual resource requirements for different types of bus operations in different scenarios, over a long term. Alongside these outputs disaggregated resource estimates are also required at State level. This is because transport is a State subject, and apart from informing any national bus programs, the outputs generated by this model can be used in defining the annual State transport budget. Such estimates can be very useful in long-term planning and resource allocation and future policy and regulatory framework development, in order to promote bus-based mobility, along with contributing to the decarbonisation of mobility in India.

1.2 Vision and Objectives

The potential of the model (for this study) to generate annual data for plotting the transition to a vision or desired level of service or technology as well providing annual resource requirements in such transition, offers inputs for a detailed action plan with annual goals to achieve national and state level vision for public buses. This is used to generate resource requirements to start and sustain urban and non-urban bus services in different States and union territories (as per an envisioned scenarios) and the findings are compiled and presented in this report. Therefore, the objective of this study is to deploy a national resource estimation model based on FLEET Tool (using the computational framework of FLEET tool) to generate the desired outputs and disseminate the specific findings to the concerned actors, as well other stakeholders. This includes the development of a national bus resource requirement plan (including resources required for the e-bus transition), along with disaggregated details for all states and union territories in India.

1.3 Current Gaps

Current gaps in bus sector supply and demand are due to limitations and capacity gaps in existing STUs/public bus companies and the absence of STUs/public bus companies in small and medium-sized cities.

Limitations with existing STUs are largely related to the fact that most do not have any long-term targets or any strategic service, business, and operational plans. These limitations are both a cause and outcome of:

- Lack of will,
- Lack of data, and
- Lack of capacity (technical, institutional, and financial).

Currently, most bus operators (especially public bus operators) are focusing on sustaining current operations with the limited resources at hand. Most lack awareness of demand trends, supply gaps, and the sector status (such as demand catered to by competing transport modes). They are thus not positioning themselves to cater to future requirements. In such a scenario, STUs face increasing challenges in meeting even basic fleet upgradation

requirements. These challenges include both land and financing constraints. This ultimately leads to the deterioration and breakdown of STUs, adversely affecting service quality and resulting in a decrease in the commuter base. At the same time, current commuters are moving to less sustainable transport modes, causing even more harm to climate and increase in local pollution. This trend is making bus manufacturers in India sceptical about their growth plans. The result is less investment in the industry, leading to no or little improvement in the quality of buses, along with an inability to fulfil any bulk orders in a short time period.

Another major challenge that most bus operators (especially STUs) currently face is their inability to recover operational costs through their current revenue streams. This is partially due to the nature of their business (and thus cannot be addressed beyond a certain point) and partially due to current financial and operational inefficiencies. Hence, public bus companies are completely dependent on government funding to overcome any operational losses, maintain and expand their fleet strength, and develop bus infrastructure. In this scenario, the state budgetary machinery and State Transport Department view each additional bus in the fleet as a liability and each rupee pledged to the STU as a sunk cost. This generates a resistance within the government to investing in STUs. This is a major bottleneck for any STU expansion and revival plans. In a scenario where financial support from the state is hard to come by, these organisations enter an accelerating downward spiral.

Since STUs have come to be viewed as less of an essential (mobility) service provider and more of a liability (especially for urban services) by many in the government, there is always resistance to expanding their services into more cities or forming new public bus companies for cities not currently served by one.

In such a situation, a long-term resource plan could help facilitate a constructive dialogue between the government and bus operators on how to enable meaningful restructuring/replanning of costs, finances, and other resources, in order to effectively meet both the current and latent demand of bus services in India. This demand is great, and there is currently a huge gap between the number of cities eligible for a bus service and those served by one. Cities or urban agglomerations with a population of over 0.1 million can have a regulated viable urban bus system[1]. Over 80 buses are required for cities with population of over 0.25 million, meaning they can have at least one formal bus depot, and a government-supported or managed urban bus company may be required to operate services in cities with this or a greater population size. As per the Census 2011, the total number of cities in India with a population of over 0.1 million was 459, that with a population of over 1 million was 51, and 3 had a population of over 10 million. It is estimated that this number will increase to 1,196 cities with a population of over 0.1 million,

[1] Based on current observations and city bus data mined for the model used in this study.

120 cities with a population of over 1 million, and 9 cities with a population of over 10 million by 2060. We estimate that, as of today, a total of 190 cities have a population above 0.25 million, and 586 cities have a population of over 0.1 million. In contrast, currently only 176 cities have some form of an organised, semi-organised, or informal bus system in India[2]. There are about 55 public bus companies that operate some form of urban bus services. This not only means that the government needs to support the establishment of multiple public bus companies at the municipal level today, but also that it needs to put a system in place for providing bus services to any city that becomes eligible. Given the current pace of urbanisation, it can be estimated that every year, six urban bus companies/operators will need to be established in different cities/urban agglomerations.

[2] Based on baseline data and outputs from the model used in this study.

2 Methodology

This study includes the development of a national bus resource aggregator model based on the thumb rule estimator of FLEET tool. This modified version allows estimation and aggregation of resource requirements in multiple geographic area. The two versions of this model generate annual urban bus resource requirement for 5,724 cities (with current population of more than 5,000) and non-urban bus resource requirement of 36 States and union territories. The outputs included in this report have been generated using these two different models – one for urban operations and one for non-urban operations. This report presents findings specific to urban and non-urban operations, along with aggregated requirements for overall bus operations in India. The functionality and methodology of the estimation in the models is similar, but the assumptions and base values may differ. This section presents the three scenarios for which findings have been derived. This is followed by an explanation of the estimation methodology used in the models for generating the outputs and findings included in the current report. The model estimates demand in terms of passenger trips, based on which the bus requirement is estimated. This, in turn, is used to estimate the overall resource requirement and other externalities in terms of financing, land, manpower, emissions, etc. The estimation methodology for each of these stages is also discussed in this chapter. Additionally, a discussion of assumptions and base values used in the model is provided.

2.1 Scenarios

Outputs from the model have been generated for a total of three scenarios. These scenarios are the BAU scenario, low ambition (LA) scenario, and high ambition (HA) scenario. These scenarios are based on the variation in mode share and time period, as well as the extent, of electrification of buses. For all scenarios, the grid emission factor reduces from 1.31 kg CO_2e/km to 0 kg CO_2e/km in 2050. In each of the scenarios, viability gap funding (VGF) has been estimated based on two different approaches to fleet procurement/induction – outright purchase and GCC. The urban mode share is generated using a modelled trend curve for buses per 1K population. These trend curves have been generated separately for the three scenarios. In contrast, non-urban mode share values are direct inputs in the model. The current mode share of non-urban public bus trips (of all non-urban trips) is 5.4 percent. This is derived from the state-wise population data, PCTR, estimate of the current non-urban bus fleet in each state, and estimated average passenger trips per bus per day. The mode share of non-urban bus trips varies significantly among states (based on the tourism potential, fleet availability, etc.). The weighted average (weighted by population) regional mode share of 16 states (with relatively higher non-urban mode shares)—Jammu & Kashmir, Himachal Pradesh, Delhi, Haryana, Punjab, Uttarakhand, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Telangana, and Andhra Pradesh—is about 8 percent. At the same time, the weighted average regional mode share of the three highest mode share states, Karnataka, Kerala, and Tamil Nadu, is over 15 percent. Therefore, these values are used in defining the LA and HA scenarios. The variations in the defined scenarios are presented in Table 1 and explained below.

Table 1: Comparison of BAU, LA, and HA scenarios

	Non-urban bus mode share (to be achieved in 10 years)	**Trips by urban services**[3]	**Electric fleet composition to be achieved for non-urban services (in number of years)**	**Electric fleet composition to be achieved for urban services (in number of years)**
BAU scenario	5.4%	35-40% of 7-15 km trips by bus	13.2% (30)	13.2% (30)
LA scenario	8.0%	66% of 7-15 km trips by bus	100% (15)	100% (10)
HA scenario	15.0%	100% of 7-15 km trips by bus	100% (15)	100% (10)

- BAU scenario – This scenario entails natural fleet growth and electrification governed by current conditions, with no intervention to accelerate electrification or expand the fleet size. The salient features of this scenario are the following:
    - Mode share - Urban and non-urban bus mode share in the future is maintained at the current levels. The model uses a bell curve for buses per 1000 population, generated from current city data in this scenario (Figure 1). The national aggregated mode share (as an outcome of this bell curve) of urban bus services increases from the current 2.5% to 4% in 2050. This is not on account of mode share increasing in individual cities, but, rather, due to an increase in the number of cities with populations above 80,000, which all require a bus system. For non-urban services, the current national average mode share of 5.4% is retained in future years.
    - Composition of electric buses in the fleet – Electric buses grow (from the current levels) linearly at the current observed rate of about 0.4% per annum, to about 13.2% per annum over a 30-year period.

[3] The model estimates the number of trips in this range using the bell curve presented in this section. A bell curve has been generated for each of the scenarios.

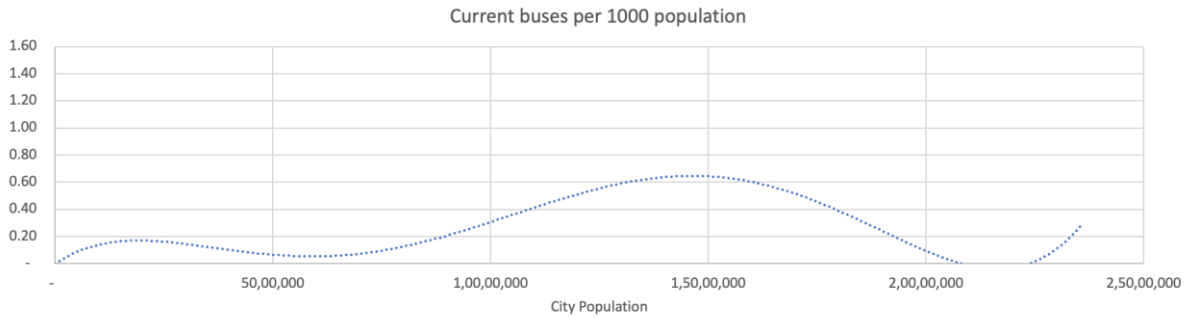


Figure 1: Current number of buses/1K population

- LA scenario – This scenario includes the impact of 100% electrification over a 10-to-15-year time period and limited fleet size expansion over a 10-year period. The fleet expansion modelled in this scenario is expected to be possible without significant supporting policy and regulatory actions. The salient features of this scenario are the following:
    - Mode share - Urban and non-urban bus mode share increase in the future. A bell curve of buses per 1000 population is derived from the expected number of passenger trips to be covered by buses. Two-thirds of all 7-15 km passenger trips are considered as potential bus trips in this scenario (Figure 2). For non-urban services, the current national average mode share increases from 5.4% in 2021 to 8% over a 10-year period.
    - Composition of electric buses in the fleet – Electric buses grow (from the current levels) to 100% electric bus procurement for the urban fleet over a 10-year period and 100% electric bus procurement for non-urban services in 15 years (100% on-road electric bus fleet before 2050).

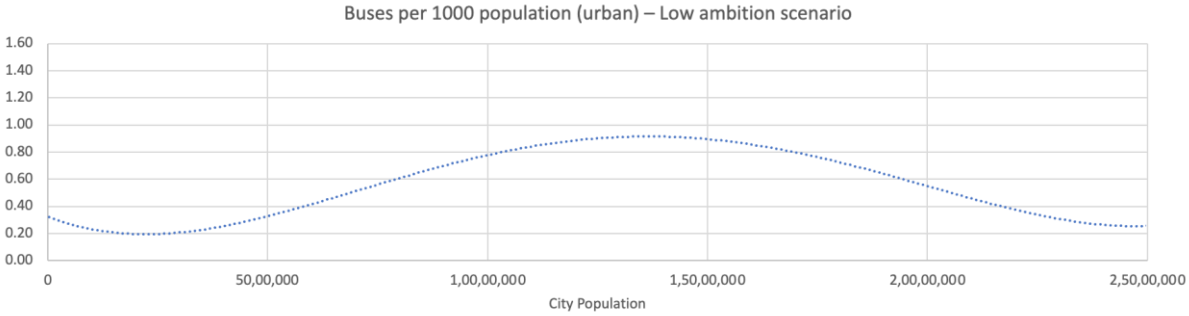


Figure 2: Number of buses/1K population in low ambition scenario

- HA scenario – This scenario includes the impact of 100% electrification over a 10-to-15-year time period and significant fleet size expansion over a 10-year period. The fleet expansion modelled in this scenario is not expected to be possible without significant supporting policy and regulatory actions. The salient features of this scenario are the following:
    - Mode share - Urban and non-urban bus mode share increase in the future. A bell curve of buses per 1000 population is derived from the expected number of passenger trips to be covered by buses. 100% of all 7-15 km passenger

trips are considered as potential bus trips in this scenario (Figure 3). For non-urban services, the current national average mode share increases from 5.4% in 2021 to 15% over a 10-year time period.

- Composition of electric buses in the fleet – Electric buses grow (from the current levels) to 100% electric bus procurement for the urban fleet over a 10-year period and 100% electric bus procurement for non-urban services in 15 years (100% on-road electric bus fleet before 2050).

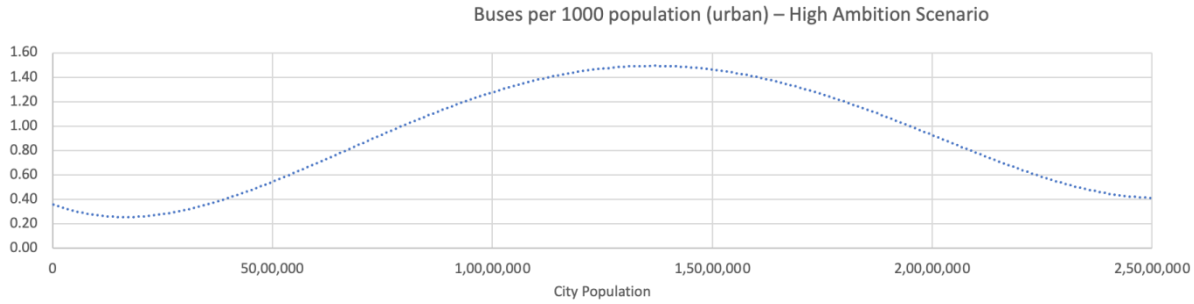


Figure 3: Number of buses/1K population in high ambition scenario

2.2 Population Projection

The demand for buses in each state/region/urban area is based on the population that needs to be served, their per capita trip rate (PCTR)[4], and the bus mode share. Furthermore, in urban areas, bus demand is also dependent on the number of passenger trips that cover a distance viable for bus use (6-15 kilometres (km)). This, in turn, depends on the city size and governs the bus mode share (including the potential mode share). For a smaller city, there are more trips in the short trip length range (less than 7 km), while for megacities, the number of trips with a length above 15 km increases. It has been found that cities with a population of around 1.4-1.5 crore will have the highest proportion of trips in this length range, which is attractive for buses. As the city size changes, the frequency distribution of trips by trip length changes, which also changes the mode share. Even if the bus mode share remains constant, with an increasing population, the demand for bus-based passenger trips will increase, as there is a direct link between the two.

Since population is one of the most important parameters in estimating travel demand, the accuracy of future demand projections is dependent on the accuracy of future population projections. The model uses projected data for the national overall and urban populations up to 2050, as given in the 2018 United Nations (UN) World Urbanisation Prospects Report (United Nations, 2018). This data is used to derive the annual average population growth

[4] The per-capita trip rate for the urban and non-urban populations is different, and these rates have been estimated separately based on census data. While various factors could increase the PCTR in the future, such as increasing incomes, other factors such as telecommuting and improvement in the urban form (increasing densities and mixed land-use) could decrease the future trip rates. Therefore, PCTR is assumed to remain the same. PCTR will only change for a population that shifts from rural to urban.

rate for the national overall and urban population. A best fit polynomial trend line with an R^2 of nearly 1 for both sets of data has been plotted (Figure 4). The equation of this trend line has been fed into the model to project the overall population for each state, urban population (for each city and aggregated for each state), and rural population (difference between the national overall and urban population) annually up to 2060. The results indicate that the total population of India is expected to increase by 21% to about 174 crores from the current 144 crores over the next 40 years, i.e., by 2060. The overall population will be around 171 crore in 2050, while the urban population in that same year is expected to be around 86 crore. The total urban population of India is expected to increase by nearly 100% (i.e., it will double) over the next 40 years, from 49 crores today to 97 crores in 2060. These numbers are used with the PCTR and mode share (discussed below) to estimate the demand in terms of bus passenger trips for both urban and non-urban services, disaggregated at the city and state level. It should be noted that since state-level population projections were not accessible, national average urban population growth rate numbers have been applied to all states and urban areas, although it is expected that the rate of growth of urban and non-urban populations will vary by region.

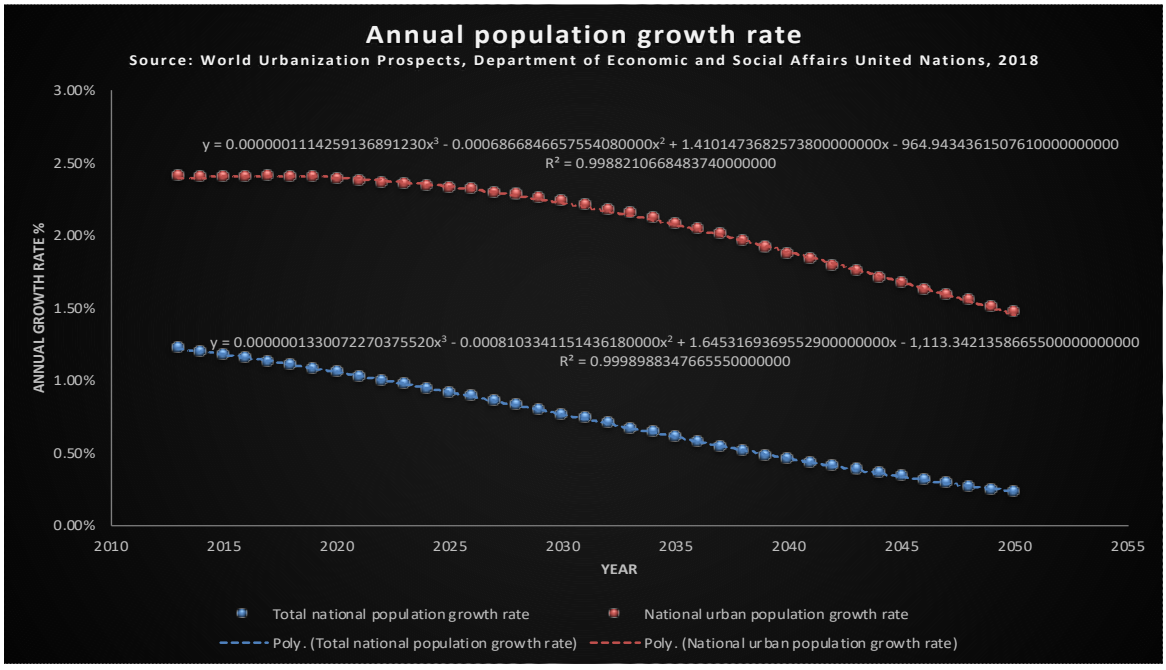


Figure 4: Urban and overall national population annual growth rates derived up to 2050 based on data from the 2018 UN World Urbanisation Prospects Report

2.3 Fleet Size Estimation

The model uses an estimated value of buses per 1000 population (buses/1K population) to derive the fleet size for both urban[5] and non-urban[6] bus operations.

[5] Urban Operations – Bus stops are at approximately 500 m intervals.

[6] Non-Urban Operations – For all buses plying outside the city limits, including regional and mofussil services.

2.3.1 Urban Bus Operations

For urban operations, the value of buses/1K population is derived using a relationship between the city size and share of population travelling a daily one-way distance of 6-15 km (considered attractive for use by urban bus systems). The number of trips with a length of 6-15 km has been derived from census data for 35 Indian cities. The number of buses or bus fleet size required to cover these trips is derived using documented urban bus operational characteristics in India. These include average occupancy, average passenger trip length, daily average vehicle utilisation, and average fleet utilisation. When used with total population numbers for each city, this yielded a value for buses/1K population for each city. These values were derived in three scenarios – 1) business as usual (BAU), with 1/3 of total trips in the city with a trip length of 6-15 km covered by buses, 2) low ambition scenario, with 2/3 of total trips in the city with a trip length of 6-15 km covered by buses, and 3) high ambition scenario – 100% of total trips in the city with a trip length of 6-15 km covered by buses. These have been used to plot a trend line for each scenario (Figure 1 to Figure 3), which was used to predict the number of buses/1K population for any city size in each scenario[7]. With this value, the bus fleet requirement for any city with a given population can be derived in the model for a defined scenario. Additionally, this allows the model to plot temporal variation of this value (and, thus, the fleet size)[8].

2.3.2 Non-Urban Bus Operations

For non-urban operations, the fleet size is derived using the average PCTR and mode share. The average PCTR for each state for each of the projection years is estimated based on known average PCTR values for non-urban trips generated/attracted by urban areas and non-urban areas. Non-urban trips generated/ attracted by urban areas have been further categorized based on the type of region—plains, hilly regions, islands, and union territories. Census data has been used for each of these regions to derive an average national PCTR value for each type of region. The model uses pre-fed urban and rural population data (from Census 2011) to estimate PCTR on non-urban trips generated/attracted by urban areas and non-urban areas in all states. This is then used to derive a weighted (weighted by urban and rural population) average PCTR for each state for each projection year. Therefore, with the changing shares of the urban and rural populations in each state (as discussed above), the average PCTR value for each state changes over the years in the projection time period. The current non-urban bus mode share of non-urban trips is estimated by the model as 10.8

[7] The bell curve in the trend line for each scenario was used for populations between 6.5 and 18 million in the BAU scenario, populations between 2.5 and 25 million in the low ambition scenario, and populations between 1.7 and 26 million in the high ambition scenario. For populations outside of this range, the value was taken as constant based on the value at the outer limits of the range. For example, in the BAU scenario, if the number of buses/1K population for a population of 6.5 million is 0.7, it is assumed to be 0.7 for any city with a population less than 6.5 million.

[8] The number of passenger trips with a length of 6-15 km varies with city size, the indicator of which is the population. This is based on the data from 35 Indian cities.

percent. Mode share projections are used for different scenarios, using which the expected mode share is estimated for each of the projection years. The projected average PCTR value, population, and mode share in each year is used to estimate the total non-urban bus trips for each state (in each projection year). This is used to estimate the number of buses/1K population for each state in each projection year. Finally, this is used to estimate the fleet requirement based on the average occupancy, passenger trip length, and vehicle utilisation of non-urban buses.

2.4 Bus Resource Requirement Estimation

The annual resource requirement estimates projected over a long term in the future can facilitate the development of a road map to bridge the gap. The current report uses a 40-year horizon period up to 2060, and estimates are generated annually for this period. The generated urban estimates have been disaggregated at the city level. To achieve this, population, annual growth rate, and existing bus fleet data have been compiled for all 5,724 Indian cities (including urban agglomerations) with a population above 5,000. City-level data and outputs have been aggregated at the state and national level. For non-urban services, outputs and data disaggregated at the state level have been compiled. These, in turn, have been aggregated at the national level. The model assumes that any form of bus services is required only in cities or urban agglomerations with a population above 1,00,000. Based on the current data available and observations made in different cities, it is assumed that minibuses (7 m length) are required for cities with a population of 1-1.8 lakh, midi buses (9 m length) are required for cities with a population of 1.8-2.6 lakh, and urban buses (12 m length) are required for cities with a population above 2.6 lakh. The total fleet size in each state is derived from national annual bus registration data (MORTH, 2019) . The existing fleet of non-urban buses for each state has been generated by calculating the difference between the total number of urban buses (compiled for each state based on secondary data) and total number of registered stage carriage buses.

The future road map for achieving the bus resource requirement and generating sufficient capacity to cater to the projected demand is based on the assumption of a transition period. The road map is generated for transitioning to the required capacity (bridging the demand and capacity gap of the bus fleet in each region) in ten years. This is because transitions in shorter timeframes are likely to entail a significant financial burden in the initial years, since the demand and supply gap for both urban and non-urban services in many regions is significant (potential non-urban demand is estimated to be three times the current supply). At the same time, transitions taking longer than ten years will make it difficult to achieve the global targets for decarbonisation of the mobility sector. Similarly, the targets for 100% electrification of the bus fleet have been set between 10 and 25 years (in different scenarios, explained below) for urban services and between 15 and 30 years (in different scenarios, as explained below) for non-urban services. These targets are for the transition to 100% new electric bus purchase, rather than use (because internal combustion engine (ICE) buses bought a year prior will remain in service for around 12 years).

The model estimates demand and supply for each year for each state/city/region (as per the methodology explained above). This estimation includes the fleet size required to serve the estimated passenger trip demand. Since the gap between the current and required bus fleet size can be very large, it is expected that cities/regions/bus operators may take several years to cover this gap. The model allows users to define this time period, and a 10-year time period for bridging this gap is currently specified in the default values. Therefore, the model estimates the supply of ICE and electric buses that will be brought into operations annually during this transition period. For the existing fleet, the assumption is that the purchase of all ICE buses currently in use has been equally spread across the defined bus service period (in years). However, all current electric buses have been defined to be inducted in 2019. This is used to estimate the number of ICE and electric buses that will get scrapped each year, along with the number that need to be purchased annually to both replace the ageing fleet and augment the fleet size in order to meet the projected targets. The annual fleet size estimates and estimates of number of buses to be purchased enable an estimation of the annual operational costs, revenue, capital expenditure, staff requirement, land requirement, emissions, etc. The gap between annual revenue and expenditure (operational + capital cost – revenue) generates the annual resource requirement in terms of budgetary support required (or viability gap funding requirement).

2.5 Model Base Values and Assumptions

The values used for estimation of outputs in the long-range bus resource requirement model can be categorised as those for demand, cost and revenue, operations, and infrastructure. As a default, the model outputs are based on capital cost values for buses in an outright purchase plus operational cost method, and not a Gross Cost Contract (GCC) method. For users to work on the GCC method, the default value of the capital cost will need to be set to 0, and the per km operational cost will need to be modified to account for the principal and interest amount on the capital cost.

2.5.1 Current Bus Passenger Trip Demand

The demand estimates for bus transport in the model (for both urban and non-urban operations) is derived from 2011 census data (GoI, 2011). Since the census data only covers work trips, the share of work trips in the total trips has been derived from literature (Tiwari & Nishant, 2018; Gupta & Dhameniya, 2016; Arora, 2014). This enables an estimation of the number of urban and non-urban trips[9] per day. This data has been computed for 56 regions (geographic areas of operations for 56 STUs), and the same has been compiled in FLEET Tool version 1.96 (SGArchitects, 2021).

[9] Bus trips confined within urban limits, i.e. routes confined to urban limits, with stops approximately every 500 m, are referred to as urban trips, while all trips on routes that entail travelling across non-urban areas, including regional trips and mofussil trips, are classified as non-urban trips.

2.5.1.1 Urban Bus Operations

Using this information, PCTR for each of these regions has been estimated. Based on this data, we know that the average PCTR for urban areas is 1.5. A total of approximately 50,000 buses are currently operating on intra-city routes (Annexure 1). These are estimated to cover about 3 crore (30 million) daily passenger trips[10], which amounts to less than 3% mode share of all urban trips[11]. This is based on an average trip length of 10 km, 70% average occupancy, and average daily vehicle utilisation of 200 km.

2.5.1.2 Non-Urban Bus Operations

For non-urban trips from non-urban areas, PCTR is 1.29 and 1.18 for plains and hilly regions/islands, respectively. The non-urban trips from union territories (such as Chandigarh) and City States (such as Delhi) are mainly intercity trips. The average PCTR of non-urban trips from urban areas derived from Census 2011 is about 0.08. However, we know based on literature that PCTR for non-urban trips from urban areas is less than 0.15 (The Economic Times, 2020; Wikipedia, 2020; Northern Railways, Indian Railways, 2019). We therefore use a PCTR value of 0.1 for non-urban trips from urban areas. These PCTR values are used to estimate the total number of non-urban trips (in the model), which, when compared with the total non-urban trips by public transport buses[12], indicates that the mode share of all non-urban trips by buses is 5.4 percent. The current bus-based non-urban work trip mode share of total trips (including work, education, and non-work trips) is 6.7%[13]. Using this, and assuming the share of non-work and education trips by buses to be the same as that of non-work trips (as derived from the census data), the mean non-urban bus trip mode share of the total non-urban trips for India is derived as 17.2 percent. This is significantly higher than the mode share by public transport or stage carriage buses (i.e. 5.4%, as mentioned above), because passenger trips by buses listed in the census include not only public transport or stage carriage bus operations, but also school bus and other contract carriage bus operations[14]. This suggests that more than twice the public bus

[10] Based on 600 passenger trips per bus per day, with an average passenger trip length of 10 km, on a 42-seater bus with an average daily occupancy of 70% and average daily vehicle utilisation of 200 km.

[11] All urban trips include all passenger trips (by all modes) in all 5,724 cities and towns in India with a population above 5,000.

[12] Based on the current number of buses registered as stage carriage buses for non-urban operations, which is approximately 4 lakhs (MORTH, 2019). These cover about 6 crore daily non-urban bus trips (based on a 60 km average passenger trip length).

[13] Derived from census data for 56 regions covered by currently operational STUs. Census data provides data on the number of work trips by different travel modes in a given region. This includes all passenger trips, including walking and non-motorised transport.

[14] Census data classifies the travel mode as “bus”, which does not necessarily mean public transport bus, but can also include contract carriage buses, school buses, private (office) buses, etc. Additionally, many buses operating on regular routes may not have a stage carriage permit issued by the Regional Transport Office (RTO).

commuter trips are by other buses in India, which includes school buses, office buses, privately hired buses, and other buses.

2.5.2 Cost and Revenue

The expected service life of an ICE bus operating approximately 200 km per day is 12 years (Nordelöf et al, 2019) (Krelling & Badami, 2019), while the expected service life of an electric bus is often considered as high as 15 years (Sheth & Sarkar, 2019). Therefore, these values are used for ICE and electric bus service life in the model, for both urban and non-urban operations.

2.5.2.1 Capital Cost

The on-road capital cost of a 12 m ICE urban bus varies significantly for standard floor and low floor buses and between compressed natural gas (CNG) and diesel buses, i.e., based on bus technology and fuel type (refer to Table 2). The cost for an urban bus varies from 35 lakh to 109 lakh for different technologies and types (Krelling & Badami, 2019).. Assuming an average fleet composition of 50% diesel standard floor non-AC buses, 40% diesel low floor non-AC buses, and 10% diesel low floor AC buses [15], the average cost of an ICE fleet is estimated at Rs. 65 lakh per bus.

Table 2: On-Road Capital Cost of ICE & Electric Urban & Non-Urban Buses

S. No.	**Bus Technology and Fuel Type**	**Standard 12 m Bus (Rs.)**	**Midi 9 m Bus (30-32-seater) (Rs.)**	**Mini 7 m Bus (15-18-seater) (Rs.)**
1.	Diesel Standard Floor (Non-AC & Urban)	35 lakh[16]	26 lakh[17]	15 lakh[18]
2.	Diesel Low Floor (Non-AC & Urban)	76+ lakh[16]		
3.	CNG Standard Floor (Non-AC & Urban)	45 lakh[16]	26 lakh	
4.	CNG Low Floor (Non-AC & Urban)	92 lakh[16]		
5.	CNG Low Floor	109[16]		

[15] Most cities are avoiding low floor buses due to their higher maintenance and capital costs. However, they are needed on each route to ensure that services are disabled-friendly. This is why many cities settle for a 50% share of low floor buses in the fleet, and the same is considered for this study.

[16] Derived from literature (Christian Krelling & Madhav G. Badami, 2019)

[17] Derived from literature (TrucksBuses AutoWeb Pvt. Ltd., 2021)

[18] Derived from online source (Quikr, 2021)

S. No.	Bus Technology and Fuel Type	Standard 12 m Bus (Rs.)	Midi 9 m Bus (30-32-seater) (Rs.)	Mini 7 m Bus (15-18-seater) (Rs.)
	(AC & Urban)			
6.	Electric Floor Standard (Non-AC & Urban)	73-110 lakh (for 100 km range) & 90-130 lakh (for 200 km range)[19]	75 lakh[20]	21-47 lakh[21]
7.	Electric Standard Floor (AC & Urban)	88-150 lakh[22]	95 lakh[22]	36-67 lakh[22]
8.	Diesel Standard Floor (Non-AC & Non-Urban)	35 lakh[16]		
9.	Diesel Standard Floor (AC & Non-Urban)	50 lakh[16]		

The capital cost for an urban mini and midi buses varies from 21 lakh to 47 lakh for different technologies and fuel type (TrucksBuses AutoWeb Pvt. Ltd., 2021; Alibaba, 2021; DHI, 2018; Quikr, 2021)

As discussed below, with the decreasing cost of batteries, the average cost of electric buses over the next 10-15 years is expected to be about 1.5 times the capital cost of their ICE counterparts. This means that for long-range estimation purposes, the average cost of a midi electric bus can be taken as Rs. 39 lakh, and that of a mini electric bus can be taken as Rs. 23 lakh. These prices are considered the same for both urban and non-urban buses. The estimated capital cost of a 12 m electric urban bus (non-AC, standard floor) varies from Rs. 73 lakh to Rs. 110 lakh for a 100 km range bus and from Rs. 90 to 130 lakh for a 200 km range bus (Ollivier et al, 2020; Basu et al, 2021). An AC bus is expected to cost Rs. 15-20 lakh more than a non-AC bus (SGArchitects, 2021).

For the ICE bus fleet, we assume a composition of 50% diesel standard floor buses, 25% diesel low floor non-AC buses, and 25% diesel low floor AC buses. This results in an average

[19] Derived from literature (Mr. Gerald Ollivier et al, 2020; Rakhi Basu et al, 2021)

[20] Derived from literature (Department of Heavy Industry, 2018)

[21] Derived from online source (Alibaba, 2021)

[22] Derived from literature (SGArchitects, 2021)

per bus price for ICE buses of around Rs. 65 lakh. For the electric bus fleet, we assume a composition of 50% standard floor non-AC electric buses with a 200 km range, 40% low floor non-AC electric buses with a 200 km range, and 10% low floor AC electric buses with a 200 km range. This yields an average per bus cost of about Rs. 107 lakh (at the current battery price for the manufacturer of United States Dollar (USD) 120/kilowatt-hour (kWh)). Based on current battery prices, the on-road cost of electric non-AC midi and mini-buses is expected to be Rs. 39 and 23 lakh, respectively, for the current year. The cost of batteries (in India) for electric buses is expected to fall by at least USD 100 kWh the next two decades (Sengupta, 2020; BNEF, 2020), from 2017-18 prices. This has been factored into the model projections.

The on-road capital cost of a 12 m standard diesel bus for non-urban services is expected to be same as that of an urban bus, i.e., approximately Rs. 35 lakh. The price of a diesel AC bus is expected to be Rs. 15 lakh higher than a diesel non-AC bus (Krelling & Badami, 2019). For non-urban operations, the on-road cost of an Indian-made luxury intercity bus such as Tata Divo is approximately Rs. 66 lakh (Mail Today, 2011), while that of a foreign brand such as the Volvo 9400 XL is approximately Rs. 90 lakh (Writer, 2021). The majority of non-urban bus services are focused on regional and rural routes, with a few services catering to intercity routes. We therefore assume that nearly 30% of buses are non-AC midi buses, 30% are non-AC standard-length buses, 30% are AC standard-length buses, 5% are local/Indian luxury coaches, and 5% are international brand luxury coaches (Volvo, Mercedes, etc.)[23] (for both the current ICE and future electric fleet). Based on this, the average on-road capital cost of a mix of ICE buses in a fleet of buses operating non-urban services is estimated as Rs. 42 lakh. The capital cost of a mix of electric buses (including battery) is estimated to be Rs. 87 lakh[24].

The on-road cost of electric buses (both in the outright purchase and GCC scenarios) is estimated as a sum of two components: the cost of the vehicle without the battery and the cost of the battery. The battery pack cost (borne by the bus manufacturer) is estimated at USD 120/kWh in 2020 (Sengupta, 2020)[25] and USD 69/kWh (BNEF, 2020)[26] in 2030 and assumed to flatten to USD 58/kWh beyond 2037. Thus, the model generates and uses a declining cost curve for electric buses up to 2037, and a fixed cost beyond that. The battery pack size varies with bus and service type in the model, and, thus, the battery pack cost is

[23] This is derived from the observed breakup of different bus types in a fleet of STUs (MSRTC, APSRTC).

[24] Non-urban buses need to be designed for ranges of over 300 km, and therefore require a bigger battery pack (about 50% bigger than for urban buses). This leads to a higher bus cost than that of similarly sized urban buses.

[25] Based on the current international expected cost of USD 100/kWh and USD 20/kWh for lithium-ion battery freight and delivery, respectively.

[26] Based on the projected average battery price (for different chemistries) of USD 61/kWh, and USD 8/kWh as local taxes and duties (assuming the bulk of batteries used in 2030 to be locally manufactured and sourced).

estimated based on the service and bus type. The cost of the electric bus without the battery is estimated by deducting the battery price cost (USD 120/kWh) from the electric bus price (including the battery) derived above. Similarly, the per km battery cost is estimated in a GCC scenario, and a per km cost of battery replacement is estimated in an outright purchase scenario[27]. The per km battery cost in a GCC model is estimated as Rs. 9 per km for a standard-length urban bus, Rs. 7 per km for an urban midi bus, and Rs. 6 per km for an urban minibus. The cost of an average non-urban bus (as per the average fleet composition discussed above) is estimated at Rs. 9 per km. Similarly, the per km cost of replacement battery (in bus operations) for urban services is approximately Rs. 3 per km for all bus types, and close to Rs. 4 per km for an average fleet type for non-urban services. These costs are based on the current battery cost of USD 120 per kWh in the GCC model and Rs. 75 per kWh in the outright purchase model (as explained below). These costs decrease (annually) in the model with the decreasing battery cost to USD 58/kWh beyond 2037.

The residual value recoverable at the time of the scrapping of the bus (at the end of its service life) is estimated to be 13.4-14.9% (Krelling & Badami, 2019). We have therefore taken 14% as the average residual value at the end of the bus's service life. This amounts to Rs. 9 lakh on an average cost of Rs. 65 lakh for an ICE urban bus. Electric buses, excluding the batteries, are expected to yield a lower value because of the longer service life and lower-cost recoverable components. The end-of-life residual value of the battery for a 120-kWh battery pack in an electric bus is estimated at approximately Rs. 2-3 lakh (Kamath et al, 2020).

Accounting for this, the end-of-life residual value of a 12 m electric bus, including the battery pack, can be assumed to be the same as that of an ICE bus. Similarly, the end-of-life residual value for both ICE and electric midi and minibuses is estimated at Rs. 5 lakh and Rs 3 Lakh, respectively.

2.5.2.2 Operational Cost

The model considers an average utilisation of 180-190 km per day for urban buses. This requires one battery replacement over the lifetime of the bus, based on 2600 charging cycles (Preger et al, 2020). The operational cost of a standard-length electric bus should incorporate the battery replacement capital cost and related interest component - assumed to be 10% per annum for 6 years in a GCC scenario. An interest component has also been considered in the outright purchase of buses; this is estimated at an average annual interest rate of 6.5% for a 6-year period. This enables the inclusion of the cost of credit to the government and, thus, an effective comparison between GCC and outright purchase scenarios (refer to Annexure 0). The battery cost over a 7-year period from today is estimated at USD 75/kWh (Debjoy Sengupta, 2020). The maintenance cost of electric buses is expected to be lower than that of ICE buses. The model assumes 10% lower maintenance

[27] The battery replacement cost is accounted for in the operational cost of buses in an outright purchase model.

staff costs (on account of the expected lower maintenance staff requirement) and 25% lower material costs for electric buses than ICE buses. Table 3 presents the breakup of cost per km (CPK) for ICE and electric urban and non-urban buses in a GCC model based on the available literature (Krelling & Badami, 2019; CIRT, 2018; CIRT, 2020; SGArchitects, 2015; Sengupta, 2020)[28]. The charging cost of urban electric buses is expected to be approximately Rs. 5-6/kWh; however, it increases to Rs. 8/kWh, if the cost of charging infrastructure (bus chargers and related infrastructure such as transformers and cabling) is included[29]. The total operational cost (TCO) of 12 m electric urban buses is estimated to be 9% higher than that of 9 m electric midi buses (Gadepalli et al, 2020). Similarly, the TCO of 9 m electric midi buses is assumed to be 9% higher than that of 7 m electric minibuses. This has been used to estimate the operational cost of 9 m electric midi buses and 7 m electric minibuses. Furthermore, the model inputs bifurcate the per km operational cost of buses into per km battery cost and per km bus cost without the battery. This is to enable the modelling of declining battery costs (explained above) over the estimation period in the model.

Table 3: CPK breakup for urban and non-urban buses in GCC model

Item (Rs.)	**12 m urban ICE bus**	**Urban ICE midi bus**	**Urban ICE minibus**	**12 m urban electric bus**	**Urban electric midi bus**	**Urban electric minibus**	**Average non-urban ICE bus**	**Average non-urban electric bus**
Per km fuel cost	26.69	16.91	12.25	9.29	9.29	8.65	20.19	7.77
Staff/ manpower cost[30]	32.37	32.37	32.37	31.92	31.92	31.92	26.41	26.13
Material cost (including spares and insurance)	7.44	7.44	7.44	5.58	5.58	5.58	9.07	4.54
Taxes	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35

[28] Spares, insurance, and manpower costs, etc. are considered to be the same for ICE and electric buses.

[29] In a situation when energy distributors install the charging infrastructure and include the same in the energy cost.

[30] All costs for staff, including crew, administration, and maintenance staff.

Item (Rs.)	12 m urban ICE bus	Urban ICE midi bus	Urban ICE minibus	12 m urban electric bus	Urban electric midi bus	Urban electric minibus	Average non-urban ICE bus	Average non-urban electric bus
Bus cost[31] (capital + Interest)	13.71	5.48	3.16	21.74	10.59	7.71	5.61	14.05
Miscellaneous and other expenses	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90
Profit and contingency	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Total	88.46	70.45	63.47	80.06	69.36	65.96	69.54	65.49

We have used a breakup of different cost components (refer to the discussion above) to estimate the cost of operations (in CPK) for non-urban services at Rs. 59 per km for a mix of midi, standard, and luxury (see above) ICE buses and Rs. 47 per km for a mix of electric buses in an outright purchase model. In comparison, the average CPK of non-urban public bus services in 2017 was Rs. 64 per km, while this value for larger STUs was Rs. 37 per km (CIRT, 2018). Considering an average inflation rate of 4% annually, these values should be Rs. 75 per km and Rs. 43 per km, respectively, today. In a GCC model, the CPK for a mix of non-urban services includes the capital and interest cost of the bus. Accounting for this, the CPK for ICE and electric non-urban services is estimated at Rs. 70 per km and Rs. 67 per km, respectively. Table 4 presents the capital cost, CPK, and earnings per km (EPK) values in the outright purchase and GCC scenarios for different bus types. These have been used as an input in the model.

2.5.2.3 Revenue

Average EPK, including non-fare box revenue for urban operations, is estimated at around Rs. 35 per km for all urban STUs (CIRT, 2018). EPK values reported in the Central Institute of Road Transport (CIRT) annual report are for different bus sizes; however, the majority of operations are by 12 m buses[32]. Based on this, the average EPK for 12 m buses is estimated

[31] For electric buses, the cost includes the battery replacement cost.

[32] This is based on the assessment of different urban STUs and their current fleet characteristics and size.

to be Rs. 40 today, assuming a 4% per annum increase in ticket prices and other non-fare box revenue. The fare box revenue is directly related to the bus occupancy, which, in turn, is linked to its seating capacity. The seating capacity of a midi bus is twice that of a minibus, while that of an urban bus is 30% more than that of a midi bus (Bhatia, 2019). This relationship is used to estimate the average EPK for midi buses and minibuses specified in the tool default values: Rs. 31 and 16 per km, respectively. These values remain the same for ICE and electric buses. They are used as default values in the model and can be edited by users where required.

The average EPK (including non-fare box revenue) for non-urban bus services in India in 2017 was Rs. 38 per km. However, the mean EPK in that year for larger operators such as Maharashtra State Road Transport Corporation (MSRTC), Karnataka State Road Transport Corporation (KSRTC), Gujarat State Road Transport Corporation (GSRTC), Uttar Pradesh State Road Transport Corporation (UPSRTC), and Andhra Pradesh State Road Transport Corporation (APSRTC) was Rs. 32 per km (CIRT, 2018). Considering an average annual inflation rate of 4%, the average EPK for non-urban services in 2021 can be estimated at Rs. 37-45 (based on the current mix of bus types). We therefore assume an EPK of Rs. 41 per km for both ICE and electric mixes (as per the composition explained above) of non-urban bus services.

Table 4: Bus capital and operational cost (for urban and non-urban operations) in outright purchase and GCC scenarios (based on 2021 battery prices)

Bus Type	**Average capital cost with battery (without battery), excluding interest (in Rs. lakh)**	**Average capital cost with battery (without battery), including interest, in outright purchase model (in Rs. lakh)**	**Average operational (CPK), including future battery replacement cost, in outright purchase model (in Rs.)**	**Average operational CPK, including future battery replacement cost, in GCC model (in Rs.)**	**Average EPK (in Rs.)**
Urban – standard-length ICE bus (mix of AC and non-AC, low floor and standard floor)	65	86	70	89	40
Urban – ICE midi bus – non-AC	26	35	60	71	31
Urban - ICE minibus – non-AC	15	20	55	64	16
Urban – standard-length electric bus (mix of AC and non-AC)	107 (75)	146 (99)	54	80	40
Urban – electric midi bus – non-AC	39 (23)	54 (31)	52	69	31
Urban - electric minibus –	23 (11)	32 (16)	50	66	16

Bus Type	Average capital cost with battery (without battery), excluding interest (in Rs. lakh)	Average capital cost with battery (without battery), including interest, in outright purchase model (in Rs. lakh)	Average operational (CPK), including future battery replacement cost, in outright purchase model (in Rs.)	Average operational CPK, including future battery replacement cost, in GCC model (in Rs.)	Average EPK (in Rs.)
non-AC					
Non-urban – mix of midi, standard, and luxury/coach ICE buses	42	56	59	70	41
Non-urban – mix of midi, standard, and luxury/coach electric buses	87 (53)	121 (70)	47	67	41

It should be noted that the breakup of the type of vehicles in a bus fleet and the CPK and EPK mentioned above for non-urban services is mostly applicable to public bus companies or STUs, because they serve most of the essential, but not profitable, routes and ensure essential mobility services in rural areas. We estimate the current share of the total fleet of non-urban buses in India operated by these public bus companies to be 25.57 percent. Although it can be accepted that private operators make profit, for estimation purposes in our model, we assume they just break even. This is because the profit earned by private operators cannot be used to cross-subsidise the public bus operations in the model. This suggests that the cost-revenue or viability gap estimated for all non-urban buses at the national level should only be considered for 25.57% of the fleet. We therefore use this factor to adjust the viability gap and revenue for non-urban services, both at the national and state level, in the model. Based on the above discussion, values for the estimation of cost and revenue have been derived and used in the model.

2.5.3 Bus Operations

Bus operation characteristics are essential to estimating the national resource outputs for both urban and non-urban operations, as they affect the number of buses required, total km operated, etc. to cater to a given demand.

2.5.3.1 Urban Bus Operations

The values used for bus operations are calculated using known trip characteristics of urban bus operations in India, including average occupancy, passenger trip length, vehicle utilisation, etc. It is known from the literature that most urban bus operators operate at an average daily occupancy not exceeding 70% (operators like Bengaluru Metropolitan Transport Corporation (BMTC)), whereas some operators operate at a high average daily occupancy of 120% (Metropolitan Transport Corporation (MTC) Chennai) (CIRT, 2018). We also know that the average length of urban bus trips is around 10 km in India, while a bus can cover 200 km per day on average in urban operations (Goel et al, 2014; SGArchitects, 2020). Based on this, the estimated number of passenger trips per urban bus per day is expected to be between 600 (at 70% average occupancy)[33] and 1000 (at 120% average occupancy)[34]. This number at 70-120% average occupancy for 30-32-seater urban midi buses will be 460-800 passenger trips per day, and for 15-18-seater urban minibuses, it will be 320-540 passenger trips per day. The model uses 70% average daily occupancy in urban buses.

2.5.3.2 Non-urban bus operations

For estimation of the fleet size for non-urban services, a region-based classification has developed for plains, hilly regions/islands, and union territories. The average passenger trips per bus have been estimated using the current mean vehicle utilisation and passenger trip length based on literature (CIRT, 2018). We estimate the current average daily bus utilisation for non-urban services at 300 km. For urban services, the vehicle utilisation is currently observed to be in the range of 190 km (CIRT, 2018). A lower limit of 169 km per day is assumed for small cities with scant bus operations. This is because services are expected to be less regulated in these conditions, and it may be possible that a crew functions in a single but smaller shift, instead of two 8-hour shifts. The mean passenger trip length for non-urban (including regional) services in the plains is estimated at 39 km (CIRT, 2018). The model assumes a 30 km average passenger trip length for non-urban services.

[33] The average occupancy of a standard bus at 70% occupancy is 30 passengers. The average passenger trip length is 10 km, with 200 km of bus operations per day. 200/10 = 20 passenger changes per day. Therefore, the total passenger trips per bus at 70% occupancy = 20 X 30 = 600. The model uses 600 passenger trips per day to estimate the total number of passenger trips by bus in the city, by multiplying it by the estimated number of buses required in the city.

[34] Passenger trips are not being calculated based on mode share, and the urban mode share is an outcome of the graph generated from the data from 35 cities (model of buses per 1000 population). We have estimated buses/1k population at 1000 passenger trips per bus per day and assess the expected mode share (based on latent demand) for different city sizes from there.

The average occupancy in 2016-17 for non-urban public bus companies in India was 72 percent. This translates to 30 passengers per bus for a 42-seater bus. Since most buses in regional and non-urban services have more than 40 seats, we assume an average occupancy of 30 passengers per bus for the estimates. This translates to approximately 300 passenger trips per non-urban bus per day.

Based on the standard accepted operational practice of holding 5% buses on standby in case of breakdown and other eventualities, the average fleet utilisation for both urban and non-urban services is assumed to be 95% in the model.

2.5.4 Manpower Requirement and Bus Emissions

Although there is some understanding of the per bus manpower requirement and per bus-km emissions, we could not find different values for urban and non-urban operations in the Indian context. We have therefore assumed the manpower requirement and per bus-km emissions to be the same in both cases.

Based on current staff data and documentation of best practices, the staff-to-bus ratio, based on 16-hour bus operations and a crew that includes conductors and all contractual and non-contractual staff for an operator, cannot be lower than 5.2 (ASRTU, 2017; CIRT, 2018). This factor is used to estimate the disaggregated and aggregated manpower requirement based on the fleet size estimated for each year in the different scenarios. Per km emissions for buses have been considered for a 12 m bus urban bus. These are based on documented values for standard length diesel buses with 1.55 kilograms (kg) carbon dioxide equivalent per km (CO_2e/km) (Embarq-WRI, 2014). Emissions from electric buses are estimated as 1.31 kg CO_2e/km. This is based on the current grid emission factor of 1.31 kg CO_2e/kWh and energy requirement of approximately 1 kWh/km for an average standard-length bus. The model assumes a linear reduction of the grid emission factor from its current value to zero by 2050 for all scenarios. When used along with the model-estimated data of the fleet size and total km operated, the per km emission factors enable aggregated and disaggregated estimation of overall bus emissions in different scenarios.

2.5.5 Infrastructure

Bus infrastructure characteristics and requirements have been estimated based on literature (SGArchitects, 2015; SGArchitects, 2017) and interactions with Indian operators such as BMTC, MSRTC, APSRTC, Jammu & Kashmir State Road Transport Corporation (JKSRTC), Himachal State Road Transport Corporation (HSRTC), and Orissa State Road Transport Corporation (OSRTC). The literature explains how the space requirement for bus infrastructure such as depots and terminals/stations can be estimated based on the fleet size. While bus depot size is directly related to the fleet size (because of the bus parking requirements), the bus terminal/station area requirement is also based on the number of bus trips per day to the station and average layover time.

2.5.5.1 Bus Depot/Workshop

The upper limit of bus depot capacity requirements (especially for electric buses, due to regulatory requirements regarding peak power demand at a site) is about 120 buses. 80-100-bus capacity bus depots are considered the most efficient in terms of operations, as well as space and equipment utilisation (SGArchitects, 2015). Therefore, a range of 80-120-bus capacity depots is used for the model (both for urban and non-urban operations). The per bus area requirement for an 80-bus depot is approximately 163 square metres (sqm), while that for a 120-bus depot is approximately 155 sqm. Therefore, an area requirement of 160 sqm per bus (both for urban and non-urban operations) is used in the model. The development costs for a bus depot and bus terminal are derived from current rule of thumb construction rates. These have been adjusted for significant differences in the open vs. built up areas for bus infrastructure (especially bus depots) and expected equipment cost. The average construction cost for a bus depot is taken as Rs. 12,500 per sqm, while that for a bus terminal is taken as an average of Rs. 14,500 per sqm (of site area) for at-grade bus parking, at-grade car parking, and maximum 2-level structures for bus terminals and semi-pucca structures (workshop sheds) for bus depots. This amounts to approximately Rs. 20 lakh per bus for depot development and Rs. 10 lakh per bus for bus terminal development.

2.5.5.2 Bus Terminal/Station

According to the literature (SGArchitects, 2015), for urban services, a 10-minute layover time with a peak flow of 100 buses per hour (or 1,000 buses per day) at a central bus terminal requires a site measuring approximately 15,000 sqm. If we assume an average route length of 18-20 km, a visit to a bus terminal every 1.5 hours by a city bus can be expected[35]. This would mean an average of 4.5 visits per day (4 round trips) per bus for each of the two bus terminals at either end of the route[36]. Thus, approximately 1000/4.5 = 222 urban buses use each bus terminal site (at a given time) designed to cater to a peak hourly flow of 100 buses per hour, or approximately 70 sqm (15,000/222) per bus. For non-urban services, an average layover time of 20 minutes per bus is assumed, and two round trips are assumed, with an average route length of 60-70 km. This requires approximately 2.5 visits per bus per terminal. In this case, a bus terminal site of approximately 28,000 sqm is required for a peak hourly bus flow of 100 buses per hour (or 1,000 buses per day), with an average layover time of 20 minutes (SGArchitects, 2015). Thus, approximately 400 buses will use each bus terminal site (1000/2.5), which amounts to 70 sqm per bus (28,000/400). Therefore, area requirement of both urban and non-urban bus terminals' is estimated at 70 sqm per bus.

[35] Based on an average operational speed of 12-14 km/hour (h) in urban settings.

[36] For estimation purposes, the smaller bus terminals on the periphery of the city are clubbed as one large terminal with the central bus terminal. This is also because we are estimating area requirement, which is derived from the number of buses, and the aggregation of small terminals into a single large one does not affect the calculation.

Based on the abovementioned assumptions, the values for the estimation of the resource requirement for infrastructure development have been derived and used in the model.

3 Model Results and Outputs

This section presents the long-range public transport or stage carriage bus resource requirement estimates generated by the model for both urban and non-urban services. The resource requirement for both these services (along with cumulative bus resource requirements) have been generated in three scenarios for a 40-year period. Projections and estimates are based on current or existing fleet size numbers derived from literature (Annexure 1), as well as current and projected population numbers.

The model output data is presented below in two parts: 1) supply and demand estimates, and 2) annual resource requirement. The data findings are discussed in the next chapter.

3.1 Supply and Demand

The supply and demand in terms of bus passenger trips have been generated by the model using base values and assumptions discussed in the previous chapter. These numbers are disaggregated at the state level, while national aggregated numbers are also presented below.

3.1.1 National Data

Aggregated national estimates of demand in terms of the population to be served, fleet size, manpower and mode share have been derived, along with estimates of buses required per 1 lakh population in the future, i.e., 2025, 2030, 2040, 2050, and 2060. These are presented as total aggregated national numbers for urban and non-urban operations for the BAU, LA, and HA scenarios and disaggregated national numbers for urban and non-urban operations for all three scenarios.

Total Outputs for Urban and Non-urban Operations

Table 5, Table 6, and Table 7 present the national estimates for supply and demand combined for urban operations and non-urban operations for all three scenarios (in both the GCC and outright purchase models), in six different (milestone) years from now till 2060.

Table 5: National supply and demand estimates for LA scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	457,704	634,032	882,510	940,836	910,806	887,266
Population in crores	143.81	149.42	155.69	165.21	170.72	173.79
Mode share	5.94%	8.78%	12.49%	13.52%	13.62%	13.77%
Buses per 1 lakh population	32	42	57	57	53	51
Manpower	2,380,061	3,296,963	4,589,080	4,892,331	4,736,168	4,613,772

Table 6: National supply and demand estimates for HA scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	457,704	924,710	1,555,489	1,674,525	1,635,846	1,591,342
Population in crores	143.81	149.42	155.68	165.21	170.71	173.79
Mode share	6.03%	12.72%	21.22%	22.96%	23.27%	23.52%
Buses per 1 lakh population	32	62	100	101	96	92
Manpower	2,380,061	4,808,482	8,088,566	8,707,522	8,506,398	8,274,973

Table 7: National supply and demand estimates for BAU scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	457,704	472,623	544,346	573,718	551,825	528,829
Population in crores	143.81	149.42	155.68	165.21	170.71	173.79
Mode share	4.26%	4.44%	4.98%	5.17%	4.88%	4.76%
Buses per 1 lakh population	32	32	35	35	32	30
Manpower	2,380,061	2,457,721	2,830,711	2,983,409	2,869,547	2,749,960

Outputs for Urban Operations

Table 8, Table 9, and Table 10 present the national values as numbers for supply and demand for urban bus operations for all three scenarios (in both the GCC and outright purchase models), in six different (milestone) years from now till 2060.

Table 8: National urban supply and demand estimates for LA scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	52,316	1,14,305	1,93,908	2,59,333	3,04,628	3,41,346
Population in crores	48.74	53.51	59.86	73.32	86.38	97.33
Mode share	3.37%	6.32%	9.89%	10.27%	10.19%	10.00%
Buses per 1 lakh population	11	18	30	28	28	27
Manpower	272,042	509,628	925,809	1,066,391	1,256,938	1,379,030

Table 9: National urban supply and demand estimates for HA scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	52,316	134,899	275,504	320,384	381,335	424,980
Population in crores	48.74	53.51	59.86	73.32	86.38	97.33
Mode share	3.55%	8.91%	15.41%	16.02%	16.14%	16.01%
Buses per 1 lakh population	11	25	46	44	44	44
Manpower	272,042	701,468	1,432,641	1,665,988	1,982,942	2,209,890

Table 10: National urban supply and demand estimates in BAU scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	52,316	57,922	70,431	88,633	94,095	105,854

Estimate	2021	2025	2030	2040	2050	2060
Population in crores	48.74	53.51	59.86	73.32	86.38	97.33
Mode share	2.51%	3.32%	4.20%	4.47%	4.02%	4.01%
Buses per 1 lakh population	11	11	12	12	11	11
Manpower	272,042	301,275	366,353	460,967	489,351	550,494

Outputs for Non-urban Operations

Table 11, Table 12 and Table 13 present national values as numbers for supply and demand for non-urban bus operations for all three scenarios (in both the GCC and outright purchase models), in six different (milestone) years from now till 2060.

Table 11: National non-urban supply and demand estimates in LA scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	405,388	536,026	704,474	735,758	669,083	622,066
Population in crores	143.81	149.42	155.68	165.21	170.71	173.79
Mode share	5.40%	6.64%	8.23%	8.80%	8.42%	8.42%
Buses per 1 lakh population	28	36	45	45	39	36
Manpower	2,108,019	2,787,335	3,663,271	3,825,940	3,479,230	3,234,742

Table 12: National non-urban supply and demand estimates for HA scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	405,388	789,811	1,279,985	1,354,141	1,254,511	1,166,362
Population in crores	143.81	149.42	155.68	165.21	170.71	173.79

Estimate	2021	2025	2030	2040	2050	2060
Mode share	5.40%	9.57%	14.83%	16.12%	15.79%	15.79%
Buses per 1 lakh population	28	53	82	82	73	67
Manpower	2,108,019	4,107,014	6,655,925	7,041,534	6,523,456	6,065,083

Table 13: National non-urban supply and demand estimates for BAU scenario for six years from now till 2060

Estimate	2021	2025	2030	2040	2050	2060
Total fleet size	405,388	414,701	473,915	485,085	457,730	422,975
Population in crores	143.81	149.42	155.68	165.21	170.71	173.79
Mode share	5.40%	5.19%	5.52%	5.78%	5.82%	5.77%
Buses per 1 lakh population	28	28	30	29	27	24
Manpower	2,108,019	2,156,446	2,464,358	2,522,442	2,380,196	2,199,466

3.1.2 State-Wise Data

State-wise comparison of estimated bus requirement is presented in Table 14.

Table 14: Number of buses required to cater to estimated passenger trip demand over five years from 2025 to 2060

State	Urban Fleet Size					Non-urban Fleet Size					Total Fleet Size				
	2025	2030	2040	2050	2060	2025	2030	2040	2050	2060	2025	2030	2040	2050	2060
Andaman and Nicobar	94	78	73	85	96	219	134	115	81	67	313	212	188	166	163
Andhra Pradesh	3,692	7,044	8,764	10,808	12,603	22,097	34,253	37024	36022	34884	25,789	41,296	45,788	46,830	47,487
Arunachal Pradesh	3	1	40	47	53	489	518	551	505	484	492	519	591	552	537
Assam	964	1,360	1,585	1,901	2,217	6,533	13,395	14914	14836	14612	7,496	14,755	16,499	16,737	16,829
Bihar	1,951	4,869	6,070	7,871	9,568	27,501	47,098	52294	52324	51936	29,452	51,966	58,364	60,195	61,504
Chandigarh	360	574	645	760	857	218	83	1	1	1	578	657	646	761	858
Chattisgarh	1,071	2,211	2,573	3,146	3,613	7,317	9,696	10199	9658	9159	8,388	11,907	12,772	12,804	12,772
Dadra and Nagar Havel	30	60	66	78	87	111	178	158	111	66	141	238	224	189	153
Daman and Diu	9	3	36	77	87	3	6	4	1	1	12	9	40	78	88
Delhi	8,426	11,534	12,904	15,203	17,128	67	26	2	2	2	8,493	11,560	12,906	15,205	17,130
Goa	183	217	216	255	322	2,825	1,151	132	24	1	3,009	1,368	348	279	323
Gujarat	9,401	21,941	27,641	34,202	38,750	23,516	16,589	16615	10752	8040	32,917	38,529	44,256	44,954	46,790
Haryana	1,611	3,964	4,584	5,562	6,519	11,700	8,331	8897	6444	5552	13,312	12,295	13,481	12,006	12,071
Himachal Pradesh	212	155	115	135	187	4,560	3,305	3945	3343	3343	4,772	3,461	4,060	3,478	3,530
Jammu and Kashmir	644	1,403	1,582	1,886	2,165	12,909	6,970	4995	3889	3608	13,553	8,372	6,577	5,775	5,773
Jharkhand	1,396	3,304	3,891	4,896	5,769	5,768	11,922	12848	12251	11578	7,164	15,226	16,739	17,147	17,347
Karnataka	13,632	21,218	22,526	22,409	20,760	26,092	18,546	19351	13434	11018	39,724	39,764	41,877	35,843	31,778
Kerala	5,380	9,192	10,888	13,941	16,906	29,342	14,594	7201	3953	2201	34,722	23,785	18,089	17,894	19,107
Lakshwadweep	-	-	-	-	-	-	2	2	1	1	-	2	2	1	1
Madhya Pradesh	3,517	8,020	9,626	12,081	14,431	26,514	26,635	28773	24203	22374	30,031	34,655	38,399	36,284	36,805
Maharashtra	15,702	30,232	36,256	45,237	52,456	28,963	27,717	26282	17979	12682	44,665	57,948	62,538	63,216	65,138
Manipur	109	247	279	365	410	559	880	917	846	778	668	1,127	1,196	1,211	1,188
Meghalaya	276	288	287	337	380	1,445	1,138	1371	1111	1068	1,720	1,426	1,658	1,448	1,448
Mizoram	162	184	234	276	310	804	403	198	100	45	966	586	432	376	355
Nagaland	69	131	148	175	196	1,462	882	782	607	563	1,531	1,013	930	782	759
Odisha	1,378	2,552	2,911	3,731	4,302	16,717	18,442	19749	18792	18343	18,095	20,994	22,660	22,523	22,645
Puducherry	190	442	540	636	754	1,187	540	72	1	1	1,377	982	612	637	755
Punjab	1,950	4,376	5,252	6,432	7,464	4,570	7,553	7458	6332	5264	6,520	11,929	12,710	12,764	12,728
Rajasthan	3,315	7,917	9,630	12,541	15,107	32,943	26,365	31221	24614	23112	36,258	34,282	40,851	37,155	38,219
Sikkim	47	60	67	79	89	218	222	237	208	197	265	282	304	287	286
Tamil Nadu	14,078	24,946	26,509	27,265	26,539	42,449	23,538	15174	8159	4329	56,526	48,485	41,683	35,424	30,868
Telangana	9,580	16,649	18,424	19,143	17,890	10,945	10,778	10829	8657	7381	20,525	27,427	29,253	27,800	25,271
Tripura	99	235	266	314	391	1,255	1,264	1379	1164	1085	1,353	1,499	1,645	1,478	1,476
Uttar Pradesh	8,180	19,860	24,358	31,459	37,914	42,774	75,495	81277	78053	74473	50,954	95,355	1,05,635	1,09,512	1,12,387
Uttrakhand	588	1,125	1,389	1,711	1,999	3,738	3,203	3707	2815	2549	4,325	4,328	5,096	4,526	4,548
West Bengal	6,453	15,818	16,946	20,115	23,027	22,069	29,336	29710	26660	23885	28,523	45,154	46,656	46,775	46,912

3.2 Annual Resource Requirement

The annual resource requirements have been estimated for the next 40-year time period for bus services in India, using the models developed for each of the three scenarios (presented in Chapter 2), in both the GCC and outright purchase scenarios. These models have been used to derive outputs for urban and non-urban services (disaggregated), i.e. 100% transition to electric buses (acquisition) in 10 years for urban services and 15 years for non-urban services in the LA & HA scenarios[37]. The data for all three scenarios is presented as a cumulative resource requirement over five time periods: 2022-25, 2026-30, 2031-40, 2041-50, and 2051-60. This data is presented below as aggregated national data and disaggregated state-wise data.

3.2.1 National Data

The resource requirements aggregated at the national level are presented below over the five abovementioned time periods. These requirements include the total land to be sourced/acquired (in hectares (Ha)), total bus terminals and depots to be developed (calculated as a difference in outputs of mentioned time periods) whereas, total ICE buses to procure, total electric buses to procure, total buses to procure (ICE + electric), total emissions (in million metric tonnes of CO_2 equivalent ($mtCO_2e$)) from all bus services, and total budgetary support required (financial aid/viability gap for the time period in Rs. crores) are sum total of mentioned time period. Except for the viability gap, the values do not change between a GCC and outright purchase (OP) scenario. However, since the viability gap values differ for these two scenarios, two separate sets of rows are presented in tables for the viability gap. The data for the three aggregated (combined urban and non-urban services) scenarios (as explained above) is presented in Table 15 to Table 17.

The disaggregated data separate for urban and non-urban services is presented in Table 18 to Table 23.

Total Outputs for Urban and Non-Urban Operations

Table 15, Table 16 and Table 17 present the annual bus resource requirements aggregated at the national level for urban and non-urban bus operations for all scenarios (in both the GCC and outright purchase models). It should be noted that bus terminal, depot and land requirement is related to each other. Like other factors, these are also estimated at the national level as a cumulative of all 36 state and union territories. However, this requirement can reduce in some states and increase in others basis the demand trend in each state. However, as a cumulative it is possible that the total number of depots and terminals is reducing in a time period, and thus it reflects as zero development of bus

[37] The transition is to 100% purchase of new electric buses. Hence, both the HA and LA scenarios assume that only electric buses will be purchased post-2036 in India. However, the existing ICE fleet will continue to operate for another 12 years and will be gradually phased out over this time period, which implies that these scenarios assume that India will see a 100% electric bus fleet on the road before 2050.

terminals or depots at the national level in that time period. However, in reality, some states may be developing more bus facilities while others may be vacating existing ones.

Table 15: National aggregated bus resource requirement in LA scenario for five time periods

Requirement	**2022-25**	**2026-30**	**2031-40**	**2041-50**	**2051-60**
Total land (Ha)	3568.79	7184.08	1683.31	0.00	0.00
Total bus terminals	3,734	5,822	1,987	186	-
Total depots	1,301	2,244	649	-	-
Total ICE buses	160,904	55,023	15,802	-	-
Total electric buses	167,690	383,788	533,608	685,898	584,684
Total buses	328,594	438,811	549,410	685,898	584,684
Total viability gap (GCC model) (Rs. crores)	288,329	473,799	1,037,164	975,901	1,012,272
Total viability gap (OP model) (Rs. crores)	306,012	463,280	677,463	696,697	703,541
Total emissions ($mtCO_2e$)	338.62	488.55	739.21	189.04	0

Table 16: National aggregated annual bus resource requirement in HA scenario for five time periods

Requirement	**2022-25**	**2026-30**	**2031-40**	**2041-50**	**2051-60**
Total land (Ha)	8253.96	16668.87	3480.11	0.00	0.00
Total bus terminals	8,031	13,189	3,801	130	-
Total depots	3,040	5,194	1,349	-	-
Total ICE buses	360,035	105,864	10,371	-	-
Total electric buses	259,237	715,248	940,720	1,275,846	1,026,206
Total buses	619,272	821,112	951,091	1,275,846	1,026,206
Total viability gap (GCC model) (Rs. crores)	399,193	772,818	1,797,225	1,656,613	1,723,738
Total viability gap (OP model)	467,332	785,126	1,160,802	1,189,519	1,184230
Total emissions ($mtCO_2e$)	445.50	811.31	1359.61	333.57	(0)

Table 17: National aggregated bus resource requirement in BAU scenario for five time periods

Requirement	**2022-25**	**2026-30**	**2031-40**	**2041-50**	**2051-60**
Total land (Ha)	1712.80	3498.58	663.53	0.00	0.00
Total bus terminals	1,678	2,969	786	-	-
Total depots	612	1,056	241	-	-
Total ICE buses	159,997	248,037	423,039	388,910	383,517
Total electric buses	7,188	14,019	34,102	50,285	44,508
Total buses	167,185	262,056	457,141	439,195	428,025
Total viability gap (GCC model) (Rs. crores)	223,038	298,025	643,775	644,296	644,330
Total budgetary requirement (OP model) (Rs. crores)	194,653	264,073	552,625	558,375	566,377
Total emissions ($mtCO_2e$)	291.57	396.51	855.67	782.10	712.05

Outputs for Urban Operations

Table 18, Table 19 and Table 20 present the national disaggregated values as numbers for annual resource requirements for urban bus for all three scenarios (in both the GCC and outright purchase models).

Table 18: National aggregated urban bus resource requirement in LA scenario for five time periods

Requirement	**2022-25**	**2026-30**	**2031-40**	**2041-50**	**2051-60**
Total land (Ha)	796.78	1693.56	1172.32	799.23	540.94
Total bus terminals	1,319	1,836	1,544	1,056	-
Total depots	296	586	464	313	-
Total ICE buses	26,108	730	-	-	-
Total electric buses	36,719	100,721	104,357	183,238	201,688
Total buses	62,827	101,451	104,357	183,238	201,688
Total budgetary requirement (GCC model (Rs. crores)	129,068	232,094	526,662	549,955	617,208
Total budgetary requirement (OP model) (Rs. crores)	153,127	252,105	361,340	427,536	472,859

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total emissions ($mtCO_2e$)	31.12	54.83	92.14	29.53	(0)

Table 19: National aggregated urban bus resource requirement in HA scenario for five time periods

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total land (Ha)	1429.43	3053.39	1960.88	1429.73	1034.65
Total bus terminals	2,082	3,298	2,480	1,760	-
Total depots	566	1,083	799	590	-
Total ICE buses	47,531	1,459	-	-	-
Total electric buses	52,189	160,567	159,817	294,860	322,668
Total buses	99,720	162,026	159,817	294,860	322,668
Total budgetary requirement (GCC model) (Rs. crores)	174,500	351,892	836,787	864,792	982,472
Total budgetary requirement (OP model) (Rs. crores)	222,608	394,564	572,898	679,952	754,681
Total emissions ($mtCO_2e$)	39.83	81.53	146.12	46.32	(0)

Table 20: National aggregated urban bus resource requirement in BAU scenario for five time periods

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total land (Ha)	205.08	512.35	445.33	115.84	258.76
Total bus terminals	367	813	593	251	-
Total depots	65	157	163	46	-
Total ICE buses	21,957	32,171	67,366	67,989	76,250
Total electric buses	786	1,759	6,166	9,099	8,816
Total buses	22,743	33,930	73,532	77,088	85,066
Total budgetary requirement (GCC model) (Rs. crores)	89,942	117,829	267,959	90,229	316,684
Total budgetary requirement (OP model) (Rs. crores)	90,321	118,726	271,807	296,831	325,397

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total emissions ($mtCO_2e$)	22.80	32.98	80.62	84.51	89.40

Outputs for Non-urban Operations

Table 21, Table 22, and Table 23 present the national disaggregated values as numbers for annual resource requirements for non-urban bus operations for all three scenarios (in both the GCC and outright purchase scenarios).

Table 21: National aggregated non-urban bus resource requirement for LA scenario for five time periods

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total land (Ha)	2772.01	5490.52	510.99	0.00	0.00
Total bus terminals	2,415	3,986	443	-	-
Total depots	1,005	1,658	185	-	-
Total ICE buses	134,796	54,293	15,802	-	-
Total electric buses	130,971	283,067	429,251	502,660	382,996
Total buses	265,767	337,360	445,053	502,660	382,996
Total budgetary requirement (GCC model) (Rs. crores)	159,261	241,705	510,503	425,946	395,064
Total budgetary requirement (OP model) (Rs. crores)	152,885	211,175	316,123	269,161	230,682
Total emissions ($mtCO_2e$)	307.50	433.72	647.07	159.51	0

Table 22: National aggregated non-urban bus resource requirement for HA scenario for five time periods

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total land (Ha)	6824.53	13615.48	1519.24	0.00	0.00
Total bus terminals	5,949	9,891	1,321	-	-
Total depots	2,474	4,111	550	-	-
Total ICE buses	312,504	104,405	10,371	-	-
Total electric buses	207,048	554,681	780,903	980,986	703,538
Total buses	519,552	659,086	791,274	980,986	703,538

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total budgetary requirement (GCC model) (Rs. crores)	224,693	420,926	960,438	791,820	741,266
Total budgetary requirement (OP model) (Rs. crores)	244,724	390,562	587,904	509,567	429,549
Total emissions ($mtCO_2e$)	405.67	729.78	1,213.49	287.25	(0.00)

Table 23: National aggregated non-urban bus resource requirement in BAU scenario for five time periods

Requirement	2022-25	2026-30	2031-40	2041-50	2051-60
Total land (Ha)	1507.72	2986.23	218.19	0.00	0.00
Total bus terminals	1,311	2,156	193	-	-
Total depots	547	899	78	-	-
Total ICE buses	138,040	215,866	355,673	320,921	307,267
Total electric buses	6,402	12,260	27,936	41,186	35,692
Total buses	144,442	228,126	383,609	362,107	342,959
Total budgetary requirement (GCC + BAU model) (Rs. crores)	133,096	180,196	375,816	354,066	327,645
Total budgetary requirement (OP model) (Rs. crores)	104,332	145,347	280,818	261,545	240,980
Total emissions ($mtCO_2e$)	268.78	363.54	775.05	697.59	622.65

3.2.2 State-Wise Data

The state-wise disaggregated resource requirement is presented as the as cumulative viability gap over each of the five time periods for both GCC and OP model. These numbers are provided for the three scenarios (discussed above), including disaggregated data for urban and non-urban services and aggregated data (sum of urban and non-urban services), in Table 24 to Table 29.

Table 24: State-wise viability gap to cater to required demand in LA Scenario in five time periods (GCC model)

State	Cumulative budget (viability gap) in crores for urban services - LA					Cumulative budget (viability gap) in crores for non-urban services - LA					Total cumulative budget (viability gap) in crores for LA Scenario				
	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60
Andaman and Nicobar	139	120	119	105	131	78	73	127	104	84	216	193	246	209	214
Andhra Pradesh	3,942	6,251	13,719	15,809	18,988	8,766	18,027	42,710	36,775	36,232	12,708	24,277	56,429	52,584	55,220
Arunachal Pradesh	5	3	63	78	92	182	280	17,293	525	511	187	283	17,357	603	603
Assam	1,419	1,608	2,399	2,686	3,225	11,030	6,885	47,297	14,859	14,889	12,449	8,493	49,696	17,545	18,114
Bihar	1,521	3,799	10,028	11,817	14,887	1,41,629	24,366	59,464	52,051	52,428	1,43,150	28,165	69,491	63,868	67,315
Chandigarh	335	475	907	1,048	1,193	83	66	79	85	89	419	541	985	1,133	1,282
Chattisgarh	895	1,708	3,951	4,336	5,166	2,837	5,191	11,770	10,081	9,742	3,732	6,899	15,721	14,418	14,909
Dadra and Nagar Havelli	24	51	130	96	110	44	96	209	138	100	68	147	339	234	210
Daman and Diu	16	11	16	87	149	2	7	16	14	16	19	18	32	102	164
Delhi	9,330	12,416	23,577	26,724	30,578	181	435	1,203	1,252	1,436	9,511	12,852	24,780	27,976	32,015
Goa	252	268	379	318	421	1,033	727	297	124	76	1,284	995	677	442	496
Gujarat	11,305	25,608	67,351	73,764	85,018	8,485	9,825	18,376	14,111	11,164	19,790	35,433	85,727	87,875	96,182
Haryana	1,283	3,026	7,449	7,831	9,292	4,142	4,793	9,394	7,616	6,575	5,425	7,819	16,842	15,447	15,866
Himachal Pradesh	353	327	219	181	232	1,597	1,811	3,828	3,423	3,342	1,950	2,138	4,047	3,604	3,574
Jammu and Kashmir	531	1,054	2,563	2,710	3,186	4,635	3,900	5,246	4,600	3,952	5,166	4,954	7,809	7,311	7,138
Jharkhand	1,113	2,489	6,240	6,893	8,547	2,454	6,234	15,442	12,800	12,376	3,567	8,722	21,682	19,693	20,923
Karnataka	17,762	27,576	54,481	47,682	40,388	9,304	10,823	20,786	16,503	13,794	27,066	38,398	75,266	64,185	54,182
Kerala	5,999	8,523	17,696	22,202	29,105	10,603	8,563	9,094	6,656	4,224	16,602	17,086	26,790	28,858	33,329
Lakshwadweep	-	-	-	-	-	1	2	5	4	4	1	2	5	4	4
Madhya Pradesh	2,864	6,414	16,202	18,502	23,091	10,216	14,655	30,103	26,004	24,484	13,080	21,068	46,304	44,505	47,575
Maharashtra	17,246	30,462	73,033	82,922	99,270	10,970	15,905	31,472	23,667	18,834	28,216	46,367	1,04,505	1,06,590	1,18,105
Manipur	100	196	439	493	582	224	472	1,111	915	864	325	668	1,551	1,408	1,446
Meghalaya	488	437	460	475	537	539	657	1,305	1,168	1,120	1,026	1,094	1,765	1,643	1,657
Mizoram	236	229	323	402	443	291	237	259	186	112	526	466	582	588	555
Nagaland	54	96	245	224	262	519	476	816	711	617	574	572	1,060	935	879
Odisha	1,443	2,187	4,609	5,190	6,133	6,243	9,836	21,350	19,077	18,859	7,686	12,023	25,960	24,267	24,993
Puducherry	215	576	1,551	1,762	2,072	1,045	830	539	224	205	1,261	1,406	2,090	1,985	2,277
Punjab	2,299	5,289	14,836	17,959	21,881	4,148	9,832	25,522	20,715	18,086	6,447	15,121	40,358	38,675	39,968
Rajasthan	4,063	10,827	31,684	40,388	52,322	29,772	38,291	80,497	73,163	68,871	33,835	49,119	1,12,181	1,13,551	1,21,194
Sikkim	64	79	174	184	224	192	296	670	611	585	256	376	844	795	809
Tamil Nadu	27,263	51,545	1,21,263	1,12,973	1,02,340	37,087	33,595	50,404	38,017	24,480	64,350	85,140	1,71,667	1,50,989	1,26,820
Telangana	19,177	37,384	92,965	91,835	82,897	9,660	14,771	32,647	27,804	24,606	28,837	52,155	1,25,613	1,19,640	1,07,503
Tripura	123	303	814	890	1,089	1,163	1,721	3,826	3,467	3,281	1,286	2,024	4,640	4,356	4,370
Uttar Pradesh	9,837	27,118	79,893	1,01,544	1,31,334	37,725	93,789	2,53,998	2,25,408	2,18,013	47,562	1,20,907	3,33,891	3,26,952	3,49,347
Uttrakhand	854	1,526	3,838	4,608	5,549	3,422	4,603	9,711	8,654	7,986	4,276	6,129	13,549	13,262	13,535
West Bengal	8,683	24,221	63,745	67,421	78,349	19,641	38,471	95,220	81,889	75,231	28,324	62,691	1,58,966	1,49,310	1,53,580

Table 25: State-wise viability gap to cater to required demand in HA Scenario in five time periods (GCC model)

State	Cumulative budget (viability gap) in crores for urban services - HA					Cumulative budget (viability gap) in crores for non-urban services - HA					Total cumulative budget (viability gap) in crores for HA Scenario				
	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60
Andaman and Nicobar	139	139	159	173	210	90	113	219	181	157	229	252	378	354	367
Andhra Pradesh	5,308	9,909	23,983	27,345	32,637	14,303	33,070	80,857	68,895	67,957	19,611	42,979	1,04,840	96,240	1,00,595
Arunachal Pradesh	5	3	120	129	150	264	496	32,489	982	957	269	499	32,609	1,110	1,107
Assam	1,441	2,036	4,052	4,605	5,591	18,612	12,844	89,943	27,862	27,919	20,053	14,880	93,995	32,467	33,509
Bihar	2,589	6,678	17,230	20,099	25,009	2,49,539	44,984	1,12,243	97,543	98,323	2,52,128	51,662	1,29,472	1,17,642	1,23,333
Chandigarh	456	745	1,702	1,900	2,307	87	78	150	156	168	543	823	1,852	2,056	2,475
Chattisgarh	1,396	2,827	6,984	7,769	9,399	4,389	9,410	22,408	18,877	18,276	5,785	12,237	29,392	26,647	27,675
Dadra and Nagar Havelli	33	91	177	156	180	71	176	394	259	188	104	267	571	415	368
Daman and Diu	16	11	22	154	259	4	17	30	30	30	21	28	52	184	289
Delhi	11,663	17,842	37,898	41,173	47,105	319	818	2,257	2,342	2,701	11,981	18,660	40,155	43,515	49,806
Goa	266	358	521	519	682	1,049	779	488	232	141	1,316	1,136	1,010	752	823
Gujarat	16,317	38,390	99,285	1,06,415	1,22,106	11,010	16,542	33,439	25,570	20,984	27,328	54,932	1,32,724	1,31,985	1,43,091
Haryana	2,074	5,060	12,943	13,563	16,154	5,462	8,180	16,848	13,808	12,351	7,537	13,241	29,791	27,371	28,504
Himachal Pradesh	335	311	296	314	375	2,116	3,149	6,755	6,220	6,273	2,451	3,460	7,051	6,534	6,647
Jammu and Kashmir	821	1,840	4,681	4,880	5,816	4,908	4,930	9,753	8,315	7,409	5,728	6,770	14,433	13,196	13,225
Jharkhand	1,843	4,350	11,136	12,552	15,656	4,442	11,626	29,022	23,994	23,207	6,285	15,975	40,159	36,546	38,863
Karnataka	21,482	37,276	79,173	70,208	63,425	12,216	18,356	37,557	29,934	25,919	33,697	55,632	1,16,730	1,00,142	89,344
Kerala	7,854	14,299	33,961	40,667	52,101	11,135	10,302	16,687	12,153	7,919	18,989	24,602	50,648	52,820	60,020
Lakshwadweep	-	-	-	-	-	1	4	9	7	8	1	4	9	7	8
Madhya Pradesh	4,793	11,264	28,993	32,200	39,912	14,323	25,782	57,778	48,577	45,957	19,116	37,046	86,772	80,777	85,869
Maharashtra	23,783	47,594	1,16,363	1,27,248	1,51,303	15,439	28,025	60,496	44,197	35,386	39,222	75,620	1,76,860	1,71,445	1,86,689
Manipur	140	321	730	797	958	367	870	2,105	1,715	1,621	507	1,191	2,835	2,512	2,578
Meghalaya	459	487	732	780	866	710	1,130	2,442	2,153	2,102	1,169	1,616	3,174	2,933	2,969
Mizoram	212	265	516	665	723	306	288	478	338	210	518	553	994	1,003	933
Nagaland	72	182	359	368	427	600	727	1,437	1,249	1,158	672	910	1,796	1,617	1,585
Odisha	1,765	3,435	7,749	8,648	10,394	9,080	17,534	40,911	35,692	35,388	10,845	20,968	48,660	44,340	45,782
Puducherry	325	920	2,568	2,912	3,515	1,104	993	948	418	383	1,429	1,913	3,516	3,330	3,898
Punjab	3,402	9,250	26,232	31,752	38,854	6,764	17,996	48,148	38,831	33,953	10,166	27,246	74,380	70,583	72,807
Rajasthan	6,351	18,314	53,672	66,356	84,457	37,989	63,865	1,50,438	1,35,629	1,29,201	44,340	82,179	2,04,110	2,01,984	2,13,659
Sikkim	72	110	252	303	362	262	511	1,275	1,143	1,098	334	621	1,527	1,446	1,460
Tamil Nadu	33,551	71,245	1,78,460	1,72,490	1,65,477	40,819	48,031	91,535	66,791	45,899	74,369	1,19,276	2,69,995	2,39,281	2,11,376
Telangana	23,133	50,262	1,29,150	1,28,989	1,22,164	13,096	25,499	62,370	52,052	46,155	36,229	75,761	1,91,520	1,81,040	1,68,319
Tripura	178	501	1,343	1,472	1,759	1,559	2,958	7,306	6,488	6,154	1,737	3,459	8,649	7,959	7,913
Uttar Pradesh	16,134	47,062	1,39,595	1,72,244	2,18,564	62,926	1,72,470	4,78,533	4,22,560	4,08,805	79,060	2,19,532	6,18,129	5,94,804	6,27,368
Uttrakhand	1,125	2,342	6,347	7,702	9,245	4,431	7,757	18,433	16,155	14,979	5,555	10,099	24,781	23,856	24,224
West Bengal	13,485	39,550	1,03,746	1,06,557	1,24,114	29,391	68,889	1,80,719	1,53,466	1,41,087	42,876	1,08,439	2,84,465	2,60,023	2,65,200

Table 26: State-wise viability gap to cater to required demand in BAU Scenario in five time periods (GCC model)

State	Cumulative budget (viability gap) in crores for urban services - BAU					Cumulative budget (viability gap) in crores for non-urban services - BAU					Total cumulative budget (viability gap) in crores for BAU Scenario				
	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60
Andaman and Nicobar	140	101	52	57	61	70	52	92	82	72	210	154	144	139	133
Andhra Pradesh	3,192	2,938	5,285	6,491	7,509	6,851	13,371	31,340	30,696	29,797	10,043	16,309	36,624	37,186	37,307
Arunachal Pradesh	5	3	26	28	32	154	218	12,531	437	421	159	221	12,557	466	453
Assam	1,397	1,027	968	1,212	1,435	8,383	5,005	30,433	12,411	12,235	9,779	6,033	31,401	13,622	13,670
Bihar	587	1,347	3,487	4,553	5,380	1,01,531	17,935	43,448	43,422	43,085	1,02,118	19,281	46,934	47,975	48,465
Chandigarh	342	208	422	488	581	80	59	55	63	72	422	267	477	551	653
Chattisgarh	514	695	1,594	2,023	2,262	2,309	3,900	8,713	8,413	8,018	2,823	4,595	10,307	10,436	10,281
Dadra and Nagar Havelli	18	24	41	42	46	35	65	153	117	82	53	89	194	159	128
Daman and Diu	16	11	7	33	54	1	5	12	12	13	18	16	19	45	67
Delhi	8,067	8,773	20,439	24,028	27,230	129	322	870	1,030	1,173	8,195	9,095	21,309	25,058	28,403
Goa	242	226	192	168	190	1,014	669	226	126	79	1,257	895	419	294	268
Gujarat	4,558	8,516	28,822	45,585	53,898	7,084	7,165	13,545	11,749	9,357	11,642	15,681	42,367	57,334	63,255
Haryana	539	1,135	2,940	3,453	4,009	3,532	3,496	6,808	6,269	5,468	4,071	4,631	9,748	9,722	9,477
Himachal Pradesh	377	366	259	173	131	1,389	1,319	2,716	2,772	2,752	1,766	1,685	2,975	2,945	2,883
Jammu and Kashmir	324	487	1,059	1,175	1,341	4,338	2,903	3,704	3,559	3,363	4,661	3,390	4,763	4,734	4,703
Jharkhand	521	943	2,405	3,027	3,520	1,754	4,528	11,167	10,725	10,191	2,276	5,470	13,571	13,752	13,711
Karnataka	14,944	17,659	34,508	21,735	20,159	7,861	7,893	15,186	13,647	11,505	22,804	25,552	49,694	35,382	31,664
Kerala	5,116	4,013	6,423	7,730	8,722	10,021	6,664	6,562	5,378	4,146	15,138	10,676	12,985	13,108	12,867
Lakshwadweep	-	-	-	-	-	1	2	4	3	4	1	2	4	3	4
Madhya Pradesh	1,568	2,482	5,798	6,842	7,861	8,887	11,366	22,730	21,640	20,184	10,454	13,848	28,528	28,482	28,044
Maharashtra	11,561	15,171	38,492	52,577	65,639	9,520	12,319	23,654	19,804	15,599	21,081	27,490	62,145	72,381	81,238
Manipur	45	91	181	226	267	172	350	814	766	712	218	441	995	992	979
Meghalaya	498	327	185	216	239	430	488	976	960	925	928	815	1,161	1,176	1,164
Mizoram	247	141	161	177	201	274	182	189	151	113	521	323	350	328	315
Nagaland	38	32	68	86	105	473	342	581	553	519	511	374	649	640	623
Odisha	1,185	1,117	1,804	2,285	2,655	5,305	7,533	16,038	15,879	15,520	6,490	8,650	17,842	18,164	18,175
Puducherry	121	212	550	676	806	981	652	405	220	149	1,102	864	955	895	956
Punjab	1,243	2,037	5,323	6,644	7,752	3,207	7,004	16,959	15,214	13,224	4,450	9,041	22,282	21,858	20,977
Rajasthan	1,645	3,148	8,669	10,917	14,427	23,720	27,327	54,809	53,222	50,333	25,365	30,475	63,478	64,138	64,760
Sikkim	52	35	52	65	79	170	223	458	447	428	222	258	510	512	507
Tamil Nadu	20,943	30,196	66,074	43,849	42,068	33,804	23,356	33,913	26,994	20,418	54,747	53,552	99,987	70,842	62,487
Telangana	14,251	21,502	55,525	53,578	30,053	8,457	11,144	22,350	20,351	17,939	22,709	32,646	77,875	73,929	47,992
Tripura	59	132	313	368	441	1,028	1,303	2,628	2,535	2,391	1,087	1,435	2,941	2,903	2,832
Uttar Pradesh	4,303	8,752	23,303	28,384	34,589	28,627	66,468	1,68,963	1,65,135	1,58,759	32,930	75,220	1,92,266	1,93,519	1,93,348
Uttrakhand	596	637	1,476	1,904	2,227	2,767	3,382	6,684	6,331	5,834	3,363	4,019	8,160	8,235	8,062
West Bengal	5,365	13,336	37,618	44,876	51,570	16,171	28,026	64,136	60,004	54,821	21,536	41,361	1,01,753	1,04,880	1,06,392

Table 27: State-wise viability gap to cater to required demand in LA Scenario in five time periods (OP model)

State	Cumulative budget (viability gap) in crores for urban services - LA					Cumulative budget (viability gap) in crores for non-urban services - LA					Total cumulative budget (viability gap) in crores for LA Scenario				
	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60
Andaman and Nicobar	116	98	92	78	92	58	52	84	61	49	174	150	176	139	142
Andhra Pradesh	4,119	6,352	9,742	12,423	14,883	10,113	17,103	26,366	24,031	21,281	14,232	23,454	36,108	36,454	36,164
Arunachal Pradesh	4	3	52	61	67	177	243	10,667	332	303	181	246	10,718	393	370
Assam	1,216	1,410	1,705	2,078	2,475	13,303	6,834	47,297	9,874	8,740	14,519	8,244	49,002	11,952	11,214
Bihar	2,055	4,208	7,154	9,508	11,695	1,41,629	23,518	36,922	34,347	30,961	1,43,684	27,727	44,076	43,855	42,656
Chandigarh	343	463	617	782	953	55	44	55	55	56	398	507	672	837	1,008
Chattisgarh	1,064	1,834	2,703	3,392	4,054	3,051	4,771	7,256	6,498	5,712	4,116	6,606	9,959	9,890	9,766
Dadra and Nagar Havelli	22	43	101	71	81	52	92	119	86	50	74	135	220	157	131
Daman and Diu	14	9	17	70	112	4	7	9	10	11	18	16	26	79	123
Delhi	9,332	11,763	16,229	19,669	24,256	233	430	795	860	891	9,565	12,193	17,024	20,530	25,147
Goa	211	219	292	268	296	647	438	166	58	55	858	657	458	326	351
Gujarat	15,877	29,988	48,347	58,782	64,256	7,135	7,542	11,499	8,081	6,435	23,012	37,530	59,845	66,862	70,691
Haryana	1,753	3,460	5,069	6,277	7,246	3,429	3,744	5,978	4,480	3,883	5,182	7,203	11,046	10,757	11,129
Himachal Pradesh	276	233	184	153	133	1,287	1,453	2,517	2,098	2,034	1,563	1,685	2,701	2,251	2,167
Jammu and Kashmir	643	1,134	1,753	2,160	2,505	3,243	2,661	3,480	2,754	2,368	3,886	3,794	5,233	4,914	4,873
Jharkhand	1,475	2,804	4,296	5,521	6,703	3,237	6,196	9,403	8,462	7,169	4,712	9,000	13,699	13,983	13,871
Karnataka	19,711	28,928	34,559	33,918	28,648	7,775	8,384	13,132	9,609	8,074	27,486	37,312	47,691	43,527	36,722
Kerala	6,334	8,768	12,818	17,903	23,407	7,251	5,639	5,762	3,694	2,338	13,584	14,408	18,580	21,597	25,745
Lakshwadweep	-	-	-	-	-	1	3	2	3	3	1	3	2	3	3
Madhya Pradesh	3,596	6,962	11,590	14,929	18,216	9,594	12,408	18,702	16,178	14,440	13,190	19,370	30,293	31,108	32,656
Maharashtra	20,611	33,204	51,771	65,621	77,186	10,359	13,521	18,805	14,232	10,454	30,971	46,725	70,576	79,853	87,640
Manipur	131	226	291	394	447	262	450	676	595	500	393	676	967	989	947
Meghalaya	407	369	323	352	427	468	520	837	712	674	875	888	1,160	1,065	1,101
Mizoram	206	201	226	304	346	200	157	164	102	61	406	358	390	405	407
Nagaland	50	85	186	165	200	384	338	545	425	370	434	423	730	590	571
Odisha	1,456	2,162	3,264	4,050	4,701	6,169	8,618	13,379	12,153	11,224	7,625	10,780	16,643	16,203	15,926
Puducherry	265	619	1,286	1,571	1,835	909	700	430	201	184	1,174	1,319	1,716	1,772	2,019
Punjab	2,598	5,447	12,412	15,986	19,463	4,519	9,674	21,639	18,080	15,225	7,116	15,122	34,050	34,066	34,689
Rajasthan	4,975	11,548	26,867	36,537	46,671	28,209	35,182	69,548	62,809	58,899	33,184	46,730	96,415	99,346	1,05,570
Sikkim	57	68	147	157	196	188	279	577	529	499	245	347	724	686	695
Tamil Nadu	30,021	54,043	98,199	98,652	88,041	32,898	29,398	43,573	31,817	20,547	62,920	83,442	1,41,771	1,30,469	1,08,588
Telangana	21,614	39,549	76,658	79,742	71,581	9,462	13,900	27,888	23,976	20,860	31,077	53,449	1,04,546	1,03,719	92,442
Tripura	155	335	671	802	973	1,132	1,613	3,287	2,996	2,798	1,288	1,948	3,958	3,799	3,770
Uttar Pradesh	12,376	29,373	67,697	92,275	1,17,474	41,668	92,628	2,16,831	1,97,672	1,85,178	54,044	1,22,001	2,84,528	2,89,947	3,02,652
Uttrakhand	888	1,543	3,216	4,083	4,893	3,270	4,258	8,351	7,437	6,809	4,158	5,801	11,567	11,520	11,702
West Bengal	11,322	26,763	51,507	60,987	70,221	20,342	37,213	81,190	71,308	63,752	31,663	63,976	1,32,697	1,32,295	1,33,974

Table 28: State-wise viability gap to cater to required demand in HA Scenario in five time periods (OP model)

State	Cumulative budget (viability gap) in crores for urban services - HA					Cumulative budget (viability gap) in crores for non-urban services - HA					Total cumulative budget (viability gap) in crores for HA Scenario				
	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60
Andaman and Nicobar	117	113	116	126	158	79	90	136	108	91	196	203	252	234	250
Andhra Pradesh	6,131	10,601	17,010	21,706	25,469	17,760	32,250	49,715	45,421	39,768	23,891	42,851	66,726	67,126	65,237
Arunachal Pradesh	4	3	100	101	110	289	460	20,019	636	563	294	463	20,120	736	672
Assam	1,337	1,878	2,914	3,594	4,333	23,775	12,834	89,943	18,555	16,374	25,112	14,712	92,857	22,149	20,707
Bihar	3,589	7,474	12,192	16,158	19,592	2,49,539	44,279	69,497	64,754	57,921	2,53,128	51,754	81,690	80,913	77,513
Chandigarh	529	799	1,181	1,489	1,831	62	56	108	100	106	591	856	1,288	1,590	1,937
Chattisgarh	1,782	3,152	4,829	6,205	7,373	5,196	9,020	13,731	12,340	10,651	6,978	12,172	18,559	18,544	18,025
Dadra and Nagar Havelli	31	81	131	116	131	90	173	224	163	93	121	254	355	278	225
Daman and Diu	14	9	24	125	199	6	18	17	21	20	20	27	41	146	220
Delhi	12,905	18,560	25,660	31,319	37,018	424	815	1,488	1,610	1,678	13,329	19,375	27,148	32,928	38,696
Goa	227	302	382	422	497	681	484	283	109	102	908	786	665	531	599
Gujarat	23,454	45,294	70,122	85,066	92,643	10,603	14,254	20,043	15,569	11,746	34,057	59,549	90,165	1,00,634	1,04,389
Haryana	2,928	5,869	8,897	10,945	12,581	5,250	7,040	10,294	8,551	7,138	8,177	12,909	19,191	19,495	19,719
Himachal Pradesh	260	222	246	266	228	2,026	2,703	4,286	3,956	3,770	2,286	2,925	4,532	4,222	3,998
Jammu and Kashmir	1,077	2,050	3,275	3,931	4,548	3,813	3,747	6,405	4,970	4,440	4,891	5,797	9,680	8,901	8,988
Jharkhand	2,551	4,996	7,769	10,148	12,241	5,981	11,625	17,661	15,895	13,431	8,532	16,622	25,430	26,043	25,672
Karnataka	25,477	40,559	50,877	51,063	46,122	11,763	15,817	22,769	18,422	14,804	37,240	56,376	73,646	69,485	60,926
Kerala	9,620	15,804	24,322	32,842	41,392	8,360	7,244	10,721	6,724	4,385	17,980	23,048	35,043	39,566	45,777
Lakshwadweep	-	-	-	-	-	2	4	5	5	5	2	4	5	5	5
Madhya Pradesh	6,386	12,602	20,664	26,008	31,280	15,265	23,584	35,429	31,133	26,770	21,651	36,186	56,093	57,140	58,051
Maharashtra	30,606	53,702	81,430	1,01,414	1,17,362	16,531	25,697	35,696	27,537	19,286	47,137	79,399	1,17,125	1,28,951	1,36,648
Manipur	197	377	483	640	737	460	850	1,278	1,124	934	656	1,227	1,762	1,764	1,671
Meghalaya	405	429	519	580	682	705	993	1,524	1,369	1,246	1,110	1,422	2,042	1,949	1,928
Mizoram	208	242	367	498	564	232	204	305	185	114	440	446	673	683	678
Nagaland	68	167	259	277	322	520	574	914	754	692	589	741	1,173	1,031	1,013
Odisha	2,009	3,545	5,464	6,762	8,073	10,087	16,364	25,384	23,230	20,881	12,096	19,909	30,847	29,992	28,954
Puducherry	416	1,002	2,129	2,604	3,118	991	848	760	375	343	1,406	1,850	2,889	2,979	3,461
Punjab	4,077	9,717	21,958	28,403	34,516	7,625	17,863	40,778	33,964	28,553	11,702	27,580	62,736	62,367	63,069
Rajasthan	8,087	19,766	45,234	59,974	75,192	37,966	60,773	1,28,936	1,17,796	1,10,014	46,054	80,539	1,74,170	1,77,769	1,85,207
Sikkim	65	95	210	259	318	271	493	1,091	997	934	336	589	1,301	1,256	1,252
Tamil Nadu	38,853	76,078	1,45,235	1,51,507	1,43,945	38,047	43,495	78,370	55,947	38,524	76,900	1,19,573	2,23,604	2,07,454	1,82,469
Telangana	27,188	53,975	1,06,251	1,12,931	1,06,074	13,543	24,650	53,057	45,250	38,995	40,731	78,625	1,59,308	1,58,181	1,45,069
Tripura	236	558	1,103	1,332	1,568	1,602	2,852	6,247	5,654	5,230	1,839	3,410	7,350	6,986	6,798
Uttar Pradesh	21,002	51,512	1,17,721	1,56,331	1,95,062	71,593	1,71,544	4,08,165	3,71,129	3,47,024	92,595	2,23,056	5,25,886	5,27,459	5,42,086
Uttrakhand	1,266	2,440	5,293	6,833	8,197	4,468	7,415	15,756	14,030	12,720	5,734	9,855	21,048	20,863	20,917
West Bengal	18,023	43,970	82,875	97,291	1,10,985	31,919	67,721	1,53,766	1,34,175	1,19,360	49,942	1,11,692	2,36,642	2,31,465	2,30,344

Table 29: State-wise viability gap to cater to required demand in BAU Scenario in five time periods (OP model)

State	Cumulative budget (viability gap) in crores for urban services - BAU					Cumulative budget (viability gap) in crores for non-urban services - BAU					Total cumulative budget (viability gap) in crores for BAU Scenario				
	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60	2022-25	2026-30	2031-40	2041-50	2051-60
Andaman and Nicobar	142	105	57	61	63	43	37	66	63	54	185	142	123	124	117
Andhra Pradesh	3,194	2,948	5,355	6,633	7,713	6,751	11,414	23,576	22,800	21,904	9,945	14,363	28,931	29,434	29,616
Arunachal Pradesh	5	3	26	29	33	123	171	9,445	325	310	129	175	9,471	354	343
Assam	1,410	1,043	1,000	1,246	1,473	8,754	4,470	30,433	9,235	8,993	10,163	5,514	31,433	10,482	10,466
Bihar	588	1,353	3,533	4,651	5,525	1,01,531	15,572	32,799	32,367	31,744	1,02,119	16,925	36,332	37,018	37,269
Chandigarh	343	209	427	499	597	48	37	44	50	55	391	246	471	548	652
Chattisgarh	515	699	1,615	2,068	2,325	2,087	3,229	6,540	6,235	5,889	2,602	3,928	8,156	8,303	8,215
Dadra and Nagar Havelli	19	24	42	43	47	35	55	113	83	57	54	80	155	126	104
Daman and Diu	16	11	7	33	55	2	5	8	9	10	18	16	15	42	65
Delhi	8,082	8,830	20,707	24,566	27,983	148	286	675	790	883	8,230	9,116	21,382	25,355	28,866
Goa	253	239	212	183	197	608	388	156	89	59	861	627	368	271	256
Gujarat	4,580	8,577	29,200	46,581	55,389	4,324	5,821	9,794	8,467	7,035	8,903	14,398	38,995	55,048	62,424
Haryana	540	1,142	2,979	3,531	4,120	2,155	2,838	4,958	4,544	4,145	2,695	3,980	7,936	8,075	8,266
Himachal Pradesh	398	395	298	198	137	850	1,071	2,007	2,030	2,109	1,248	1,465	2,305	2,228	2,245
Jammu and Kashmir	336	502	1,087	1,207	1,378	2,621	1,727	2,872	2,741	2,549	2,956	2,228	3,960	3,947	3,927
Jharkhand	522	948	2,437	3,095	3,617	2,075	4,050	8,368	7,934	7,448	2,597	4,998	10,806	11,028	11,065
Karnataka	14,968	17,757	34,964	22,229	20,710	4,797	6,417	11,030	9,859	8,697	19,765	24,174	45,994	32,088	29,407
Kerala	5,120	4,030	6,509	7,905	8,968	6,040	3,888	5,083	4,046	3,005	11,161	7,918	11,592	11,951	11,972
Lakshwadweep	-	-	-	-	-	1	1	3	2	3	1	1	3	2	3
Madhya Pradesh	1,600	2,527	5,915	7,014	8,080	6,884	8,706	17,037	16,009	14,854	8,484	11,233	22,953	23,023	22,933
Maharashtra	11,629	15,310	39,056	53,755	67,425	7,419	9,472	17,436	14,319	11,197	19,048	24,782	56,491	68,074	78,622
Manipur	45	92	183	231	275	172	300	609	565	520	218	392	792	796	794
Meghalaya	498	327	187	221	246	274	400	725	703	688	772	727	912	924	933
Mizoram	247	141	163	181	207	165	106	146	113	81	412	248	309	294	288
Nagaland	38	32	69	89	108	286	237	424	427	394	324	269	493	515	502
Odisha	1,200	1,138	1,849	2,346	2,727	4,344	5,960	12,094	11,821	11,468	5,544	7,098	13,943	14,167	14,195
Puducherry	121	213	555	685	819	820	539	362	193	136	941	752	917	877	955
Punjab	1,244	2,044	5,365	6,729	7,873	3,253	6,593	15,149	13,533	11,721	4,497	8,636	20,514	20,262	19,594
Rajasthan	1,674	3,189	8,776	11,073	14,654	20,295	25,172	48,968	47,355	44,986	21,969	28,360	57,744	58,428	59,640
Sikkim	52	35	52	66	81	154	202	411	400	382	206	237	464	466	463
Tamil Nadu	20,962	30,292	66,557	44,378	42,714	28,272	19,911	30,343	24,288	18,142	49,234	50,203	96,899	68,666	60,857
Telangana	14,278	21,584	55,947	54,240	30,519	7,702	10,091	19,998	18,131	15,960	21,980	31,676	75,945	72,371	46,479
Tripura	59	133	315	372	448	931	1,176	2,358	2,266	2,135	990	1,308	2,673	2,638	2,582
Uttar Pradesh	4,333	8,808	23,516	28,762	35,132	29,506	62,778	1,51,534	1,47,641	1,41,462	33,839	71,586	1,75,050	1,76,402	1,76,594
Uttrakhand	602	645	1,496	1,931	2,262	2,423	3,084	5,977	5,637	5,187	3,025	3,729	7,473	7,568	7,448
West Bengal	5,386	13,394	37,910	45,441	52,356	15,529	25,983	57,422	53,526	48,775	20,915	39,377	95,332	98,966	1,01,131

4 Findings and Inferences

This section details the broad findings and inferences from the model outputs in three scenarios. We detail the temporal and cross-sectional variation (between urban and non-urban) across the three scenarios, based on the obtained results.

The broad findings from the outputs can be discussed at the national and state level. As explained above, the urban bus service resource requirement estimates are based on disaggregated estimates at the city level, and a total of 5,724 cities have been included in the study. For resource requirement estimates of non-urban bus services, disaggregated data at the state and union territory level has been used. Although the estimates have been generated at the said level of disaggregation, the disaggregated results should be cautiously considered, as national averages have been used to estimate city- and state-level disaggregated outputs. For example, the population growth rates used for all cities and states are the average national urban and overall population growth rates, respectively. Similarly, the model estimates demand for buses based on the estimated 'number of buses per 1000 population' (estimated by the tool). This method does not consider the specific conditions of different regions, cities, or states. For example, some states such as Goa, Kerala, and Rajasthan attract higher numbers of tourists than others. This means that these states are likely to have higher per capita numbers of buses in non-urban services. Similarly, some states such as Jharkhand have very low tourism potential, and the same is reflected in the current bus numbers. Additionally, buses operating in some states may be registered in other states due to cheaper registration cost, which will also reflect in higher per capita bus numbers than national or regional averages. However, the model inherently relates the bus demand to the population, resulting in estimations with no per capita variations between states. This results in significantly lower estimated non-urban bus demand in some states with high current supply of buses and significantly higher estimated demand in other states with current very low supply of buses. Thus, the model suggests that in states like Goa, the share of non-urban bus demand will significantly decrease while in states like Jharkhand, a rapid increase in demand can be expected (Annexure 3). As explained, this may not be an accurate picture at individual state level because of variations in tourism rates and bus registration costs. However, since the values used in the estimation are derived from national averages, the overall aggregation at the national level for non-urban services and at the state level for urban services is likely to be accurate. The broad findings at the national and state level for both urban and non-urban services (in all three scenarios) are presented below under four subsections – resource requirement for urban services, resource requirement for non-urban services, overall resource requirement, and overall emissions.

4.1 Urban Public Transport or Stage Carriage Bus Resource Requirement

1. At a national level, the current year (2020-2021) average number of public transport or stage carriage buses per lakh population is 10.73[38]. In the BAU scenario, this number will marginally increase to 10.92 by 2050. However, in the LA and HA scenarios, an average of 28 and 44 (urban) buses per lakh population, respectively, is expected by 2050.
2. The current urban public transport or stage carriage fleet size in India is 52,316 buses, which is only about 40% of the required fleet (today) of 1,32,195 buses in the LA scenario and ~25% of the required fleet of 2,06,083 buses in the HA scenario.
3. The current national average public bus mode share for urban services in India is 3 percent. In the BAU scenario, this number will increase to about 4% by 2050. However, it will increase to about 10.2% in the LA scenario and 16.14% in the HA scenario by 2050.
4. The total urban public transport or stage carriage fleet size will grow to about 0.96 lakh buses by 2050 in the BAU scenario, 2.4 lakh buses in the LA scenario, and 3.8 lakh buses in the HA scenario, from a little over 0.5 lakh buses today. Therefore, while the urban population is expected to increase to about 177% of the current population, by 2050, the urban fleet size is expected to increase to about 183% in the BAU scenario, 454% in the LA scenario, and about 726% in the HA scenario.
5. The urban public bus fleet will cater to about 52 million passenger trips (or 520 million passenger km) per day in 2050 in the BAU scenario, 132 million passenger trips (or 1.32 billion passenger km) per day in the LA scenario, and 209 million passenger trips (or 2.09 billion passenger km) per day in the HA scenario.
6. The total number of buses expected to be operating in all Indian cities combined is estimated to be 0.17 million, catering to close to more than 92 million daily passenger trips (or 920 million daily passenger km) per day by 2031 in the LA scenario.
7. Urban buses alone will provide direct employment to 12.6-19.8 lakh people (in the LA and HA scenarios) by 2050, up from only 2.7 lakh today. In the BAU scenario, this number will increase to about 4.9 lakh people.
8. To achieve this, an average annual state support (budgetary requirement for viability gap) of nearly Rs. 26,000 crores is required (for all urban bus services in India) in both the GCC and outright purchase models for the BAU scenario. In the LA scenario, an annual average VGF of Rs. 50,000 crores is required in a GCC model, and 41,000 crore is required in an OP model. Similarly, in the HA scenario, an annual average VGF of 77,000 crore is required in a GCC model, while this figure is Rs. 65,000 crores in an OP model.

[38] This should be a minimum of 32 for small cities with populations of 0.1-1 million.

9. This will be used to purchase an average of 7,148 urban buses annually up to 2050 in the BAU scenario, 15,582 buses annually in the LA scenario, and 24,704 buses annually in the HA scenario. Additionally, these funds will be used to cover annual operational losses and develop urban bus infrastructure.
10. It is estimated that for urban services, approximately 1,300 hectares of land is currently being utilised for approximately 1,562 urban bus terminals and 477 urban bus depots in India. These requirements will increase to approximately 2,892 bus terminals and 743 bus depots, requiring 2,050 Ha of land, in the BAU scenario, 7,146 bus terminals and 2,107 bus depots, requiring 5,395 Ha of land, in the LA scenario, and 11,403 bus terminals and 3,590 bus depots, requiring 8,850 Ha of land, in the HA scenario.
11. This means that approximately 30 Ha of land needs to be developed for an average of 46 bus terminals and 9 bus depots annually in the BAU scenario. In the LA scenario, this requirement becomes 141 Ha of land for an average of 193 bus terminals and 56 bus depots annually, and 260 hectares of land needs to be developed annually for an average of 339 bus terminals and 107 bus depots in the HA scenario.
12. The average overall cost of ownership of urban electric buses over the next 10-15 years is expected to be less than that of ICE buses. What this means is that the sooner cities shift to electric, the more beneficial it will be for them both environmentally and financially.

4.2 Non-Urban Bus Resource Requirement

1. The non-urban population is expected to shrink by 23% over the next 40 years, from approximately 95 crores today to about 77 crore in 2060.
2. Since non-urban bus services serve both the urban and non-urban population, the number of buses per lakh population is derived based on the total Indian population. The average today is an impressive 28.19 buses per lakh population. This is mainly because the total non-urban bus fleet in the country, based on official stage carriage data, is approximately 4.05 lakh. The desired fleet size to cater to the latent demand is estimated today at about 7.16 lakh in the LA scenario and 13.42 lakh in the HA scenario.
3. The model estimates the resource requirements based on a target mode share of 16% and 30%, respectively, in the LA and HA scenarios (compared to the current mode share of 10.8%), to be achieved in 10 years.
4. Since the non-urban per capita trip rate of the non-urban population is higher (1.1-1.3) than that of the urban population (0.1), the rural-urban population shift effectively reduces the non-urban passenger trip demand, along with the resultant non-urban bus fleet requirement. This reduces the average national requirement of buses per lakh population to 26.81 in 2050 from 28.19 today in the BAU scenario. However, the projected increase in mode share in both the LA and HA scenarios pushes the bus requirement up. The outcome is 39.19 buses per lakh population in the LA scenario and 73.48 buses per lakh population in the HA scenario in 2050.

5. The total non-urban public transport or stage carriage fleet size will grow to about 4.5 lakh buses in 2050 in the BAU scenario, 6.7 lakh buses in the LA scenario, and 12.5 lakh buses in the HA scenario, from about 4.05 lakh buses today. Therefore, while the total population (urban + non-urban) is expected to increase by 18% by 2050, the non-urban fleet size is expected to increase by about 11% in the BAU scenario, about 65% in the LA scenario, and about 309% in the HA scenario in the same period.
6. These buses will cater to about 69 million passenger trips (or 4.1 billion passenger km) per day in 2050 in the BAU scenario. This will increase to 100 million passenger trips (or 6 billion passenger km) per day in the LA scenario and 188 million passenger trips (or 11.3 billion passenger km) per day in the HA scenario.
7. The total number of public transport or stage carriage non-urban buses expected to be operating in India is estimated to be 0.73 million, catering to over 112 million daily passenger trips (or 6.7 billion daily passenger km) per day by 2031 in the LA scenario.
8. Even though the non-urban fleet size is not expected to increase significantly in the long term in the BAU scenario, buses need to be procured to replace an ageing fleet. The current average annual bus procurement demand is approximately 41,000 units today. This is reducing in a BAU scenario. In a BAU scenario the average annual requirement for non-urban buses to be procured is estimated at 38,532 up to 2050. This number is expected to increase to 53,477 units in the LA scenario and 1,01,755 buses in the HA scenario.
9. Only about 25.57% of the total non-urban fleet is under public operations. These buses are deemed non-profitable, operating at a loss of Rs. 4.0-9.0 per km (refer to Section 2). Since the rest of the (private) fleet is not expected to generate operational losses, the overall viability gap or annual state support requirement for non-urban services is comparable with that for urban services, or an average of about Rs. 35,972 crores annually in the BAU scenario, Rs. 46,118 crores on average in the LA scenario, and Rs. 82,685 crores in the HA scenario, up to 2050.
10. It is estimated that currently about 6,300 hectares of land is used for approximately 8,131 non-urban bus terminals and approximately 3,383 non-urban bus depots. However, only about one-fourth of these depots and terminals are estimated to be formally organised to provide bus services, while the rest remain largely informal. This is because of the many small private fleet operators in the non-urban bus service sector.
11. If a 15-year timeline is set for the transition to electric, the entire urban fleet in India will be 100% electric by 2048.

4.3 Total (Urban + Non-Urban) Bus Resource Requirement

1. The overall fleet requirement will increase from 4.58 lakh public transport or stage carriage buses today to 5.47 lakh in the BAU scenario by 2050, about 9.09 lakh buses in the LA scenario, and 16.35 lakh buses in the HA scenario (Figure 5).

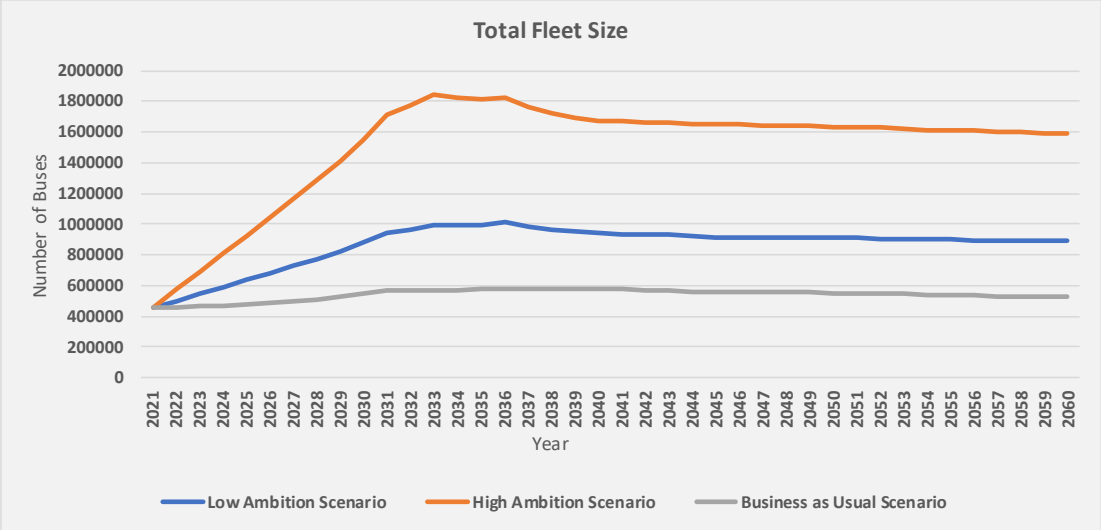


Figure 5: Total fleet size to be achieved with 10-year (urban) & 15-year (non-urban) transition period to achieve 100% bus fleet electrification (in LA & HA scenarios)

2. The total number of public transport and stage carriage buses expected to be operating in the country will double to about 9 lakh (0.9 million) in the LA scenario, catering to close to 203 million passenger trips per day and grow by almost 3.5 times to 16 lakh (1.6 million), catering to 352 million daily passenger trips, in the HA scenario by 2031.
3. An average of about 0.45 lakh buses will need to be procured annually up to 2050 to maintain the fleet size in the BAU scenario. This number will increase to close to 0.71 lakh buses annually in the LA scenario, and 1.27 lakh buses annually in the HA scenario.
4. The total average annual budgetary allocation or VGF to meet all operational, fleet procurement, and infrastructural development requirements (for both urban and non-urban services) is approximately Rs. 62,384 crores in the BAU scenario, Rs. 95,696 crores in the LA scenario, and Rs. 159,512 crores in the HA scenario – in a GCC model (Figure 6). In an OP model, the average annual VGF is approximately Rs. 54,128 crores in the BAU scenario, Rs. 73,912 crores in the LA scenario, and Rs. 124,234 crores in the HA scenario (Figure 7). The current viability gap funded by the state governments in India is estimated to be approximately Rs. 50,000 crore per annum. This implies that any state and central government programmes designed to achieve the desired electric fleet size should commit to an annual average budget of between Rs. 33,000 crore and 97,000 crore (for the LA and HA scenarios, respectively) in a GCC model, and Rs. 20,000 crore and 70,000 crore (for the LA and HA scenarios, respectively) in an OP model.

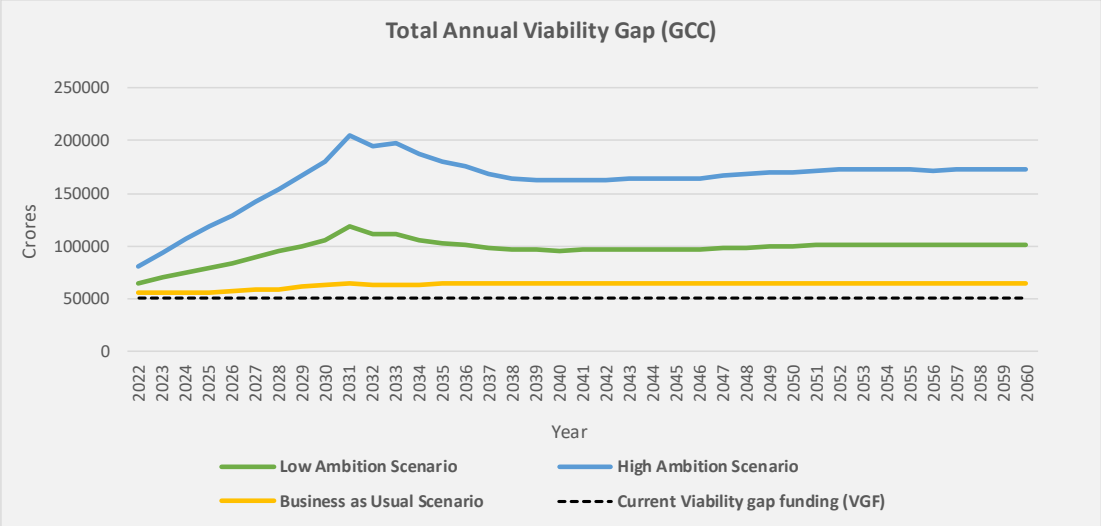


Figure 6: Total annual viability gap (GCC model): Total – 10-year (urban) & 15-year (non-urban) transition to 100% electric (in LA & HA scenarios)

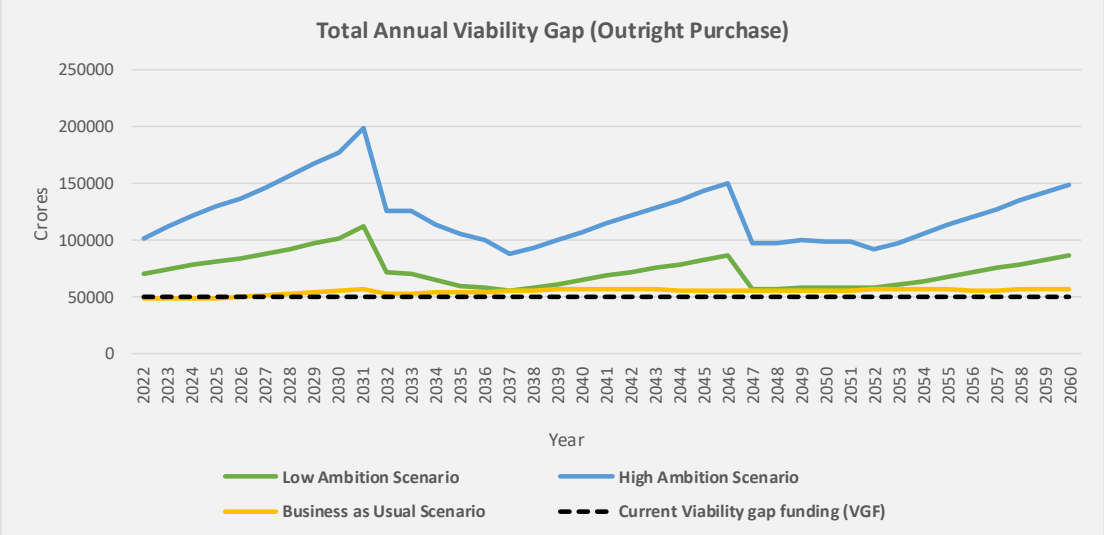


Figure 7: Total annual viability gap (OP model): Total – 10-year (urban) & 15-year (non-urban) transition to 100% electric (in LA & HA scenarios)

5. The viability gap in a GCC model is 30% more than that in the OP model in the long term (up to 2050). One reason for this discrepancy is the higher interest rates on capital in a GCC model. However, the GCC model is beneficial in the short term, when initial investments amounting to large capital requirements may be difficult to access. It is estimated that over the next 10 years (up to 2031), when investments will be sought to expand the fleet size to match the target in the LA or HA scenario, a GCC model will require up to 5% less funding than an OP model. Over the next 5-year period (up to 2026), up to 13% less funds will be required to meet the fleet expansion and electrification targets in a GCC model than that required in an OP model.

6. When STUs are supported through low-cost loans (6.5% interest rate considered in the study) or grants from the government, the cost of purchasing buses is far lower than through a typical GCC model, where private entities rely on commercial finance (with an interest rate of 10% considered in this study). Therefore, if GCC is the preferred model, states should consider reducing the lending rate to bus operators, e.g., through preferential loans, blended finance, etc.
7. The total direct manpower requirement for public bus services in India will increase from 2.38 million today to 2.87 million in 2050 in the BAU scenario, 4.74 million in the LA scenario, and 8.51 million in the HA scenario (Figure 8). Thus, the bus sector, which is already a significant employment generator, will see up to a fourfold increase in the direct jobs created by bus operations alone. Additional jobs will be created in the manufacturing, recycling, etc. and can be estimated separately. The overall impact of bus fleet expansion and electrification on jobs in India can be a subject of another study.

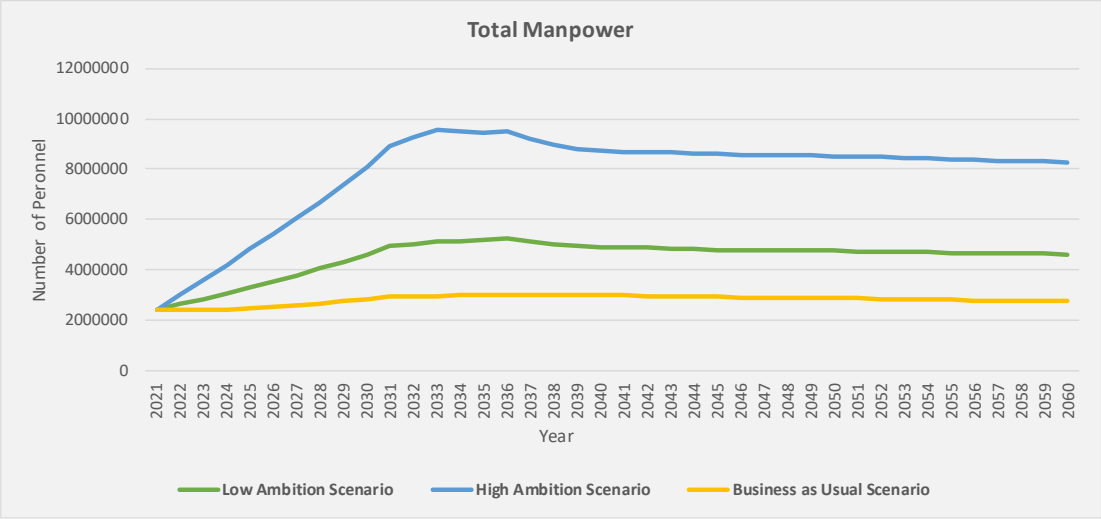


Figure 8: Total manpower requirement: Total – 10-year (urban) & 15-year (non-urban) transition to 100% electric (in LA & HA scenarios)

8. Overall, 7,700 hectares of land with an estimated 9,693 bus terminals and 3,860 bus depots, including informal bus infrastructure[39], is estimated to have been developed up until now. The aggregated national requirement will increase to about 12,436 Ha of land required to develop 11,950 bus terminals and 4,508 bus depots in the BAU scenario, 20,783 Ha of land for 20,560 bus terminals and 7,685 bus depots in the LA

[39] Such infrastructure is used by private operators, which are owners of small fleets who often lack access to a proper organised bus terminal and depot like those available for STU buses.

scenario, and 37,704 Ha of land for 36,558 bus terminals and 14,050 bus depots in the HA scenario, by 2050 (Figure 9).

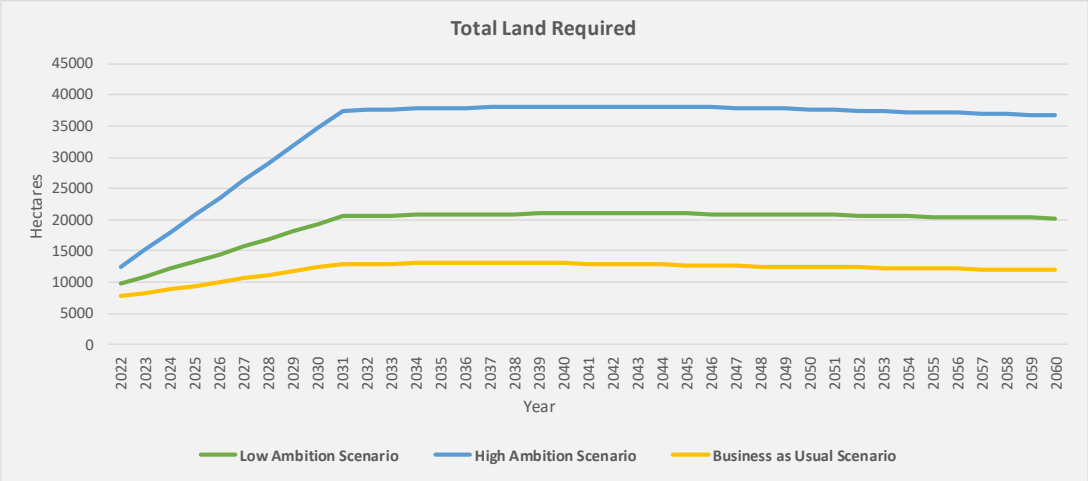


Figure 9: Total land requirement: Total – 10-year (urban) & 15-year (non-urban) transition to 100% electric (in LA & HA scenarios)

9. The total land area and number of terminals and depots is estimated for all public buses (formal and informal operations) for non-urban services, including privately operated services by small operators. This means that investments may need to be aligned, not just to formalise the current informal and dilapidated bus infrastructure for STUs, but also to acquire an additional 4,836 hectares of land in the BAU scenario (for 2,257 additional bus terminals and 648 depots), 13,183 Ha in the LA scenario (for 10,867 additional bus terminal and 3,825 bus depots), and 30,104 Ha in the HA scenario (for 26,865 additional bus terminals and 10,190 bus depots), up to 2050.

4.4 Public Bus Service Emissions

1. It is estimated that all public (or stage carriage) buses combined (both government and private) currently produce almost 0.2 million tCO_2 per day. This will increase to about 0.4 million tCO_2 per day if the fleet is expanded as per the LA scenario in 2031, but the pace of electrification is not accelerated (i.e., if the current pace of electrification is maintained).
2. In both the LA and HA scenarios, the total carbon emissions from public buses will decrease to 'zero' by 2050, i.e., emissions from buses in the HA or LA scenario in 2050 and beyond can be expected to be 'zero' (Figure 10). Thus, in 2050, the per day emissions prevented from public bus or stage carriage buses would be 0.2 million metric tCO_2 in the BAU scenario, 0.32 million tCO_2 in the LA scenario (for fleet expansion, if the current pace of electrification is maintained), and 0.6 million tCO_2 in the HA scenario (for fleet expansion, if the current pace of electrification is maintained).

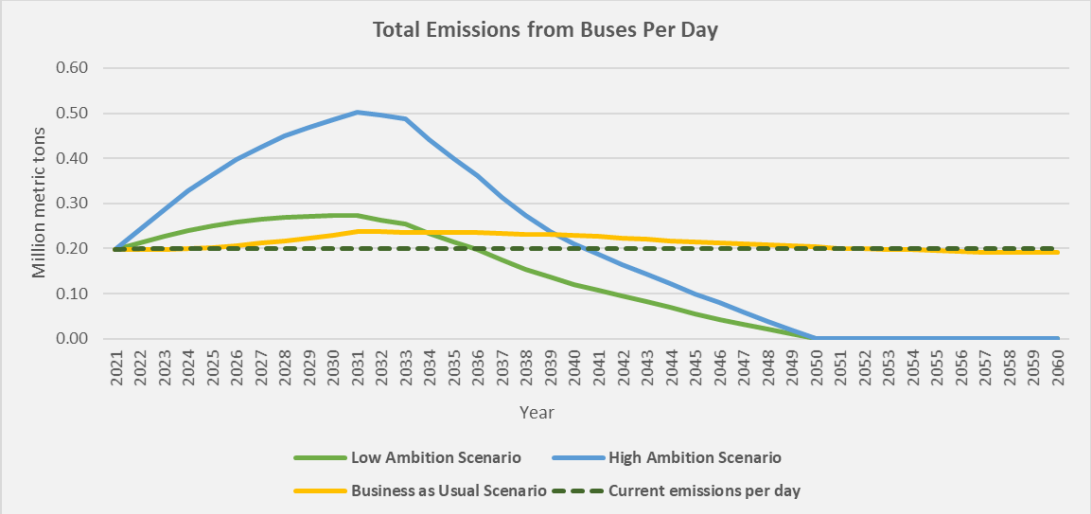


Figure 10: Total annual emissions: Total – 10-year (urban) & 15-year (non-urban) transition to 100% electric (in LA & HA scenarios)

3. The total emissions from ICE public transport or stage carriage buses in the BAU scenario up to 2050 is estimated to be 2.4 billion tCO_2. In the LA and HA scenarios, these emissions will be a total of 1.8 billion $tCO_2$and 3.0 billion tCO_2, respectively[40]. In a scenario where the fleet size planned for LA and HA scenarios is achieved without accelerating the current pace of electrification, the total emissions from buses by 2050 will be 3.3 billion tCO_2 and 5.7 billion tCO2, respectively. This means that 0.6-1.5 billion tCO_2 can be abated in the LA scenario. In the HA scenario, total emissions may increase by 0.6 billion tCO_2 if the fleet size is not expanded, but savings of 2.7 billion tCO_2 can be expected if fleet expansion as per the HA scenario is achieved. In both scenarios, emissions from public bus operations will become 'zero' by 2050, and even in the meantime, significant additional emissions will be avoided, because increasing the number of public bus trips will mean that a similar number of inefficient private motorised trips are avoided. Additional benefits include reduction in noise pollution. These benefits can be quantified as a part of other studies.

[40] In the LA and HA scenarios, complete electrification of the entire operational fleet is not achieved before 2048. During this time, the procurement of ICE buses is gradually phased out, while that of electric buses is accelerated over a 10-year time period for urban services and 15-year time period for non-urban services. The emissions are estimated from both ICE buses and grid emissions for the electric fleet, until the grid emissions drop to 0 in 2050.

Annexures

Annexure 1

Total Number of Fleet Size in each state and Union Territory of India

S. No.	States	Total Reg. Buses (a)	Stage Carriage (b)	(b/a) %	Urban Buses	Current no. of ICE buses	Current no. of Electric buses
1	Andaman & Nicobar Islands UT	1089	396	36%	110	**96**	**14**
2	Andhra Pradesh	41187	14245	35%	1782	**1782**	
3	Arunachal Pradesh	5192	471	9%	4	**4**	
4	Assam	18459	1943	11%	772	**727**	**45**
5	Bihar	33751	12273	36%	198	**198**	
6	Chandigarh UT	2932	567	19%	240	**240**	
7	Chhattisgarh	15484	5811	38%	398	**398**	
8	Dadra and Nagar Haveli UT	594	72	12%	13	**9**	**4**
9	Daman and Diu UT	0	0	0%	13	**13**	
10	Delhi	41682	2433	6%	6867	**6867**	
11	Goa	11888	4323	36%	175	**125**	**50**
12	Gujarat	74855	30673	41%	1899	**1859**	
13	Haryana	57696	14551	25%	206	**206**	
14	Himachal Pradesh	9633	5875	61%	262	**165**	**97**
15	Jammu & Kashmir	29079	17861	61%	190	**150**	**40**
16	Jharkhand	10398	1220	12%	260	**260**	
17	Karnataka	93690	41431	44%	9499	**9499**	
18	Kerala	117720	44157	38%	3243	**3243**	
19	Lakshadweep UT	0	0	0%	0	**0**	
20	Madhya Pradesh	53468	29020	54%	790	**686**	**104**
21	Maharashtra	141289	36673	26%	6715	**6575**	**140**
22	Manipur	2583	329	13%	25	**25**	

S. No.	States	Total Reg. Buses (a)	Stage Carriage (b)	(b/a) %	Urban Buses	Current no. of ICE buses	Current no. of Electric buses
23	Meghalaya	5518	2006	36%	286	**286**	
24	Mizoram	1268	1268	100%	150	**150**	
25	Nagaland	5926	1960	33%	33	**33**	
26	Orissa	27621	16025	58%	687	**637**	**50**
27	Puducherry UT	3834	1699	44%	40	**40**	
28	Punjab	45378	0	0%	515	**515**	
29	Rajasthan	108680	39520	36%	555	**455**	**100**
30	Sikkim	363	263	72%	41	**41**	
31	Tamil Nadu	187073	64482	34%	7409	**7409**	
32	Tripura	2953	1370	46%	16	**16**	
33	Uttar Pradesh	75309	18250	24%	1195	**1105**	**90**
34	Uttarakhand	12031	4627	38%	303	**253**	**50**
35	West Bengal	46963	17078	36%	822	**782**	**40**
36	Telangana	51580	16530	32%	5580	**5540**	**40**
	Total	**13,37,166**	**4,49,402**	**34%**	**42,909**	**41,068**	**359**

Source

1. For Stage Carriage Bus Numbers: Annexure 3.3d (Road Transport Yearbook 2016-17)

2. Online data mining for urban bus numbers

Annexure 2

Interest rate for bus finance

Using the CIRT report 2018 (CIRT, 2018) – a total of 5672.9 Cr was spent on purchasing buses in 2017-18. 26% (1449.36 Cr) of this amount was financed by 19 loans with interest rates ranging from 14.5% (DTC) to 6.5% (BMTC). A mean of 9.76% per instance of loan, and a mean of 9.95% when weighted by the quantum of the loan amount is estimated. Nine cases of interest free loans were provided in the form of equity or grants, amounting to 4223 Cr, out of which 3818 Cr (90%) belonged to just two STUs, DTC and KnSRTC. In both instances, the STUs had taken additional loans to finance bus purchases. Therefore, if the two instances of DTC and KnSRTC are ignored, it may be assumed that as a norm, STUs have borrowed loans at a rate of close to 10% to finance their bus purchases.

In both the low ambition and high ambition scenarios, it is assumed that there is an increase in public transport service as an outcome of a greater public transport provision (refer Chapter 2). It is outside the scope of this study, to assume whether various state and city governments are able to raise the additional revenue required from its own revenues, i.e., either by diverting existing revenues or establishing new taxes or cases. The resource burden to finance fleet expansion is therefore assumed to be met by raising finances through the current norm of loans or through some form of blending through bonds and low-cost loans from development finance institutions. Therefore, for the purposes of this study, a rate of 6.5% (as a cost of the capital to the government in case of grants for bus purchase) has been assumed (which is lowest rate of a loan observed in 2018) in an outright purchase model (for 6-year time). While the average cost of commercially financing bus purchase in a GCC model is taken as the weighted average of current interest rates at 10% (Table 30).

Table 30: Source of finance obtained for buses in India as of March 2018

Sr. No.	Name of STU	Source	Loan Amount (Crore)	Period of Loan (yrs. - Months)	Interest Rate (%)
1	APSRTC	State Govt.	229.13		
2	TSRTC	Commercial banks	131	6-0	10.50,9.25,10.75
3	GSRTC	State Govt. (Equity)	573.83	1-0	0
		State Govt. (Loan)	194.69		
4	KnSRTC	Commercial banks	276.38	5-0	8.25
		Depreciation Fund	1834.77		
5	NEKnRTC	State Govt.	0.13		
		Canara Bank	22.91	6-0	8.45 (Floating)

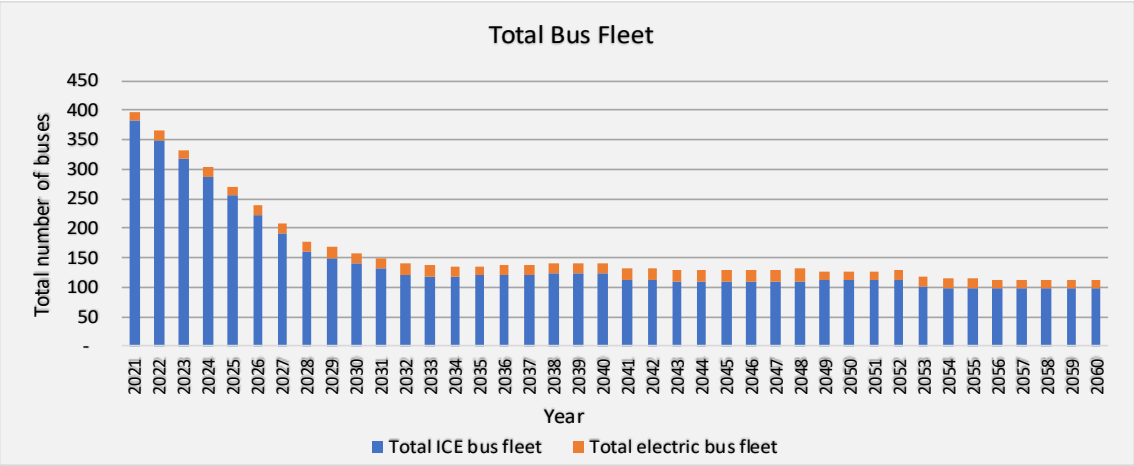
Sr. No.	Name of STU	Source	Loan Amount (Crore)	Period of Loan (yrs. - Months)	Interest Rate (%)
		Canara Bank	0.09	6-0	8.55 (Floating)
		Canara Bank	45.72	7-0	8.30
		State Bank of Hyderabad	2.17	6-0	9.10 (Floating)
6	NWKnrtc	Commercial bank (Canara Bank)	100	7-0	8.40
7	TNSTC-KUM	State Govt.	6.82		
8	TNSTC-SLM	State Govt.	21.60		
9	TNSTC-CBE	TDFC	17.90	8-4	9.75
10	TNSTC-TNV	State Govt.	2.19	5-0	11.50
		TDFC Ltd. Chennai	0.71	8-4	9.75
11	SETC-TN	State Govt.	10.15	5-0	11.00
		TNTD Finance Corporation Ltd.	10.53	8-4	9.75
			10.00	4-2	10.00
12	SBSTC	State Govt.	18.59	15-0	12.50
13	HRTC	Commercial banks	72.48	5-0	8.50
14	NGST	HUDCO	2.00	10-0	10.15
15	BMTC	Commercial banks	176.8		8.75
		DULT	5.00		
		KUIDFC	371.35		**6.50**
16	DTC	State Govt. A) Equity Capital	1983.85		
		State Govt. A) Plan Loan	511.3	13-0	10.50 to 14.50
17	MTC-CNI	State Govt. Loan	34	5-0	11.50
		TDFC - Chassis	4.44	8-4	9.75

Annexure 3

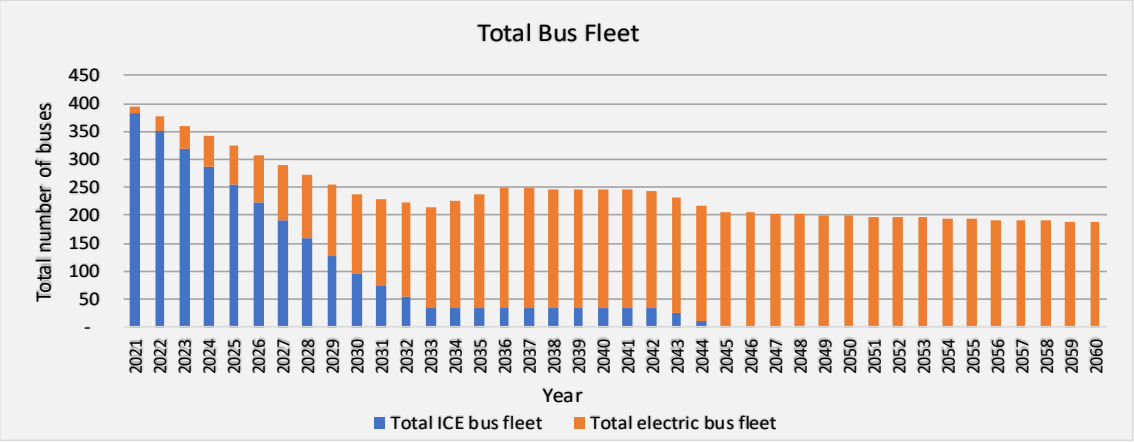
This section presents State wise output graphs, cumulative for year urban and non-urban services in high ambition, low ambition, and business as usual scenario. These outputs include annual - bus fleet size, estimated bus demand and supply, land requirement, types of buses to be procured, revenue as well viability gap in GCC model and revenue as well viability gap in outright purchase model. Although the estimates have been generated disaggregated at State level, these should be cautiously considered, as national averages have been used to estimate city- and state-level disaggregated outputs (for urban services). For example, the population growth rates used for all cities and states are the average national urban and overall population growth rates, respectively. Similarly, the model estimates demand for buses based on the estimated 'number of buses per 1000 population' (estimated by the tool). This method does not consider the per capita bus variation because of specific conditions of different regions, cities, or states. For example, some states such as Goa, Kerala, and Rajasthan attract higher numbers of tourists than others. This means that these states are likely to have higher per capita numbers of buses in non-urban services. Similarly, some states such as Jharkhand have very low tourism potential, and the same is reflected in the current non-urban service bus numbers. Additionally, buses operating in some states may be registered in other states due to cheaper registration cost, which will also reflect in higher per capita bus numbers than national or regional averages. However, the model inherently relates the bus demand to the population, resulting in estimations with no per capita variations between states. This results in significantly lower estimated non-urban bus demand in some states with high current supply of buses and significantly higher estimated demand in other states with current very low supply of buses. Thus, the model suggests that in states like Goa, the share of non-urban bus demand will significantly decrease while in states like Jharkhand, a rapid increase in demand can be expected.

1. State / UT: Andaman and Nicobar

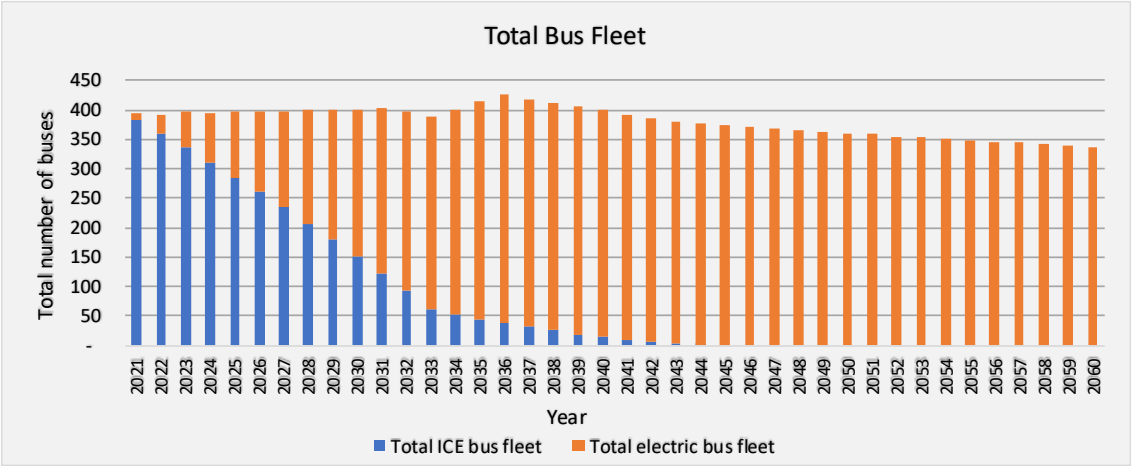
Business as usual Scenario



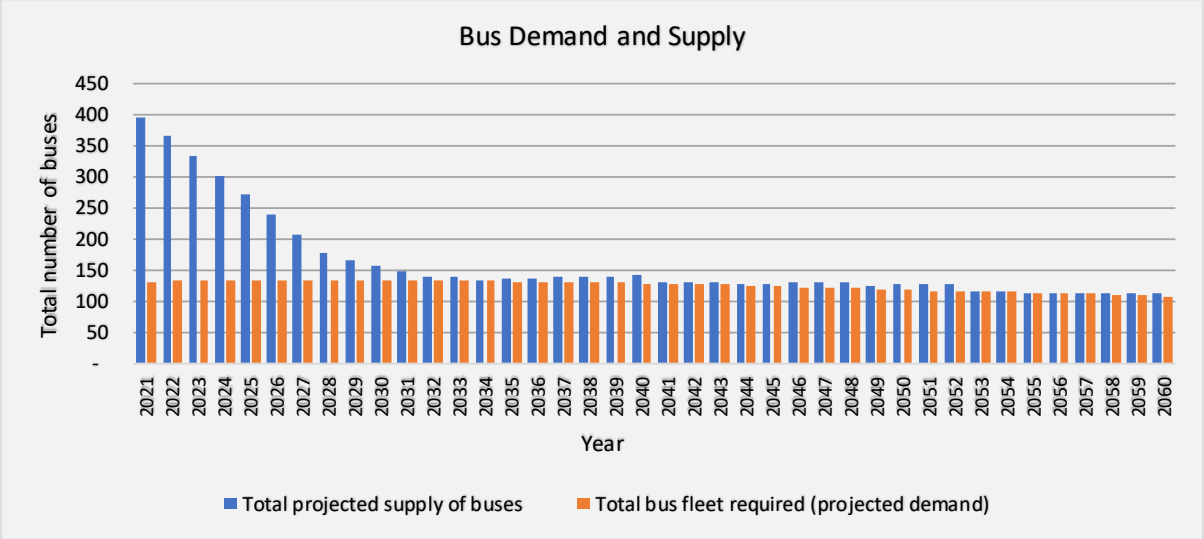
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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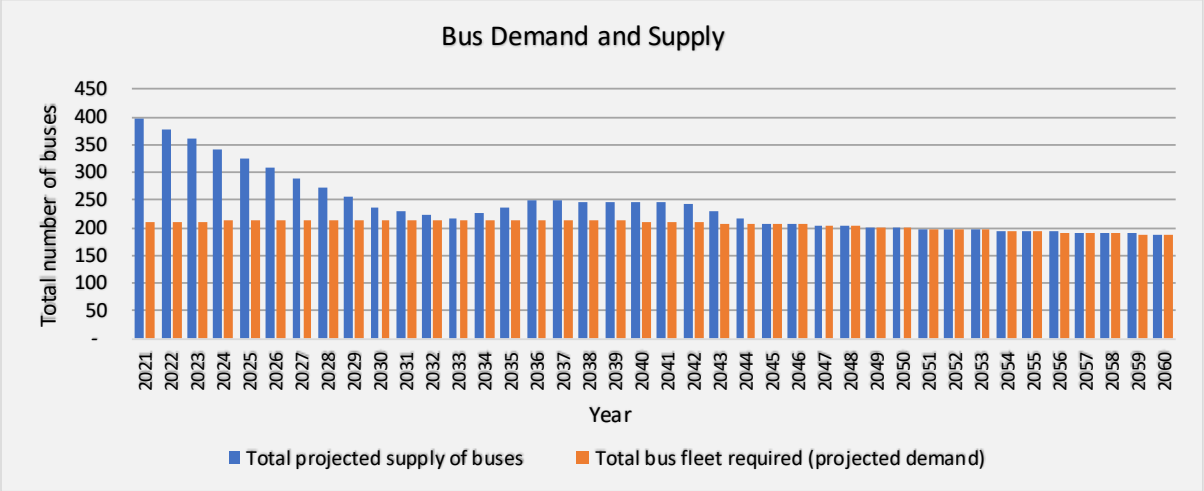

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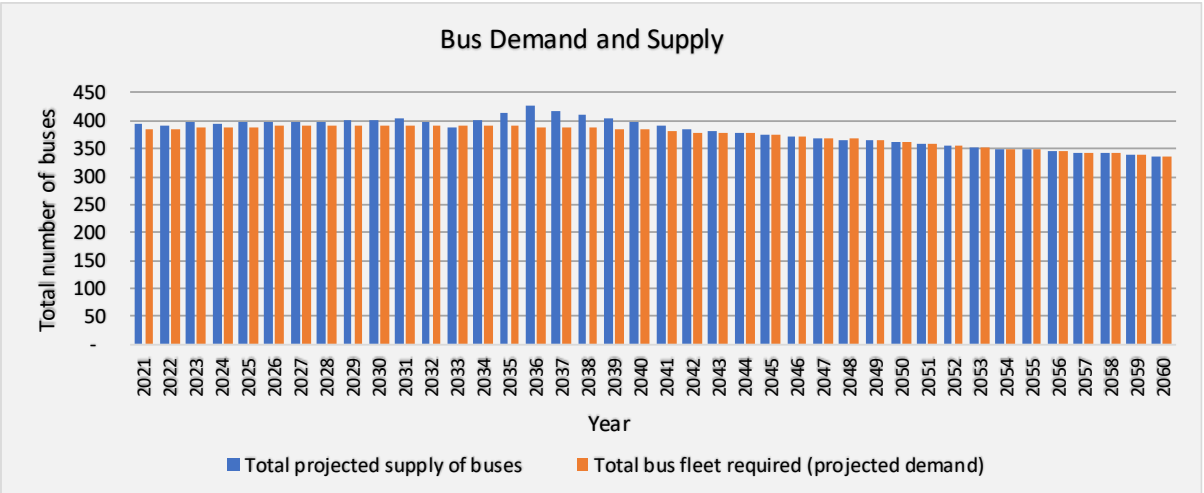

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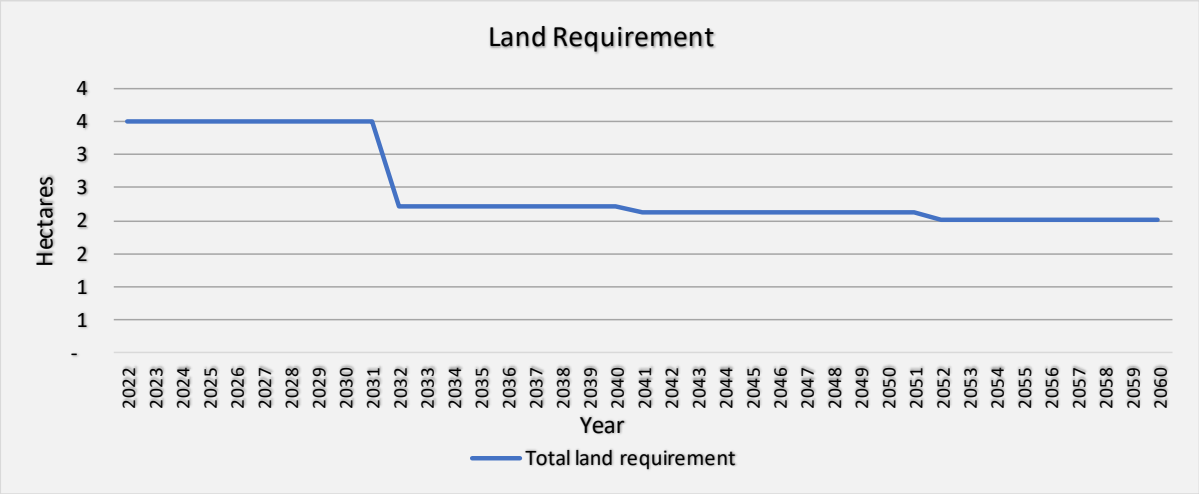

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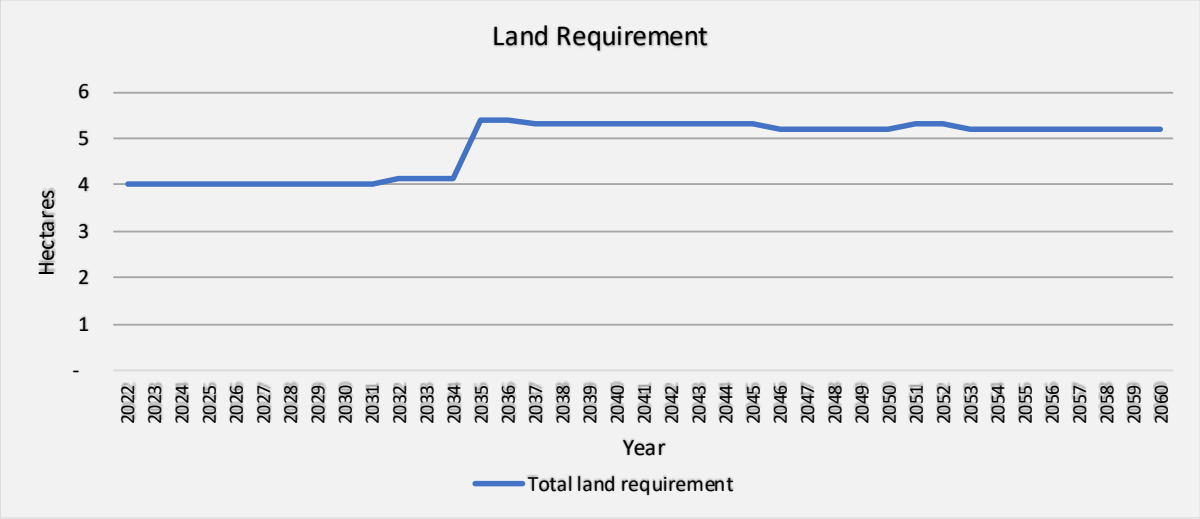

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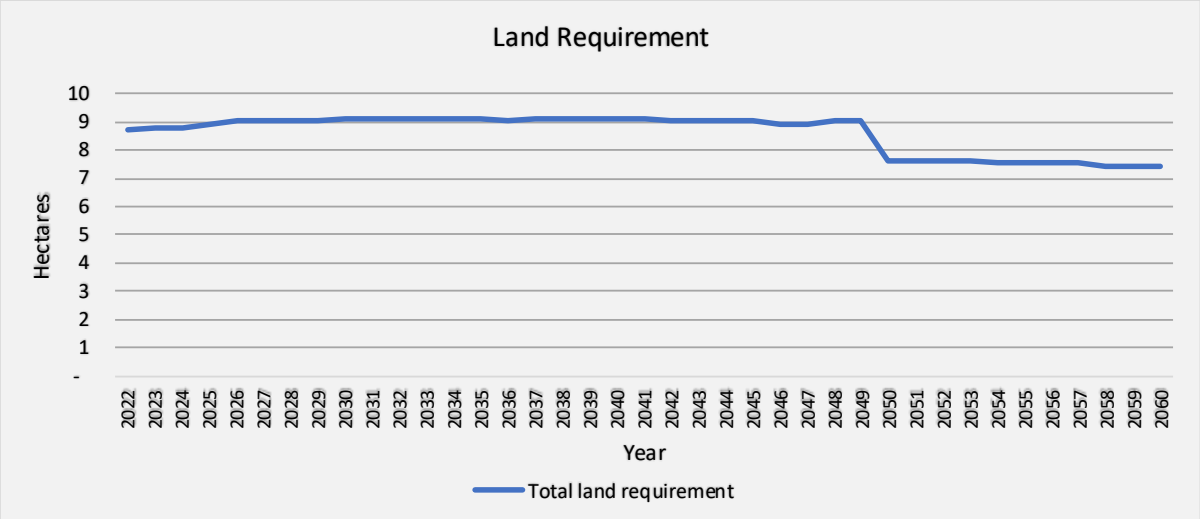
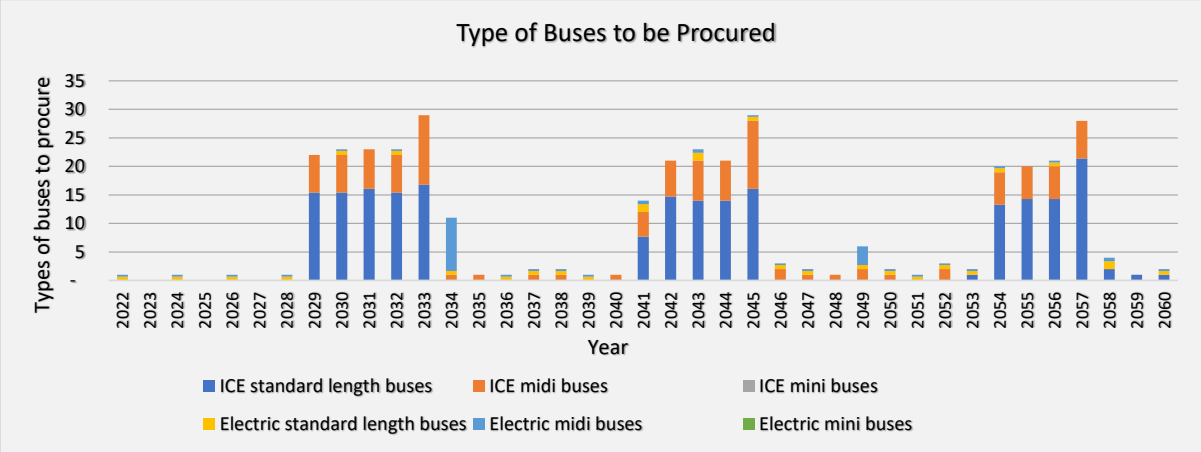
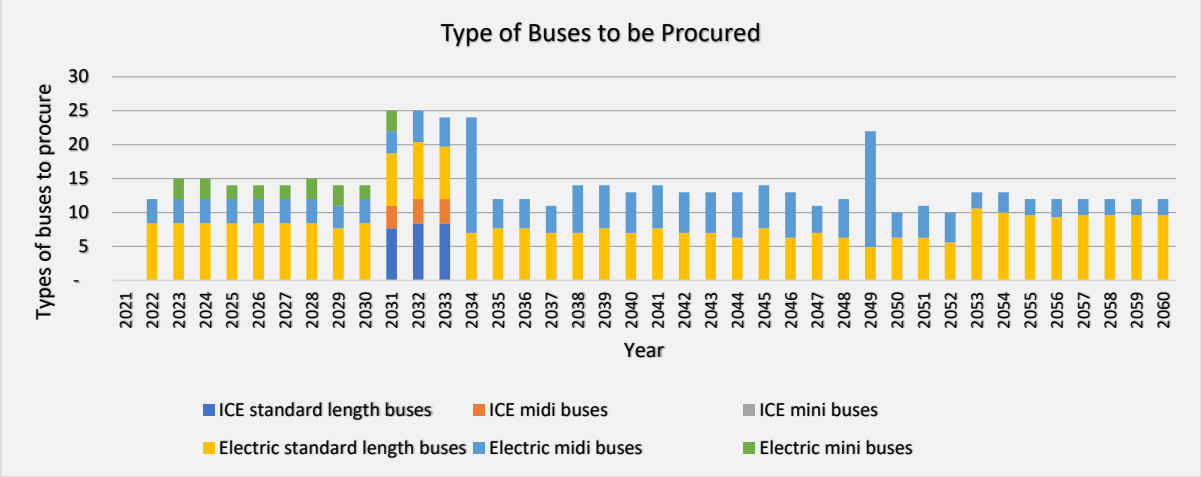


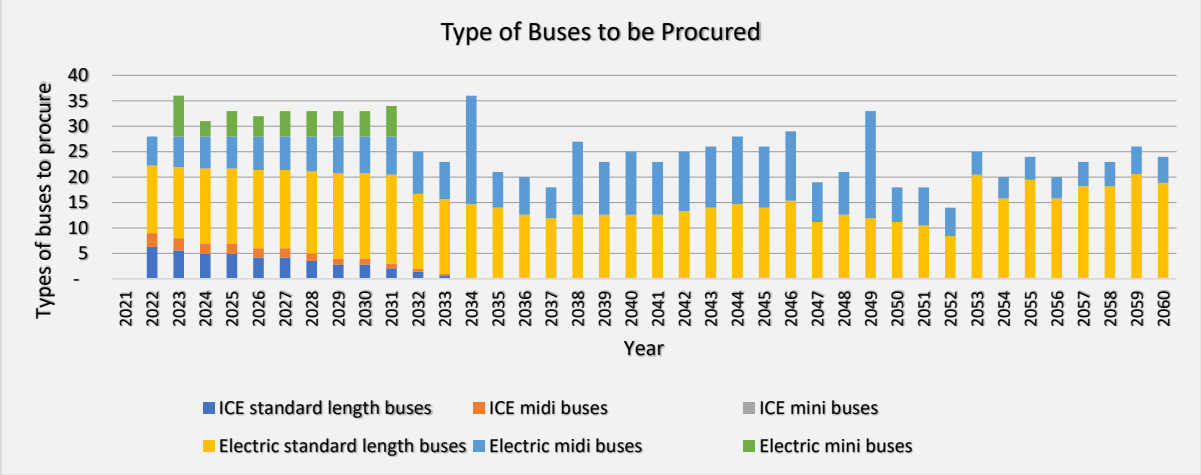
Business as Usual Scenario



Low Ambition Scenario

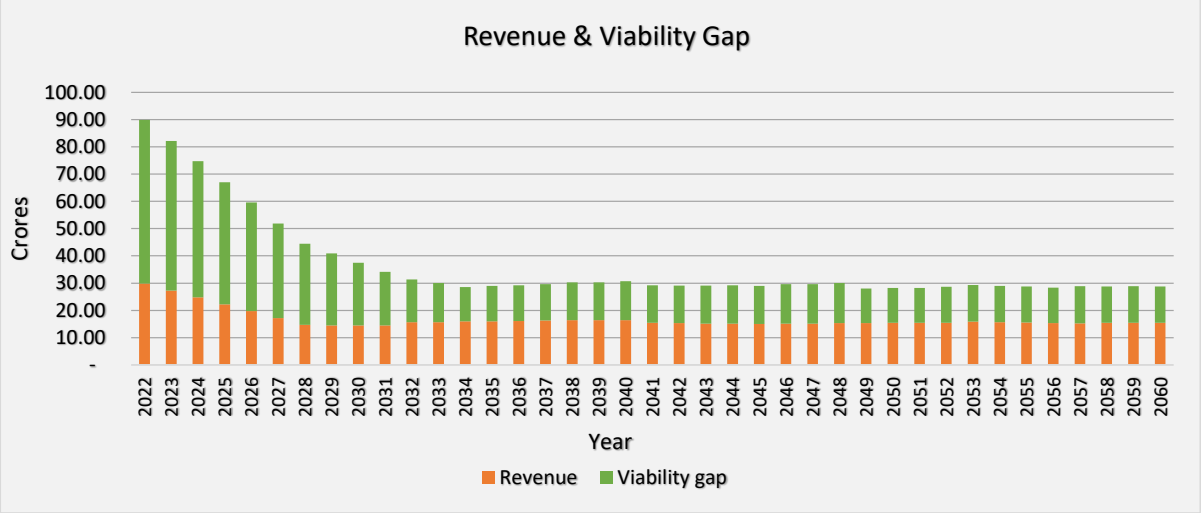


High Ambition Scenario

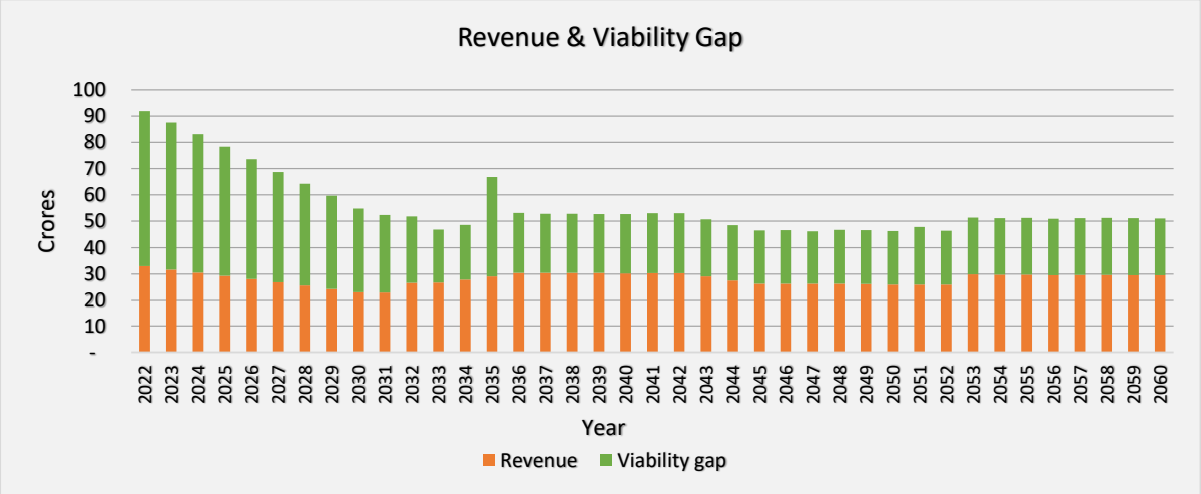


Revenue and Viability Gap: GCC Model

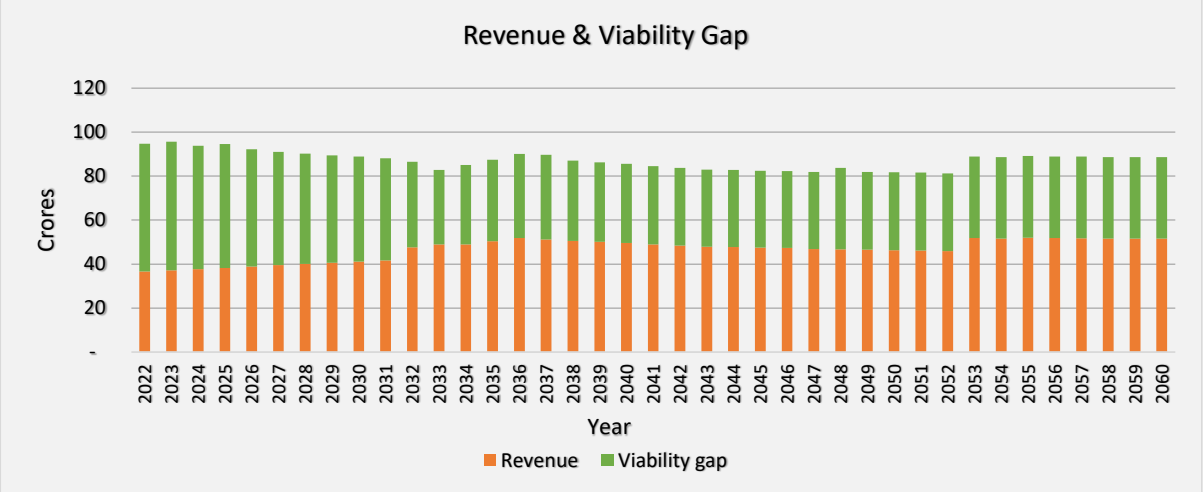
Business as Usual Scenario



Low Ambition Scenario

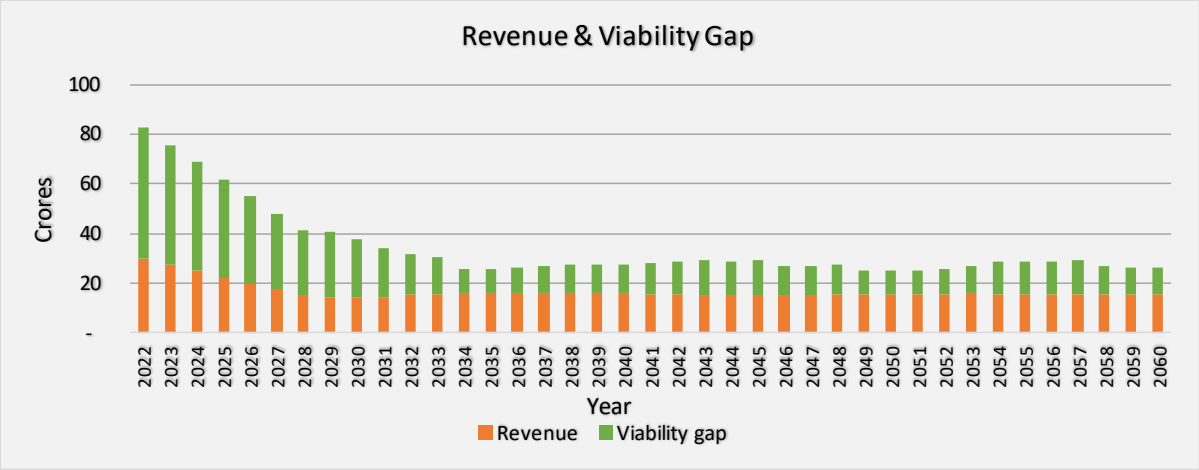


High Ambition Scenario

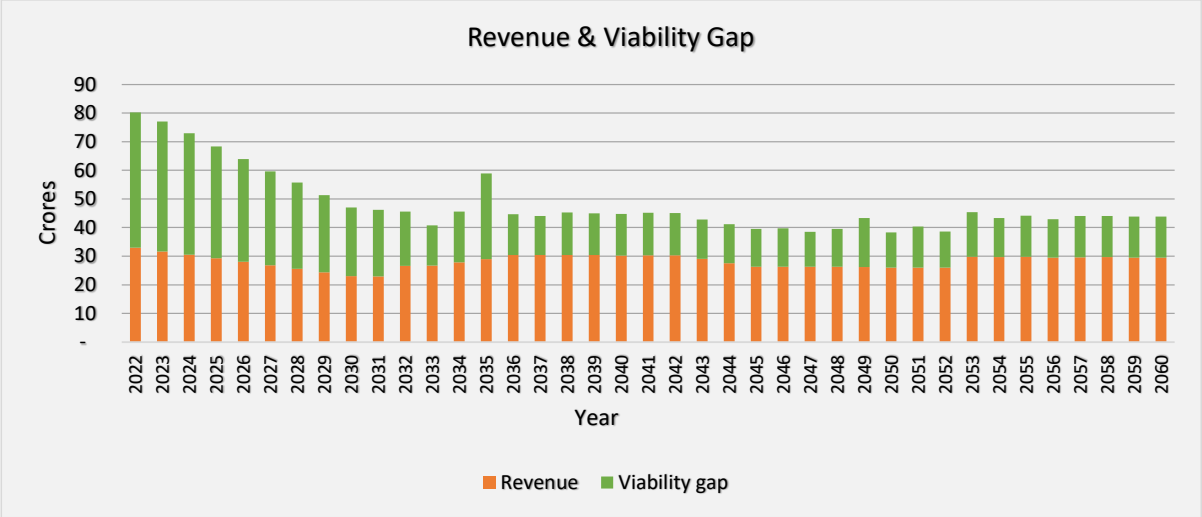


Revenue and Viability Gap: Outright Purchase Model

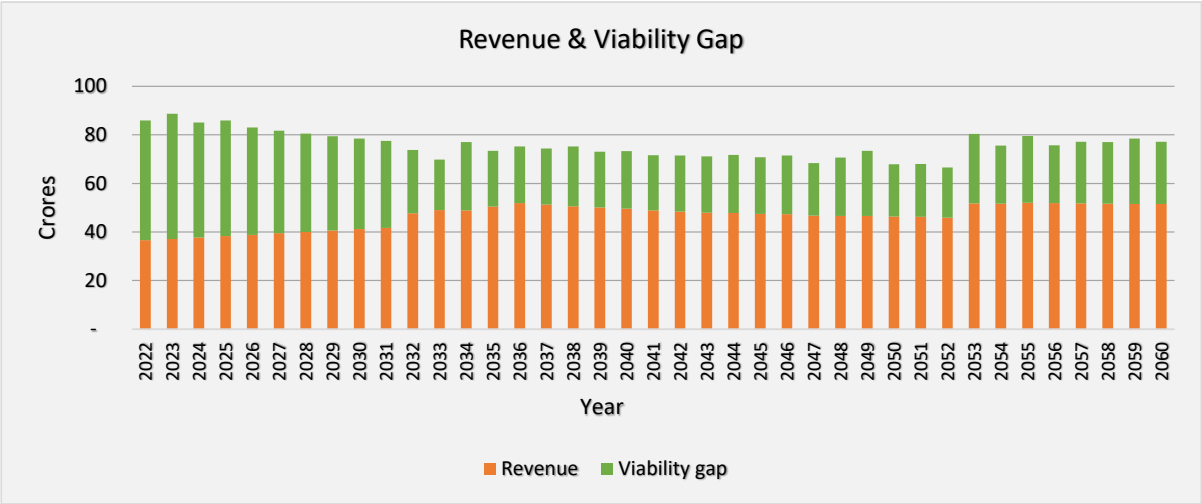
Business as usual Scenario



Low Ambition Scenario

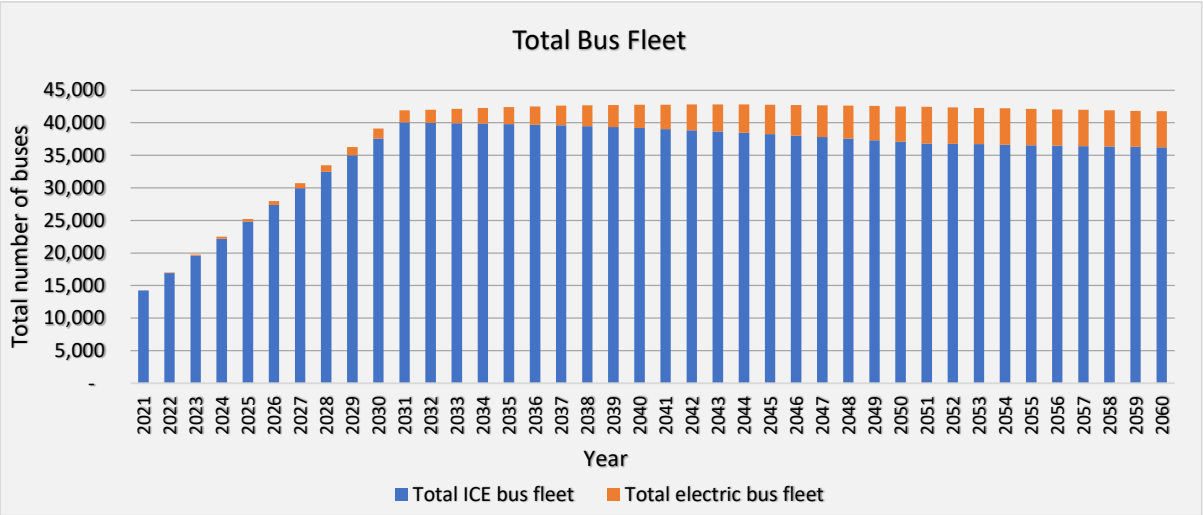


High Ambition Scenario

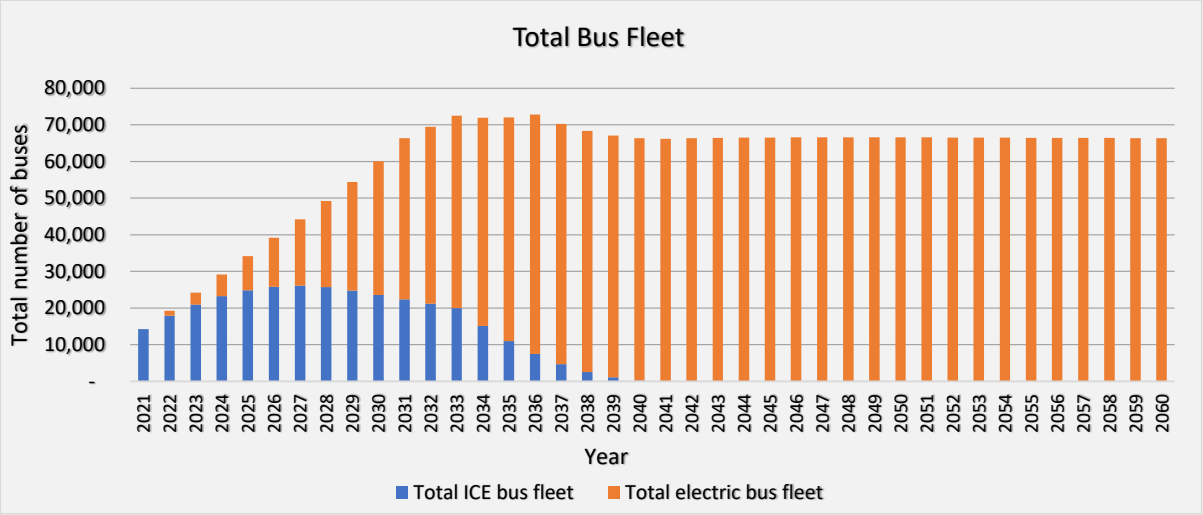


2. State / UT: Andhra Pradesh

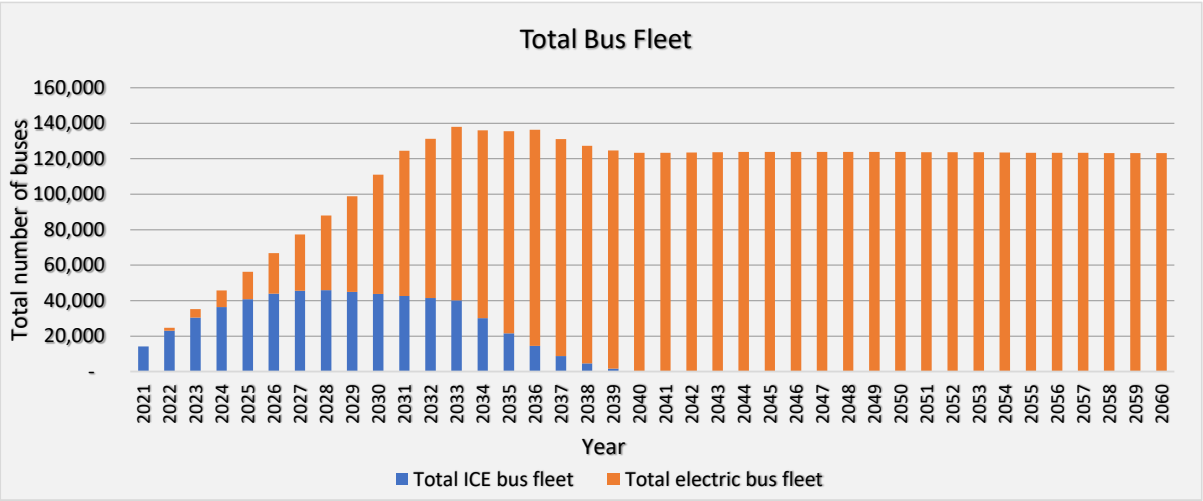
Business as usual Scenario



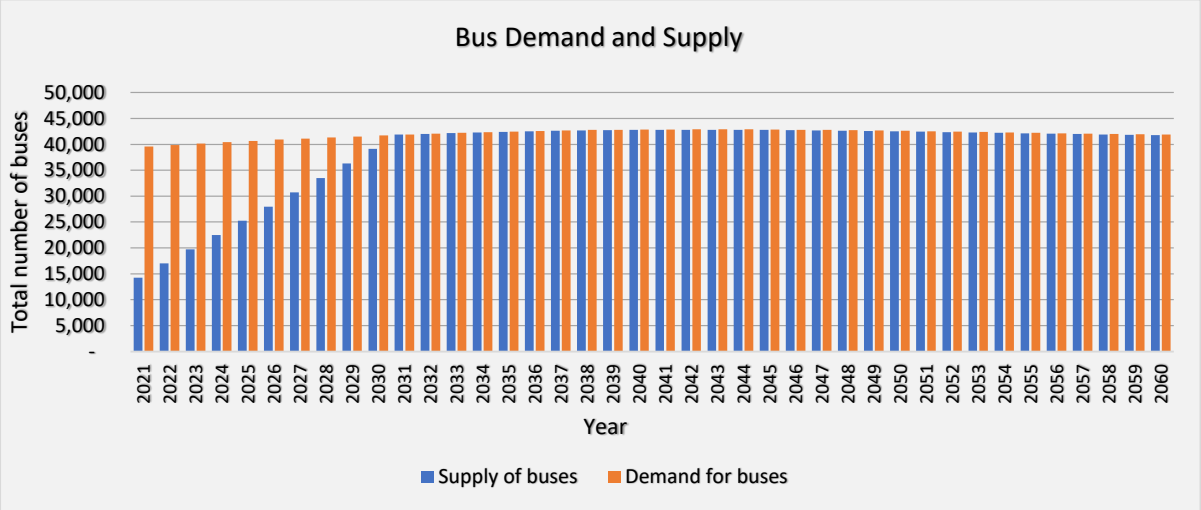
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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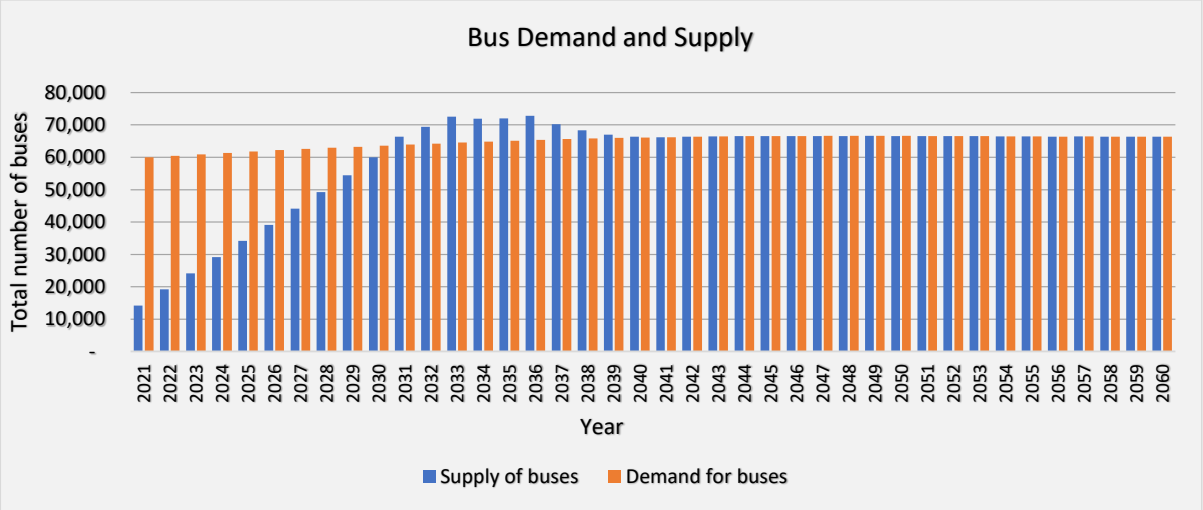

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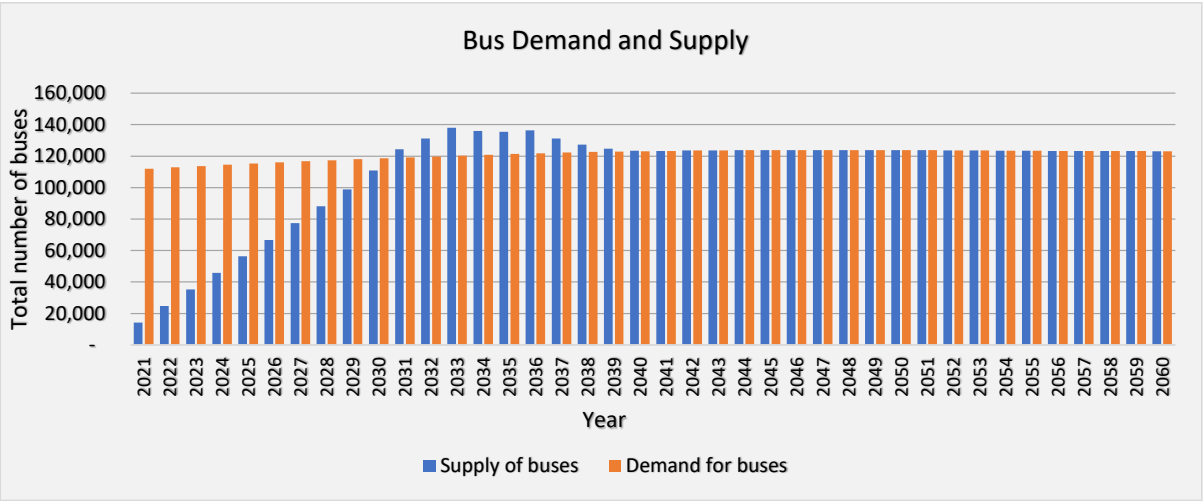
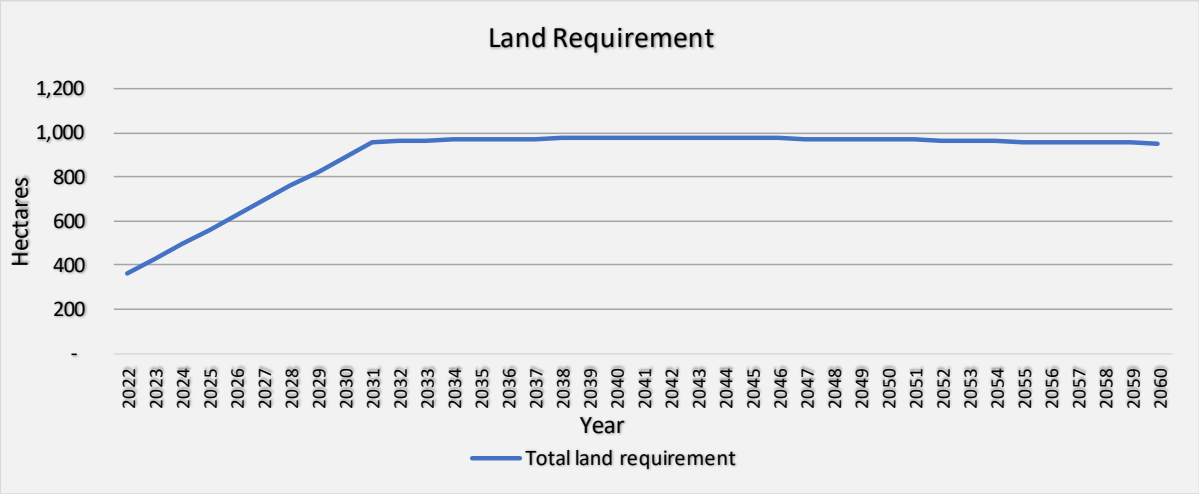


Business as Usual Scenario



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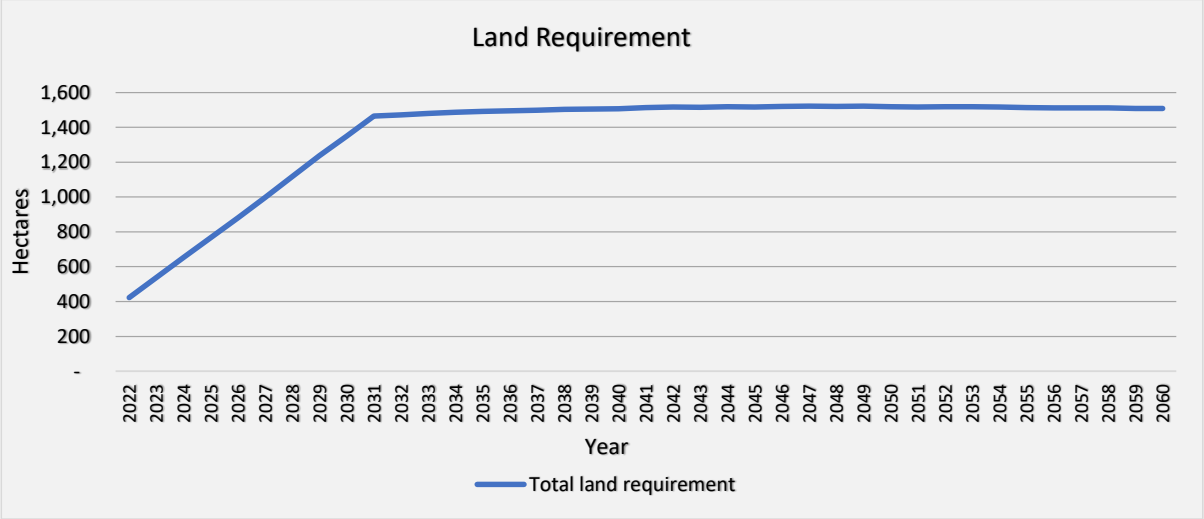

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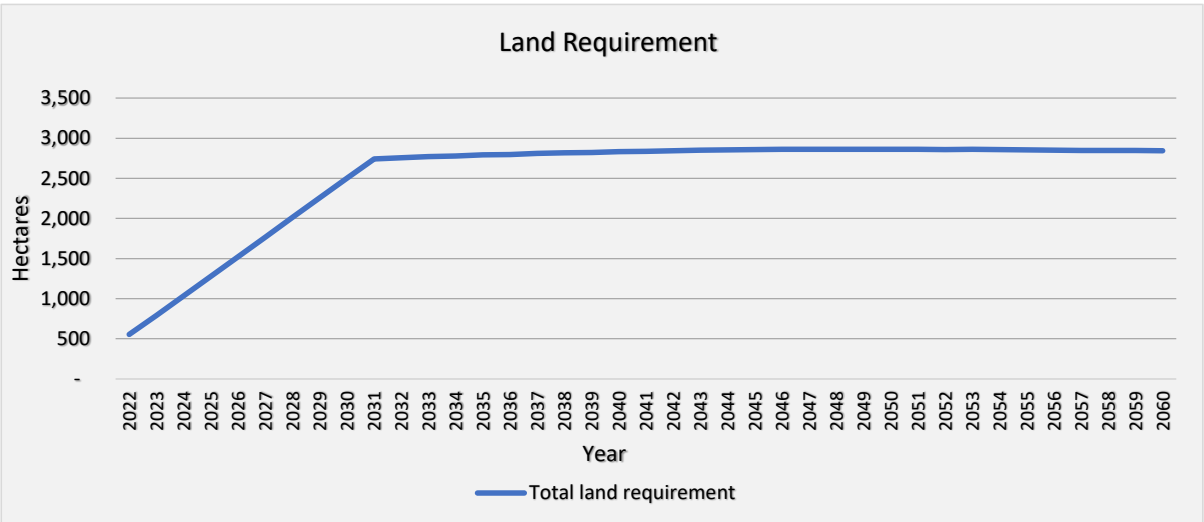
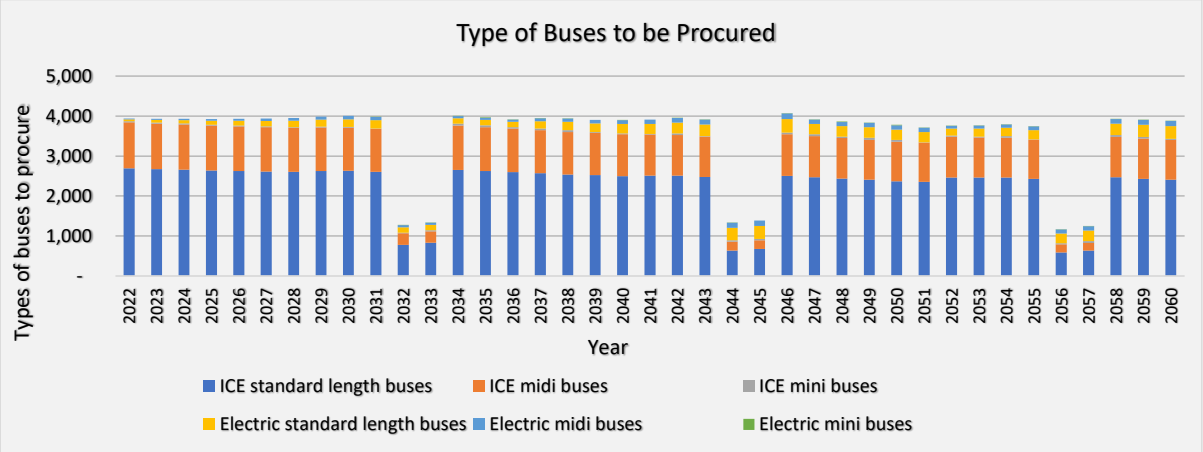


Business as Usual Scenario



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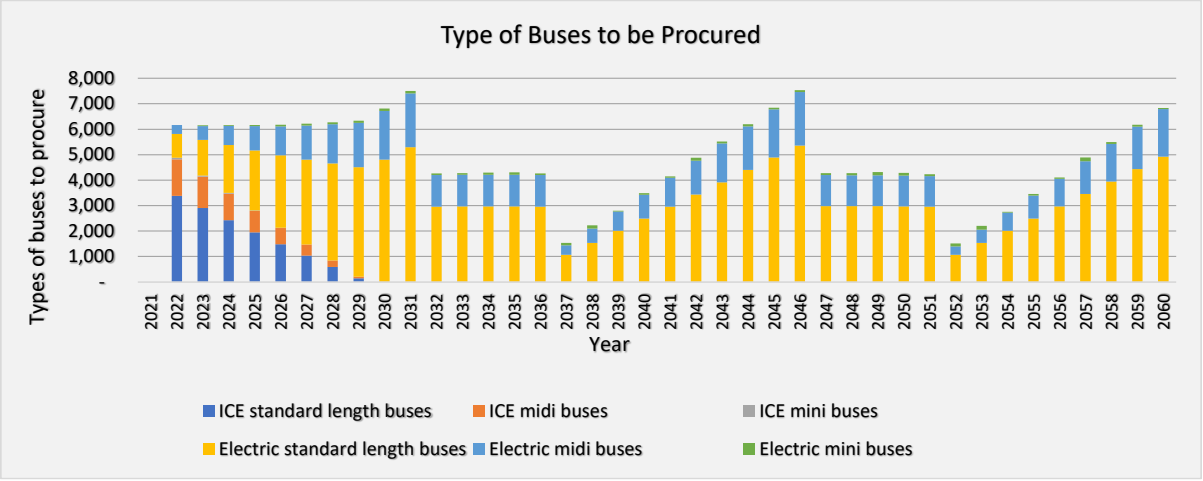
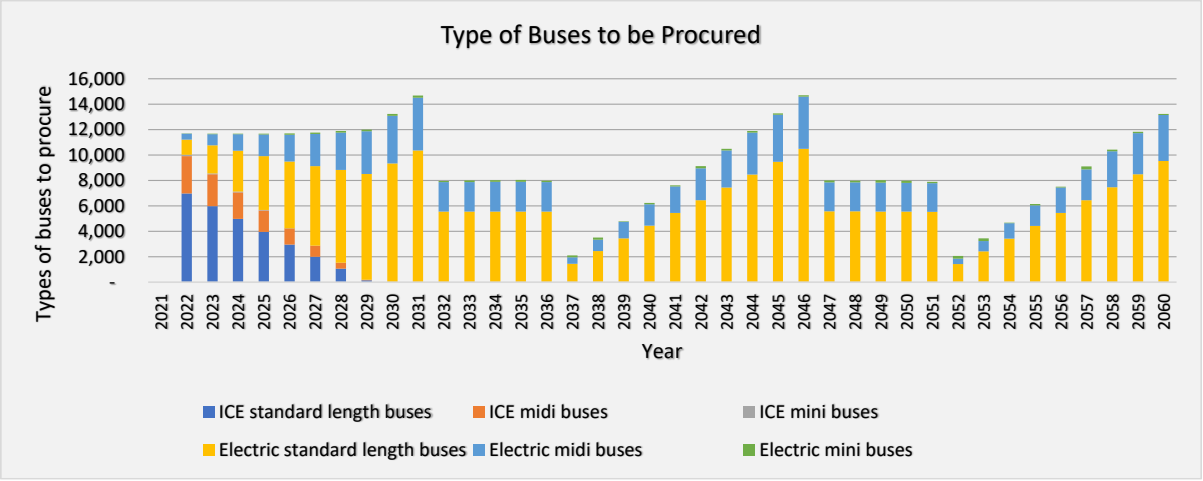
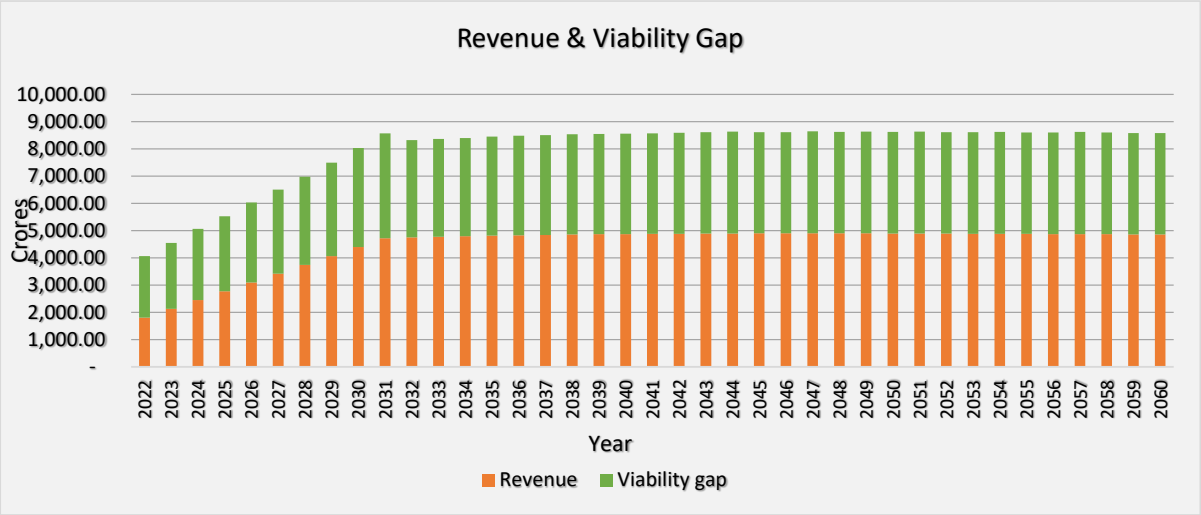


High Ambition Scenario

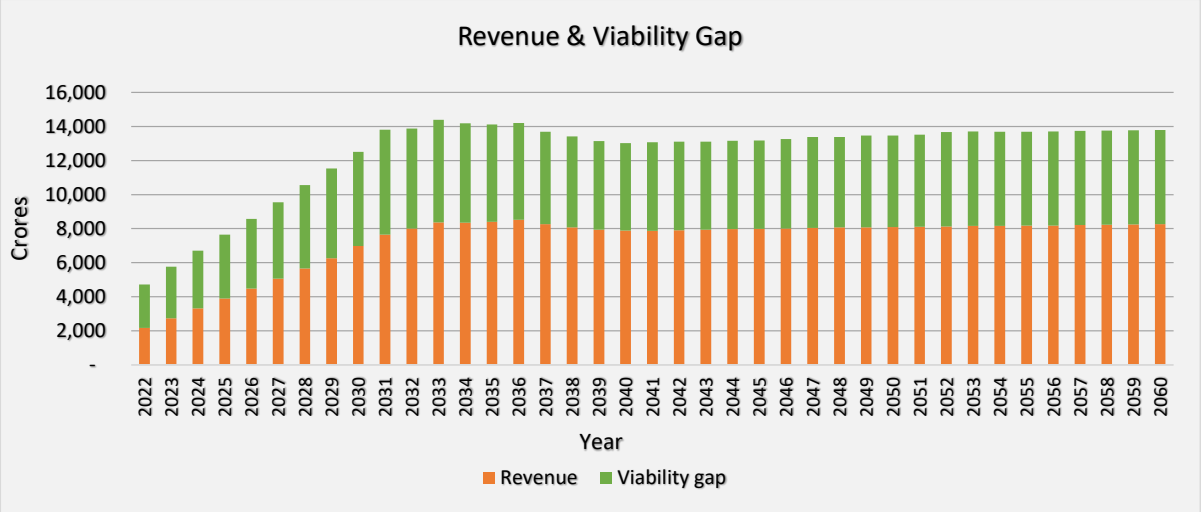


Revenue and Viability Gap: GCC Model

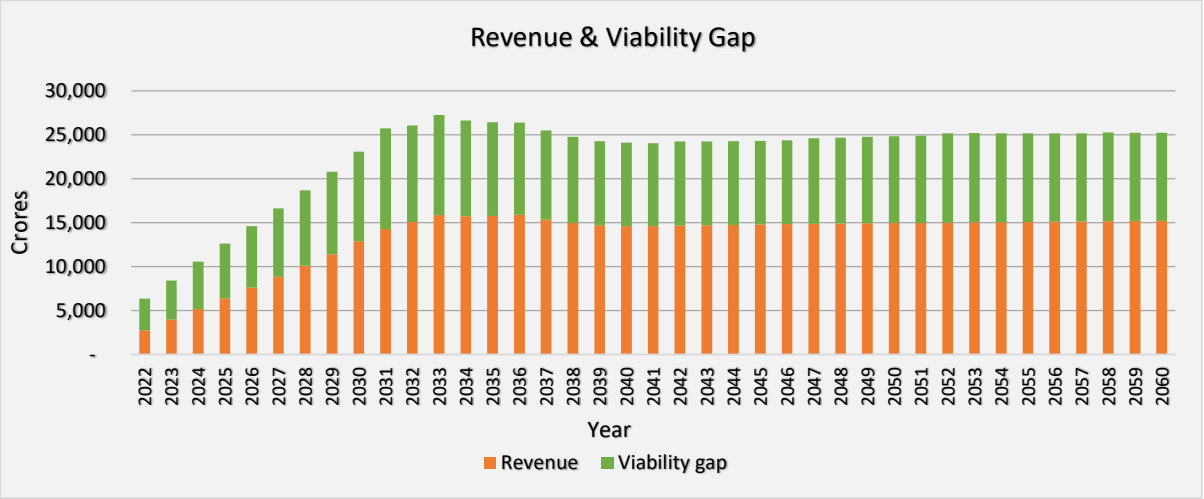
Business as Usual Scenario



Low Ambition Scenario

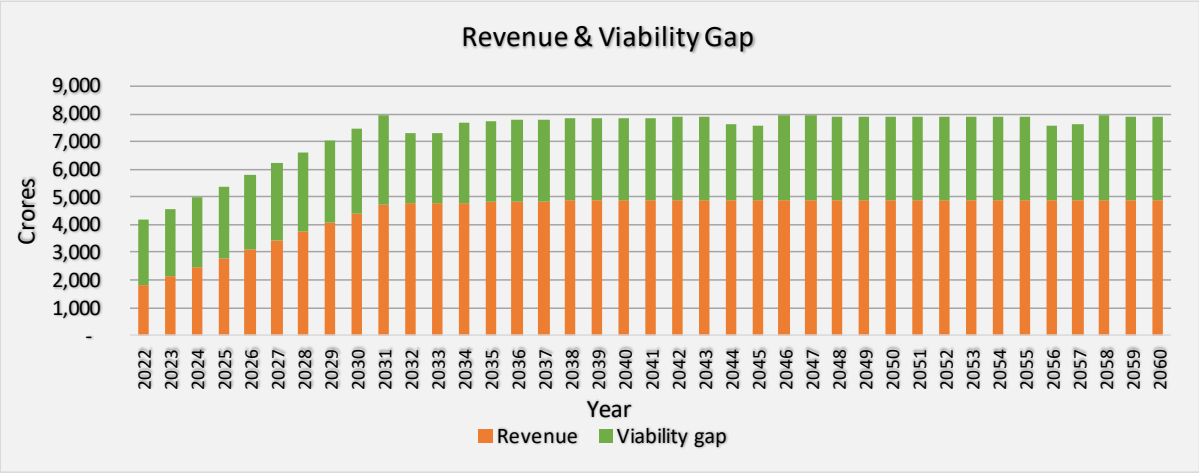


High Ambition Scenario

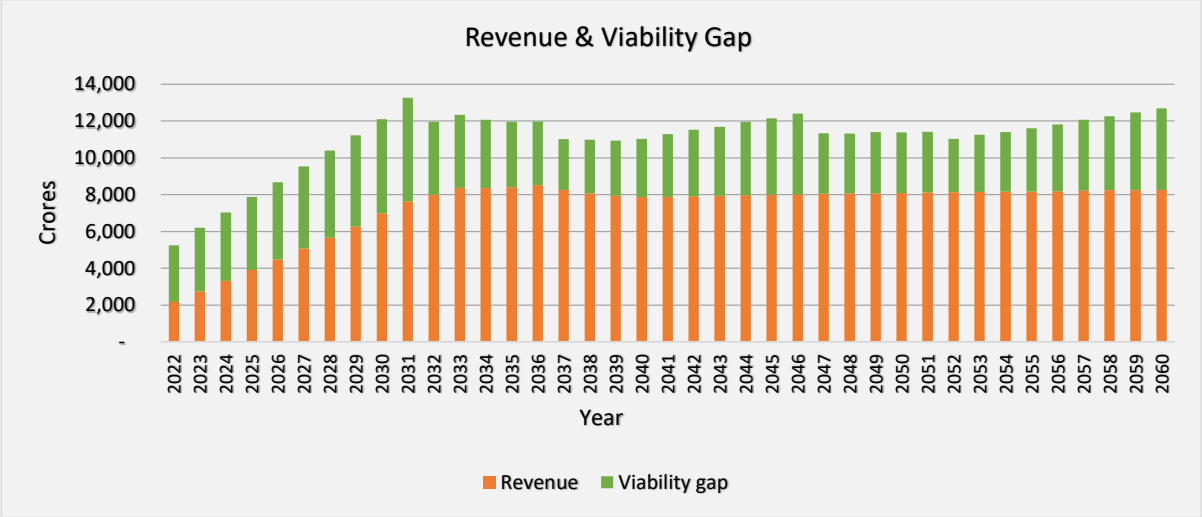


Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



Low Ambition Scenario



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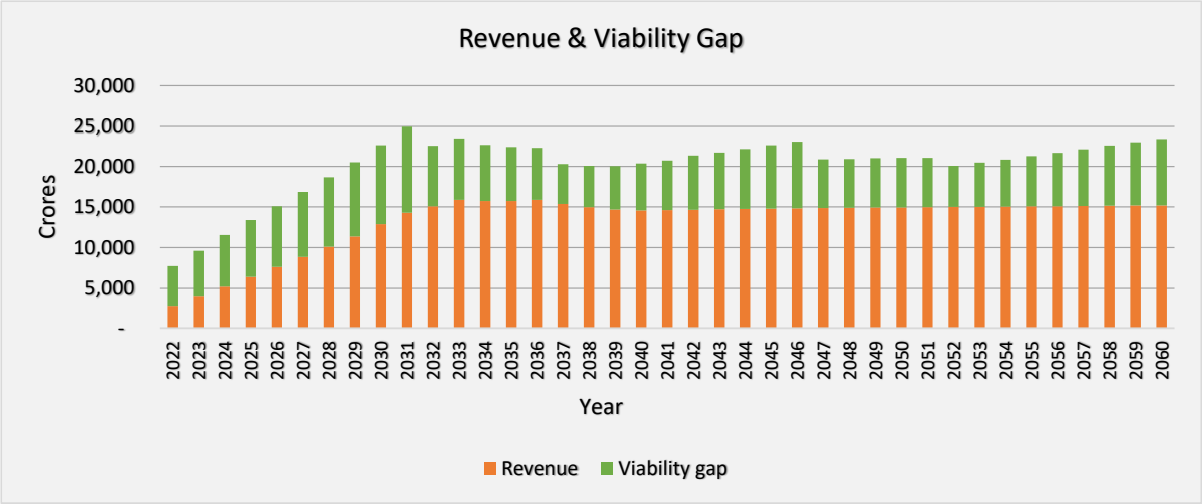
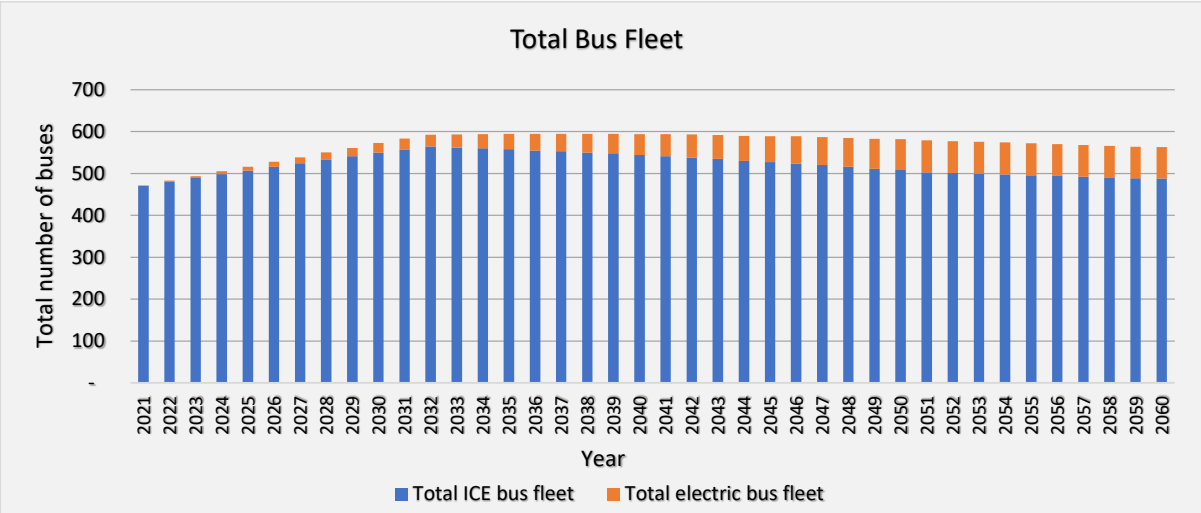
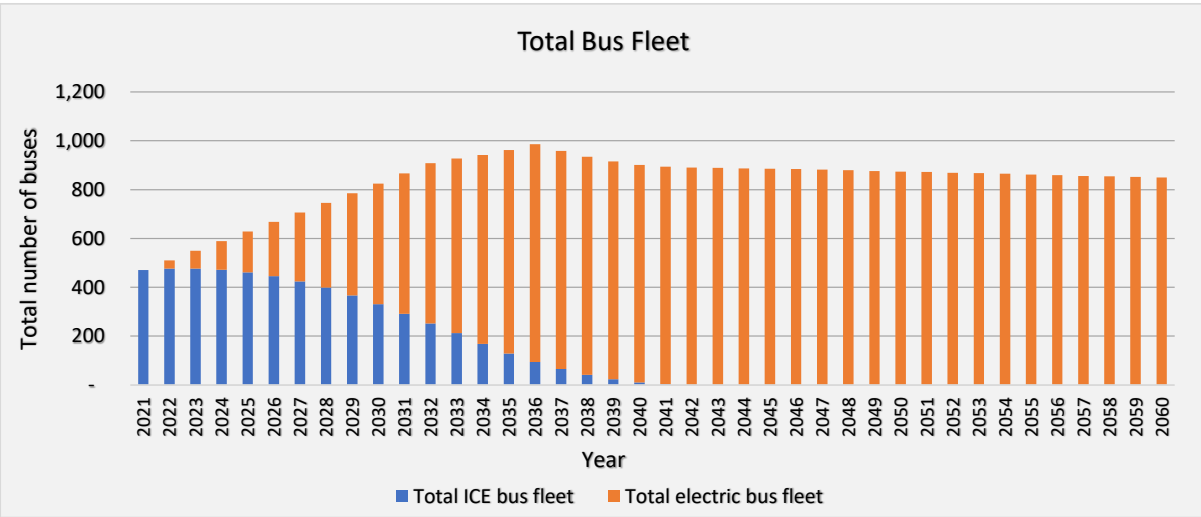


3. State / UT: Arunachal Pradesh

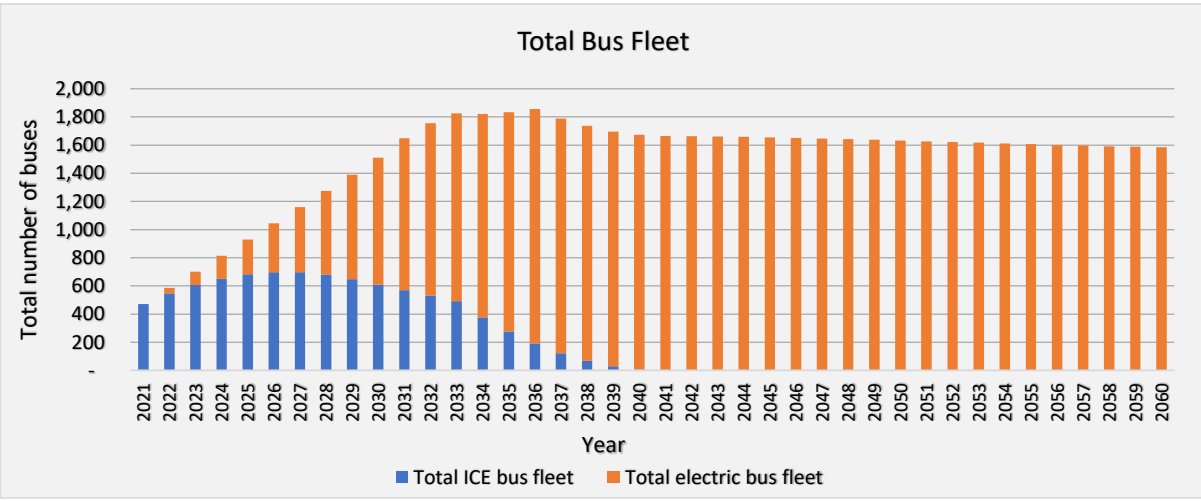
Business as usual Scenario



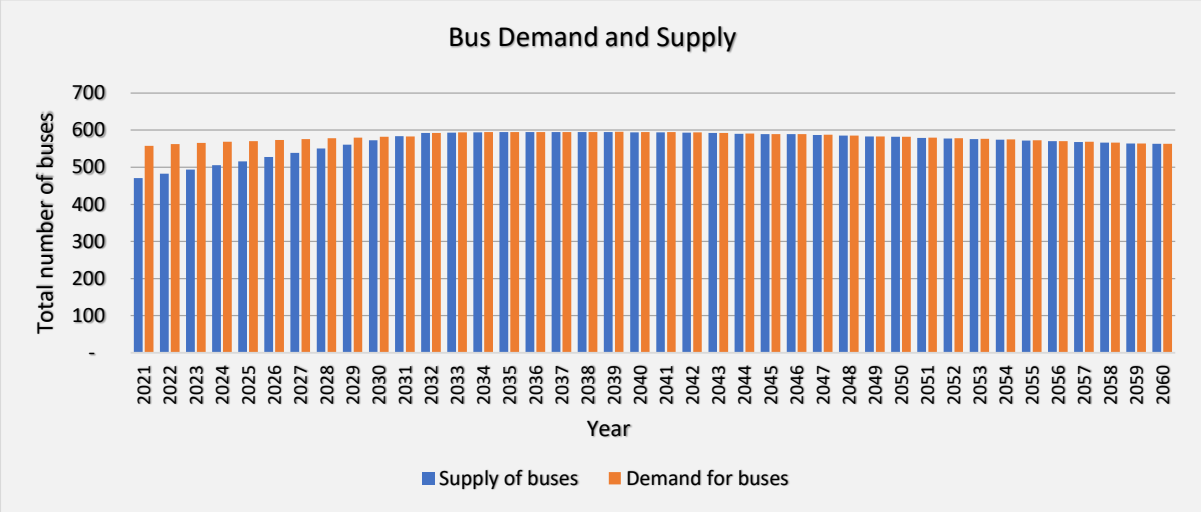
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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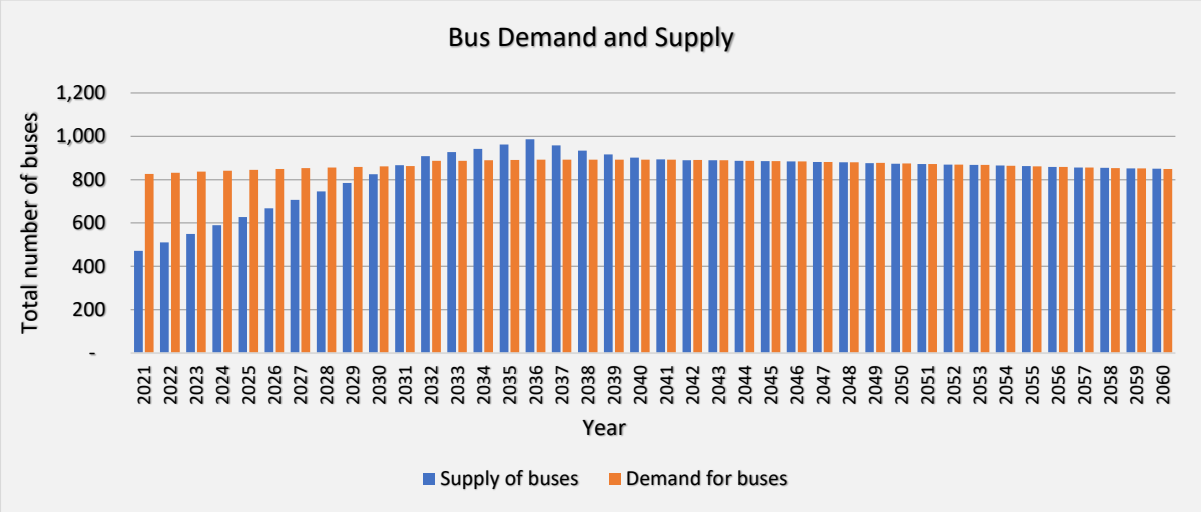

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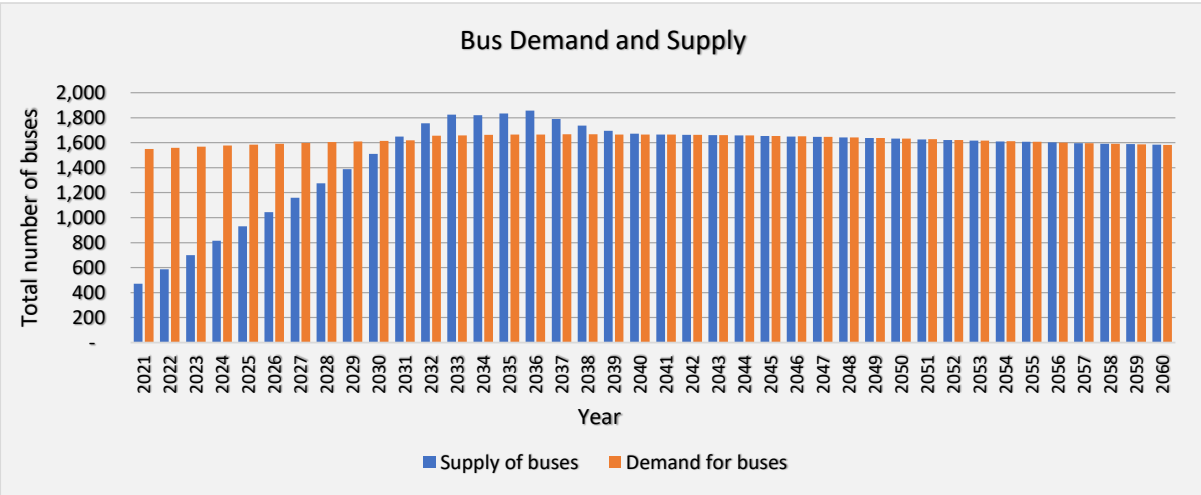
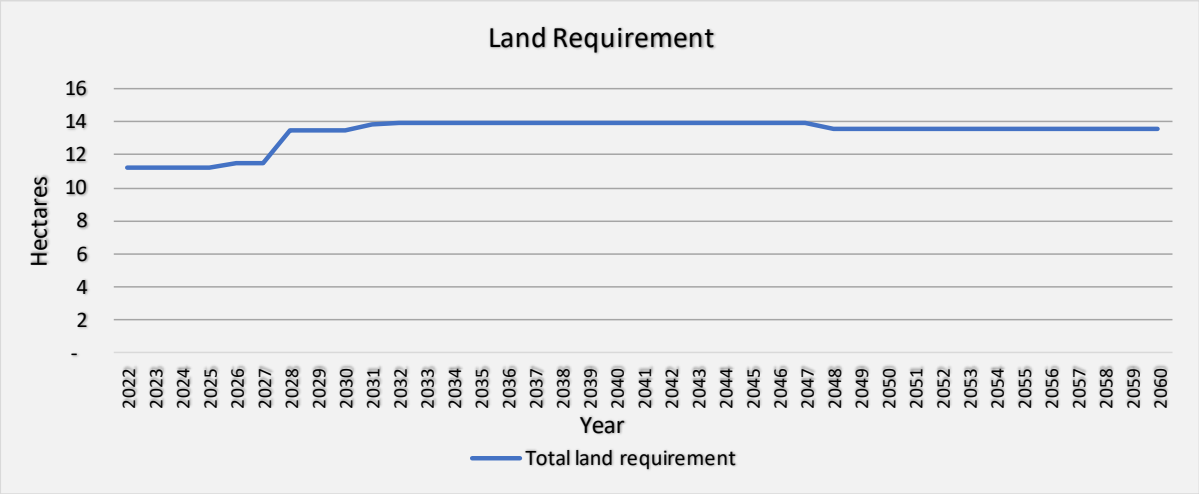


Business as Usual Scenario



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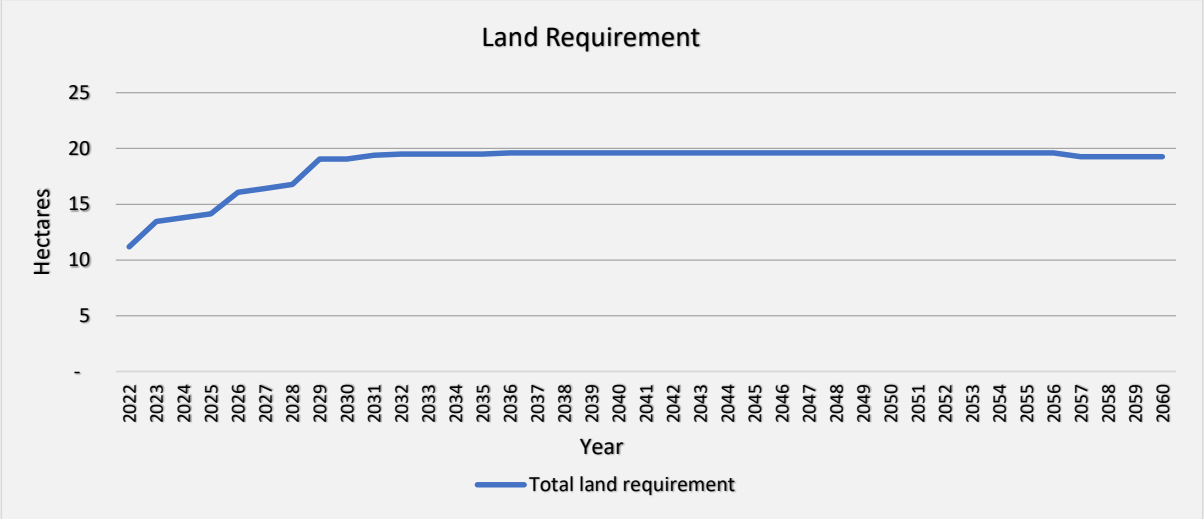
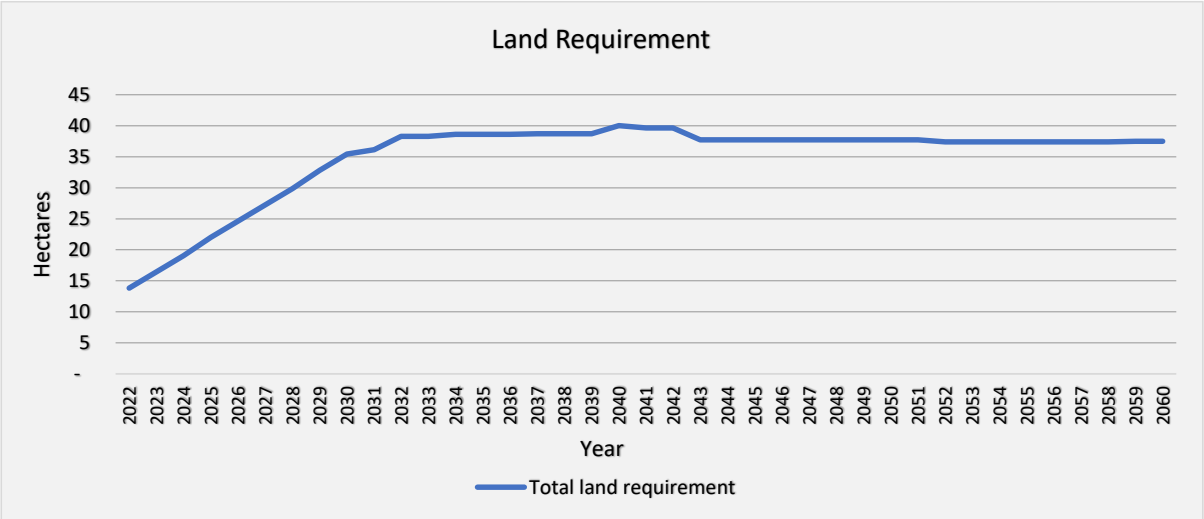
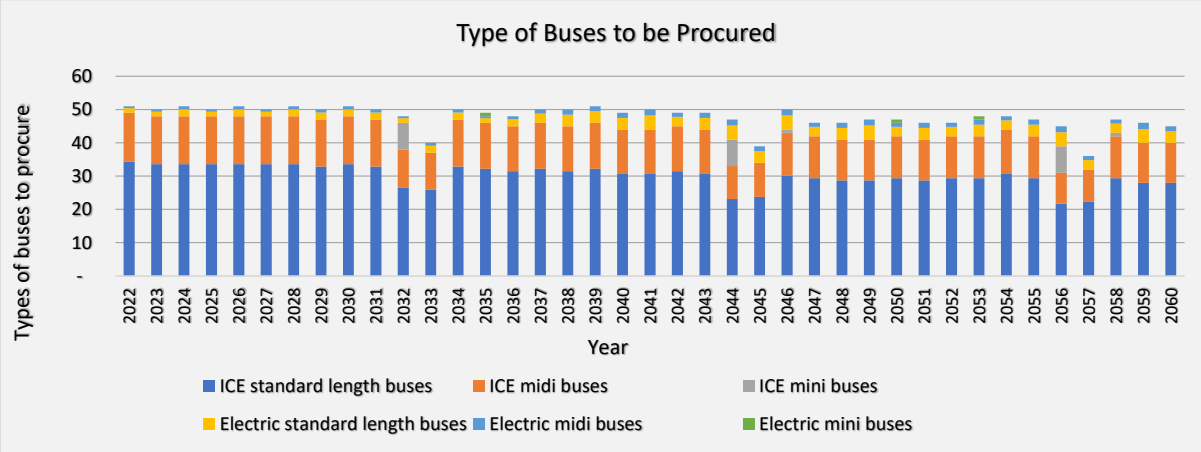


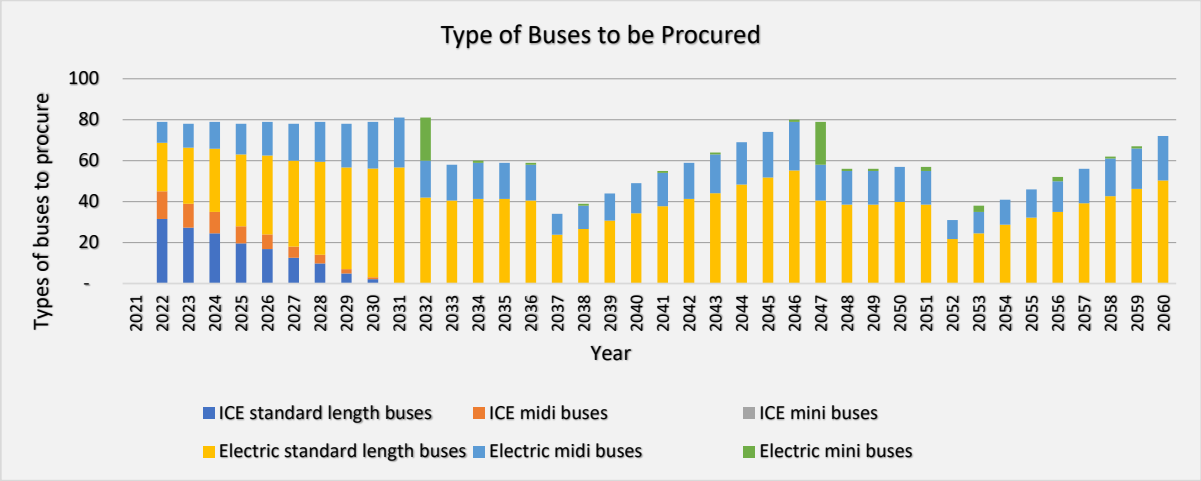
High Ambition Scenario



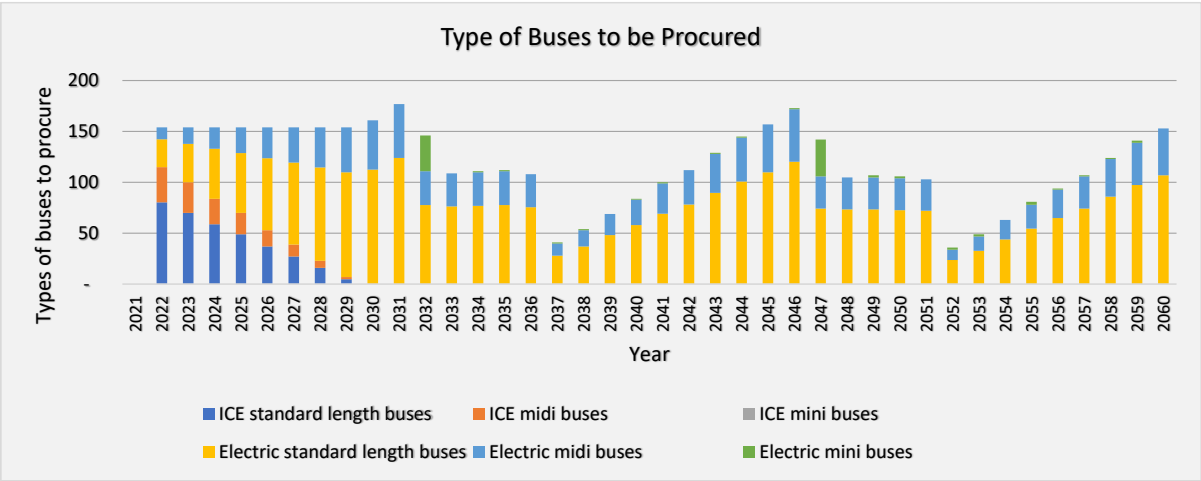
Business as Usual Scenario



Low Ambition Scenario

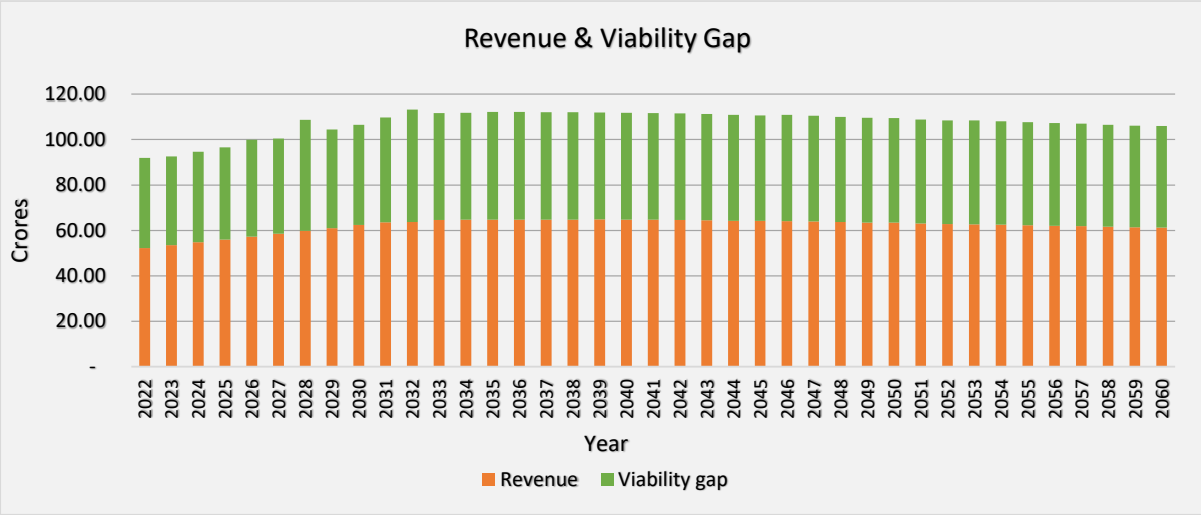


High Ambition Scenario

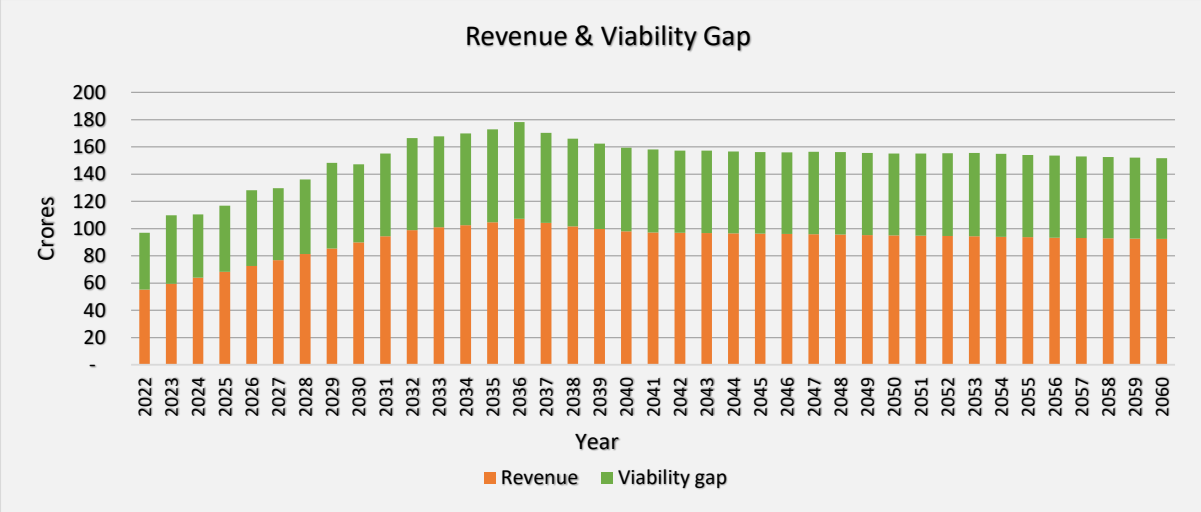


Revenue and Viability Gap: GCC Model

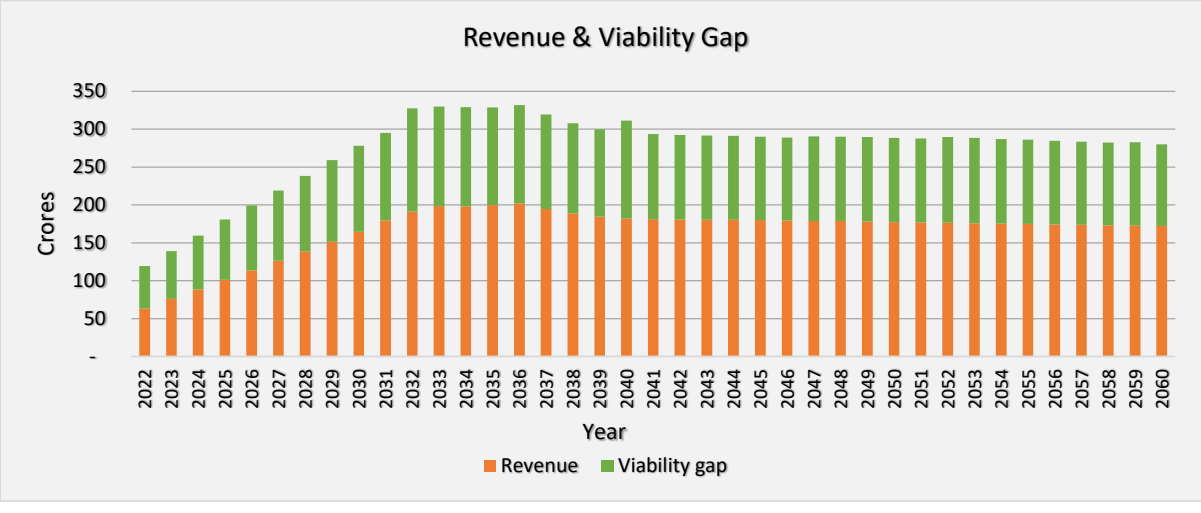
Business as Usual Scenario



Low Ambition Scenario

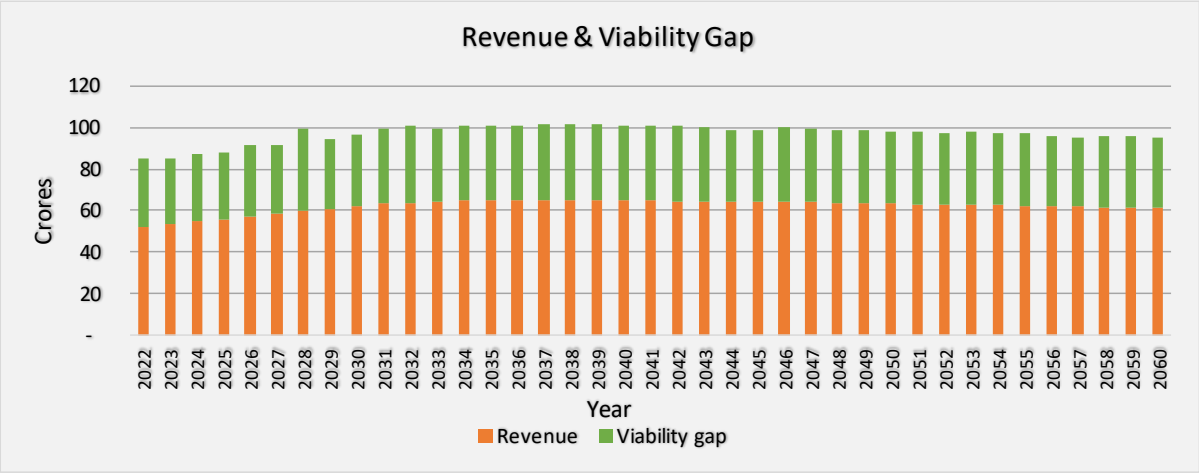


High Ambition Scenario

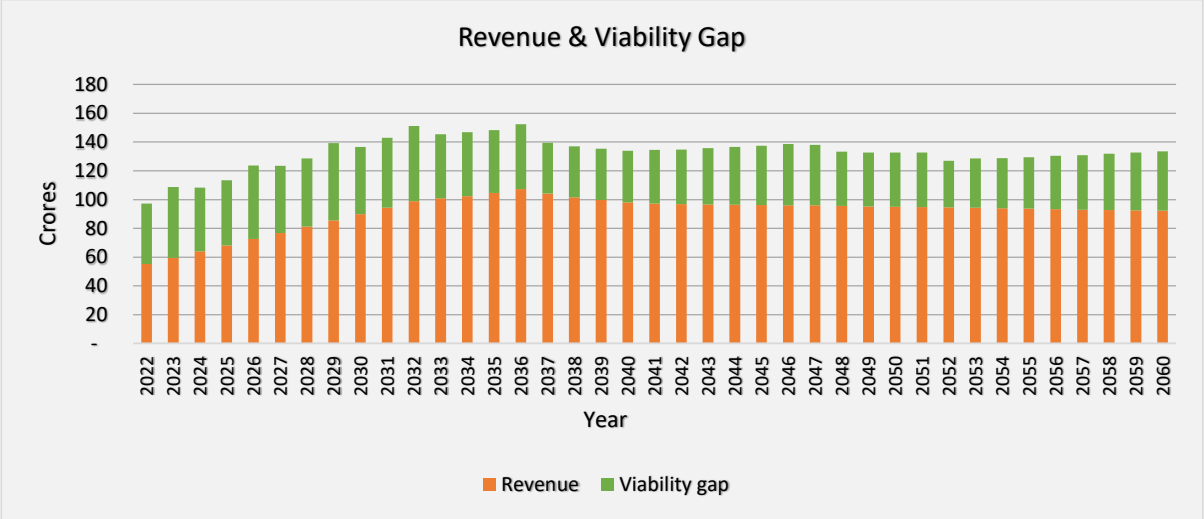


Revenue and Viability Gap: Outright Purchase Model

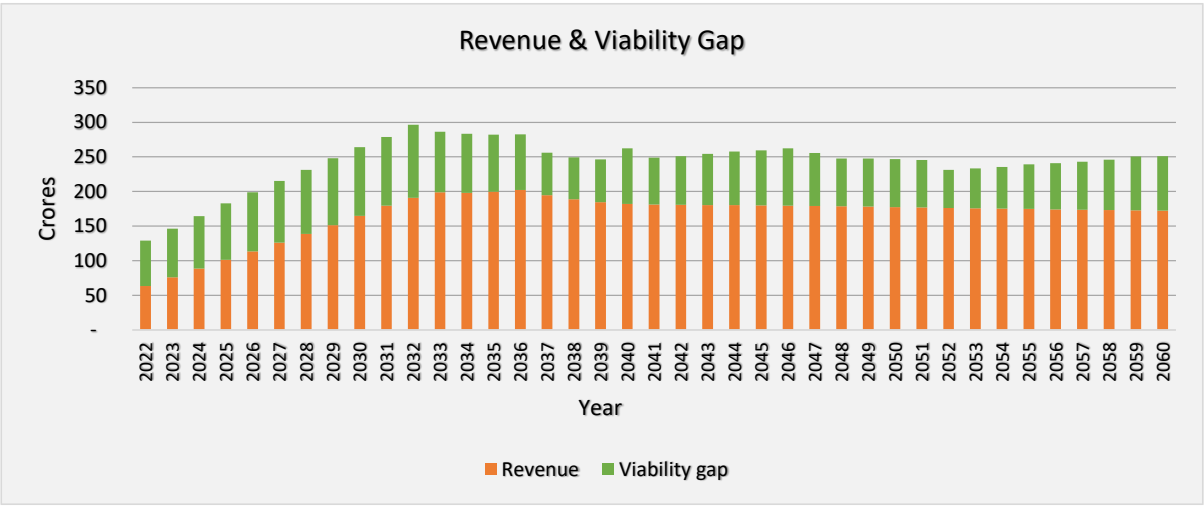
Business as usual Scenario



Low Ambition Scenario

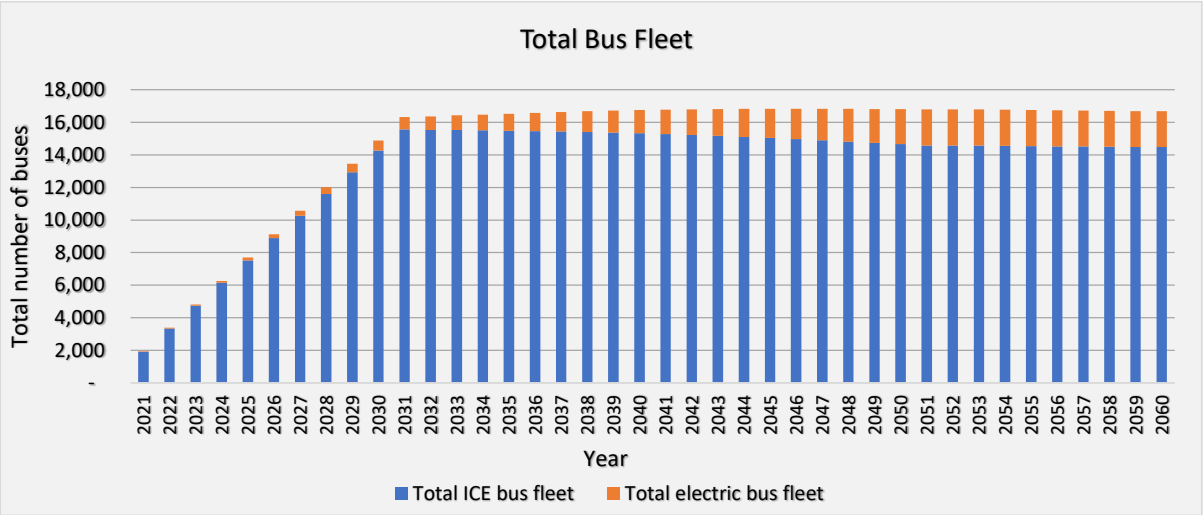


High Ambition Scenario

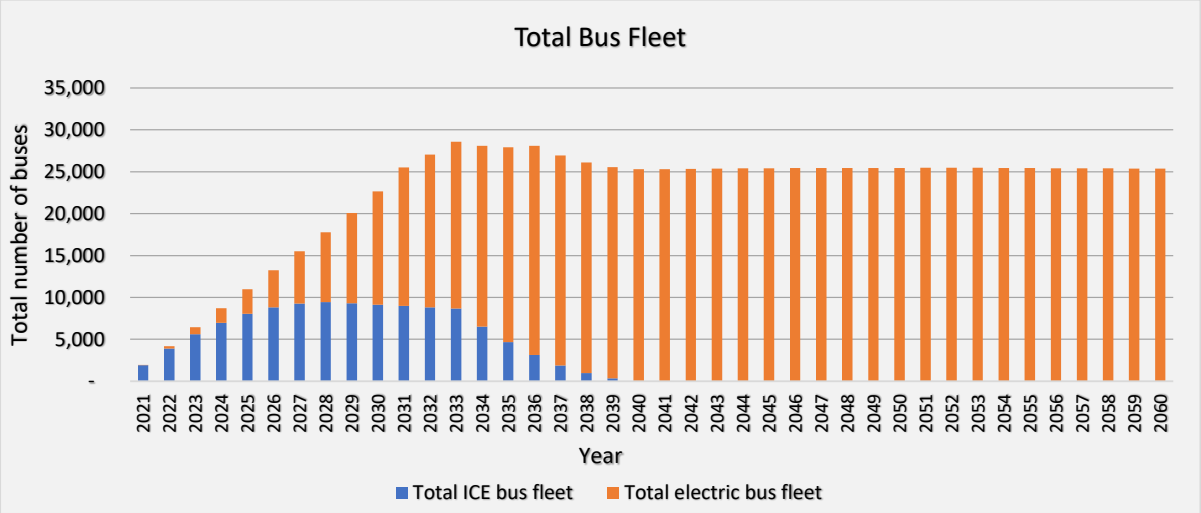


4. State / UT: Assam

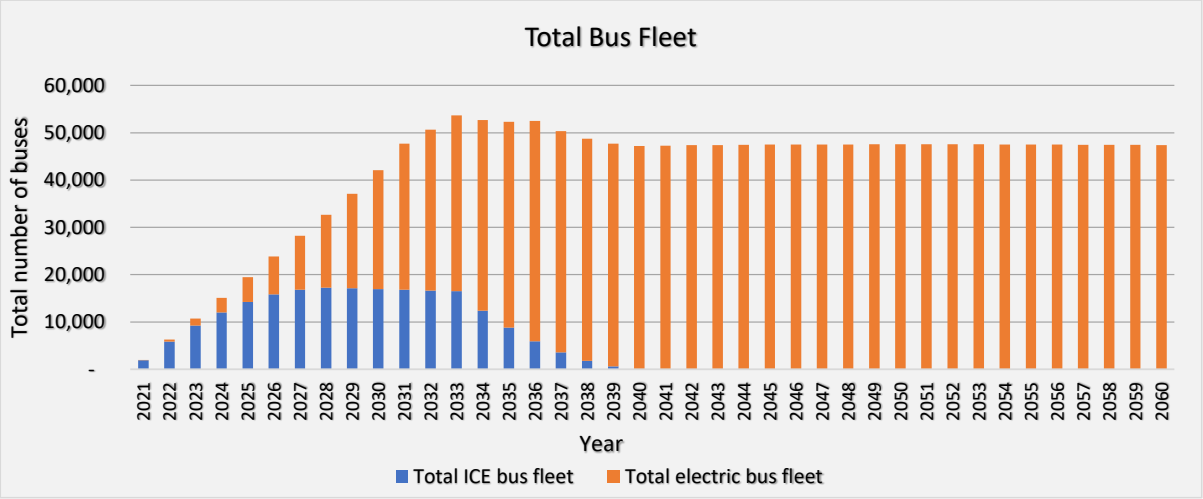
Business as usual Scenario



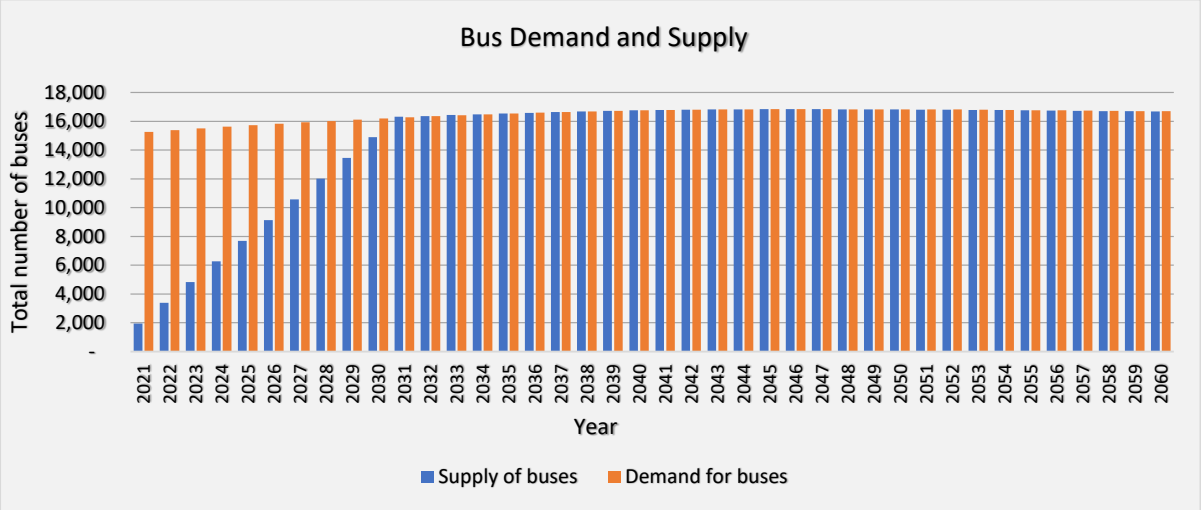
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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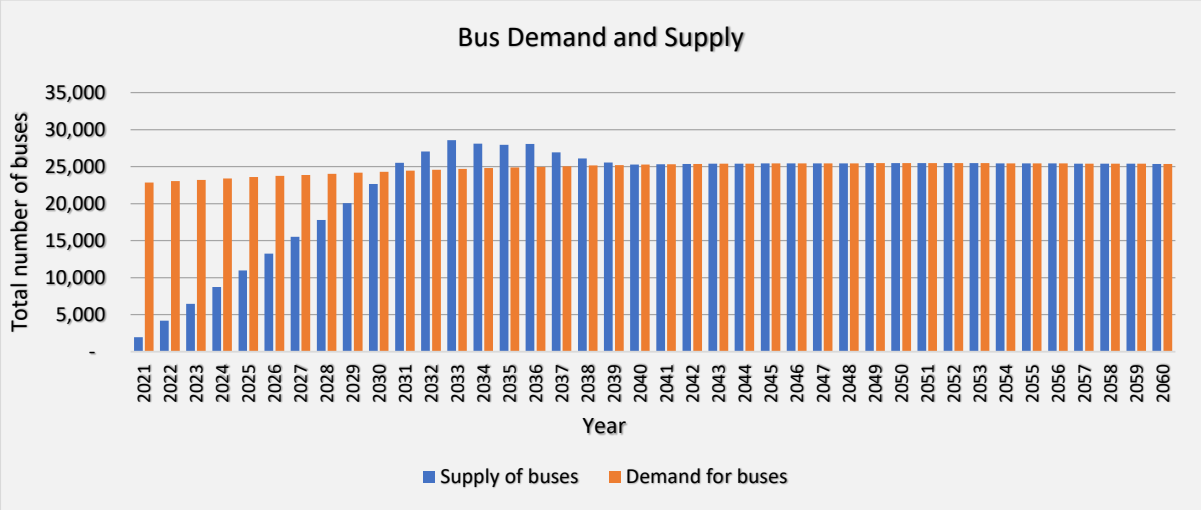

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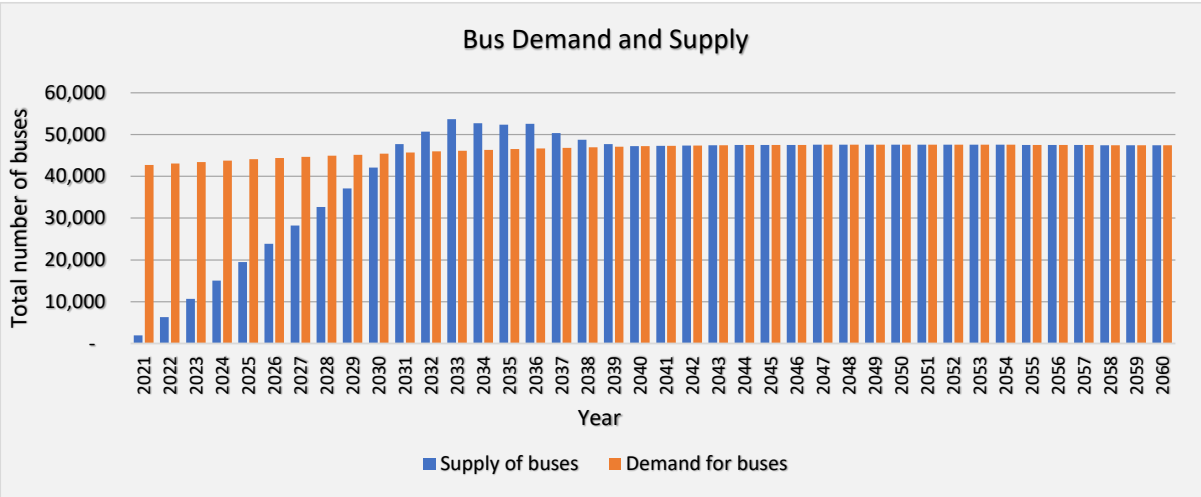
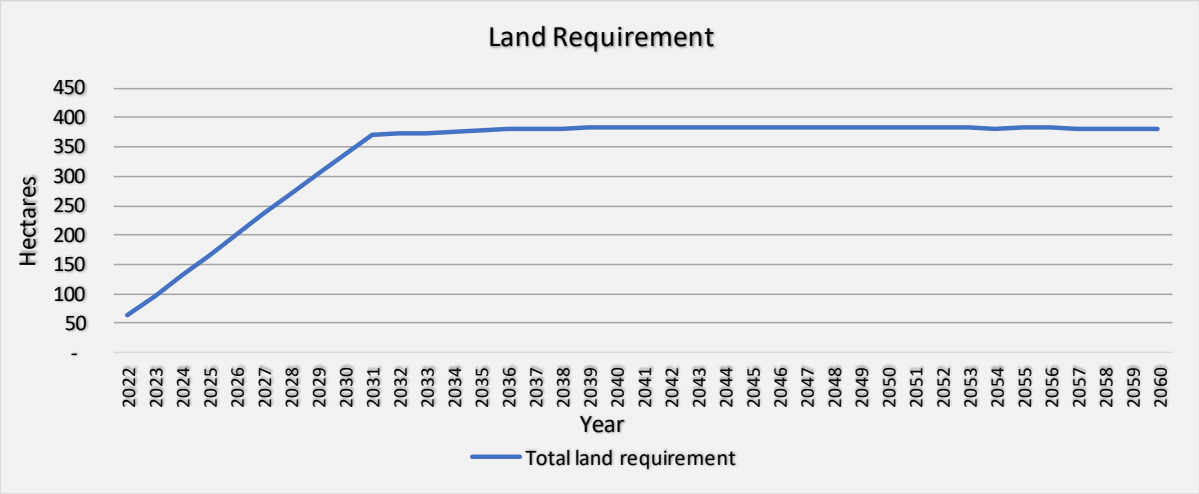
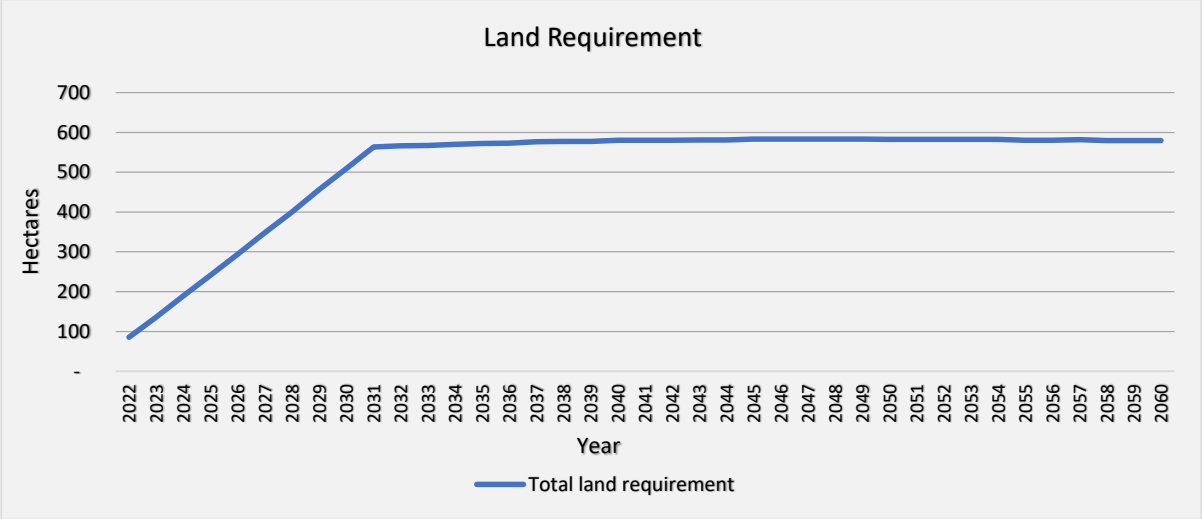


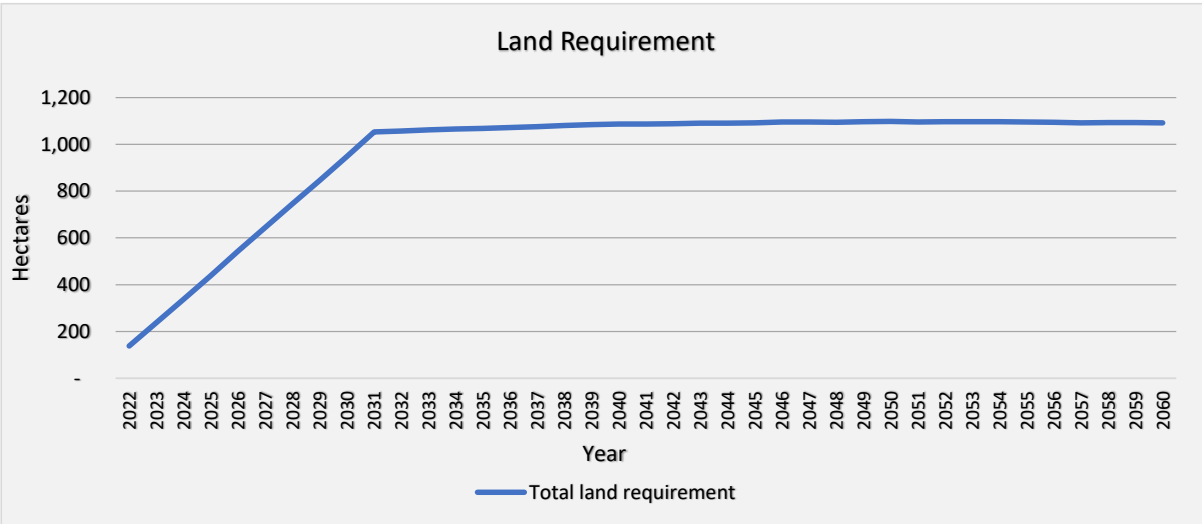
Business as Usual Scenario



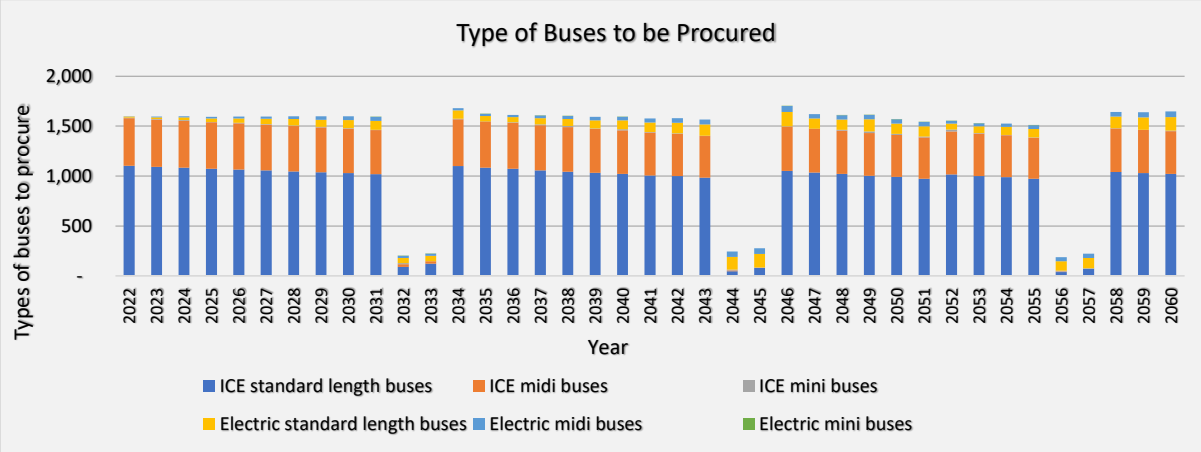
Low Ambition Scenario



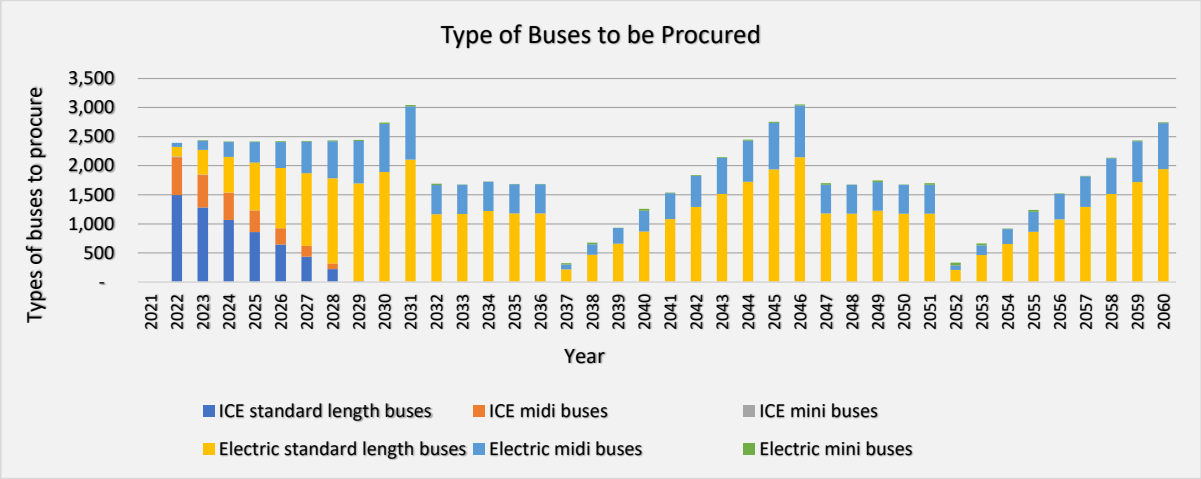
High Ambition Scenario



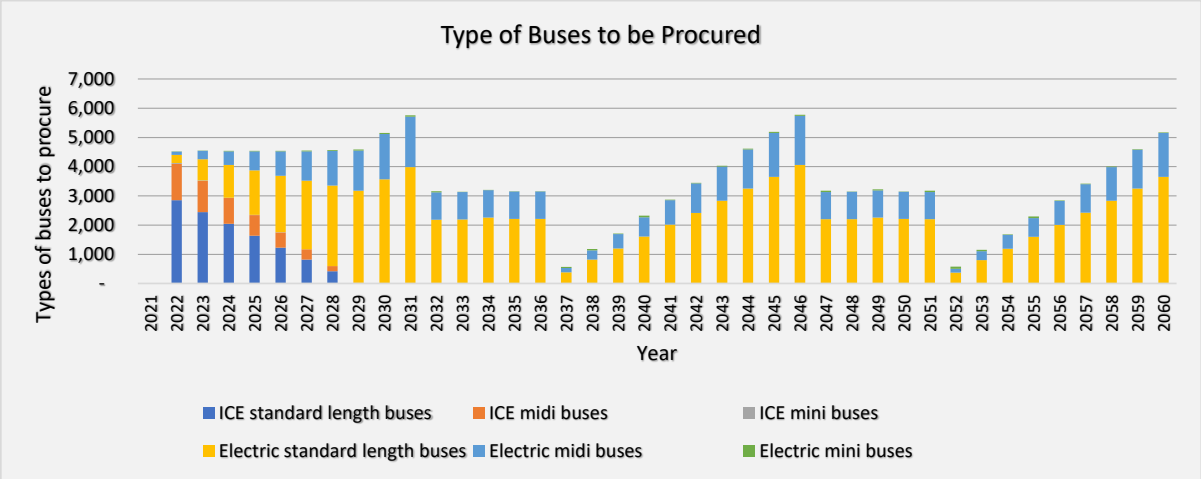
Business as Usual Scenario



Low Ambition Scenario

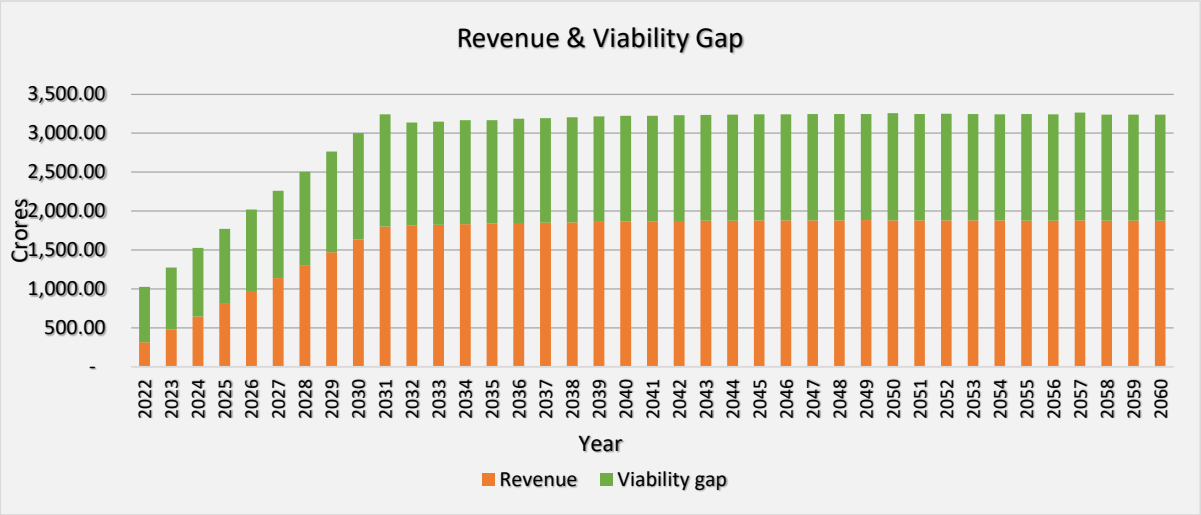


High Ambition Scenario

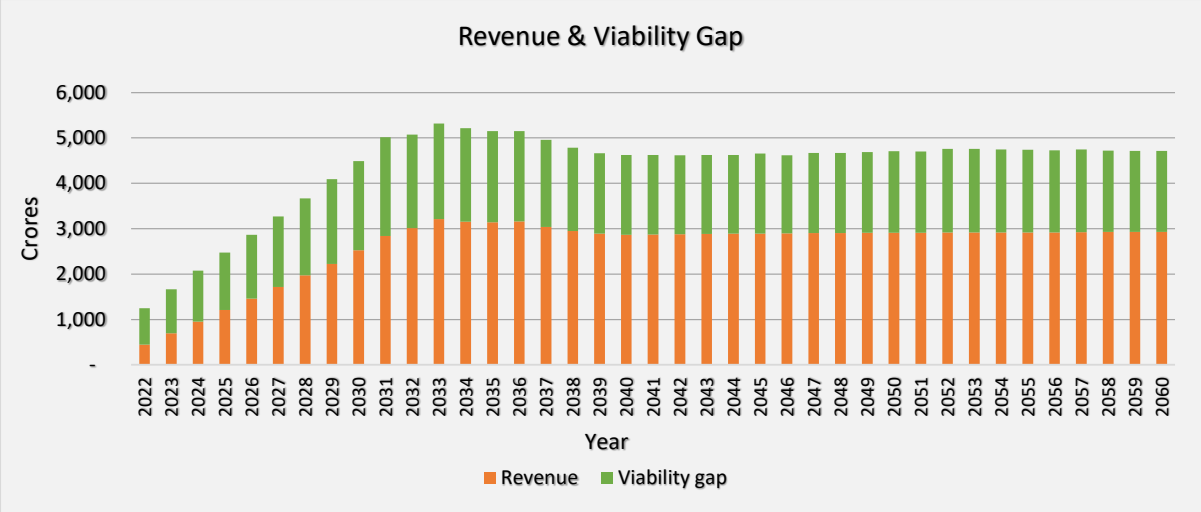


Revenue and Viability Gap: GCC Model

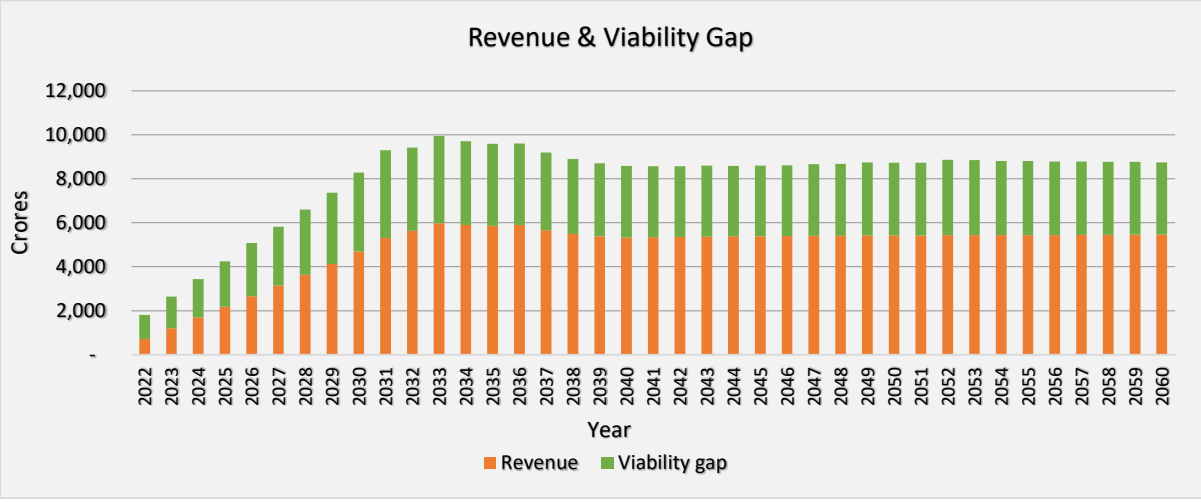
Business as Usual Scenario



Low Ambition Scenario

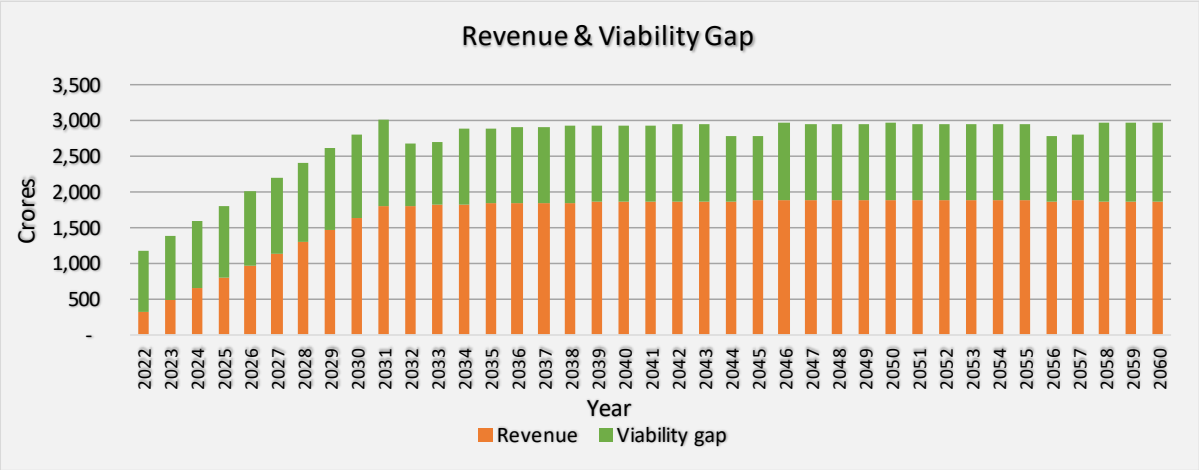


High Ambition Scenario

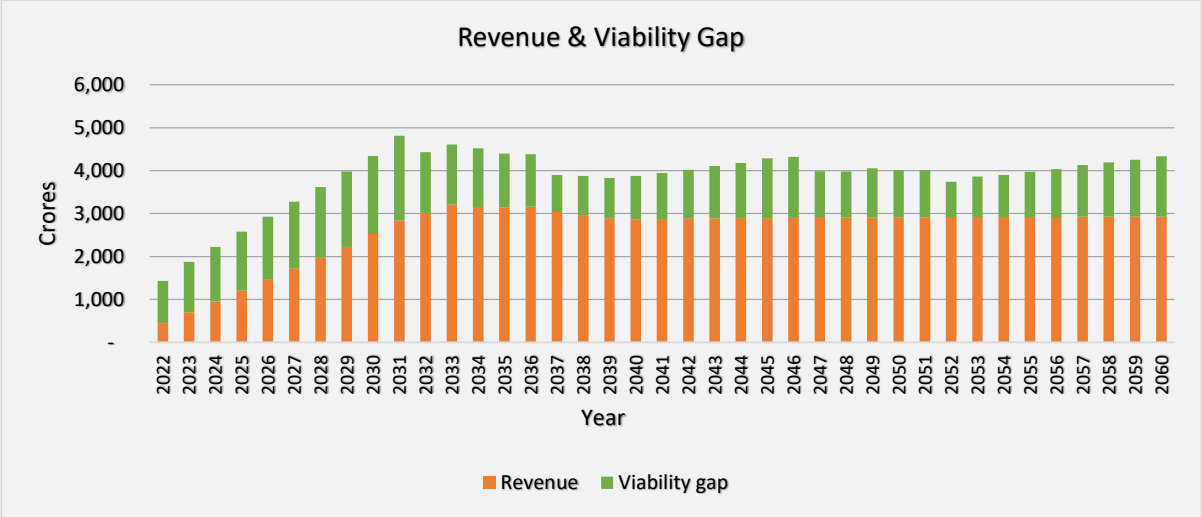


Revenue and Viability Gap: Outright Purchase Model

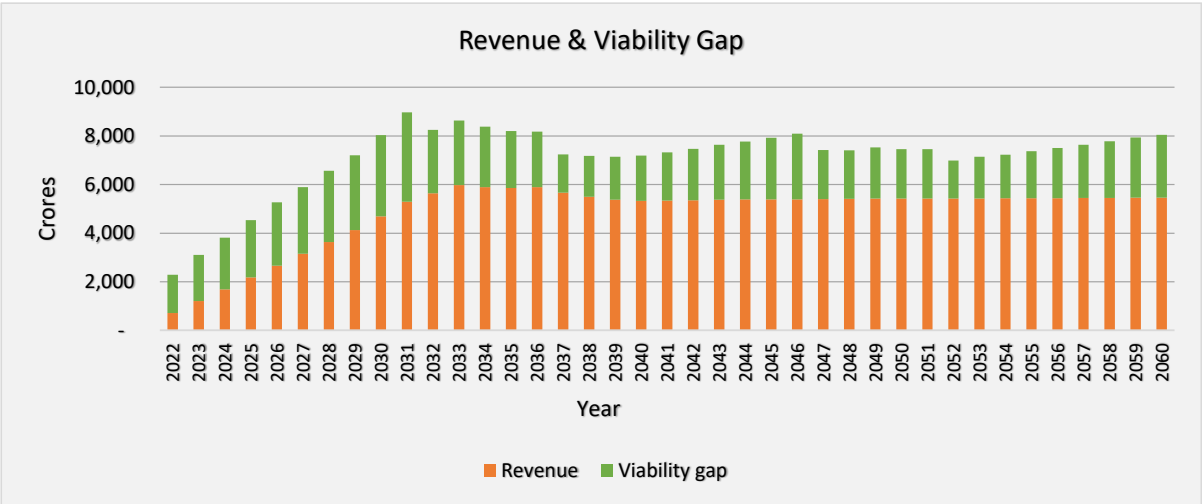
Business as usual Scenario



Low Ambition Scenario

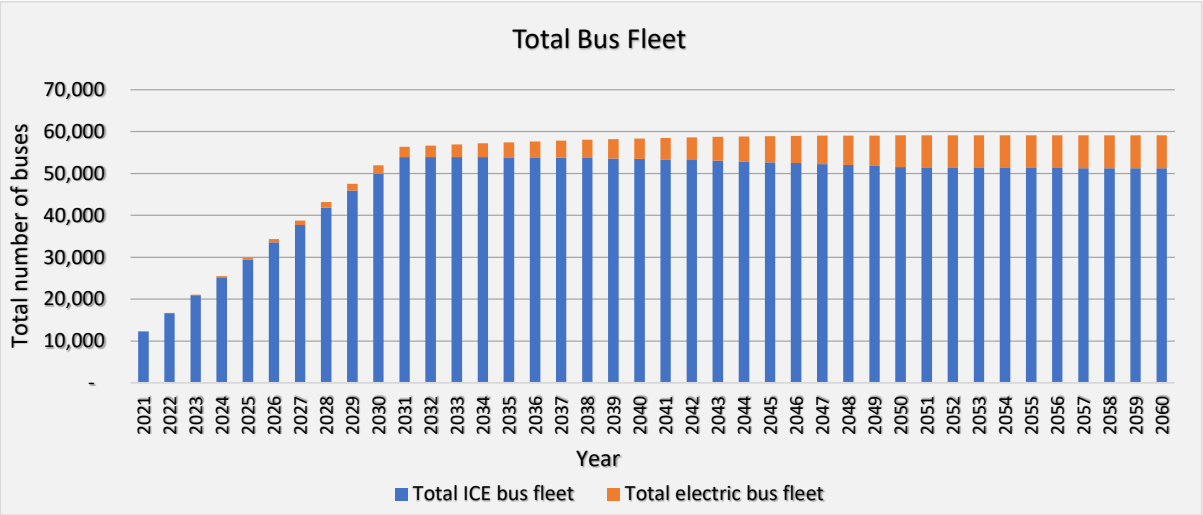


High Ambition Scenario



5. State / UT: Bihar

Business as usual Scenario



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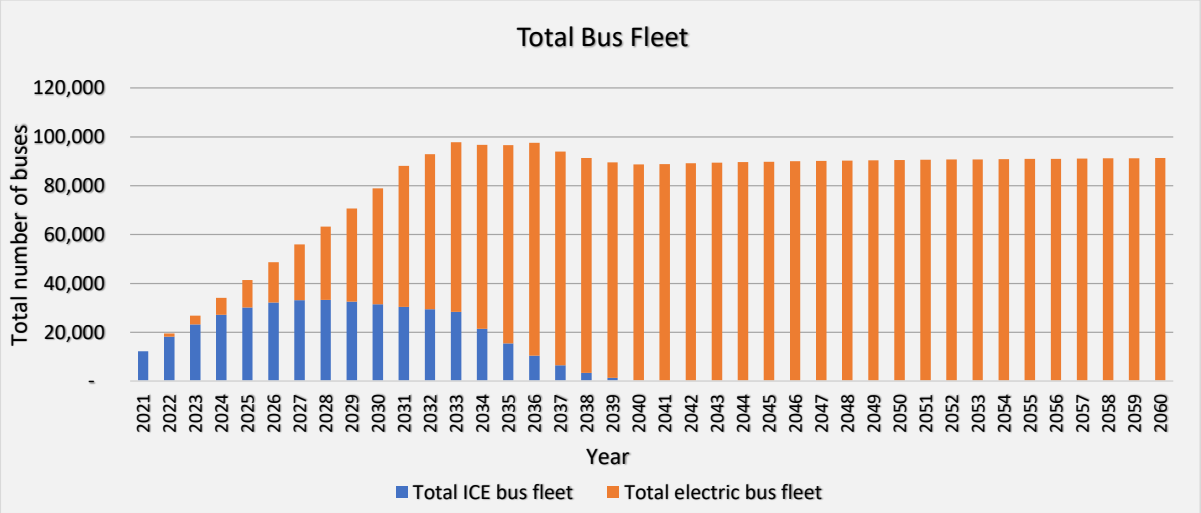

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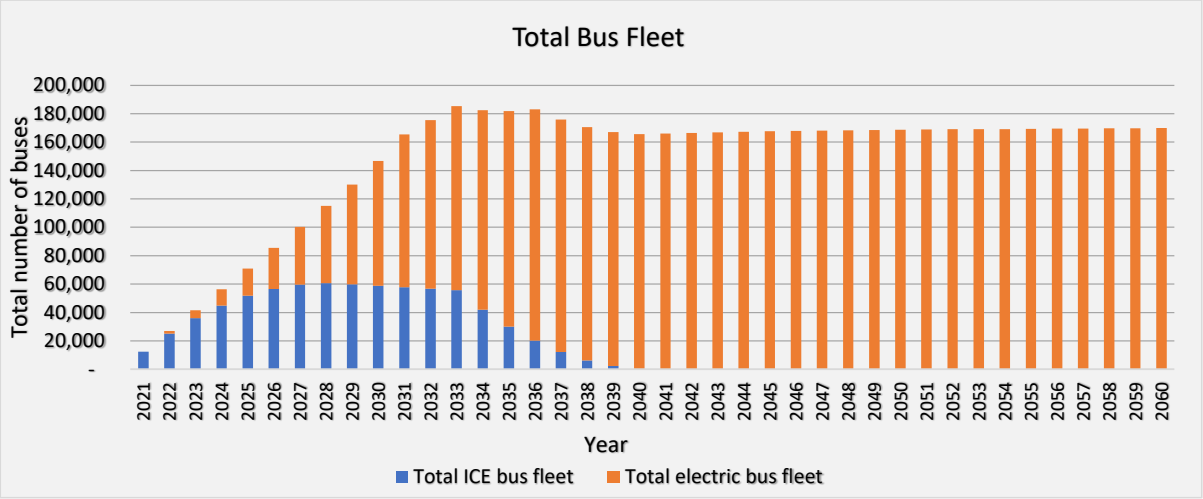
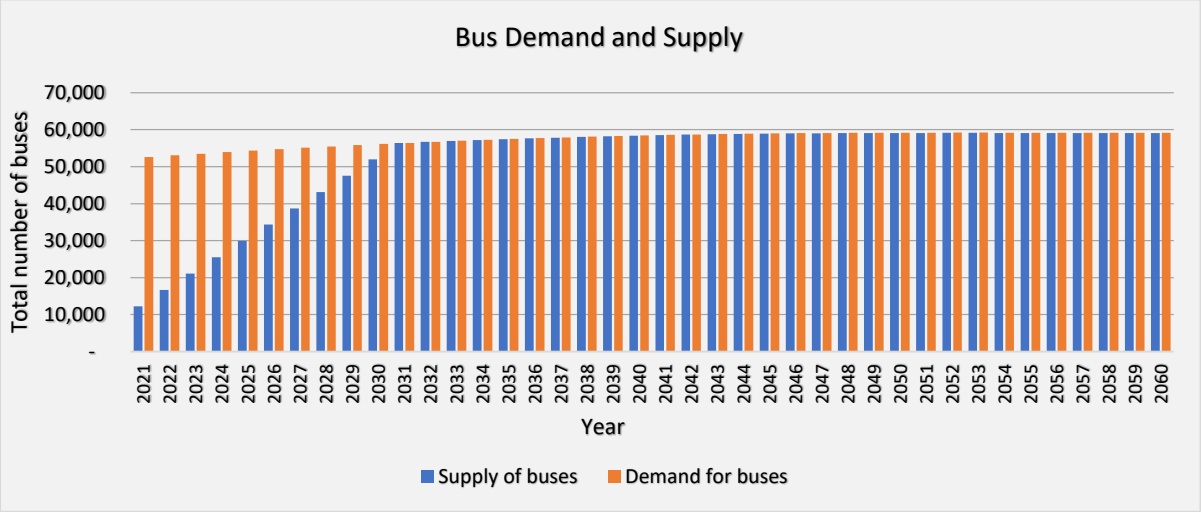


Business as Usual Scenario



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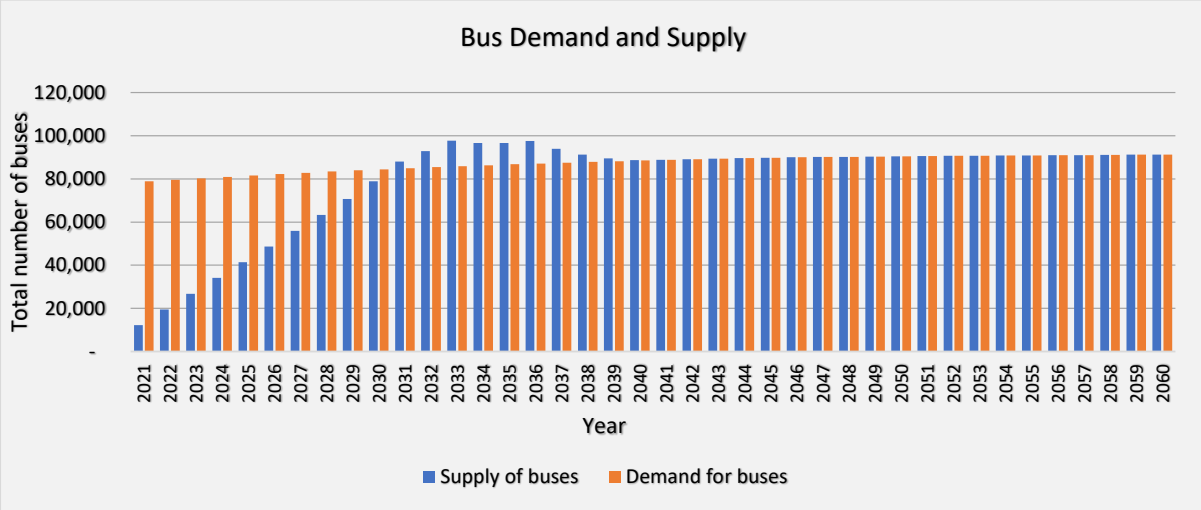

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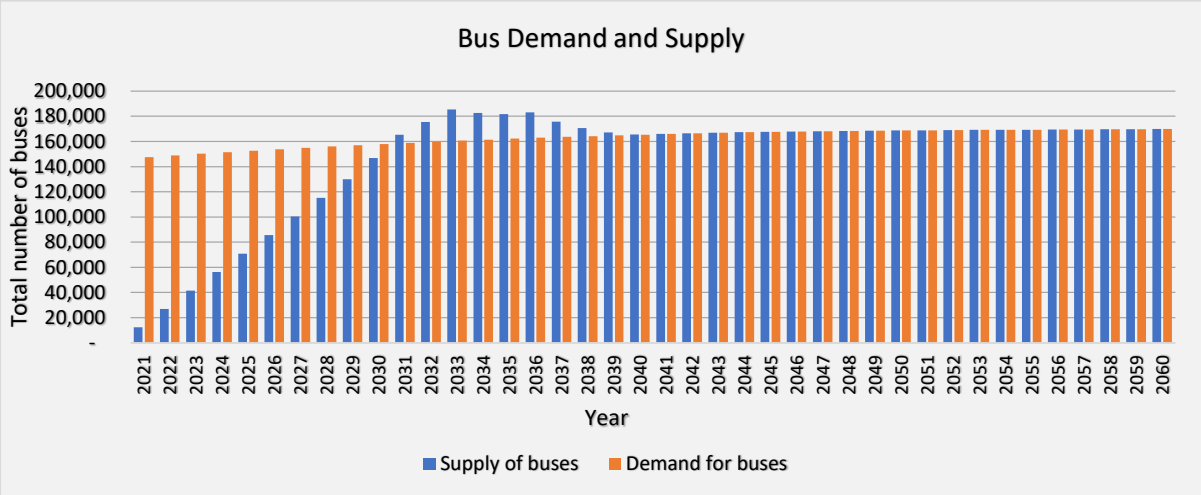
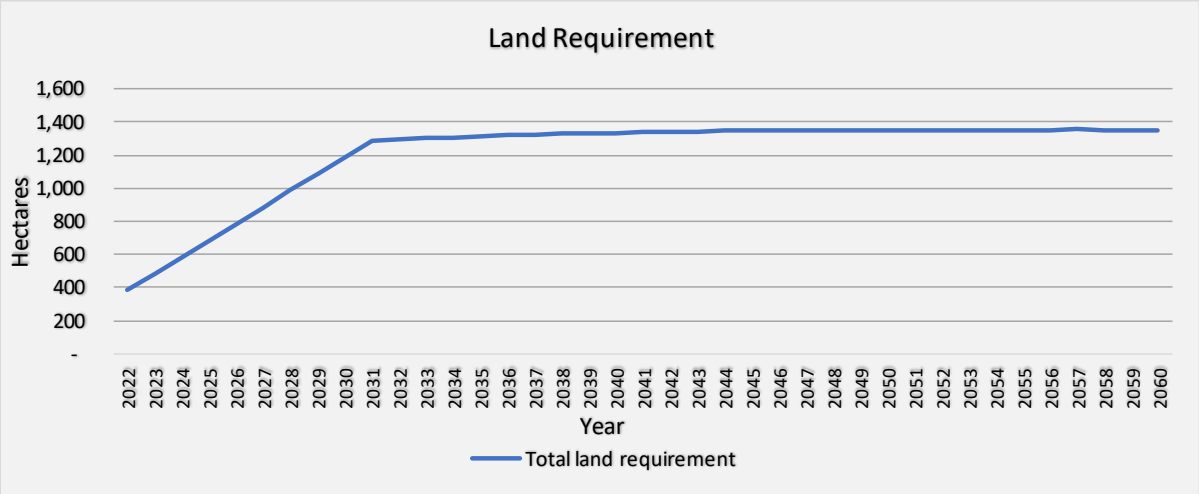


Business as Usual Scenario



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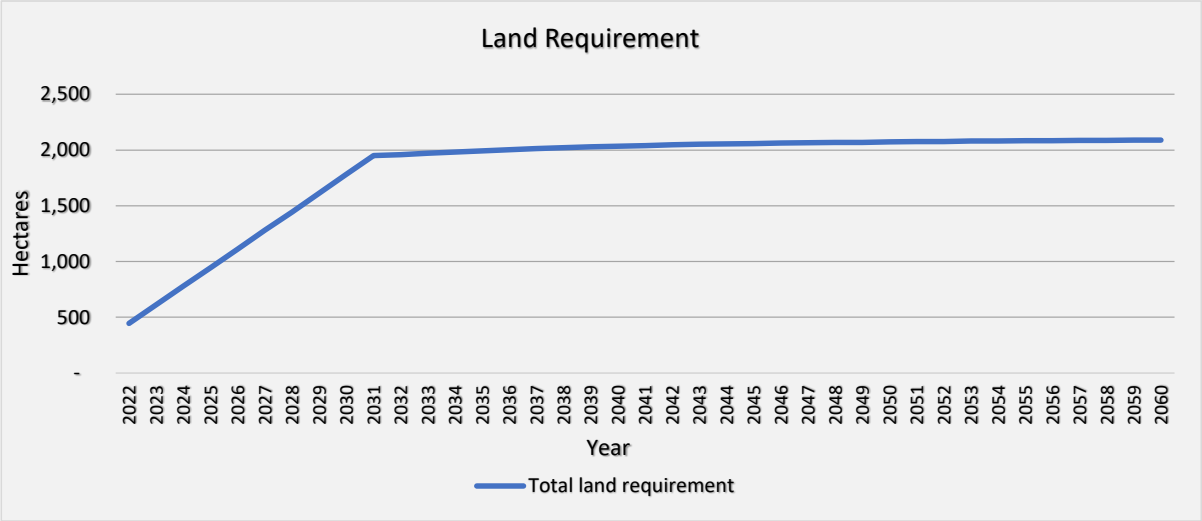

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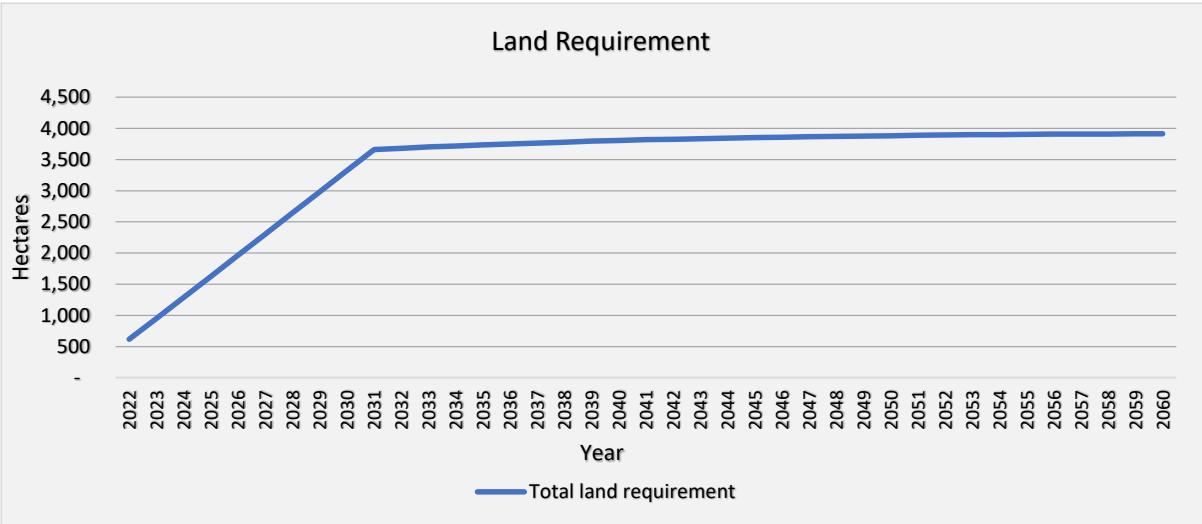
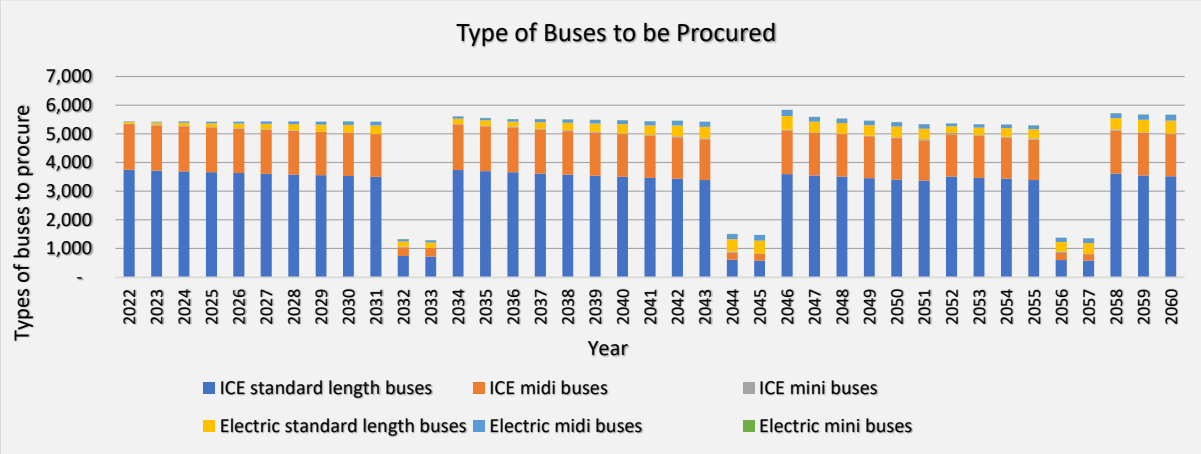


Business as Usual Scenario



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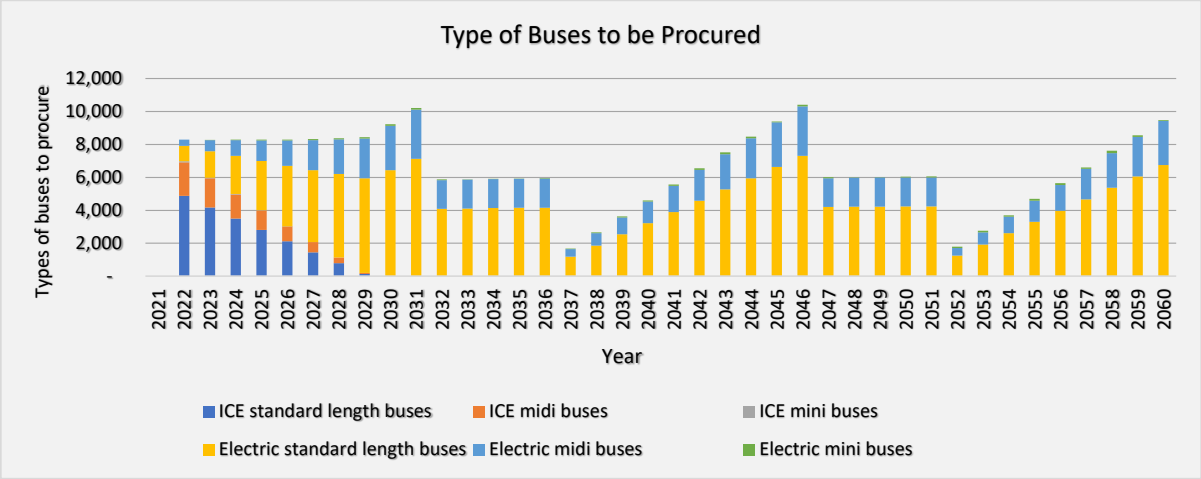
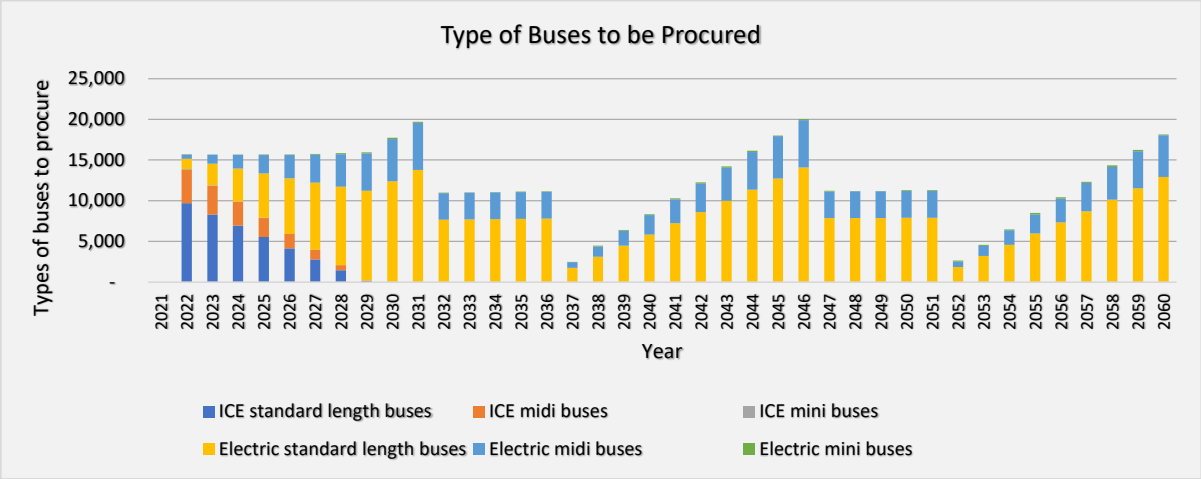
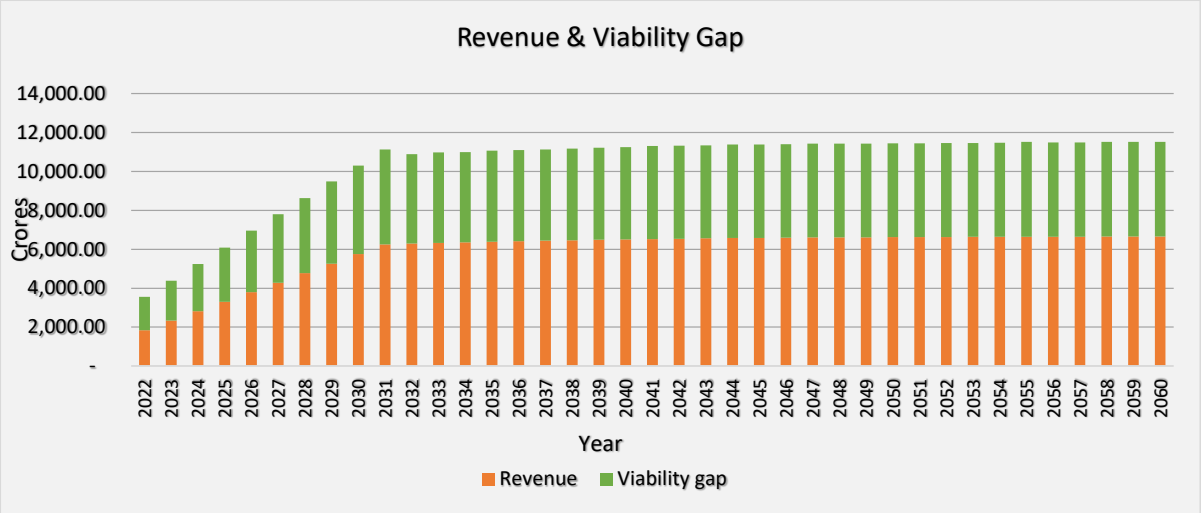


High Ambition Scenario

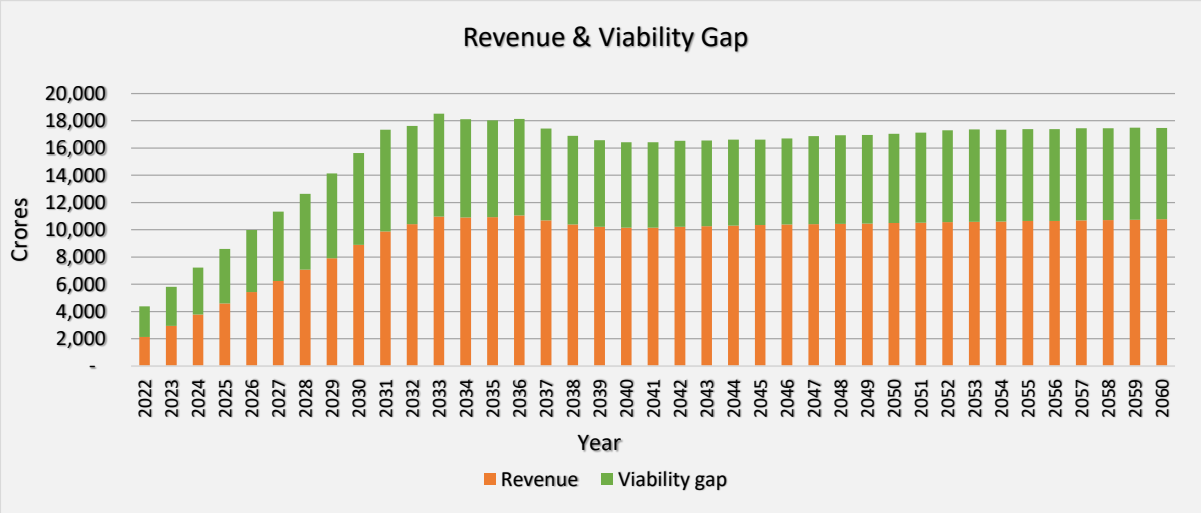


Revenue and Viability Gap: GCC Model

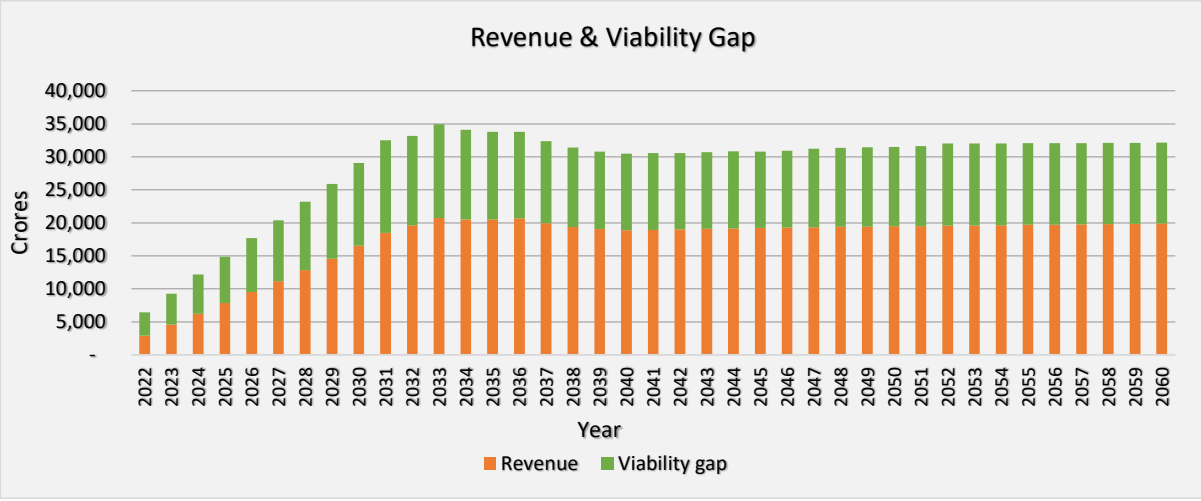
Business as Usual Scenario



Low Ambition Scenario

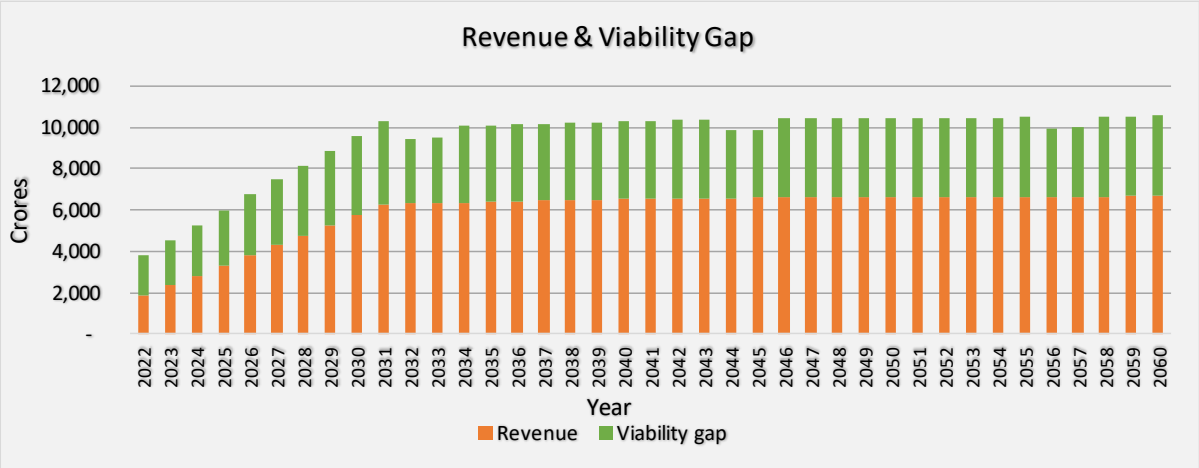


High Ambition Scenario



Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



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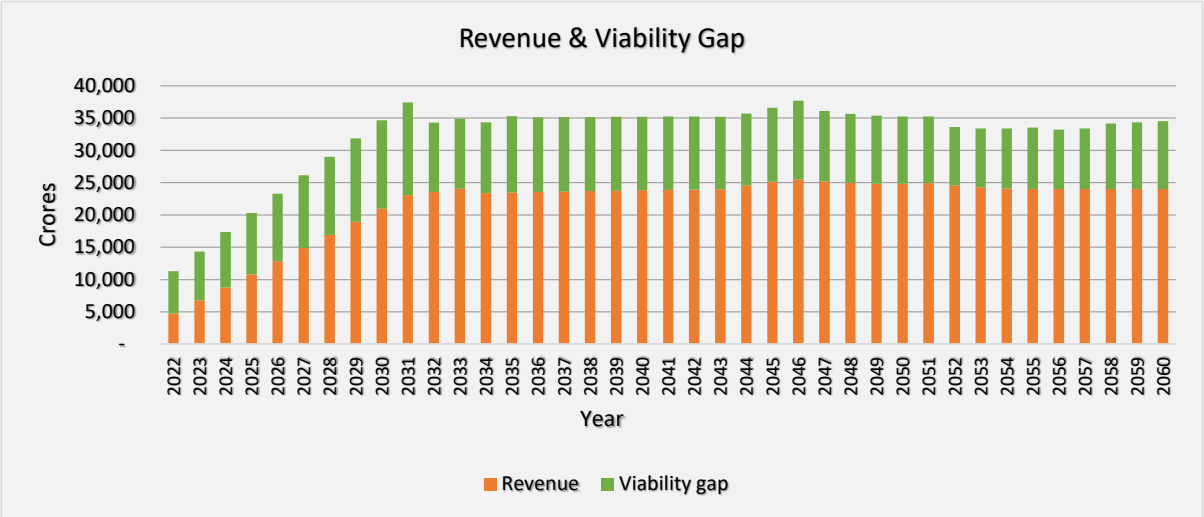

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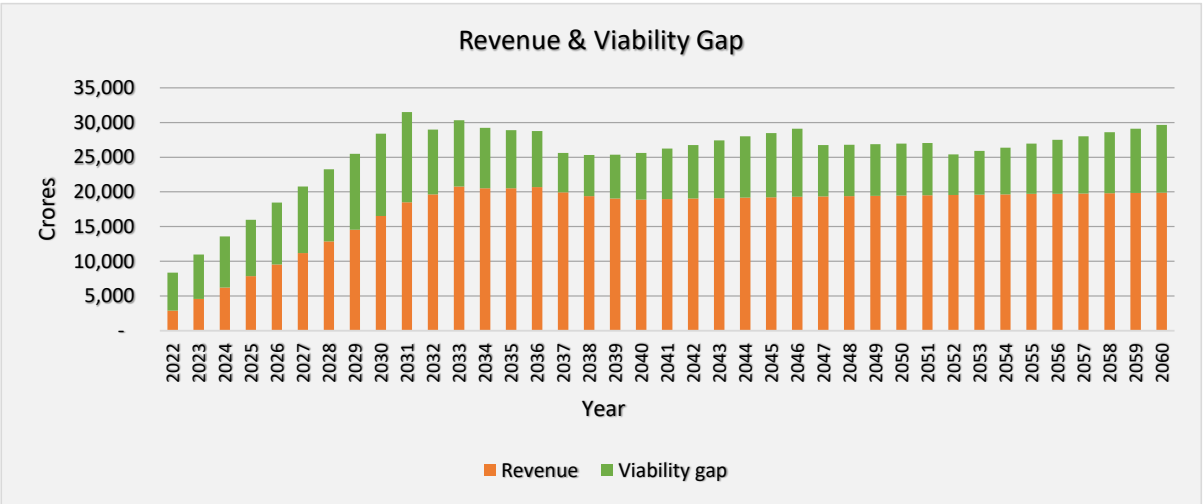
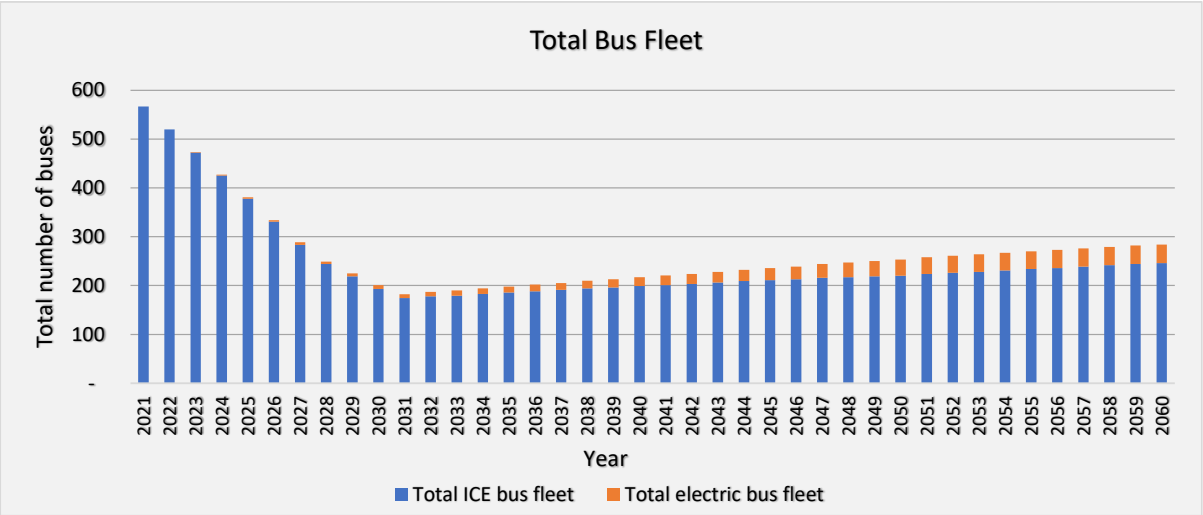
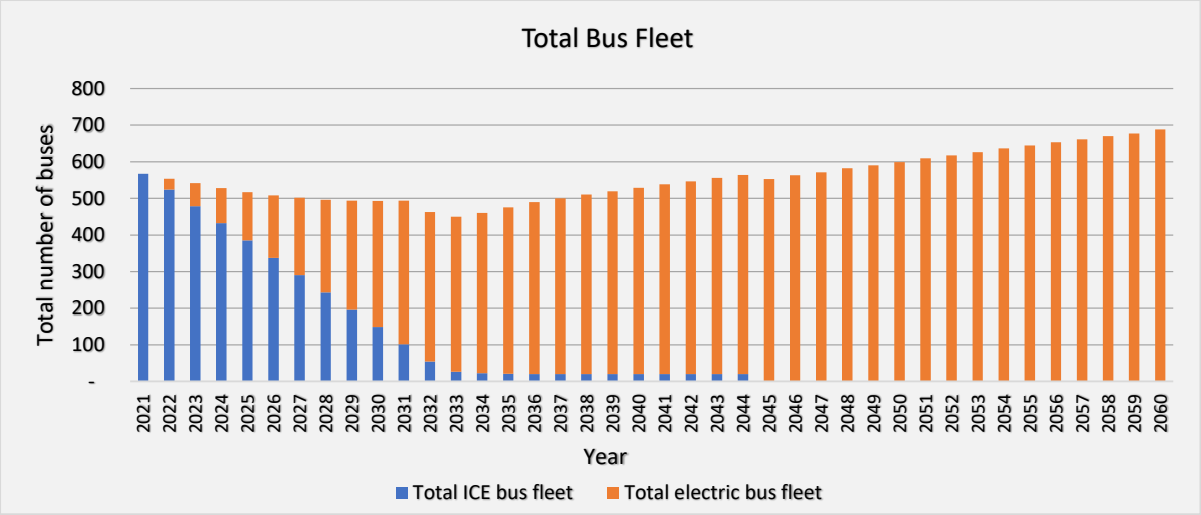


6. State / UT: Chandigarh

Business as usual Scenario



Low Ambition Scenario



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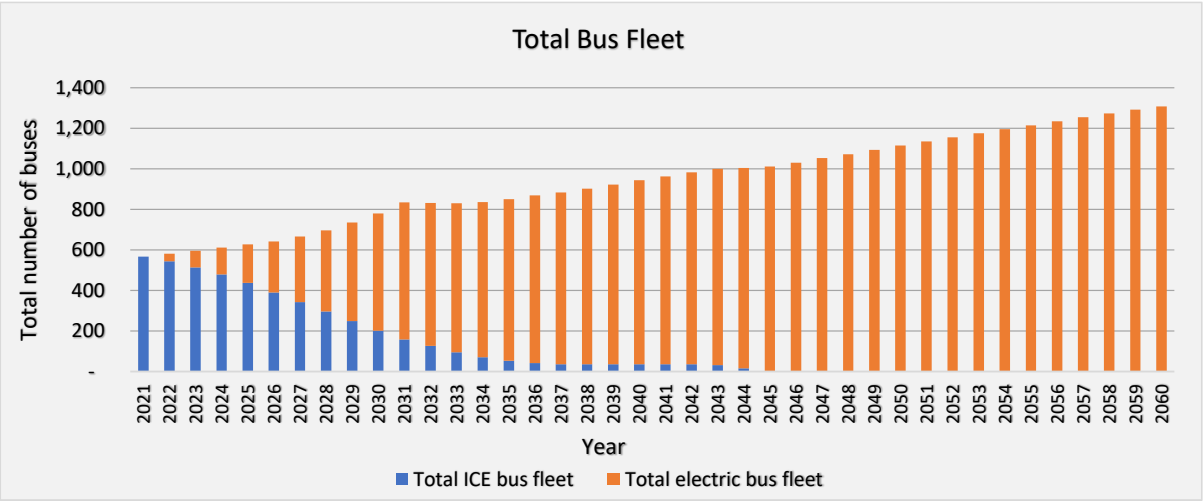
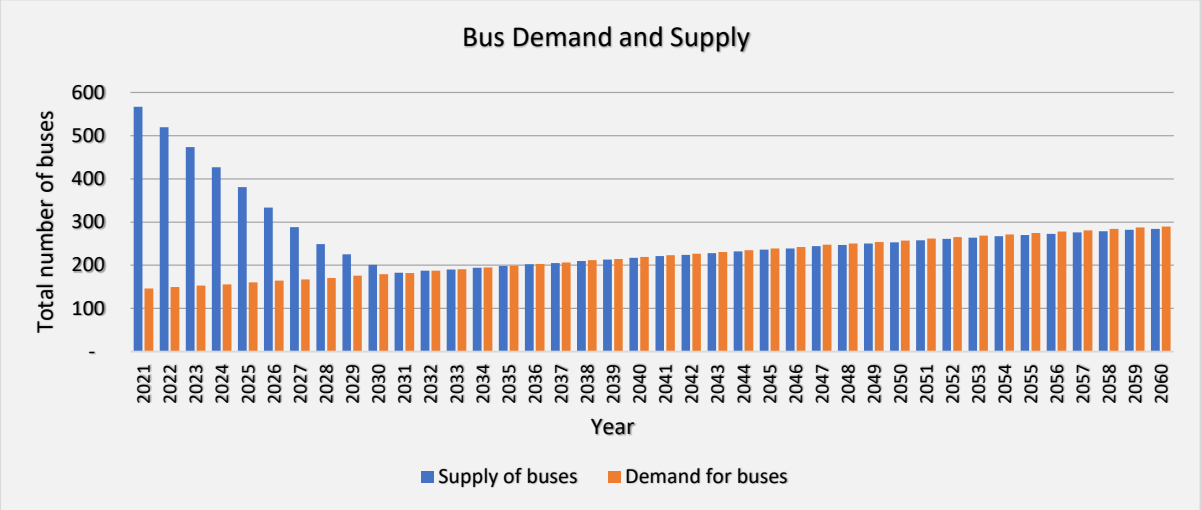


Business as Usual Scenario



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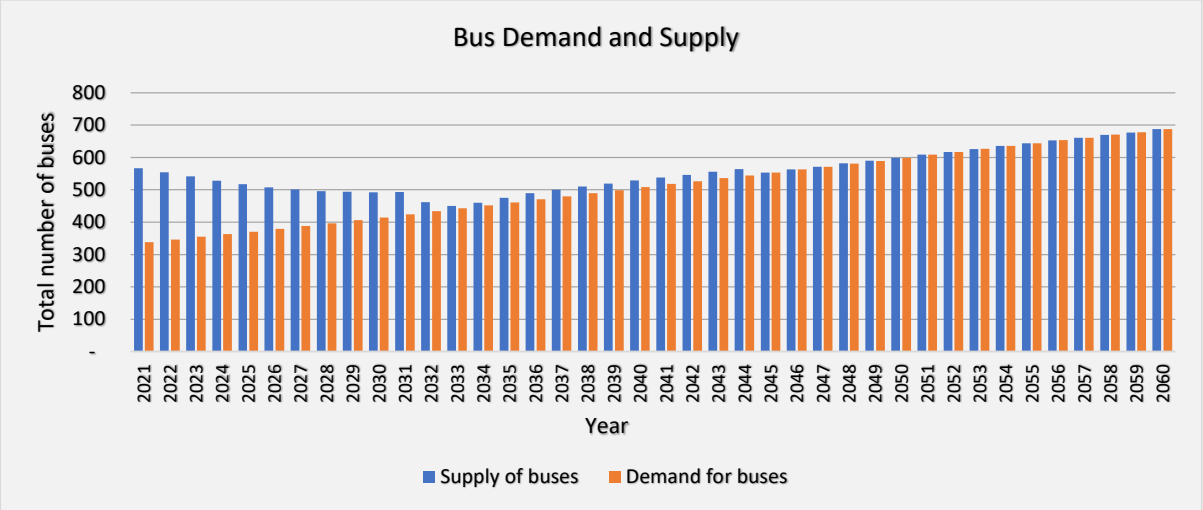

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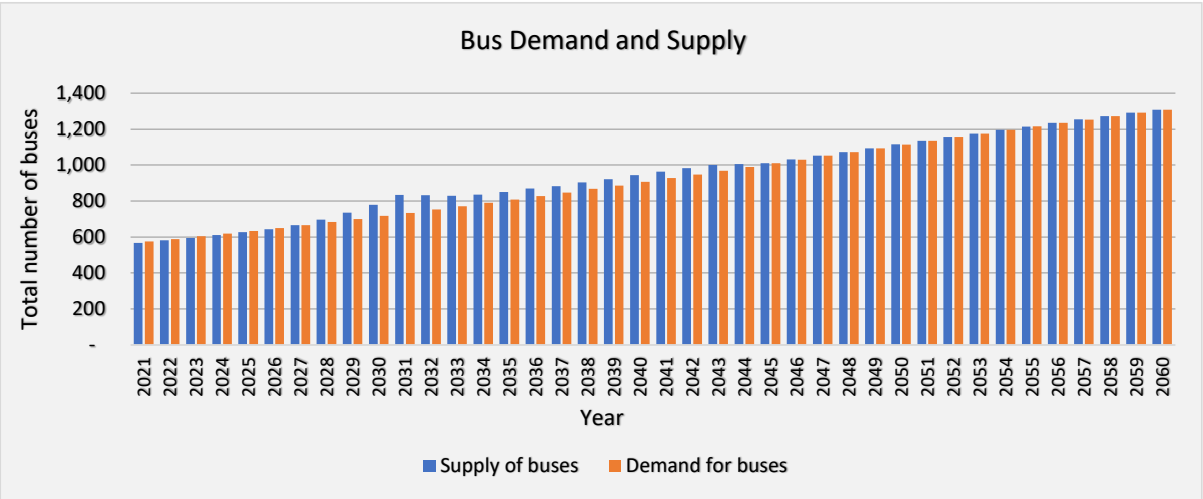
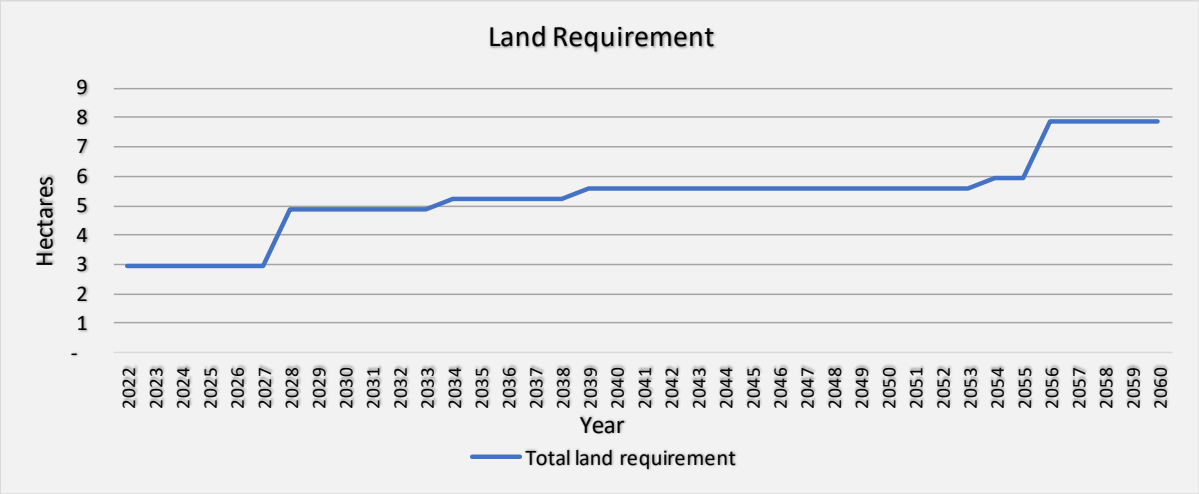


Business as Usual Scenario



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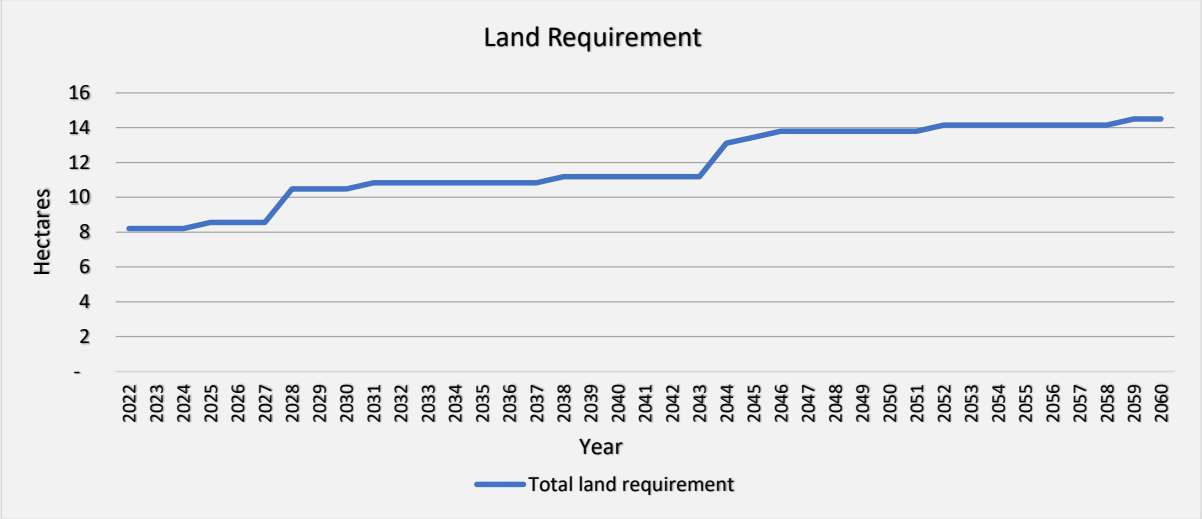
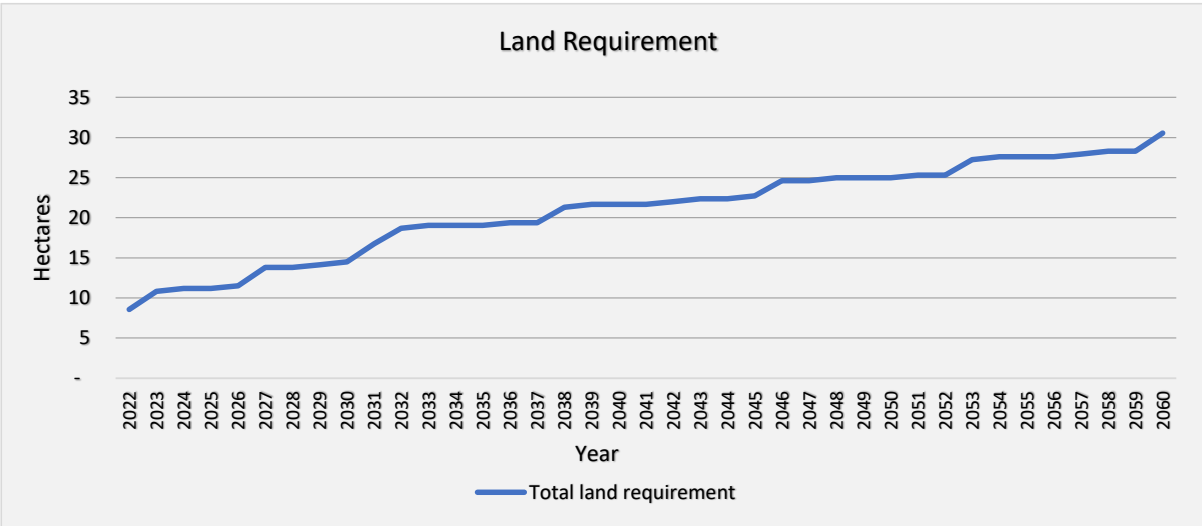
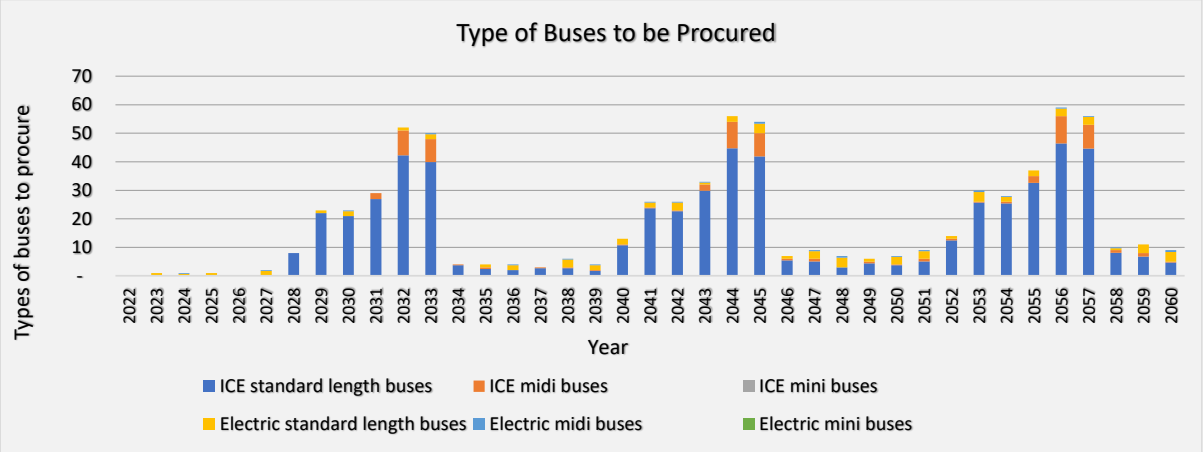


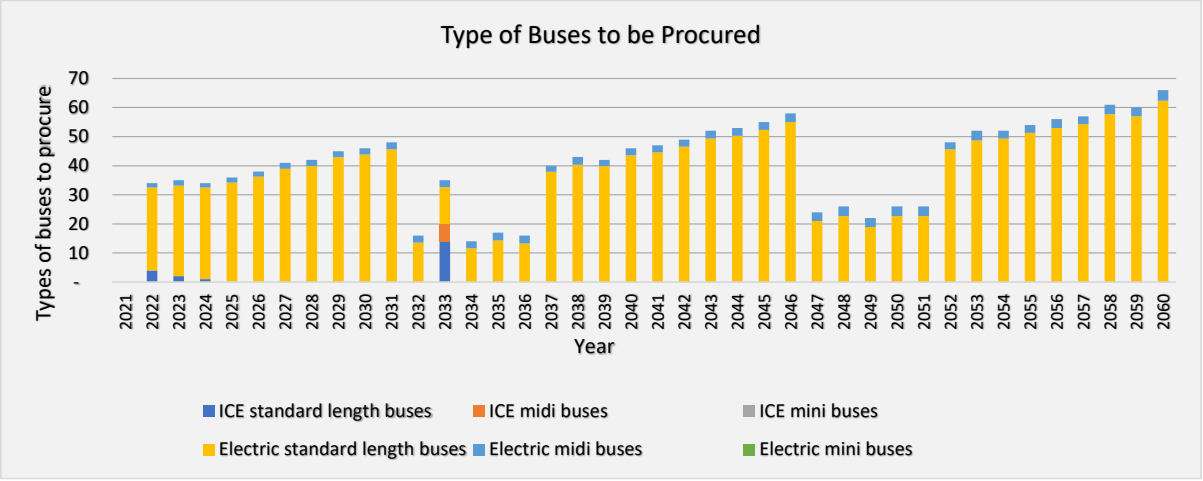
High Ambition Scenario



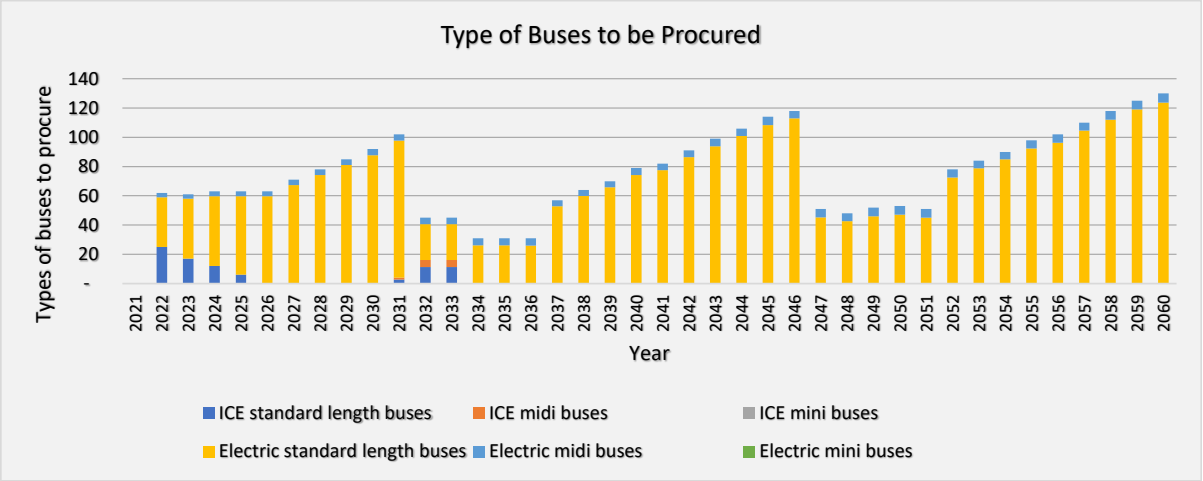
Business as Usual Scenario



Low Ambition Scenario

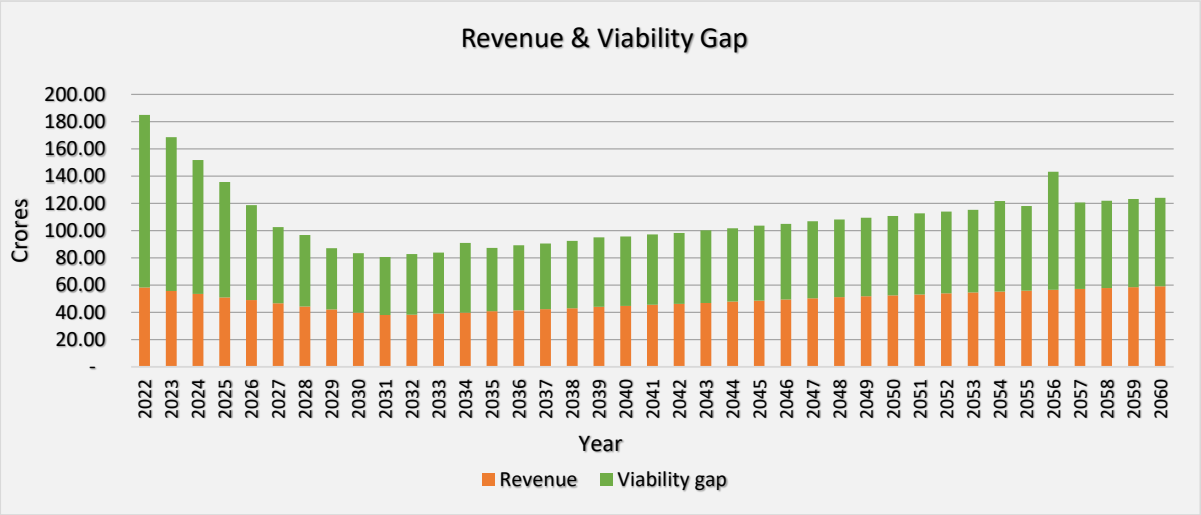


High Ambition Scenario



Revenue and Viability Gap: GCC Model

Business as Usual Scenario



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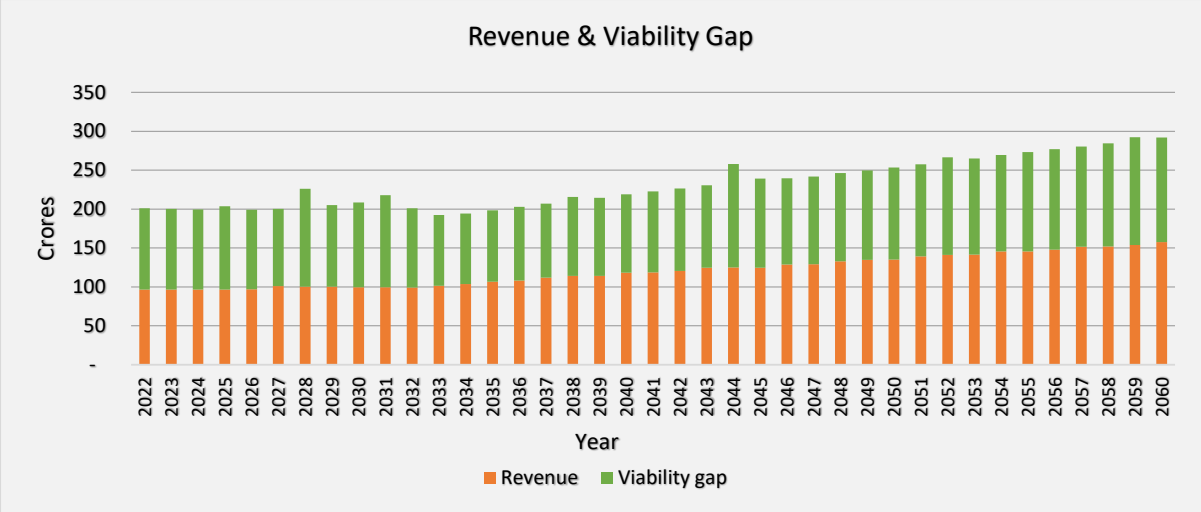
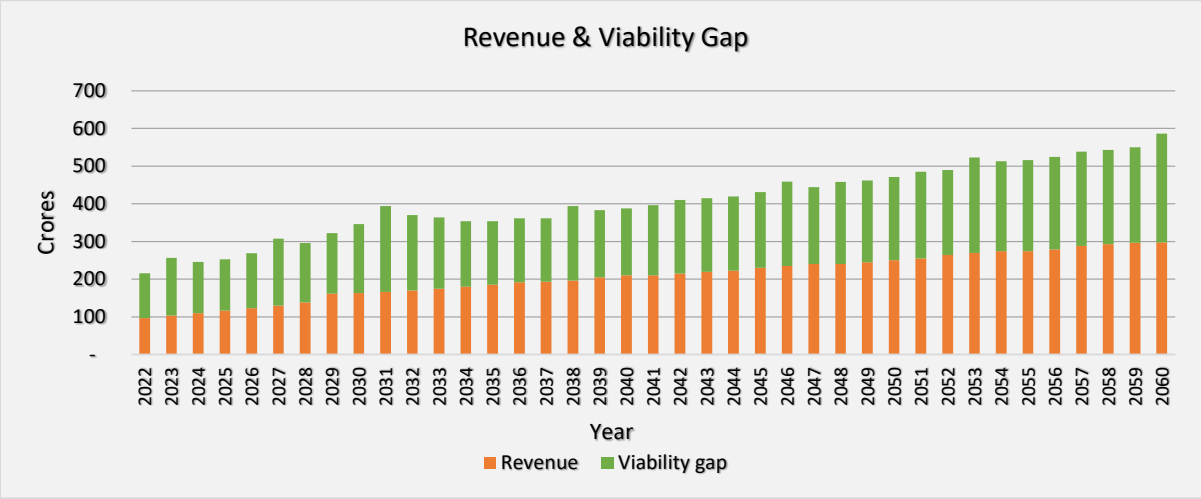
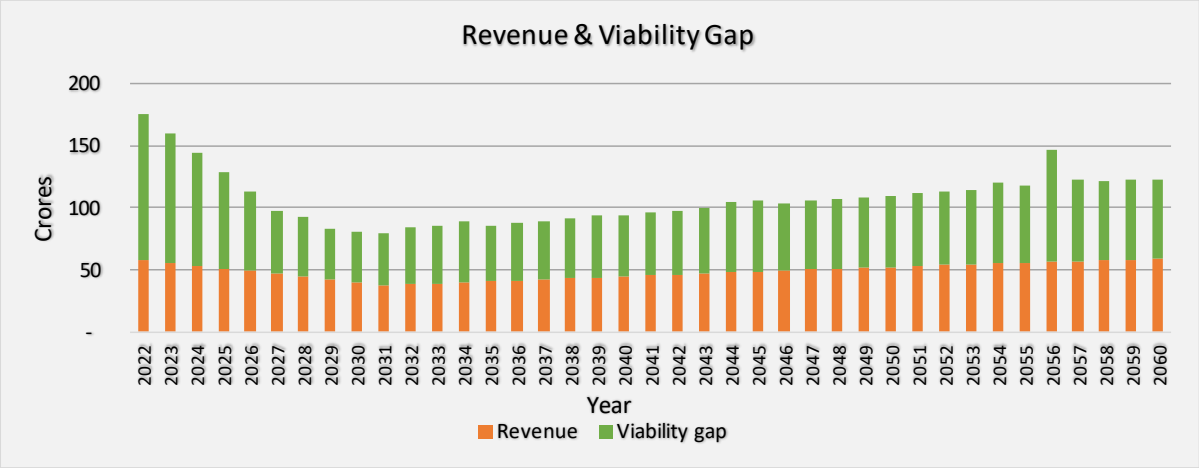


High Ambition Scenario



Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



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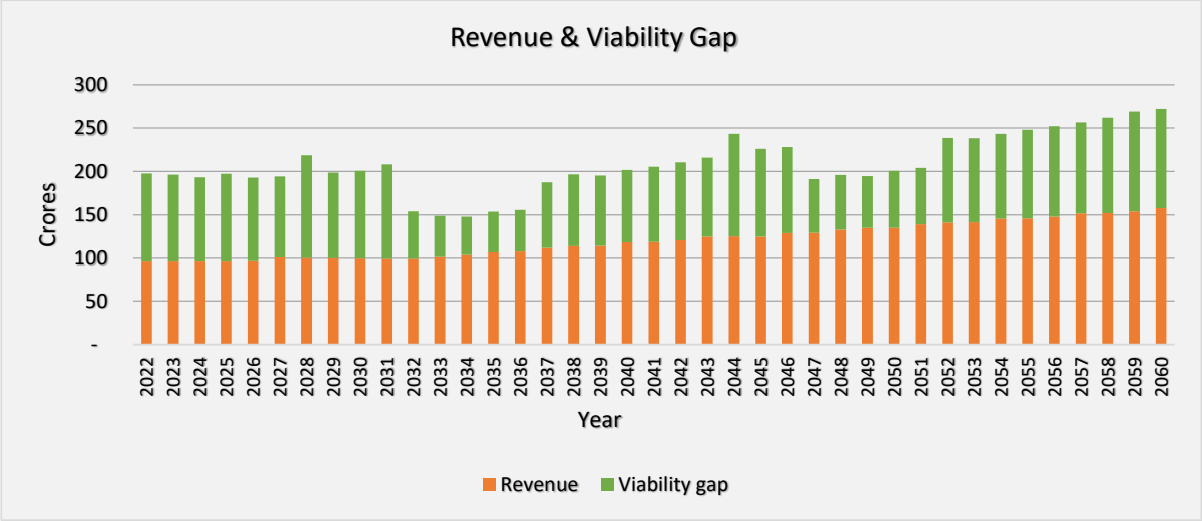
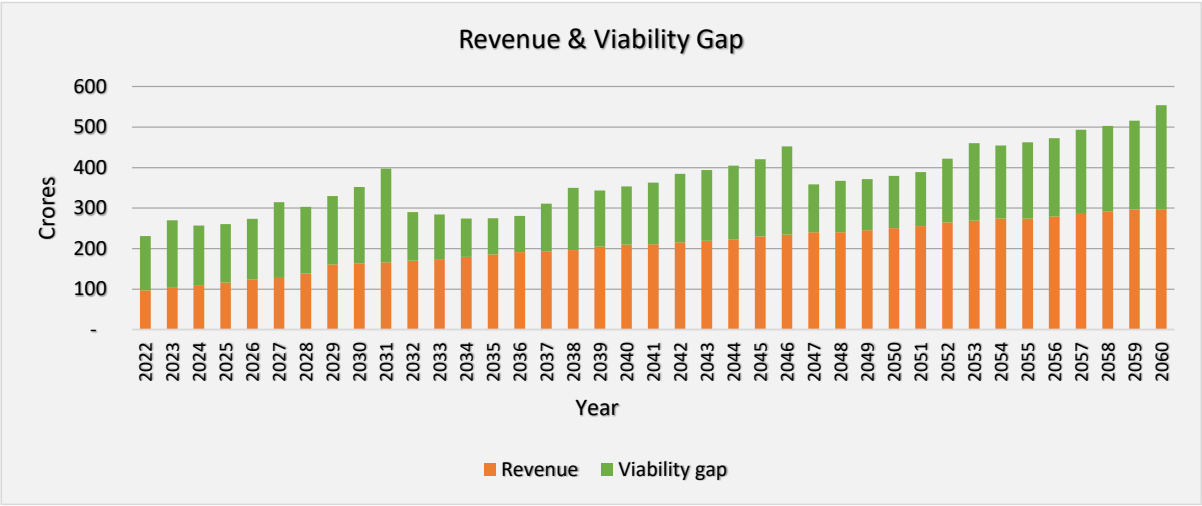
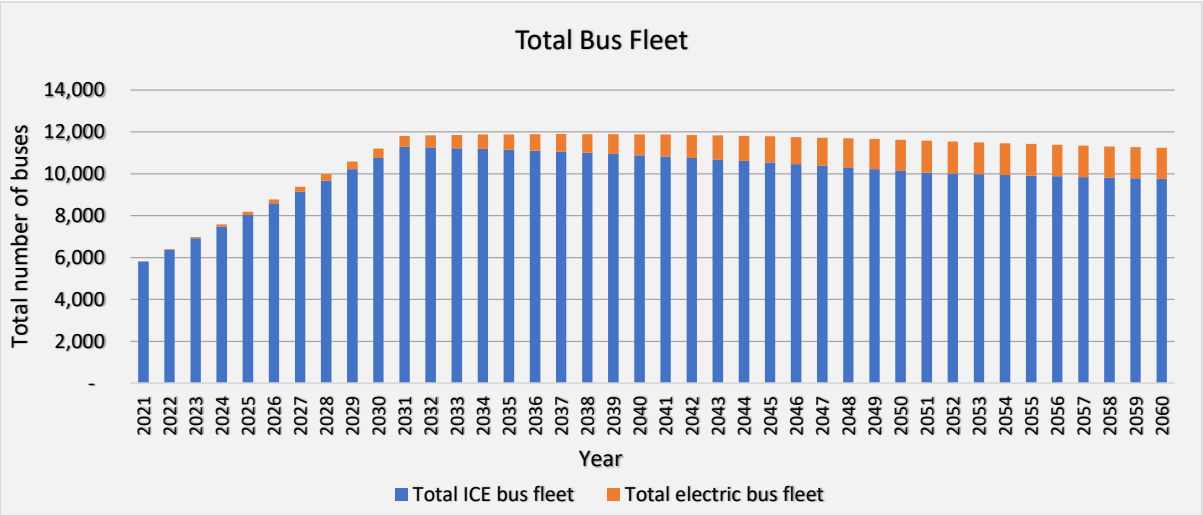


High Ambition Scenario



7. State / UT: Chattisgarh

Business as usual Scenario



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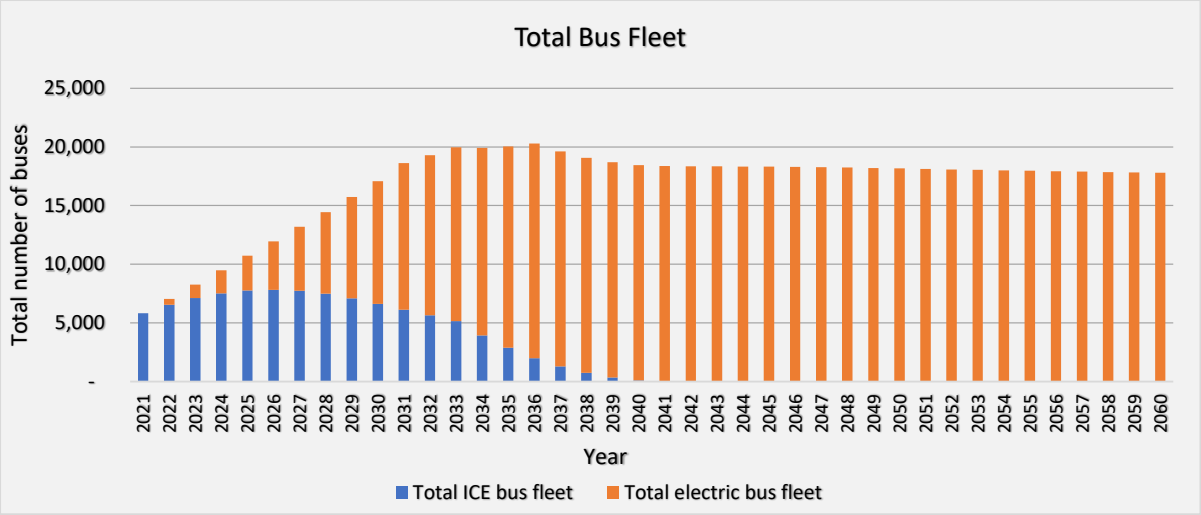

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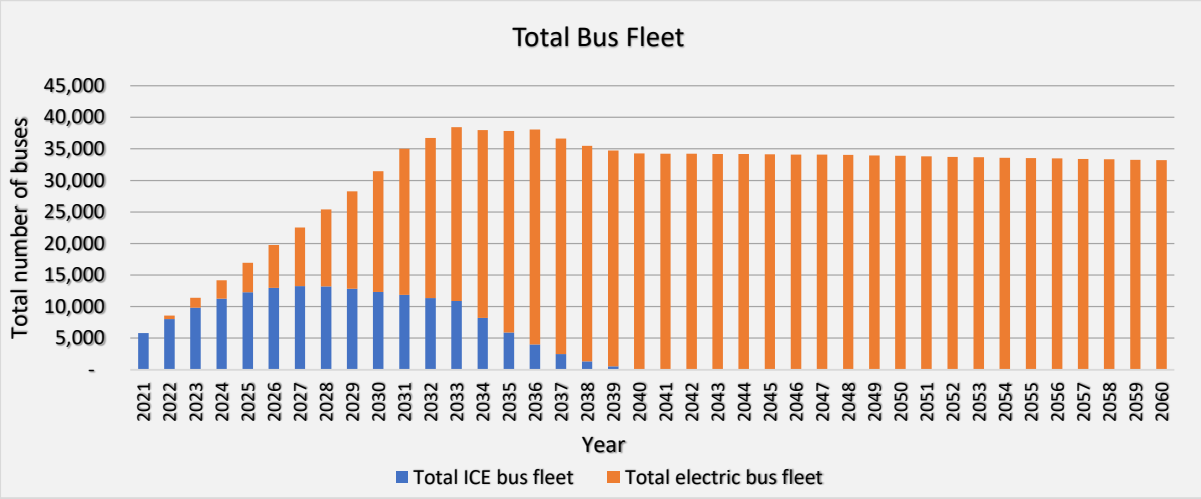
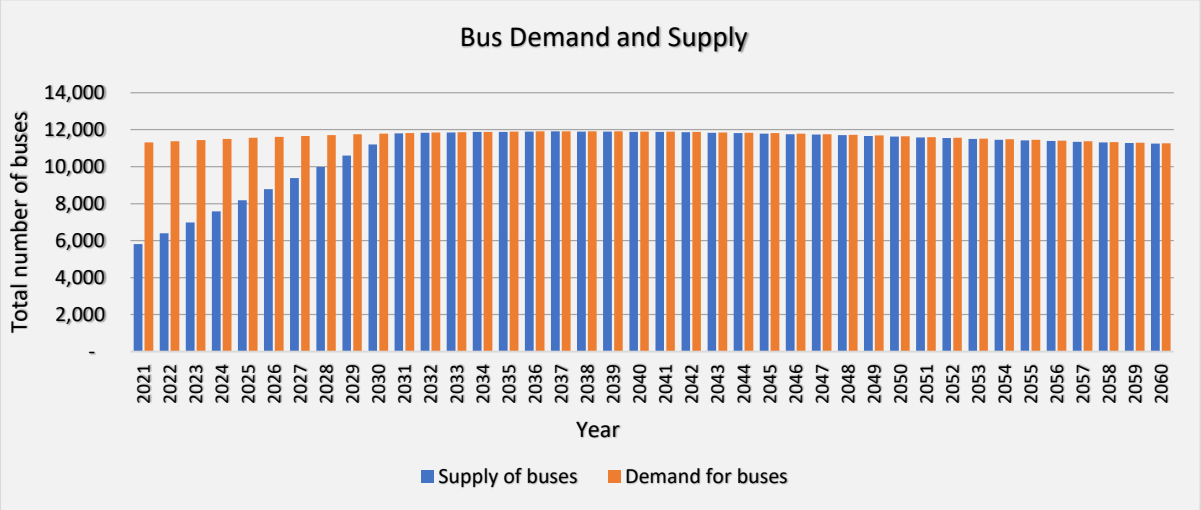


Business as Usual Scenario



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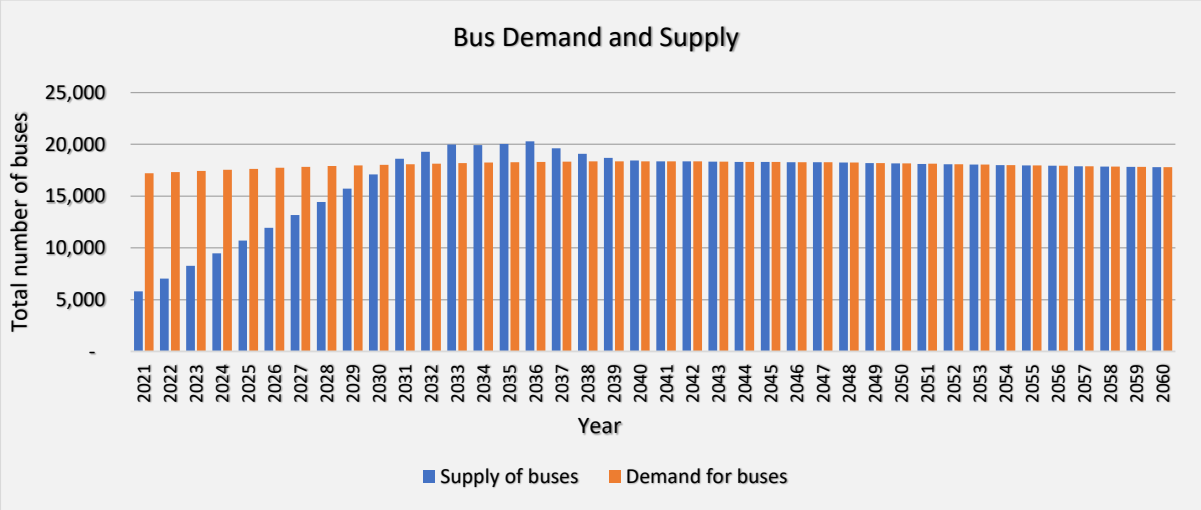

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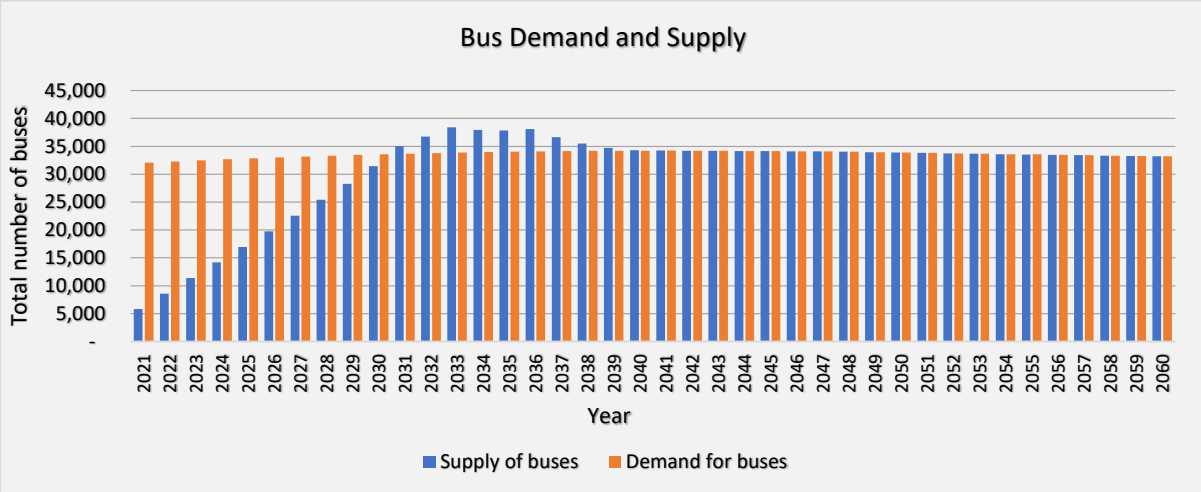
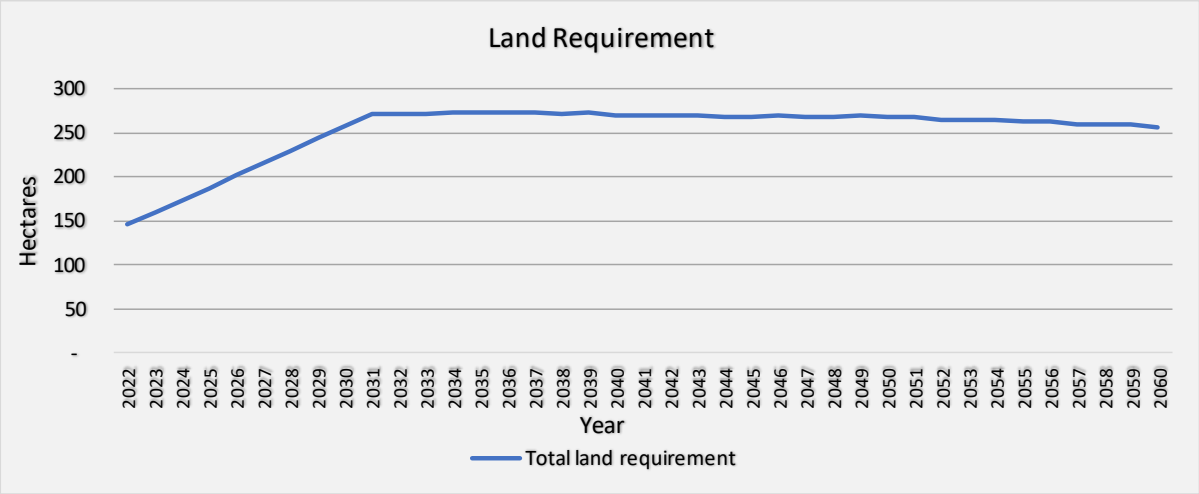


Business as Usual Scenario



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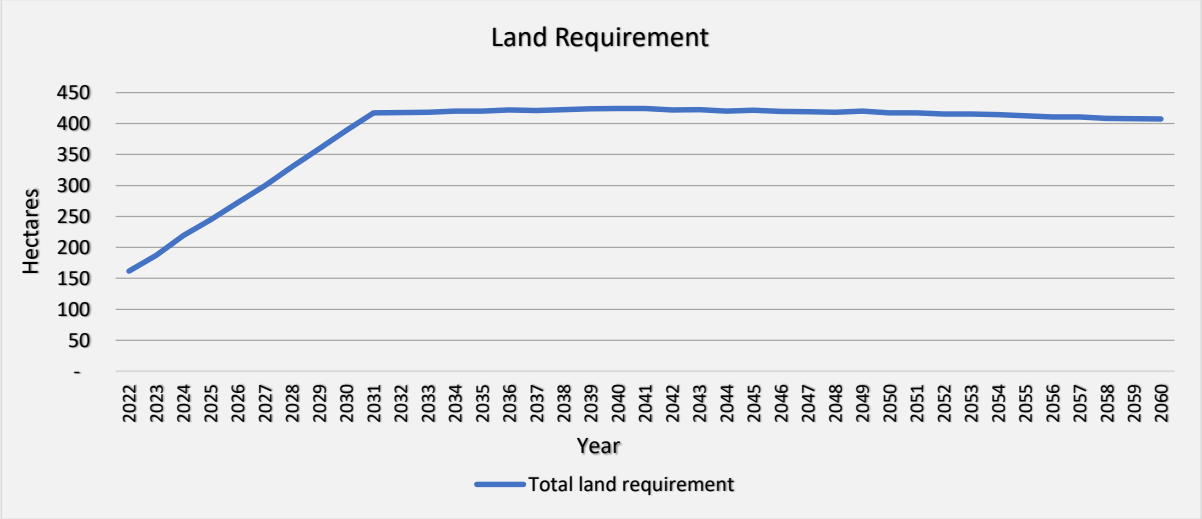

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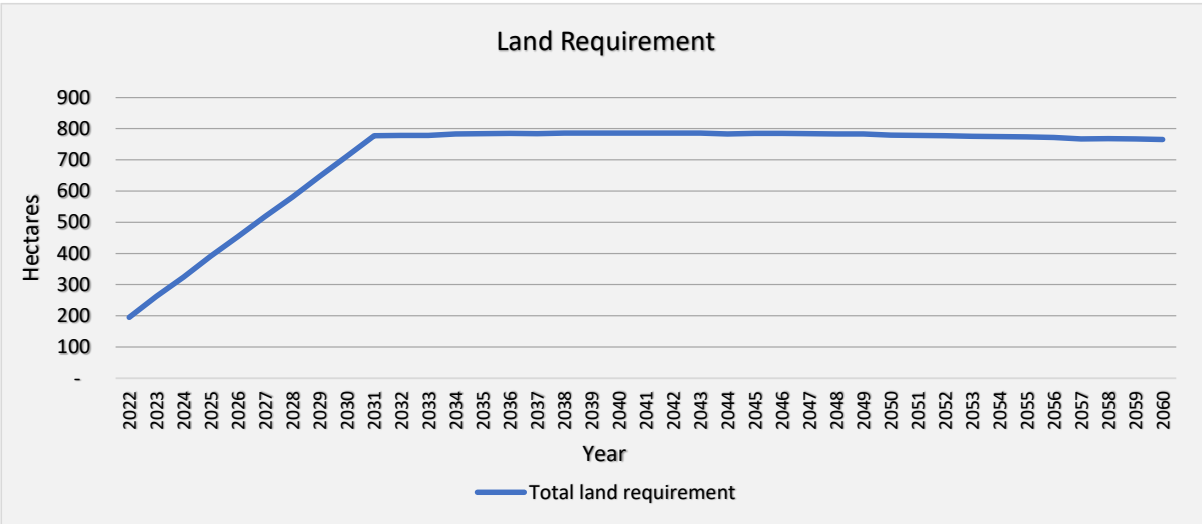
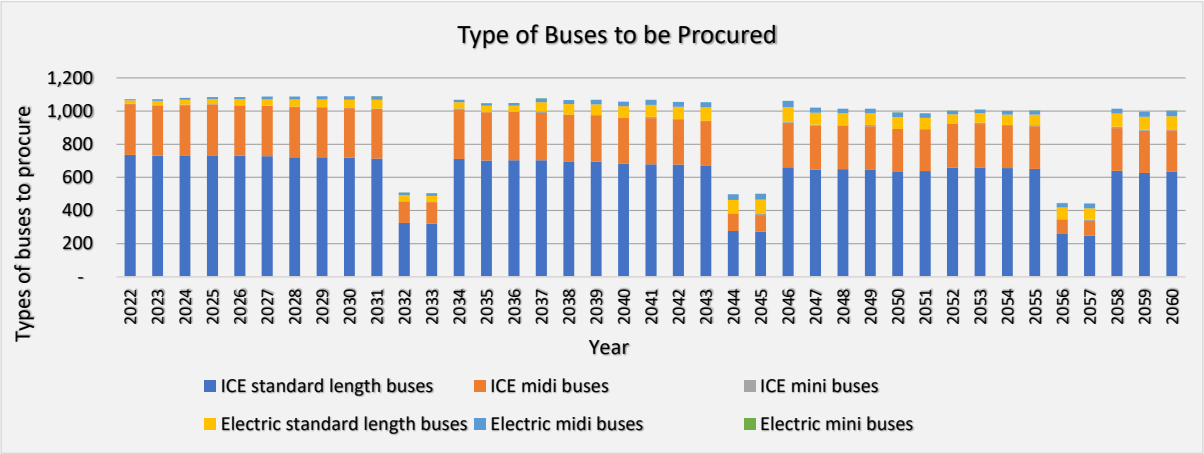


Business as Usual Scenario



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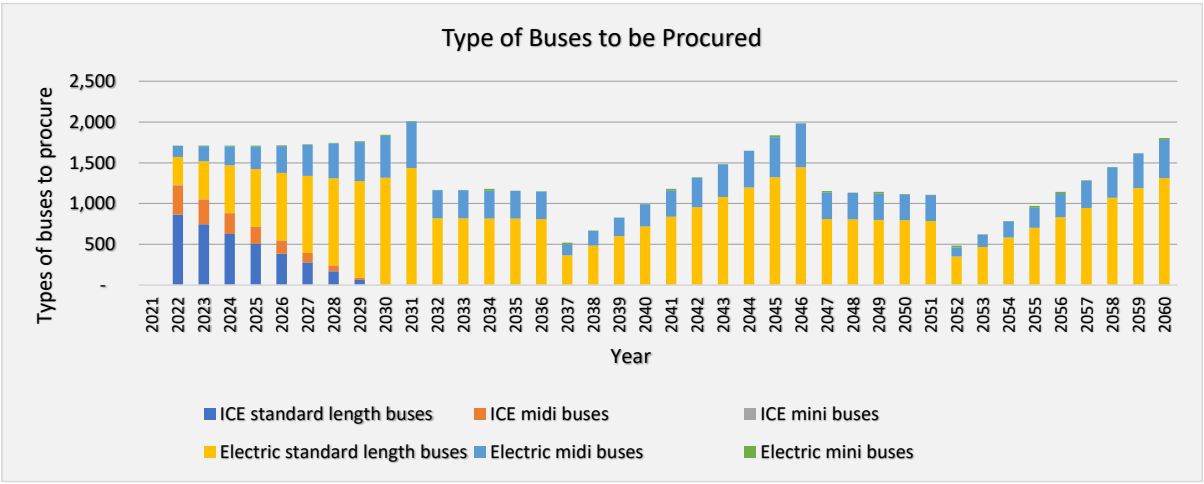
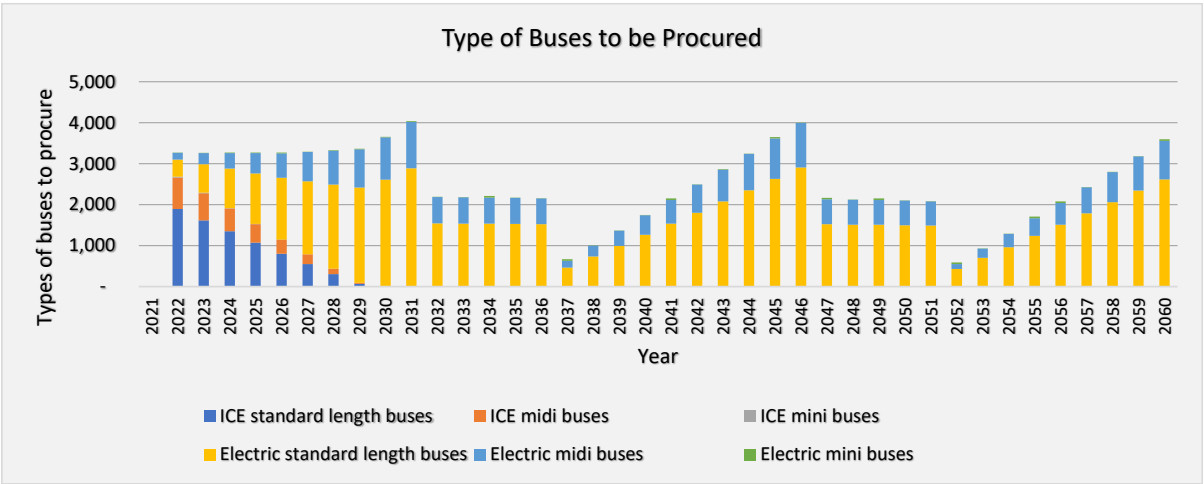
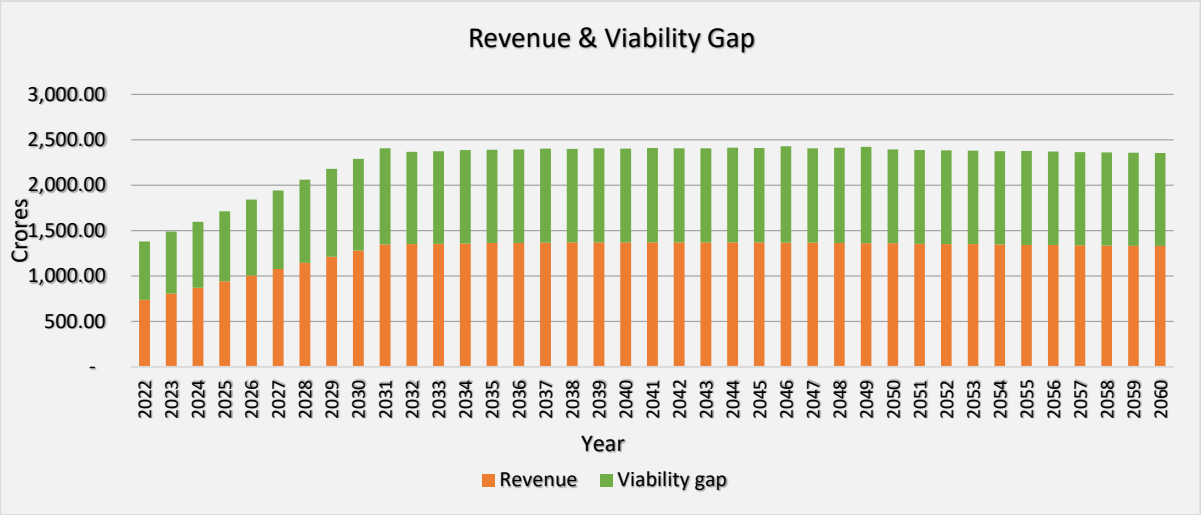


High Ambition Scenario

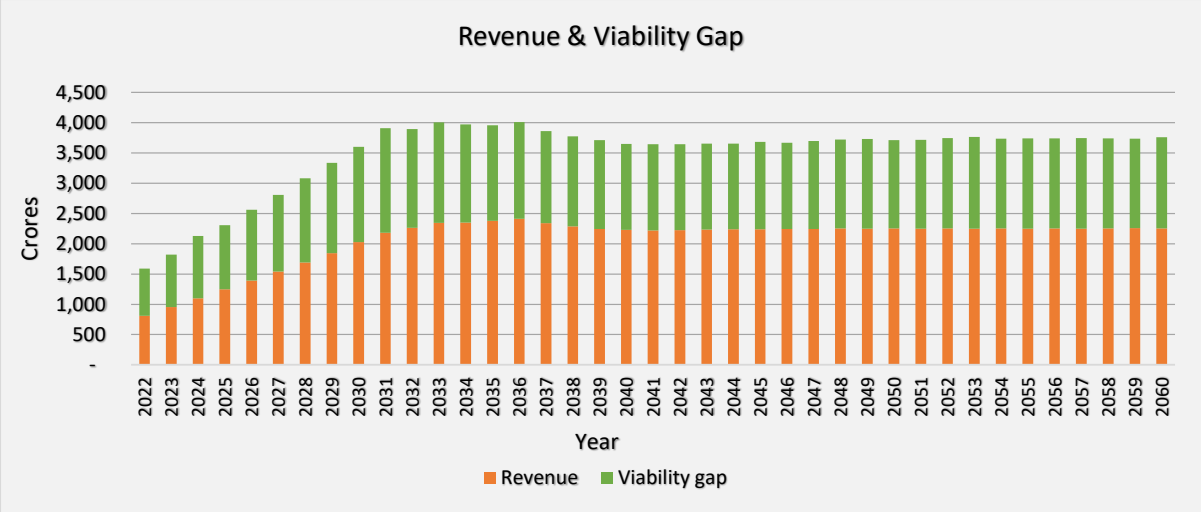


Revenue and Viability Gap: GCC Model

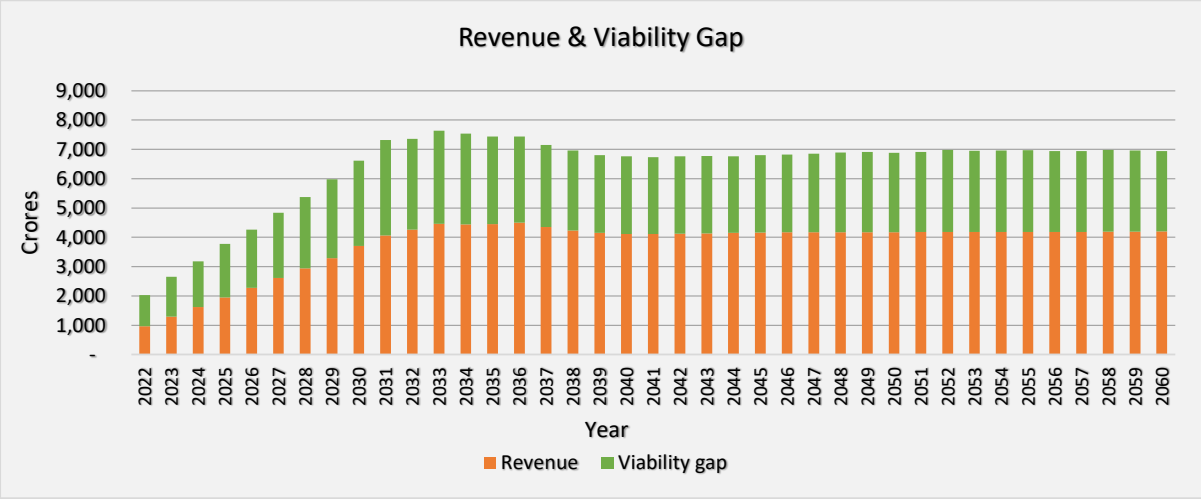
Business as Usual Scenario



Low Ambition Scenario

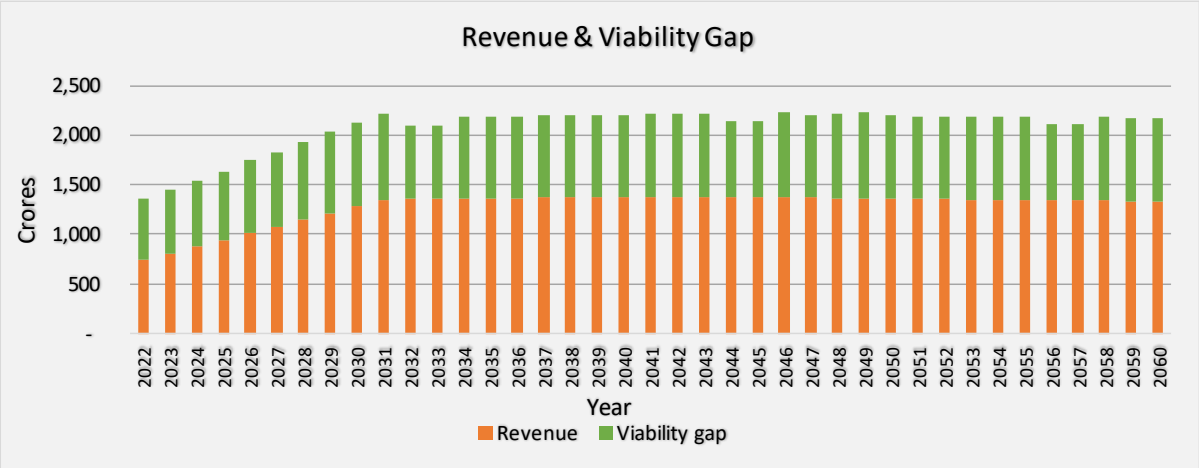


High Ambition Scenario

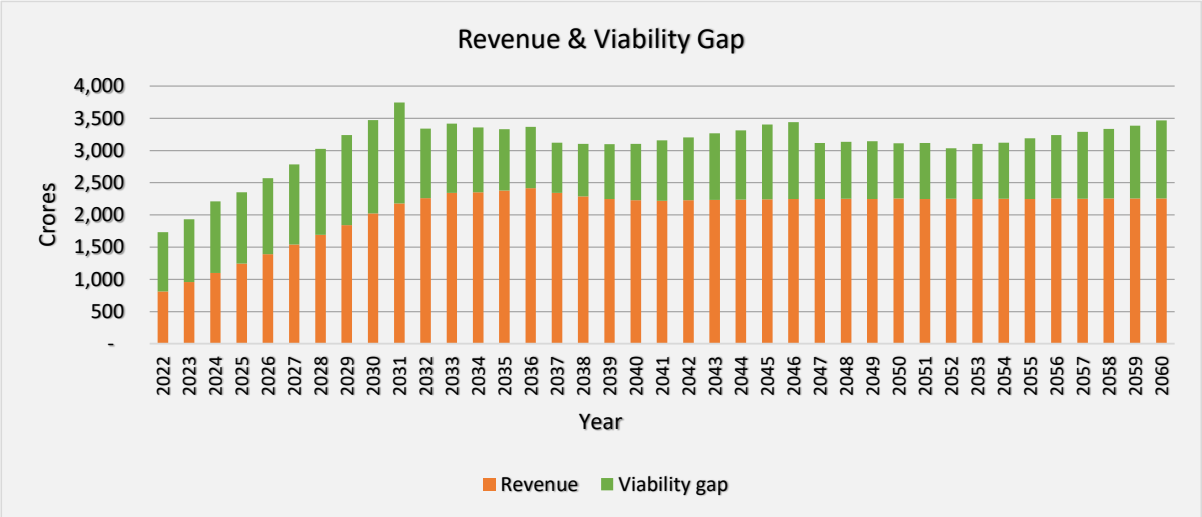


Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



Low Ambition Scenario



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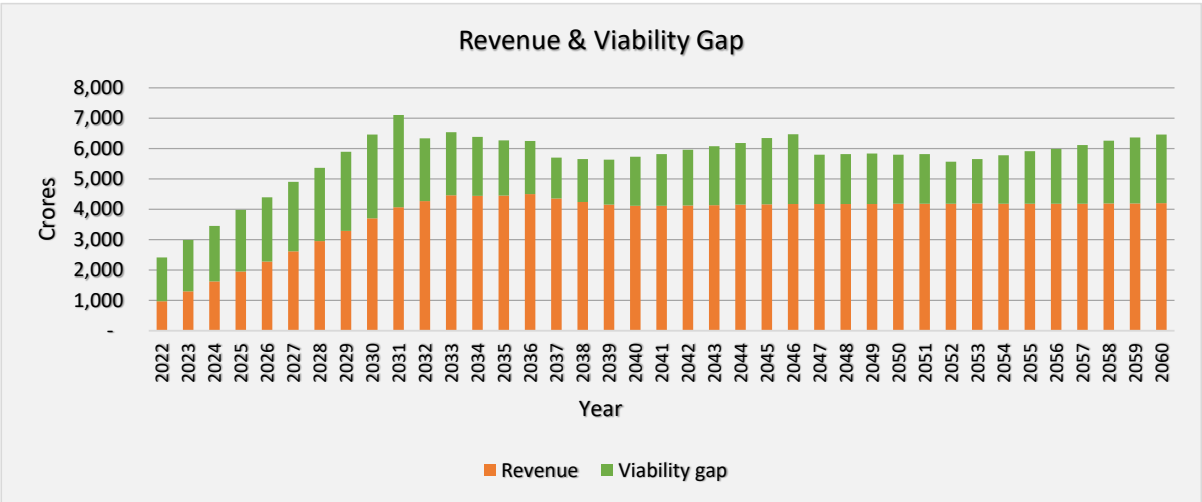
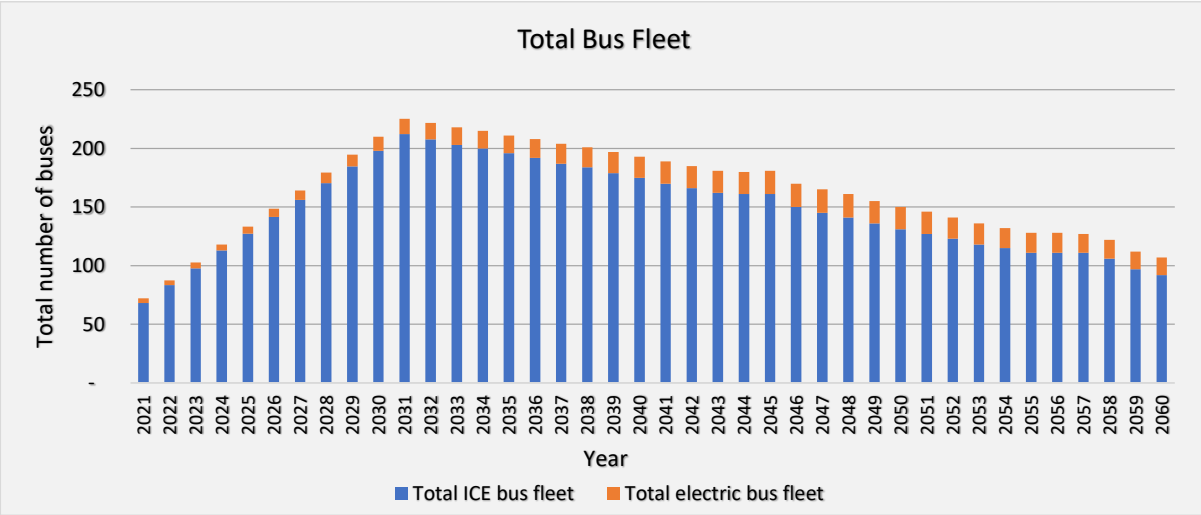


8. State / UT: Dadra and Nagar Havelli

Business as usual Scenario



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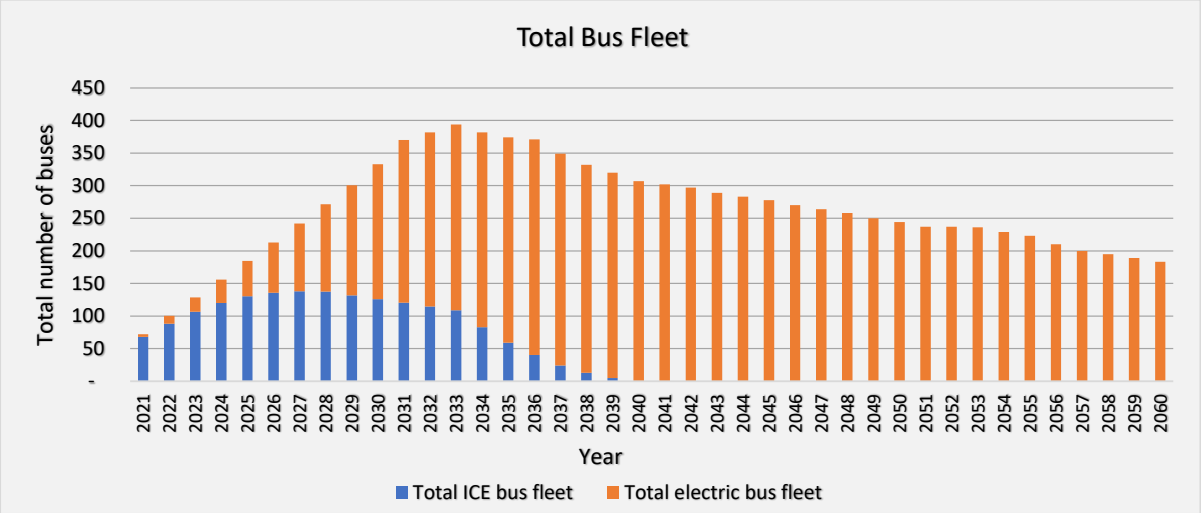
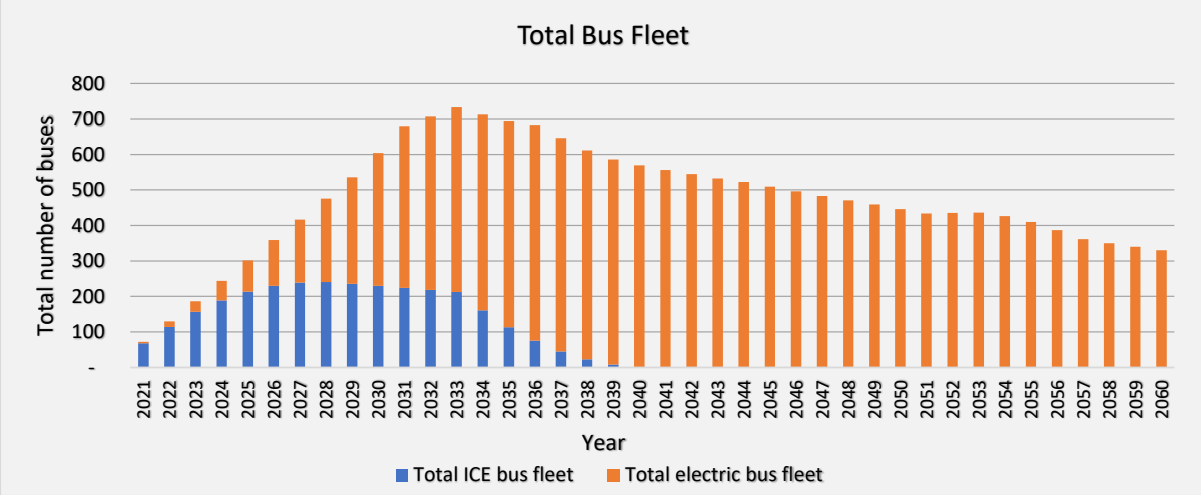
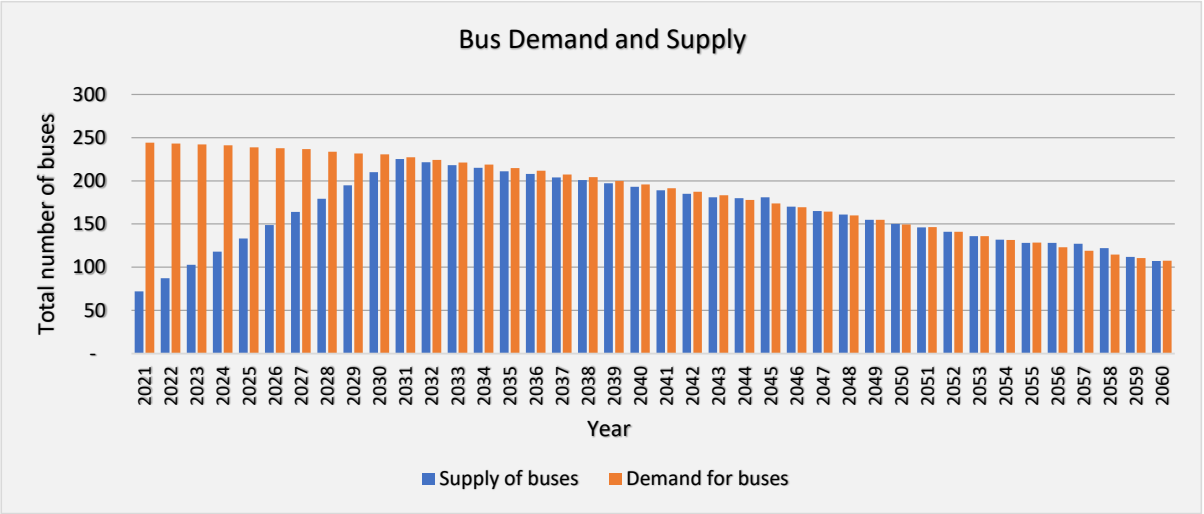


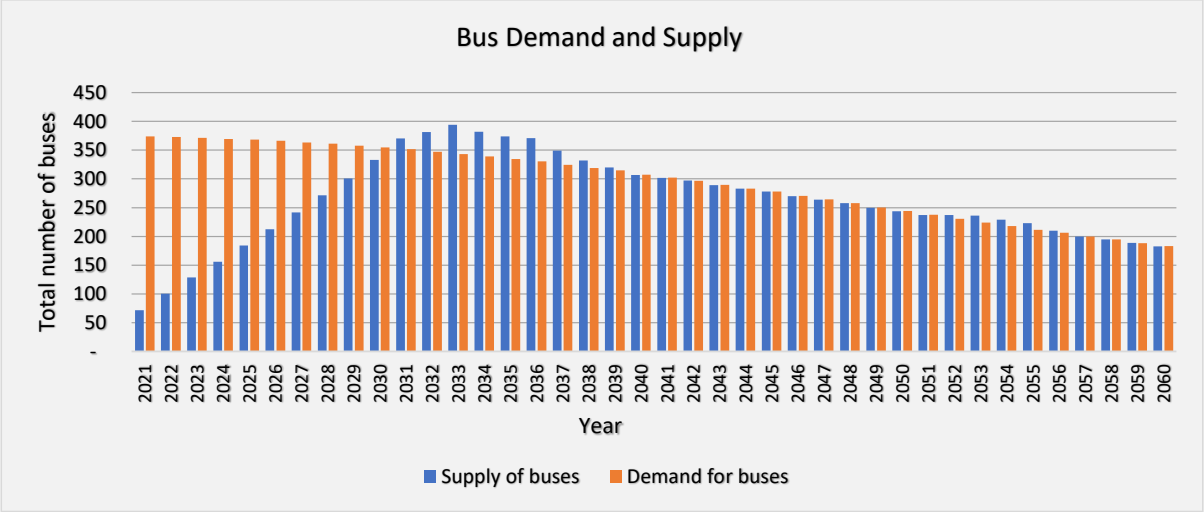
High Ambition Scenario



Business as Usual Scenario



Low Ambition Scenario



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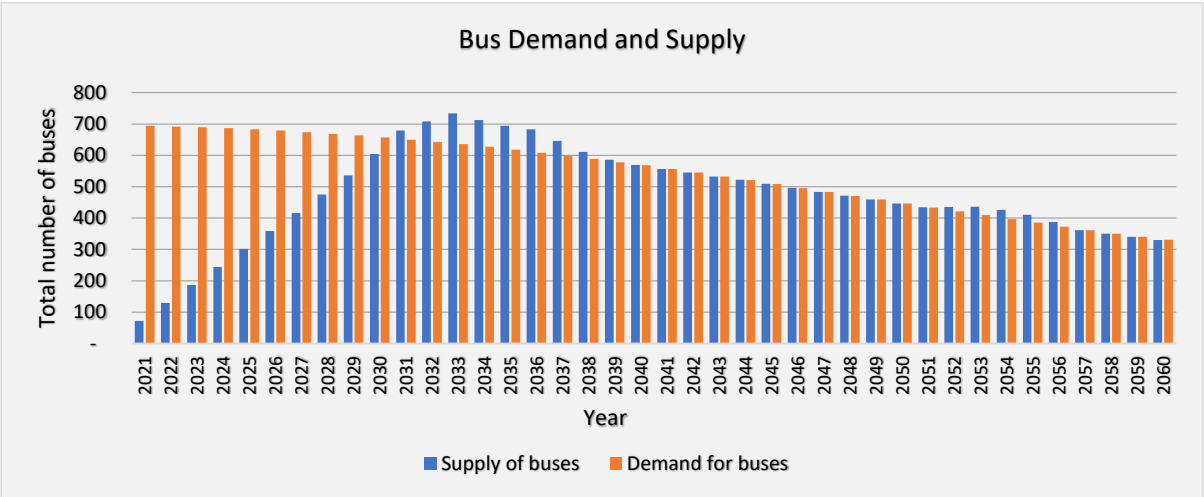
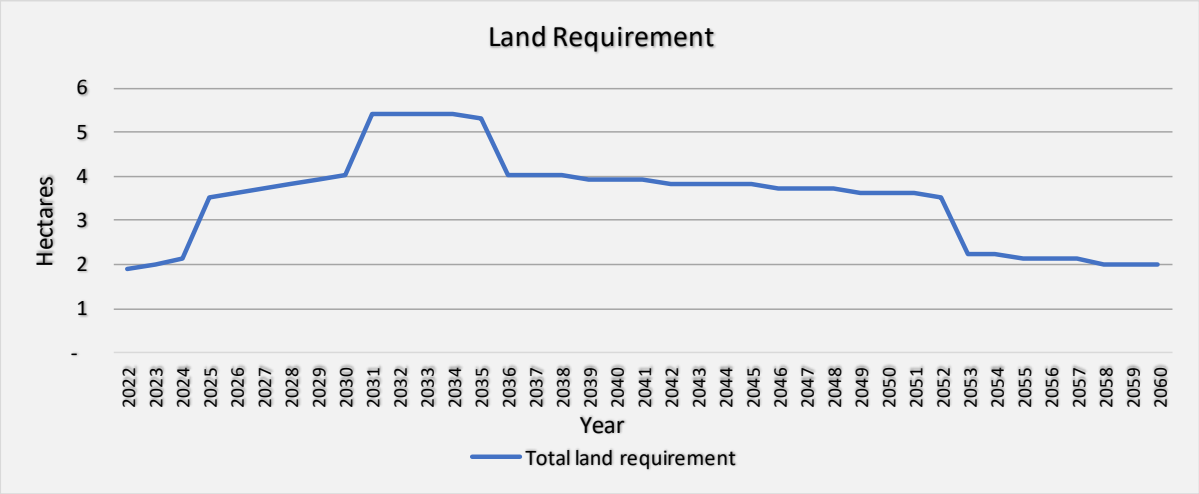


Business as Usual Scenario



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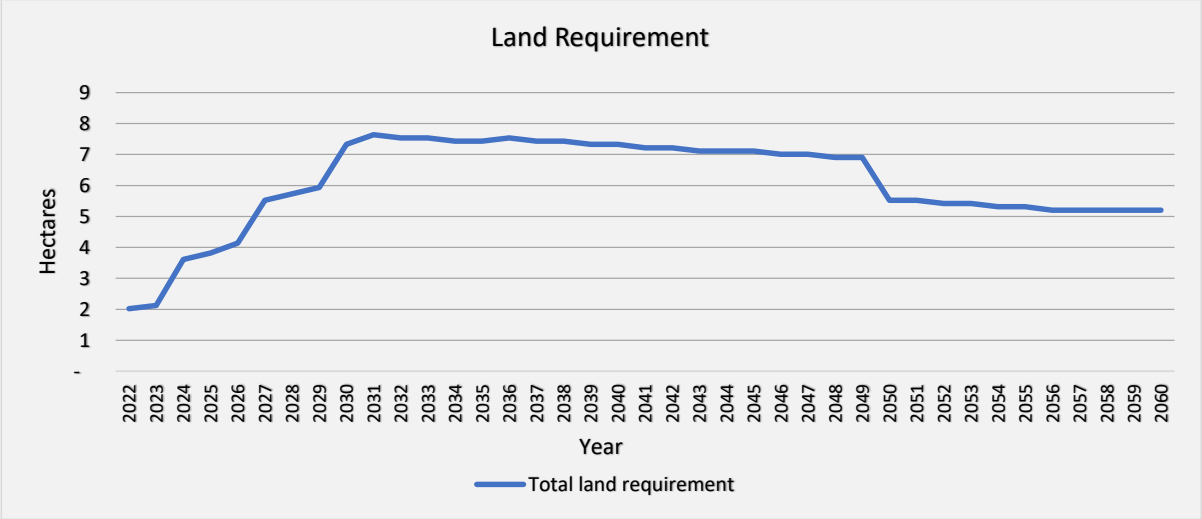

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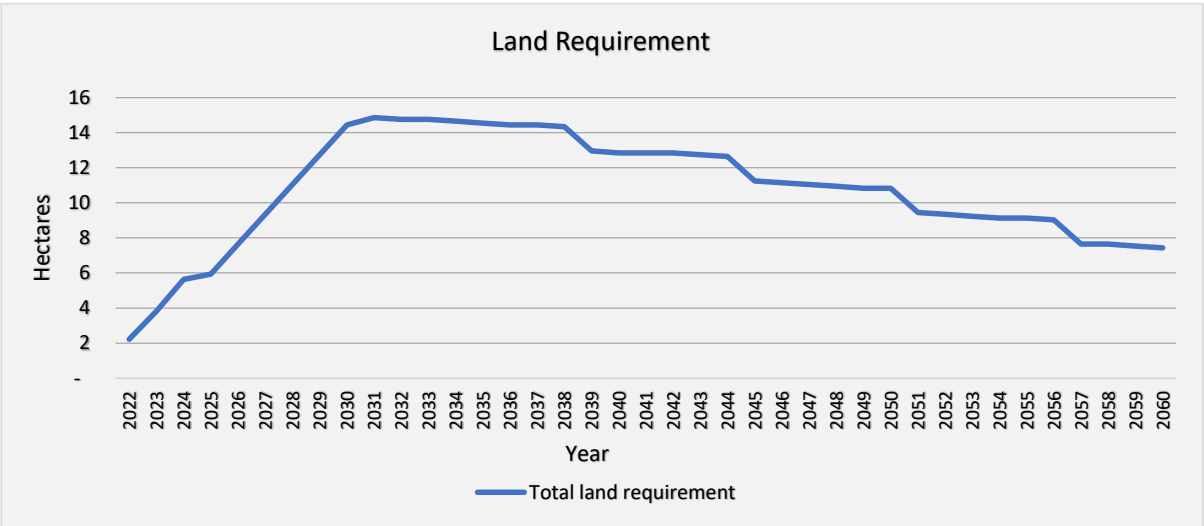

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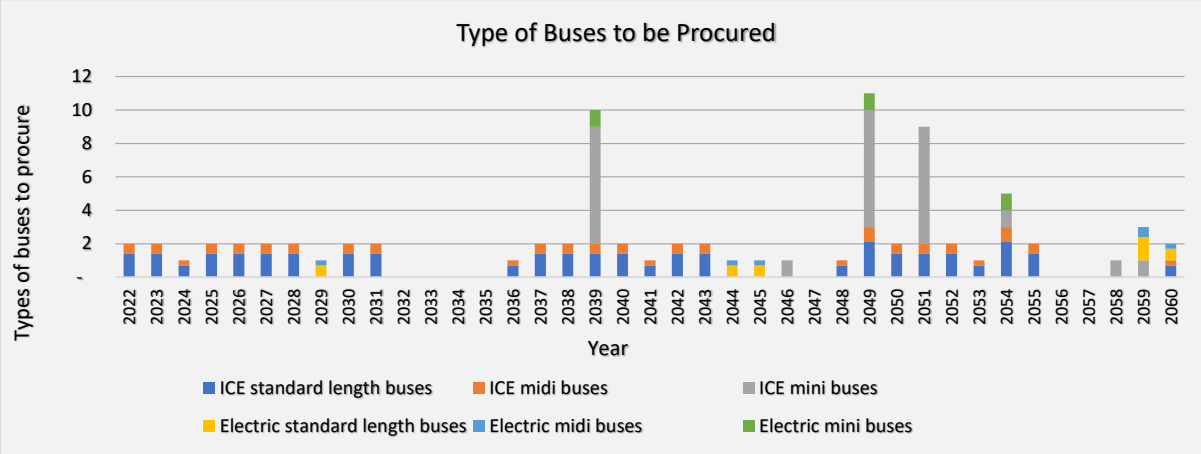

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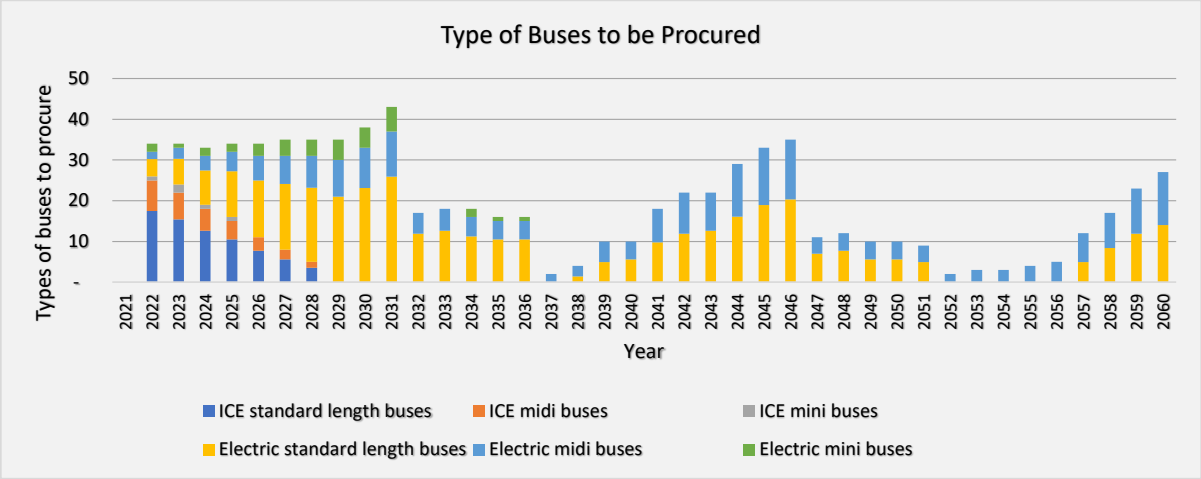

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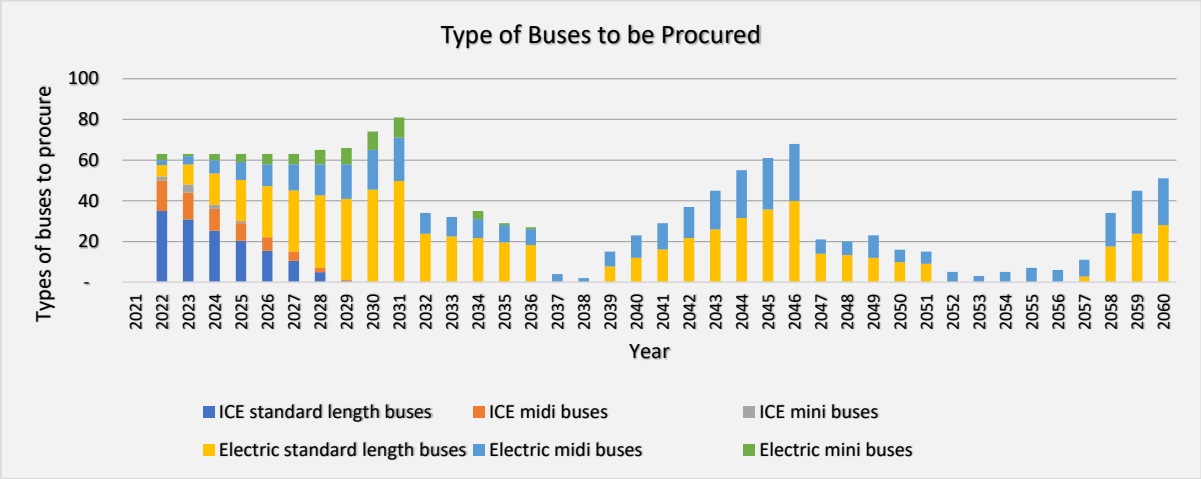
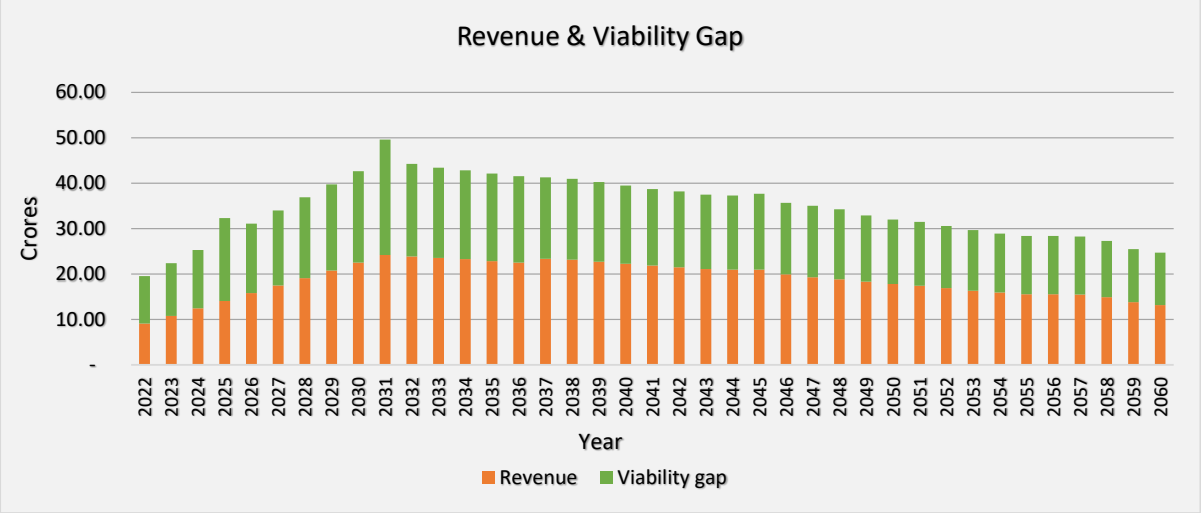


Revenue and Viability Gap: GCC Model

Business as Usual Scenario



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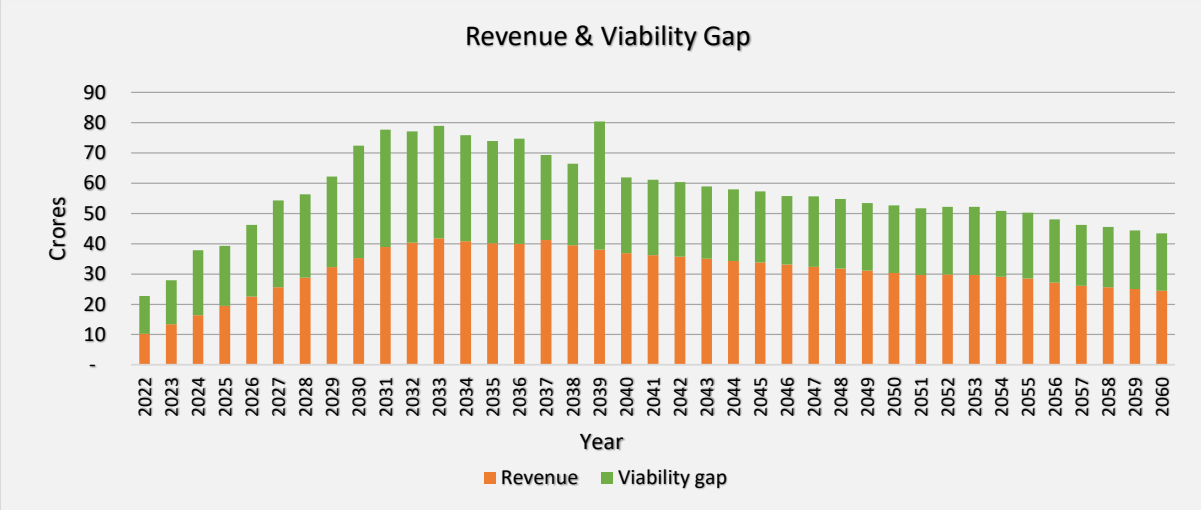
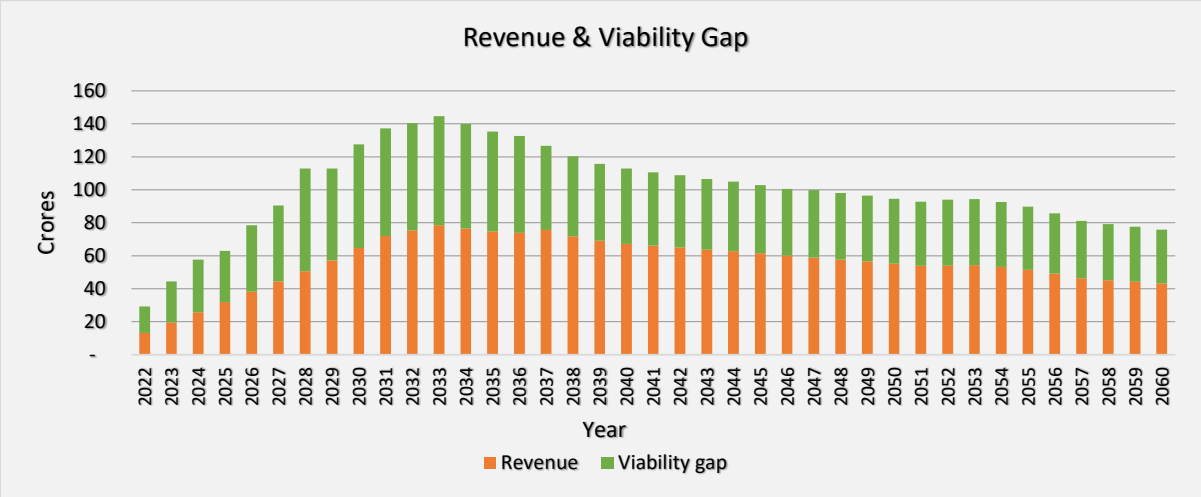
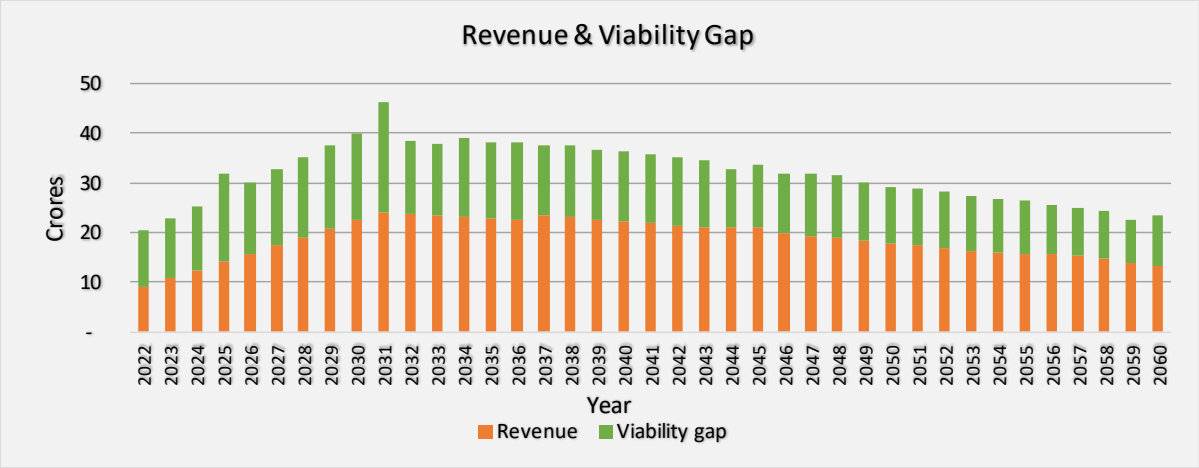


High Ambition Scenario

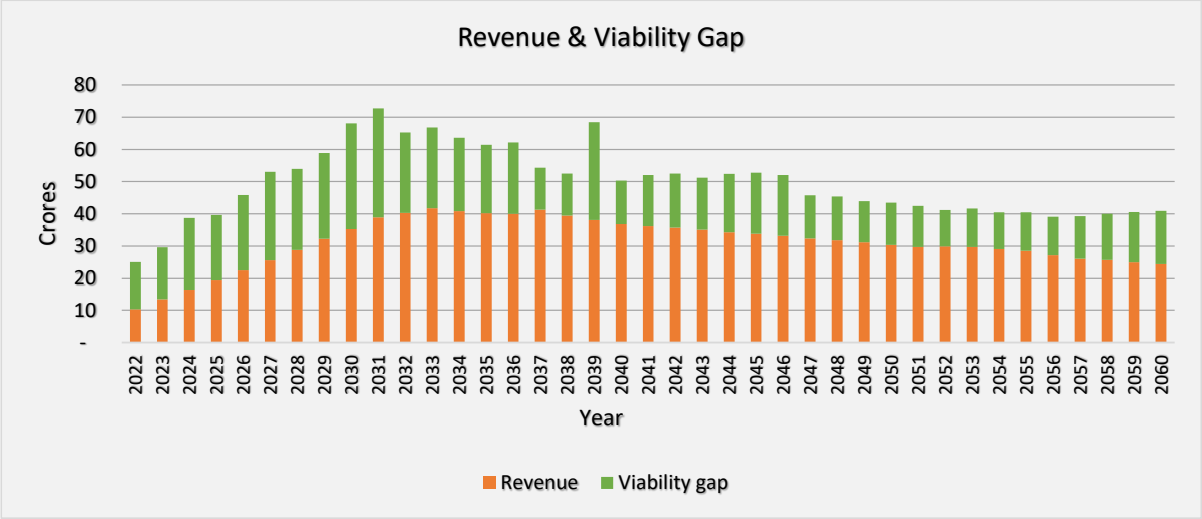


Revenue and Viability Gap: Outright Purchase Model

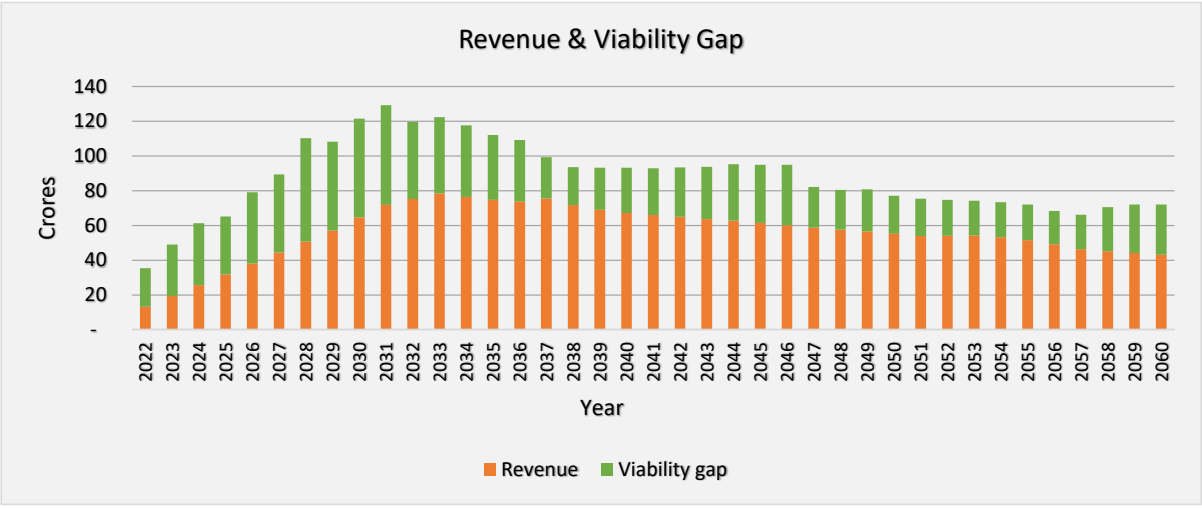
Business as usual Scenario



Low Ambition Scenario

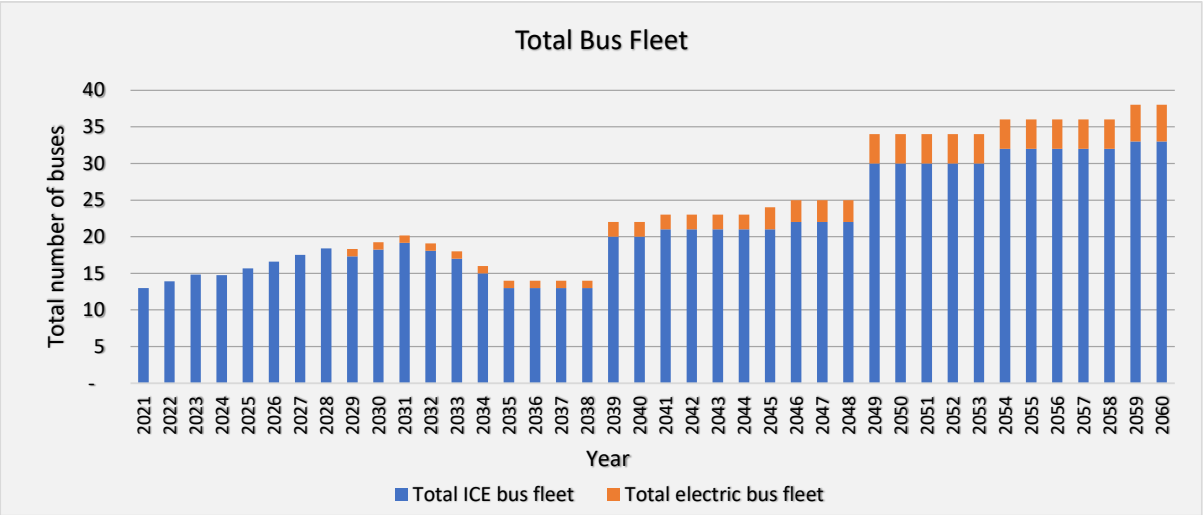


High Ambition Scenario

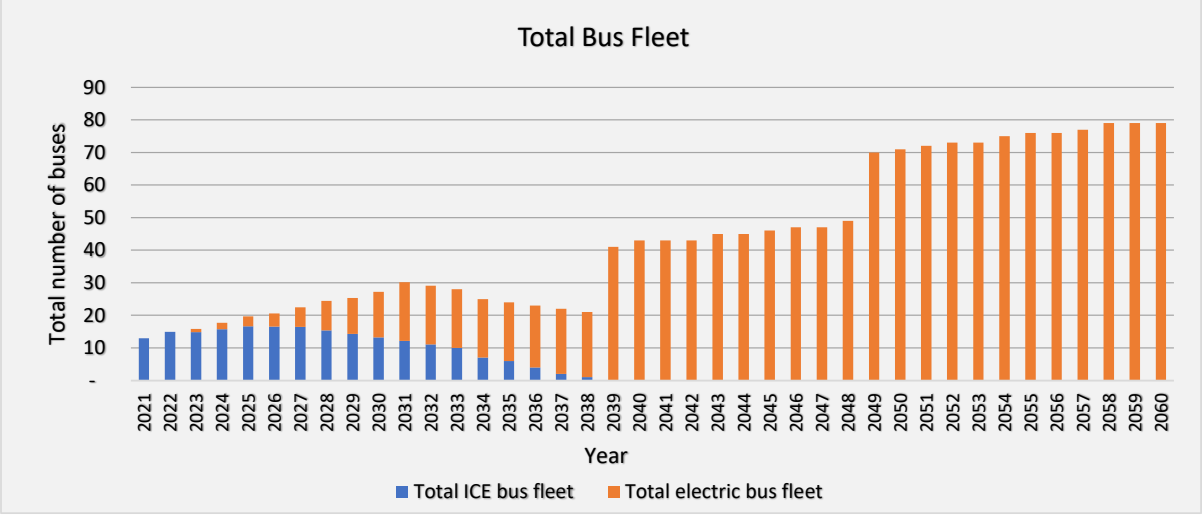


9. State / UT: Daman and Diu

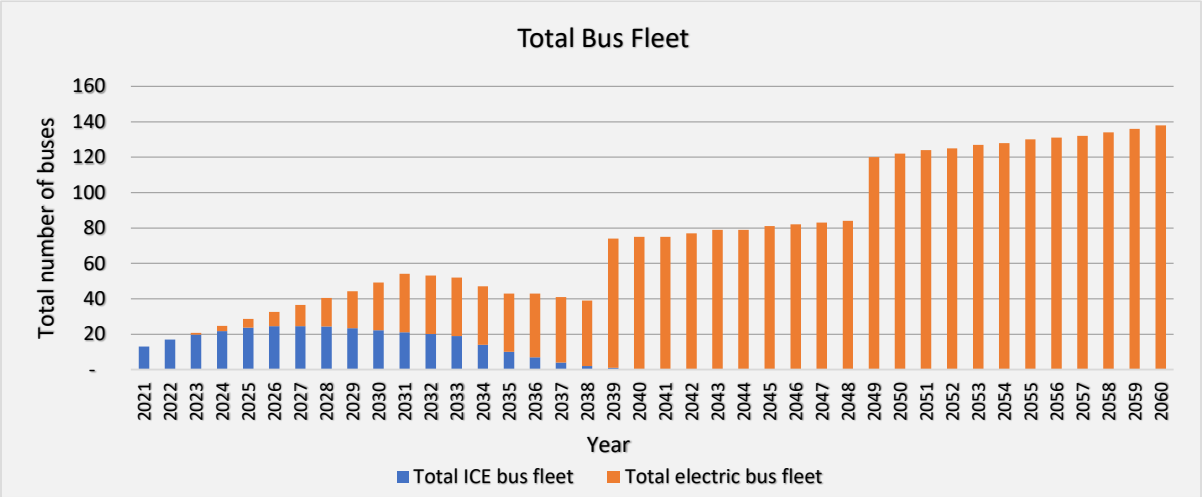
Business as usual Scenario



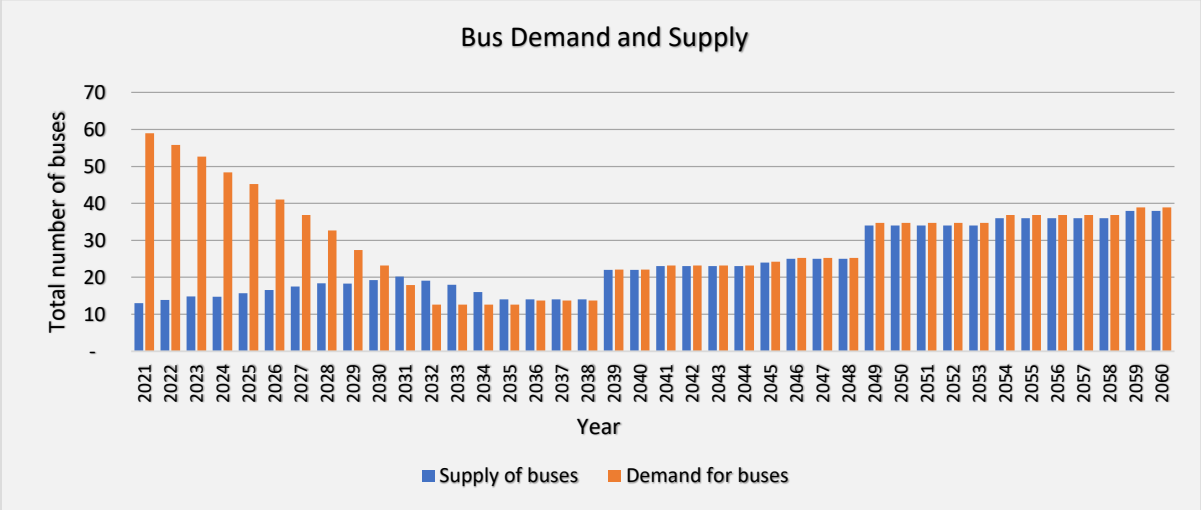
Low Ambition Scenario



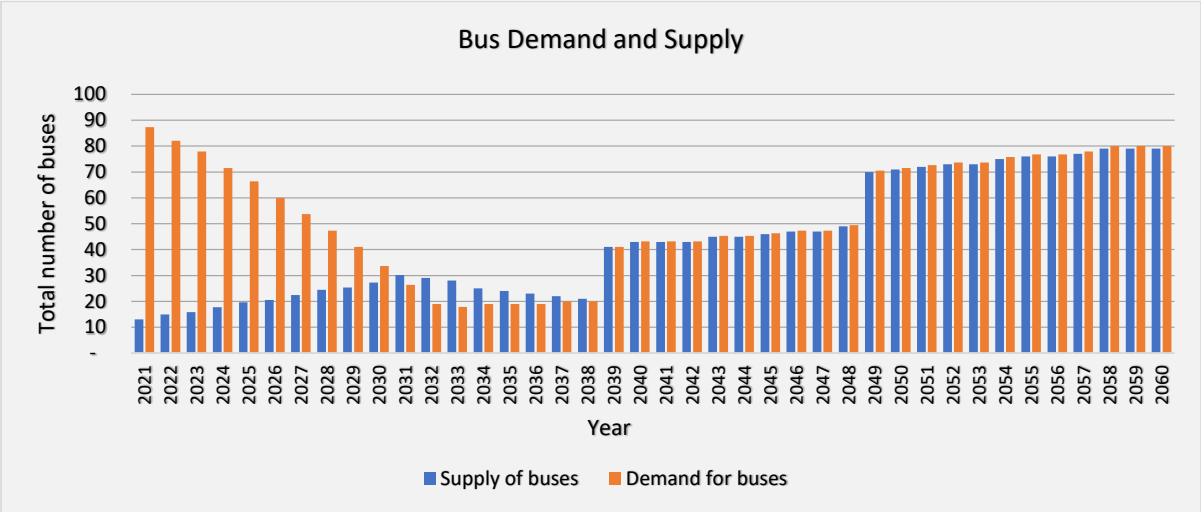
High Ambition Scenario



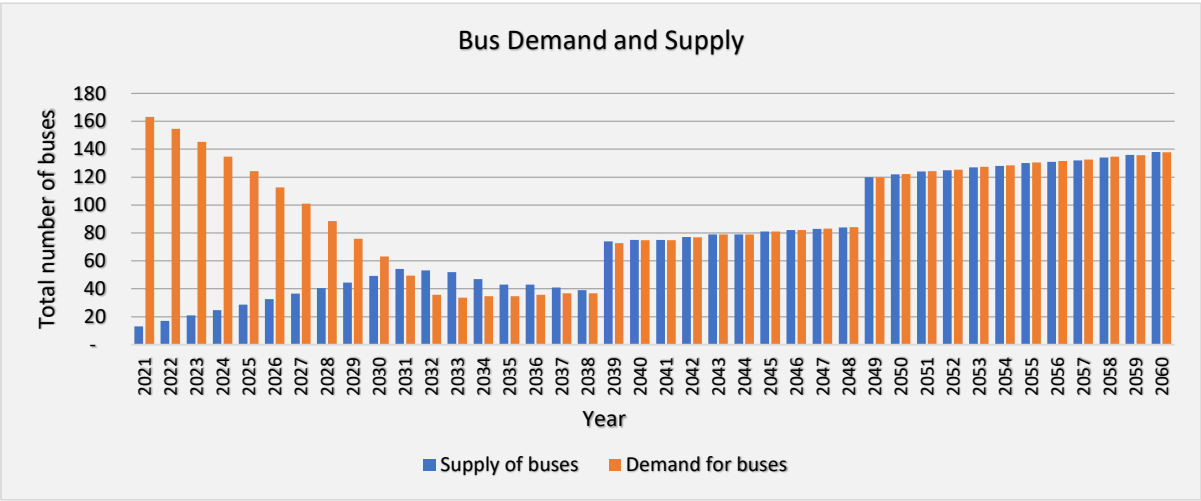
Business as Usual Scenario



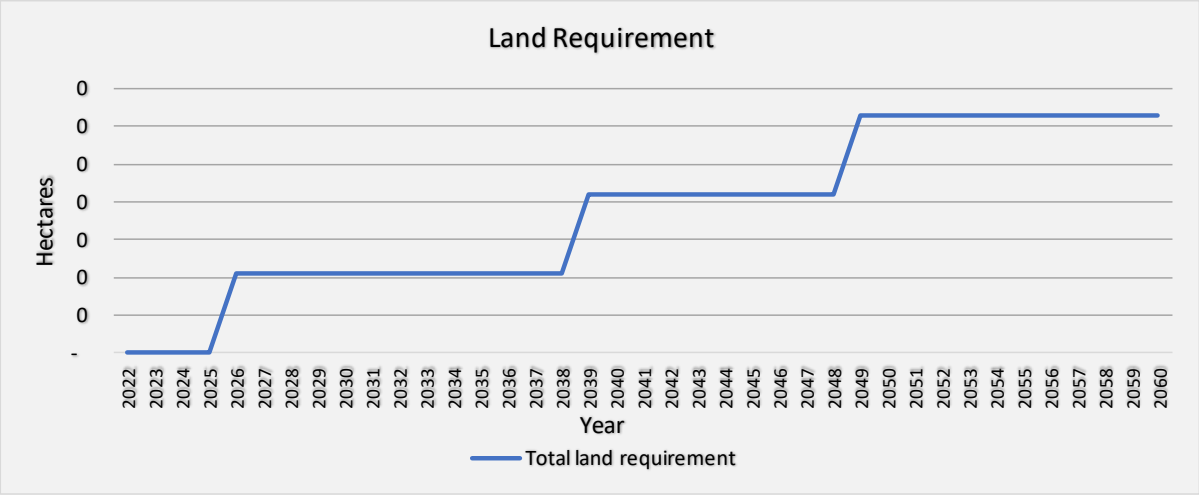
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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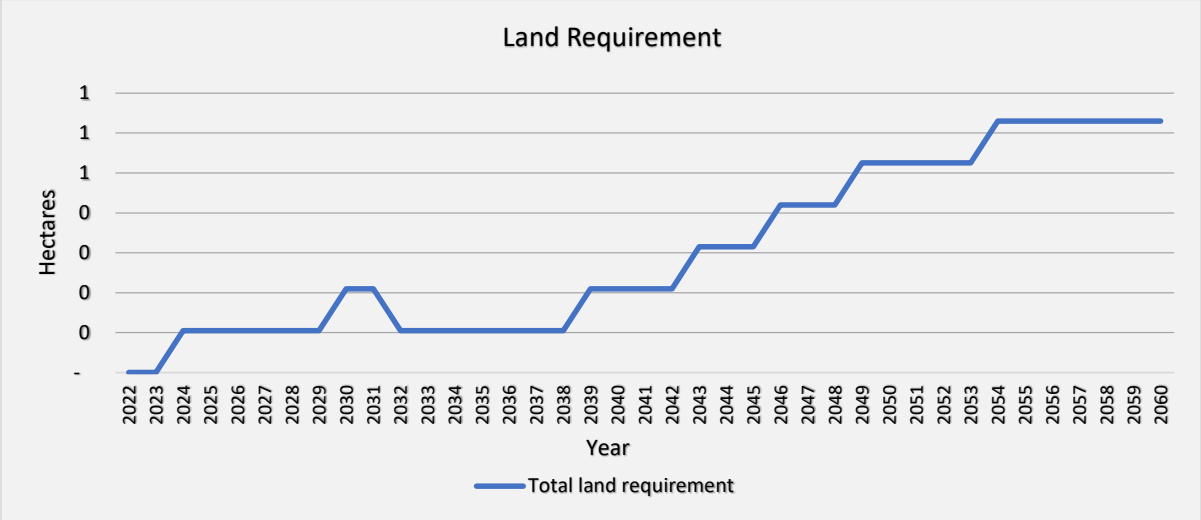
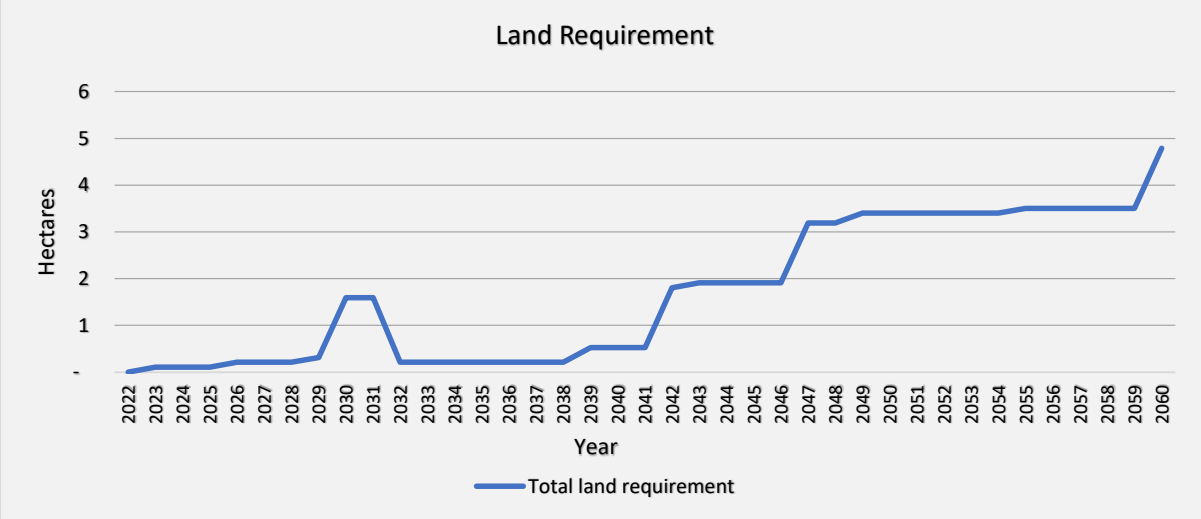
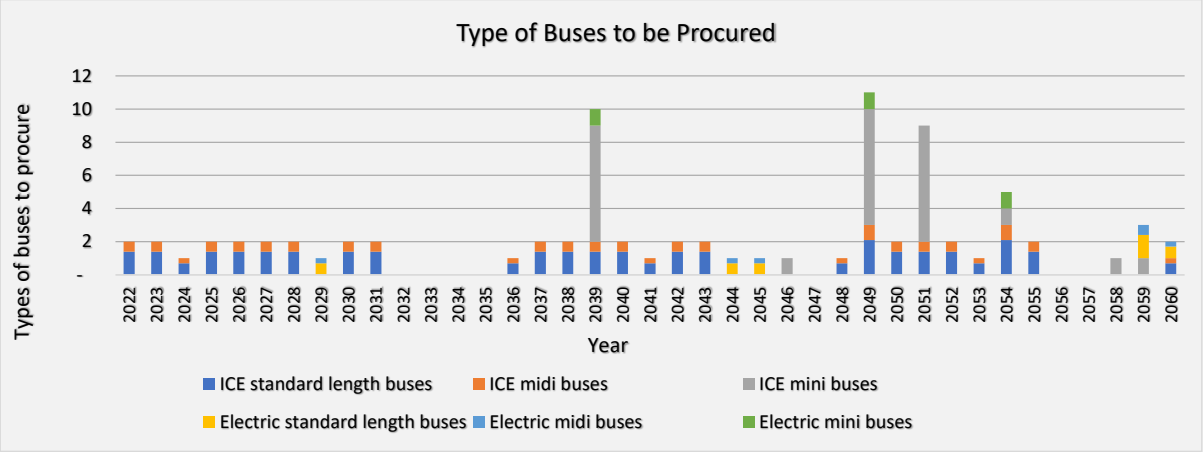


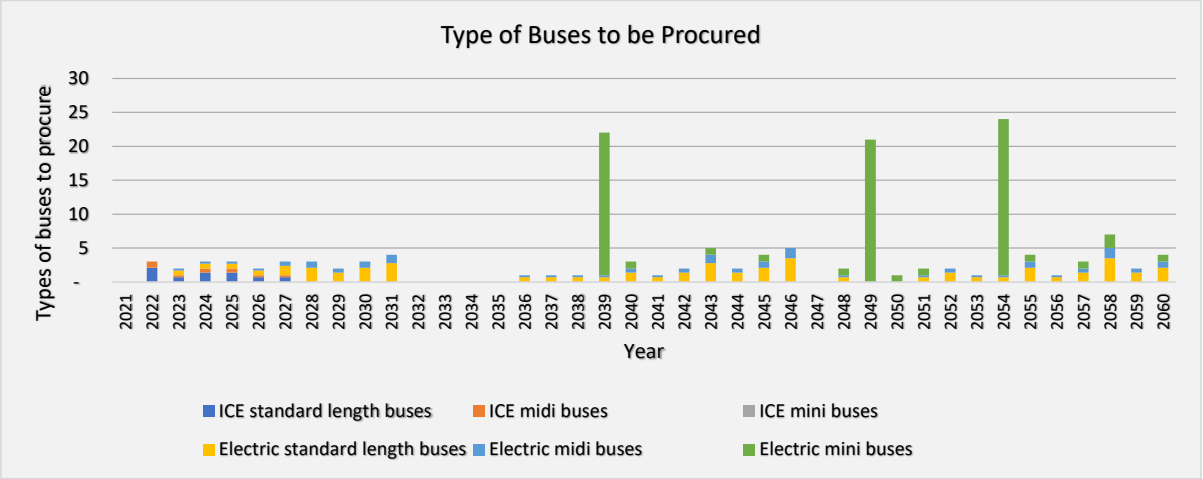
High Ambition Scenario



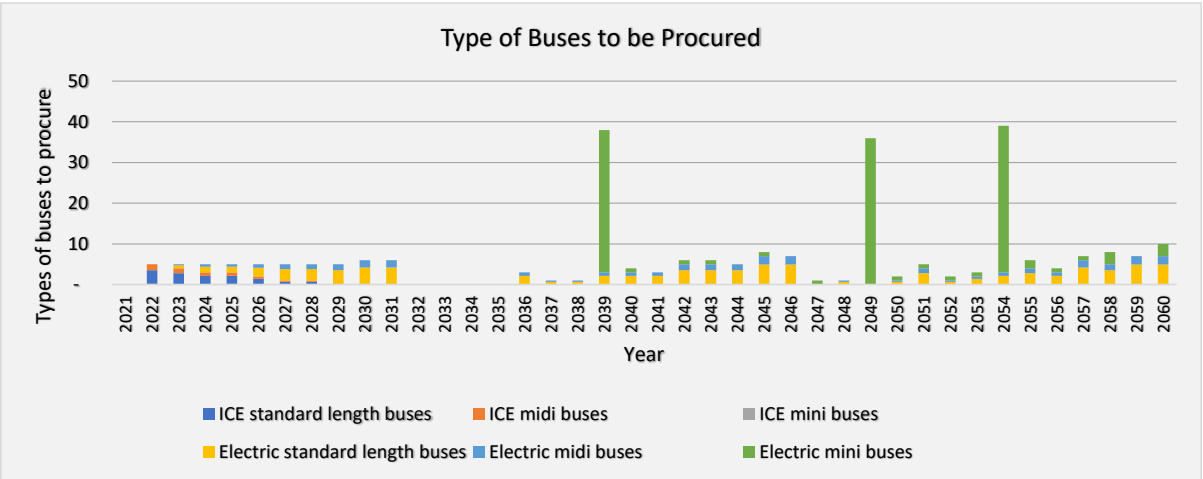
Business as Usual Scenario



Low Ambition Scenario

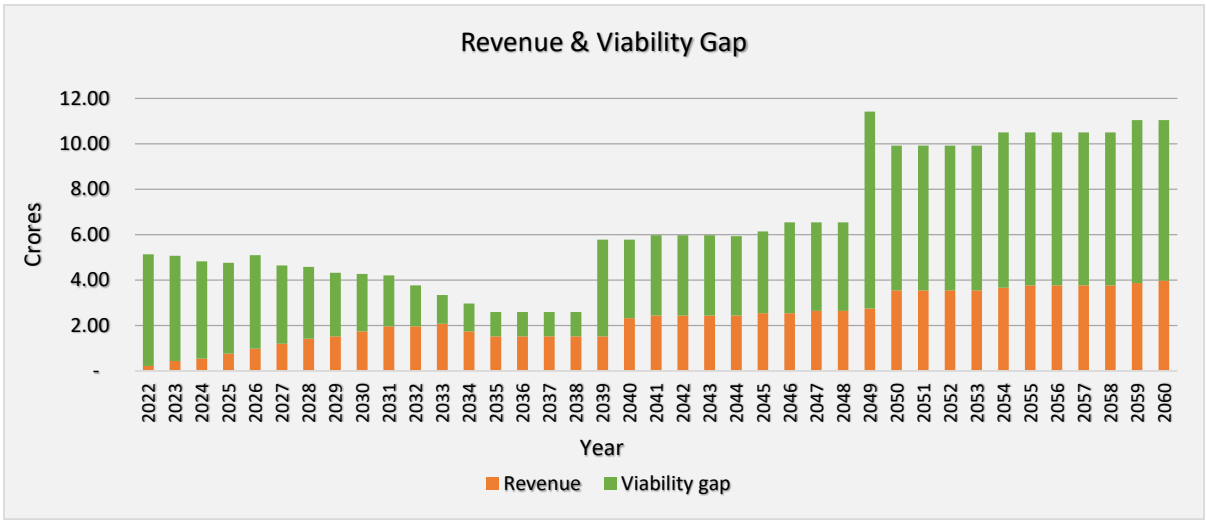


High Ambition Scenario

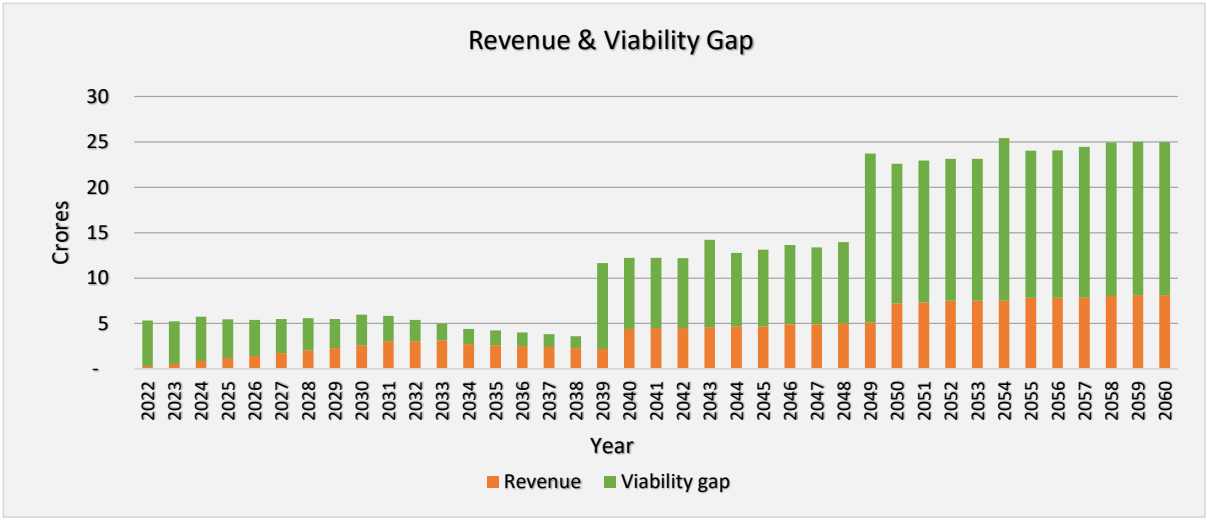


Revenue and Viability Gap: GCC Model

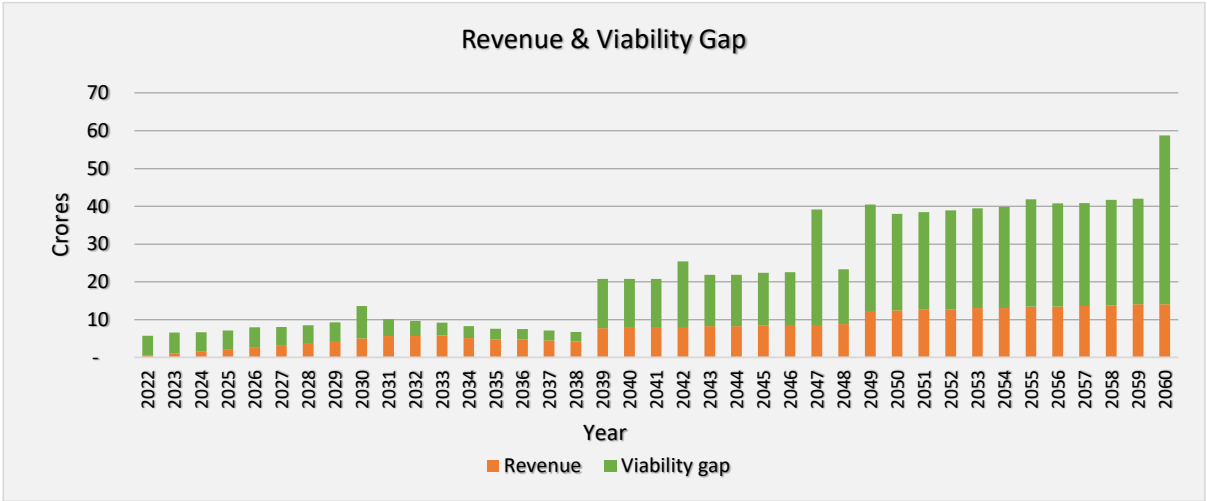
Business as Usual Scenario



Low Ambition Scenario

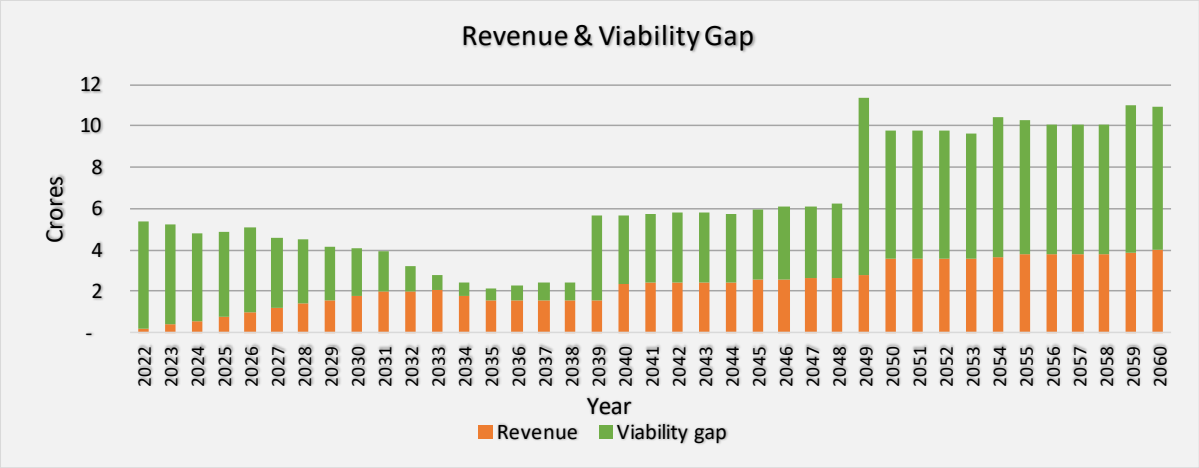


High Ambition Scenario

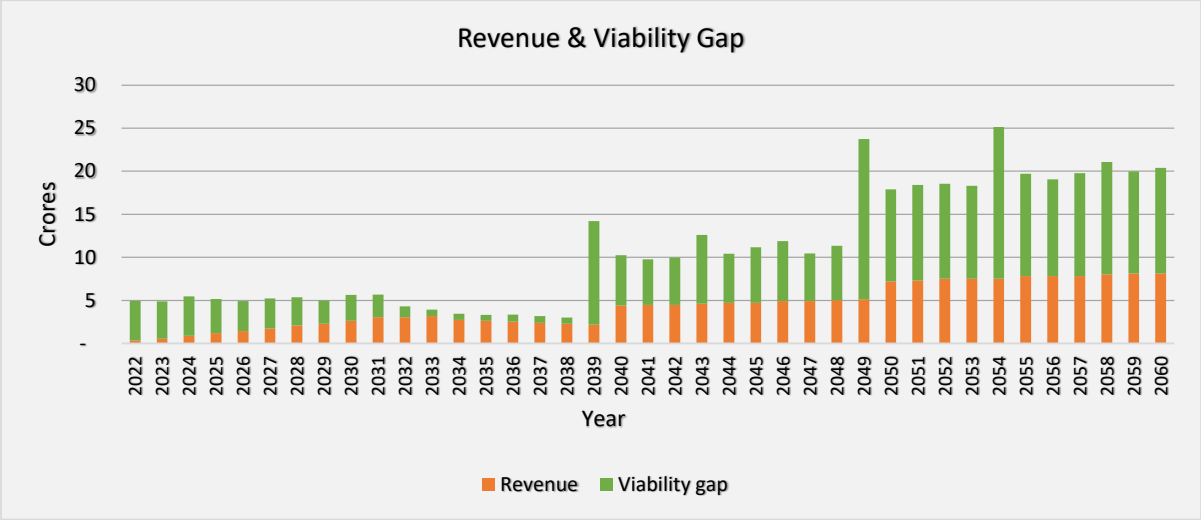


Revenue and Viability Gap: Outright Purchase Model

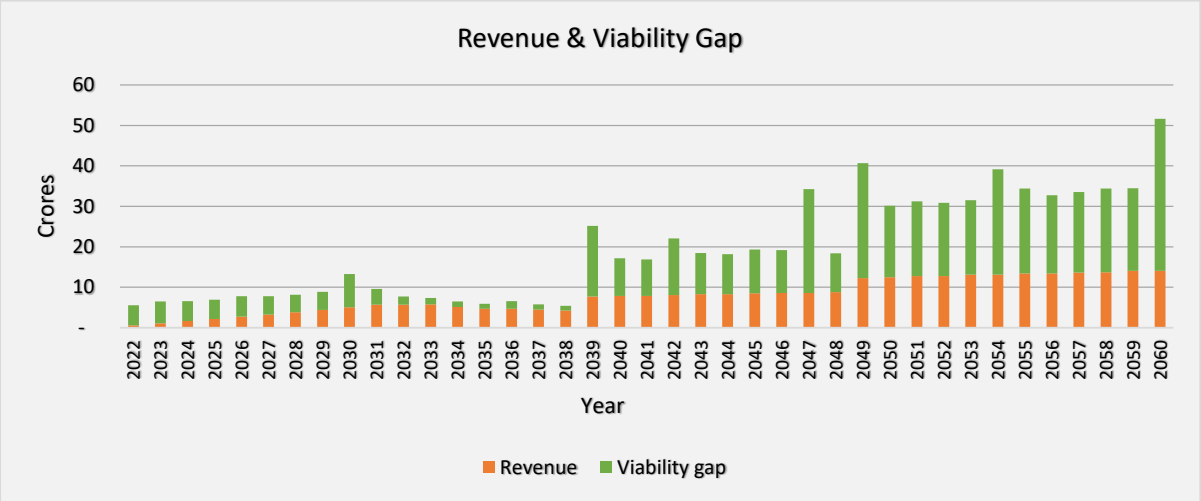
Business as usual Scenario



Low Ambition Scenario

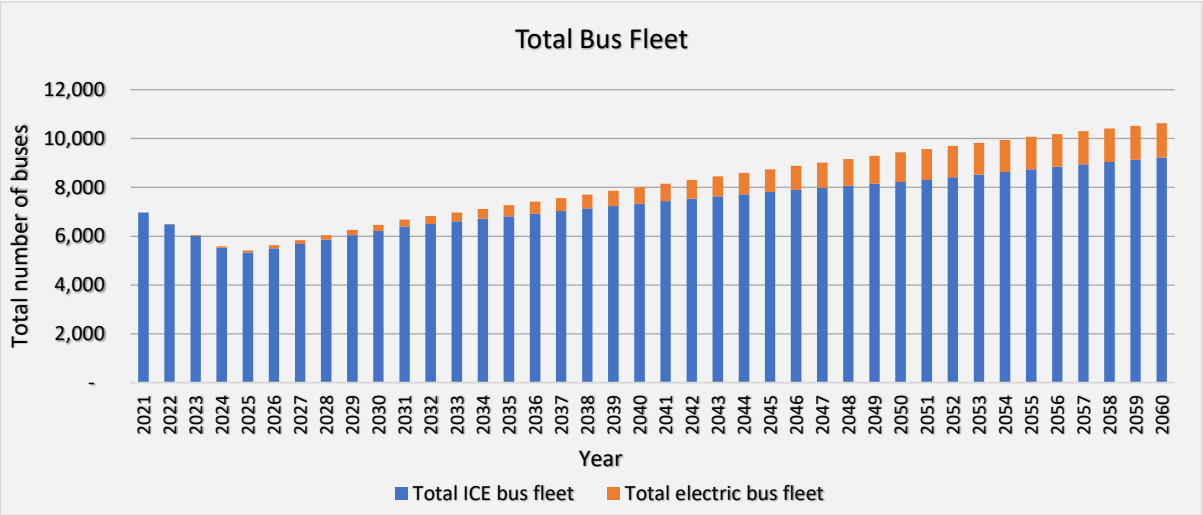


High Ambition Scenario

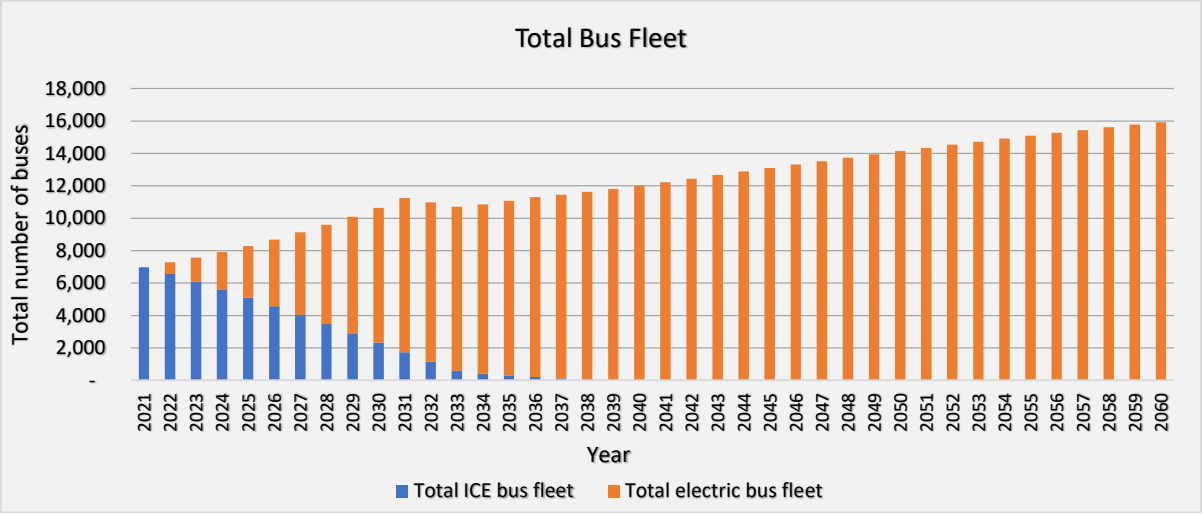


10. State / UT: Delhi

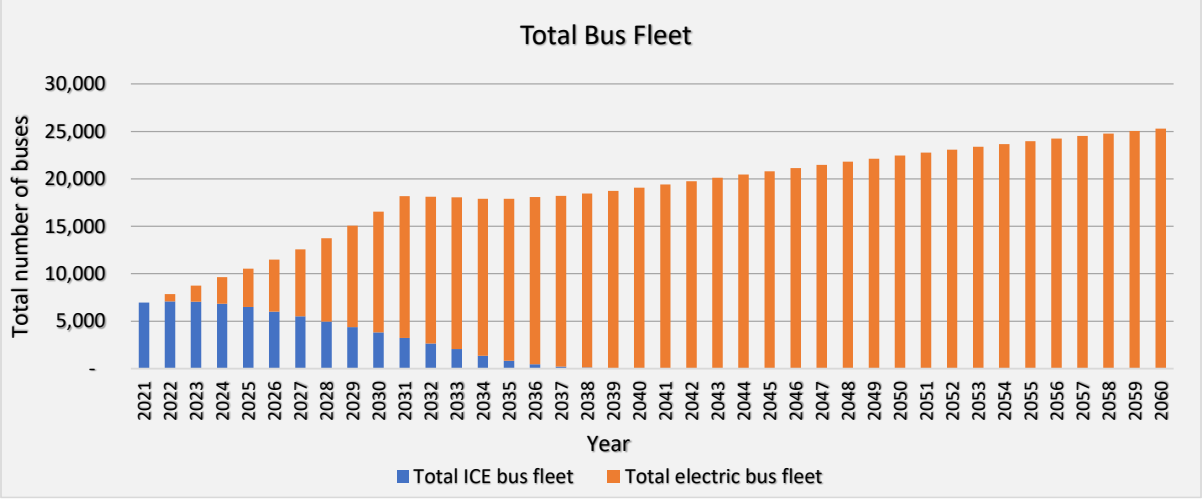
Business as usual Scenario



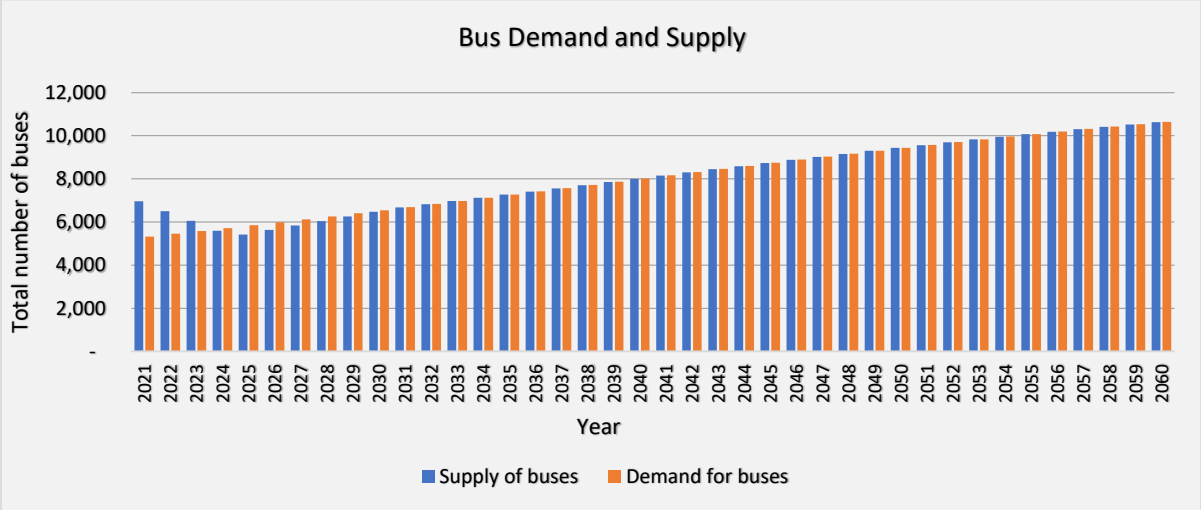
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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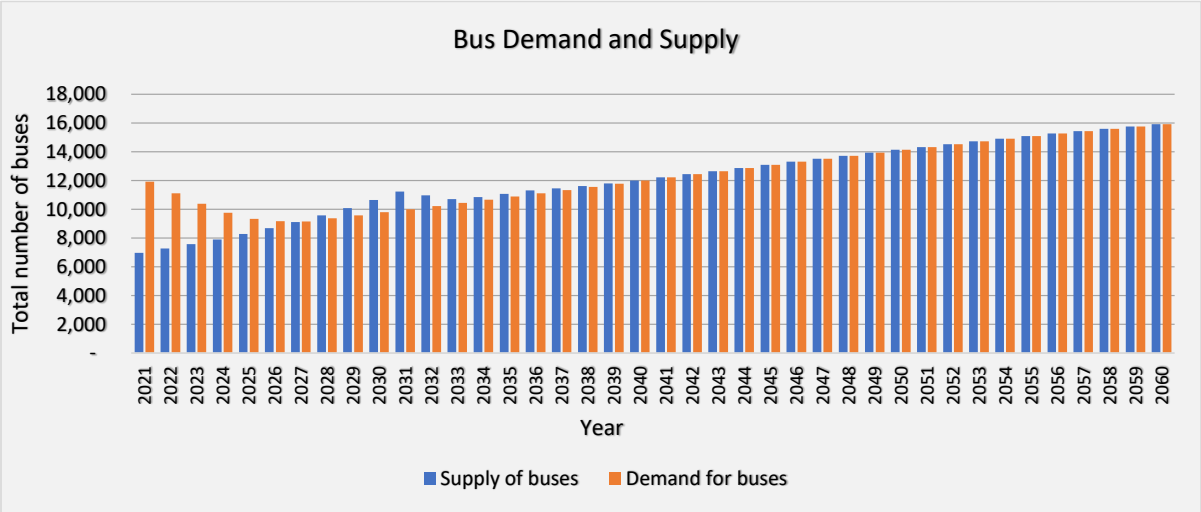

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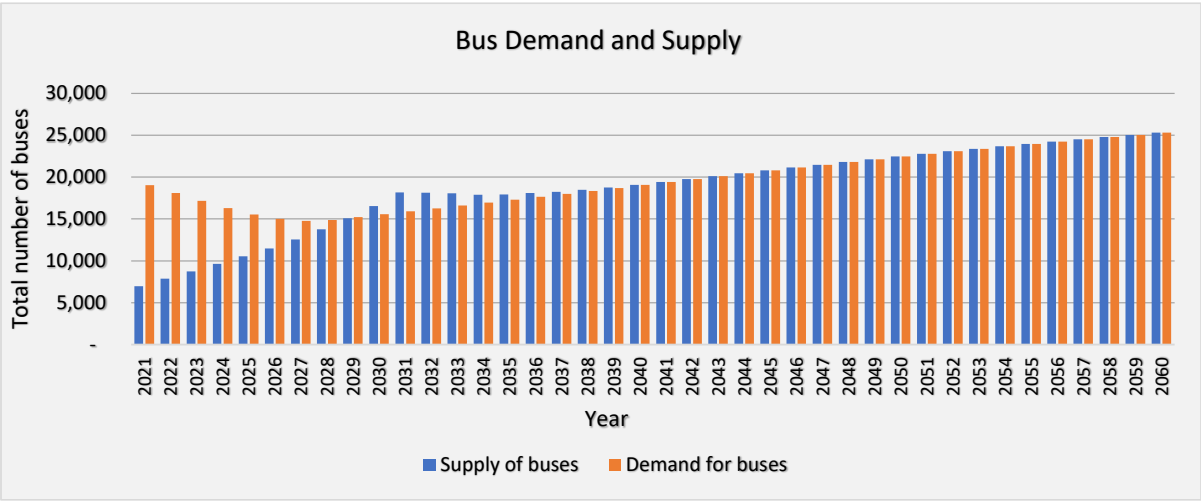
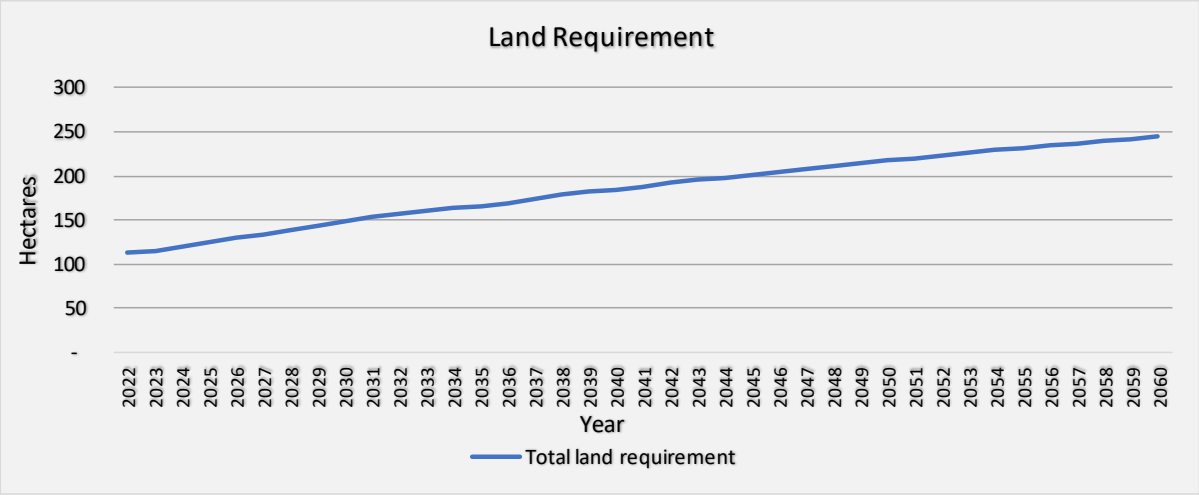


Business as Usual Scenario



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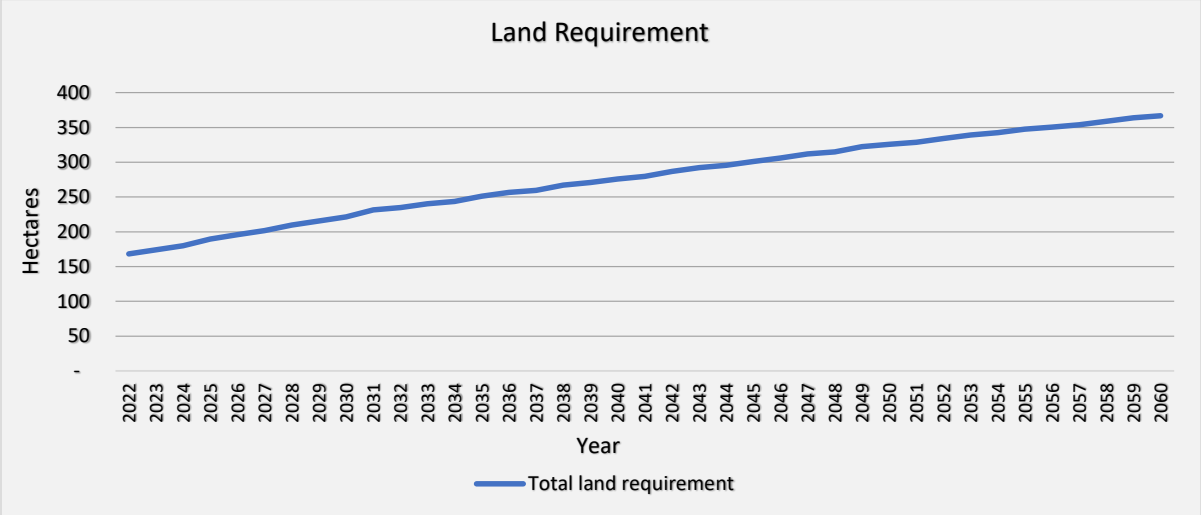

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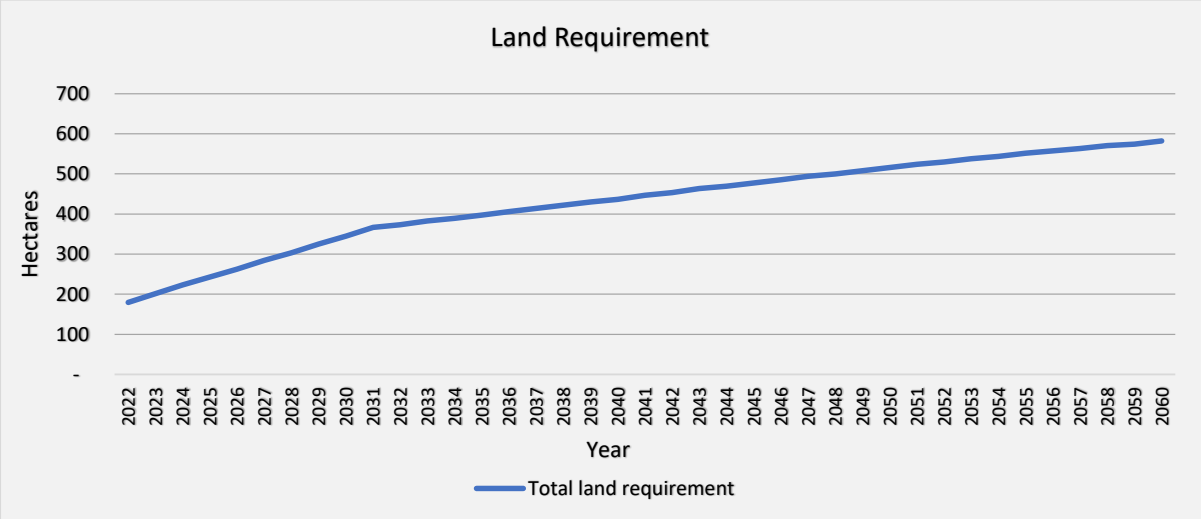
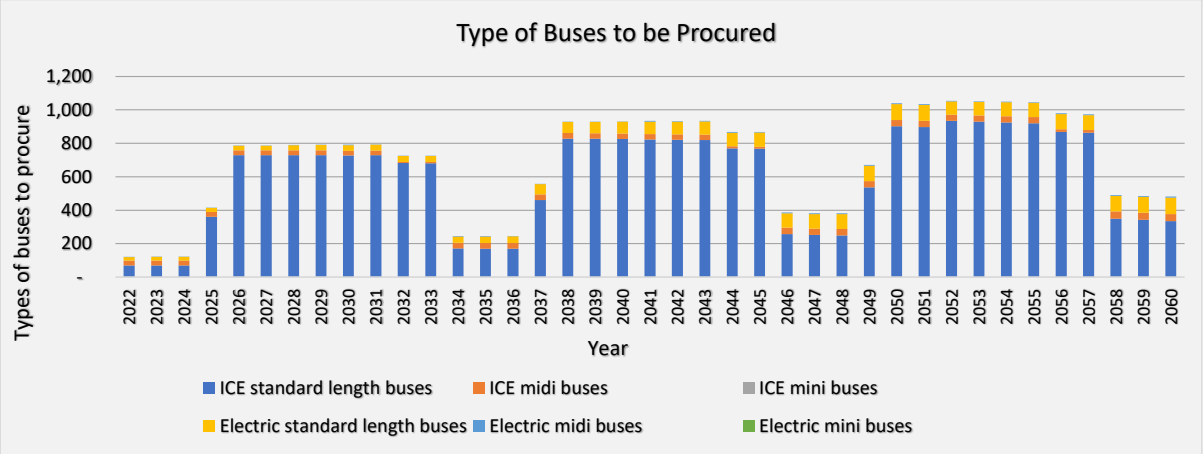


Business as Usual Scenario



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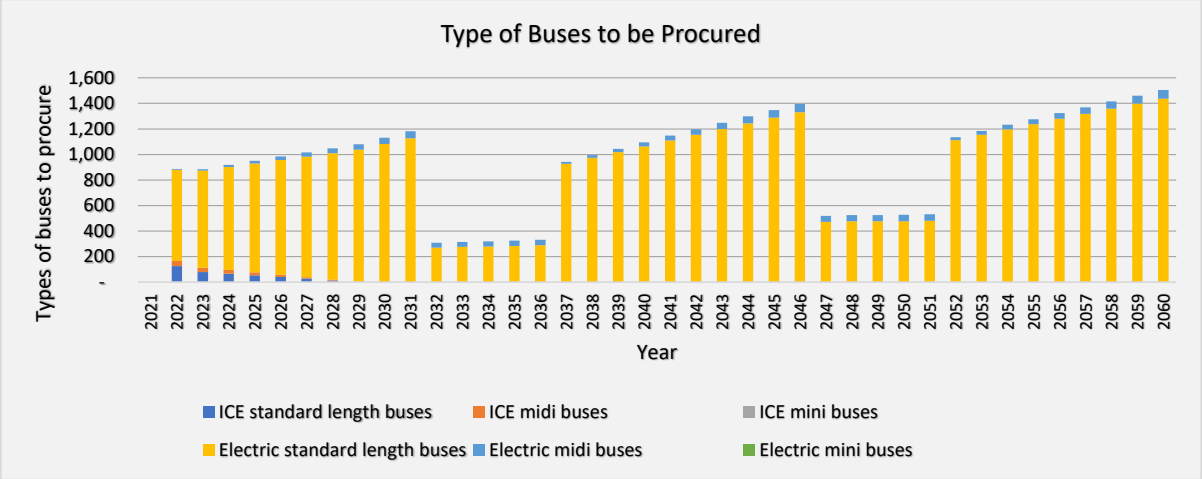
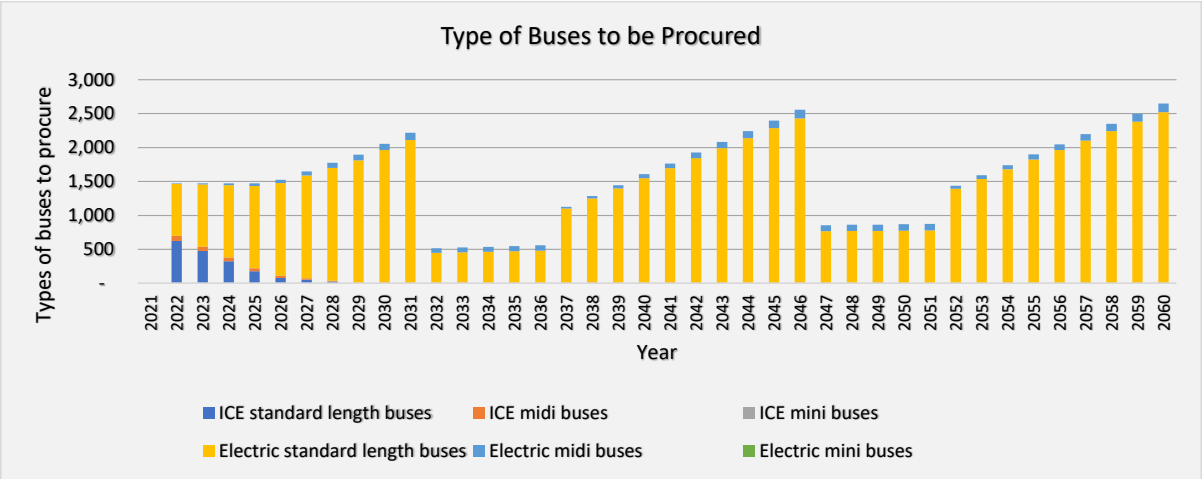
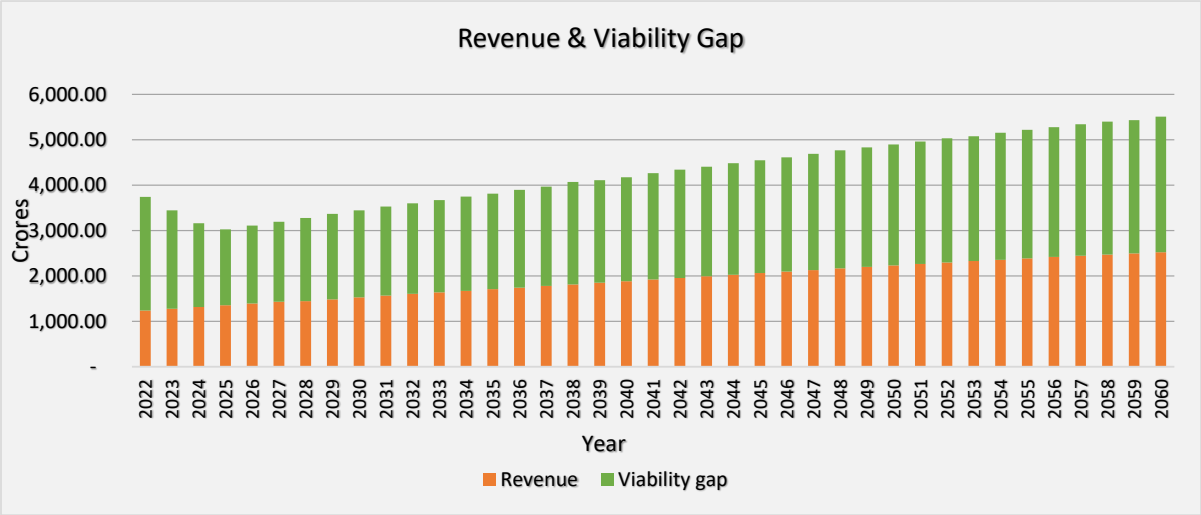


High Ambition Scenario



Revenue and Viability Gap: GCC Model

Business as Usual Scenario



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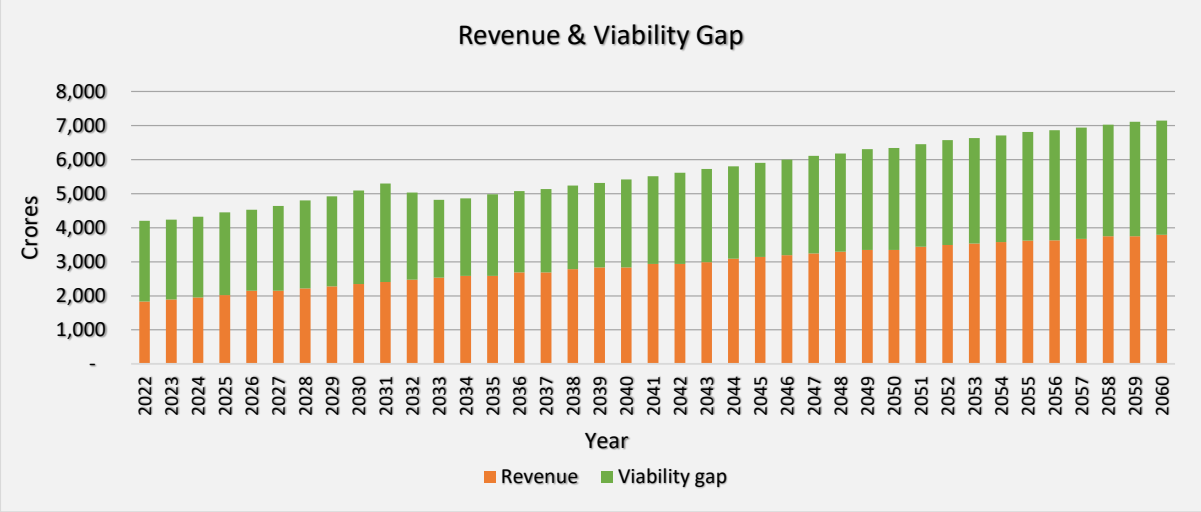
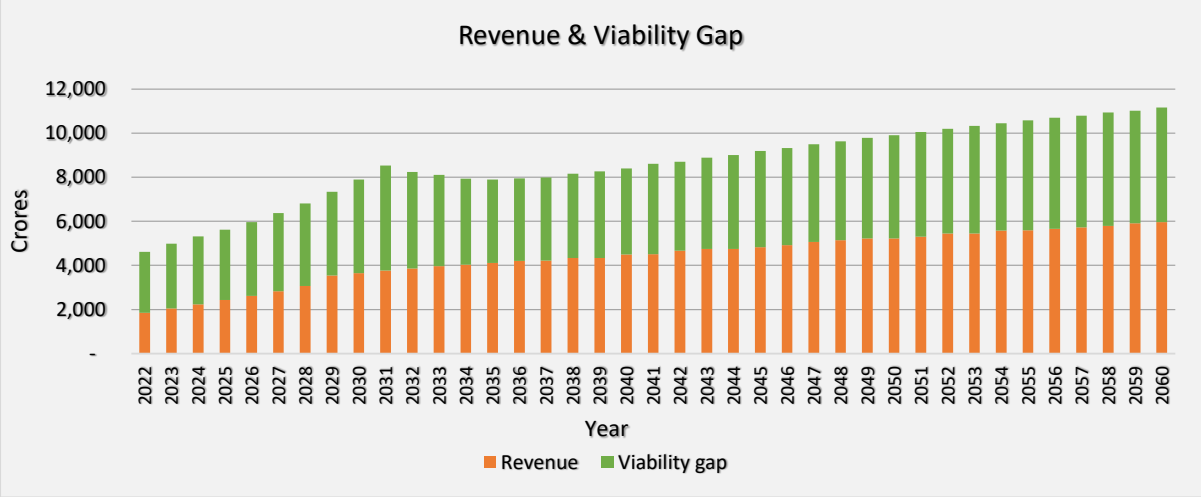
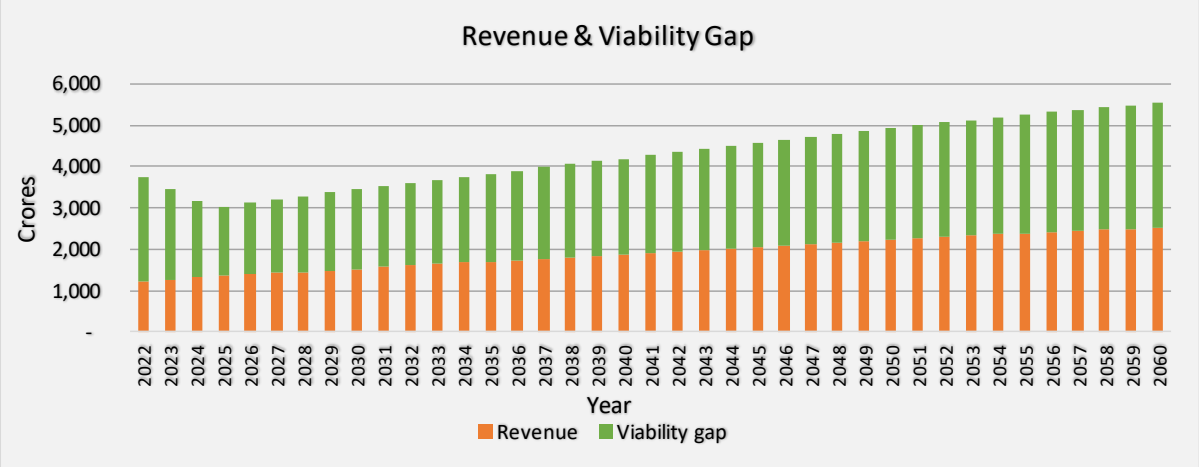


High Ambition Scenario



Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



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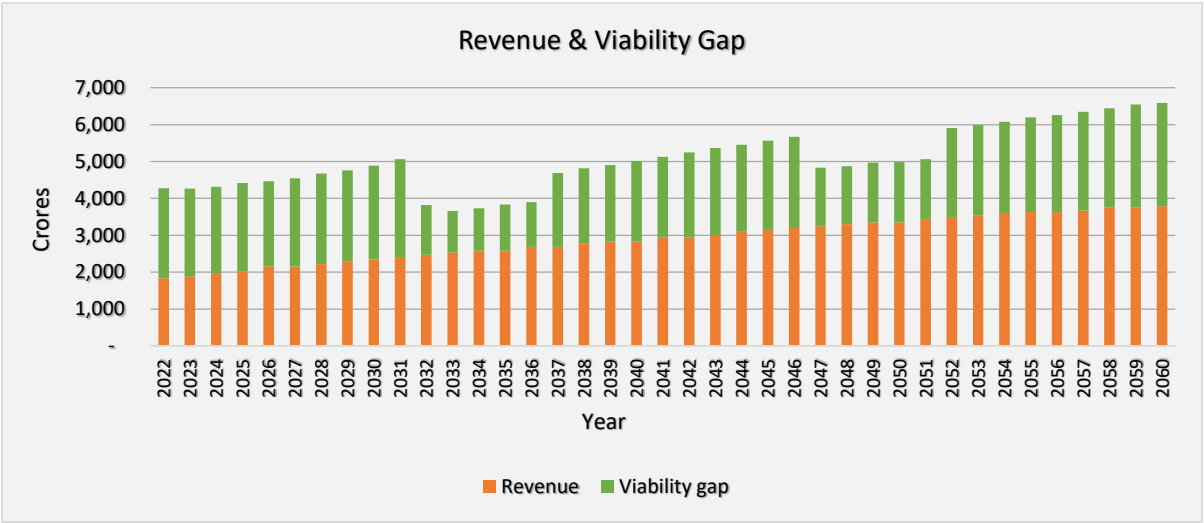
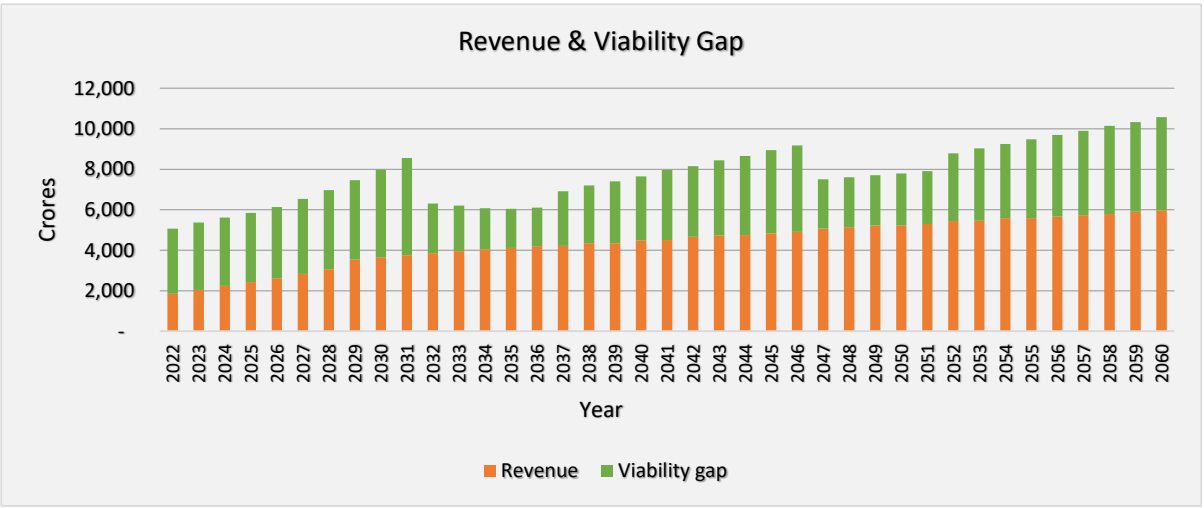
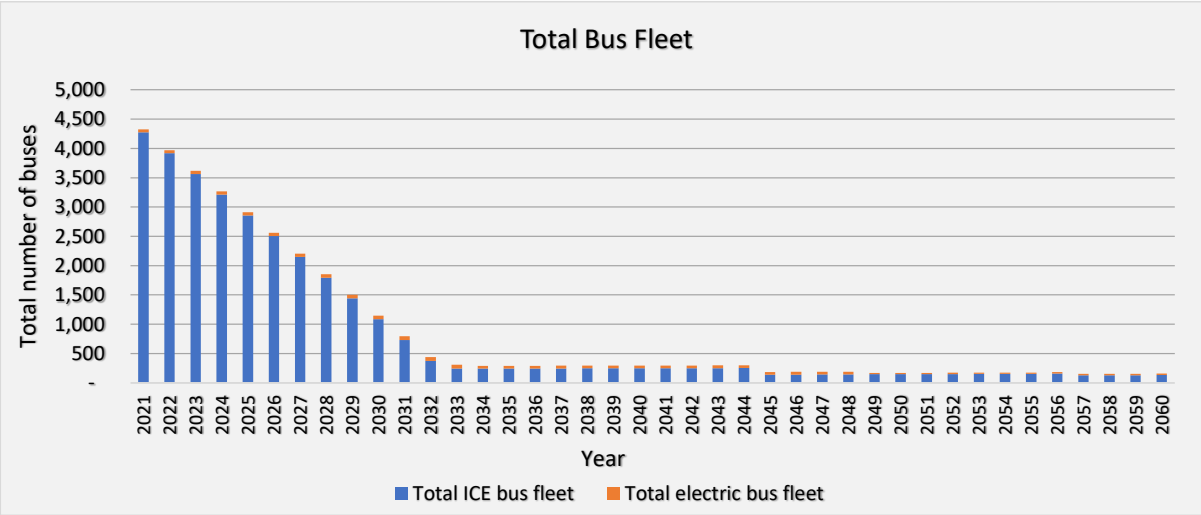


High Ambition Scenario

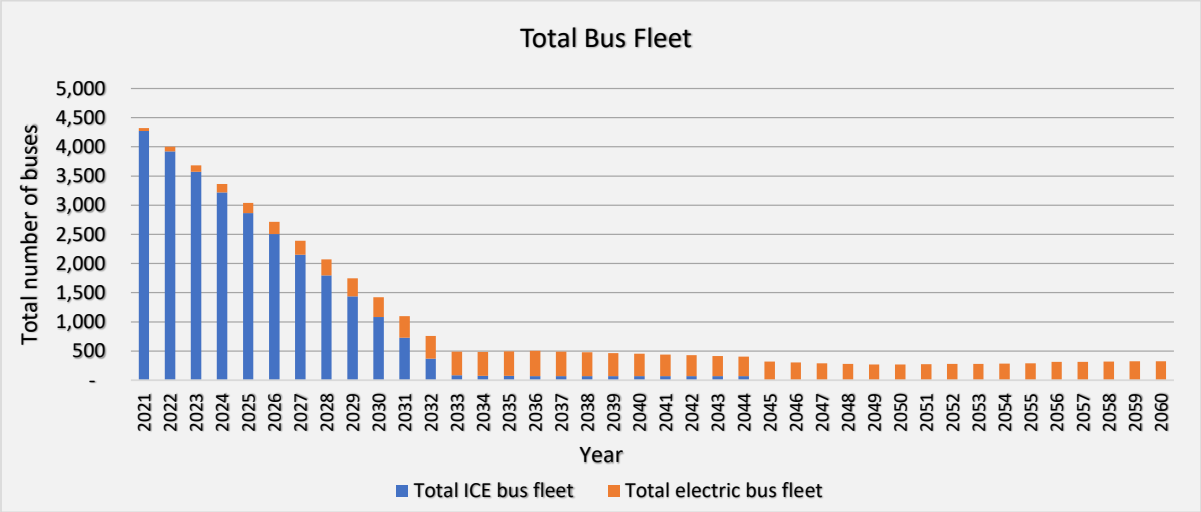


11. State / UT: Goa

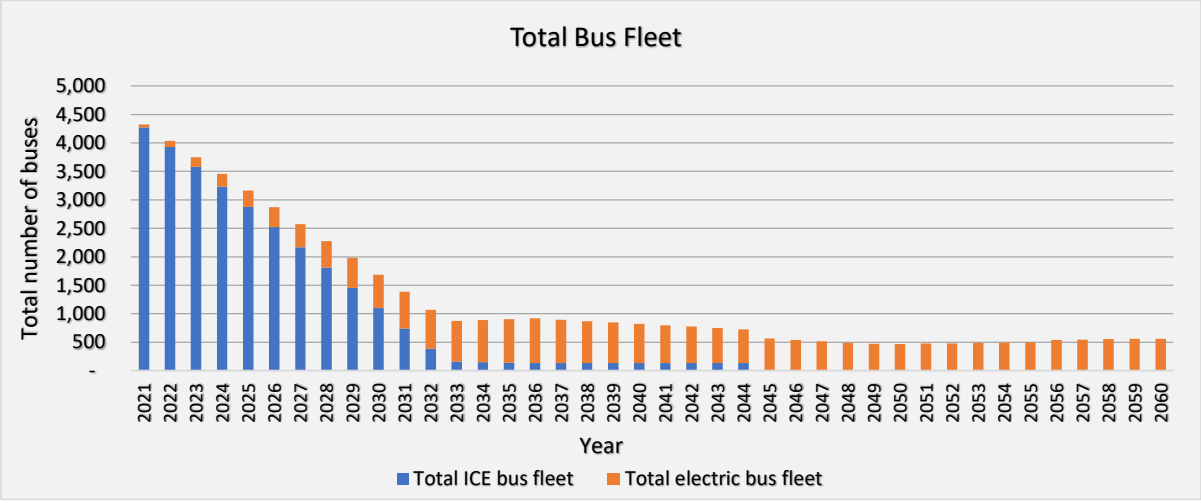
Business as usual Scenario



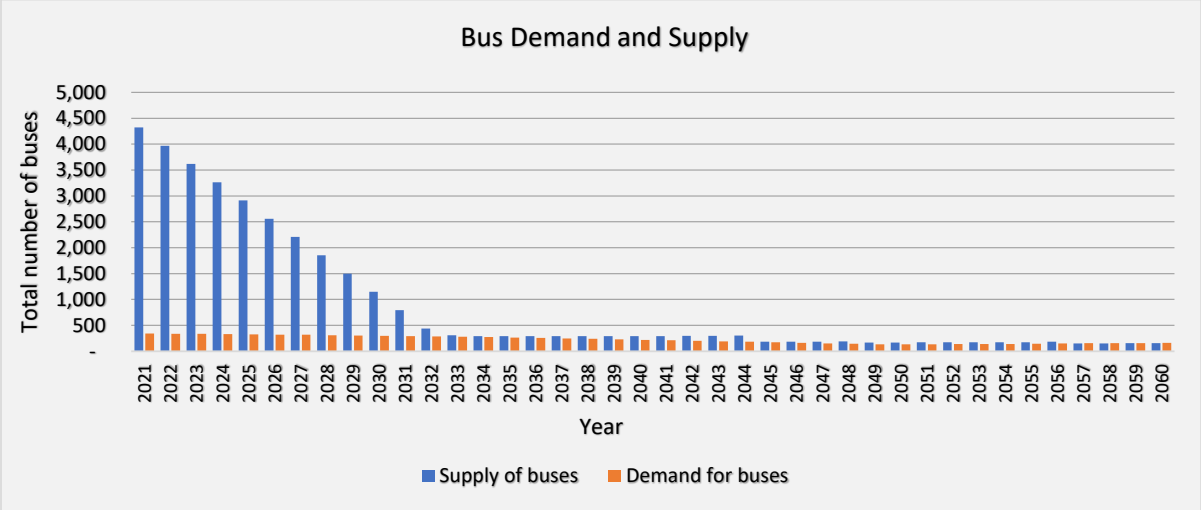
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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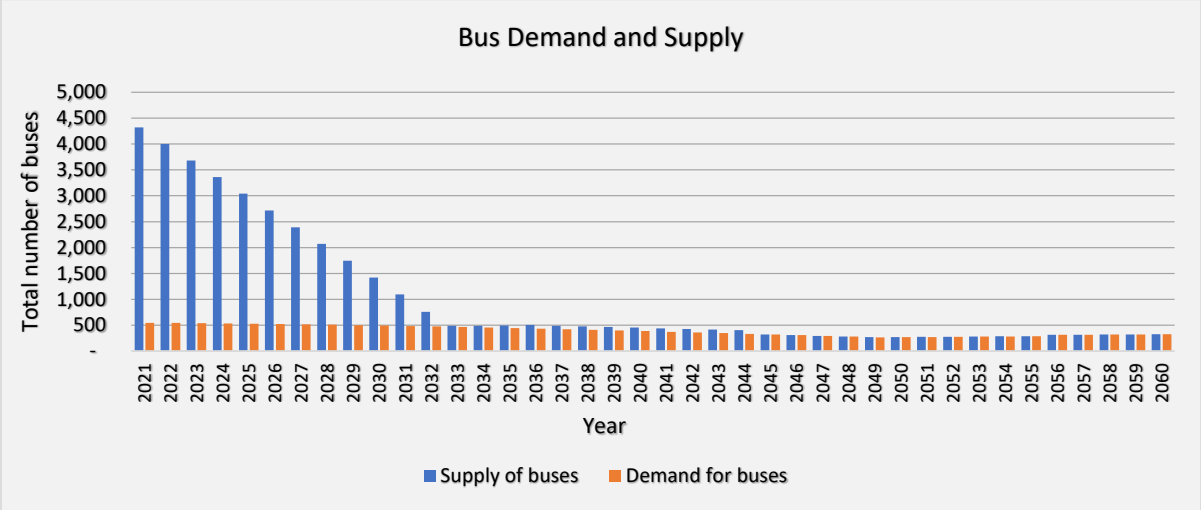
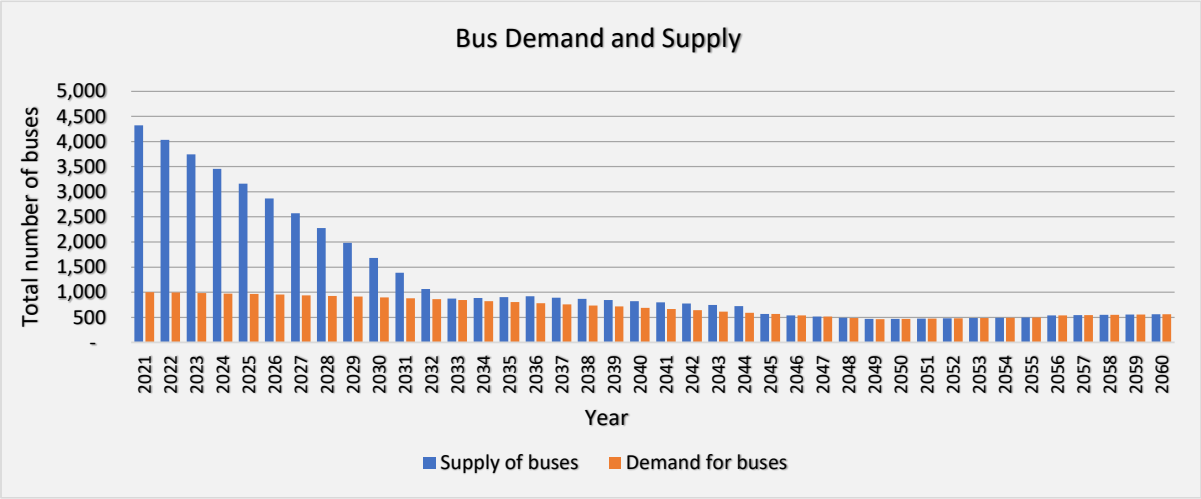
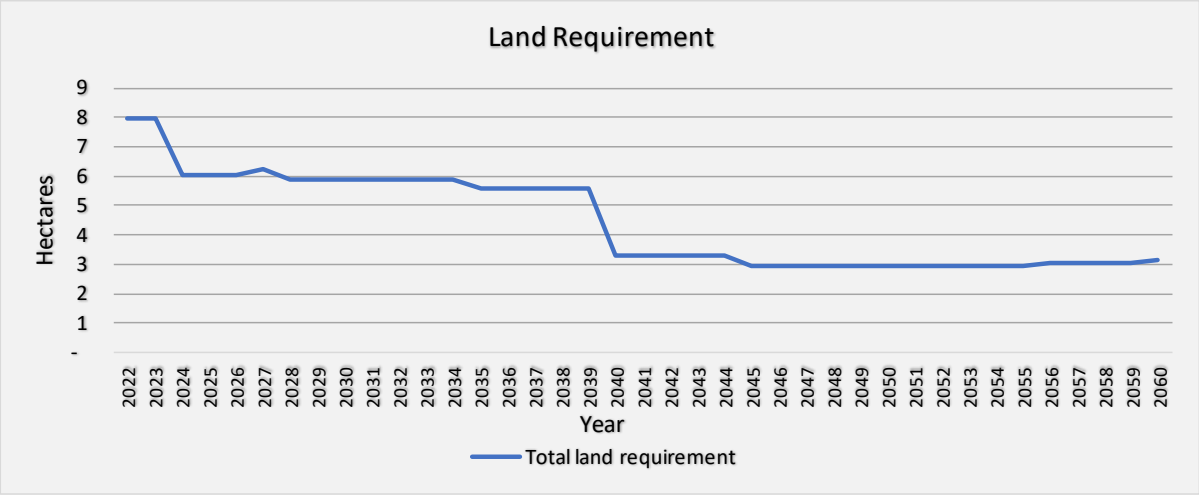


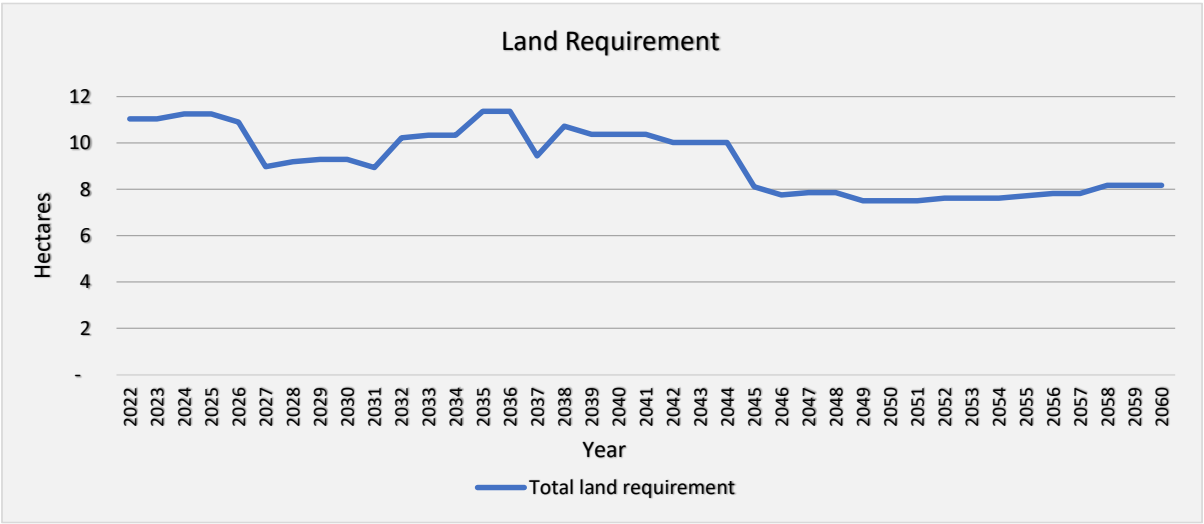
High Ambition Scenario



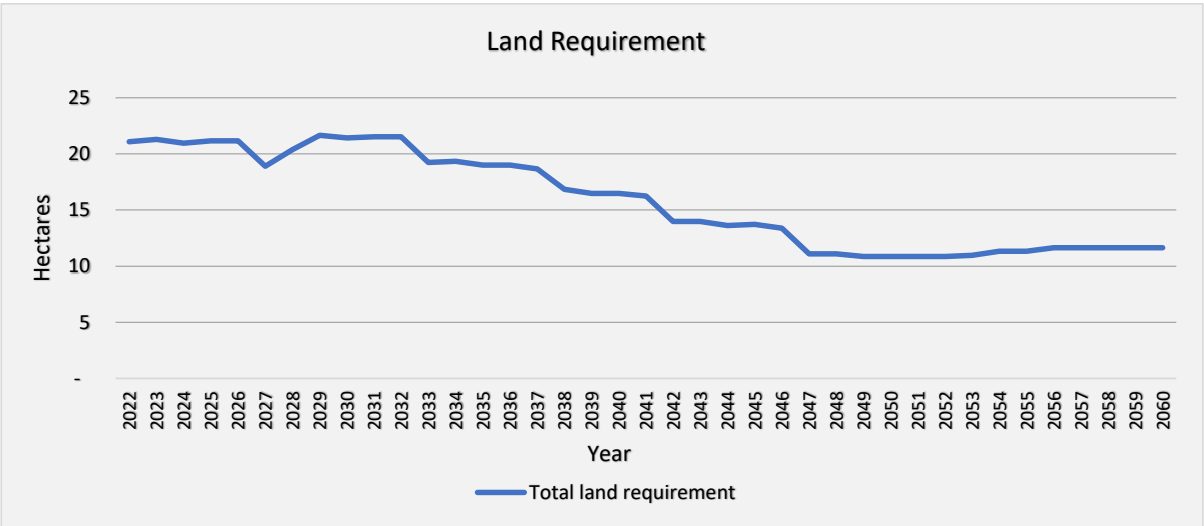
Business as Usual Scenario



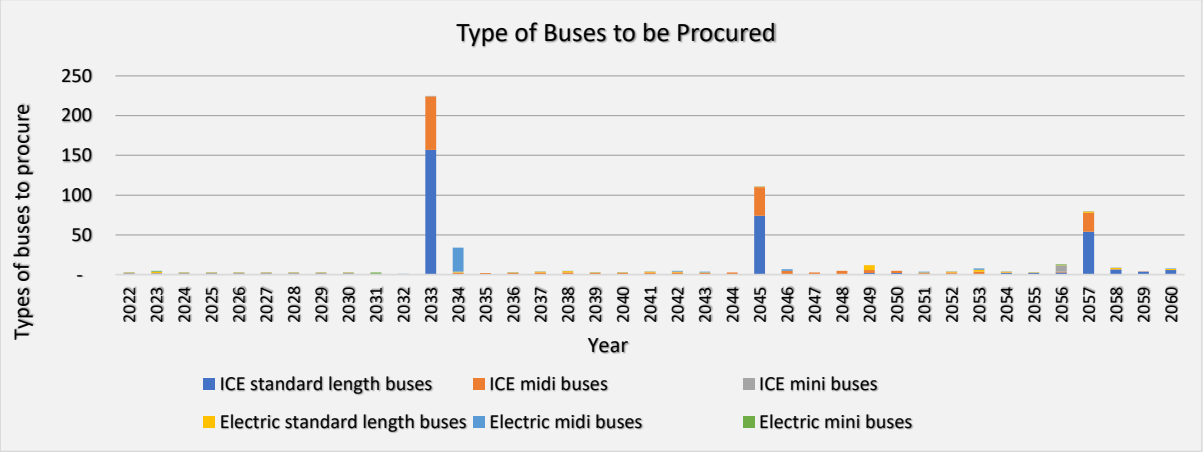
Low Ambition Scenario



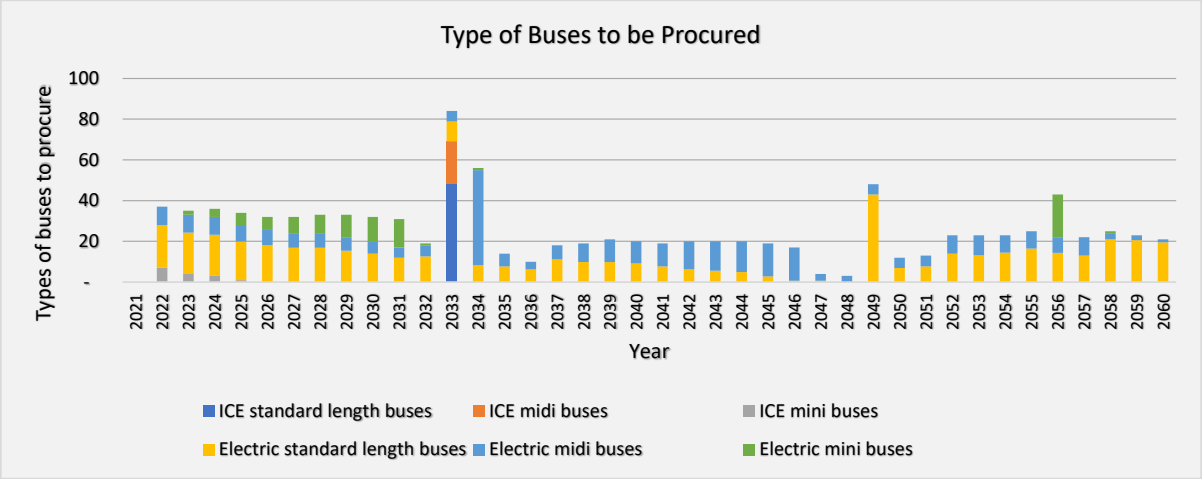
High Ambition Scenario



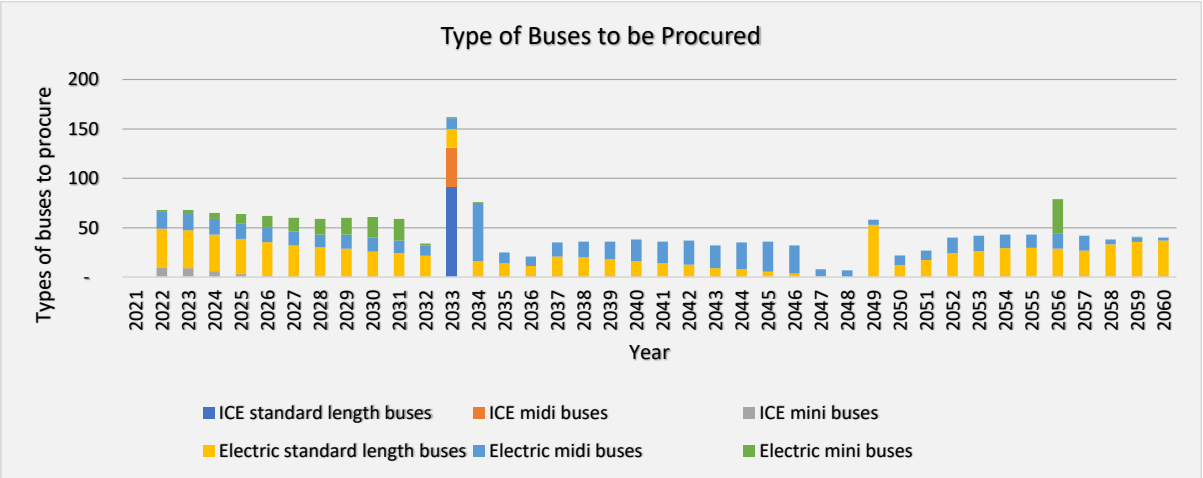
Business as Usual Scenario



Low Ambition Scenario

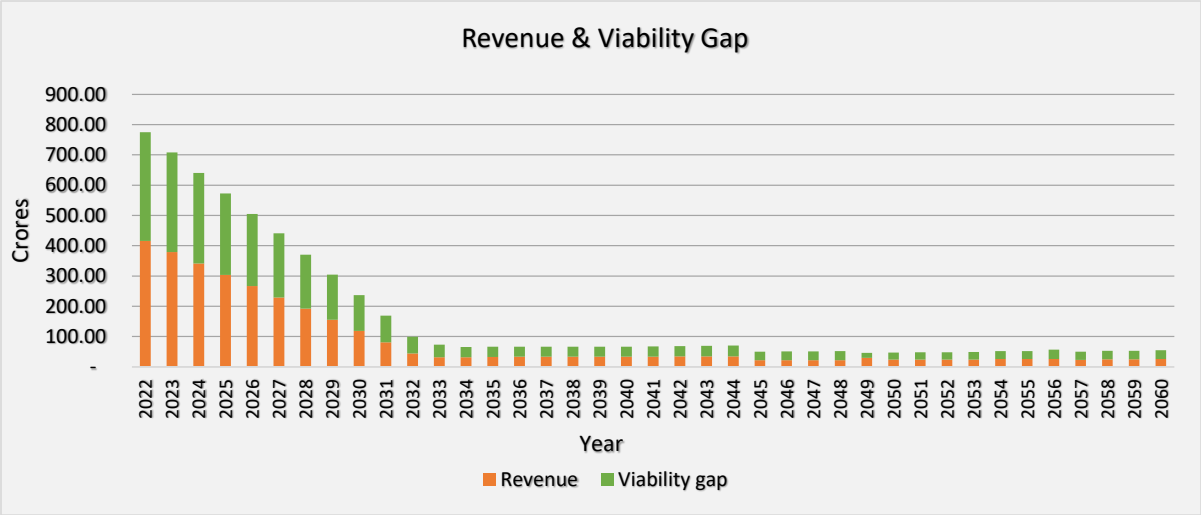


High Ambition Scenario

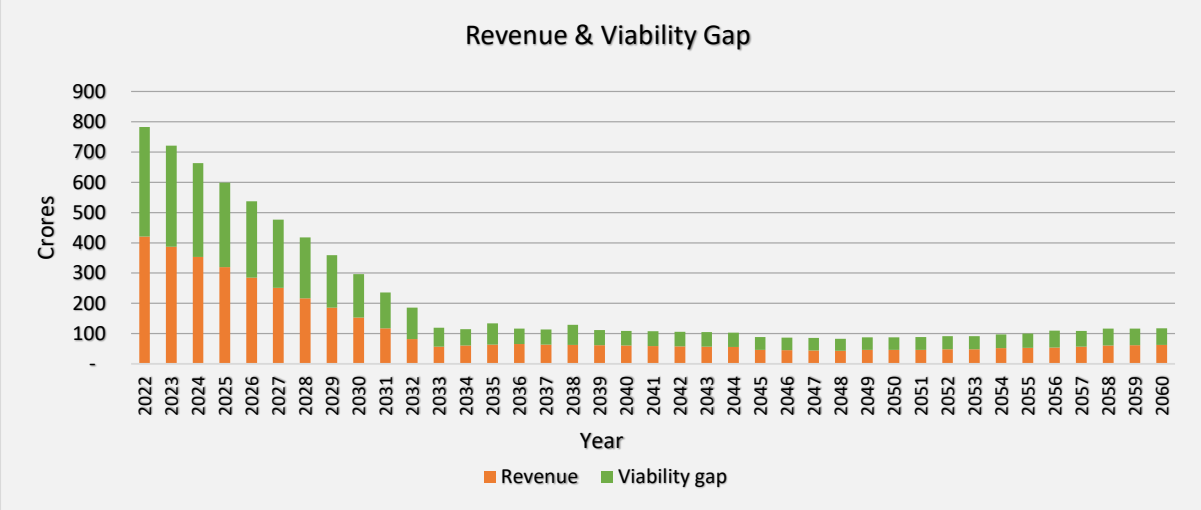


Revenue and Viability Gap: GCC Model

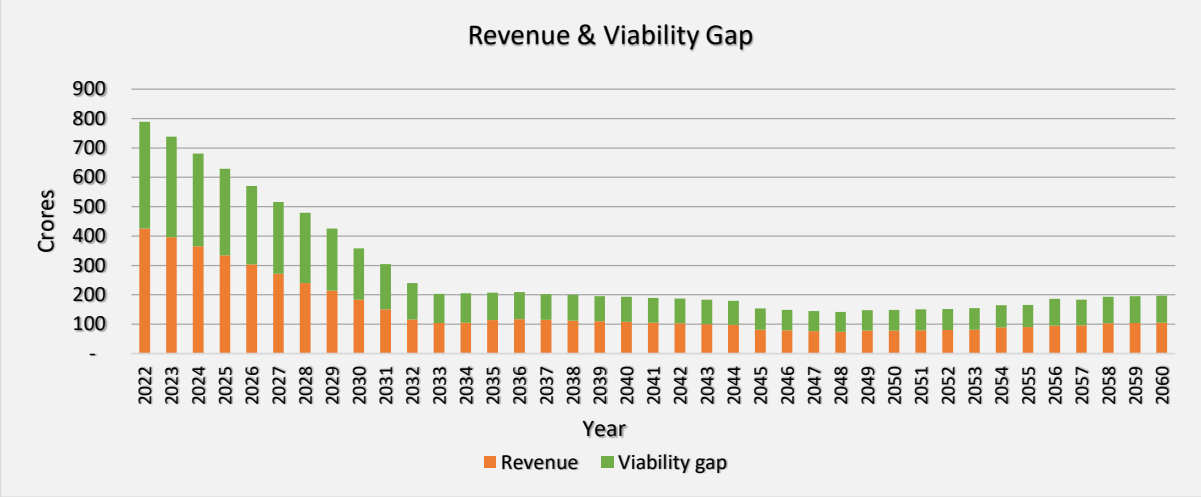
Business as Usual Scenario



Low Ambition Scenario

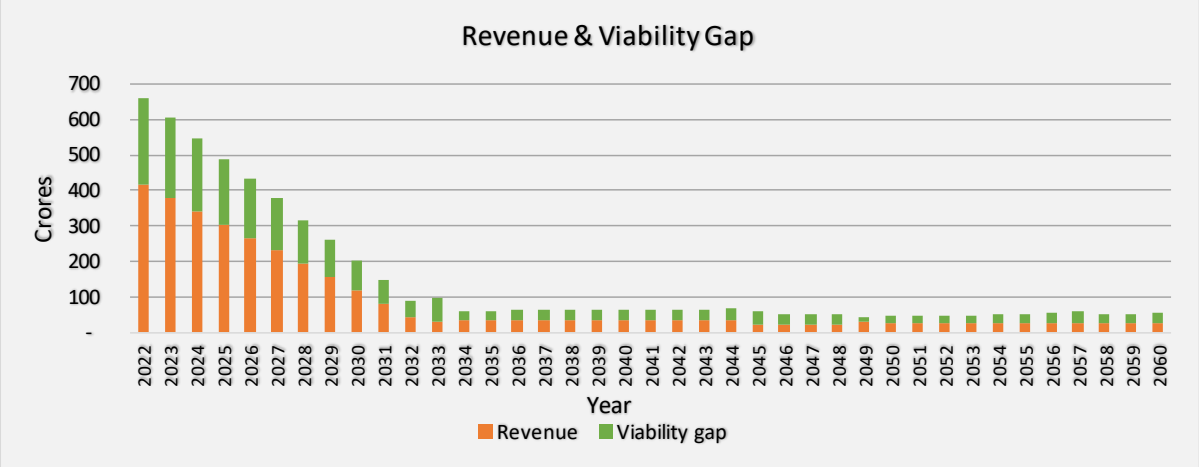


High Ambition Scenario

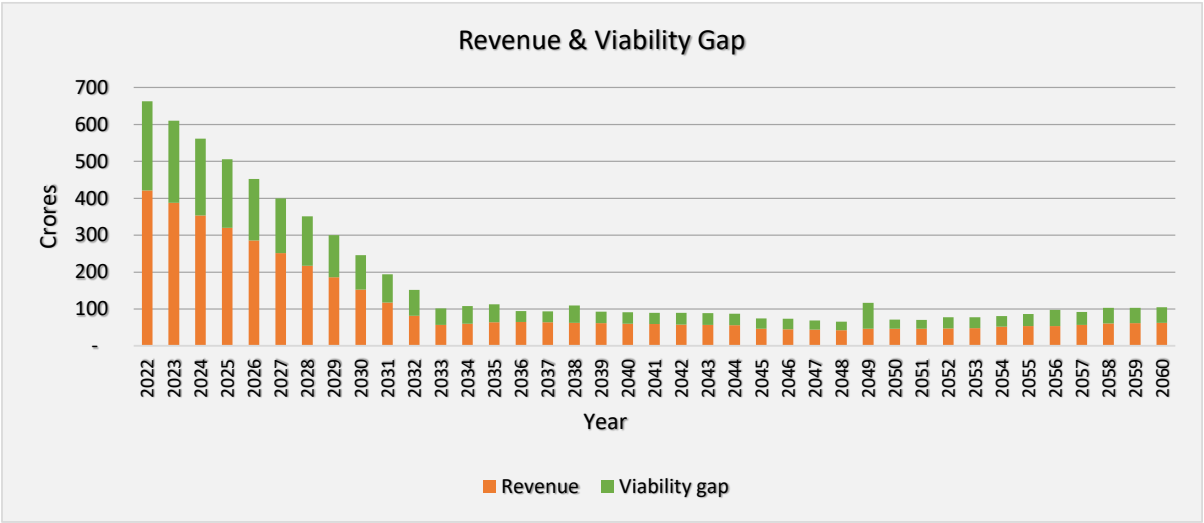


Revenue and Viability Gap: Outright Purchase Model

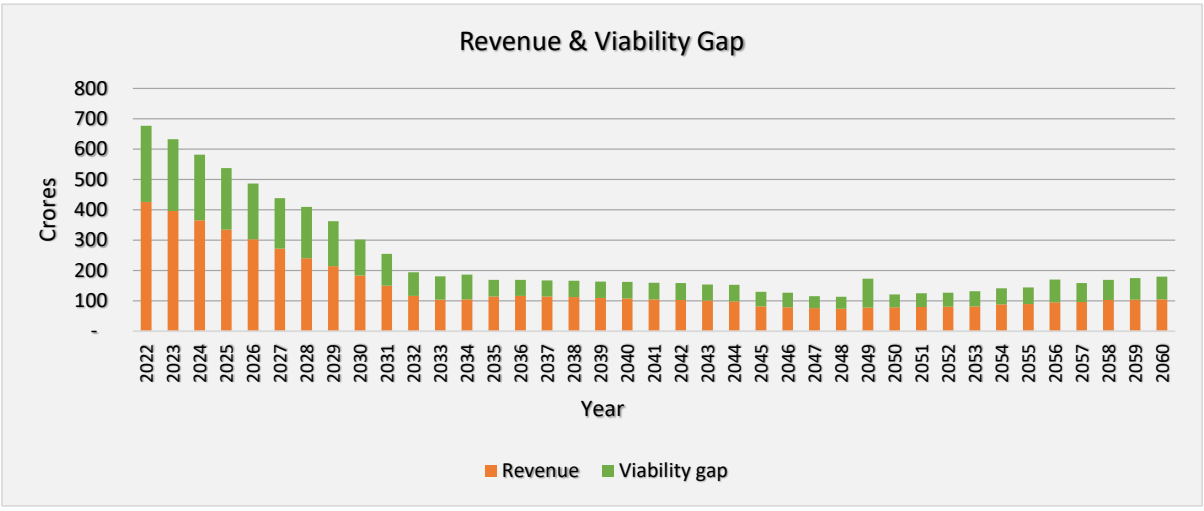
Business as usual Scenario



Low Ambition Scenario

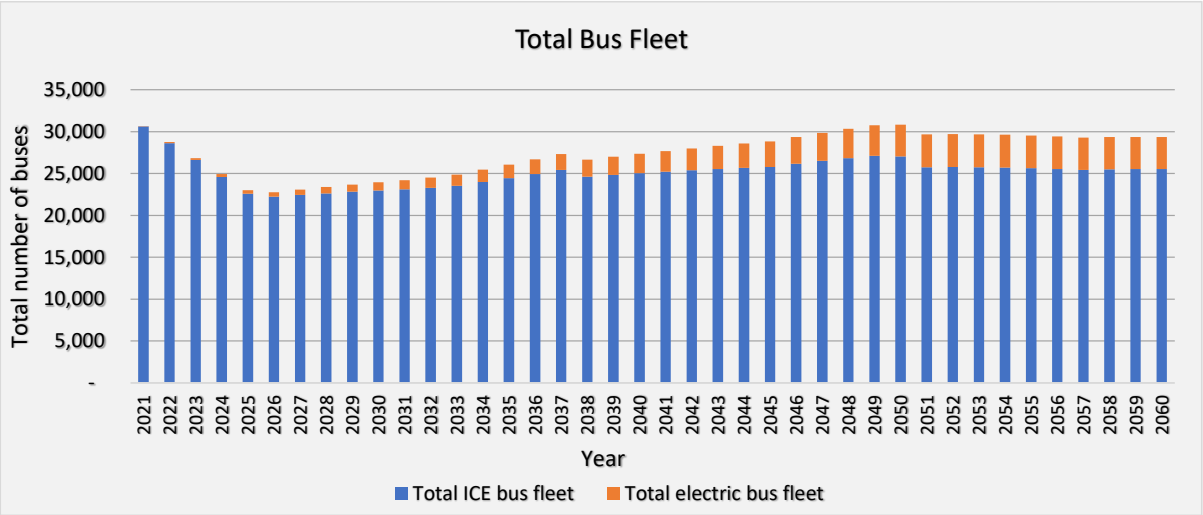


High Ambition Scenario

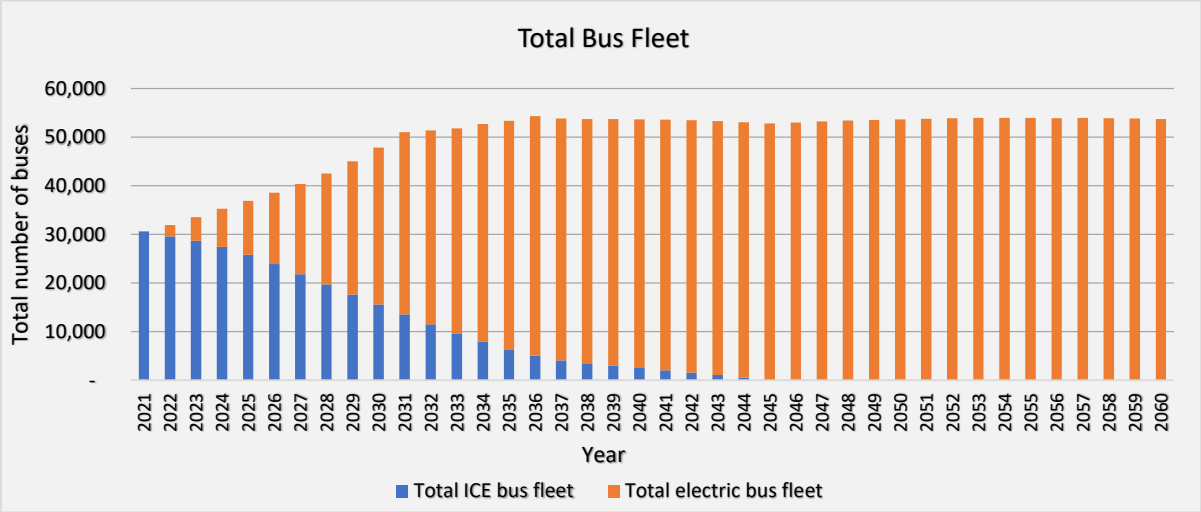


12. State / UT: Gujarat

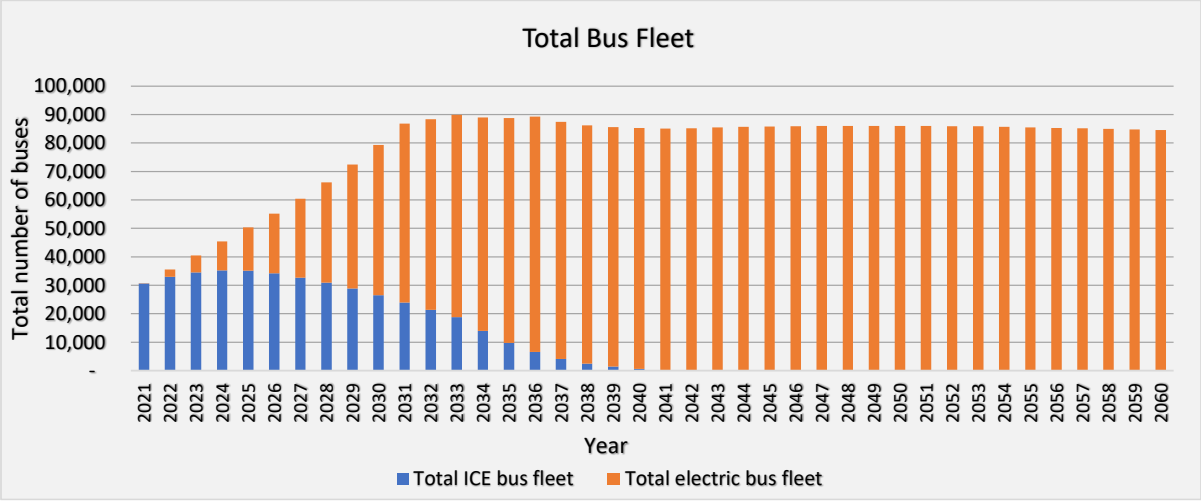
Business as usual Scenario



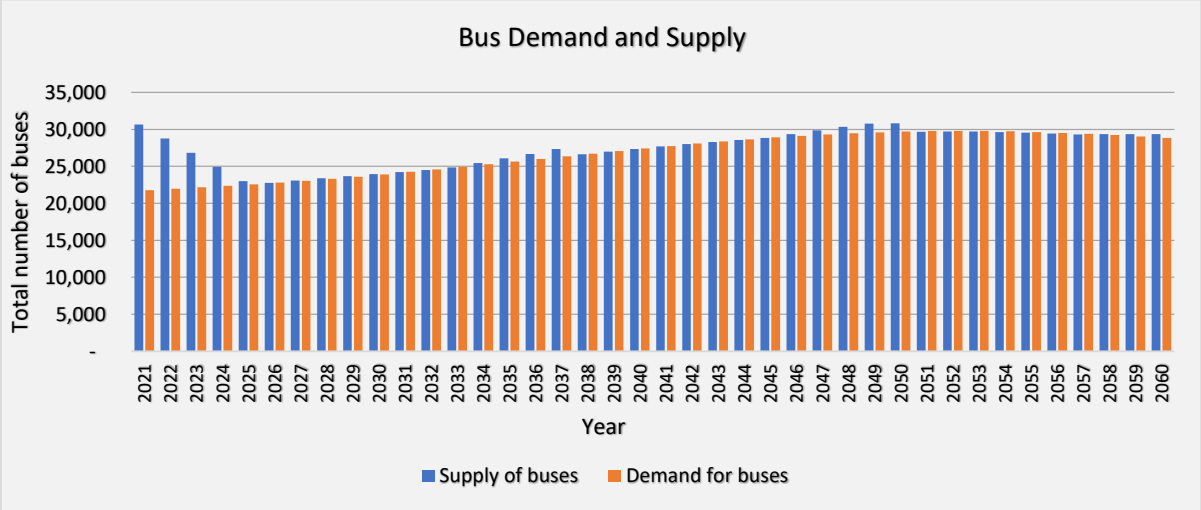
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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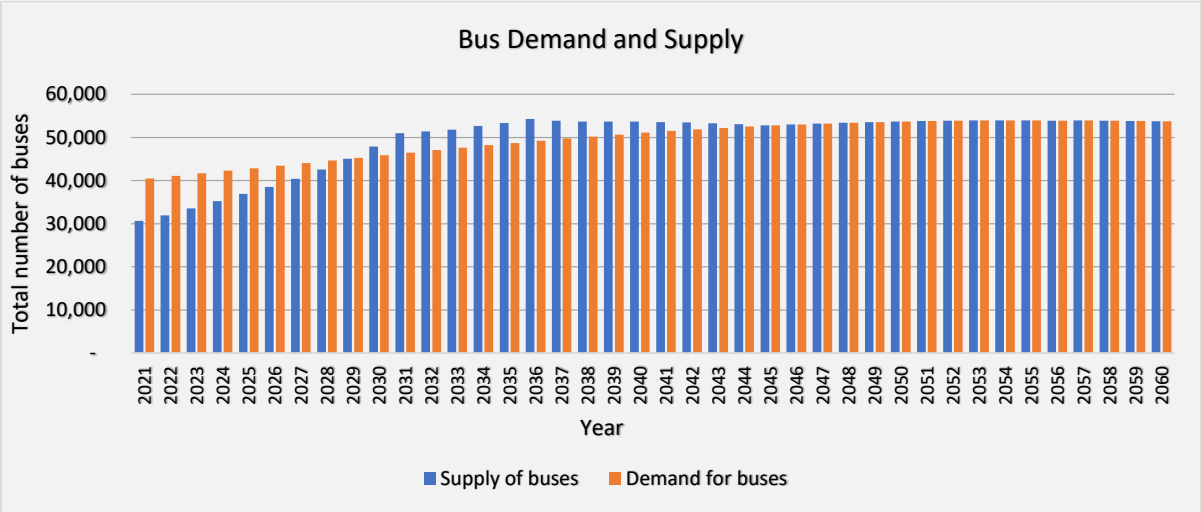
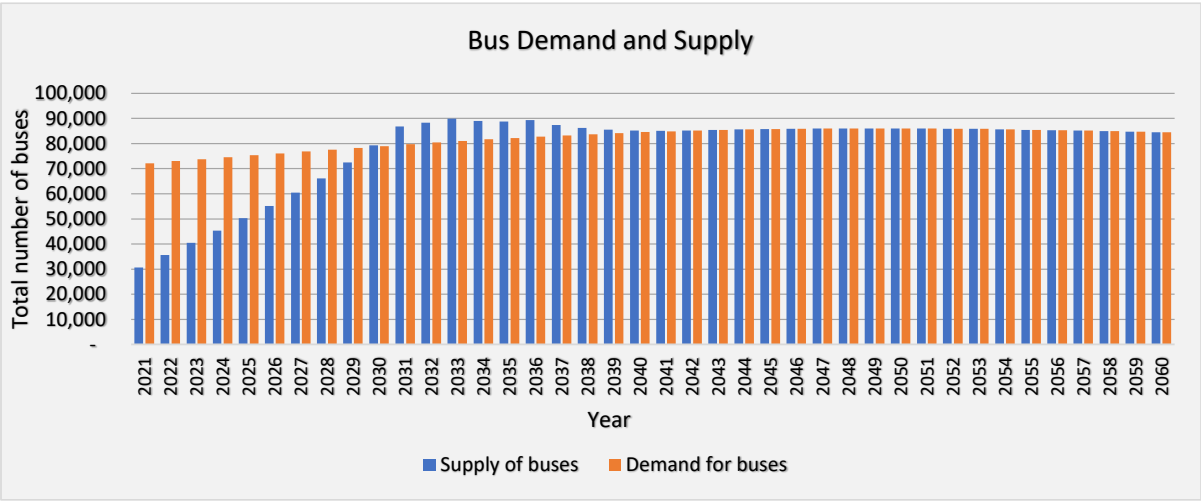
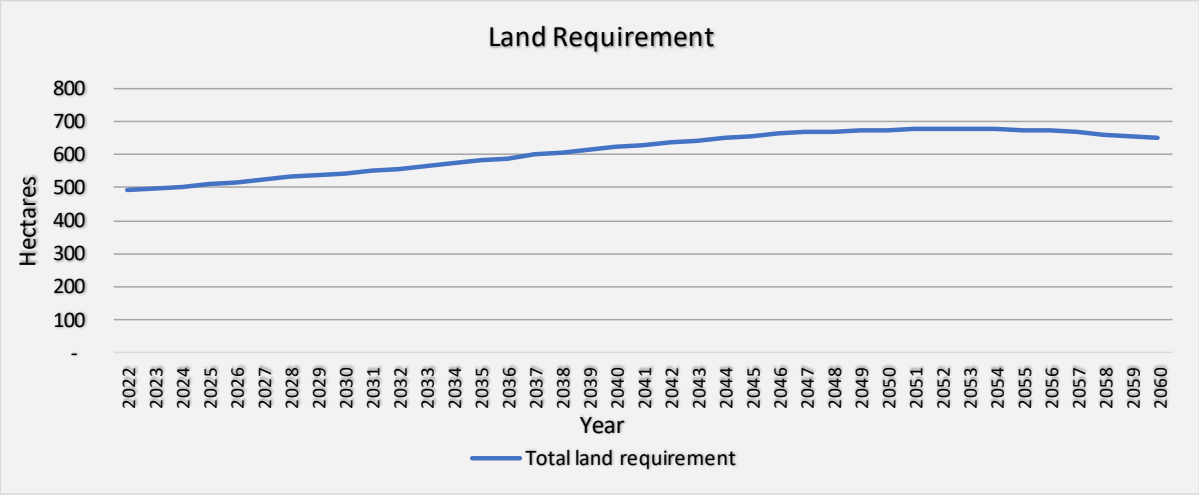


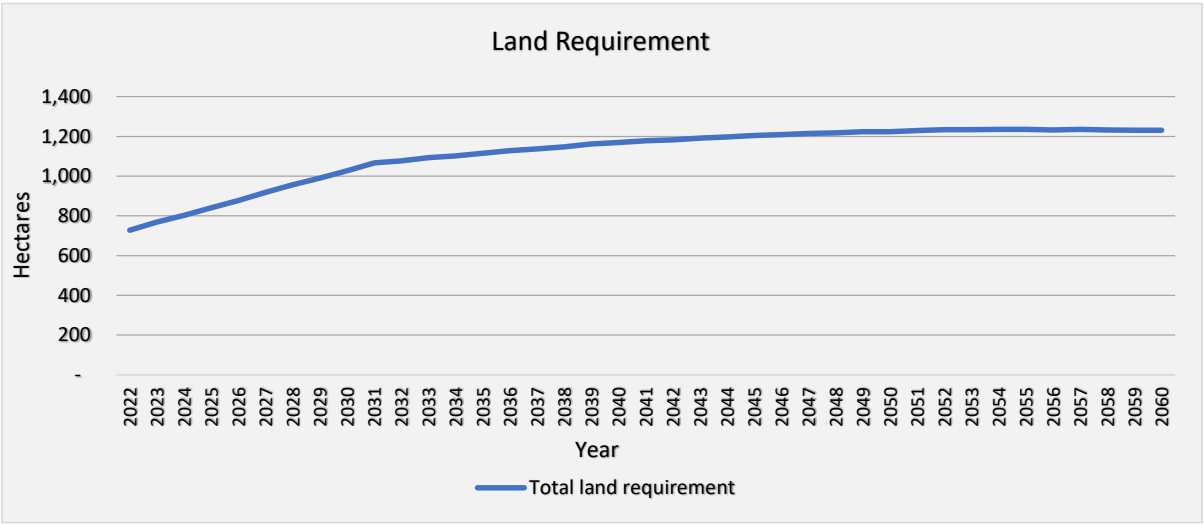
High Ambition Scenario



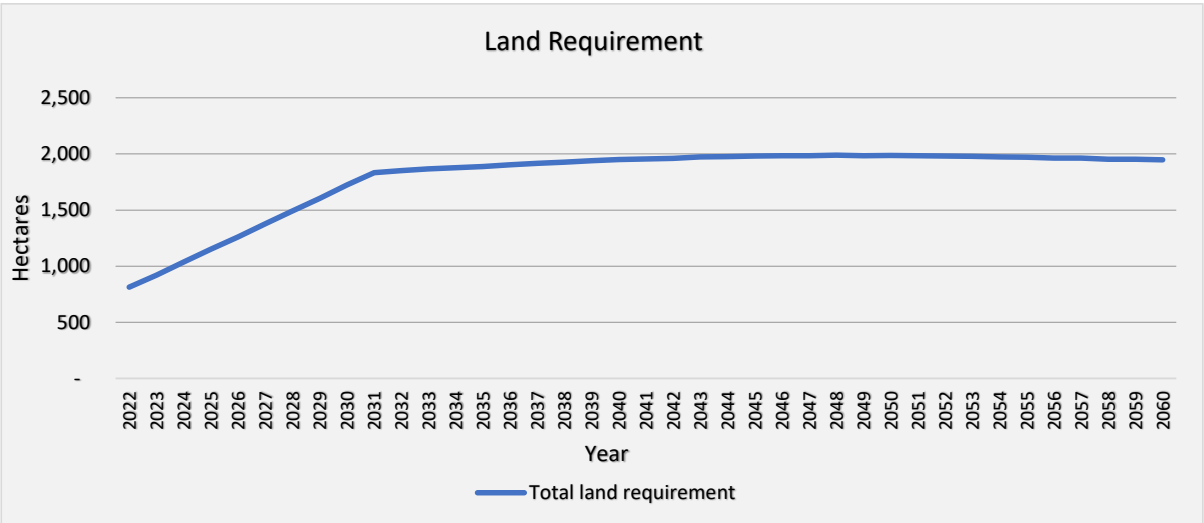
Business as Usual Scenario



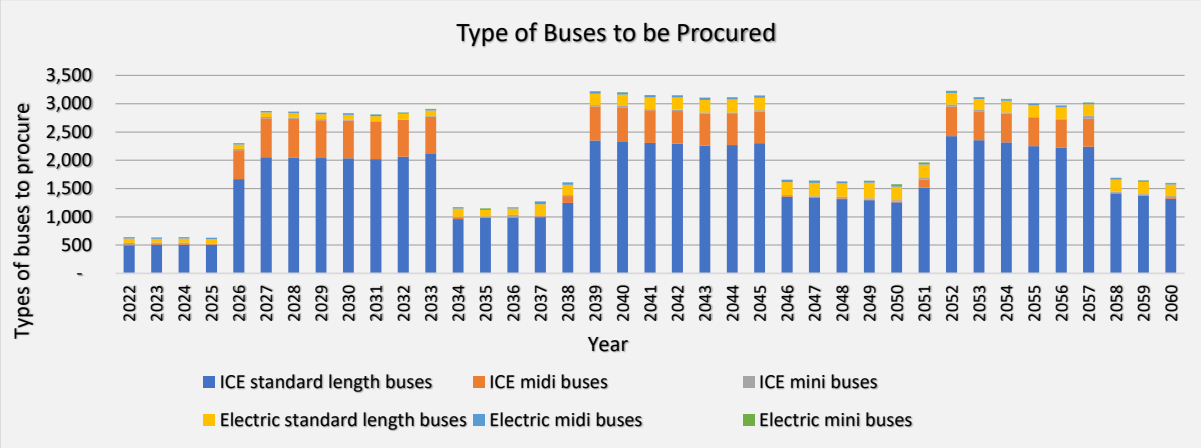
Low Ambition Scenario



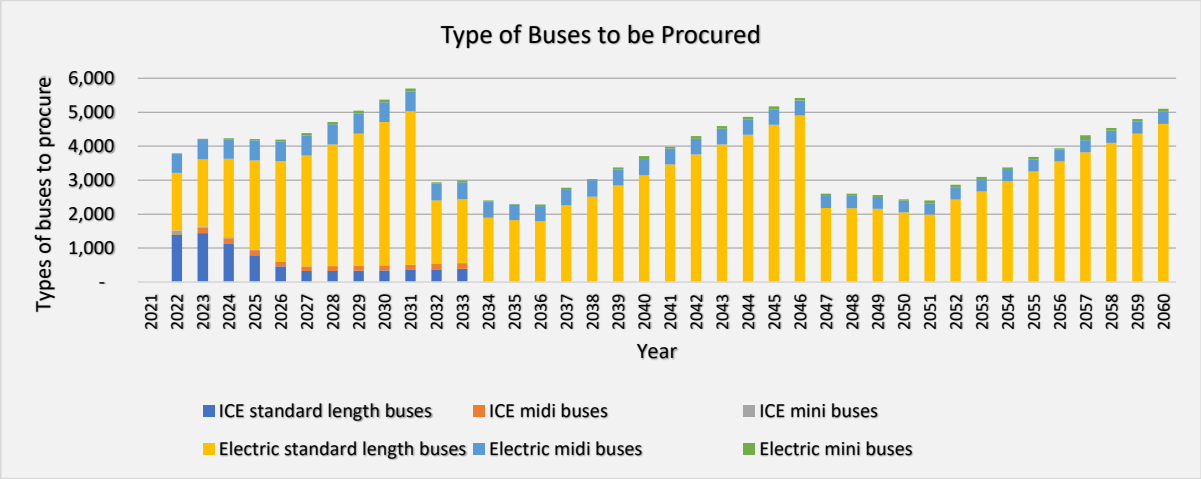
High Ambition Scenario



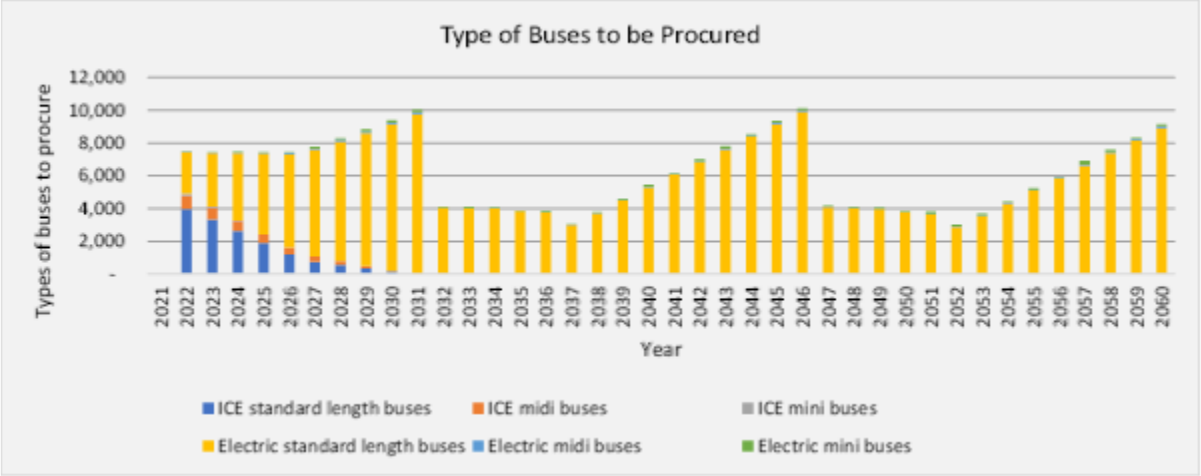
Business as Usual Scenario



Low Ambition Scenario

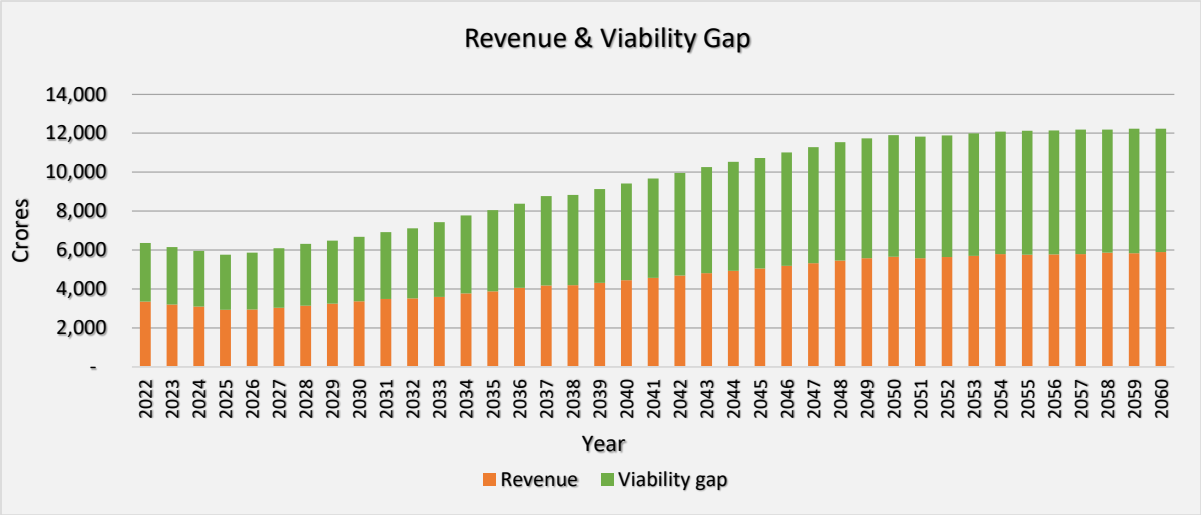


High Ambition Scenario

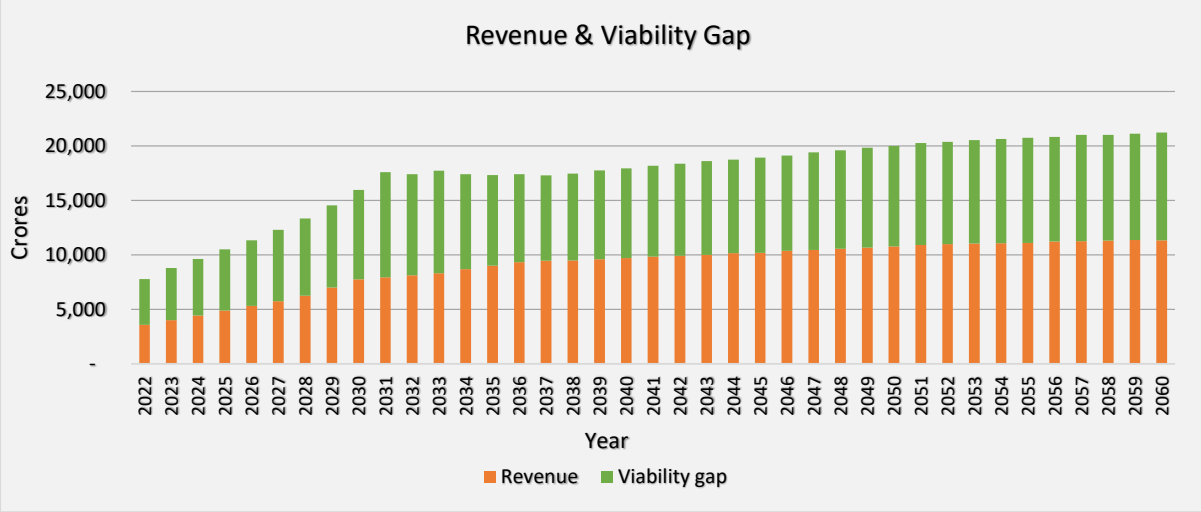


Revenue and Viability Gap: GCC Model

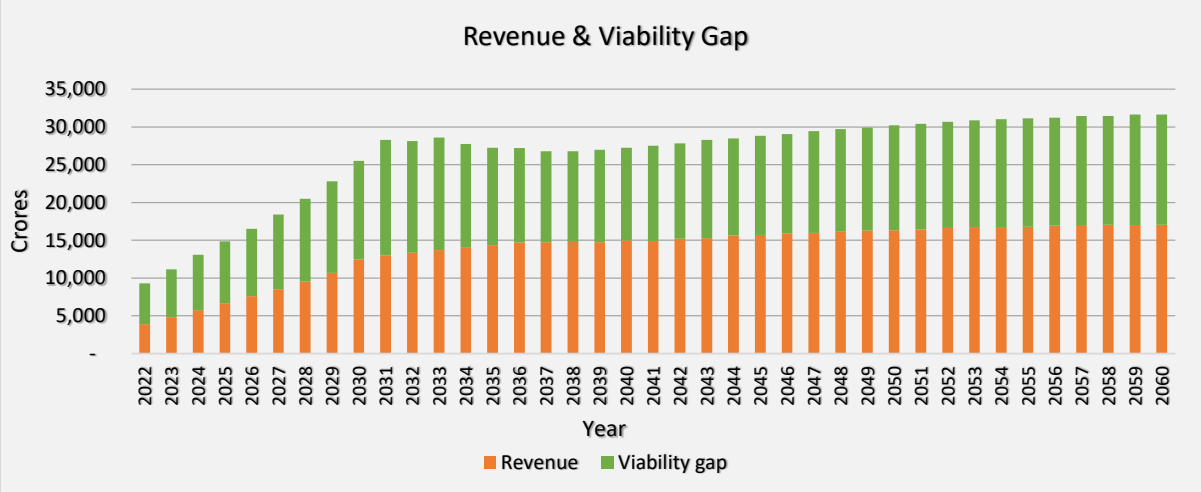
Business as Usual Scenario



Low Ambition Scenario

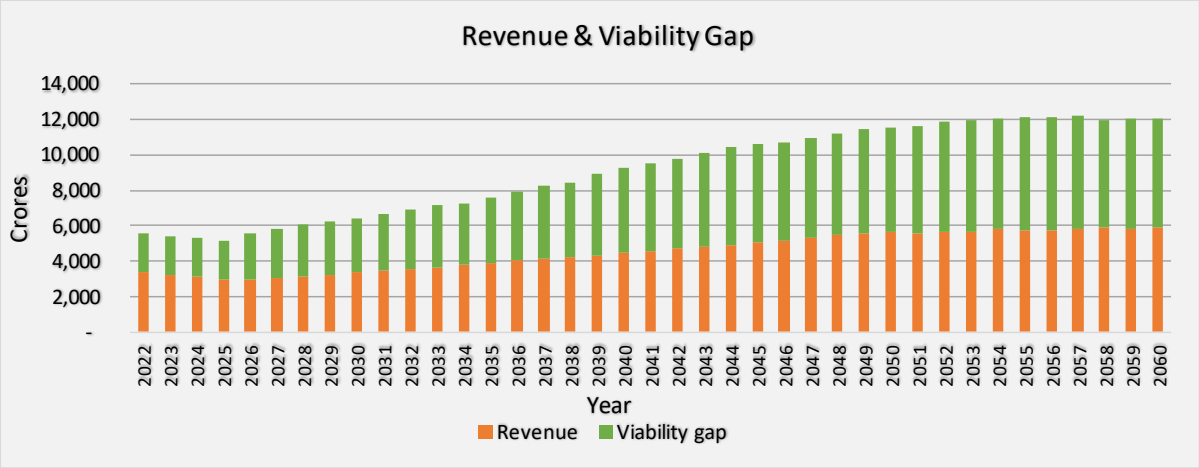


High Ambition Scenario

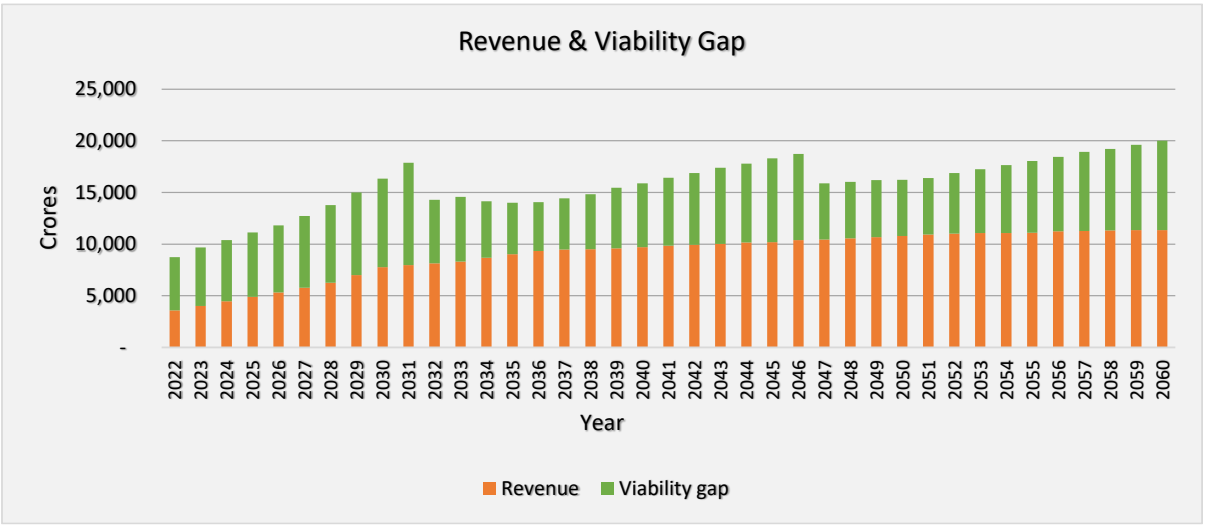


Revenue and Viability Gap: Outright Purchase Model

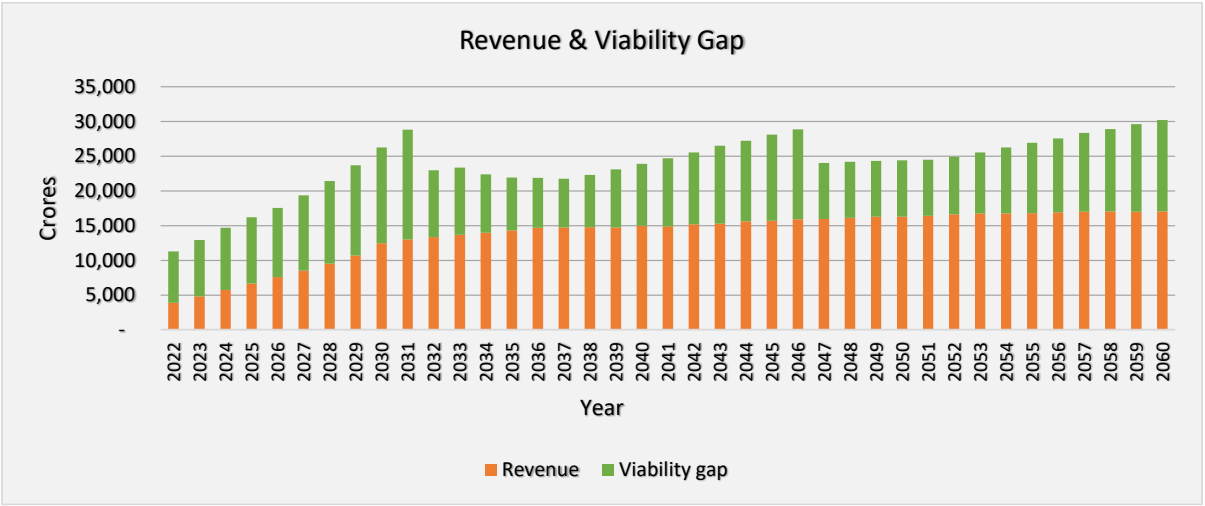
Business as usual Scenario



Low Ambition Scenario

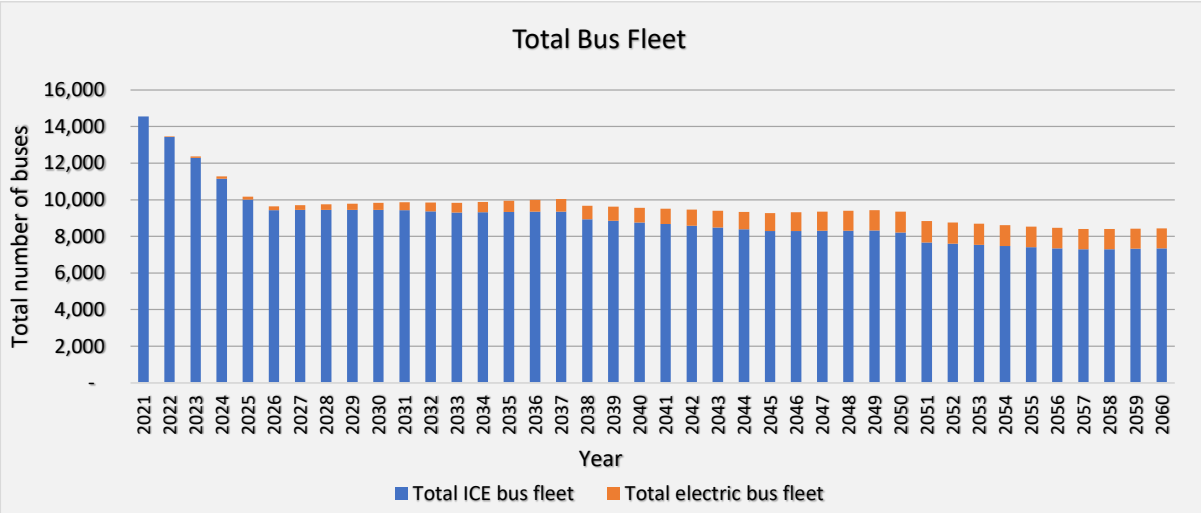


High Ambition Scenario

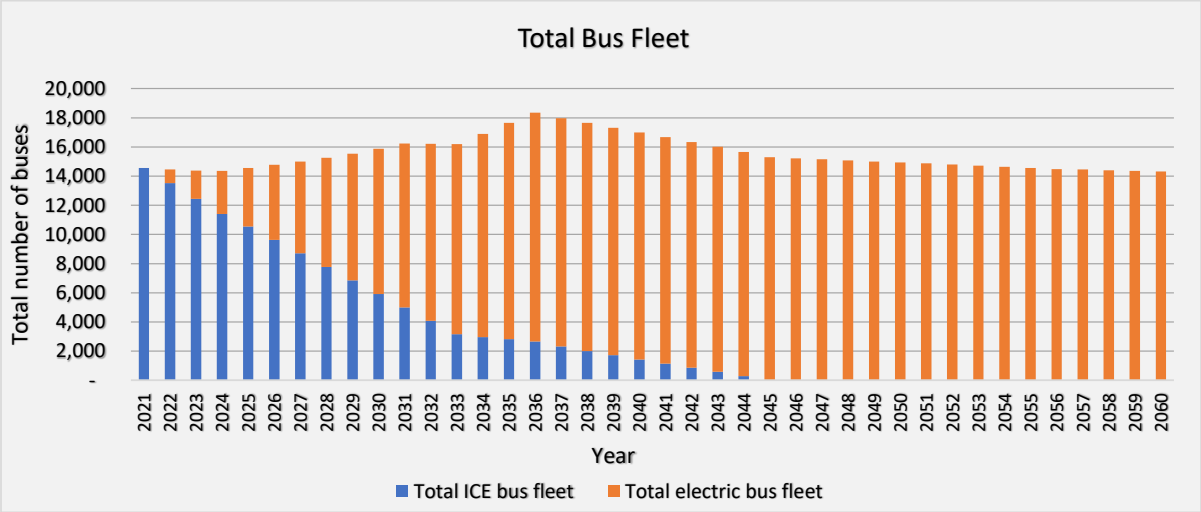


13. State / UT: Haryana

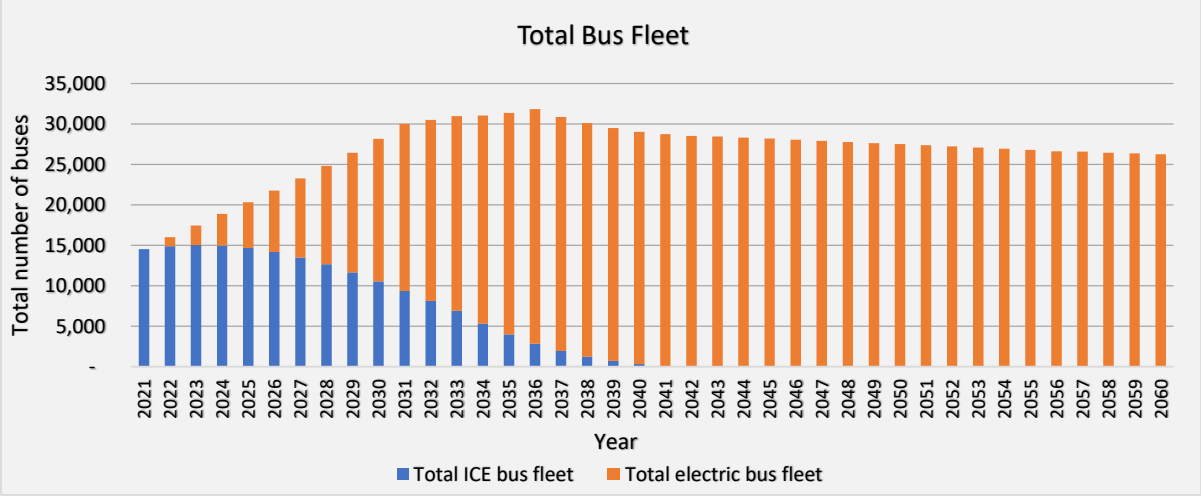
Business as usual Scenario



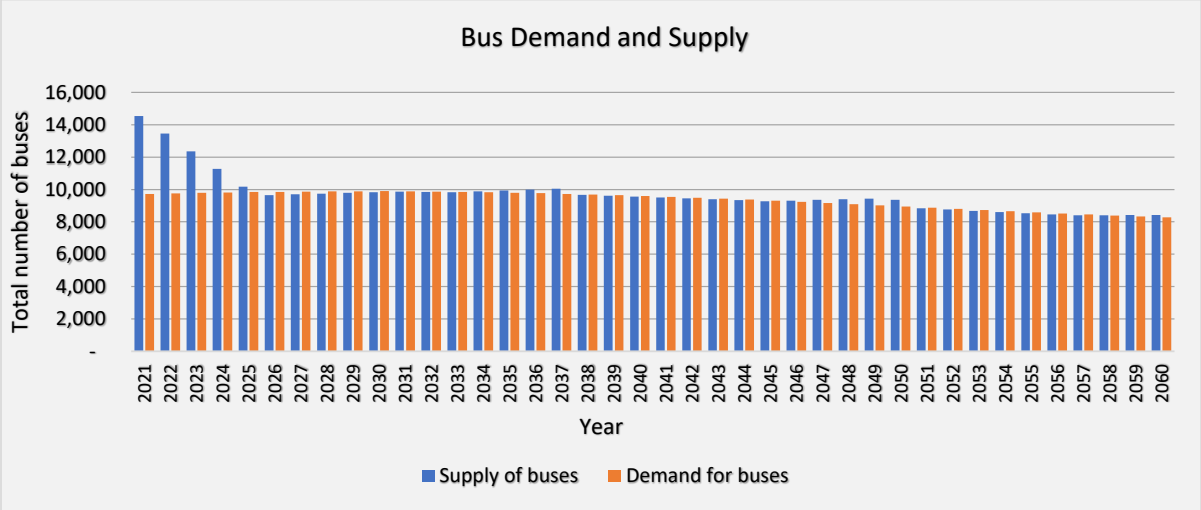
Low Ambition Scenario



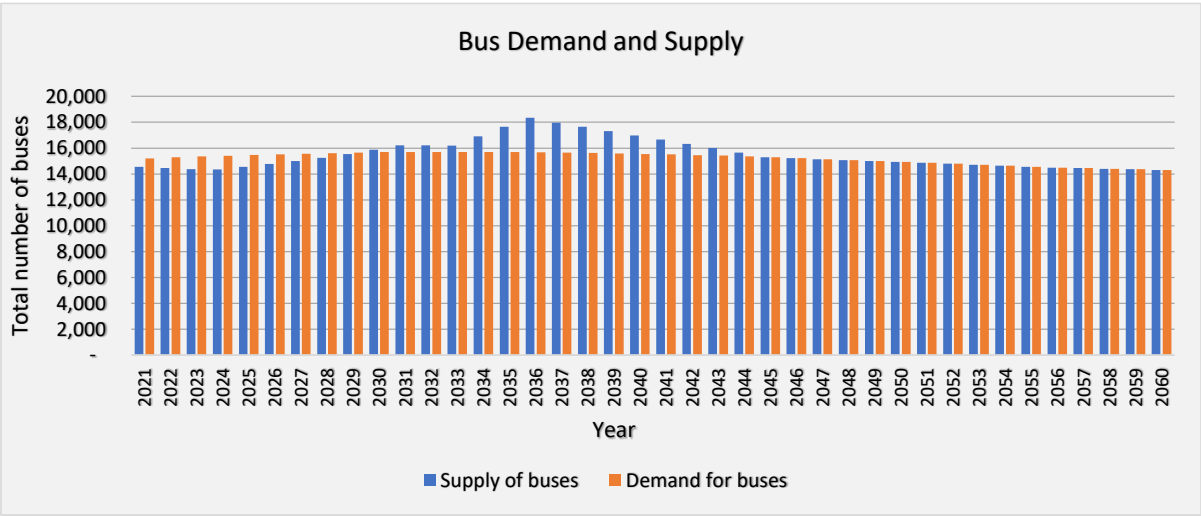
High Ambition Scenario



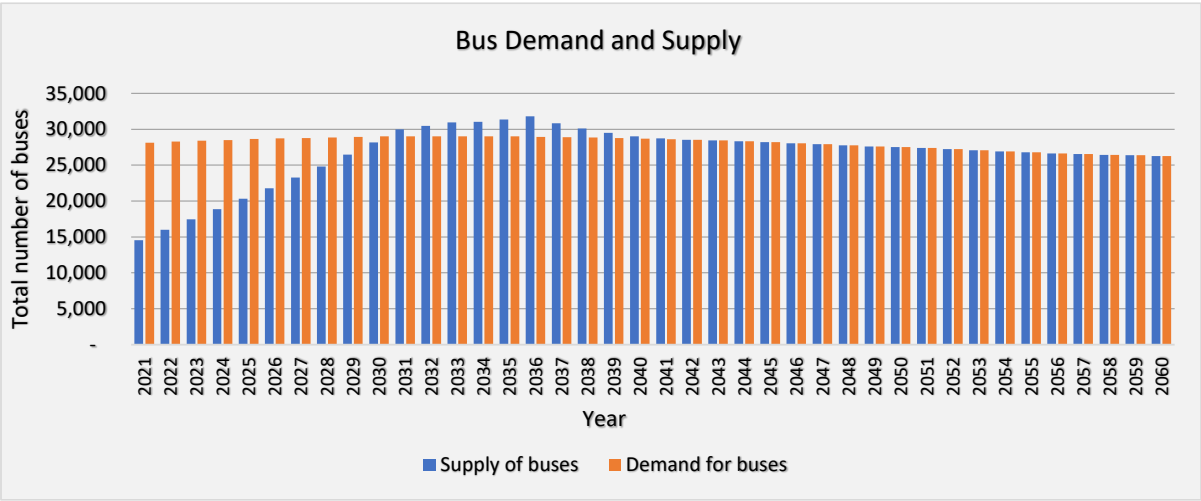
Business as Usual Scenario



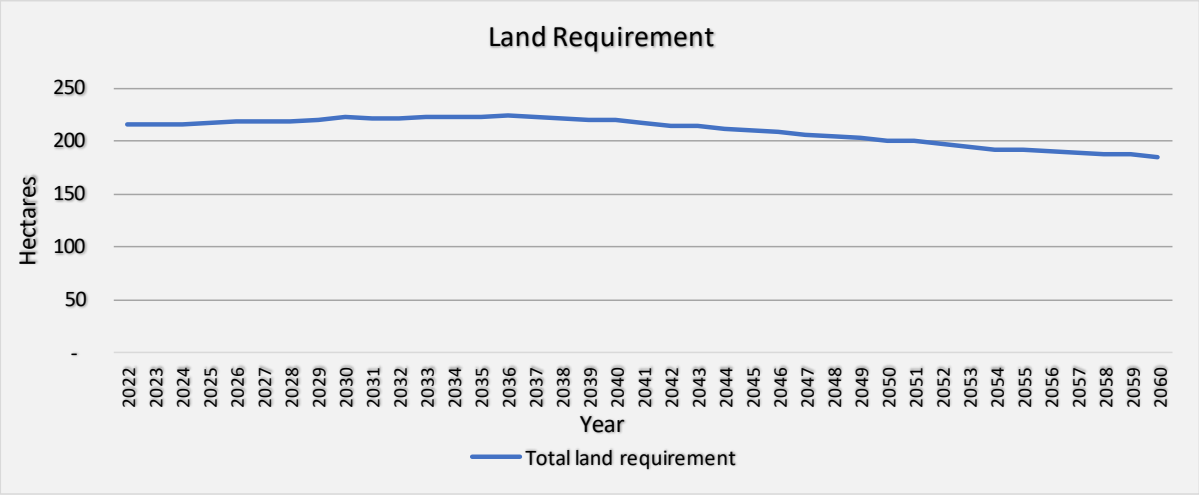
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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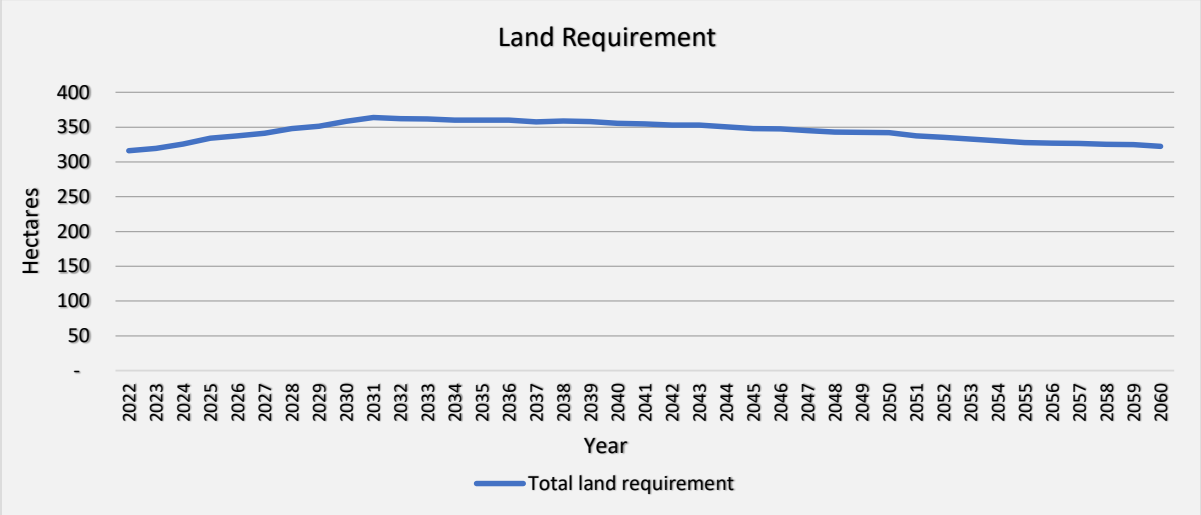

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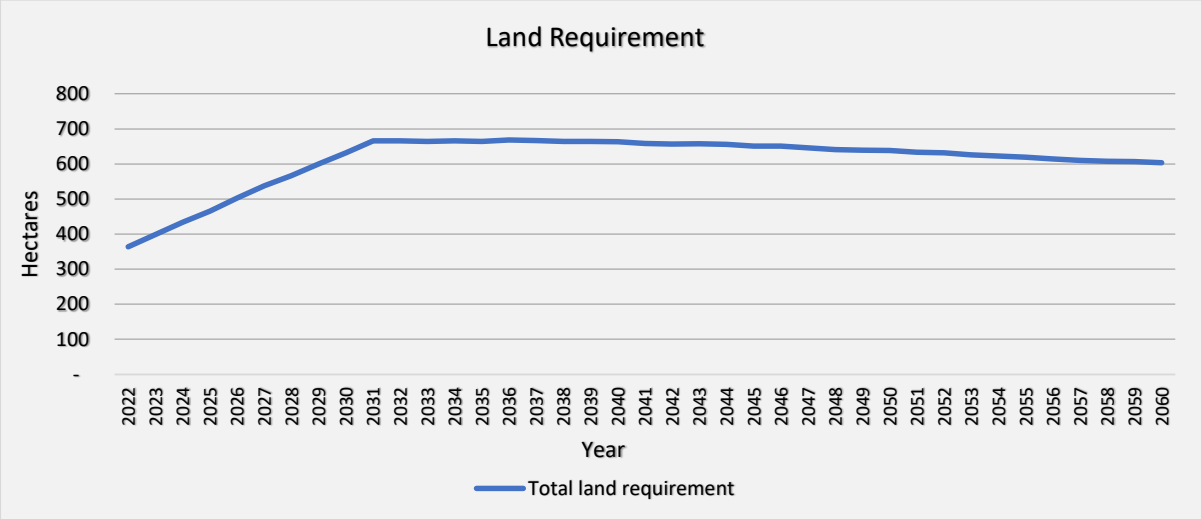
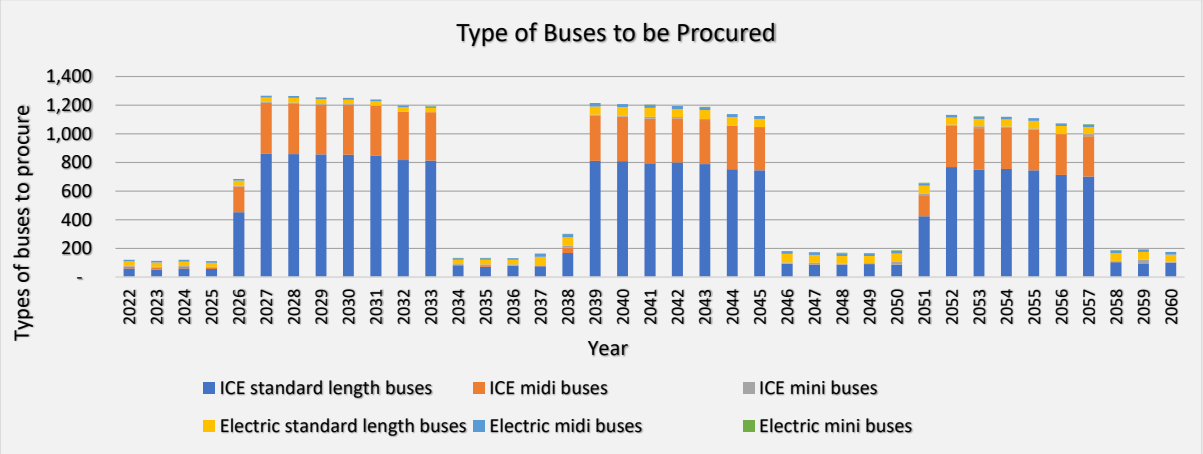
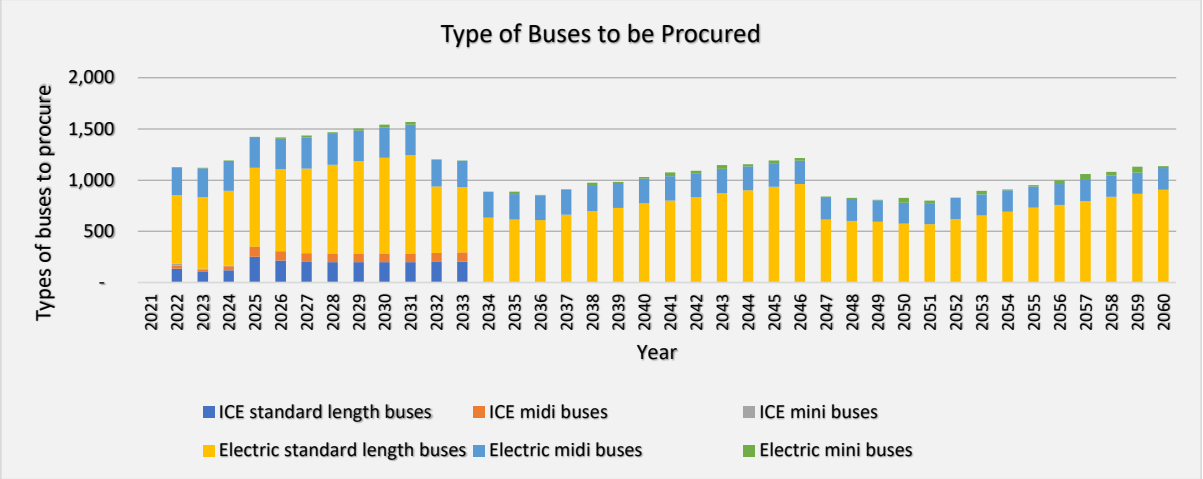


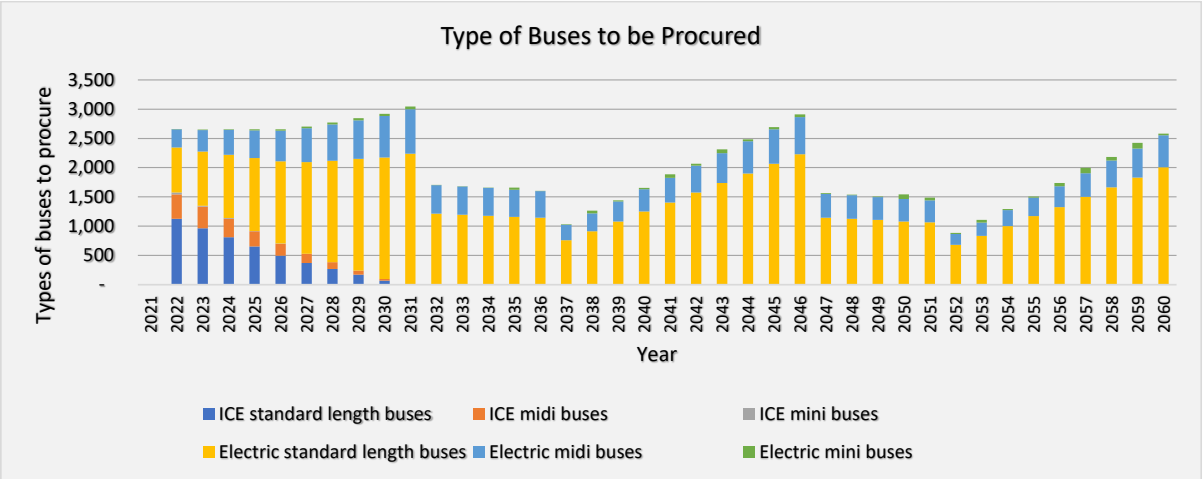
Business as Usual Scenario



Low Ambition Scenario

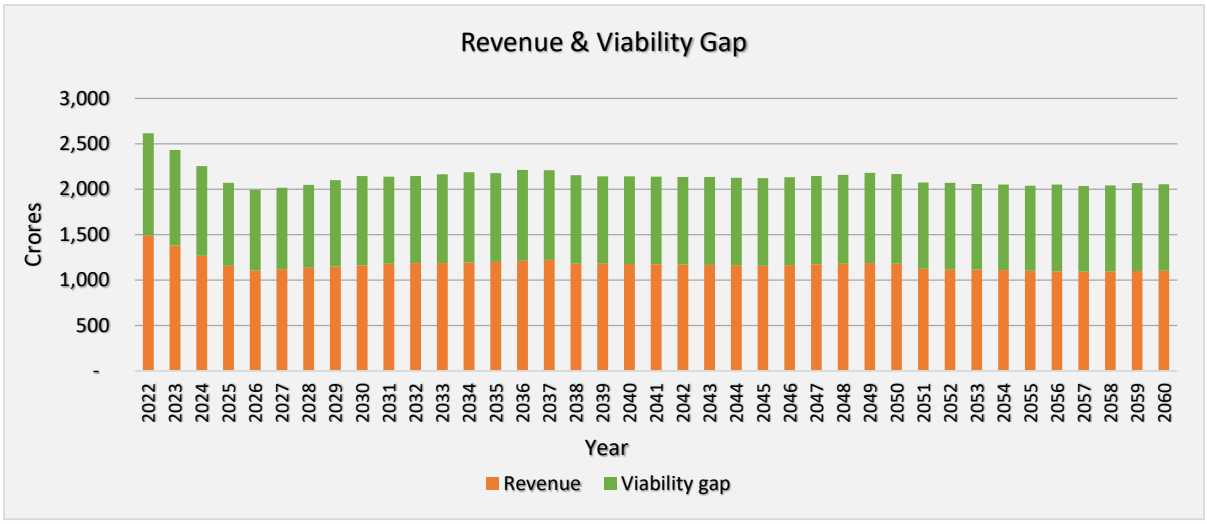


High Ambition Scenario

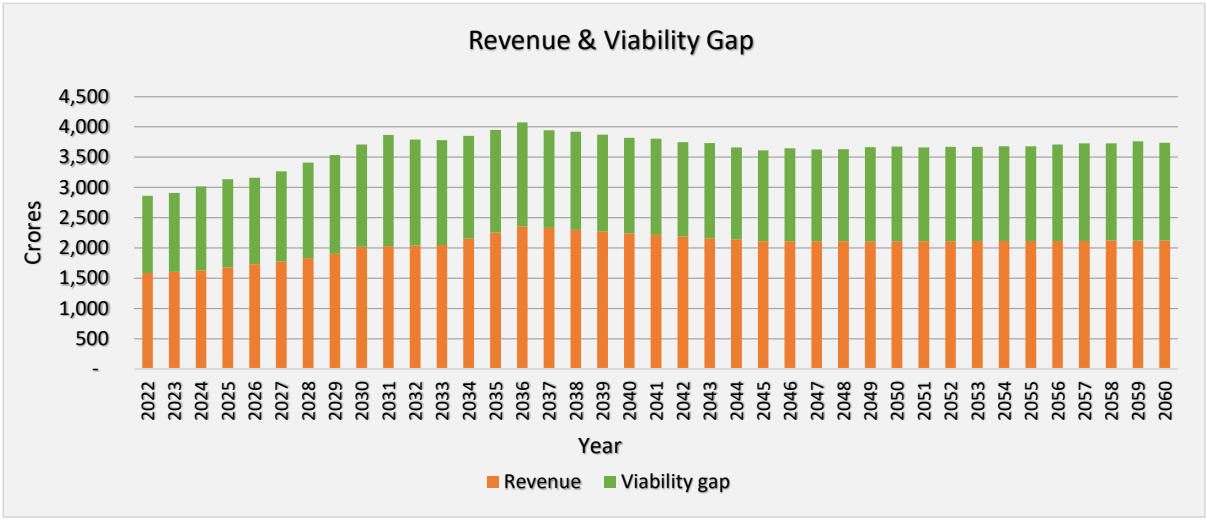


Revenue and Viability Gap: GCC Model

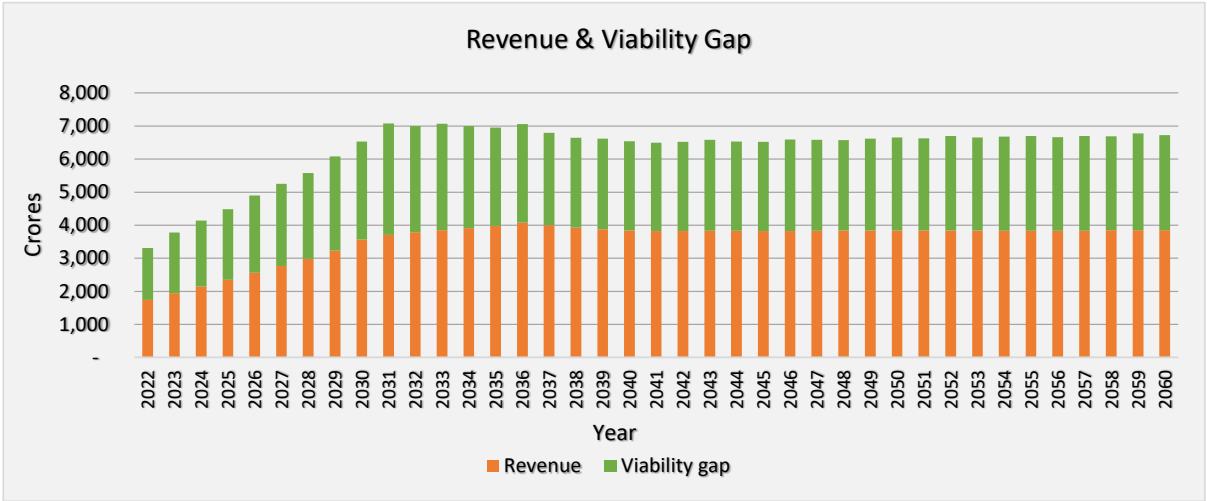
Business as Usual Scenario



Low Ambition Scenario

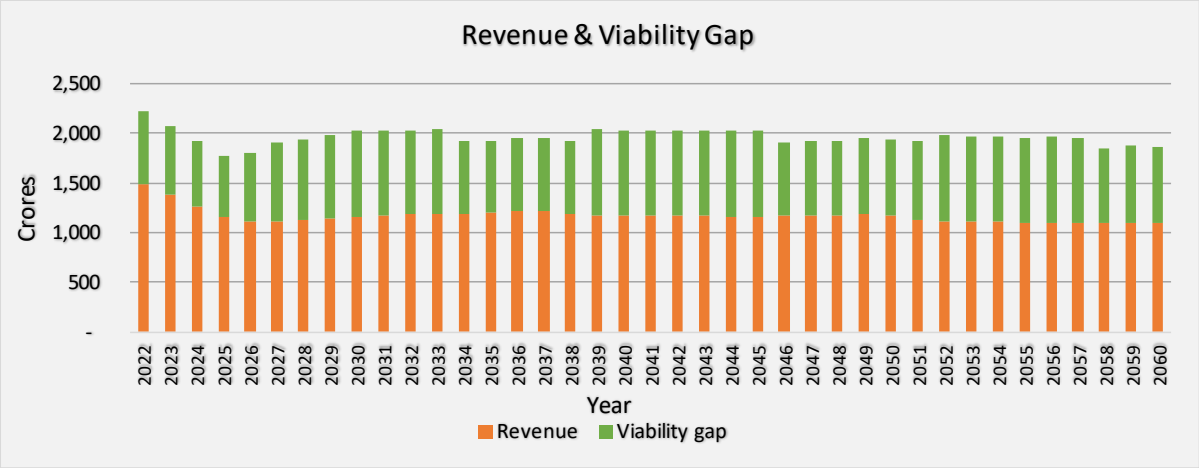


High Ambition Scenario

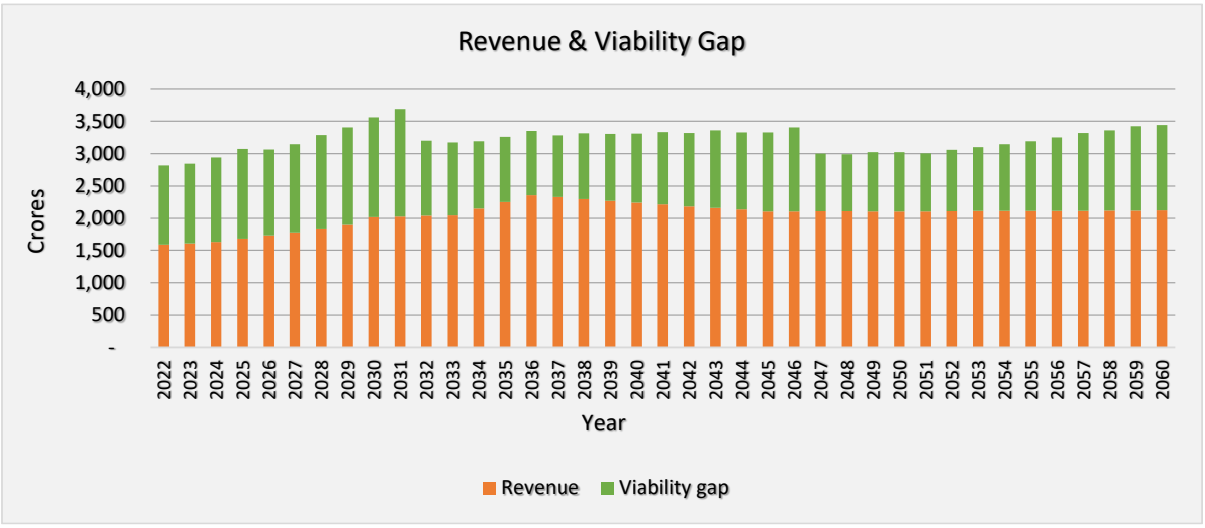


Revenue and Viability Gap: Outright Purchase Model

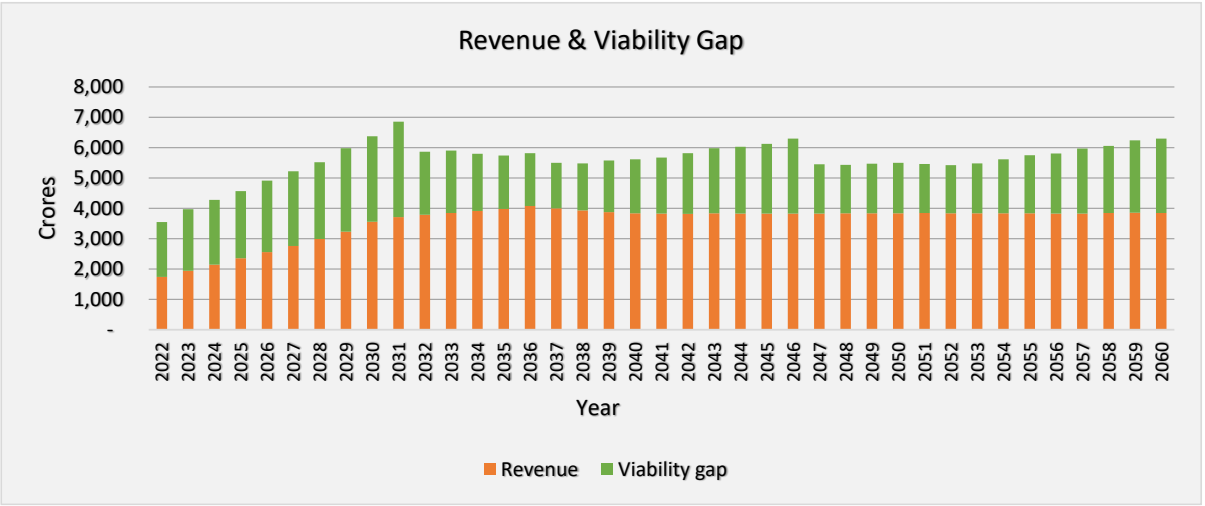
Business as usual Scenario



Low Ambition Scenario

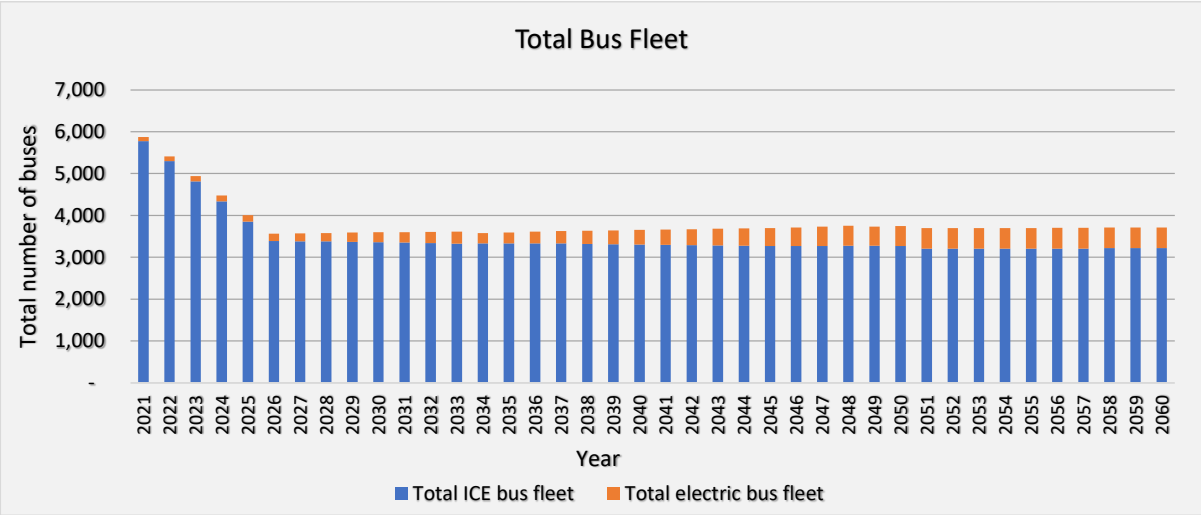


High Ambition Scenario

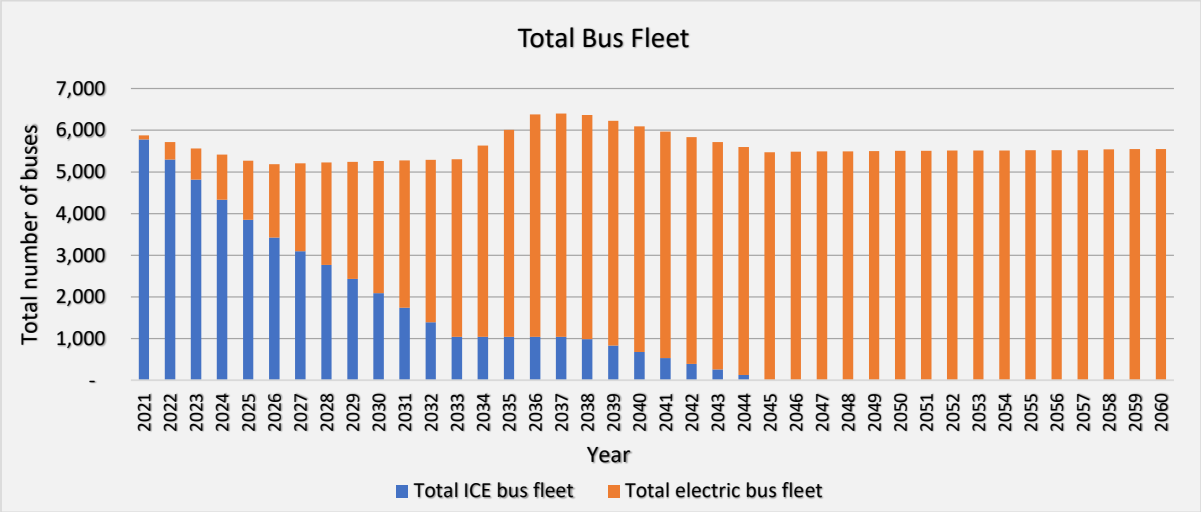


14. State / UT: Himachal Pradesh

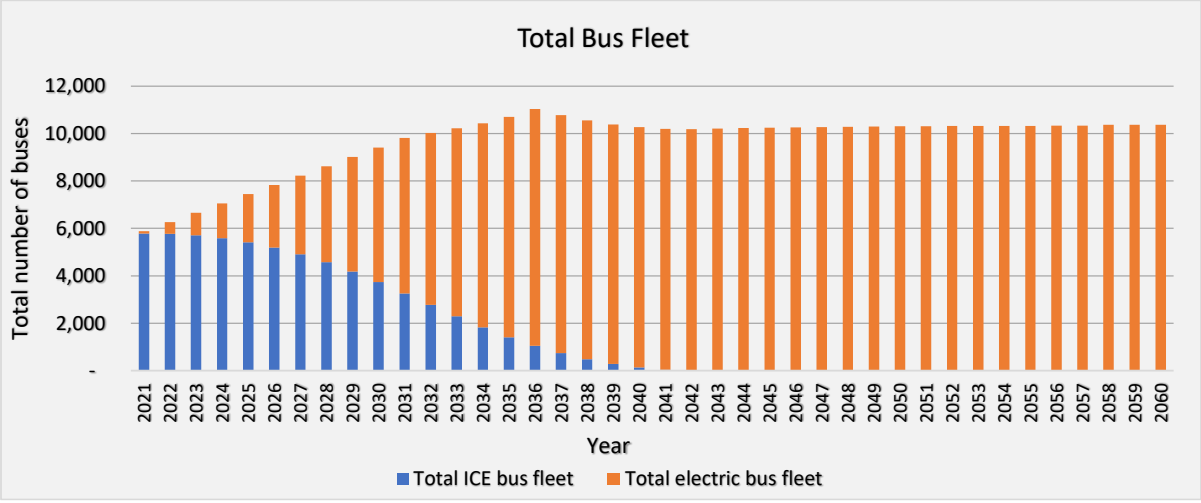
Business as usual Scenario



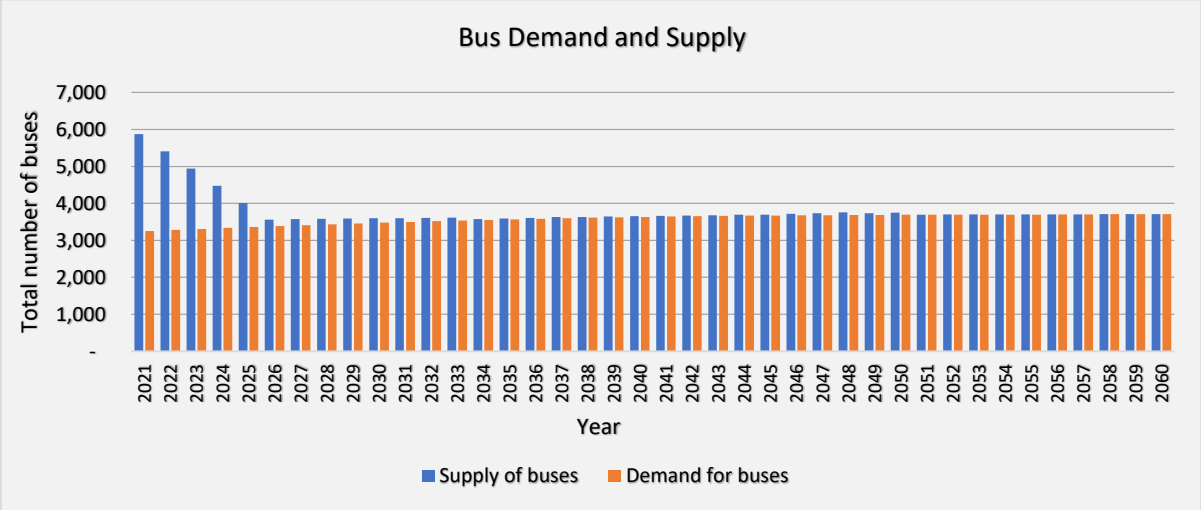
Low Ambition Scenario



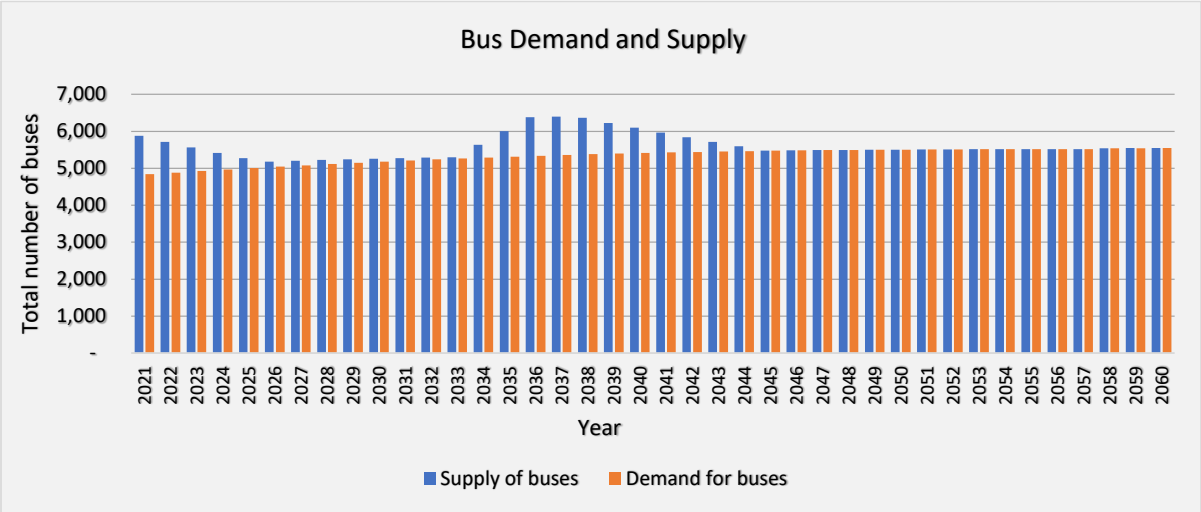
High Ambition Scenario



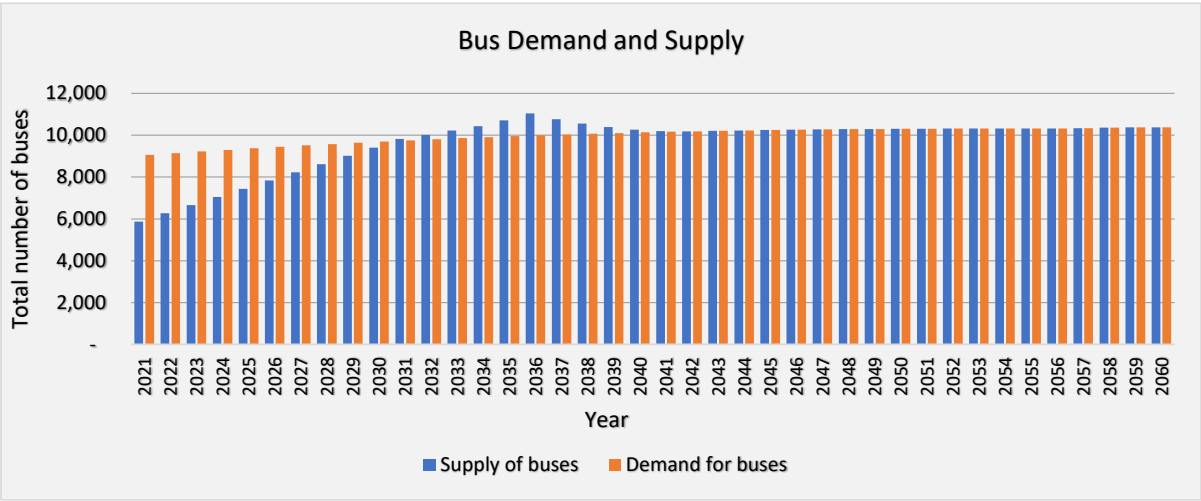
Business as Usual Scenario



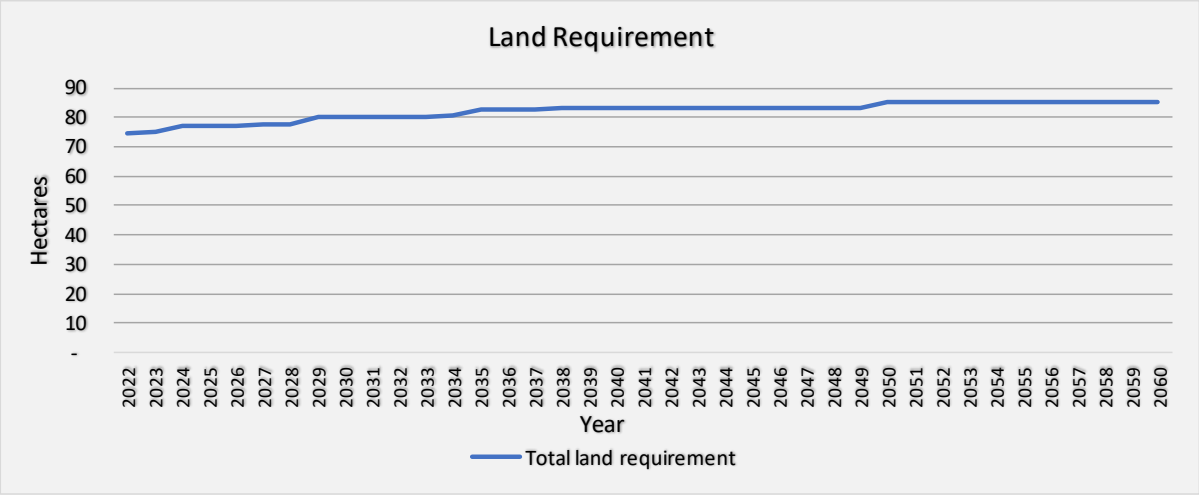
Low Ambition Scenario



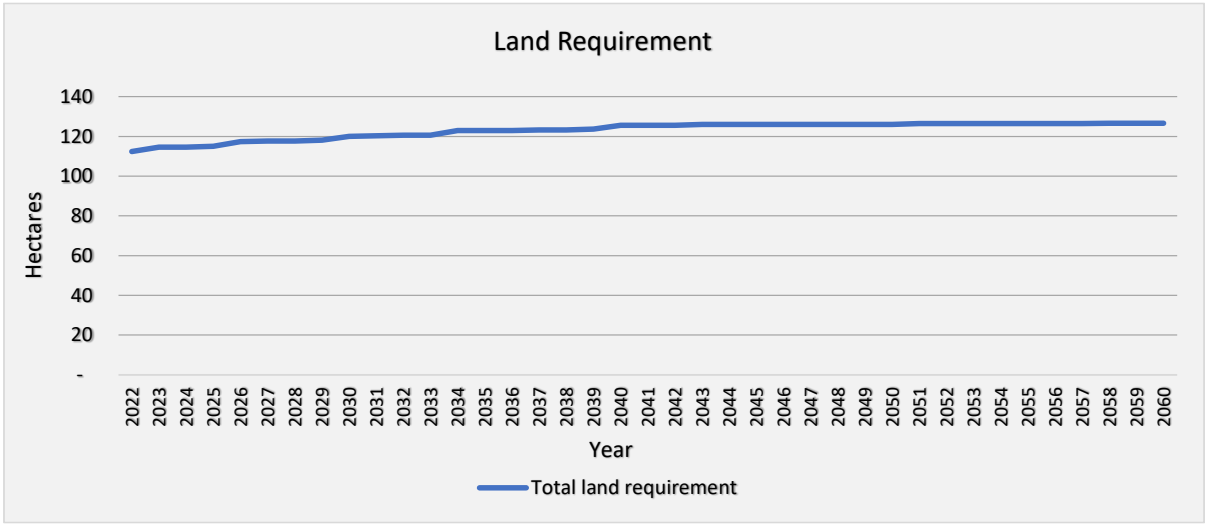
High Ambition Scenario



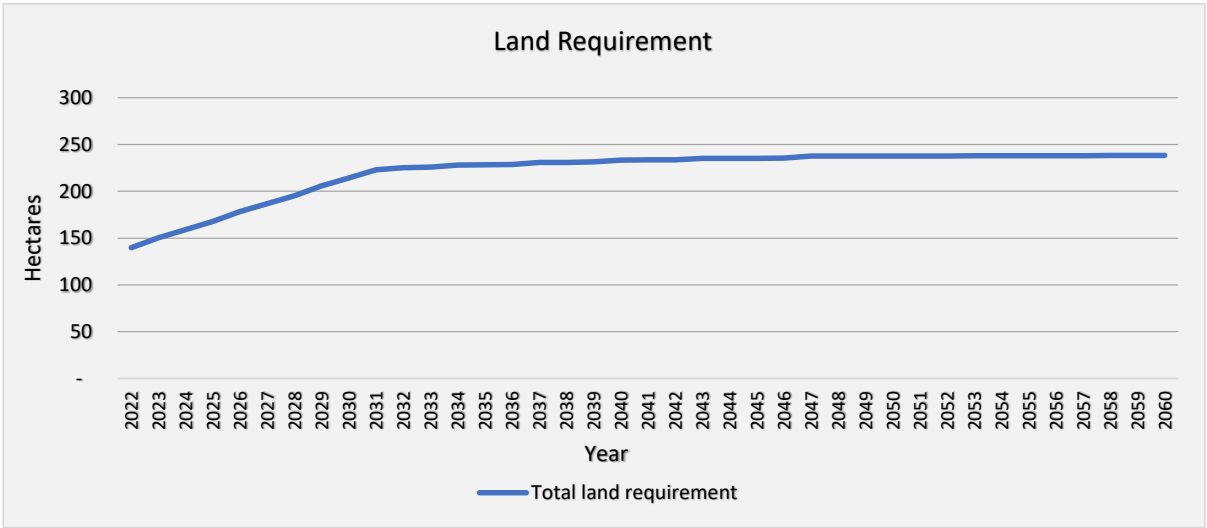
Business as Usual Scenario



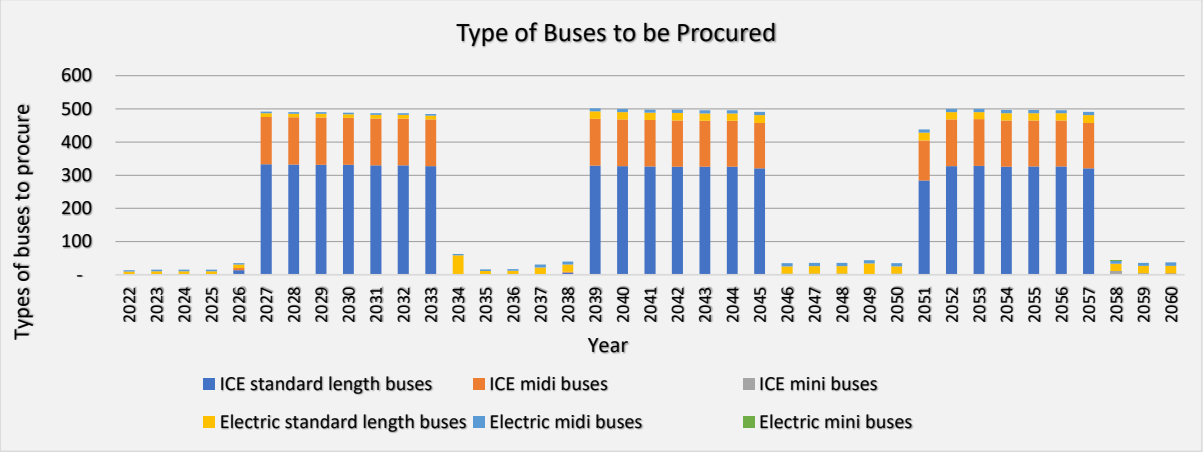
Low Ambition Scenario



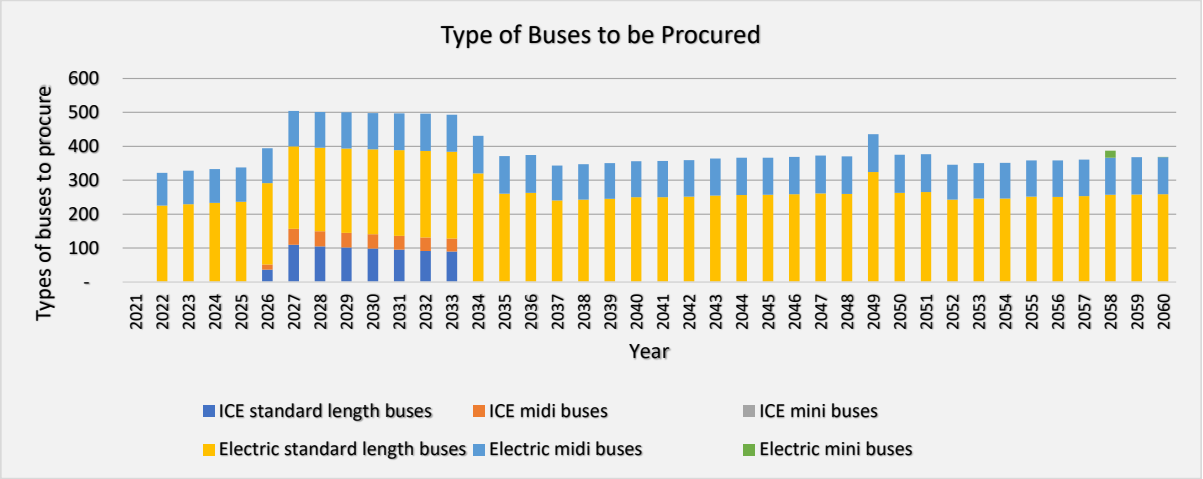
High Ambition Scenario



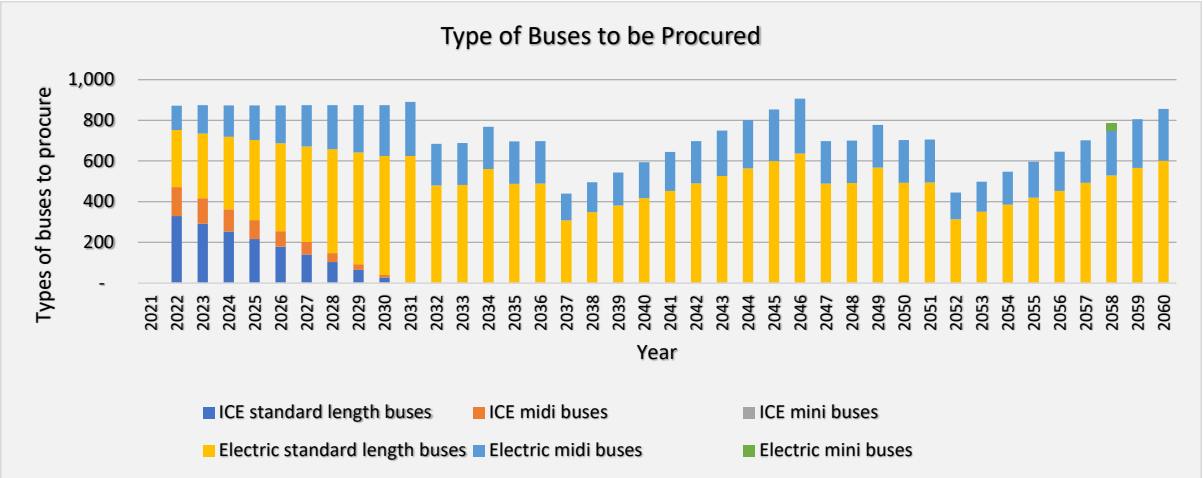
Business as Usual Scenario



Low Ambition Scenario

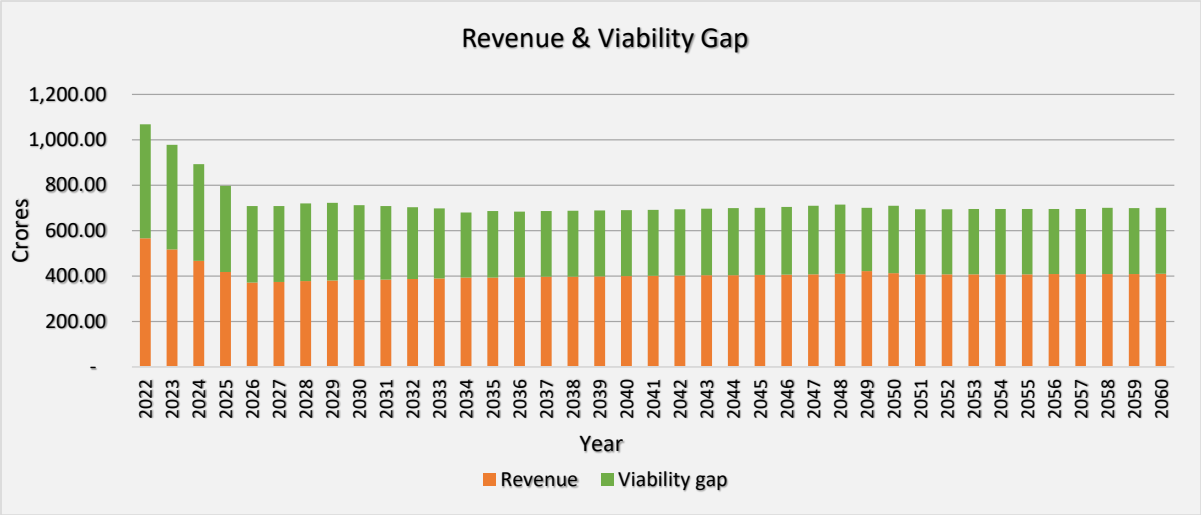


High Ambition Scenario

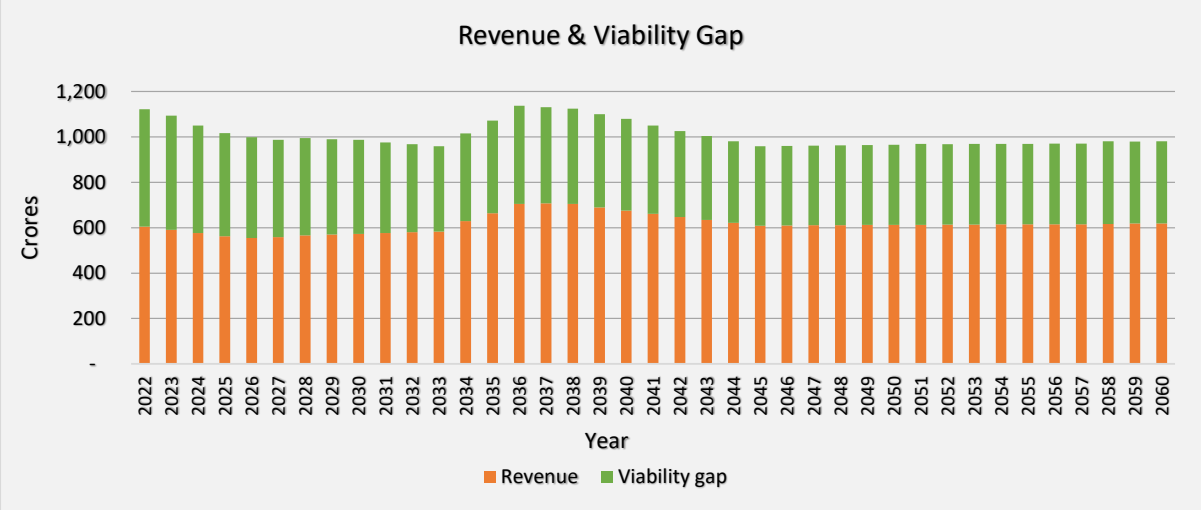


Revenue and Viability Gap: GCC Model

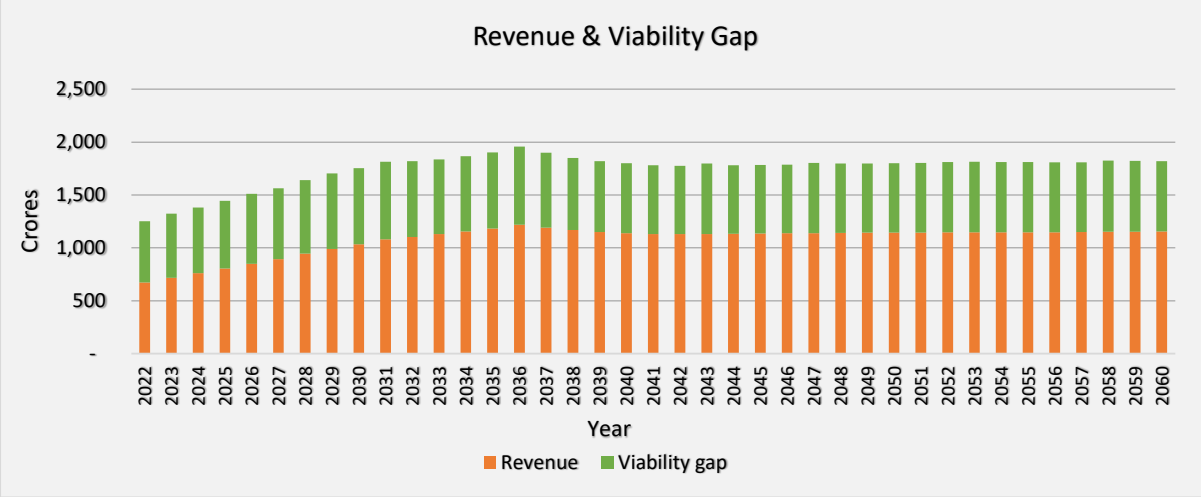
Business as Usual Scenario



Low Ambition Scenario

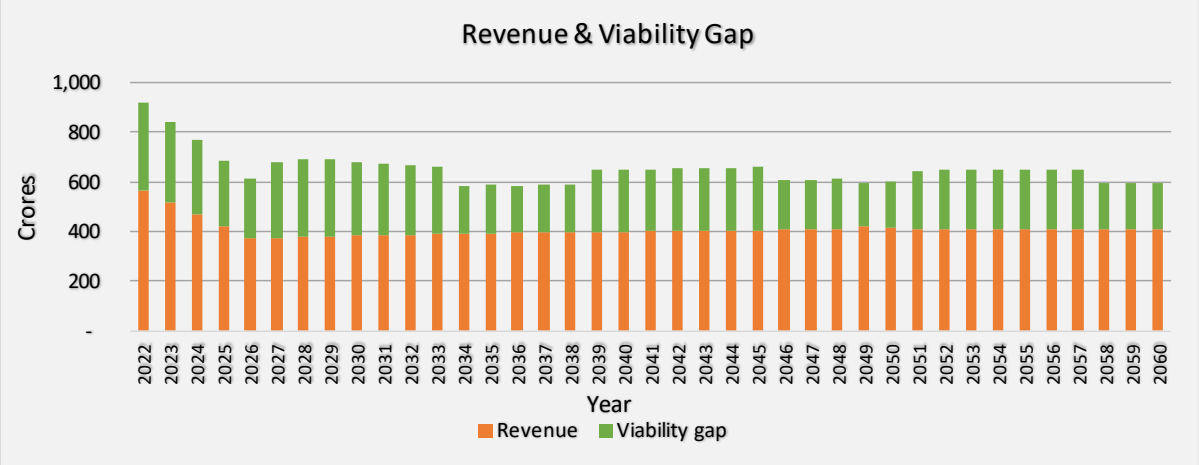


High Ambition Scenario

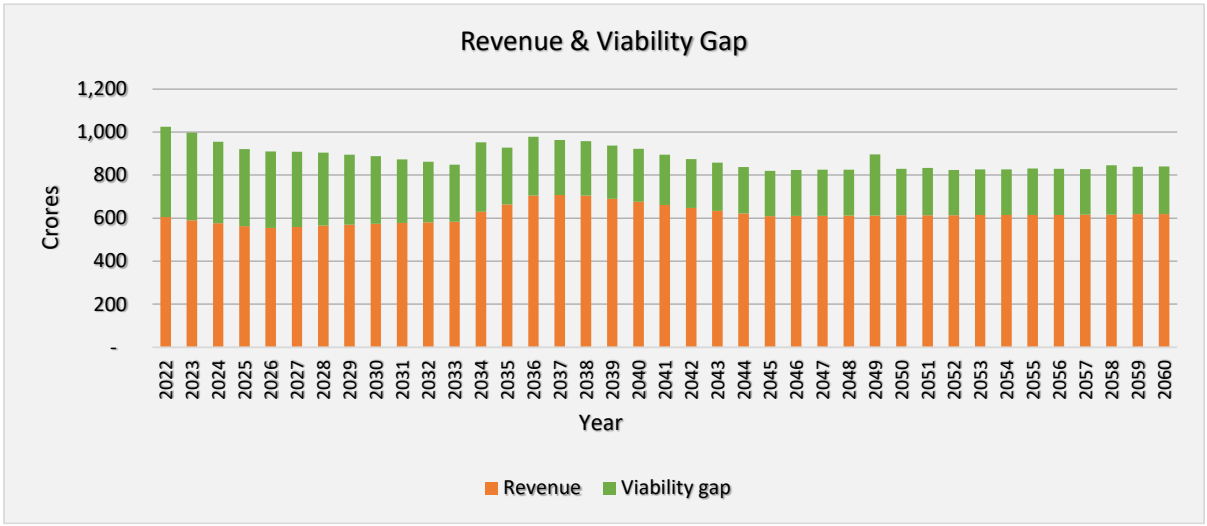


Revenue and Viability Gap: Outright Purchase Model

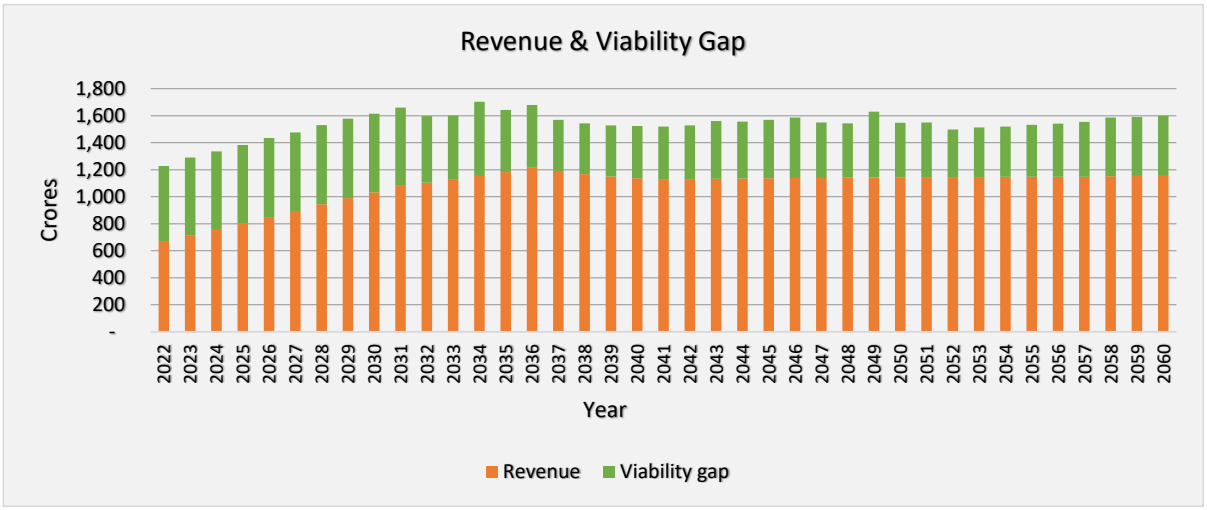
Business as usual Scenario



Low Ambition Scenario

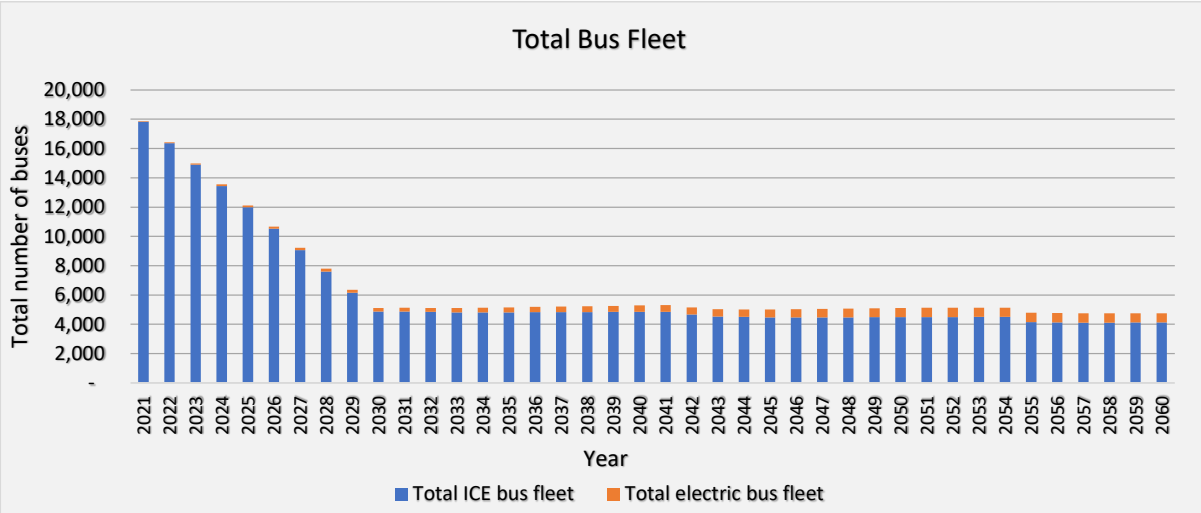


High Ambition Scenario

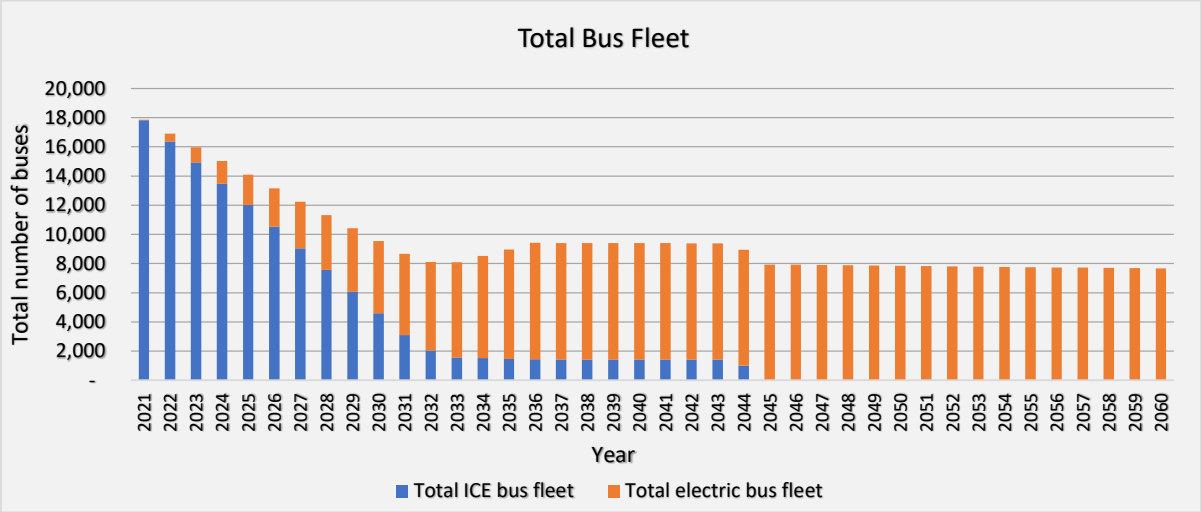


15. State / UT: Jammu and Kashmir

Business as usual Scenario



Low Ambition Scenario



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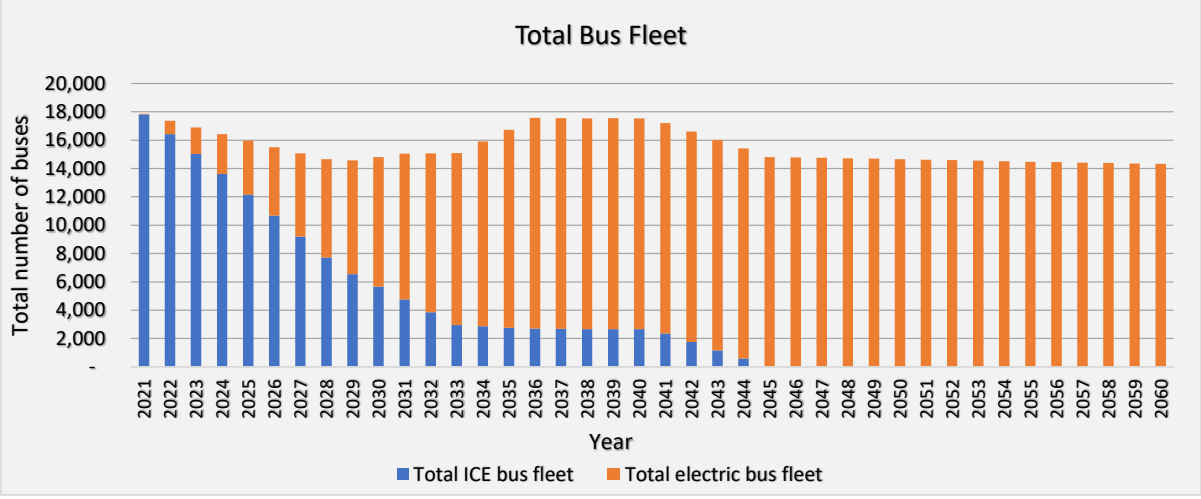
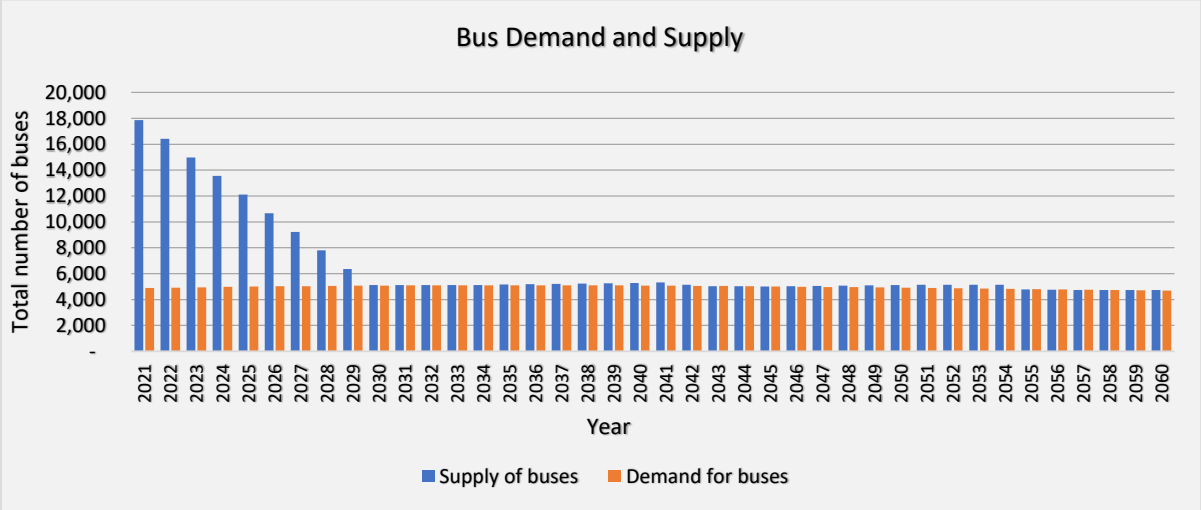


Business as Usual Scenario



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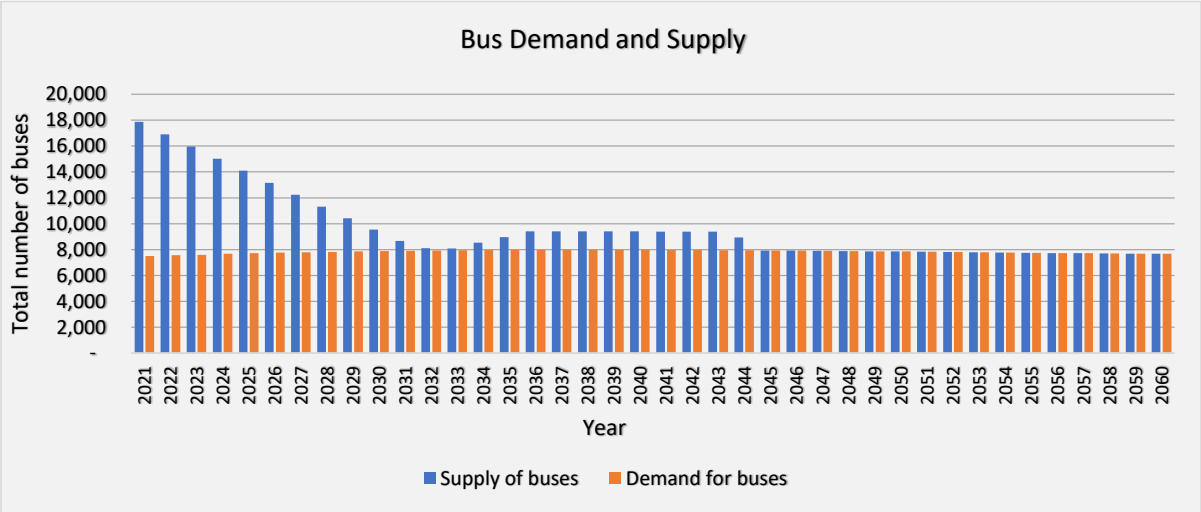
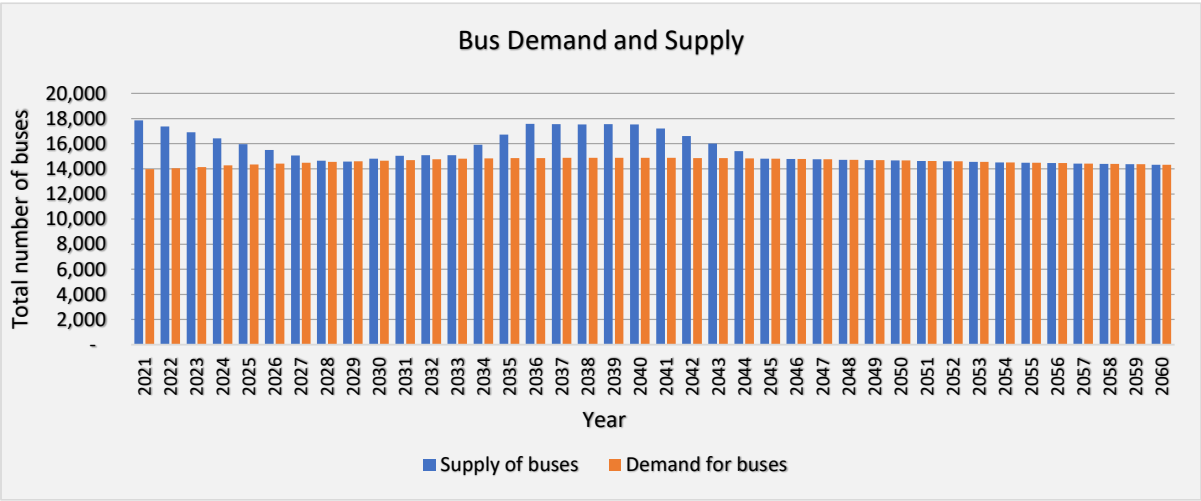
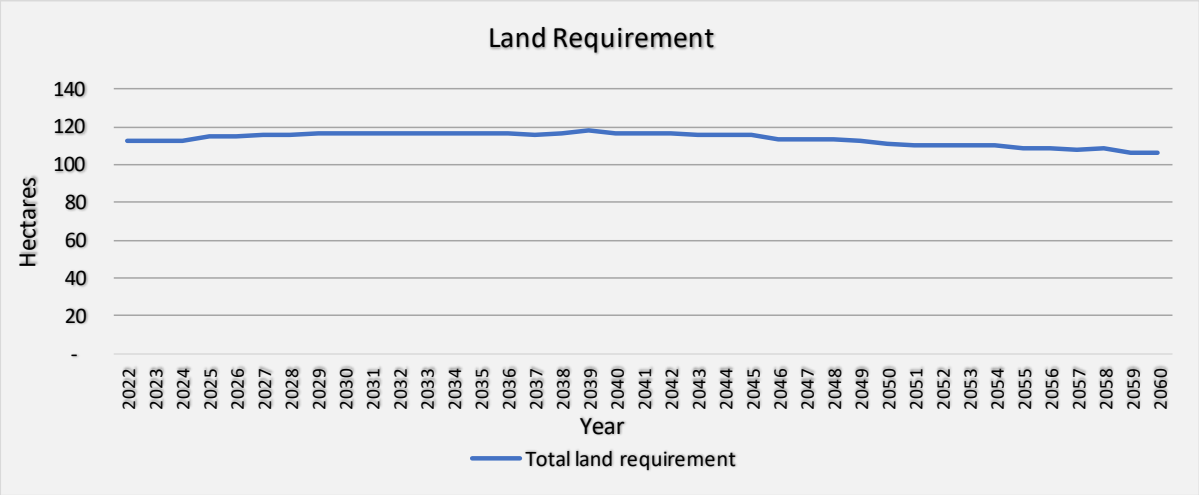


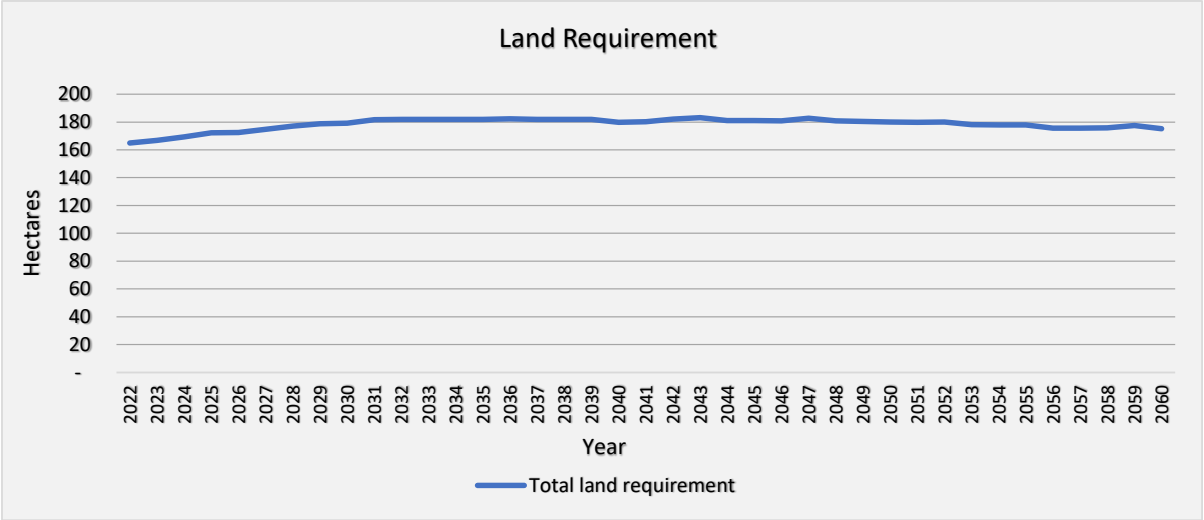
High Ambition Scenario



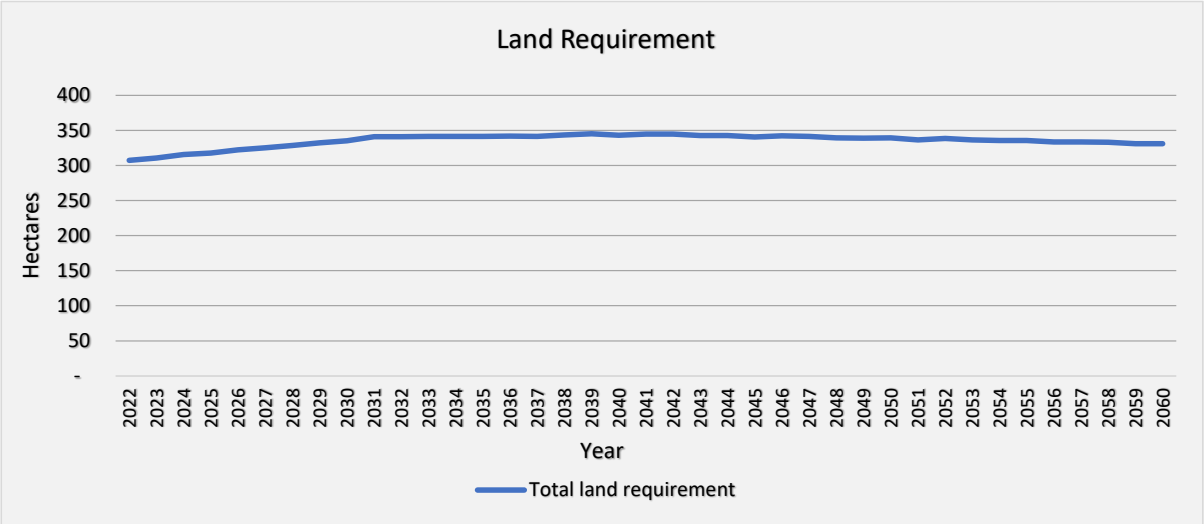
Business as Usual Scenario



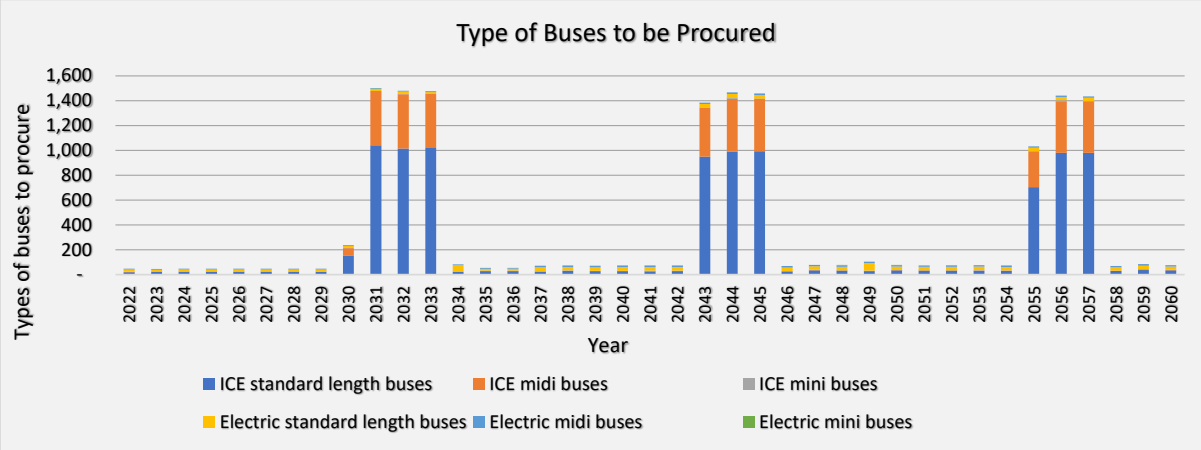
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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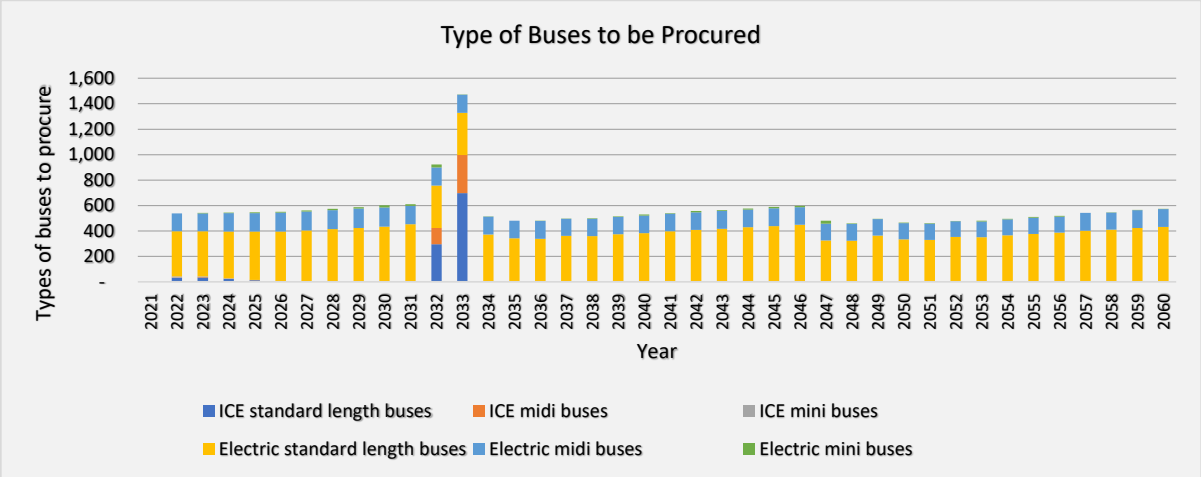
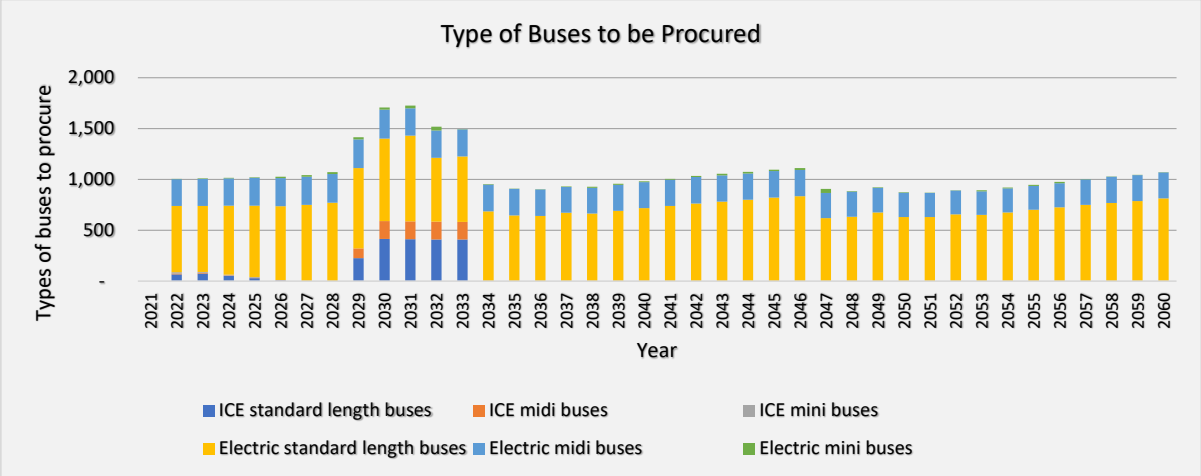
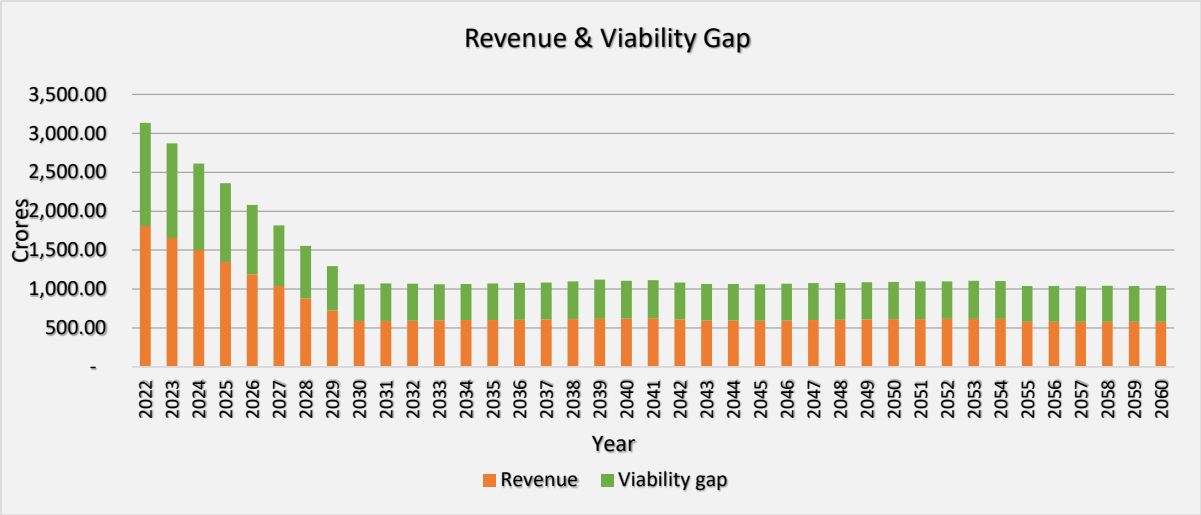


High Ambition Scenario



Revenue and Viability Gap: GCC Model

Business as Usual Scenario



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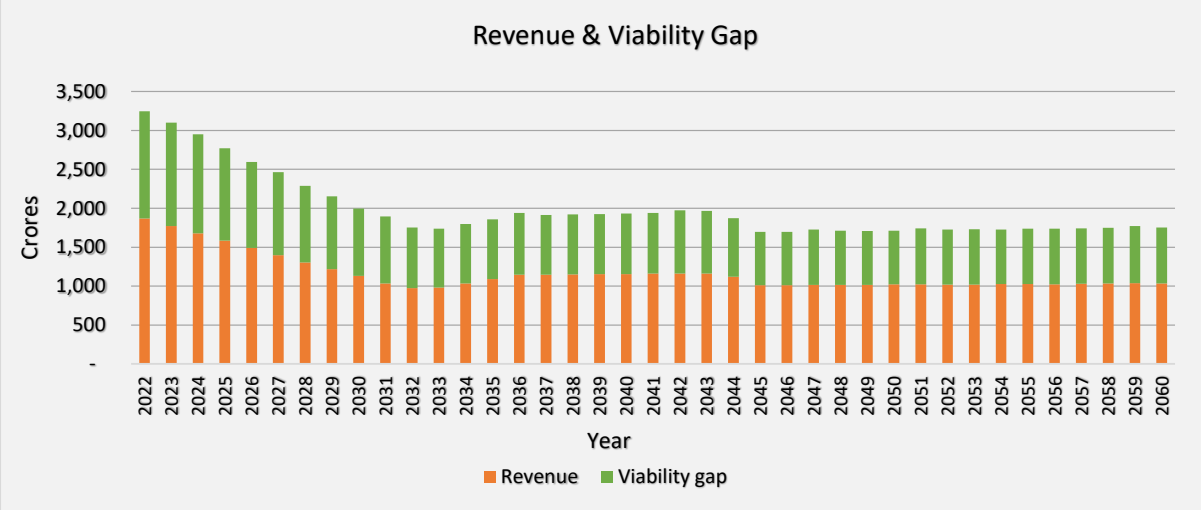
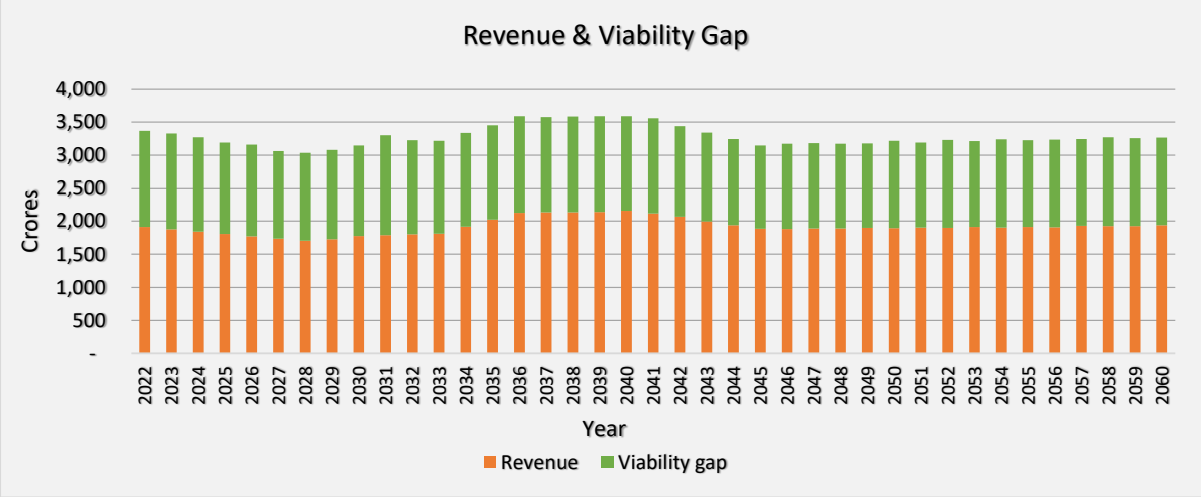
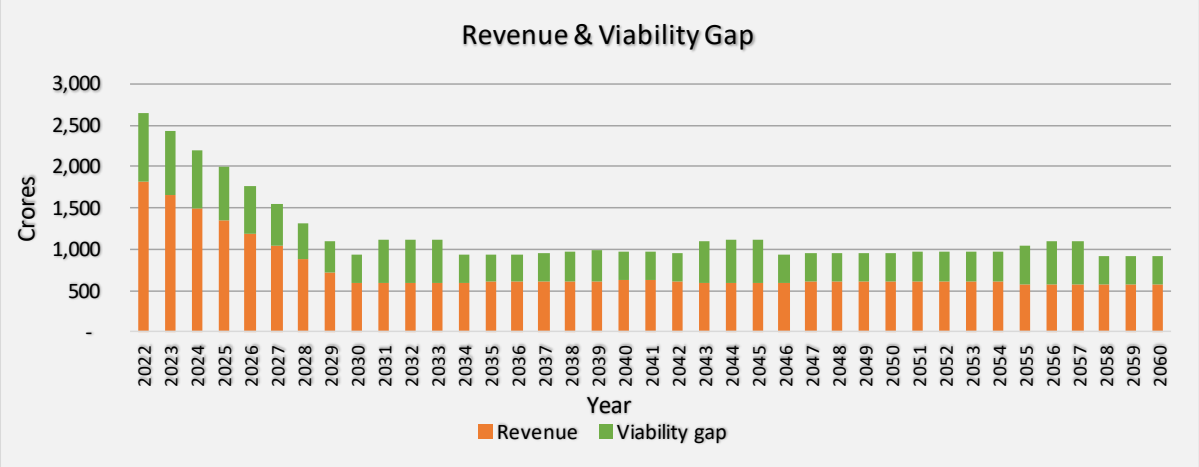


High Ambition Scenario



Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



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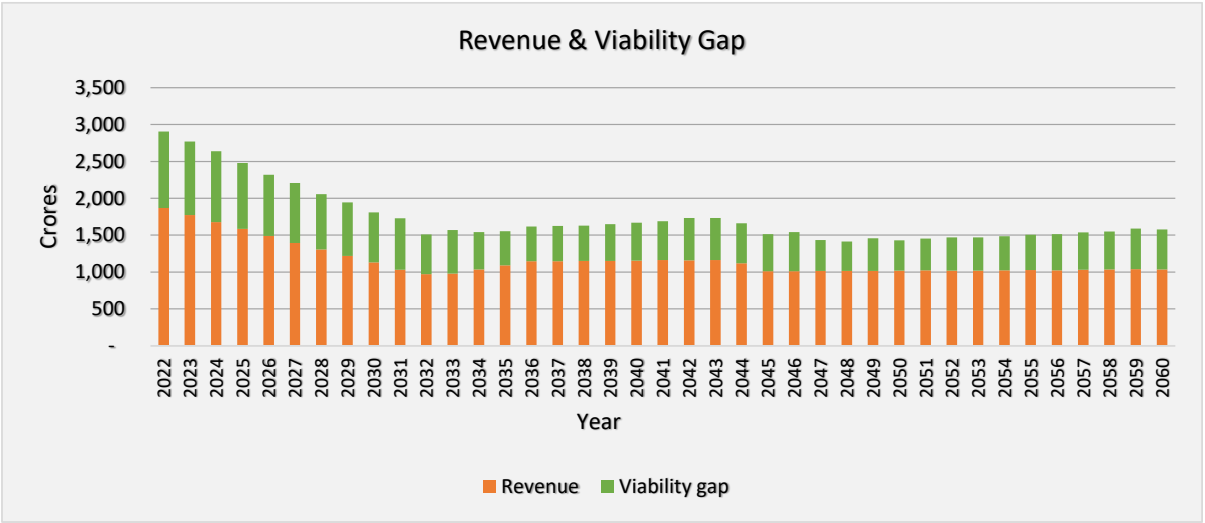

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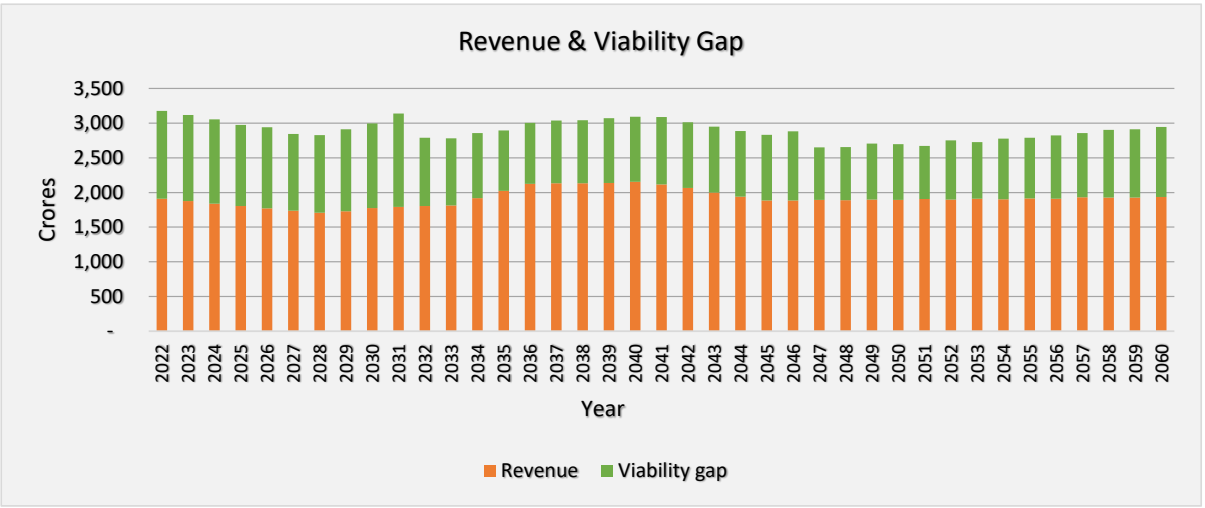
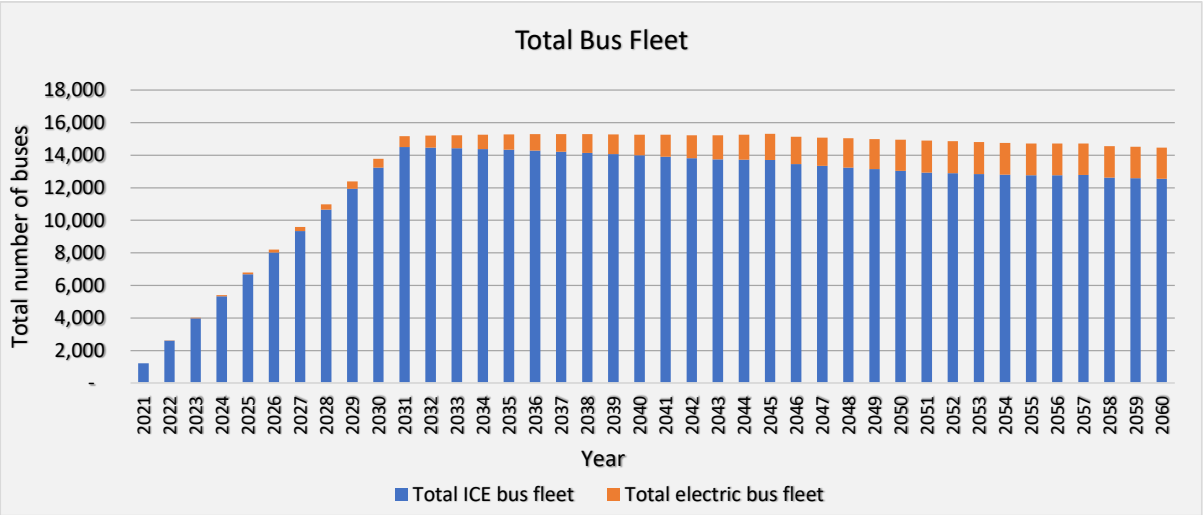


16. State / UT: Jharkhand

Business as usual Scenario



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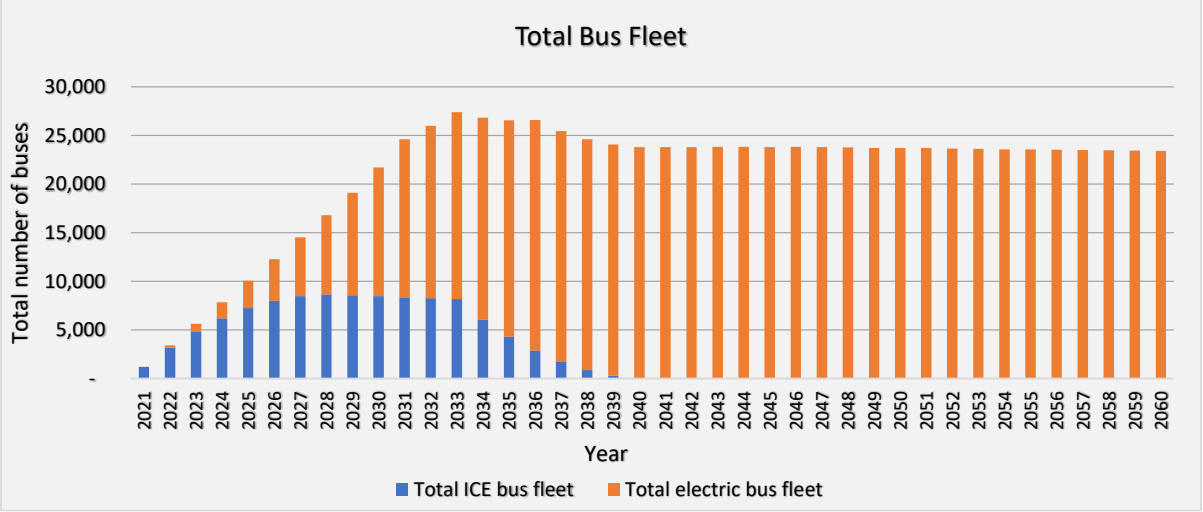

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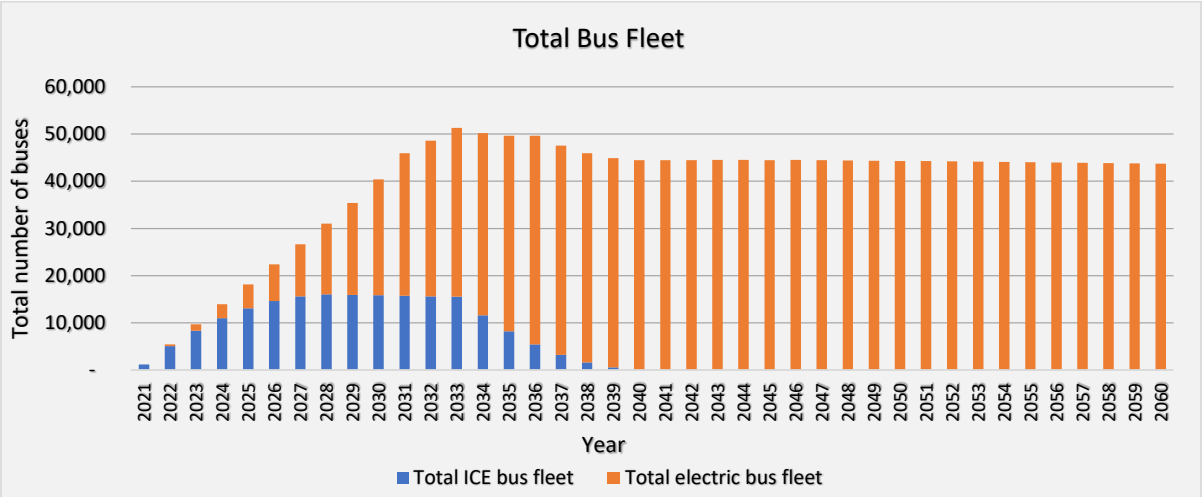
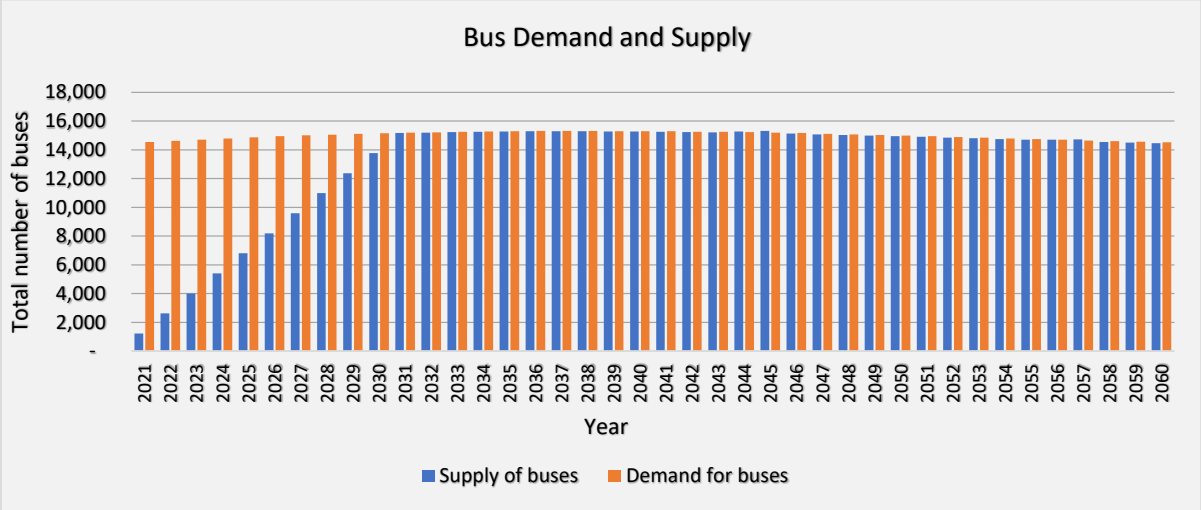


Business as Usual Scenario



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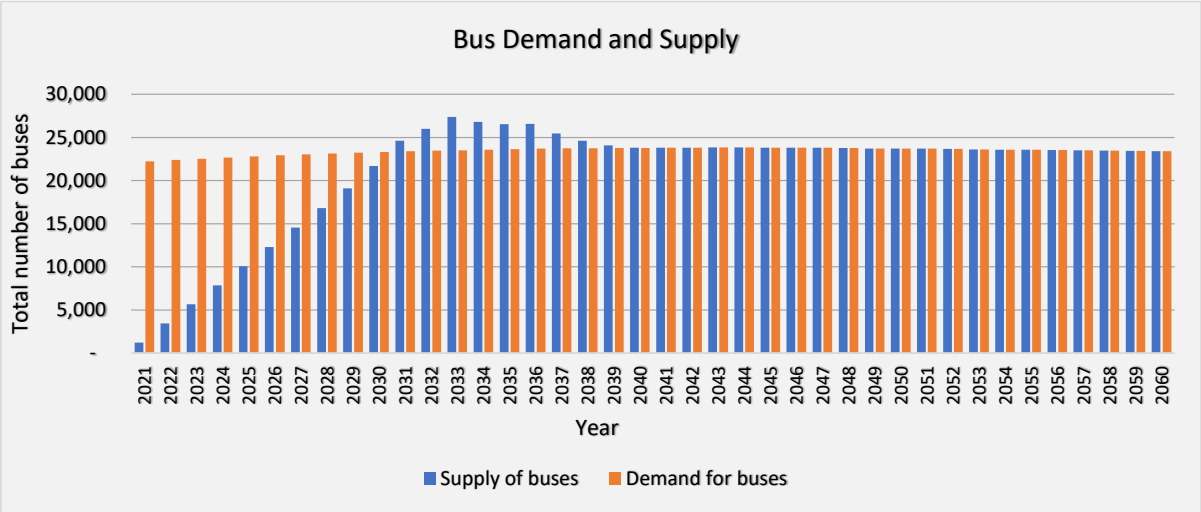

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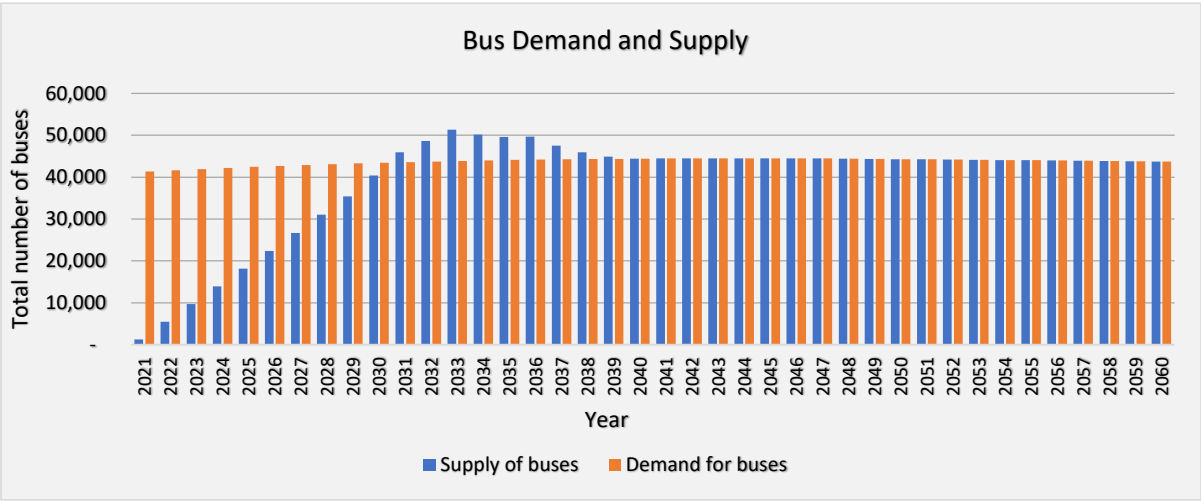
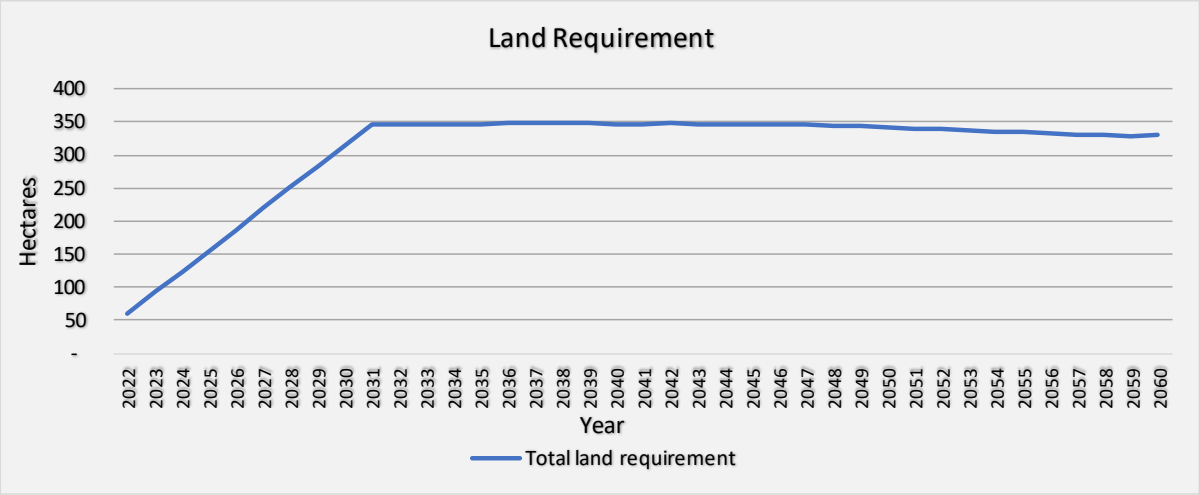
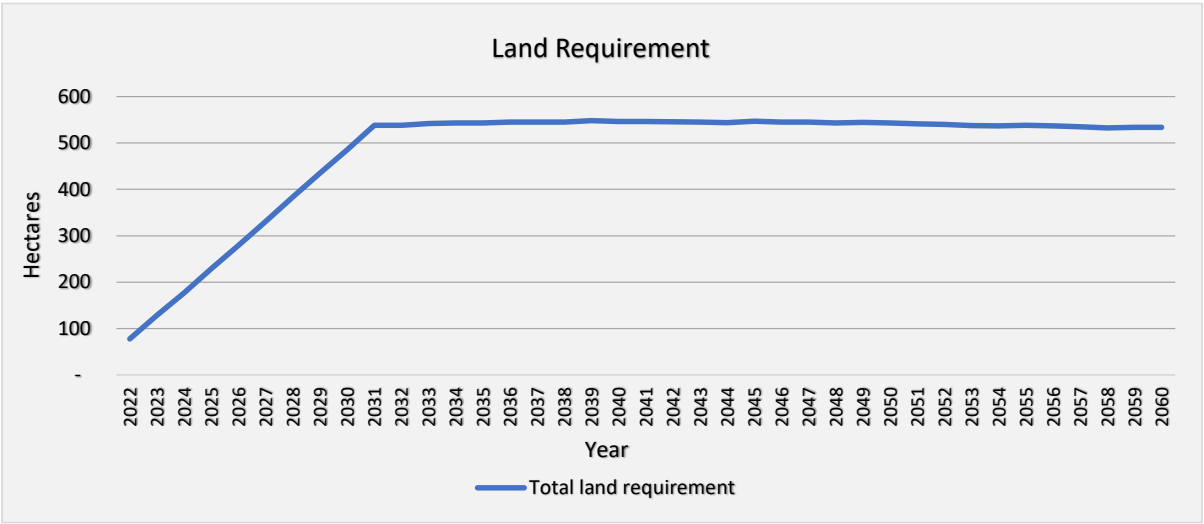


Business as Usual Scenario



Low Ambition Scenario



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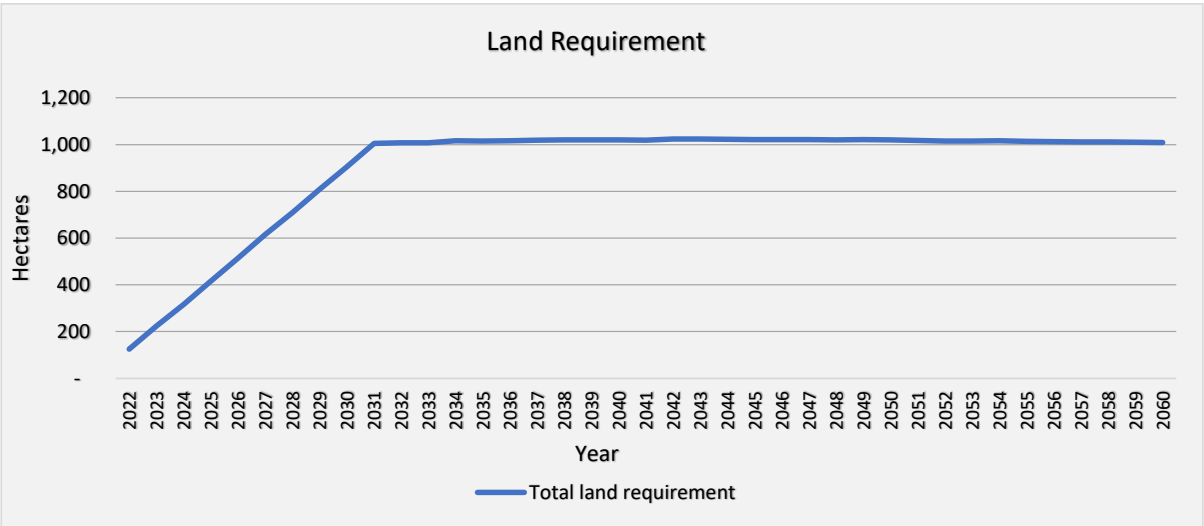
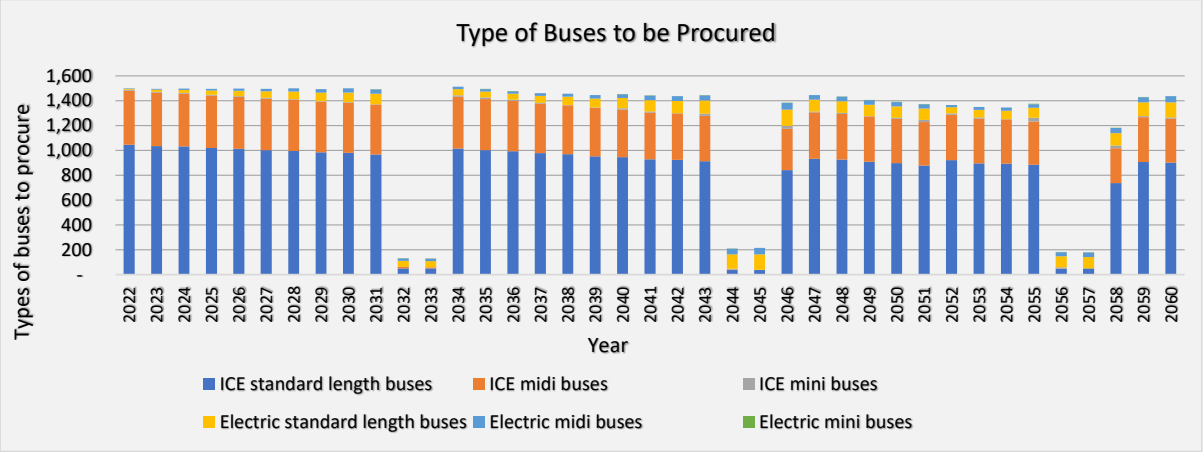


Business as Usual Scenario



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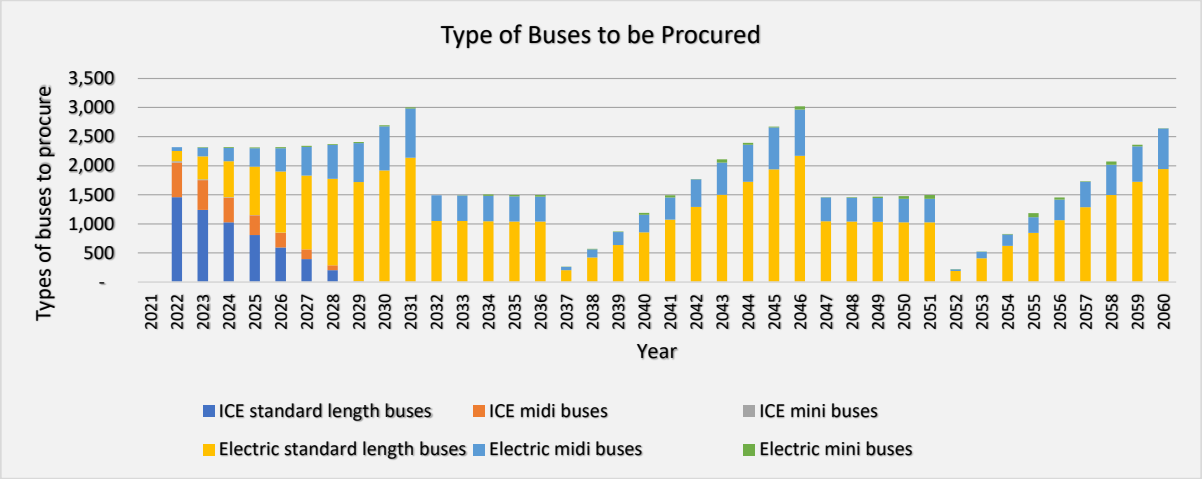
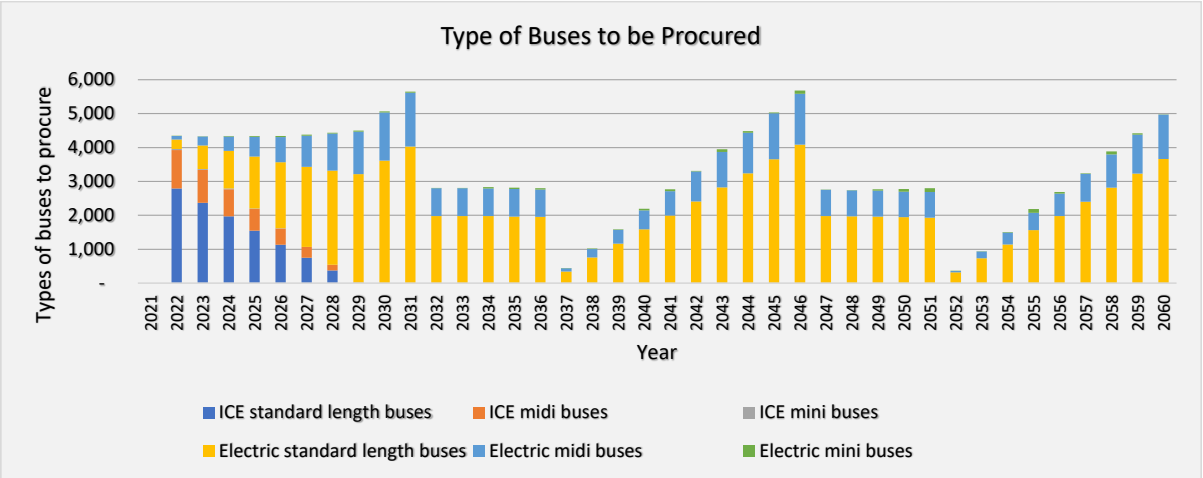
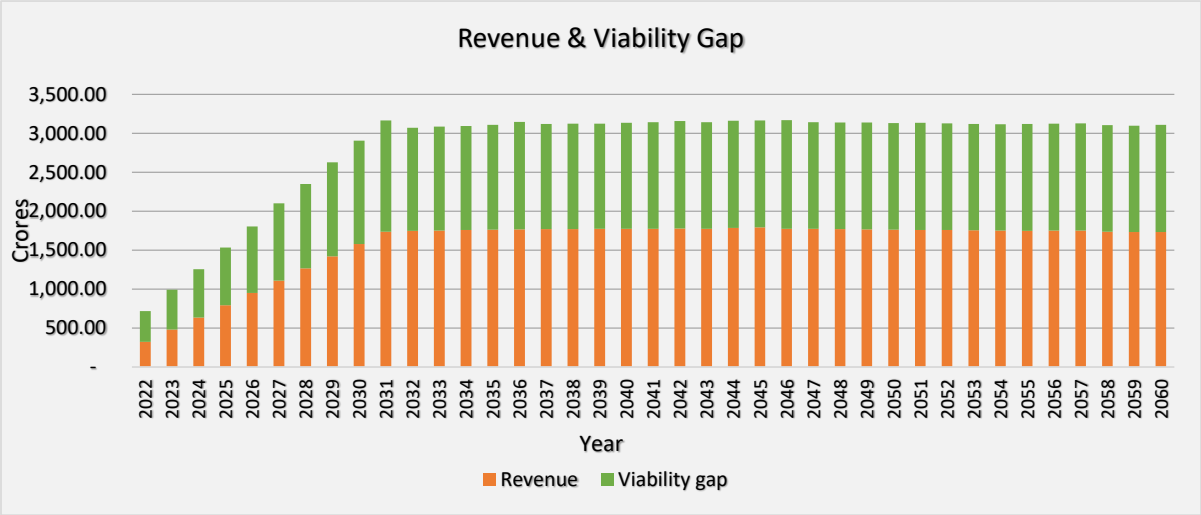


High Ambition Scenario

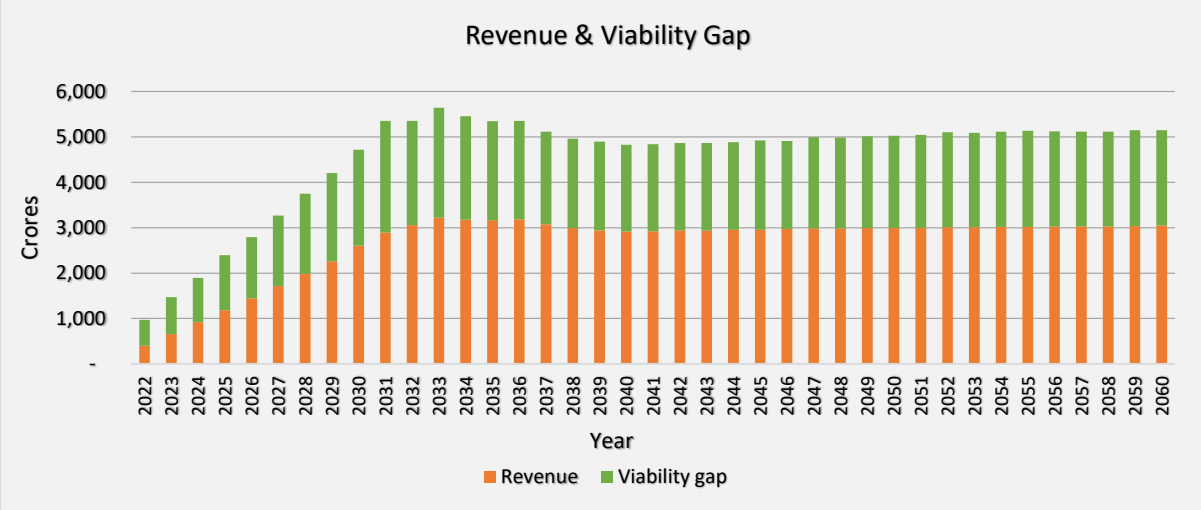


Revenue and Viability Gap: GCC Model

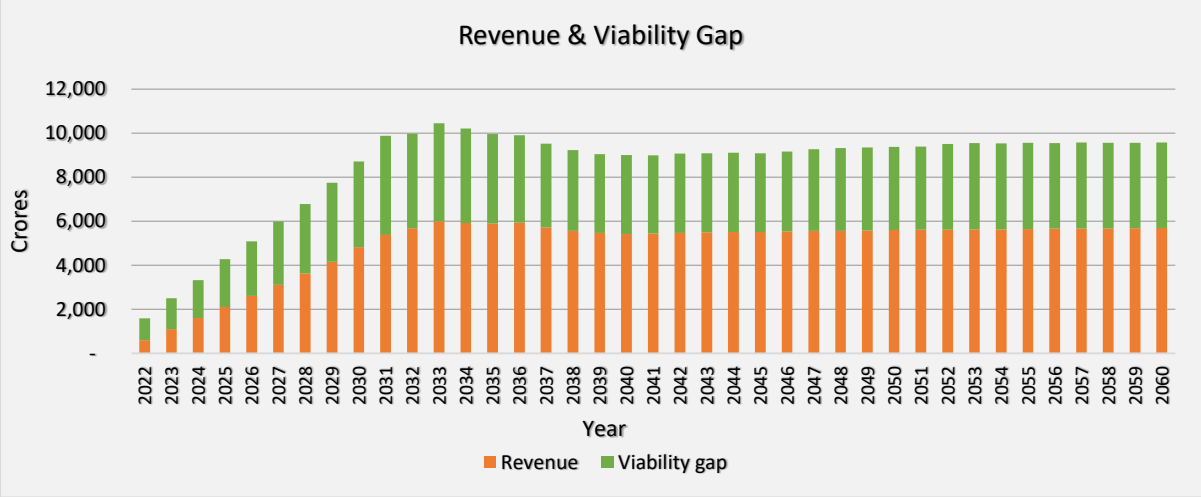
Business as Usual Scenario



Low Ambition Scenario

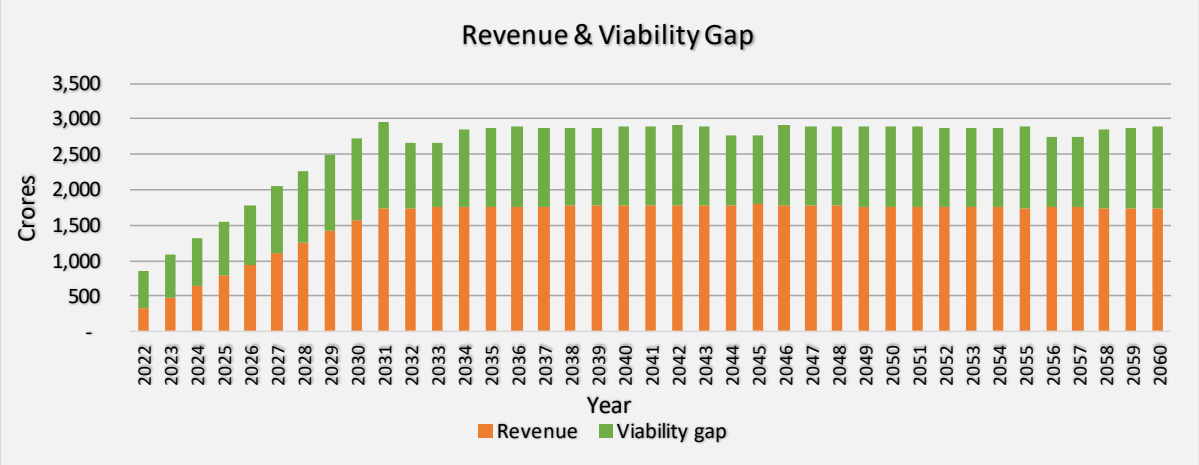


High Ambition Scenario

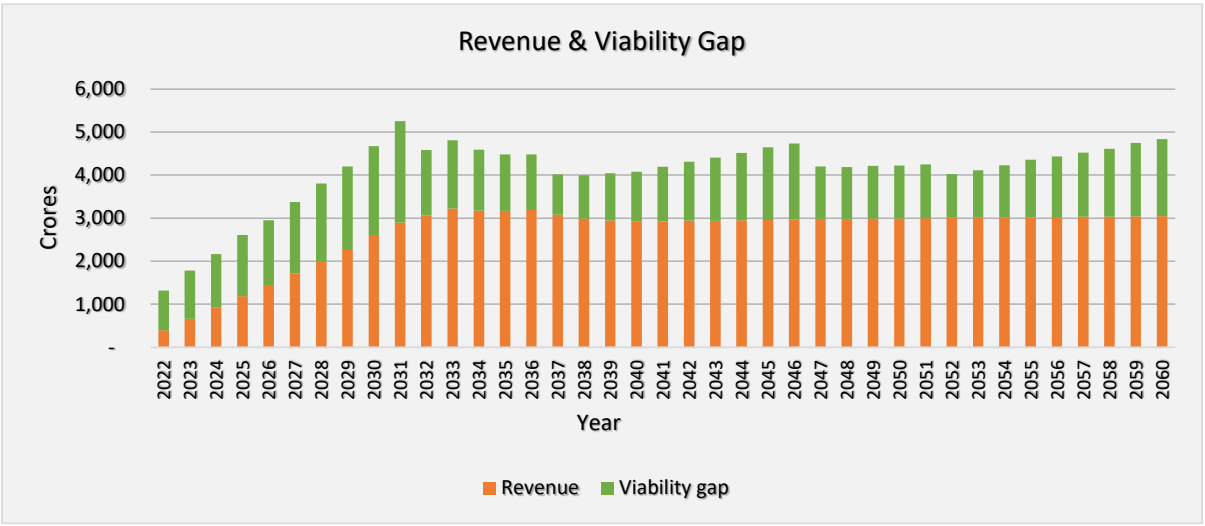


Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



Low Ambition Scenario



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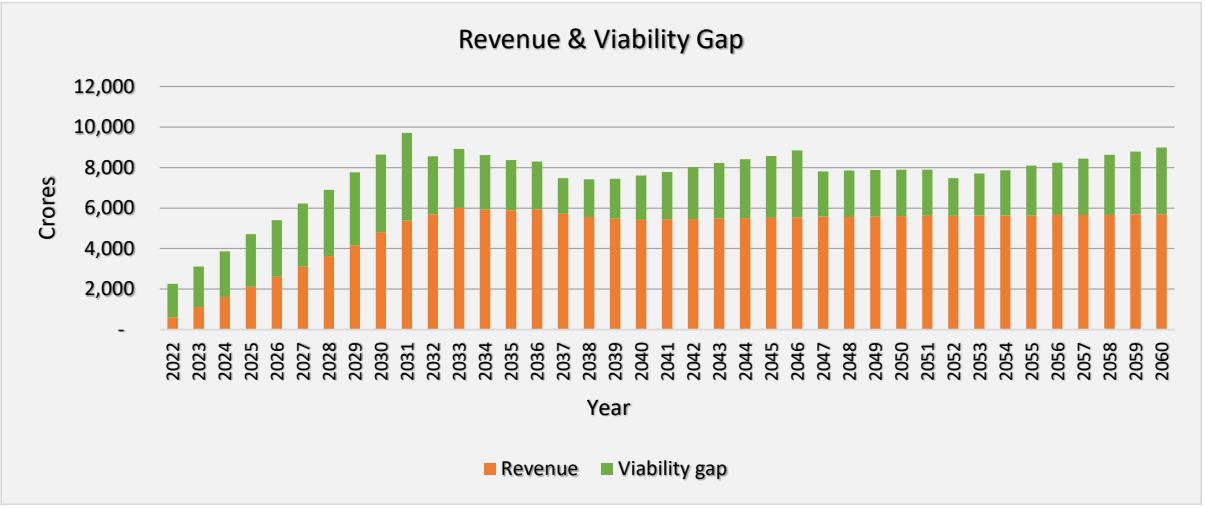
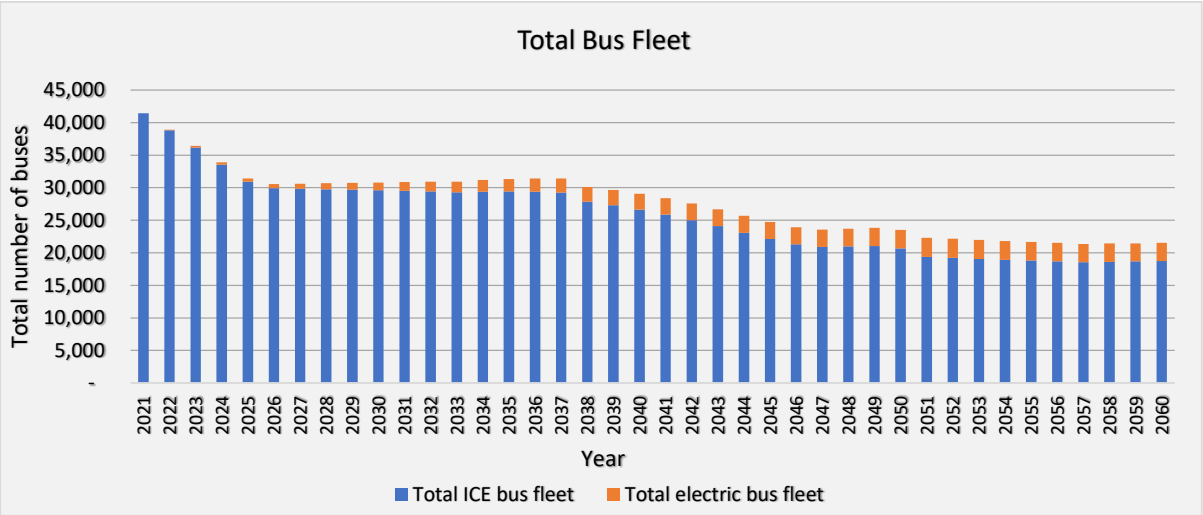
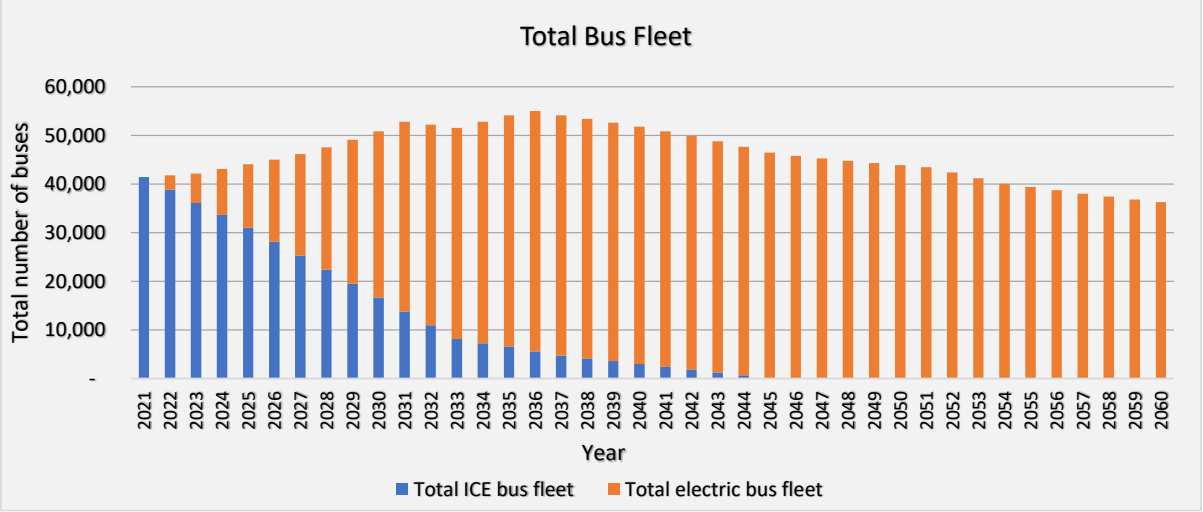


17. State / UT: Karnataka

Business as usual Scenario



Low Ambition Scenario



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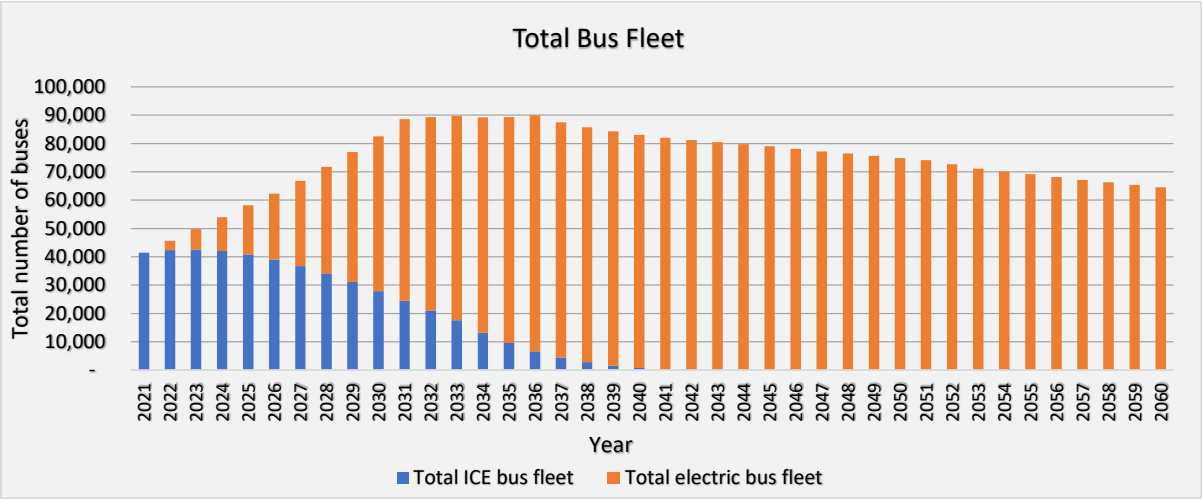
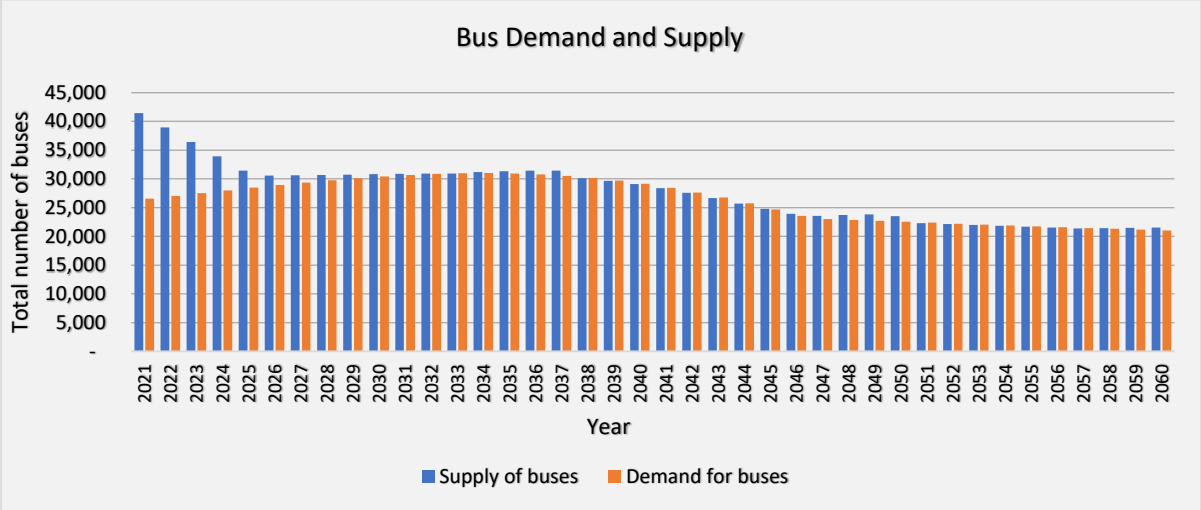


Business as Usual Scenario



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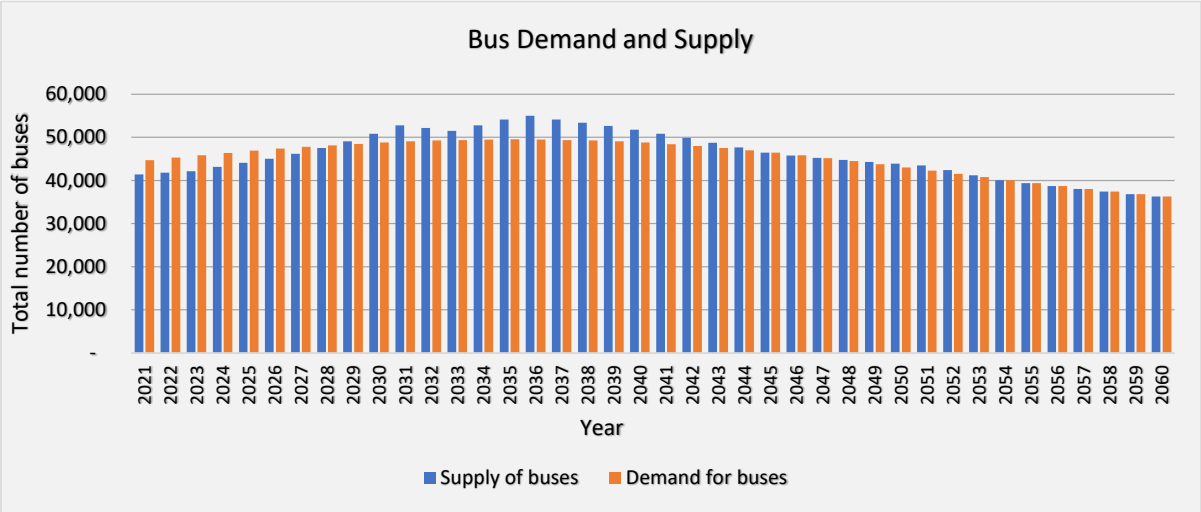
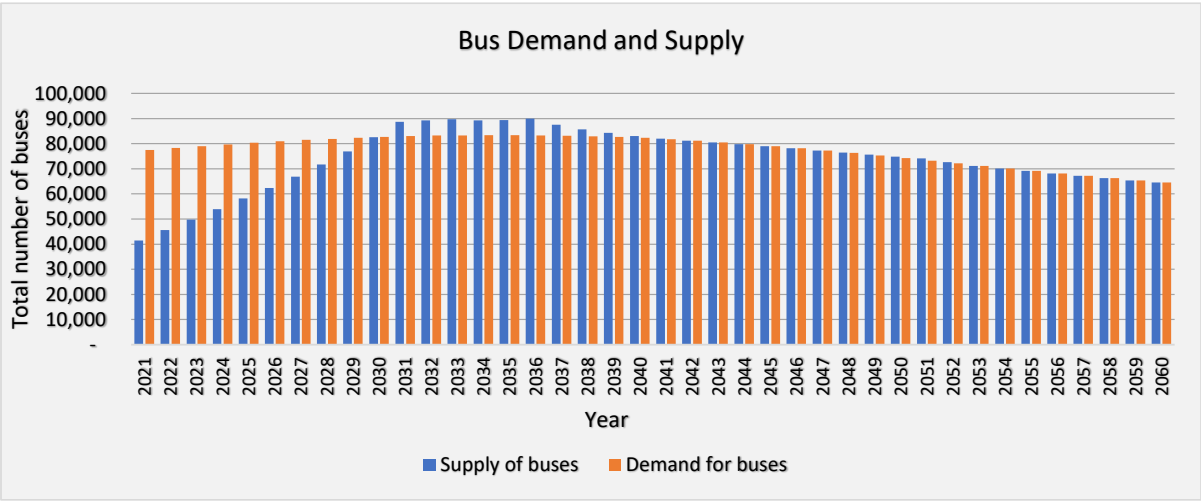
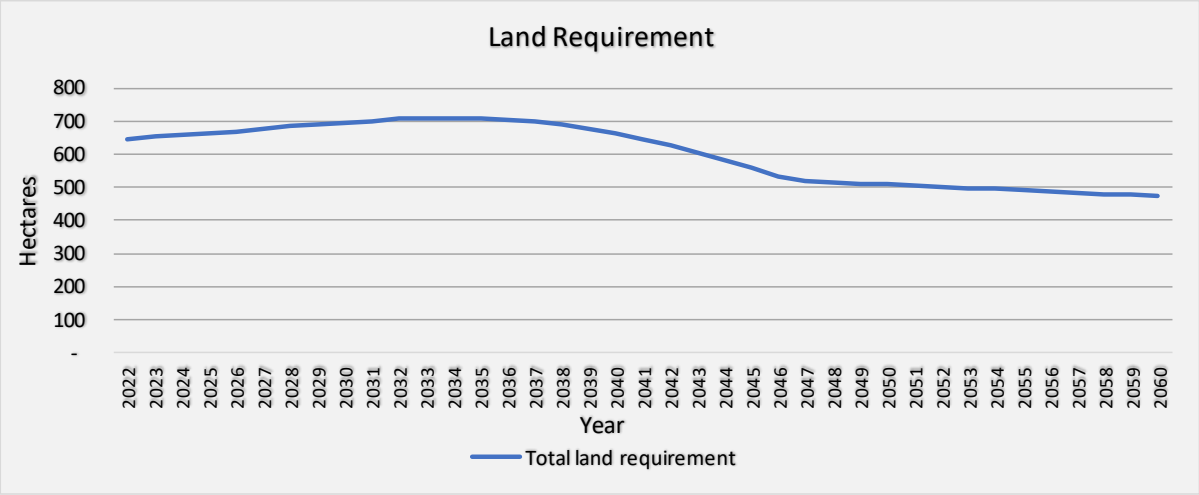


High Ambition Scenario



Business as Usual Scenario



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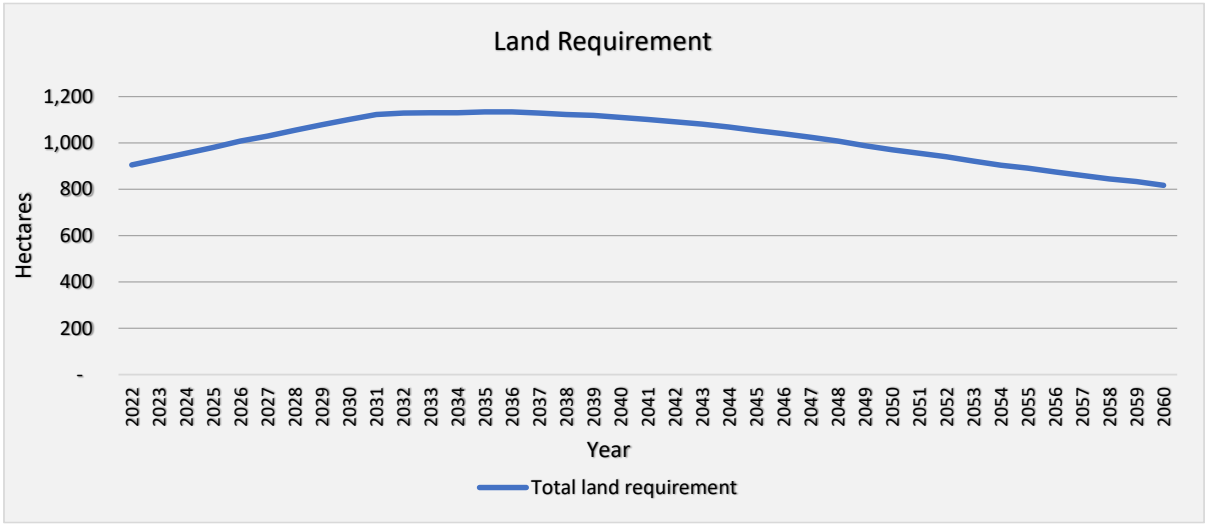
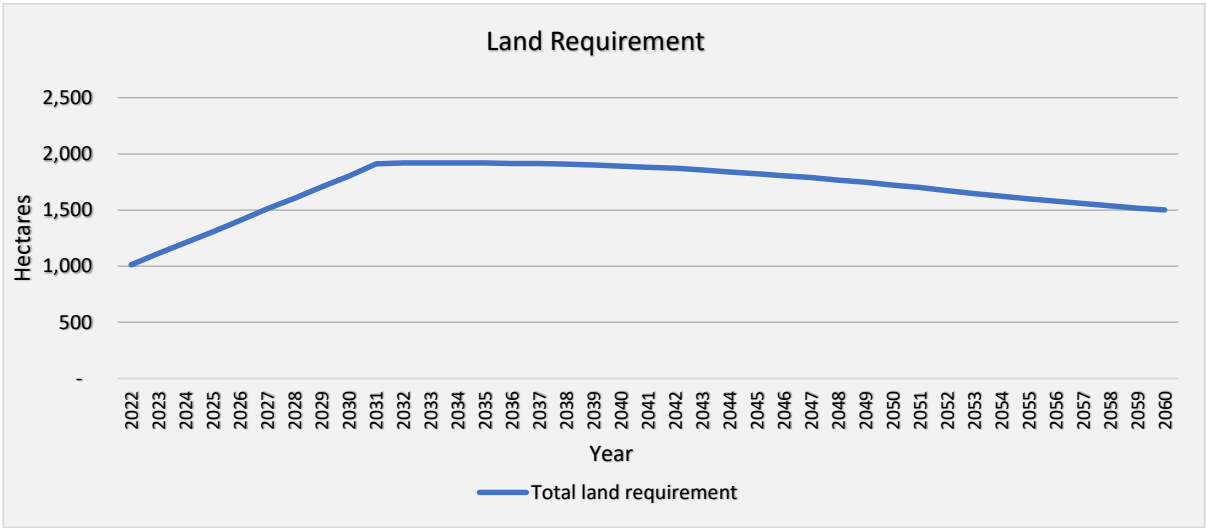
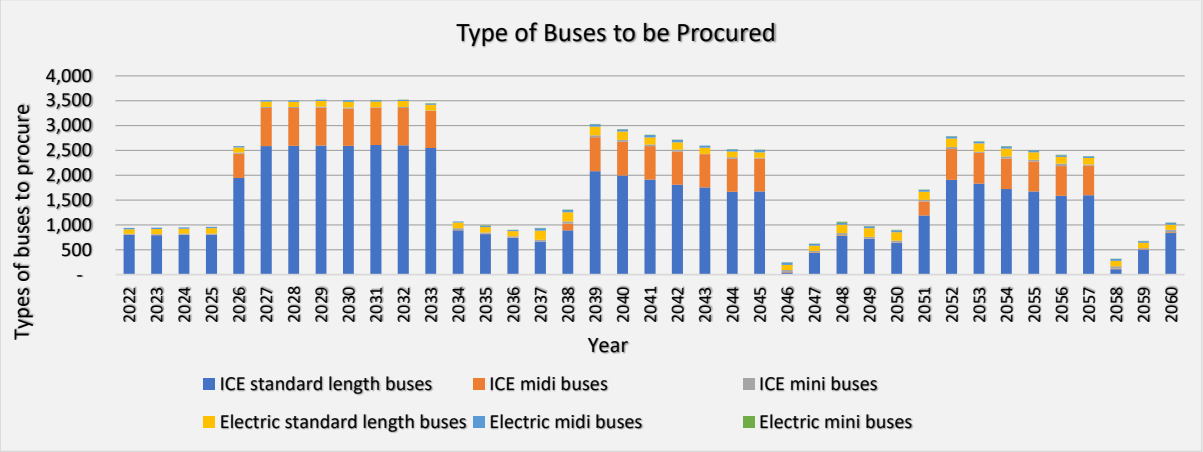


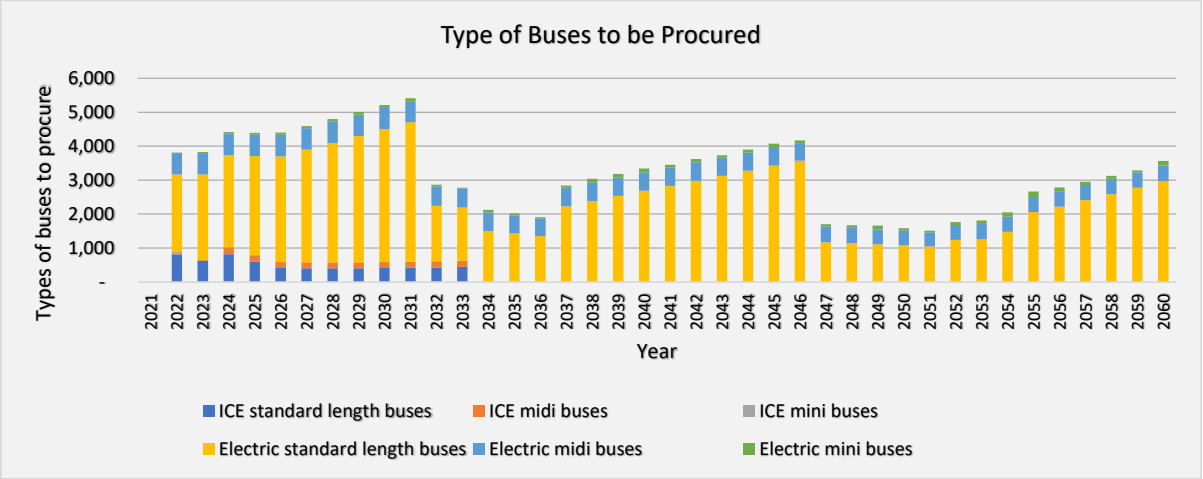
High Ambition Scenario



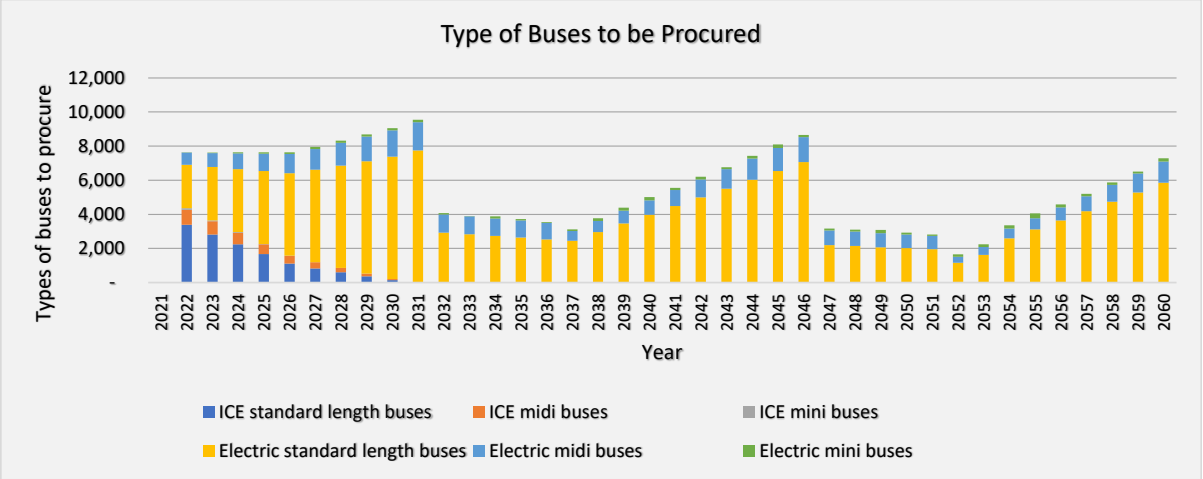
Business as Usual Scenario



Low Ambition Scenario

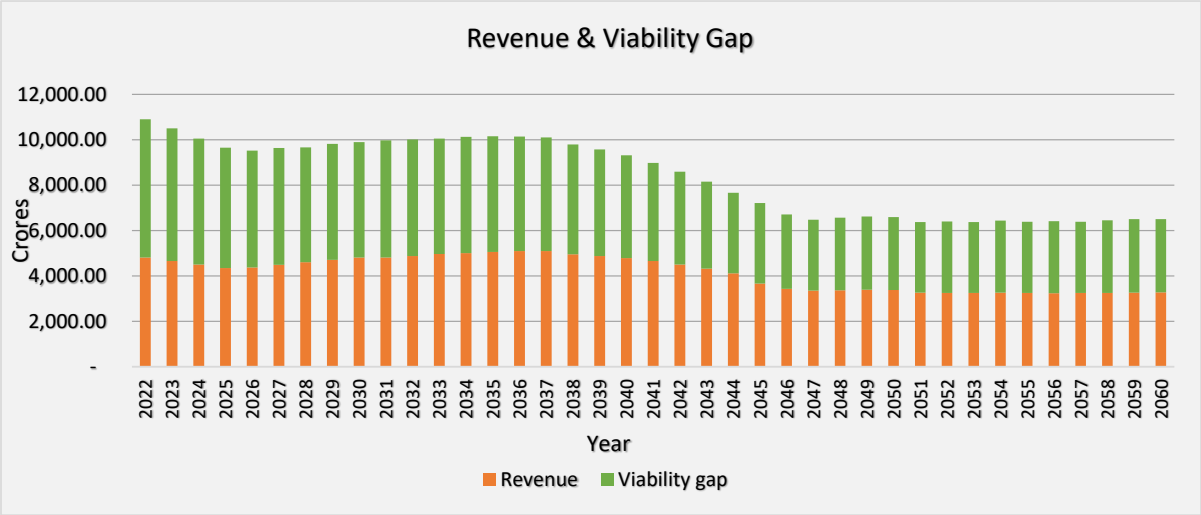


High Ambition Scenario

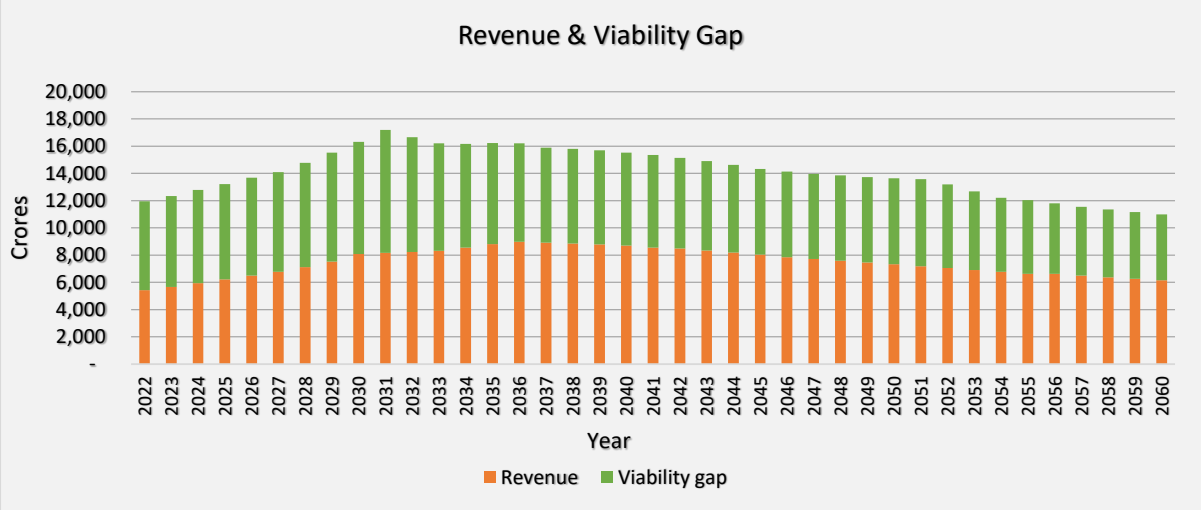


Revenue and Viability Gap: GCC Model

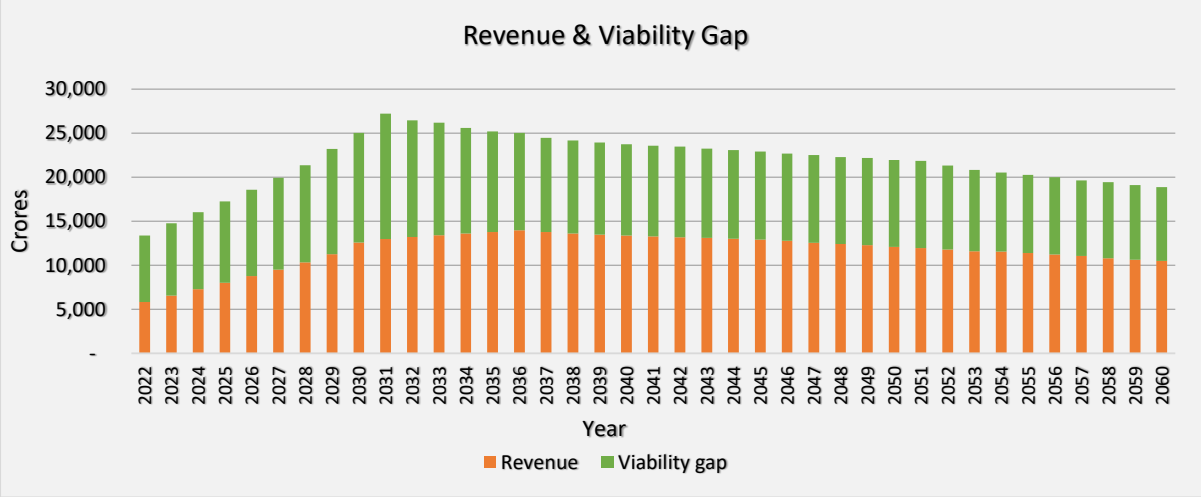
Business as Usual Scenario



Low Ambition Scenario

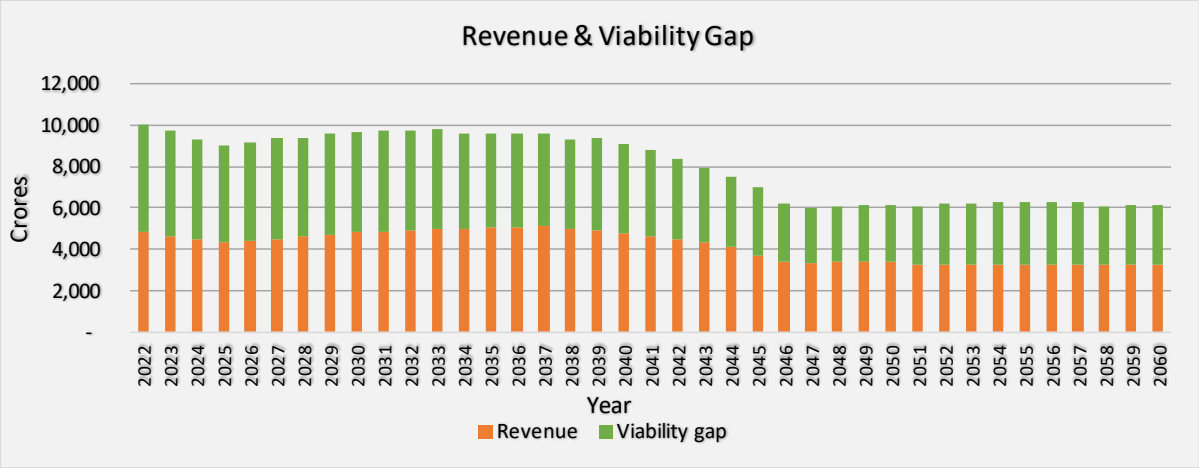


High Ambition Scenario

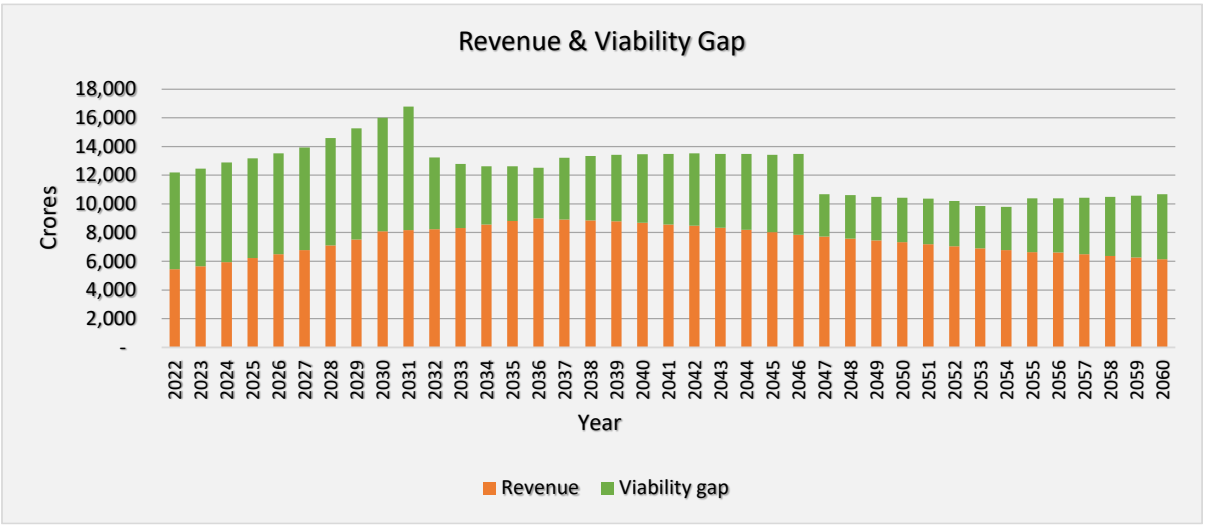


Revenue and Viability Gap: Outright Purchase Model

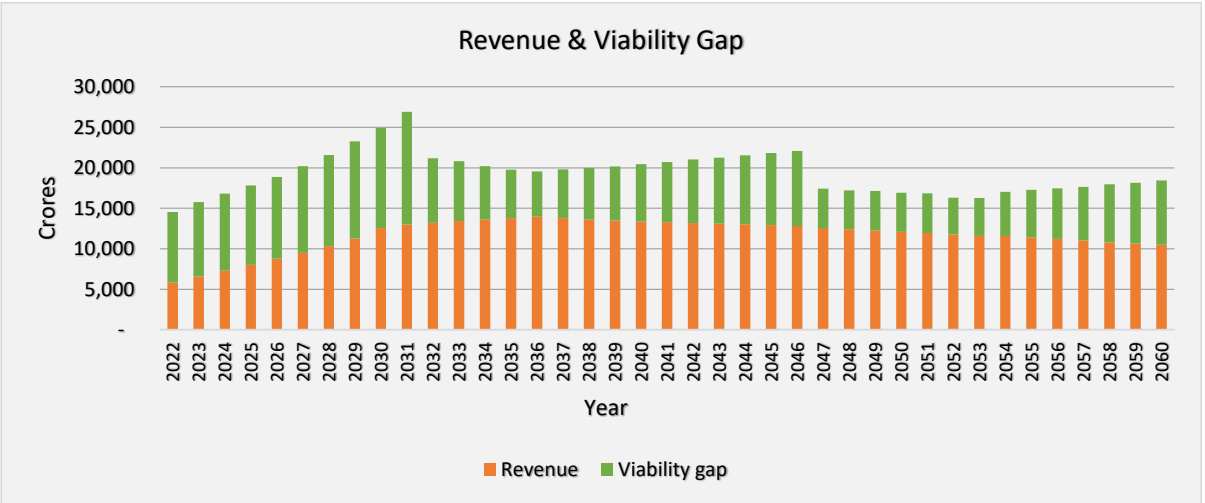
Business as usual Scenario



Low Ambition Scenario

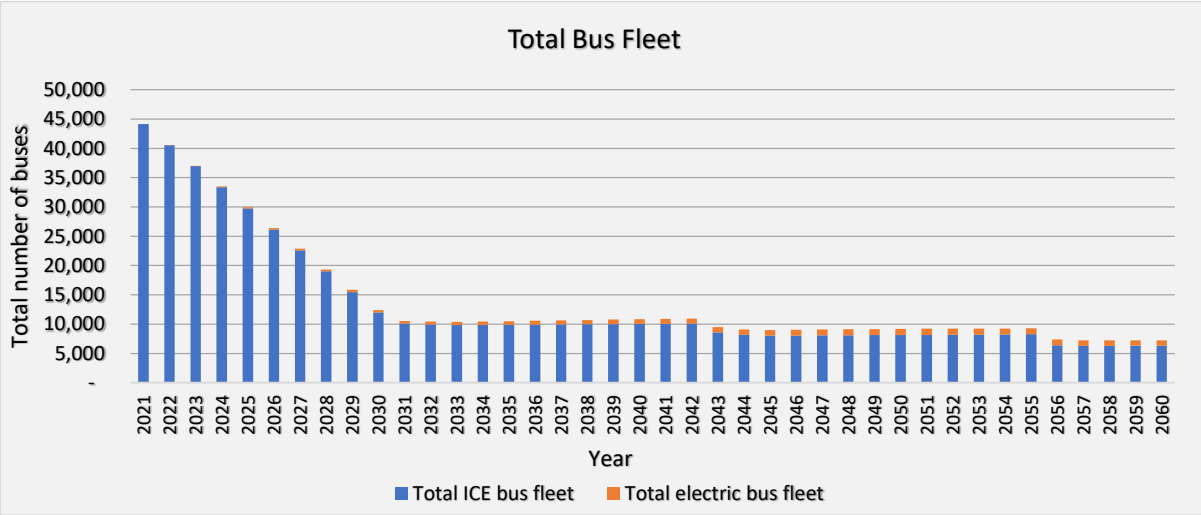


High Ambition Scenario

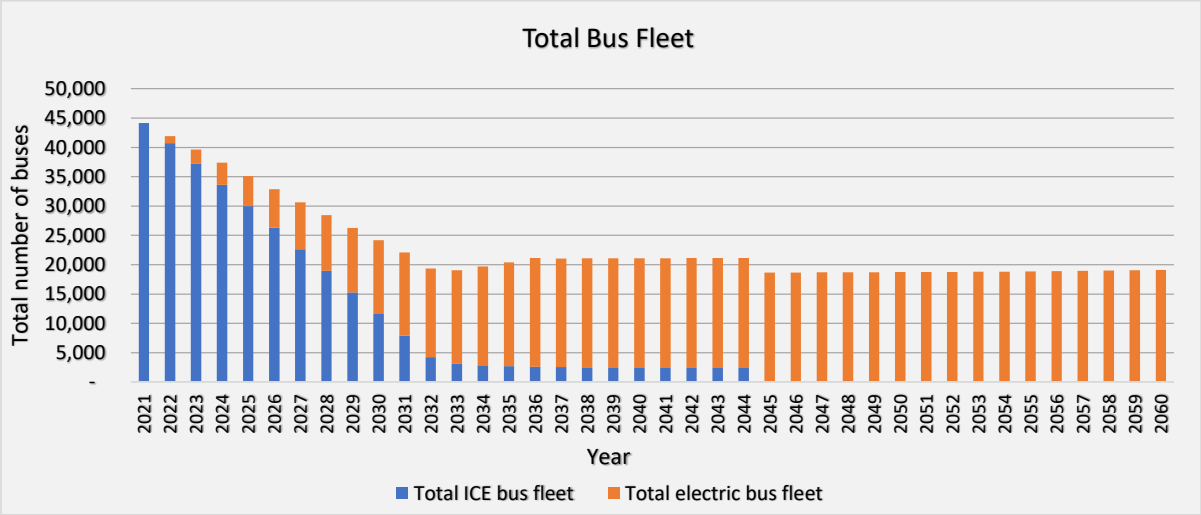


18. State / UT: Kerala

Business as usual Scenario



Low Ambition Scenario



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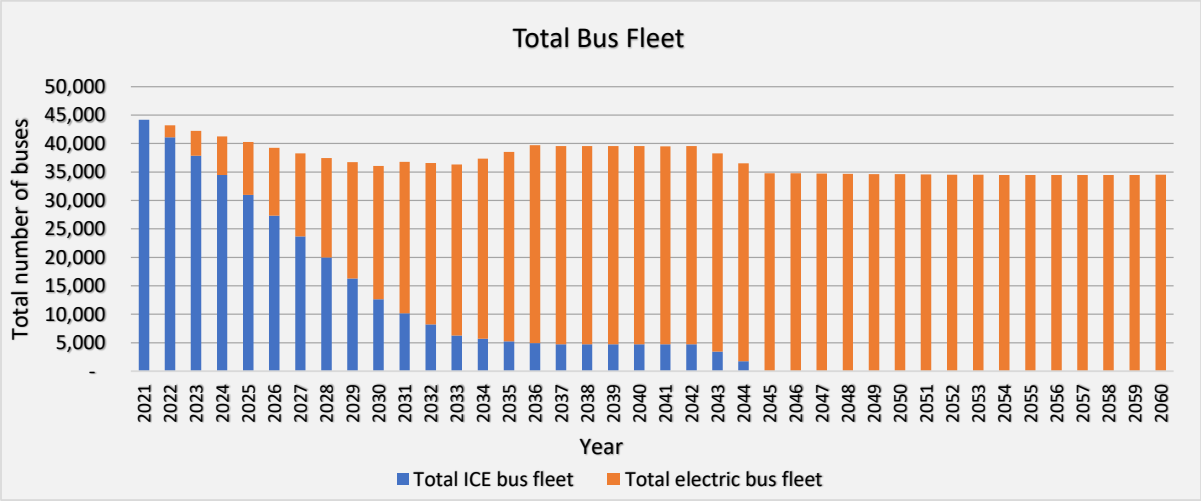
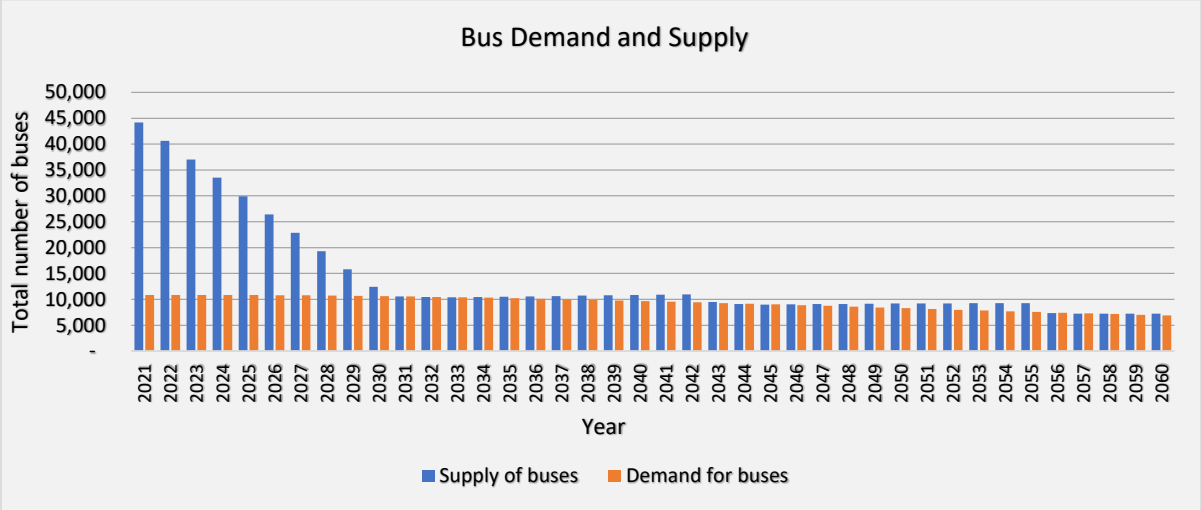


Business as Usual Scenario



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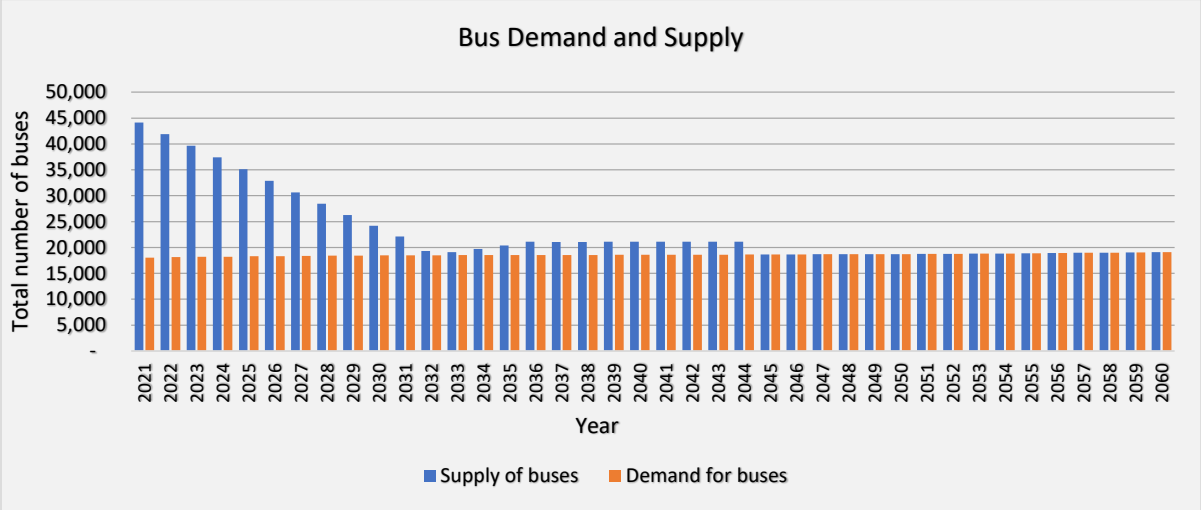
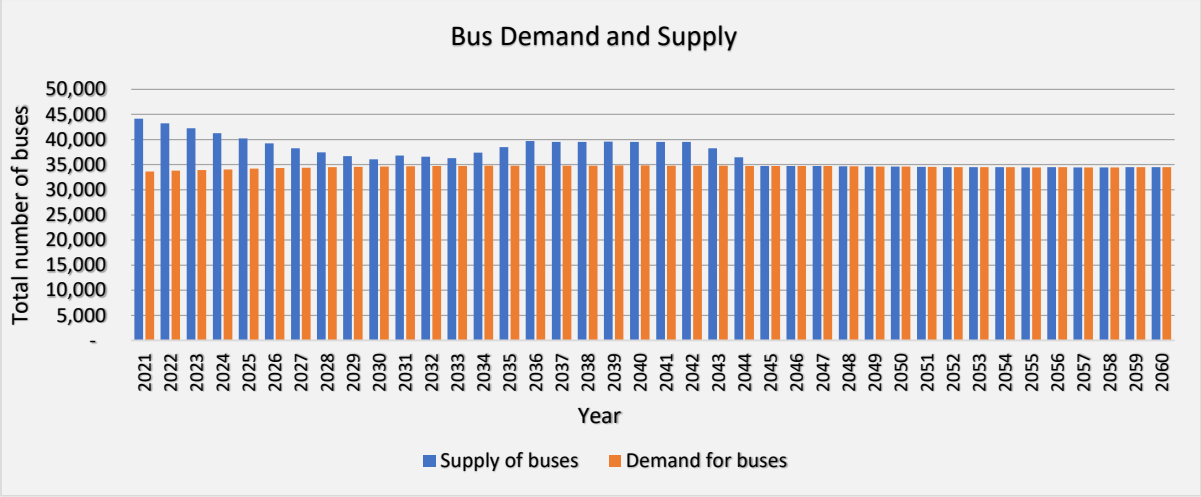
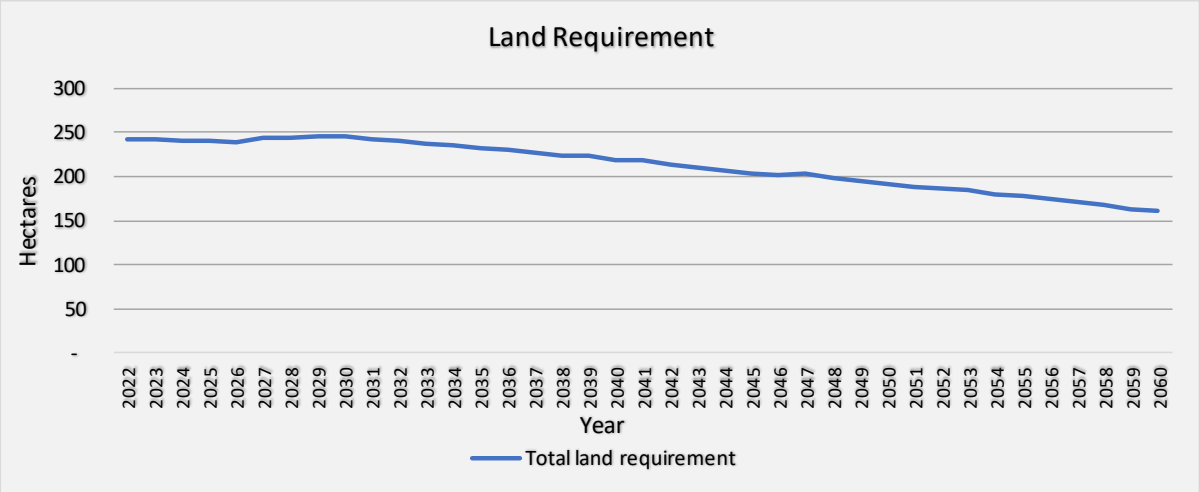


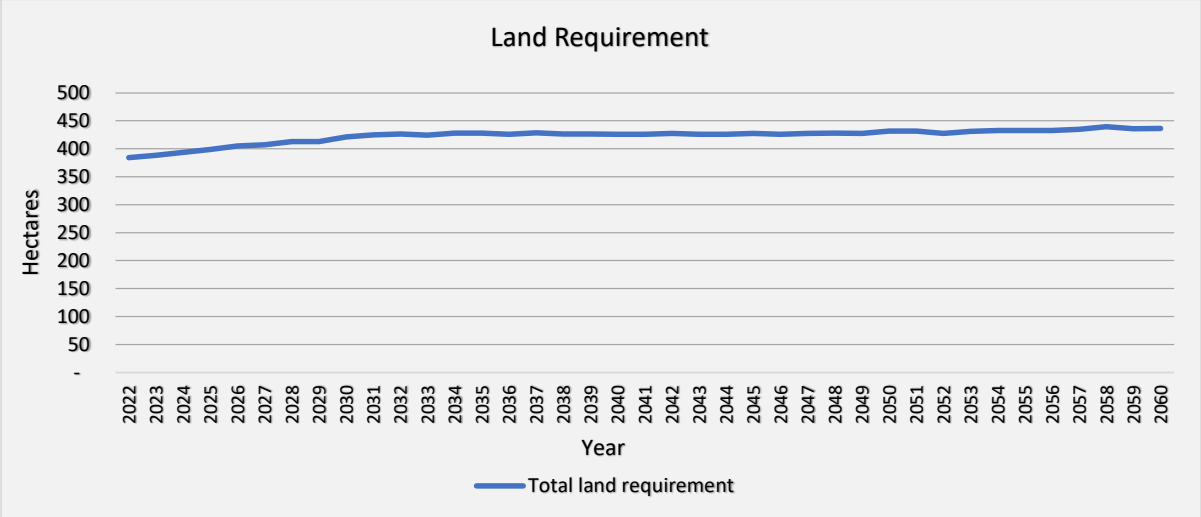
High Ambition Scenario



Business as Usual Scenario



Low Ambition Scenario



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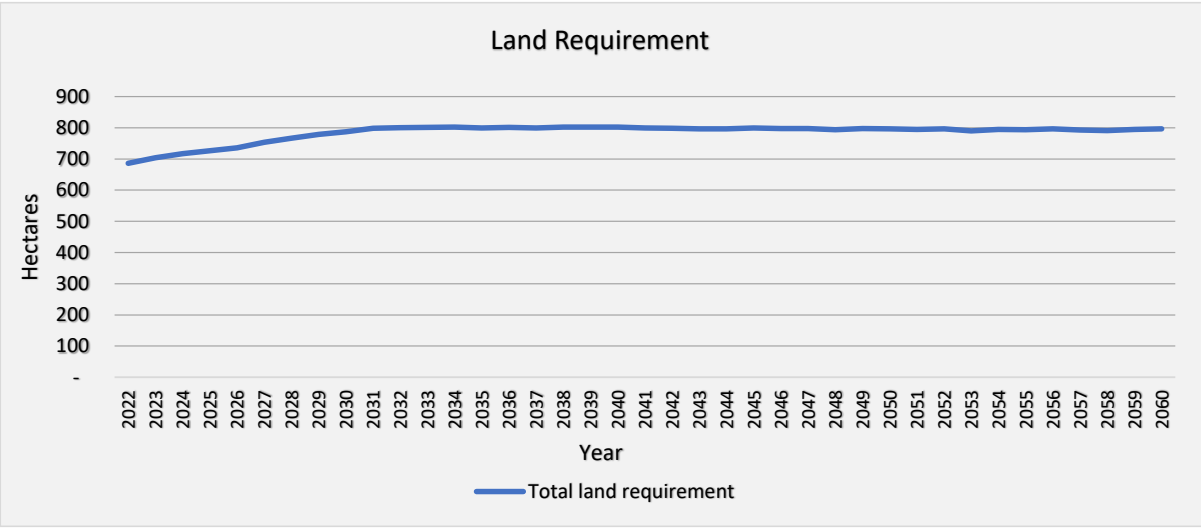
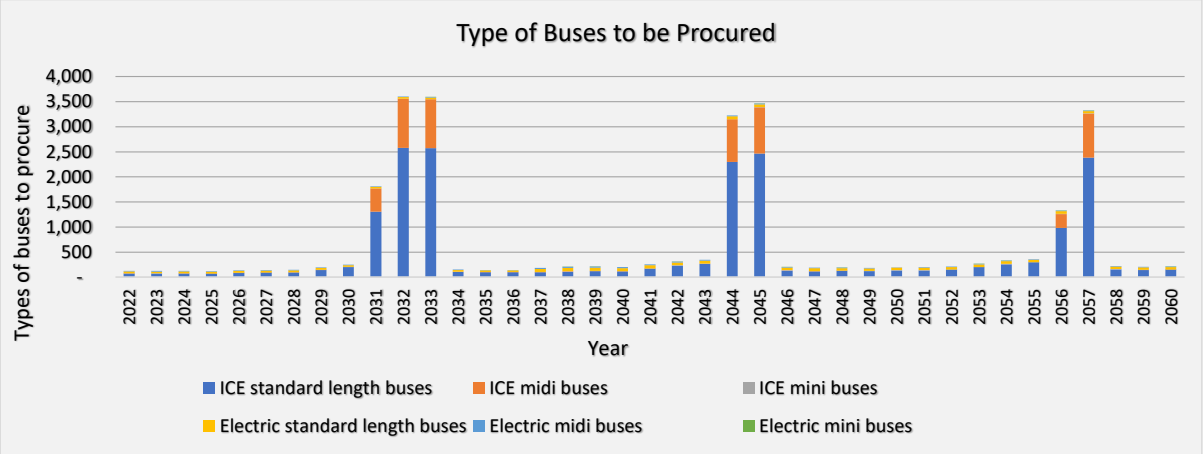
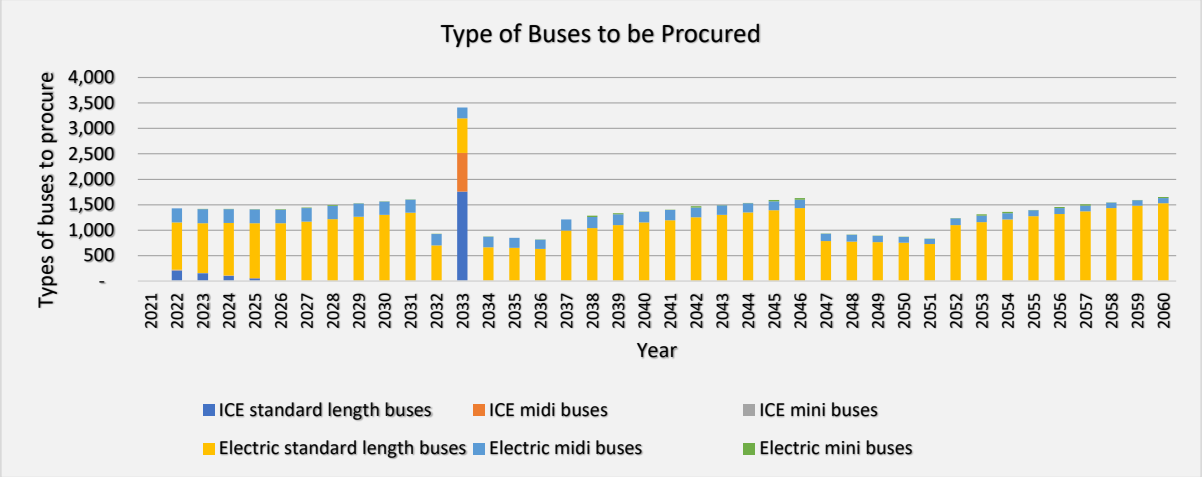


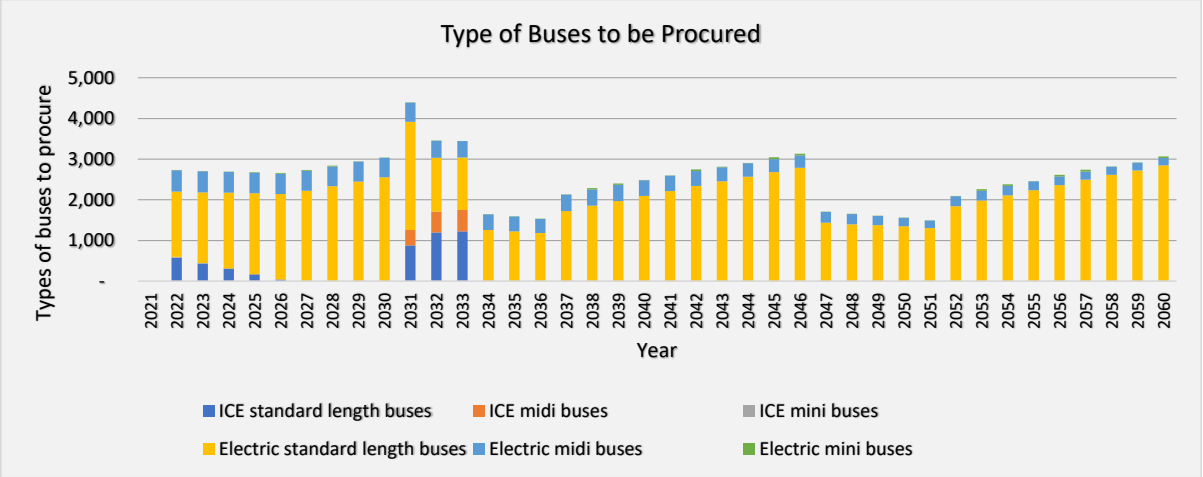
Business as Usual Scenario



Low Ambition Scenario

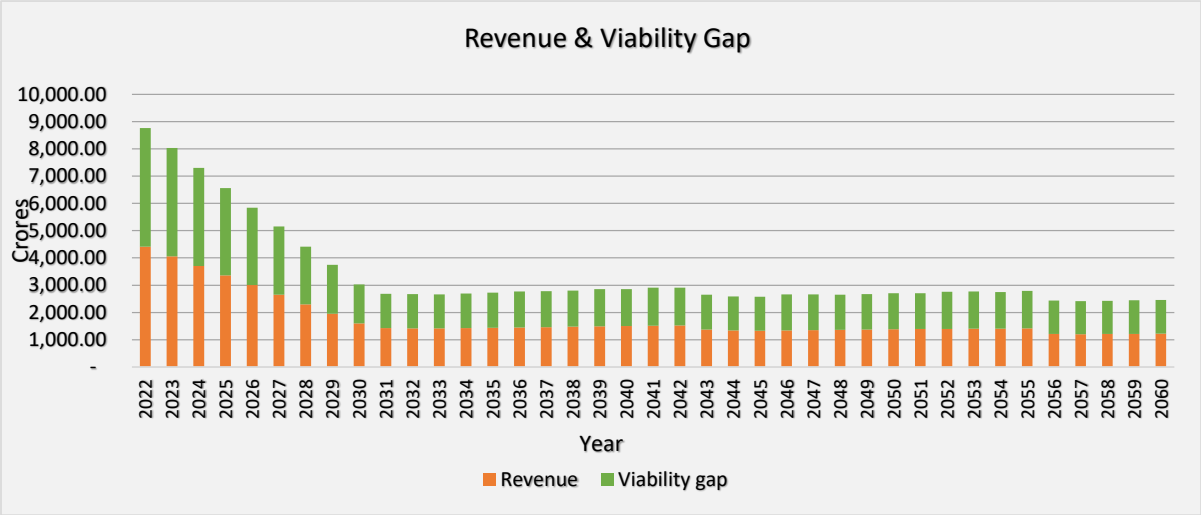


High Ambition Scenario

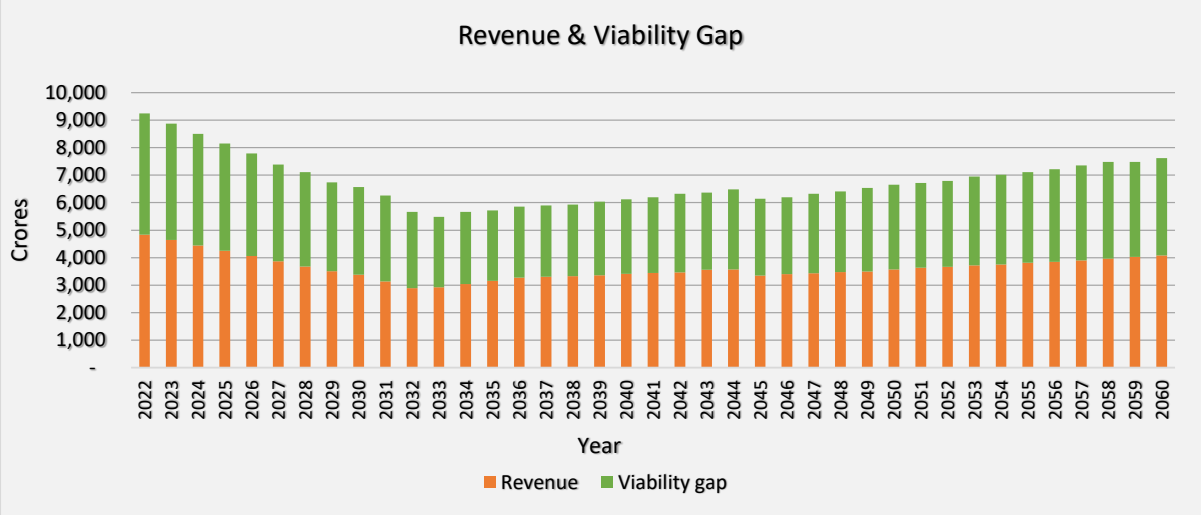


Revenue and Viability Gap: GCC Model

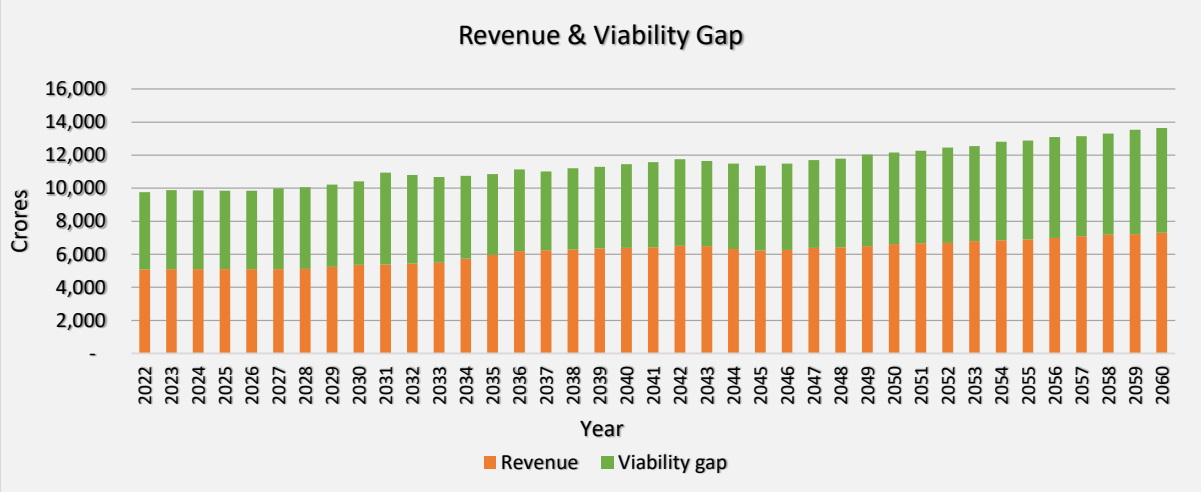
Business as Usual Scenario



Low Ambition Scenario

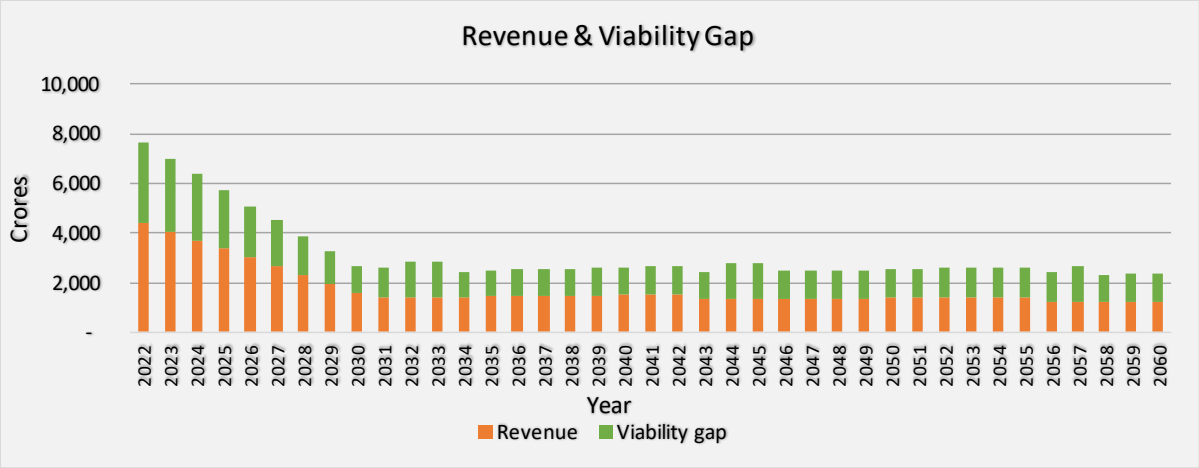


High Ambition Scenario

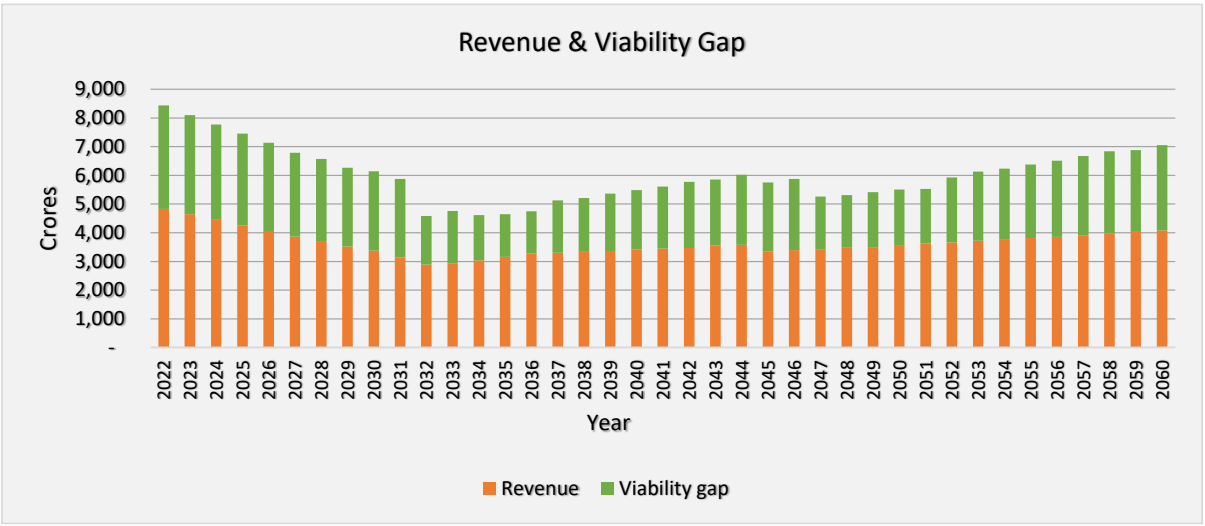


Revenue and Viability Gap: Outright Purchase Model

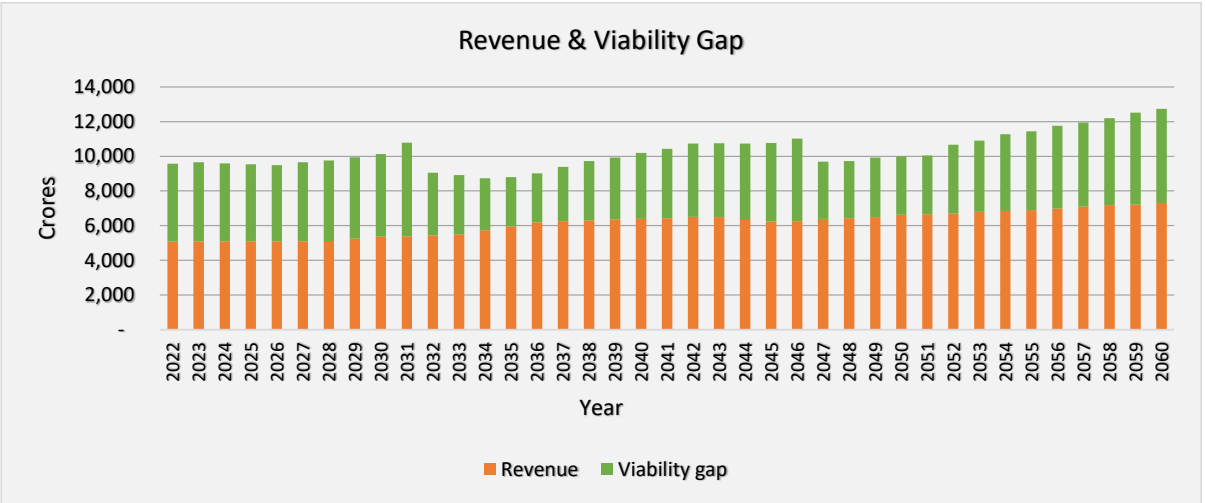
Business as usual Scenario



Low Ambition Scenario

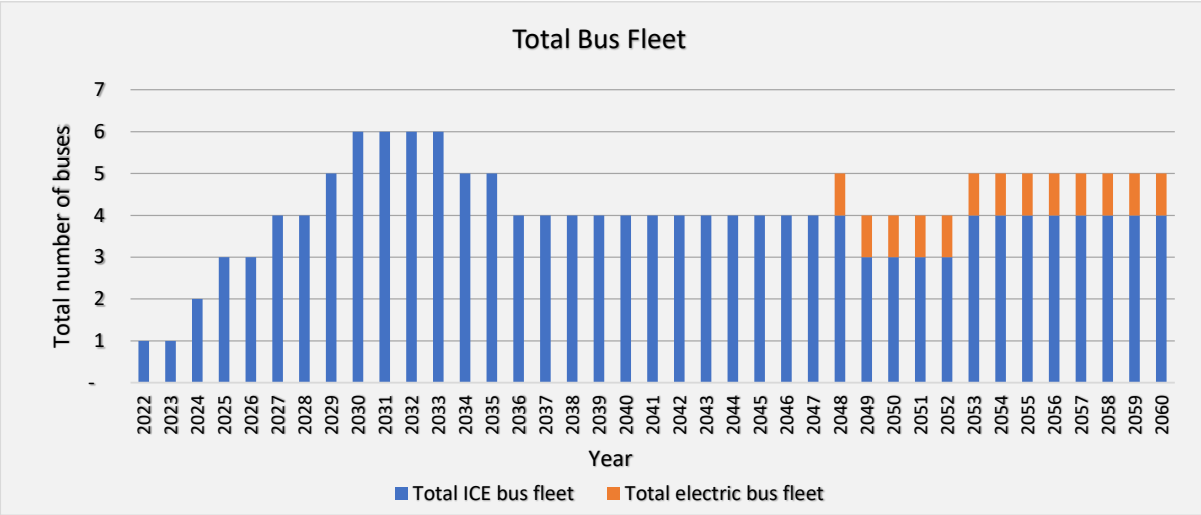


High Ambition Scenario

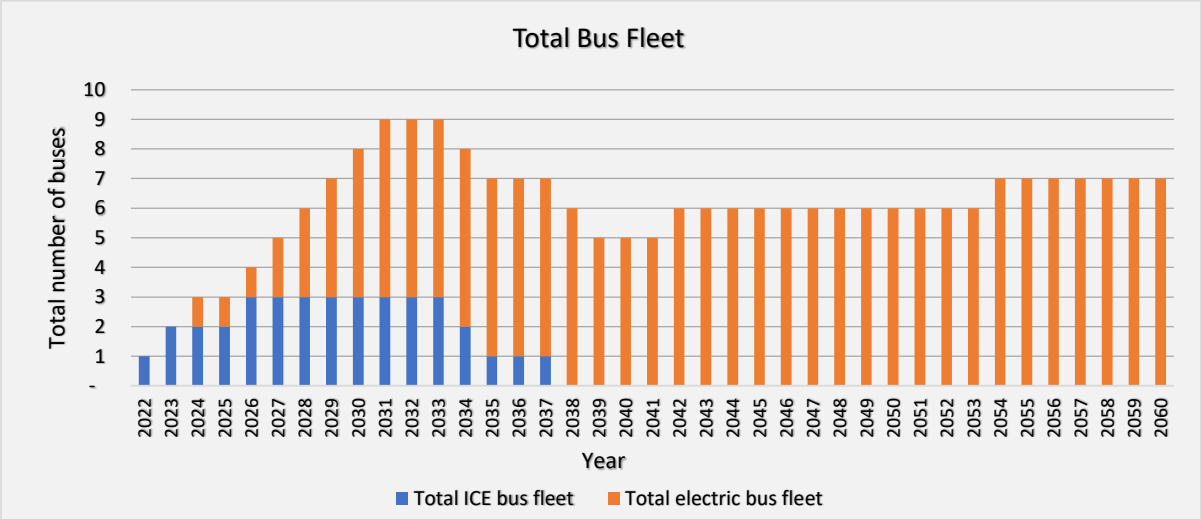


19. State / UT: Lakshadweep

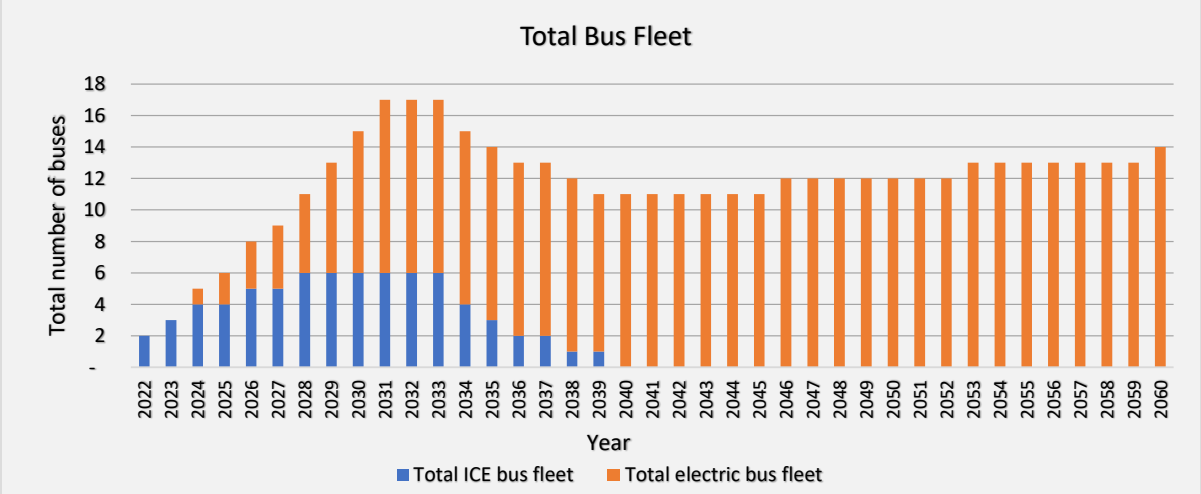
Business as usual Scenario



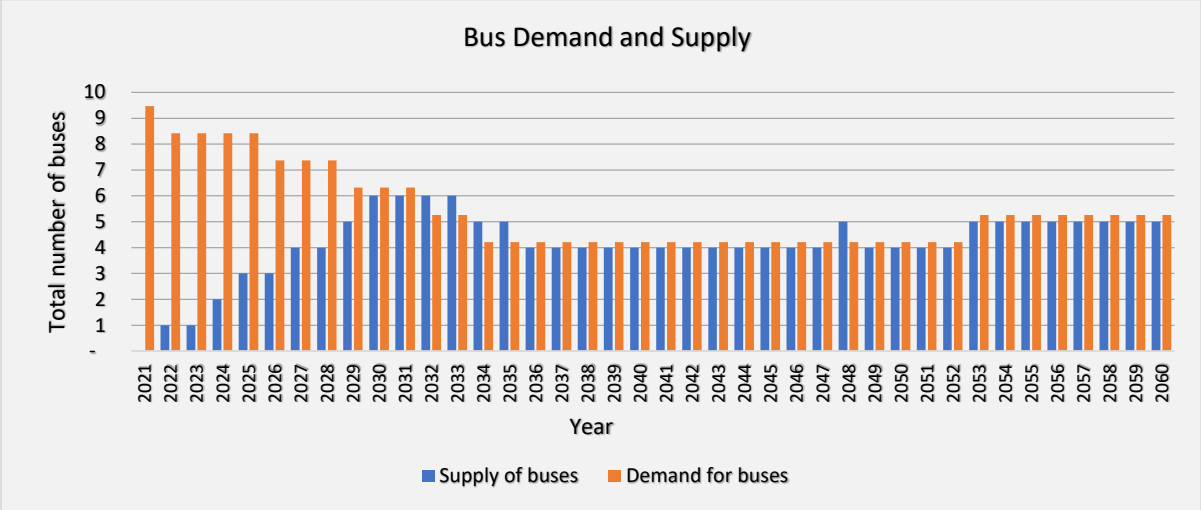
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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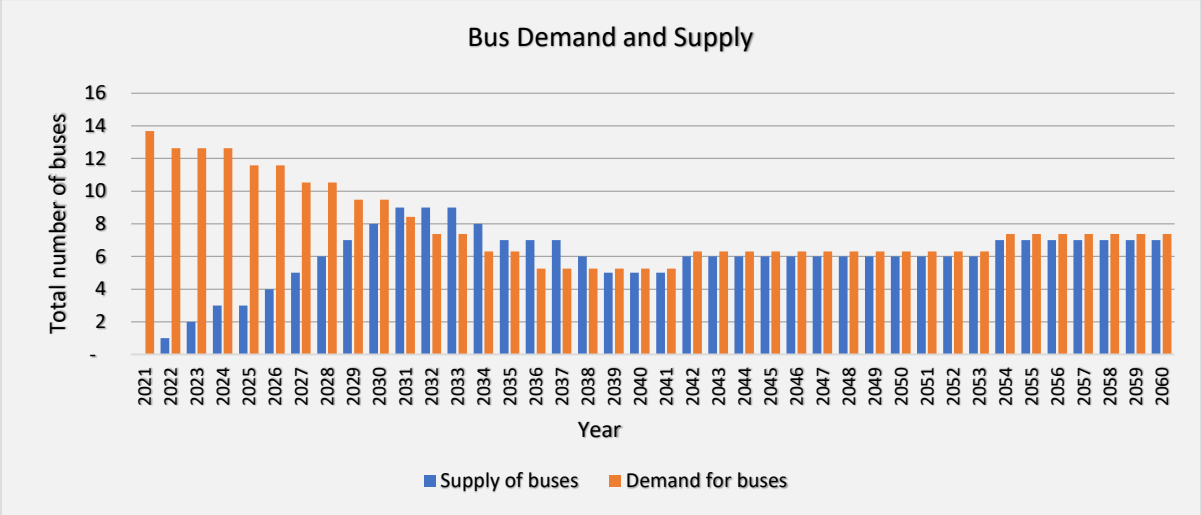
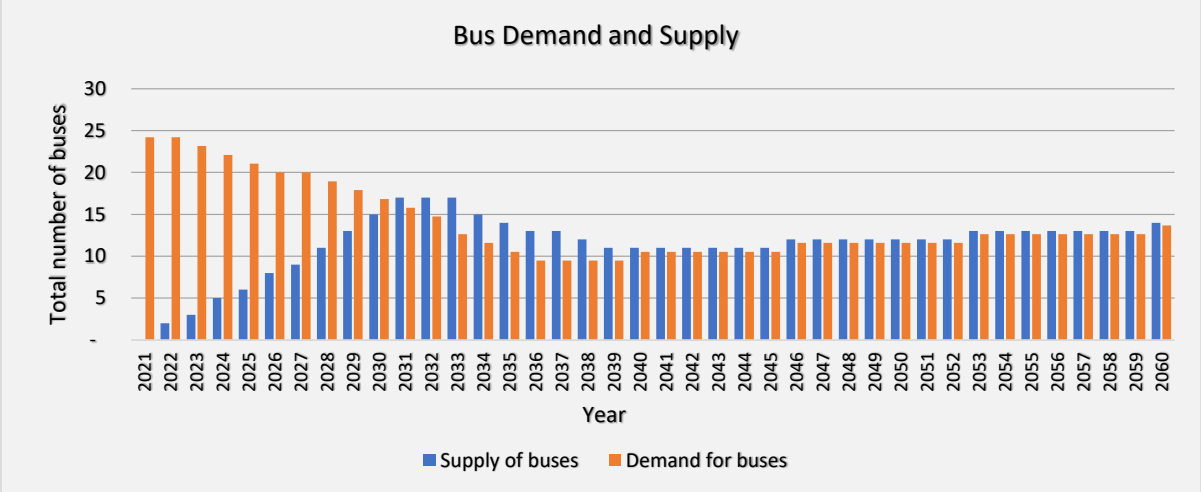
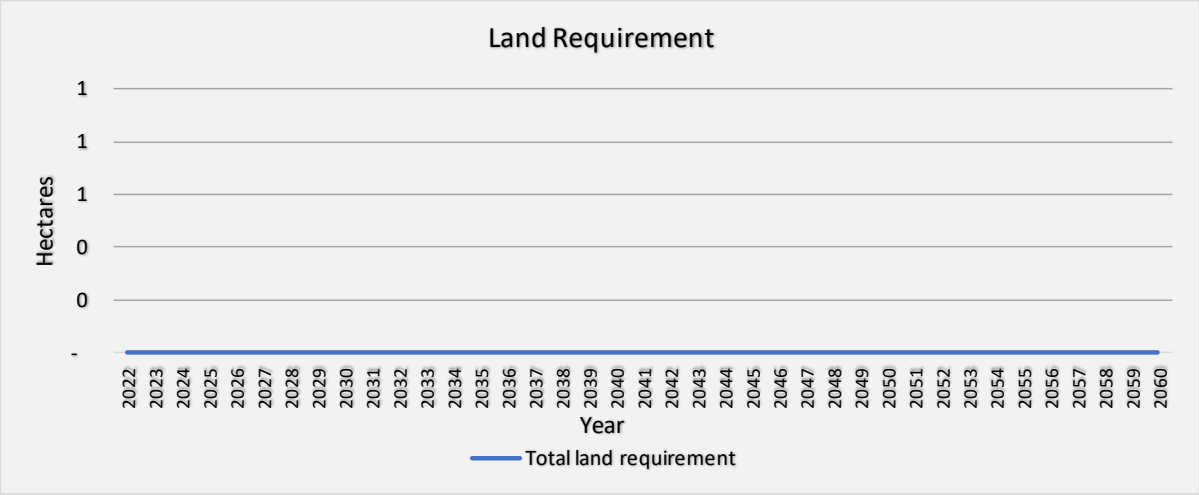


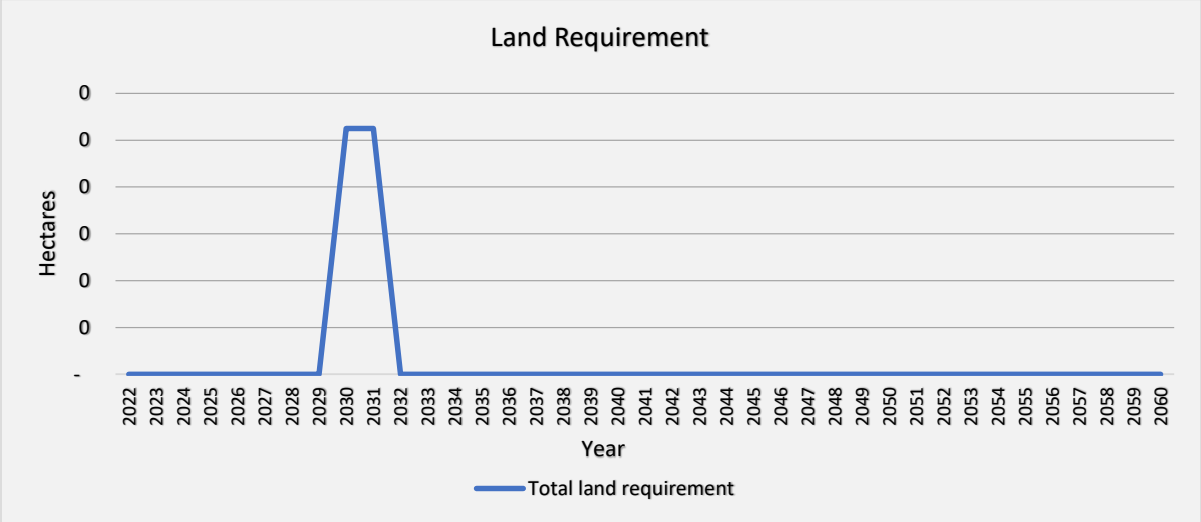
High Ambition Scenario



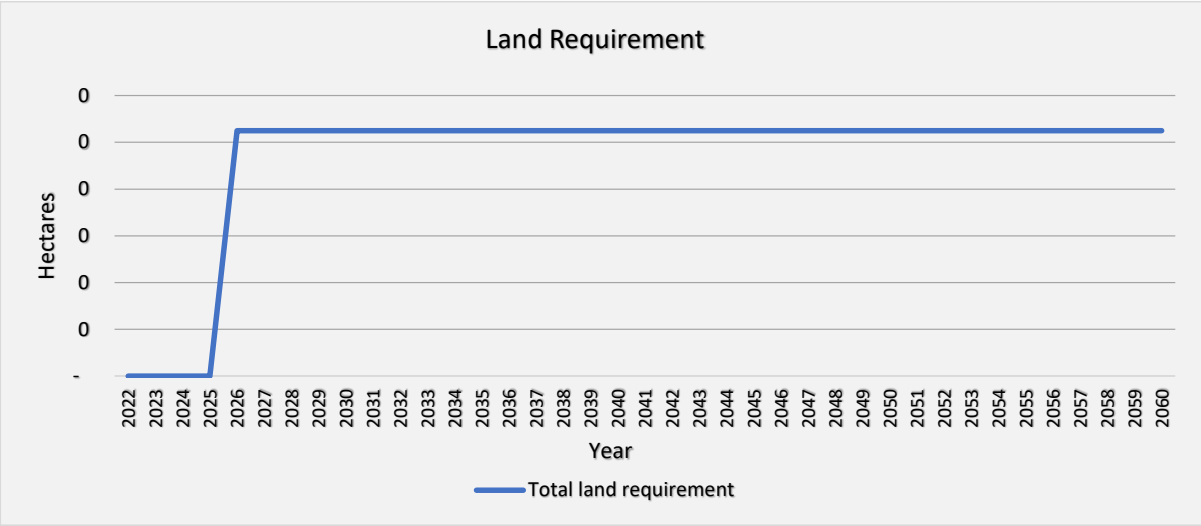
Business as Usual Scenario



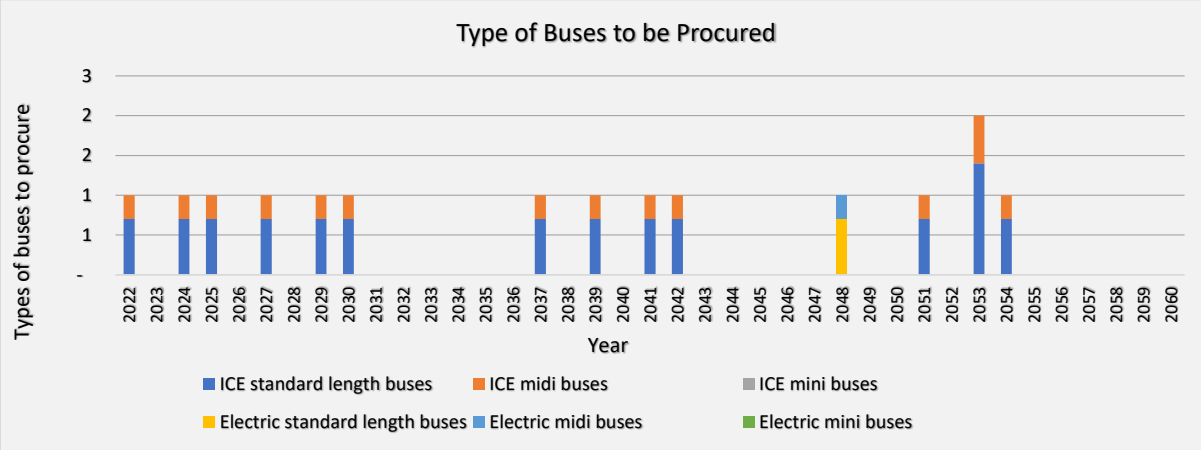
Low Ambition Scenario



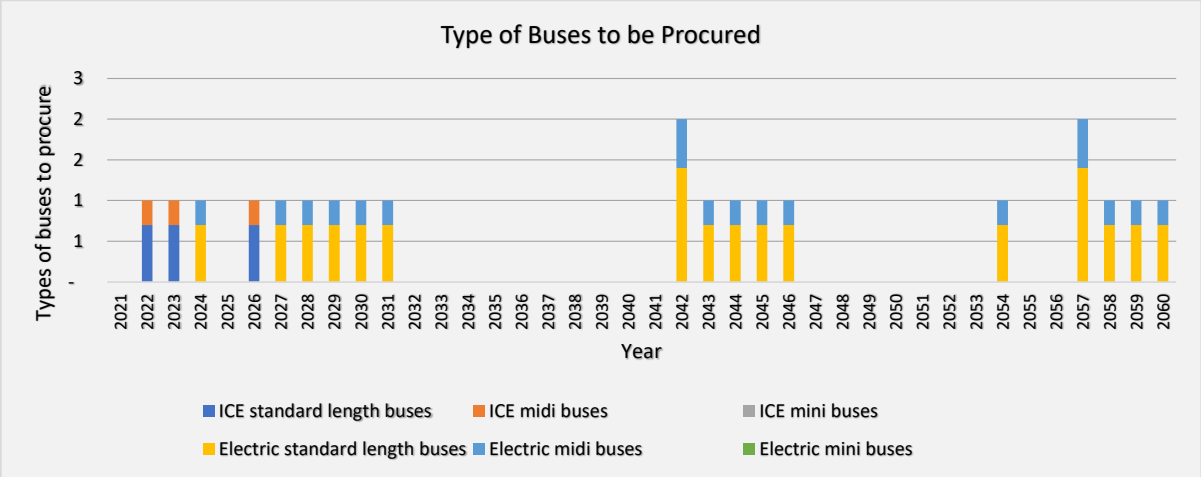
High Ambition Scenario



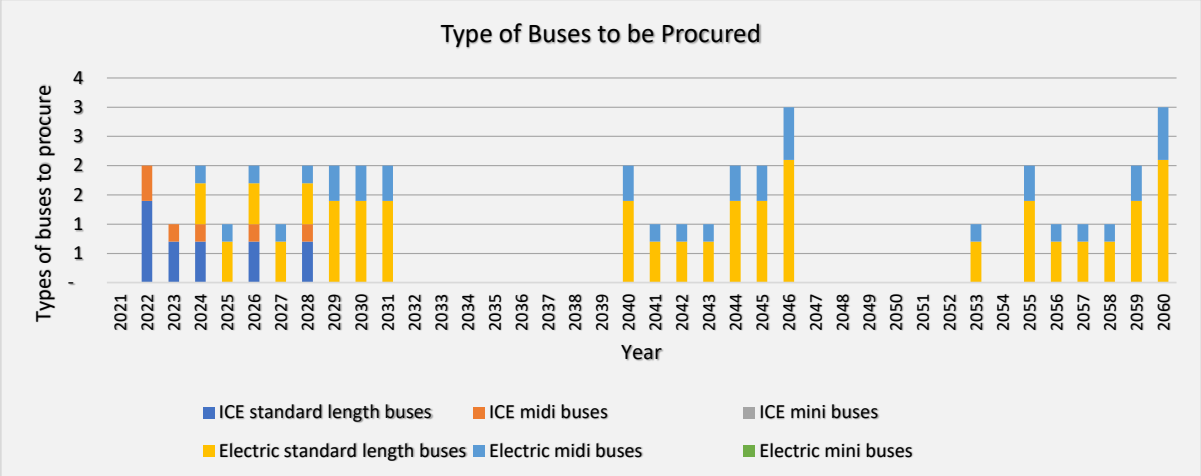
Business as Usual Scenario



Low Ambition Scenario

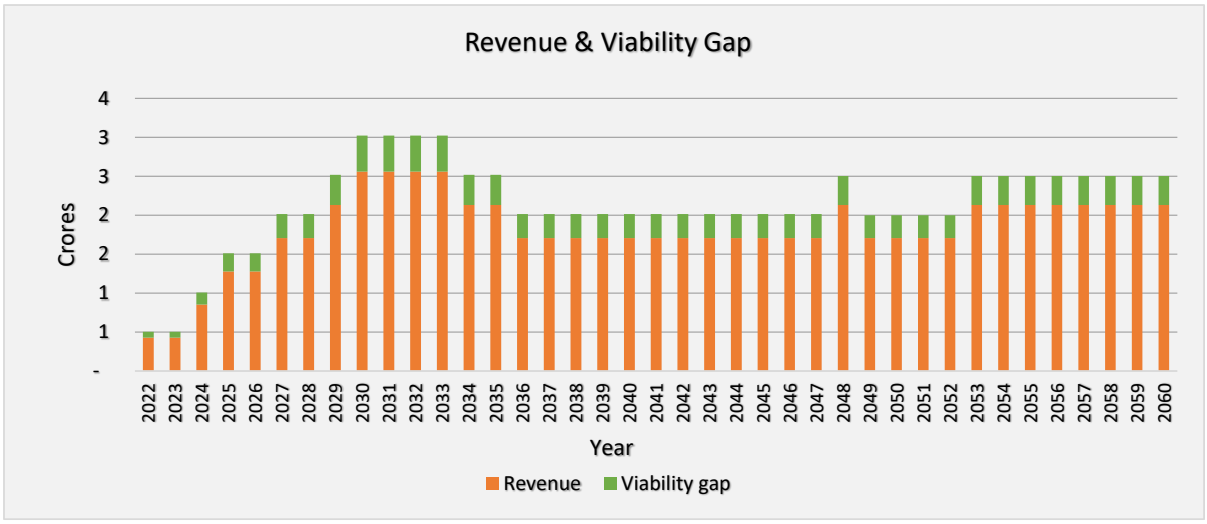


High Ambition Scenario

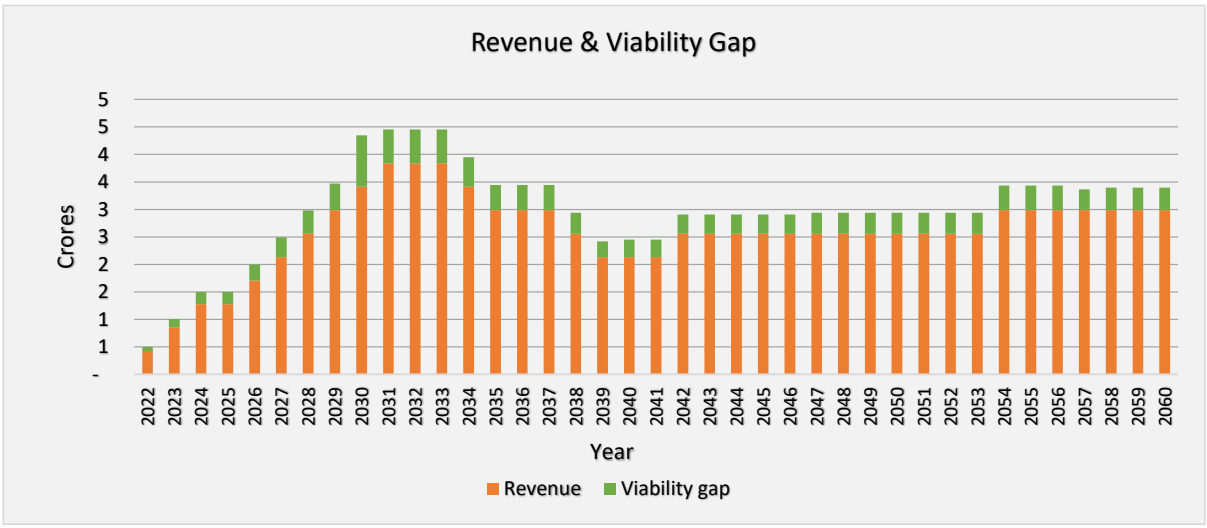


Revenue and Viability Gap: GCC Model

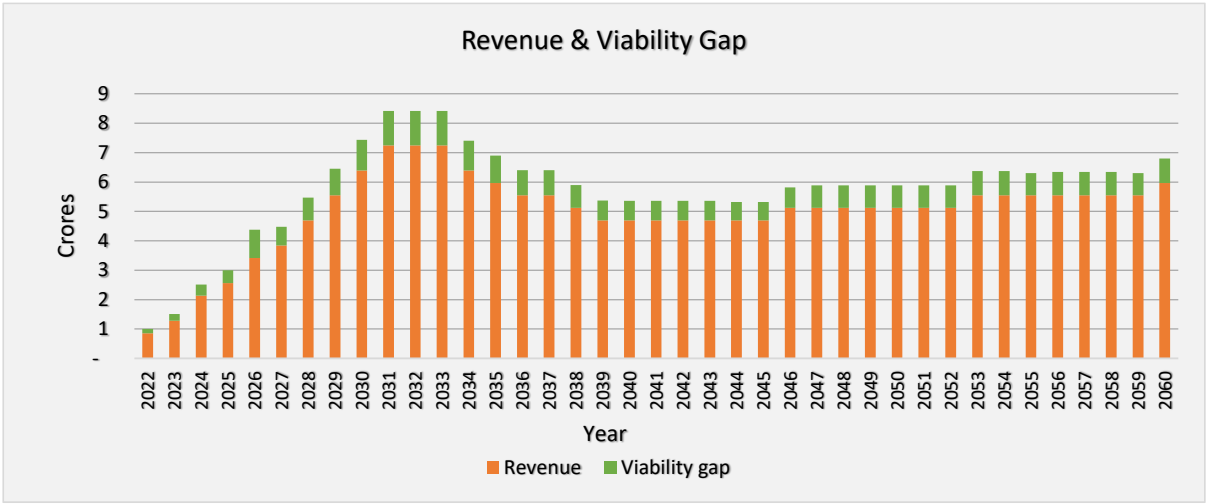
Business as Usual Scenario



Low Ambition Scenario

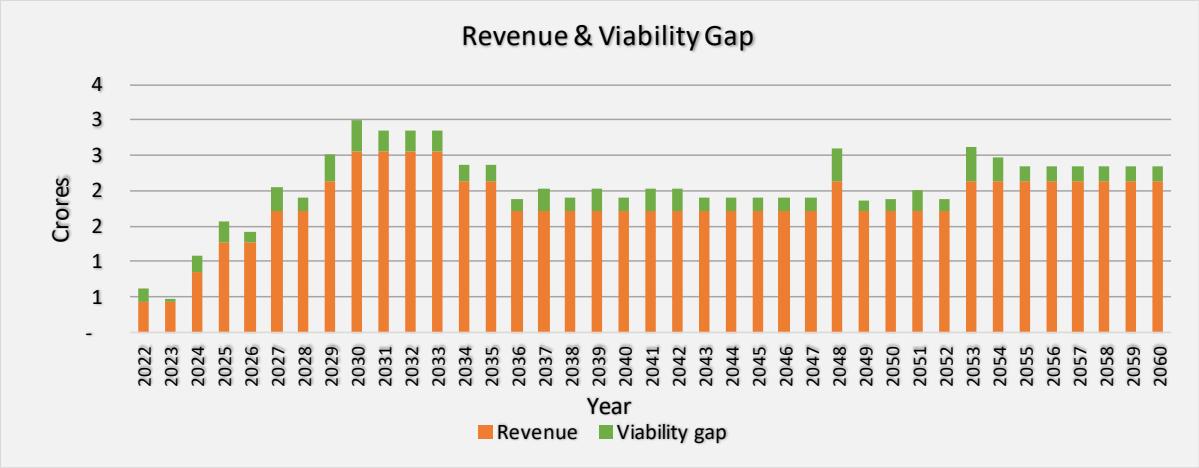


High Ambition Scenario

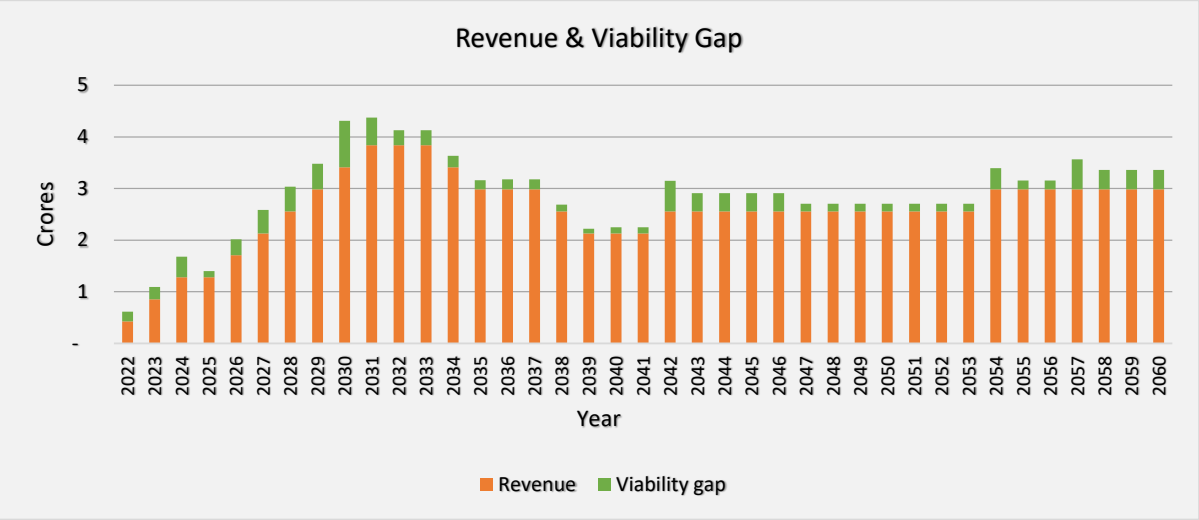


Revenue and Viability Gap: Outright Purchase Model

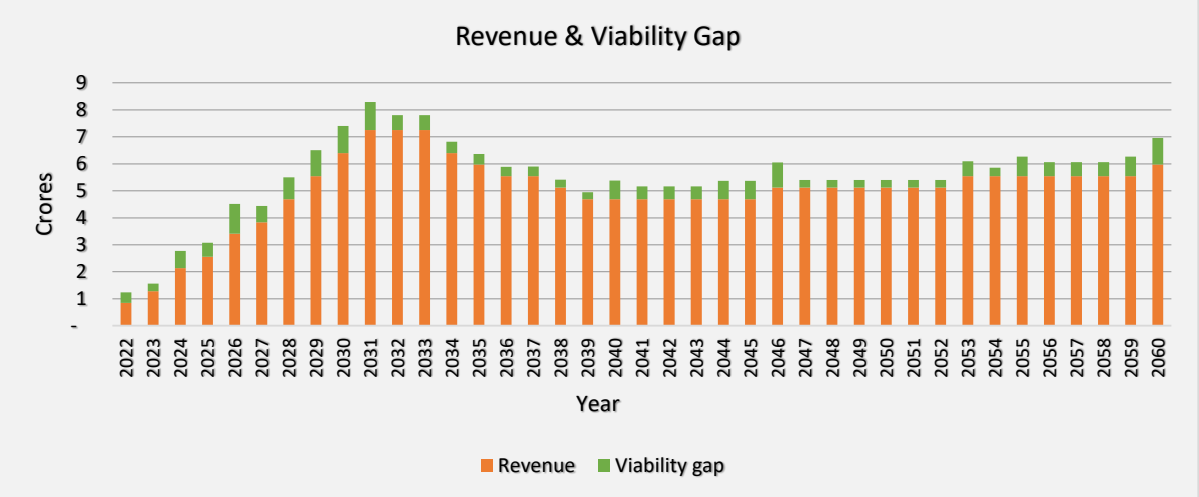
Business as usual Scenario



Low Ambition Scenario

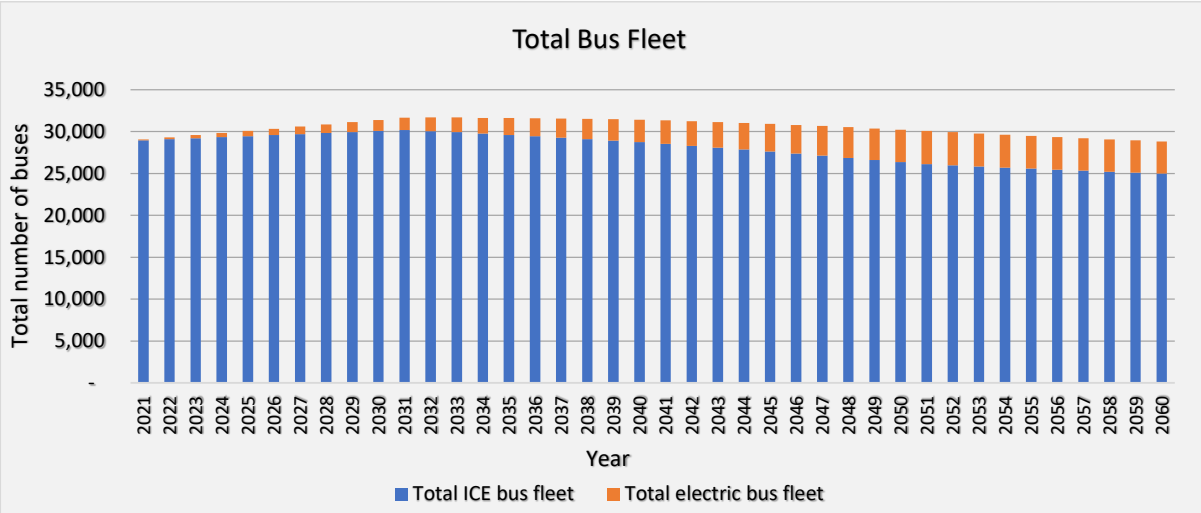


High Ambition Scenario

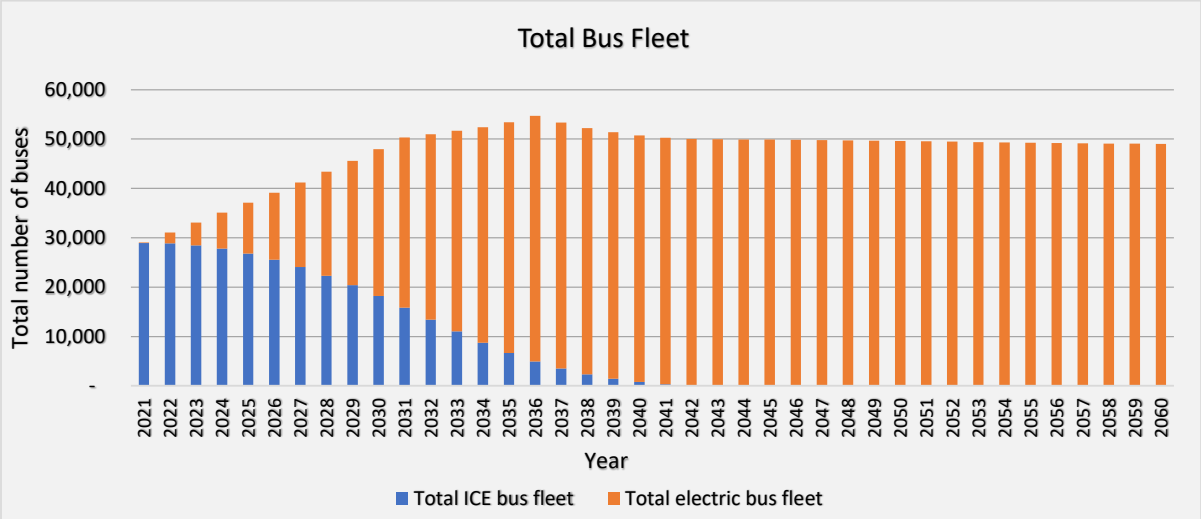


20. State / UT: Madhya Pradesh

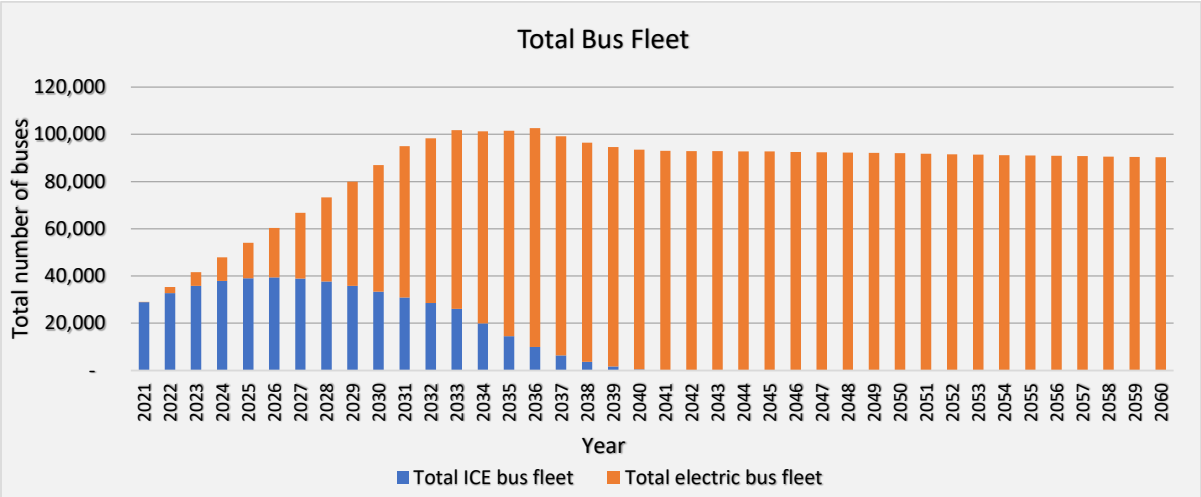
Business as usual Scenario



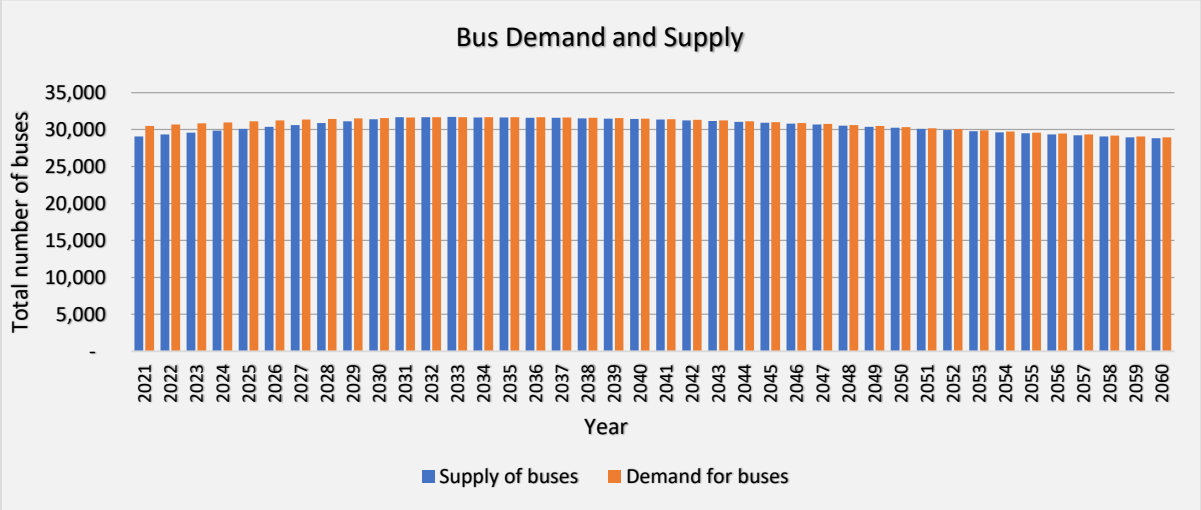
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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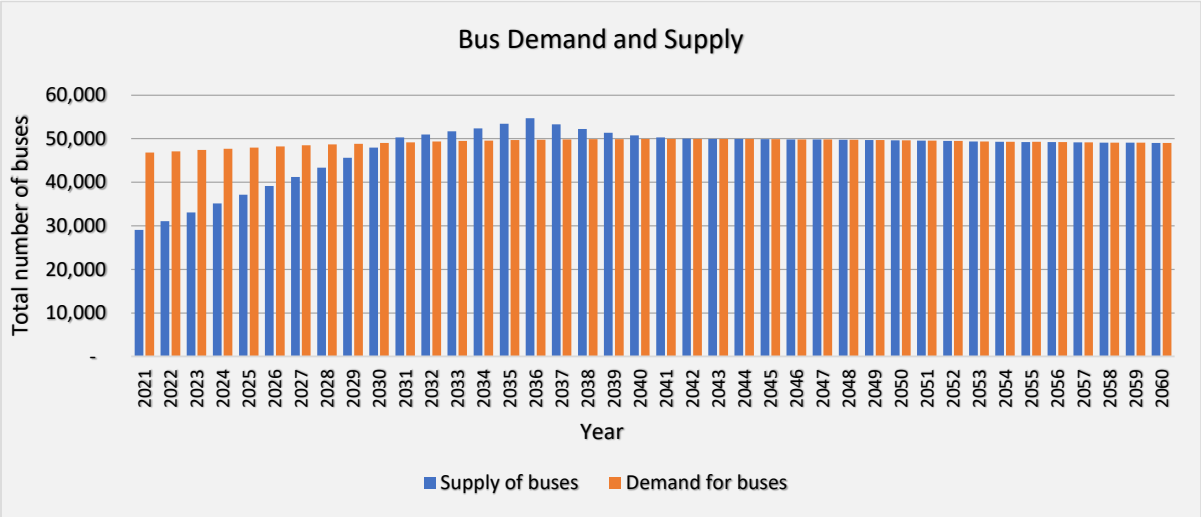
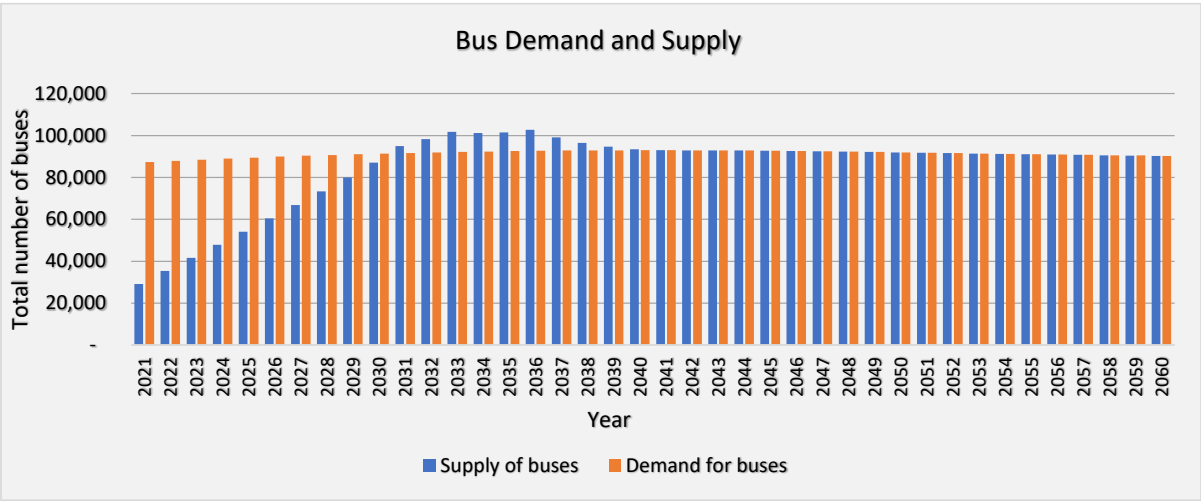
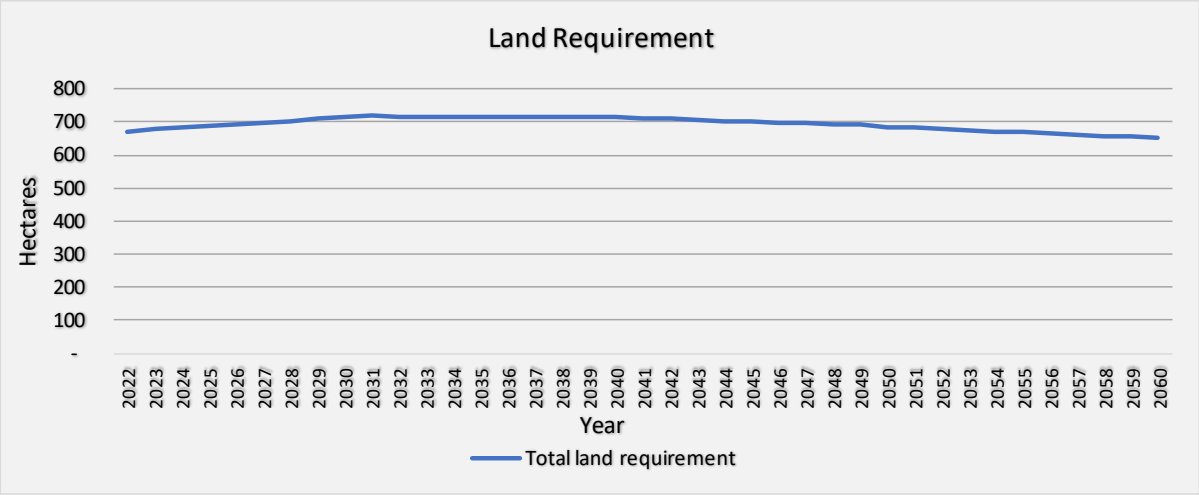


High Ambition Scenario



Business as Usual Scenario



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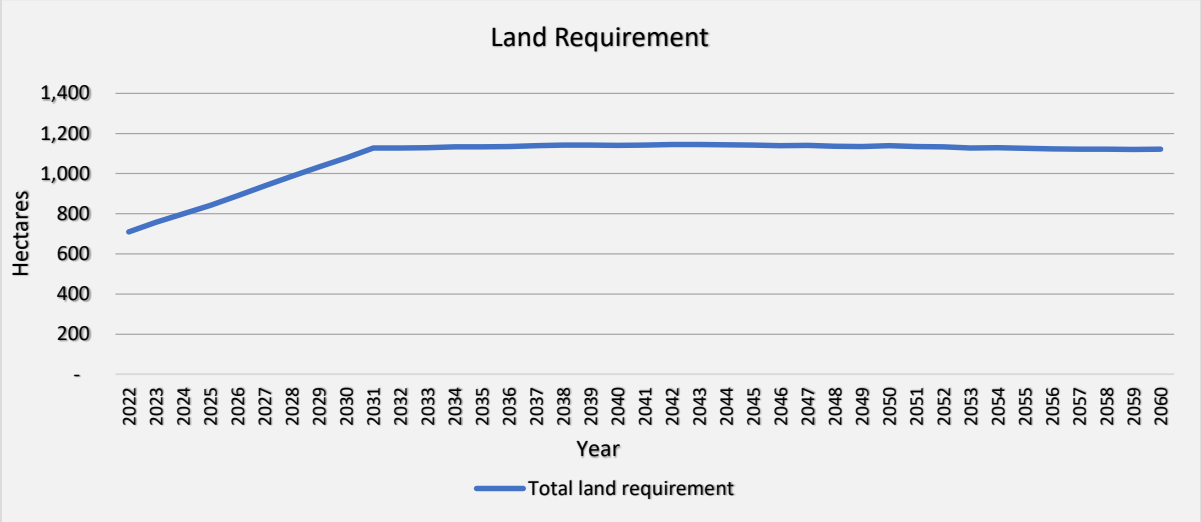
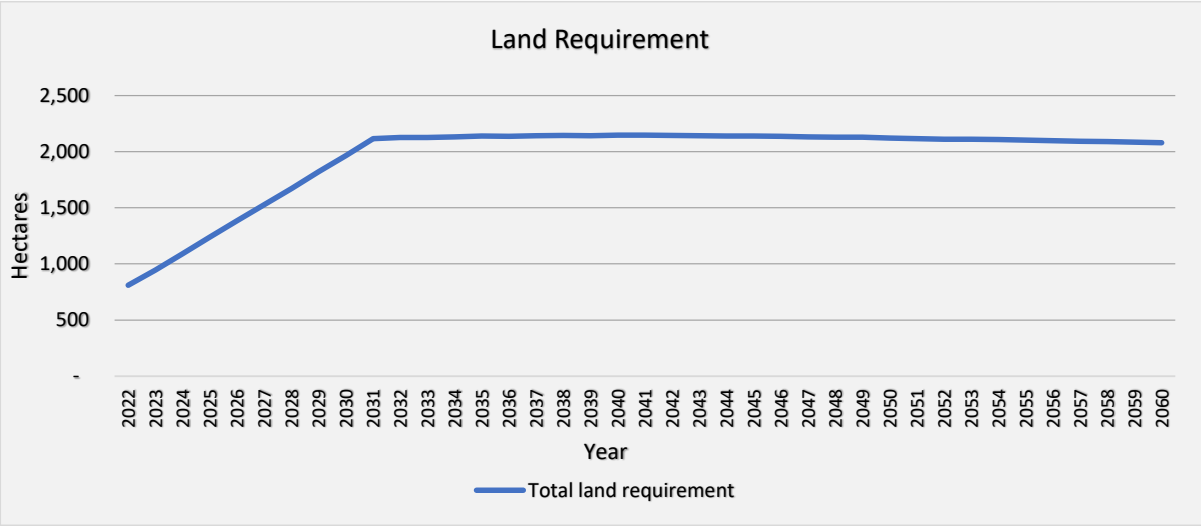
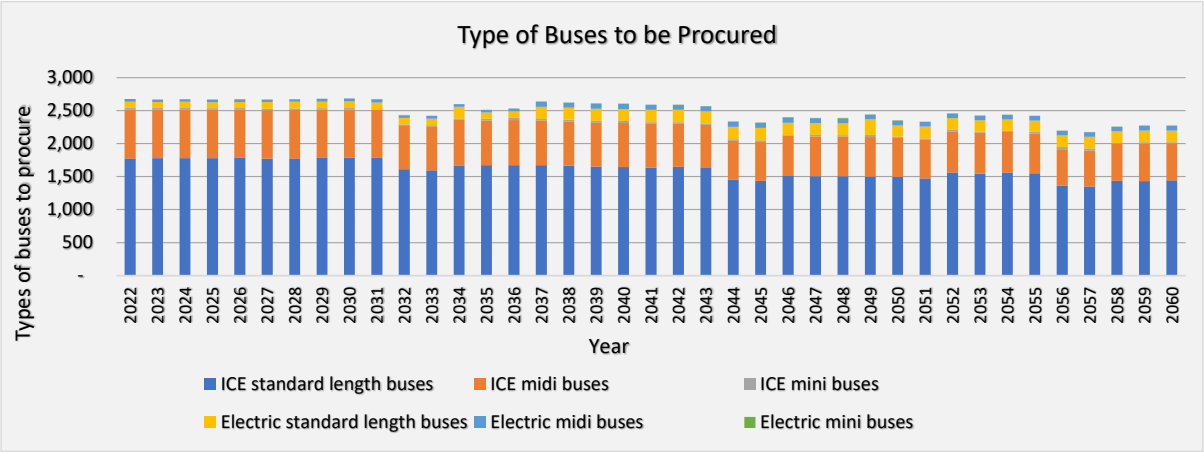


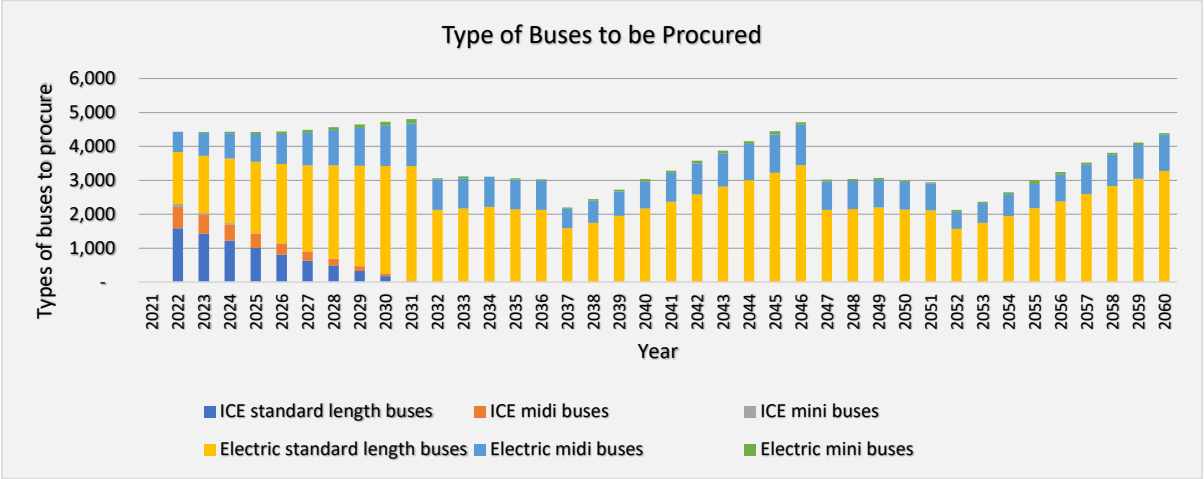
High Ambition Scenario



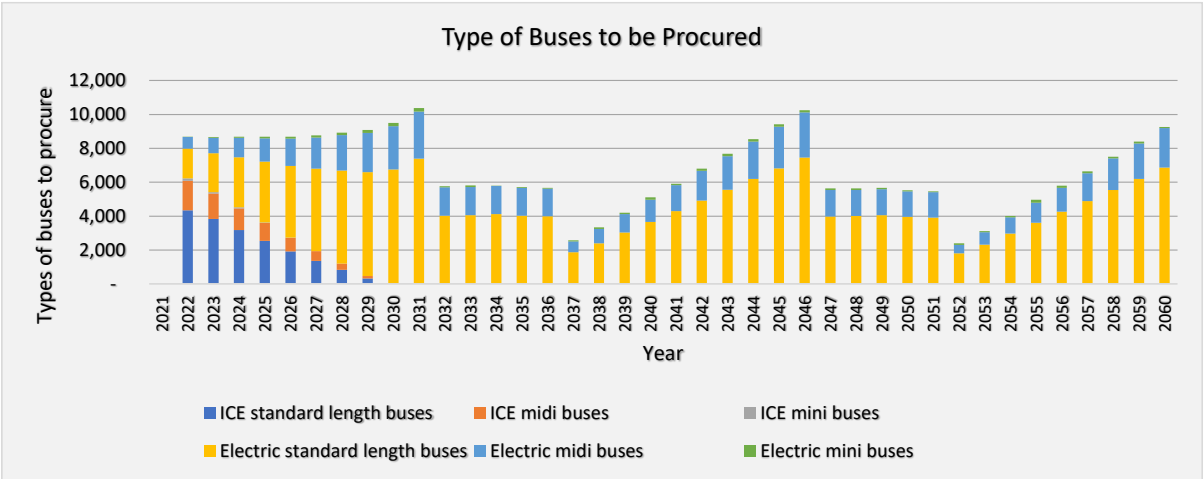
Business as Usual Scenario



Low Ambition Scenario

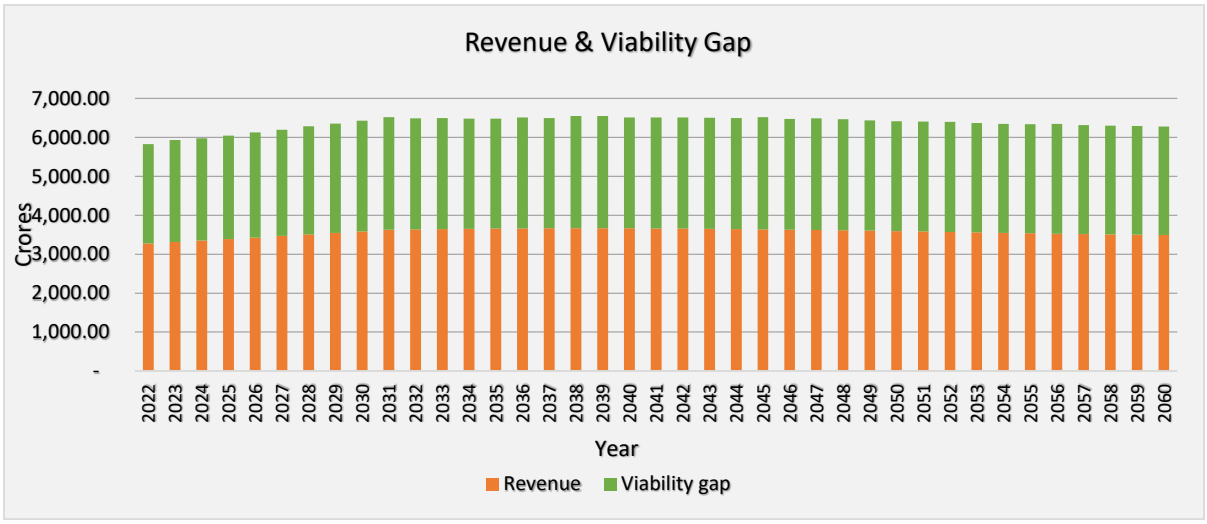


High Ambition Scenario

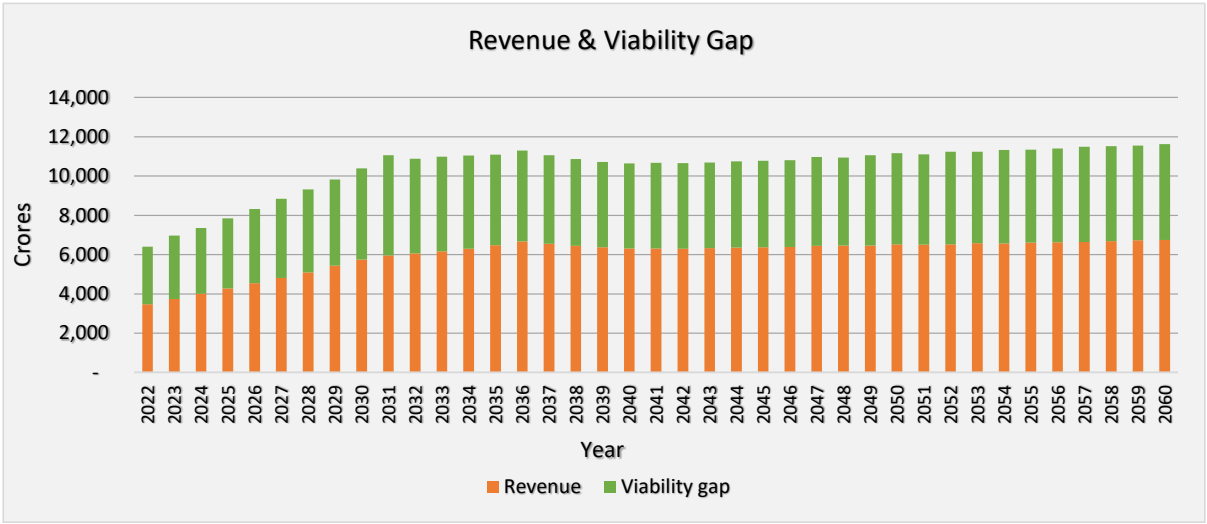


Revenue and Viability Gap: GCC Model

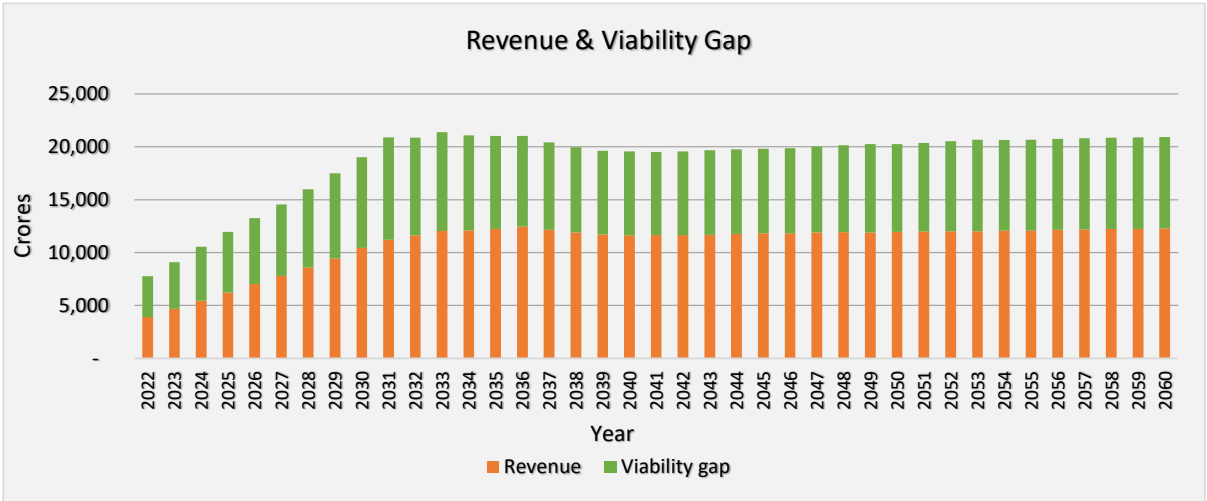
Business as Usual Scenario



Low Ambition Scenario

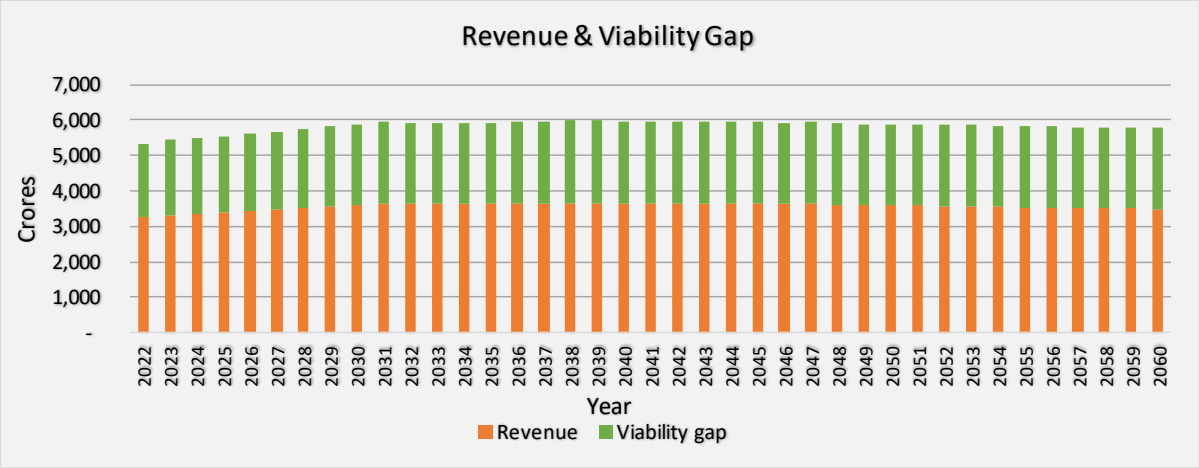


High Ambition Scenario



Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



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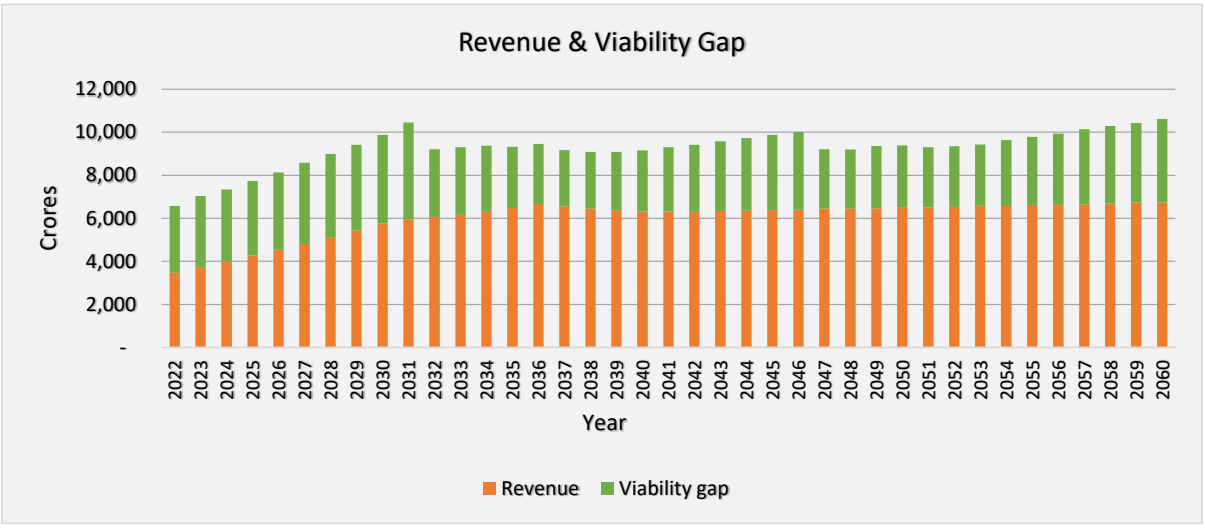
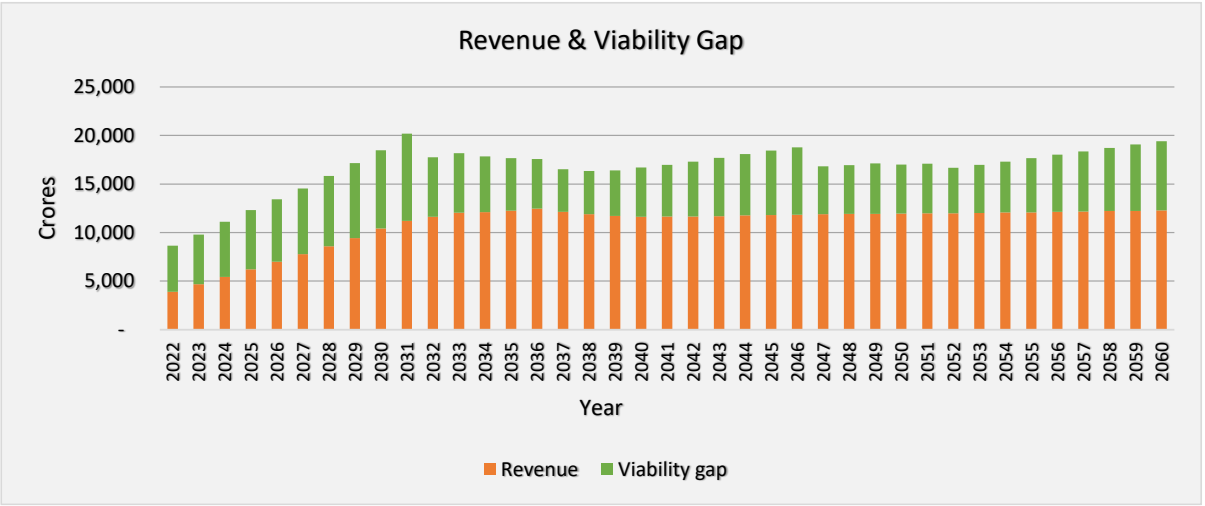
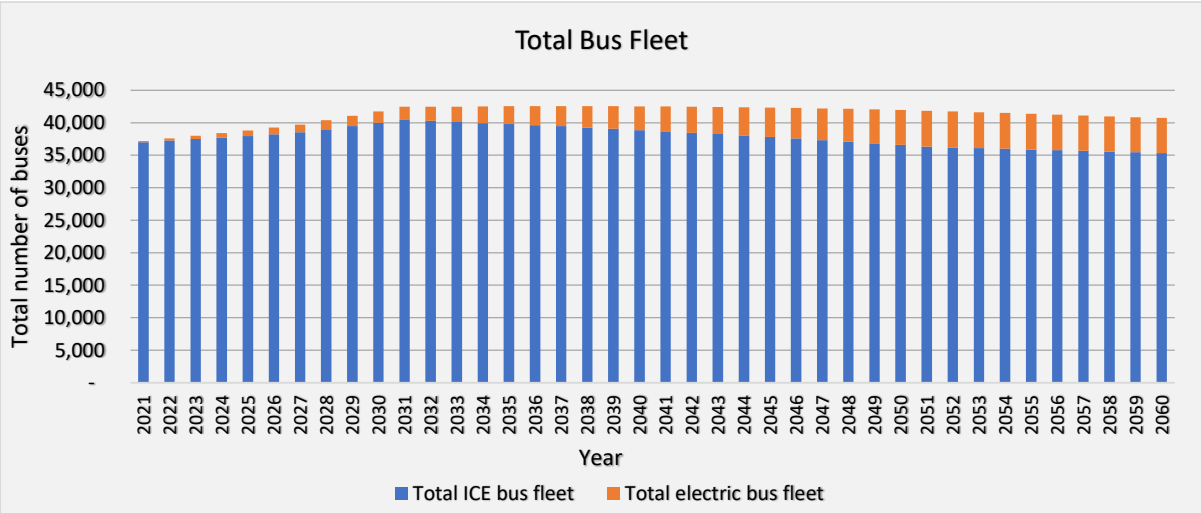


High Ambition Scenario

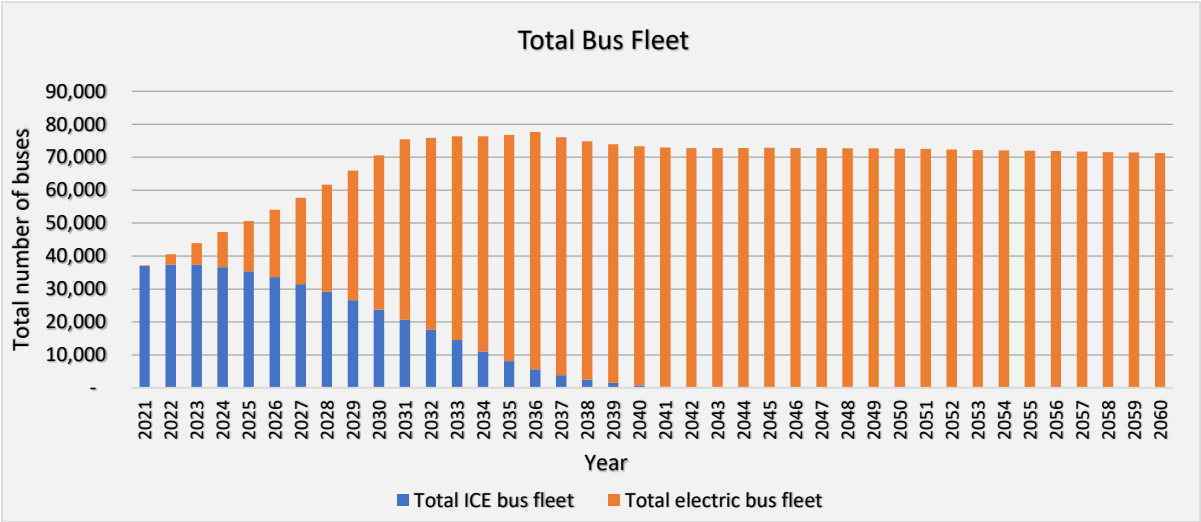


21. State / UT: Maharashtra

Business as usual Scenario



Low Ambition Scenario



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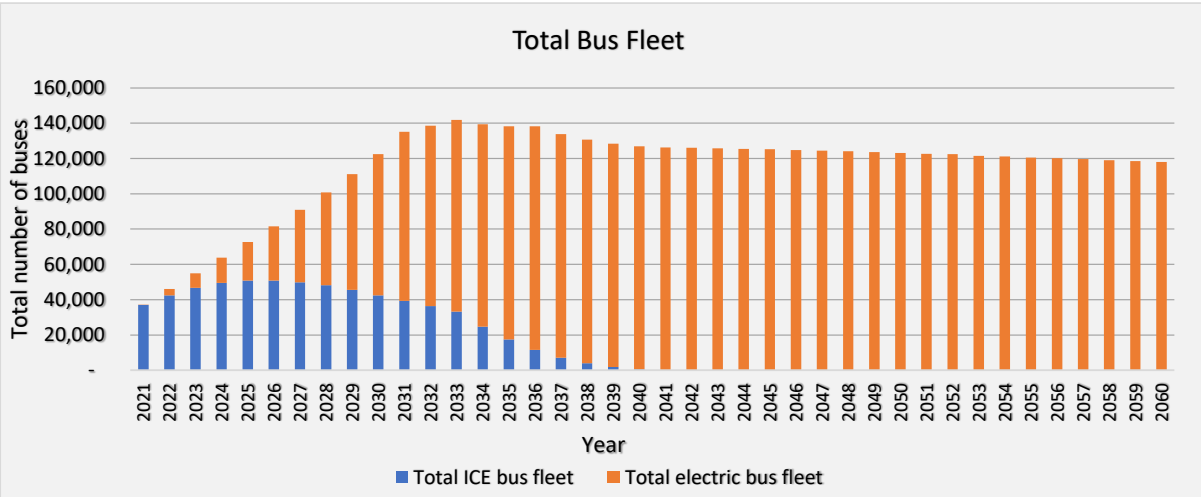

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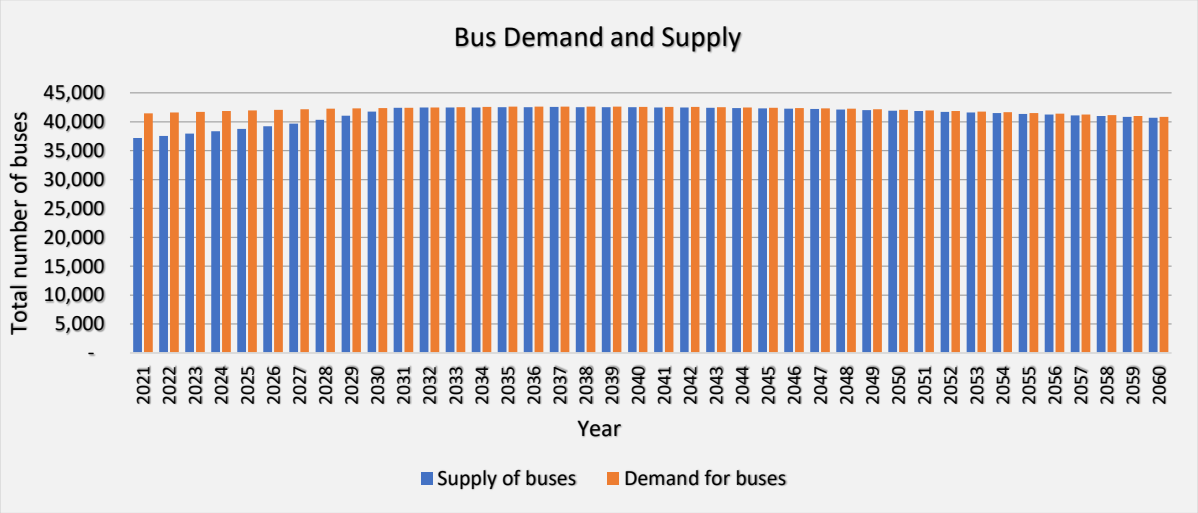

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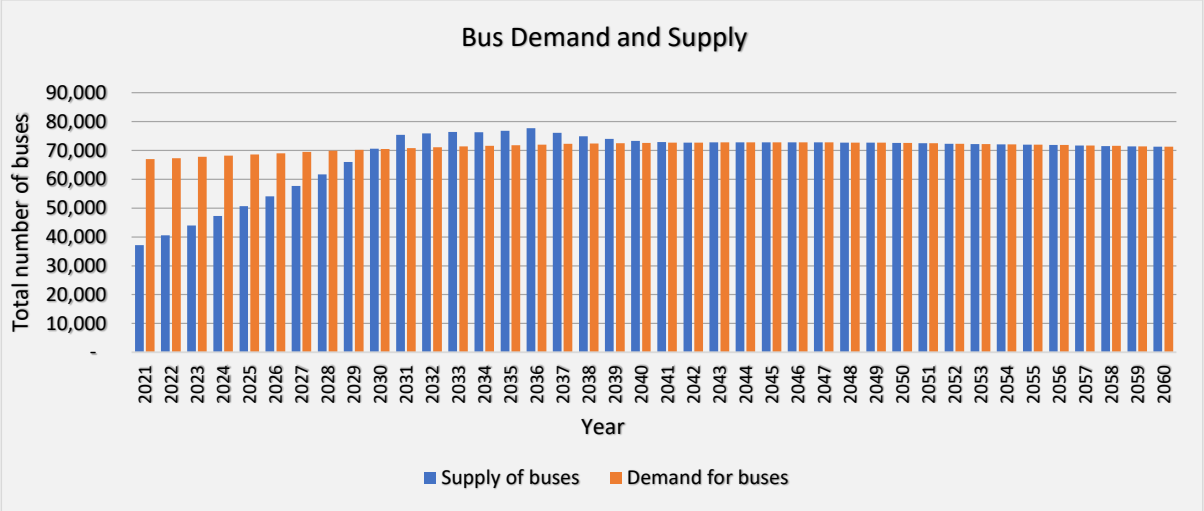

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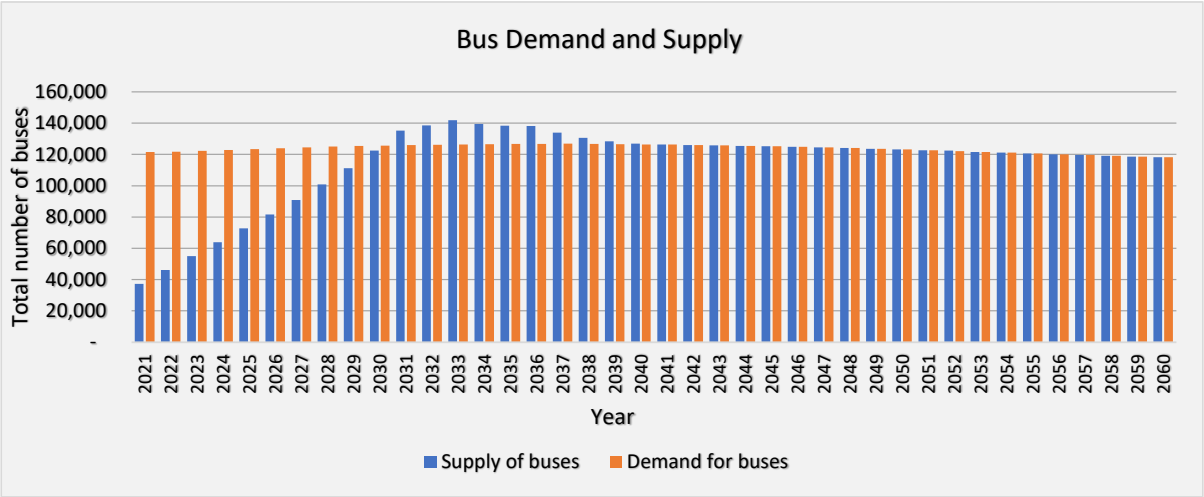

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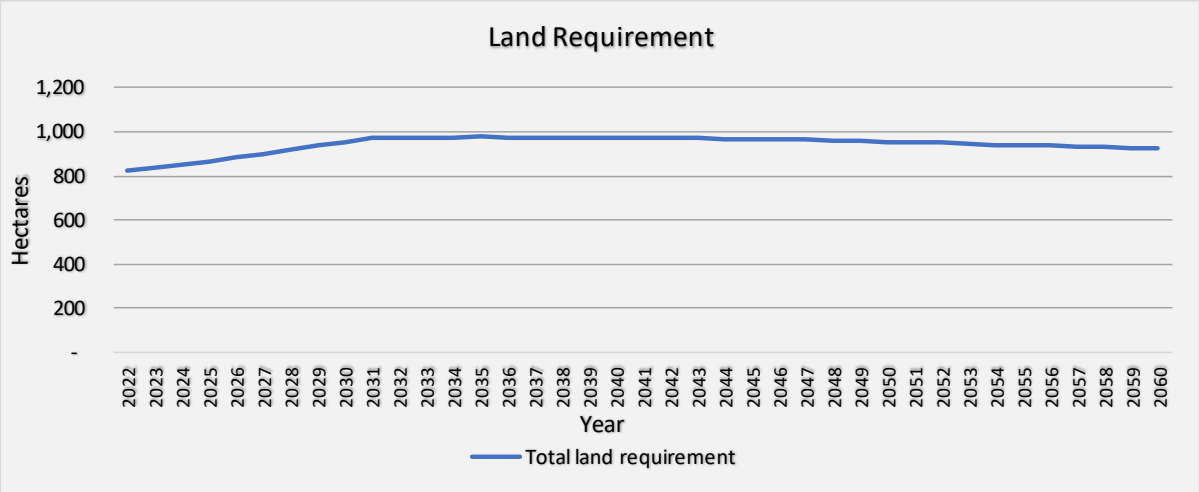

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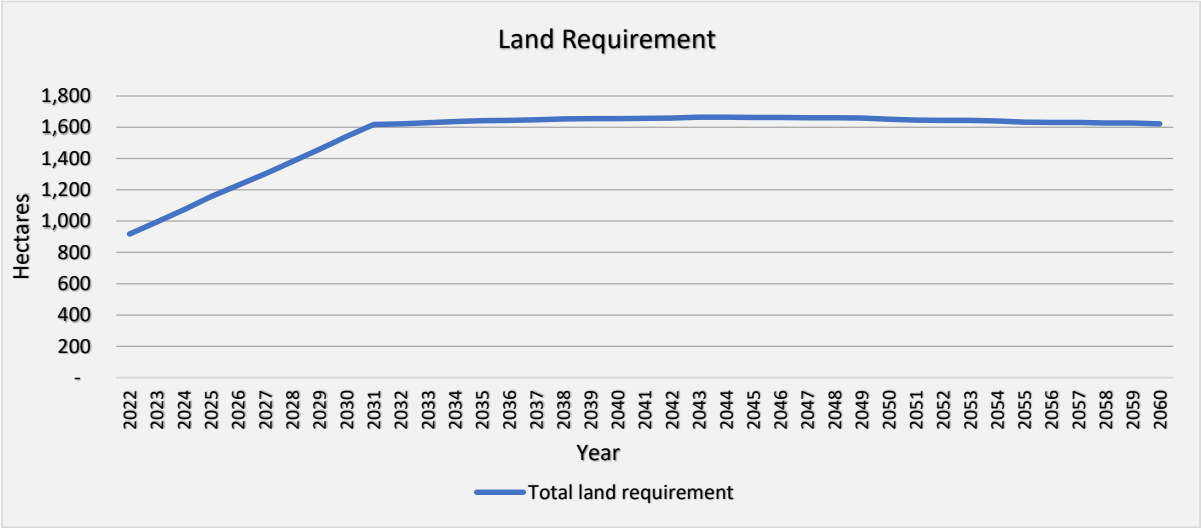

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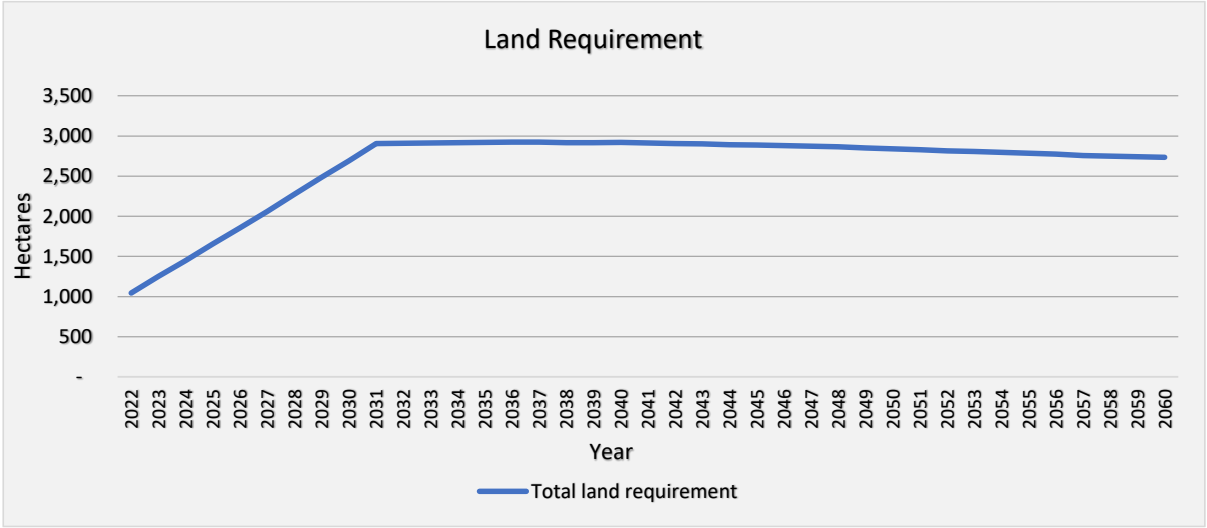

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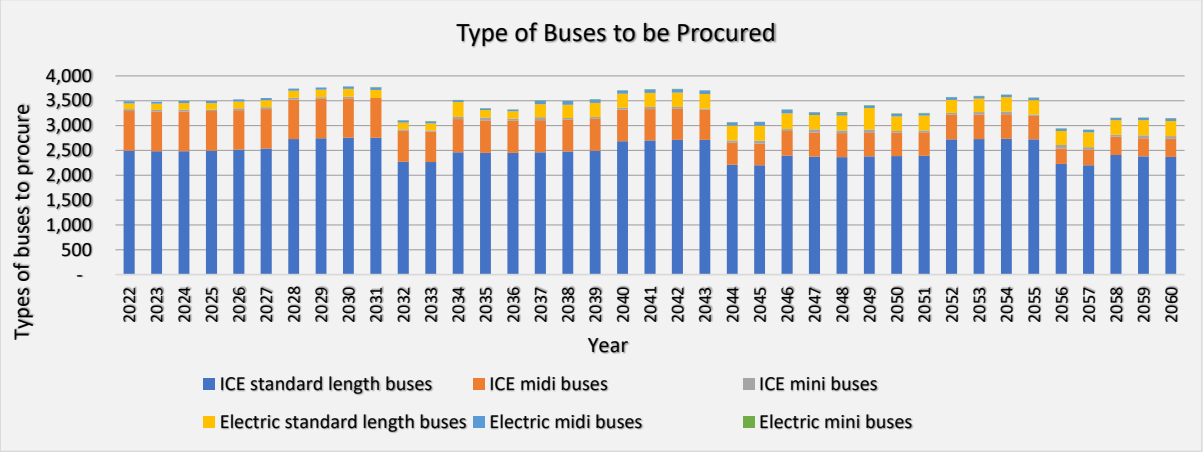

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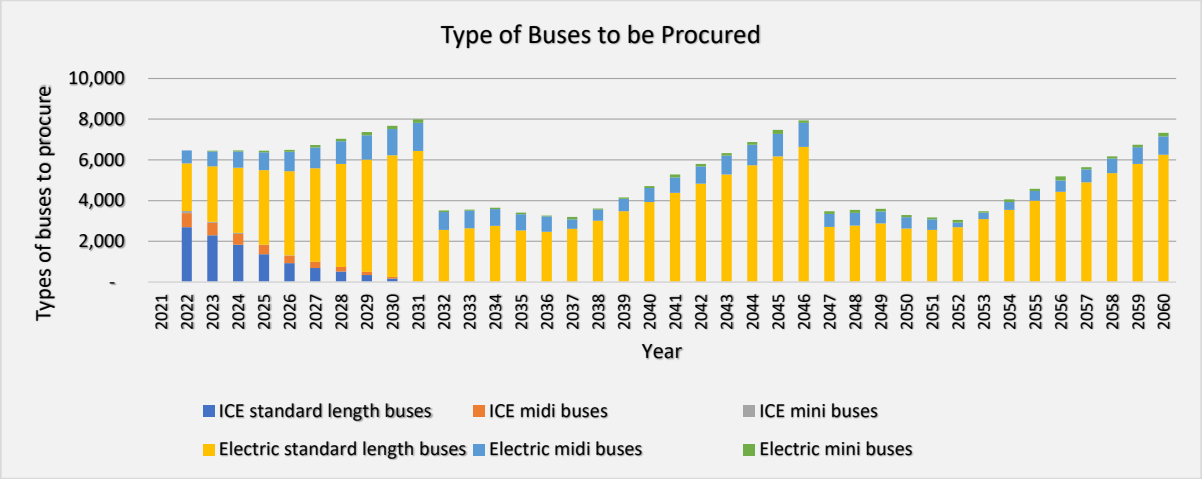
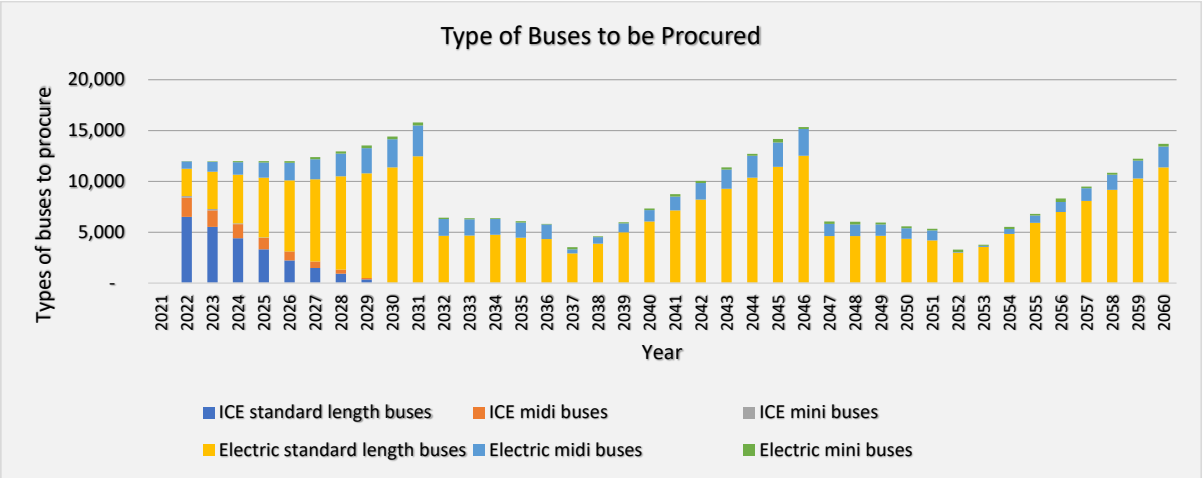
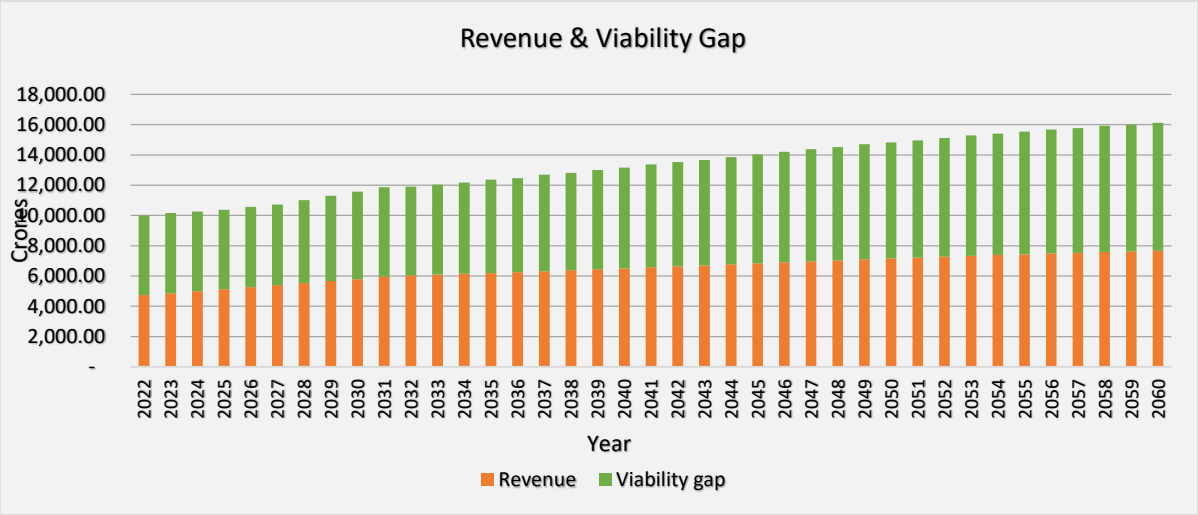


High Ambition Scenario

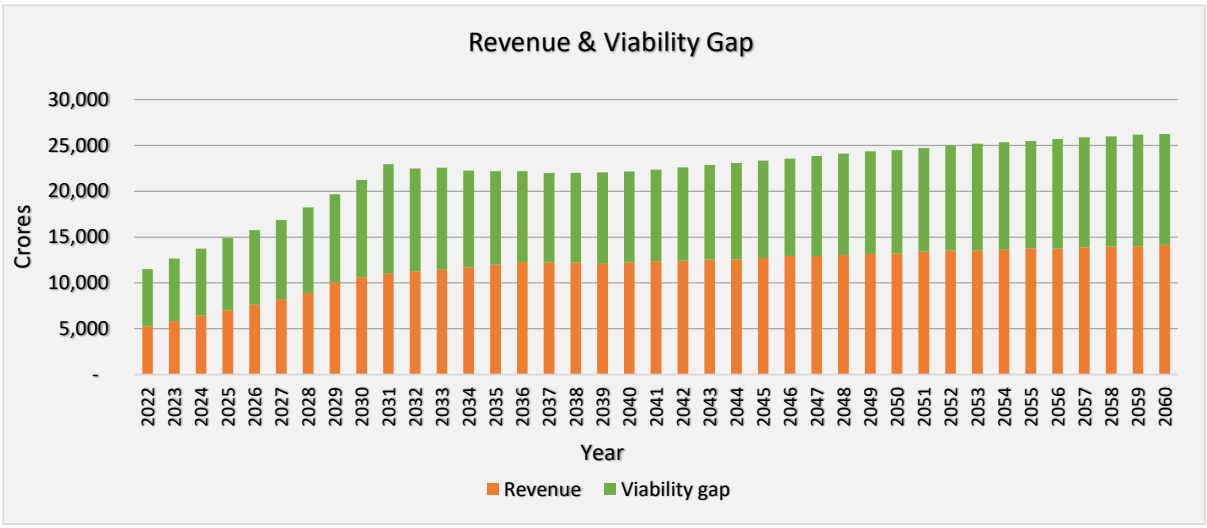


Revenue and Viability Gap: GCC Model

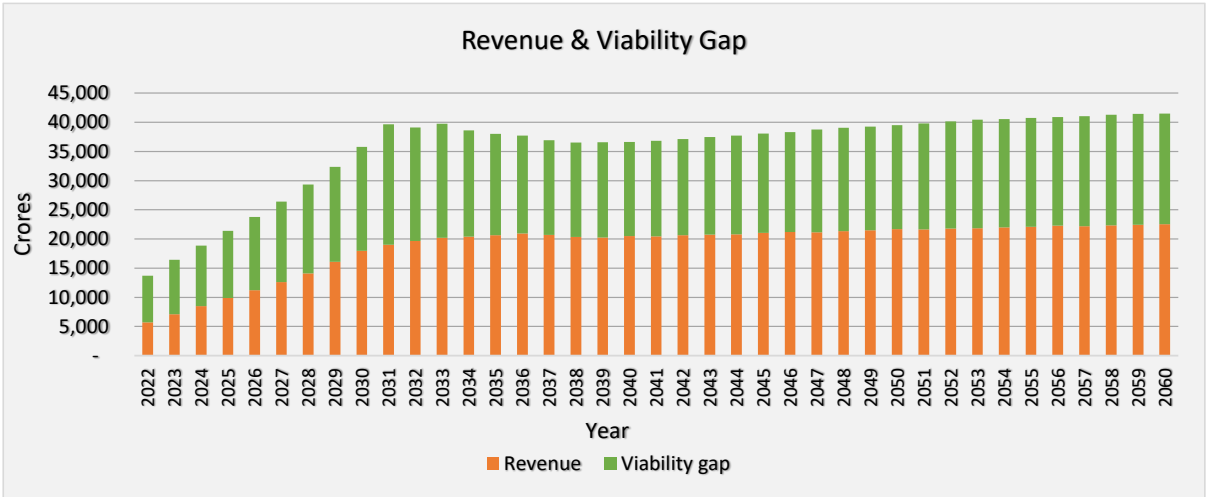
Business as Usual Scenario



Low Ambition Scenario

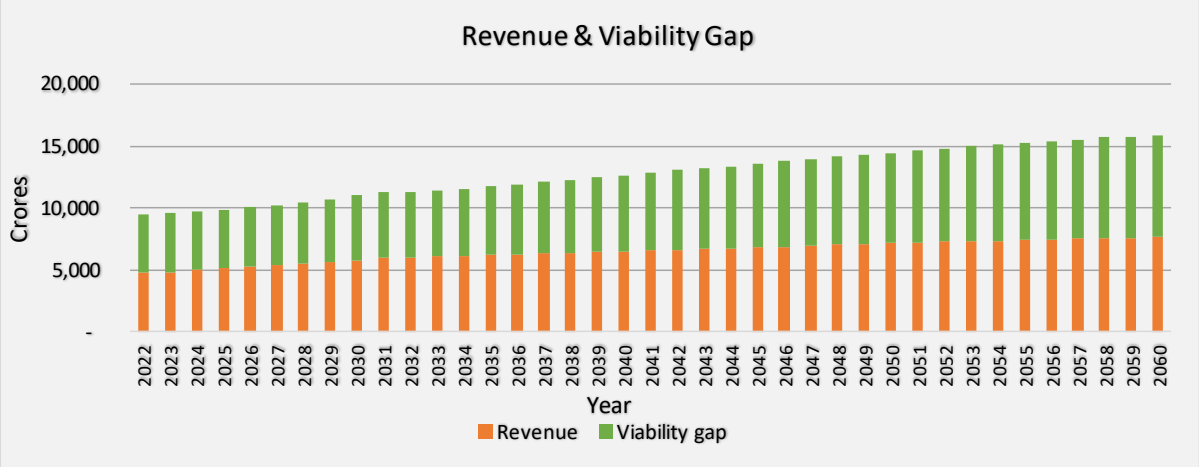


High Ambition Scenario

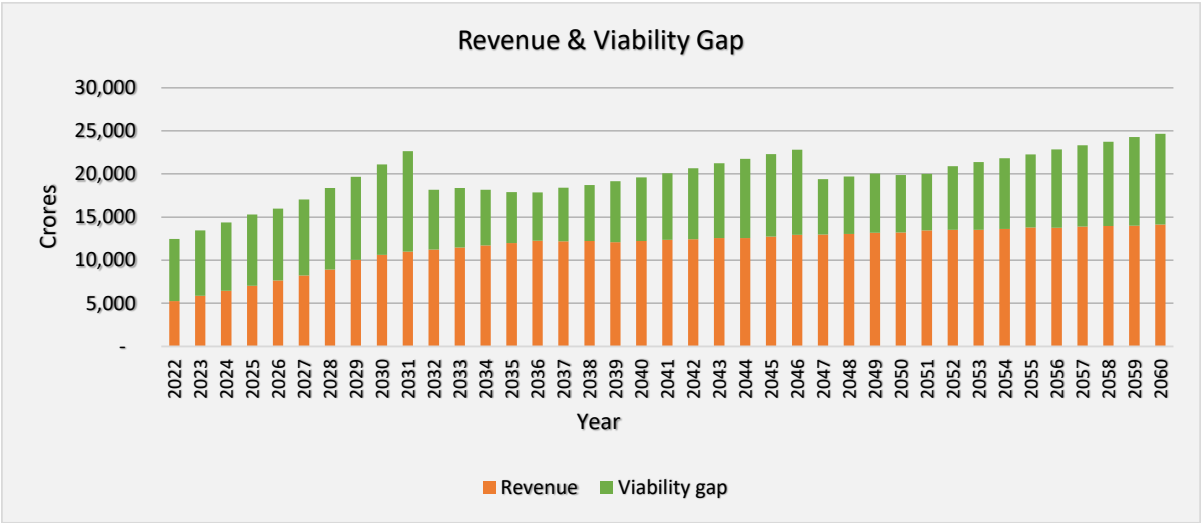


Revenue and Viability Gap: Outright Purchase Model

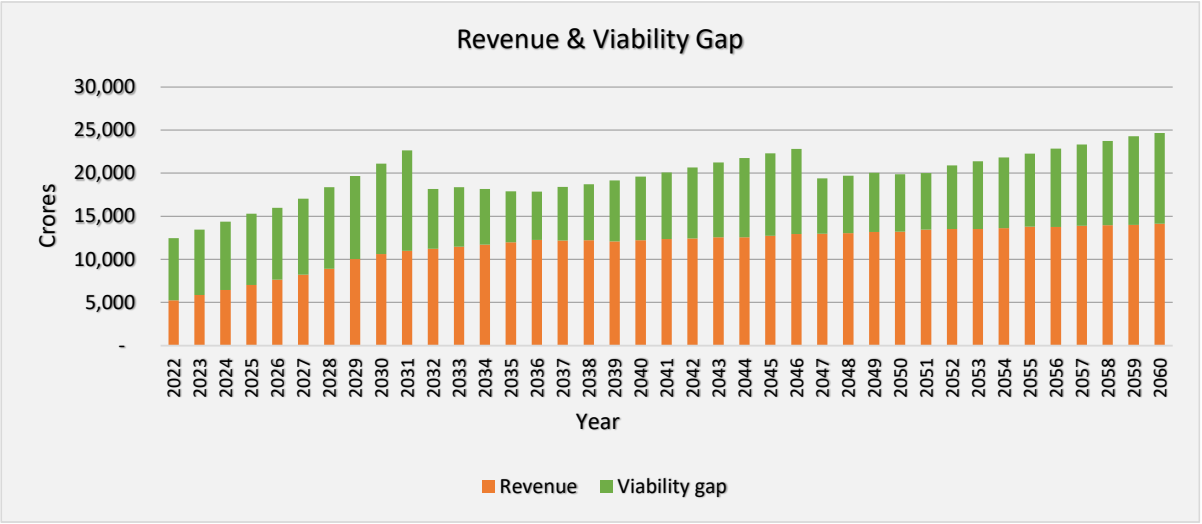
Business as usual Scenario



Low Ambition Scenario

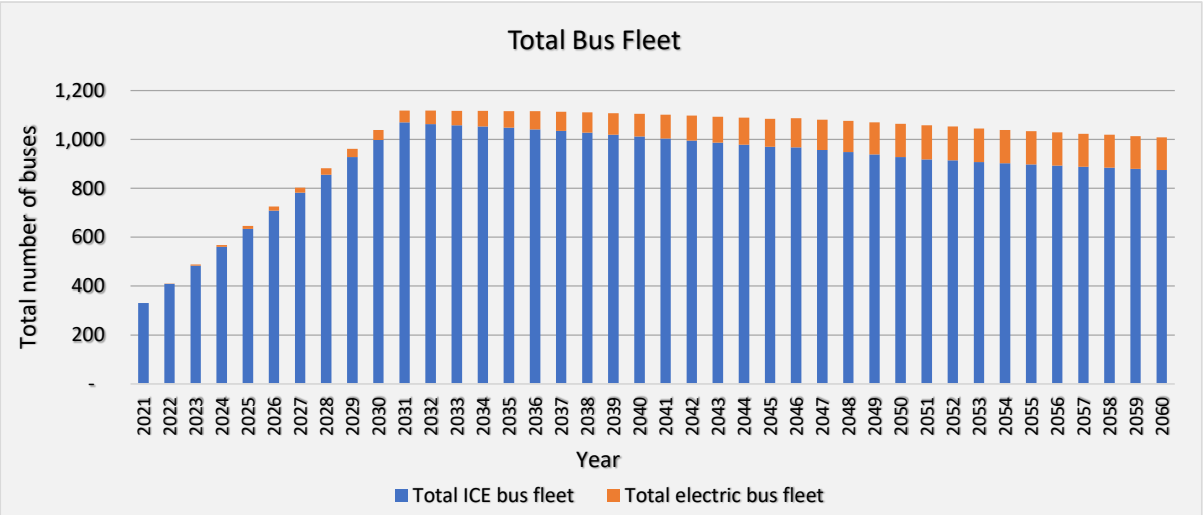


High Ambition Scenario



22. State / UT: Manipur

Business as usual Scenario



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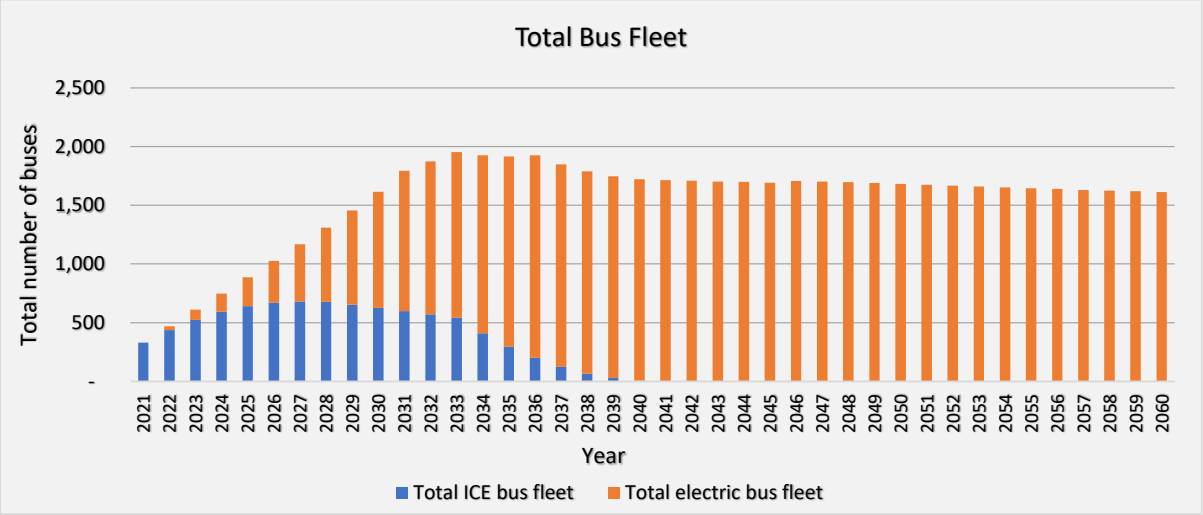

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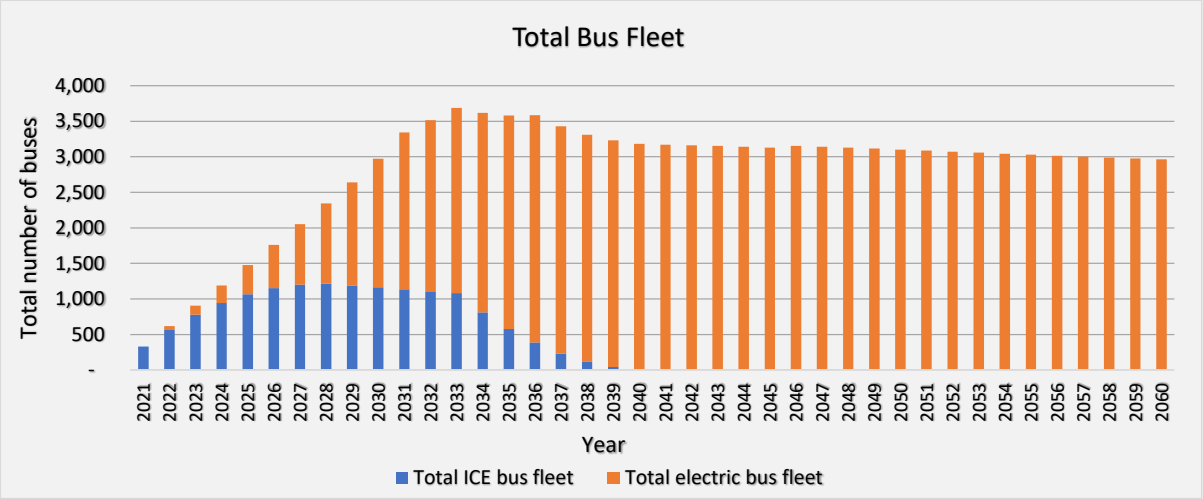
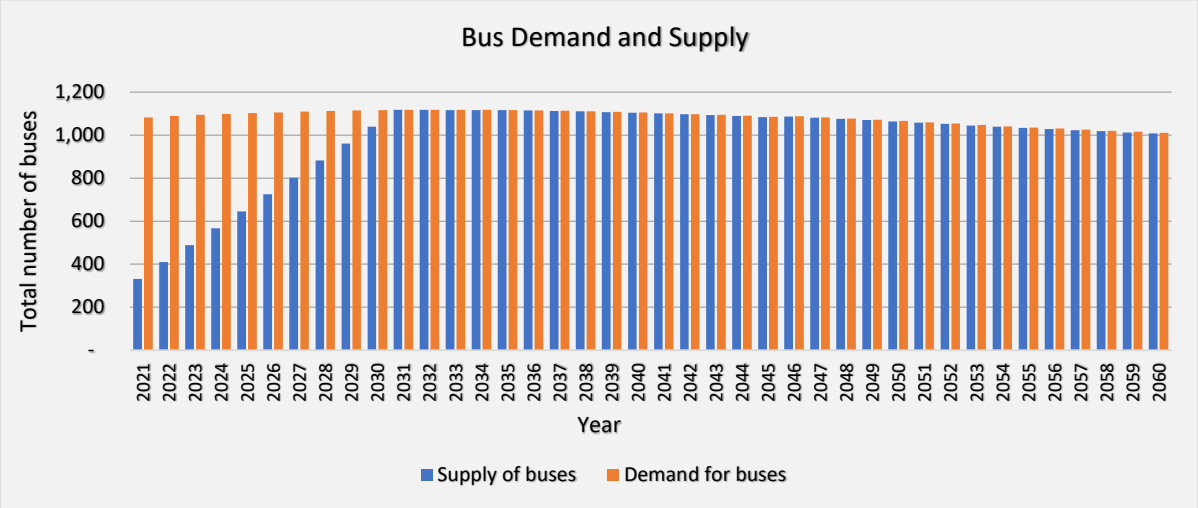


Business as Usual Scenario



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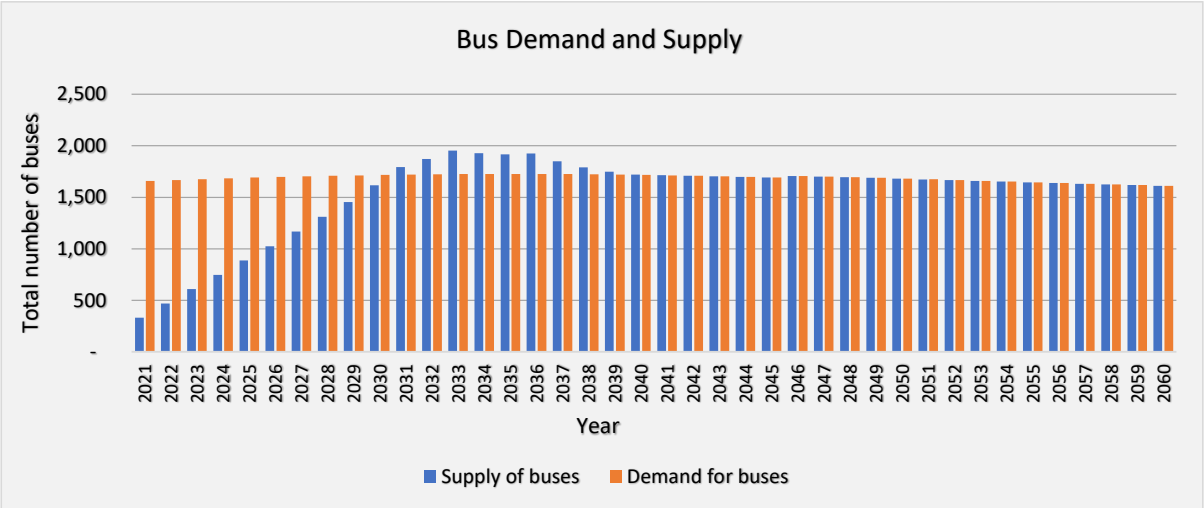

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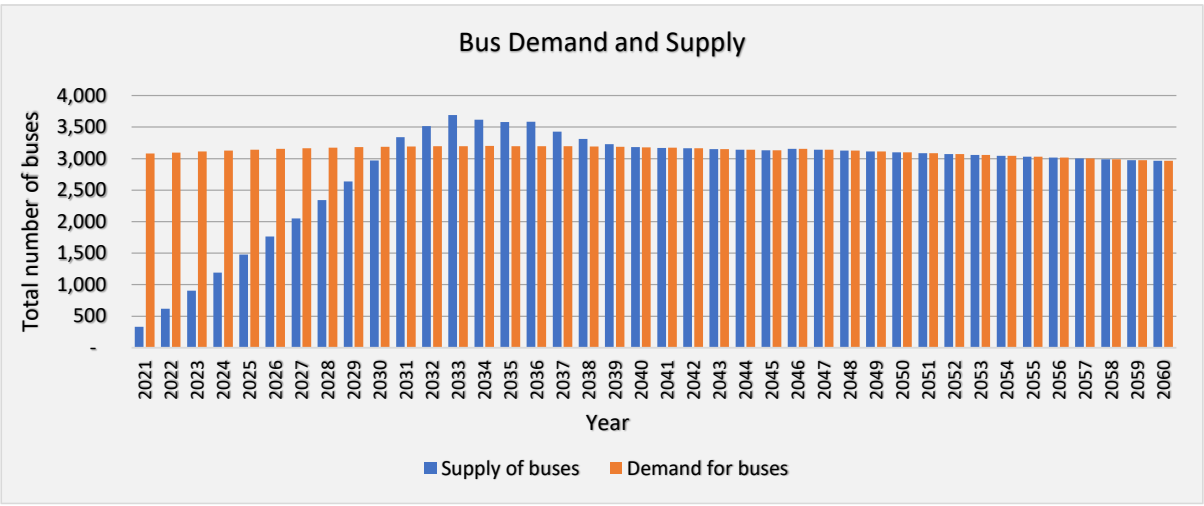
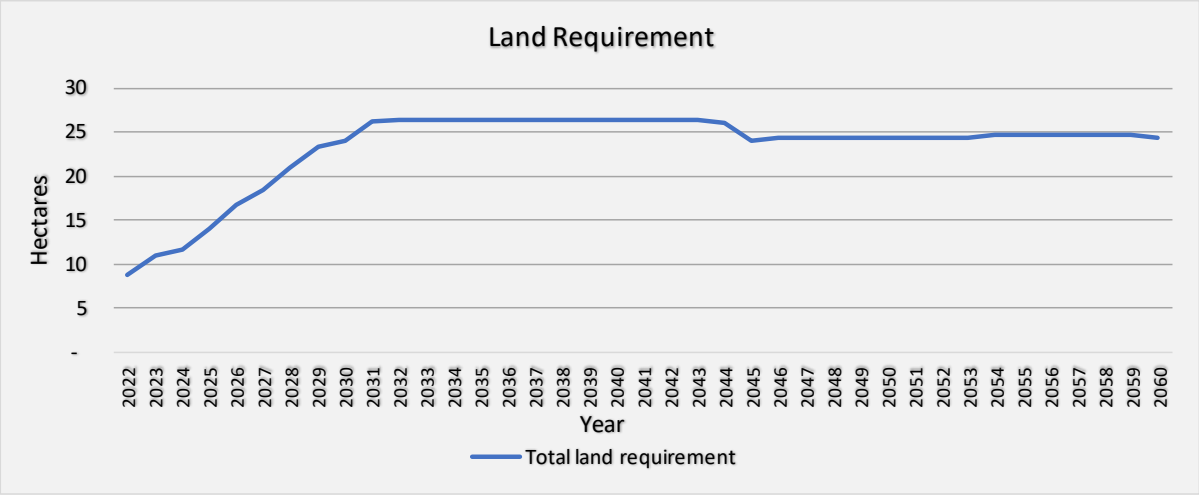


Business as Usual Scenario



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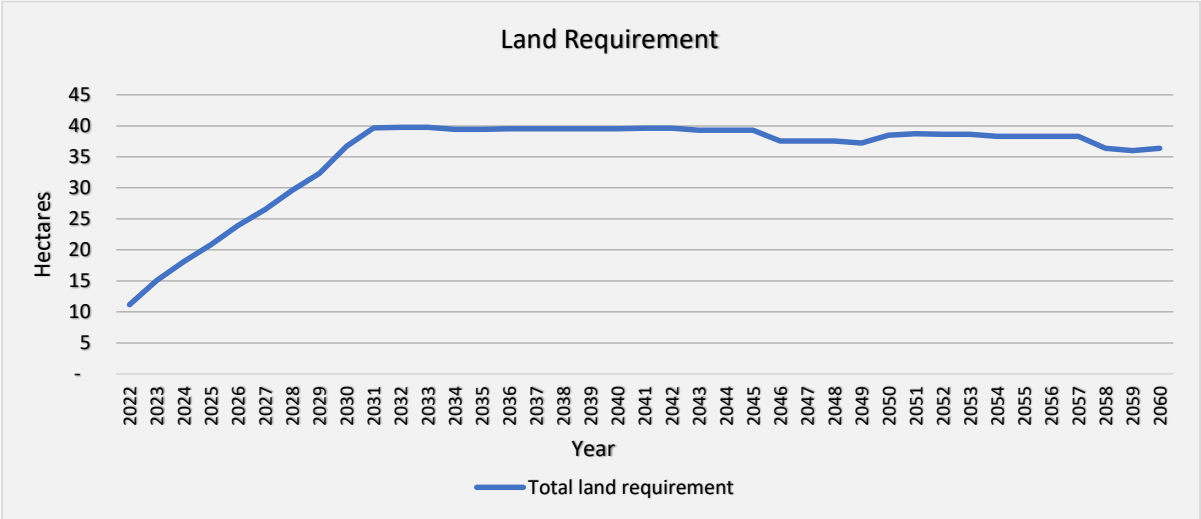

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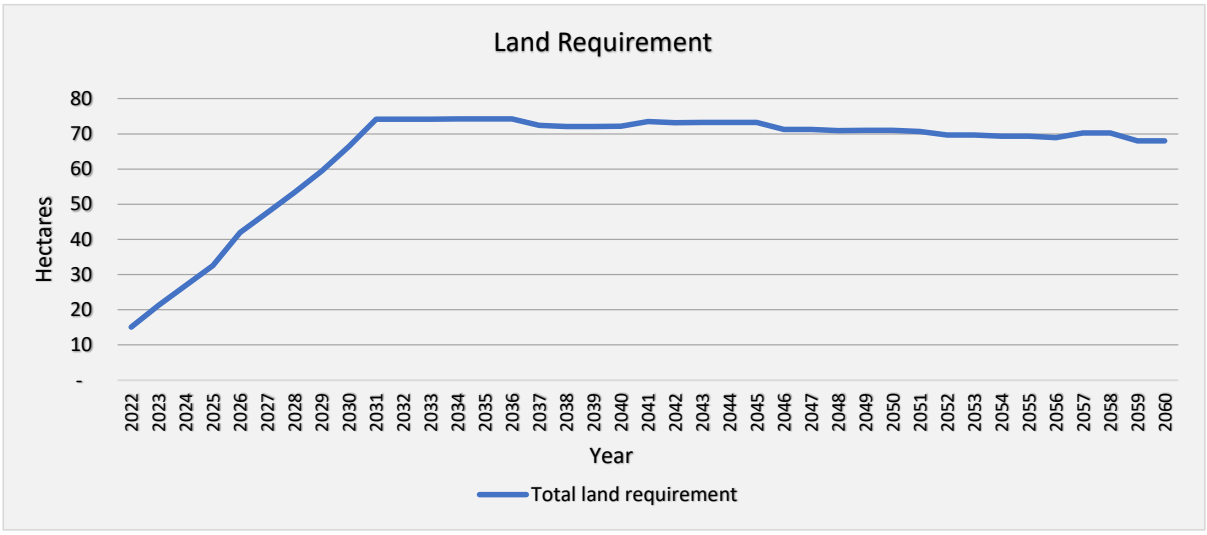
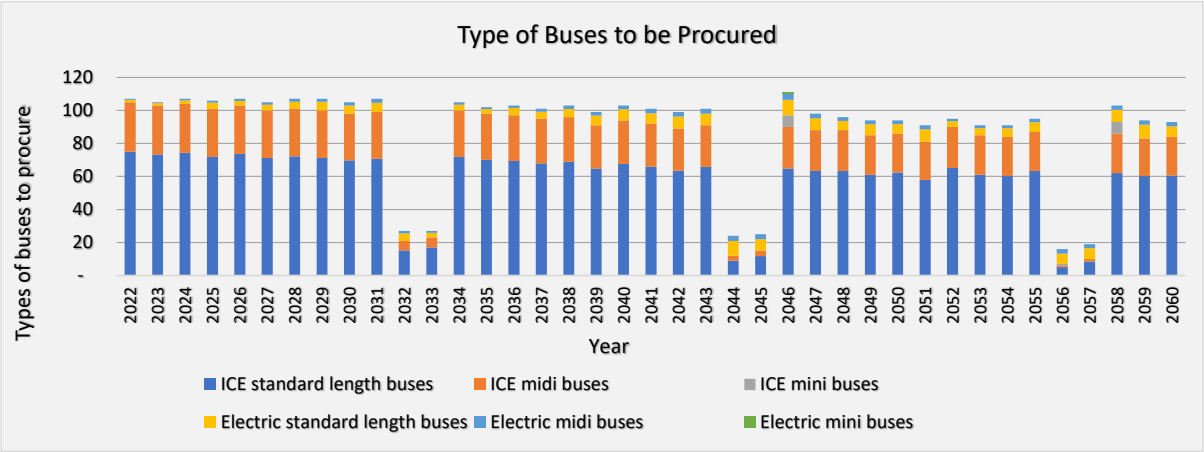
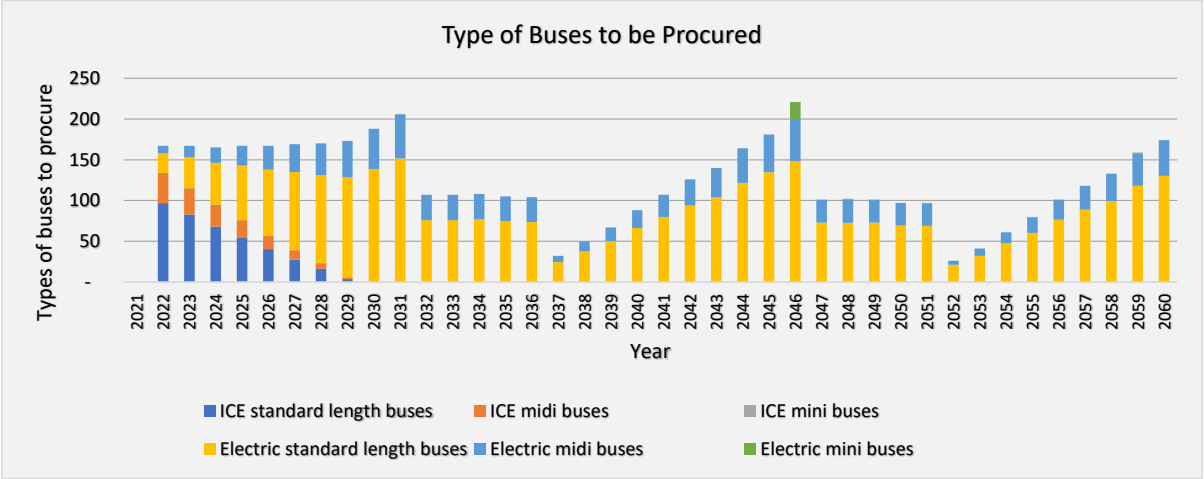


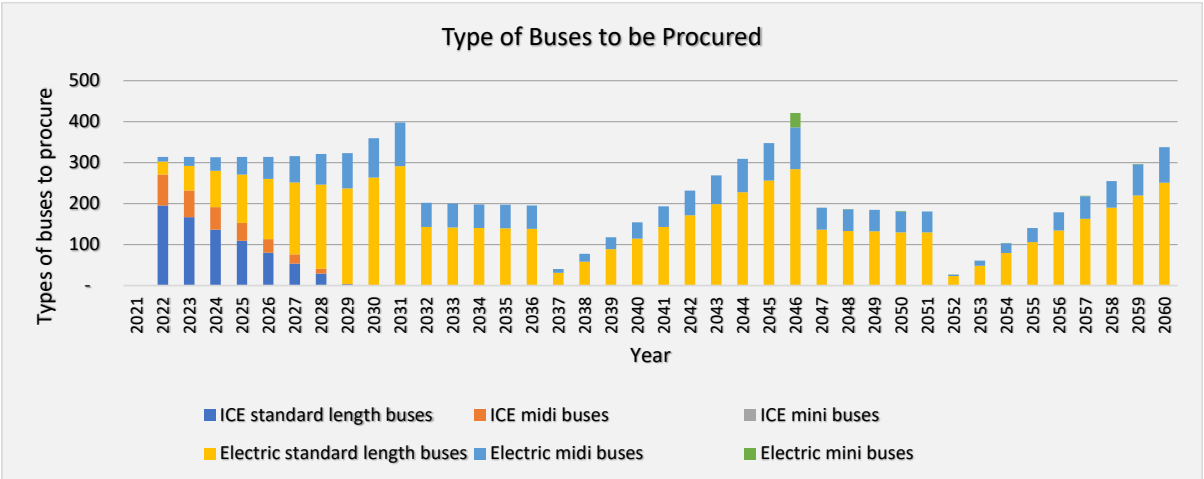
Business as Usual Scenario



Low Ambition Scenario

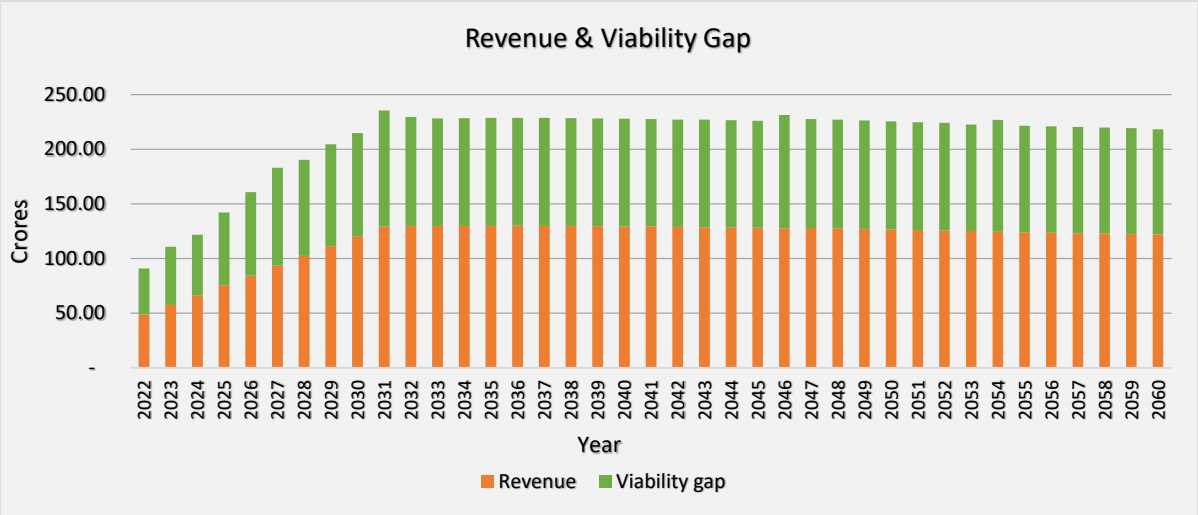


High Ambition Scenario

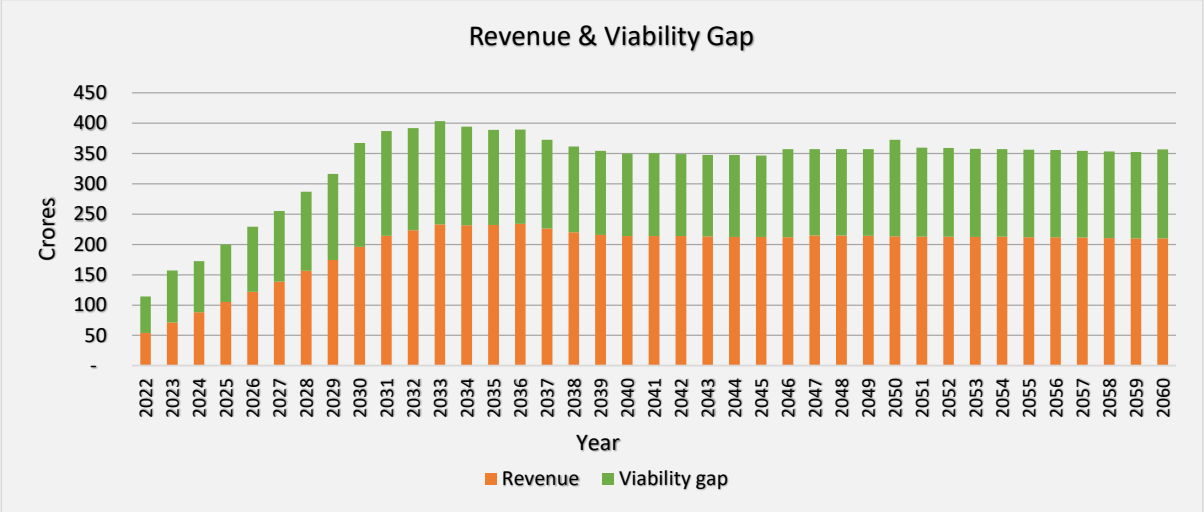


Revenue and Viability Gap: GCC Model

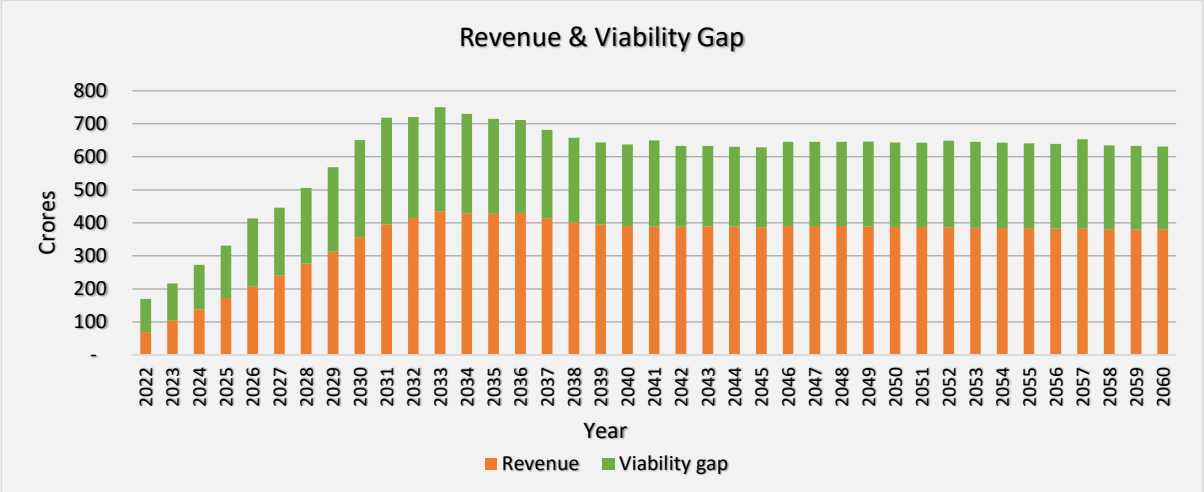
Business as Usual Scenario



Low Ambition Scenario

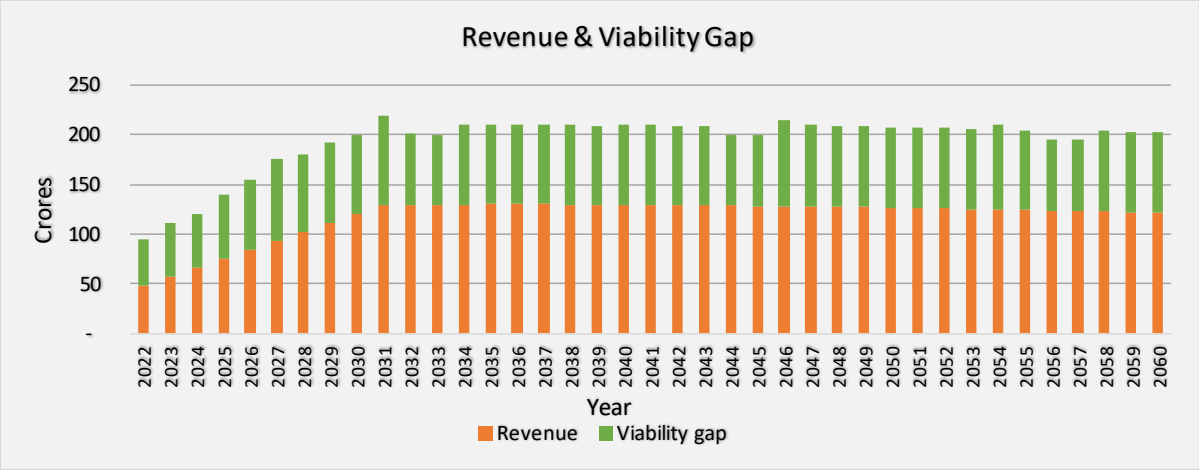


High Ambition Scenario

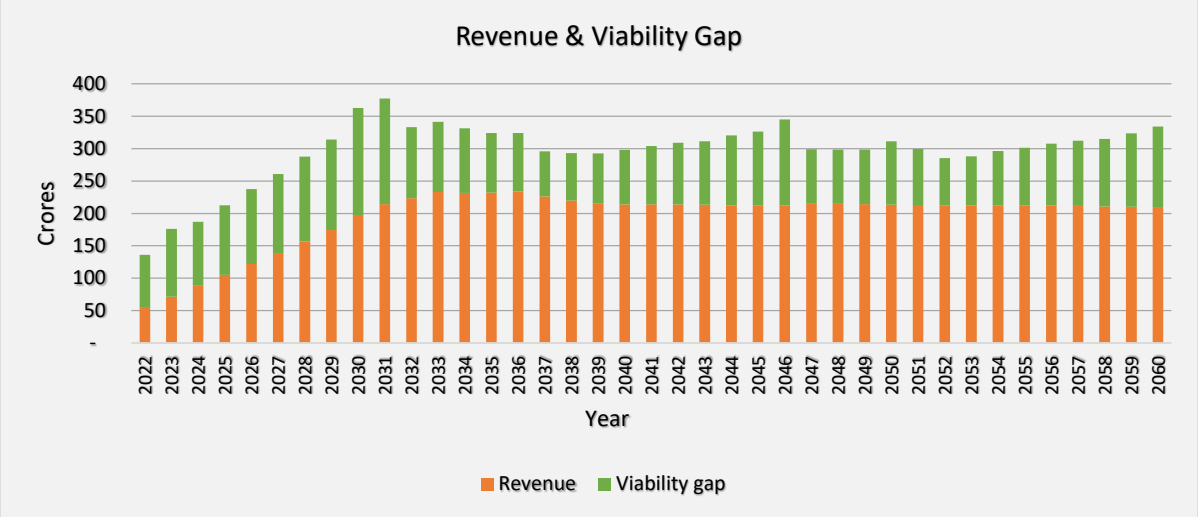


Revenue and Viability Gap: Outright Purchase Model

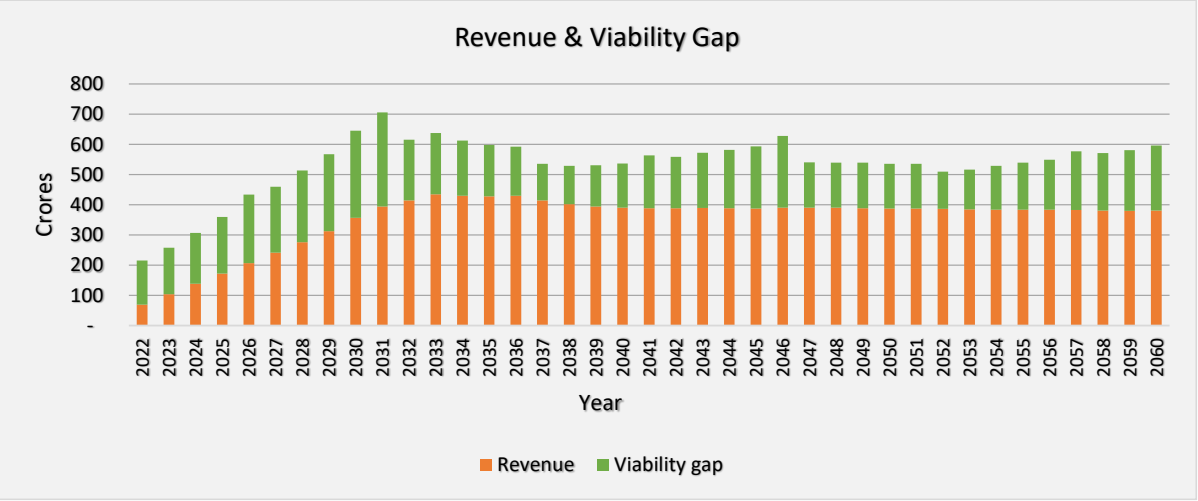
Business as usual Scenario



Low Ambition Scenario

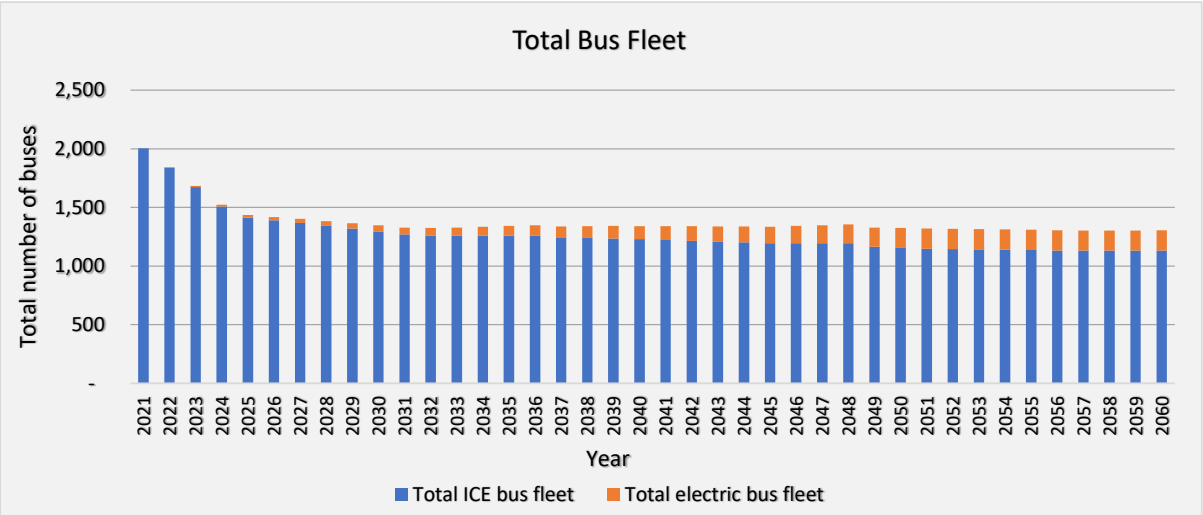


High Ambition Scenario



23. State / UT: Meghalaya

Business as usual Scenario



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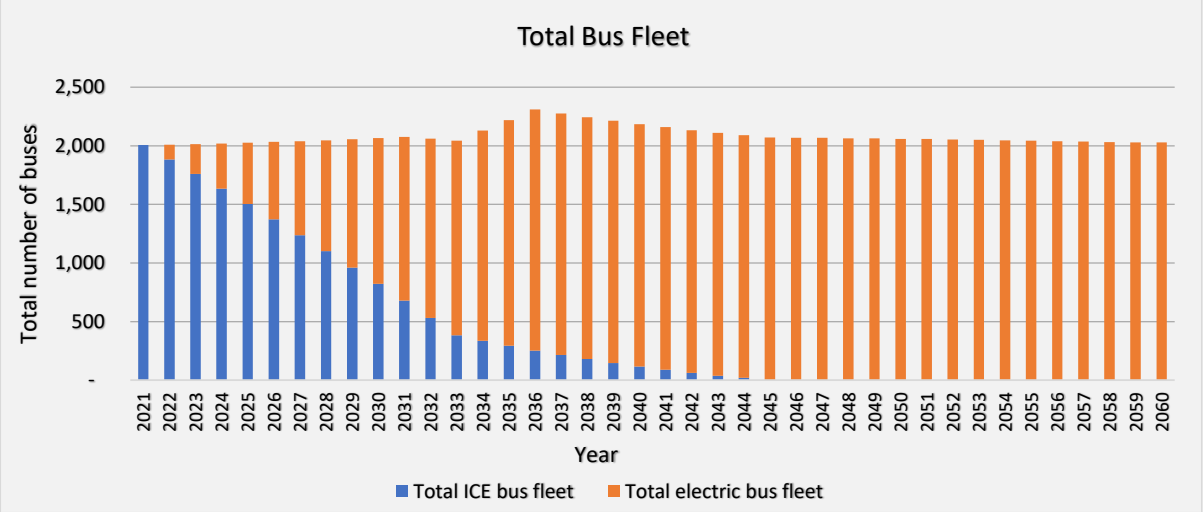

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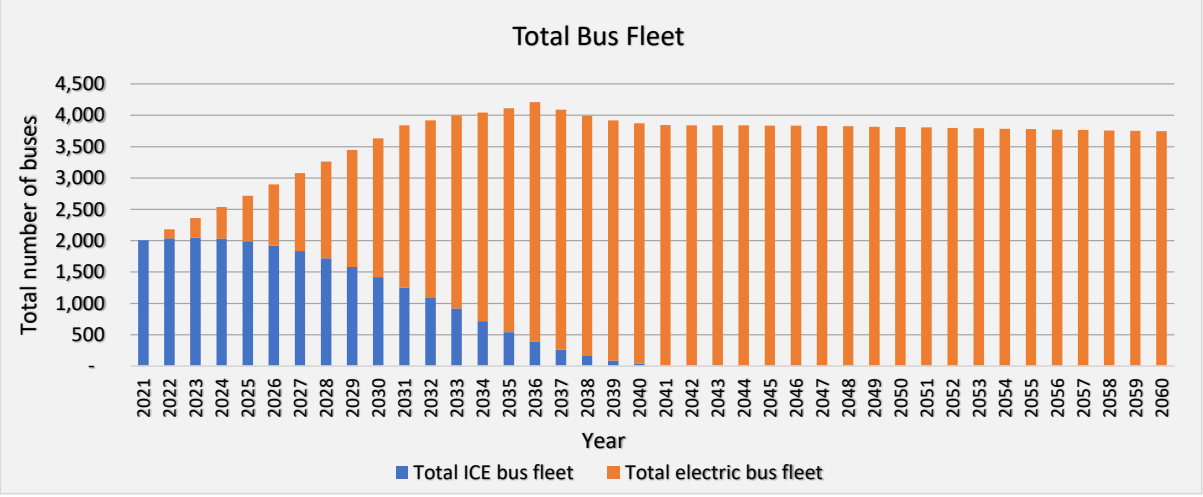
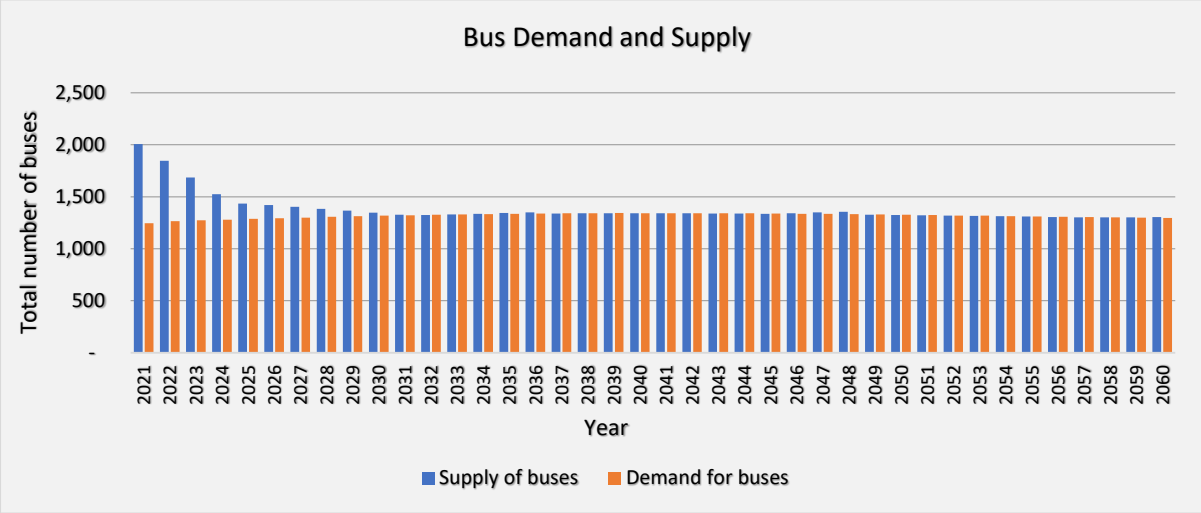


Business as Usual Scenario



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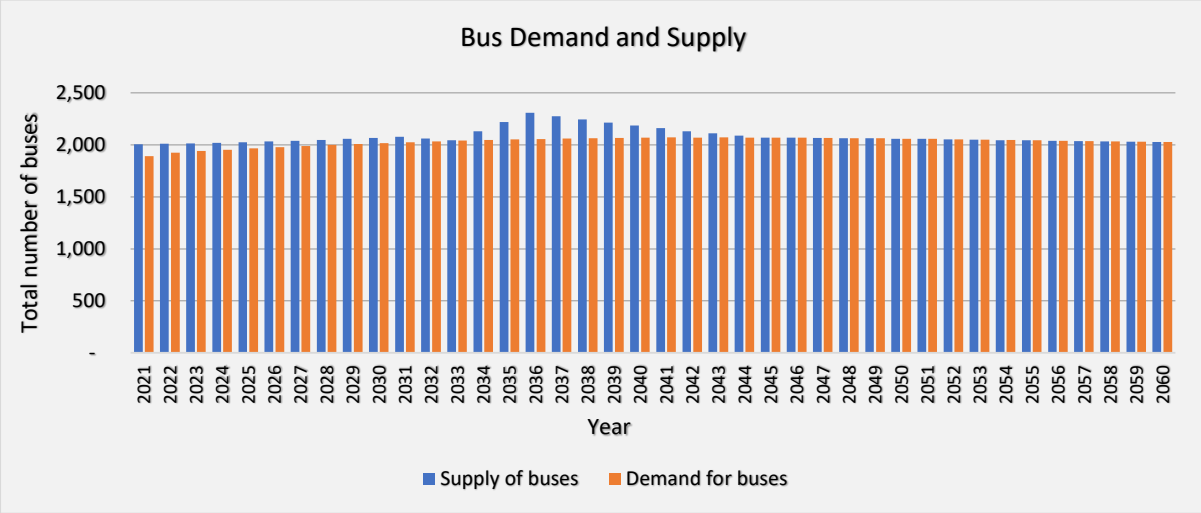

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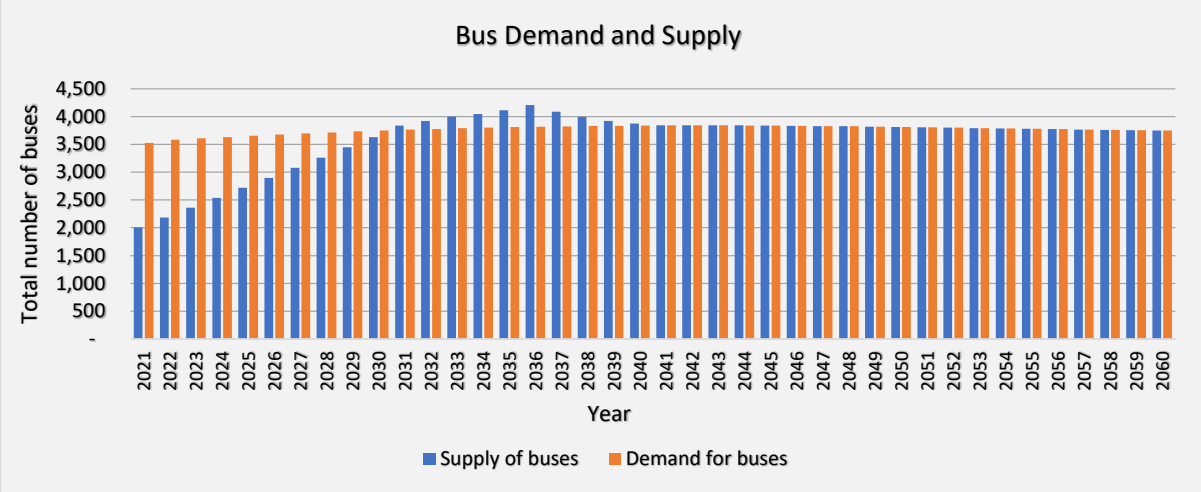
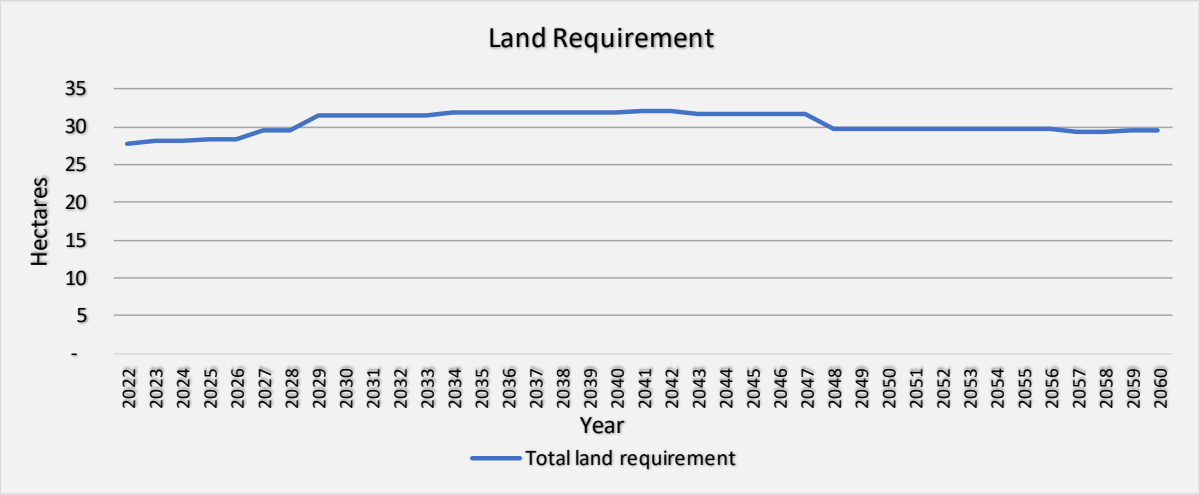


Business as Usual Scenario



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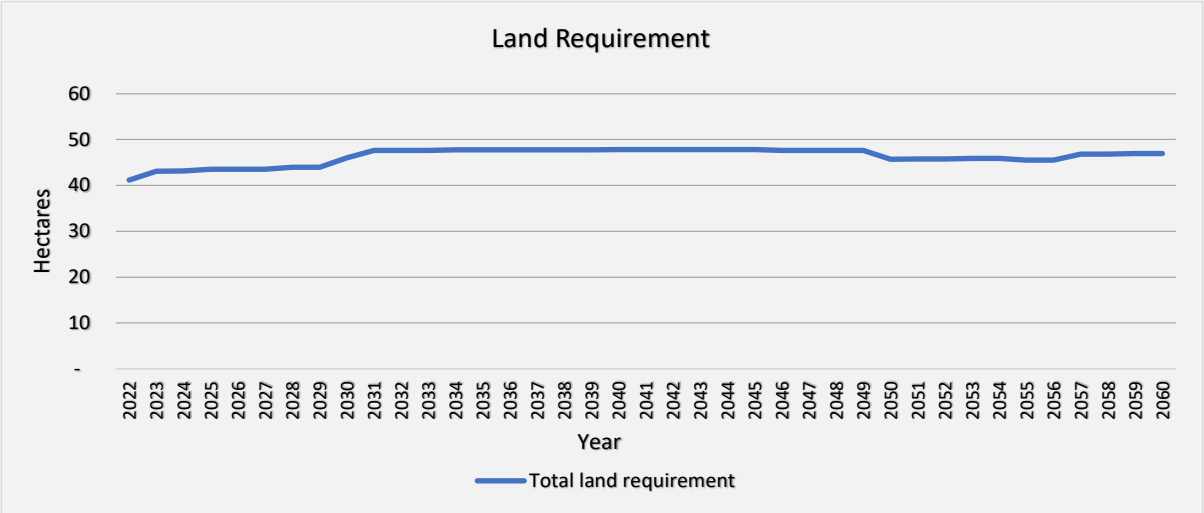

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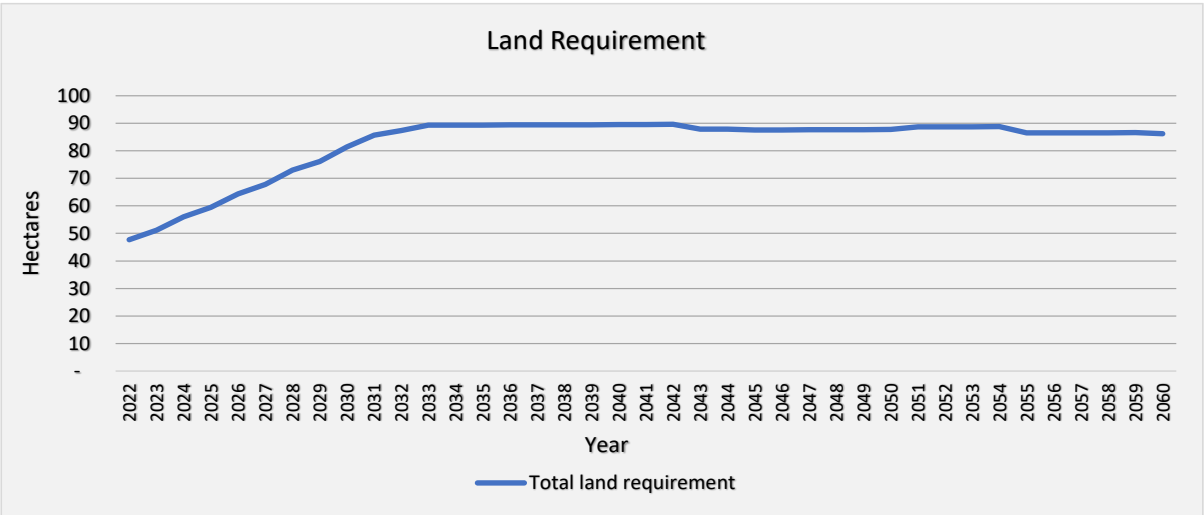
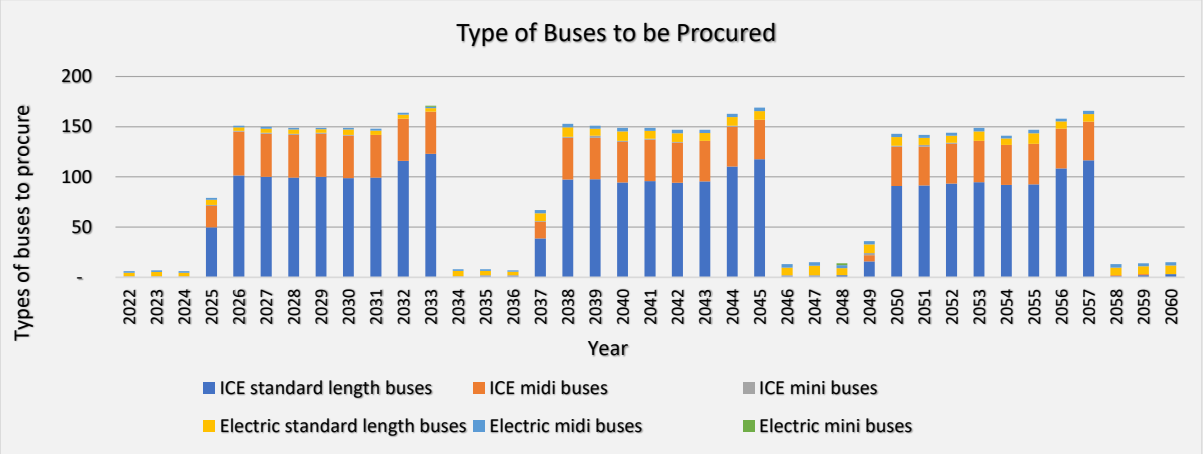


Business as Usual Scenario



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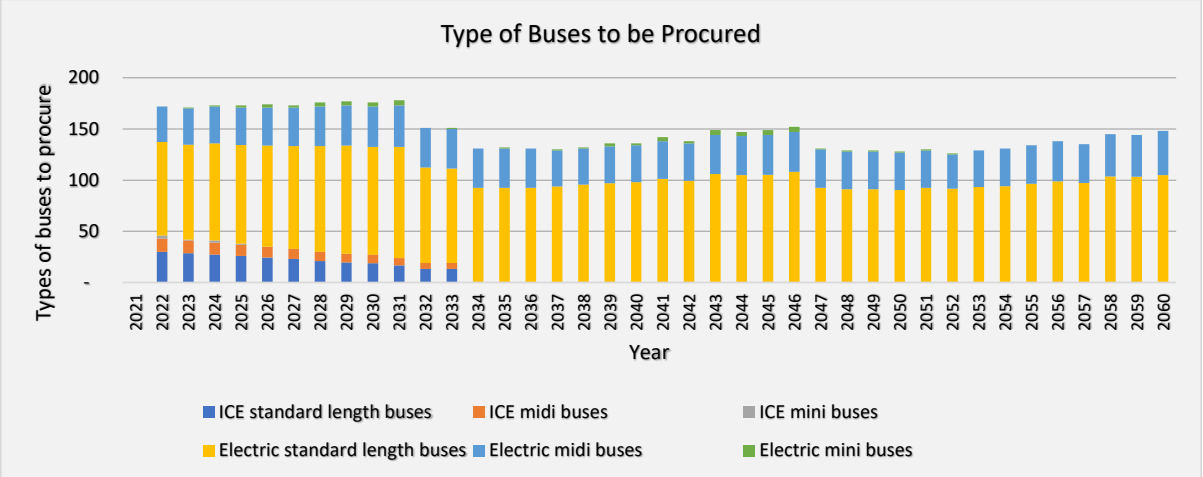
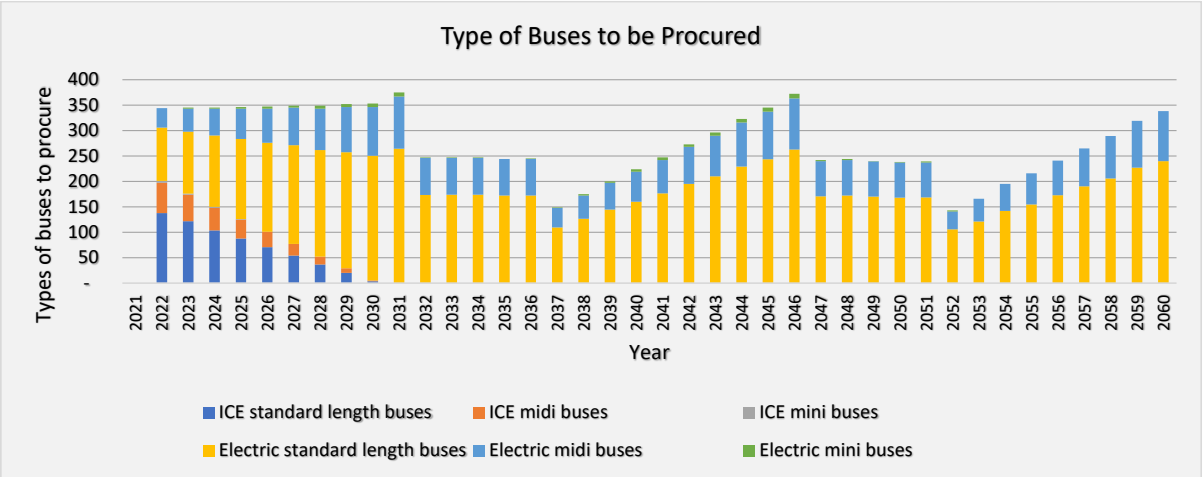
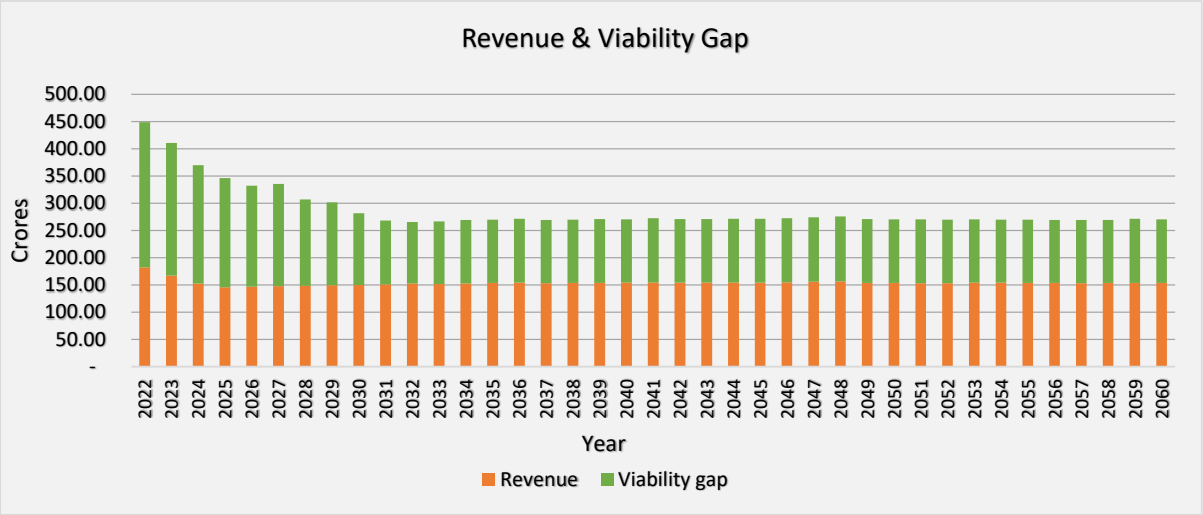


High Ambition Scenario

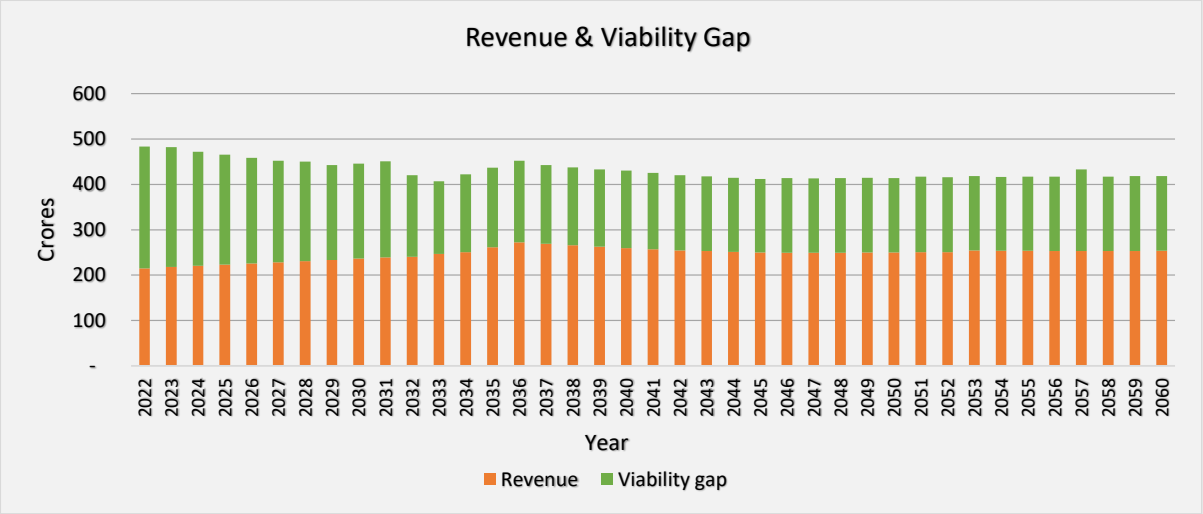


Revenue and Viability Gap: GCC Model

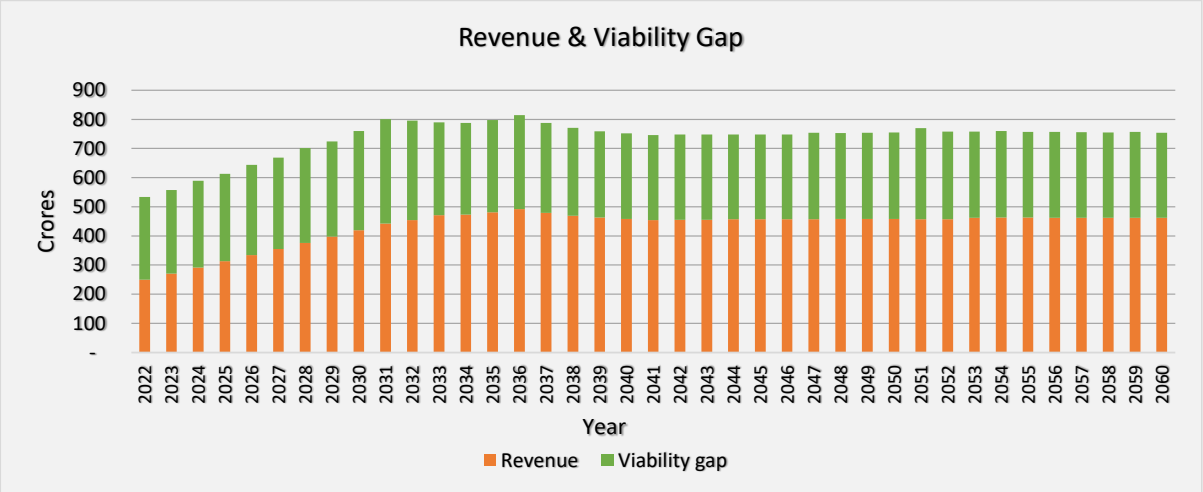
Business as Usual Scenario



Low Ambition Scenario

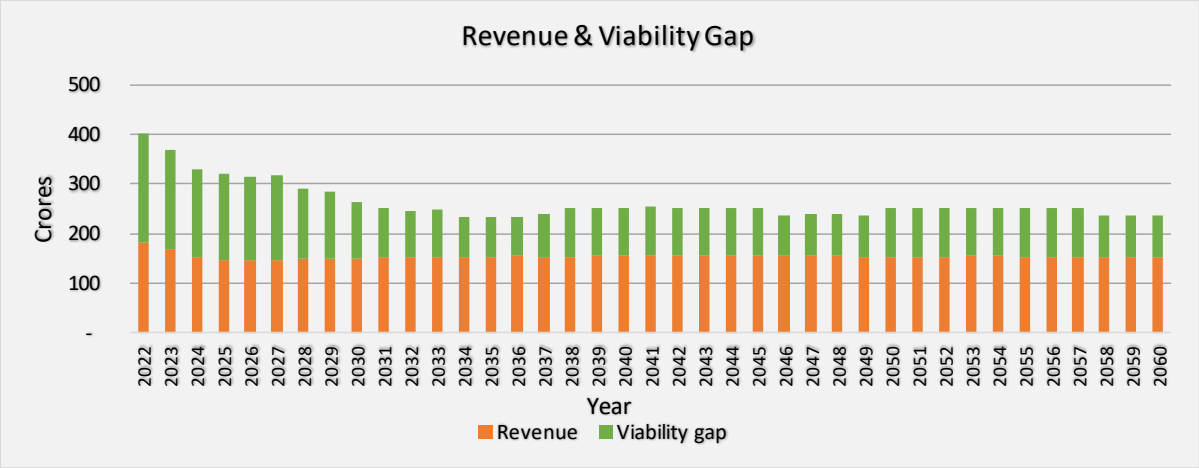


High Ambition Scenario



Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



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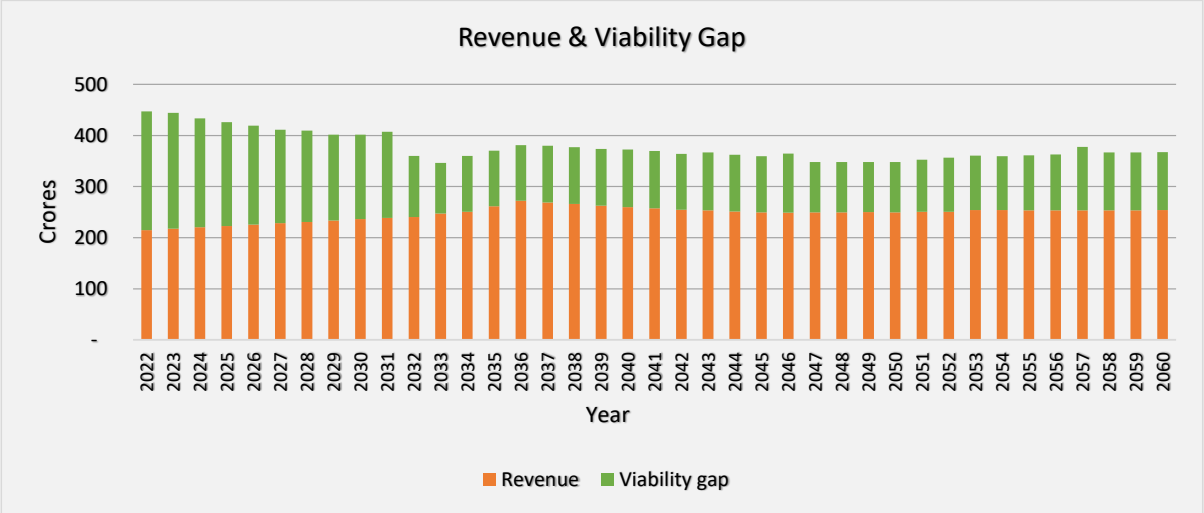
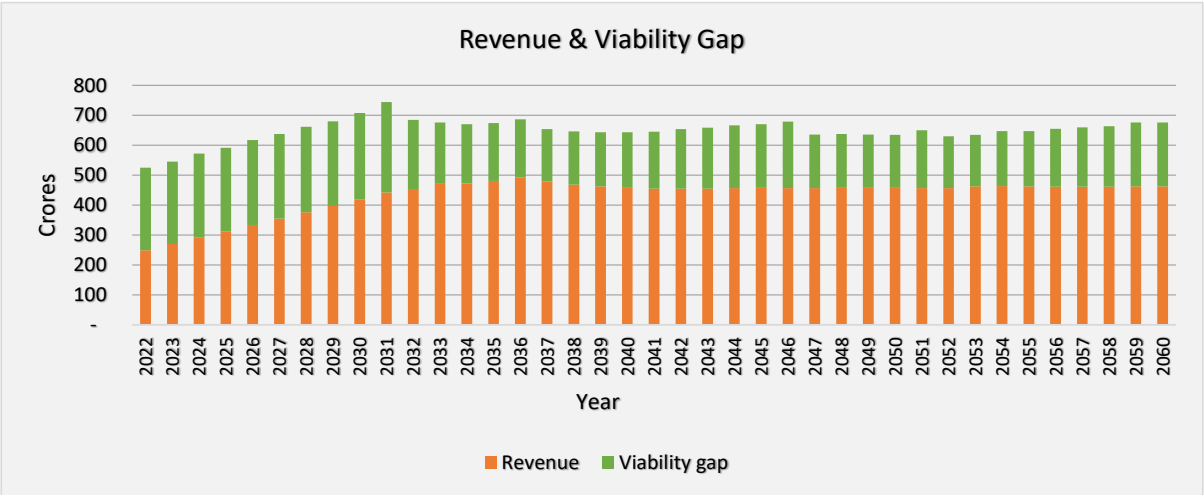
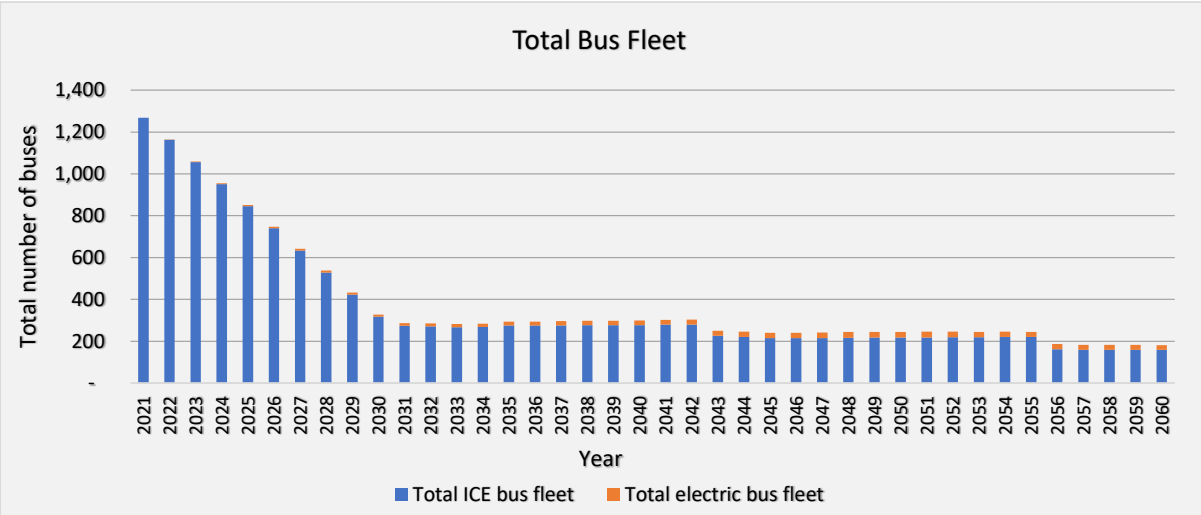


High Ambition Scenario

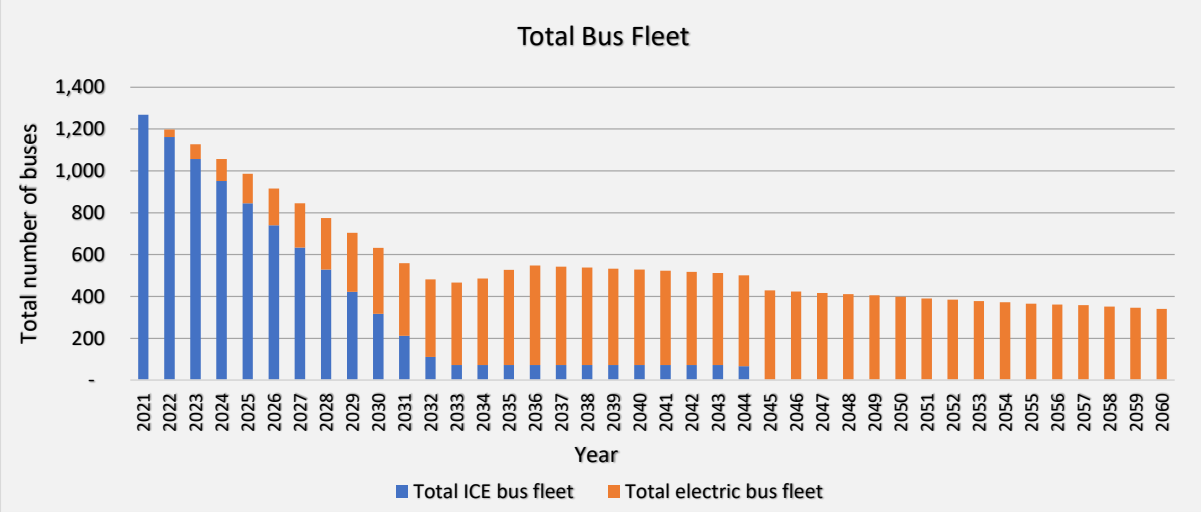


24. State / UT: Mizoram

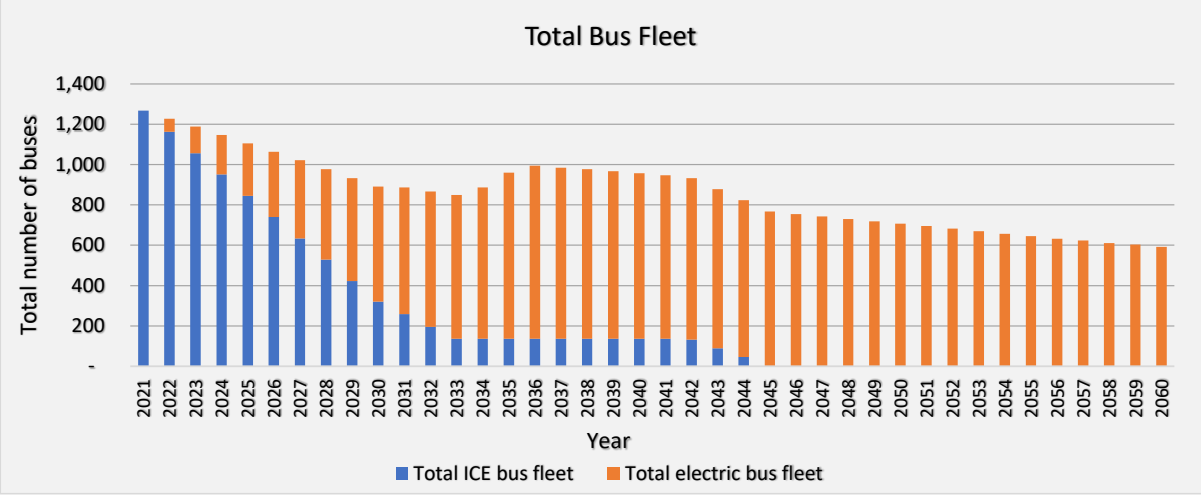
Business as usual Scenario



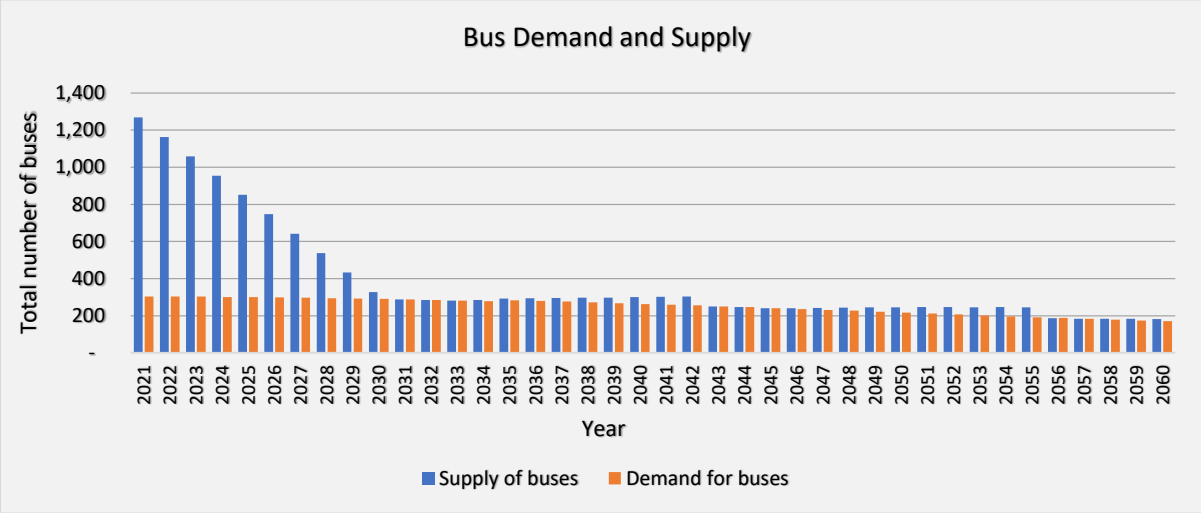
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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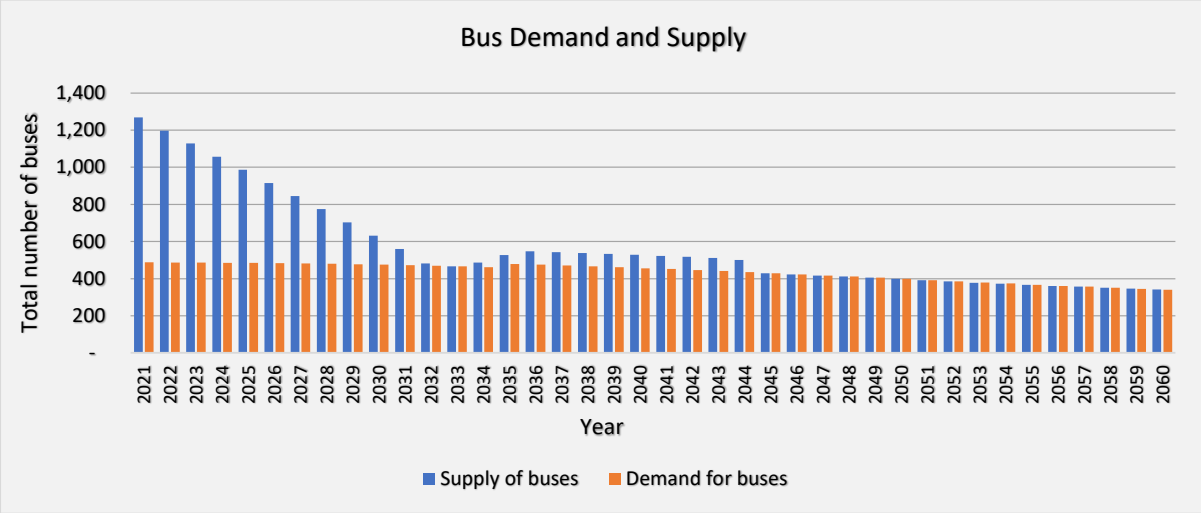
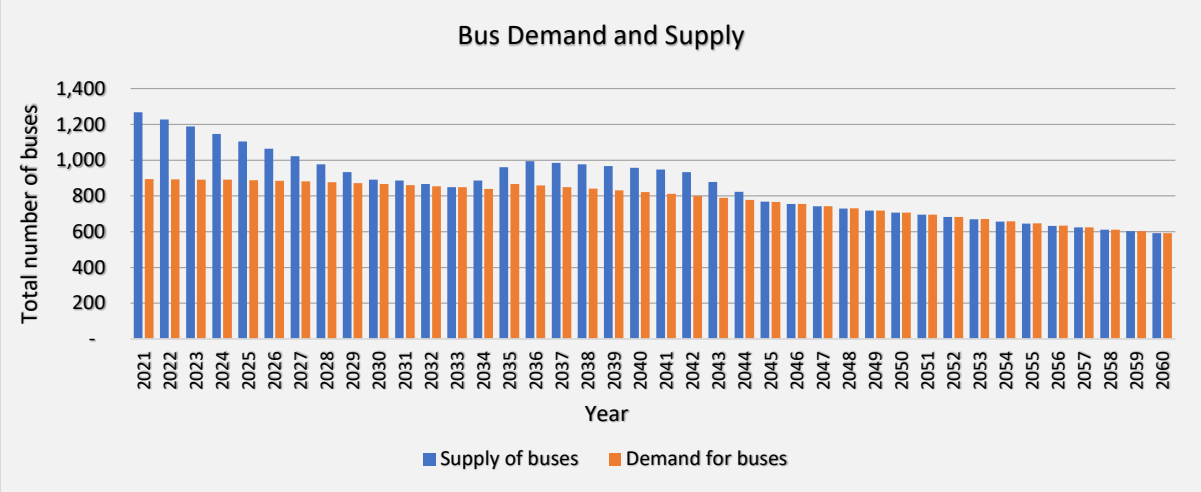
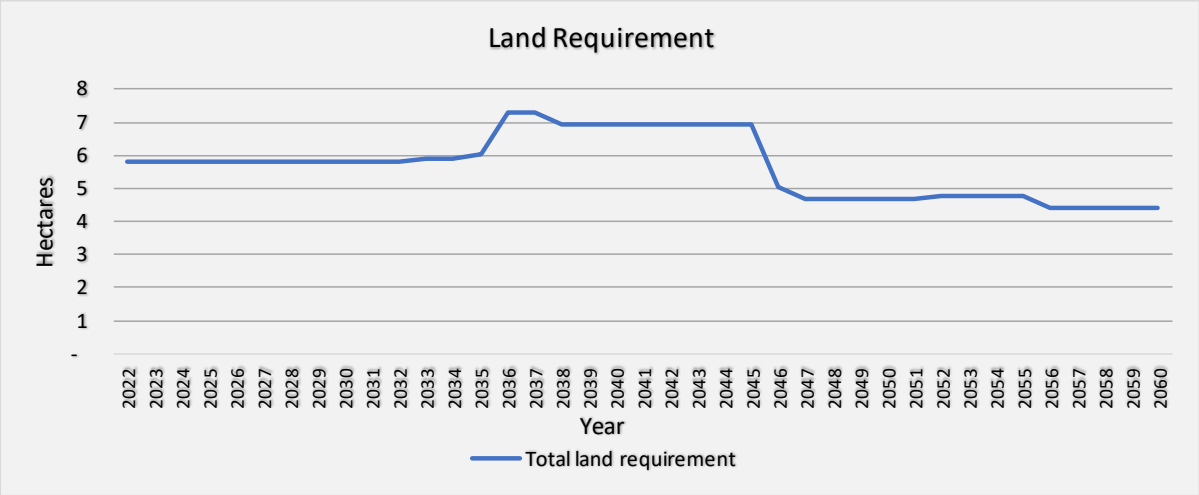


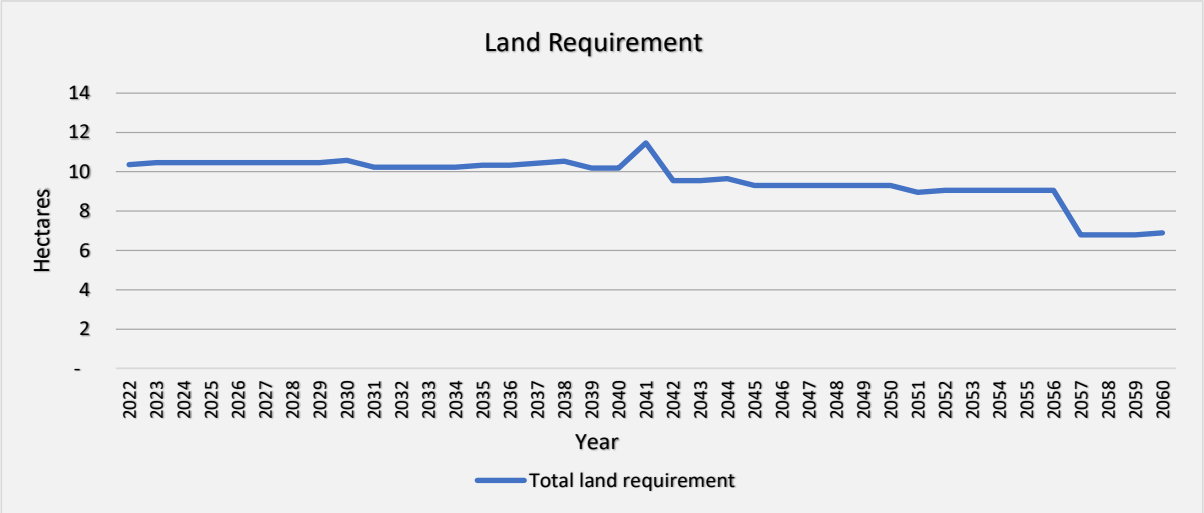
High Ambition Scenario



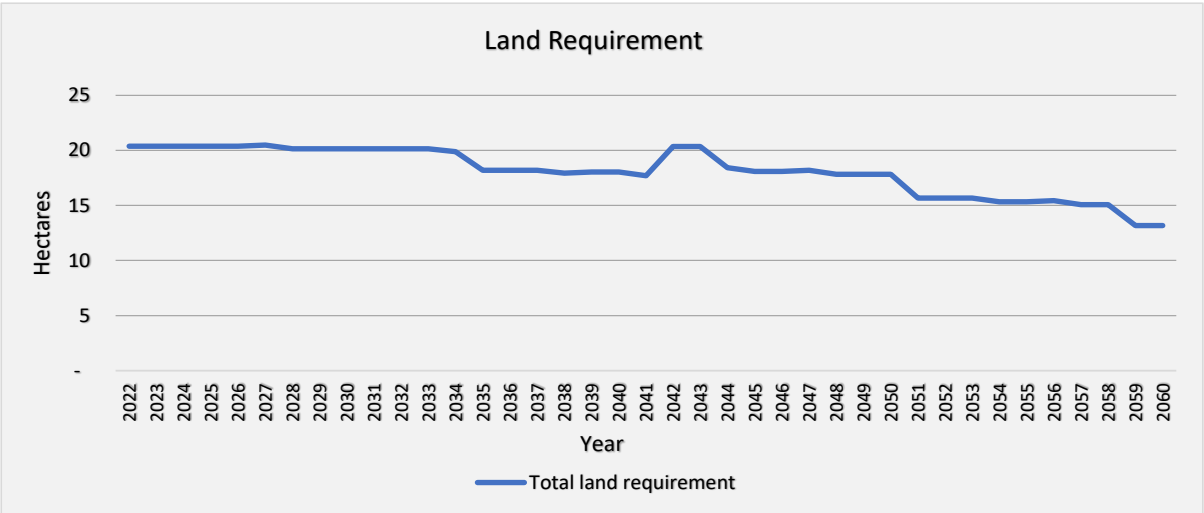
Business as Usual Scenario



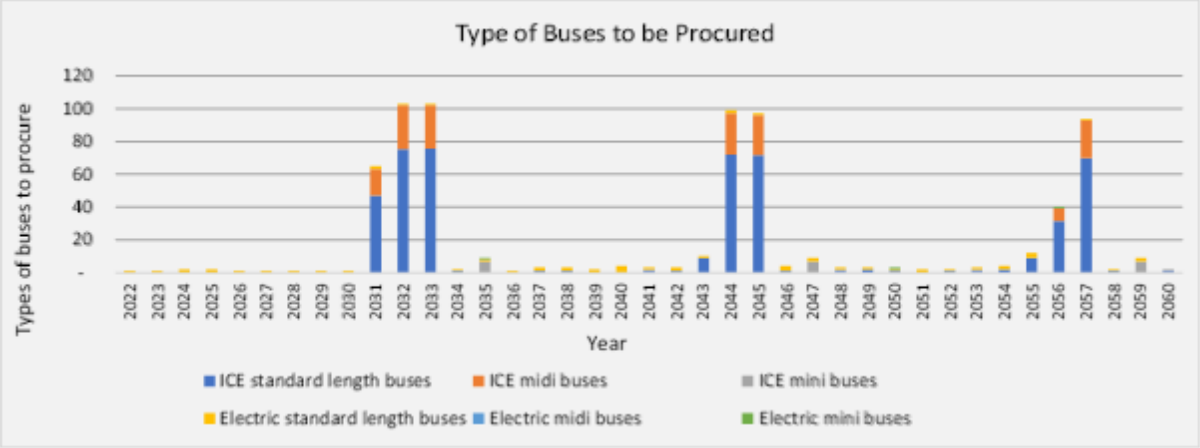
Low Ambition Scenario



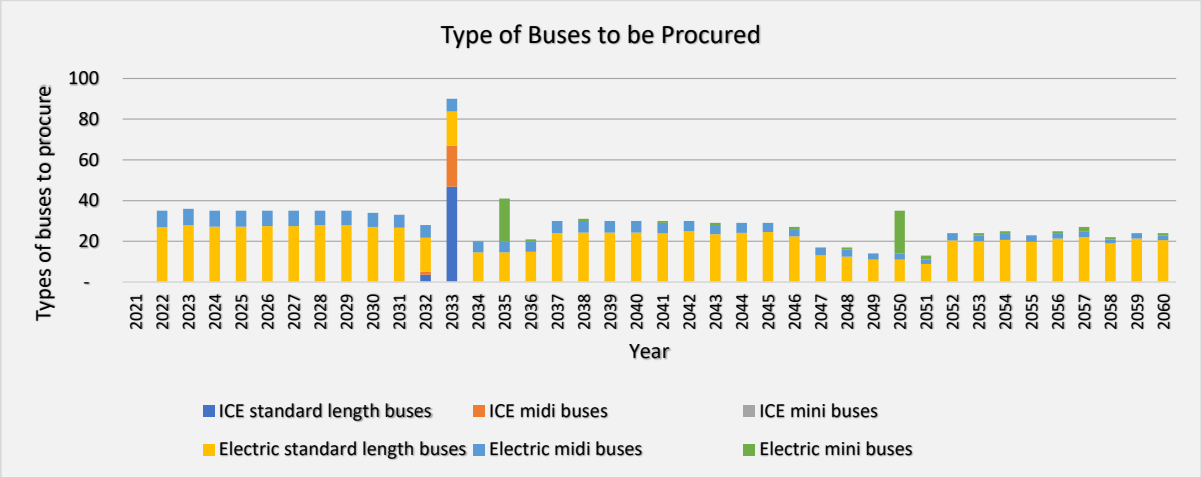
High Ambition Scenario



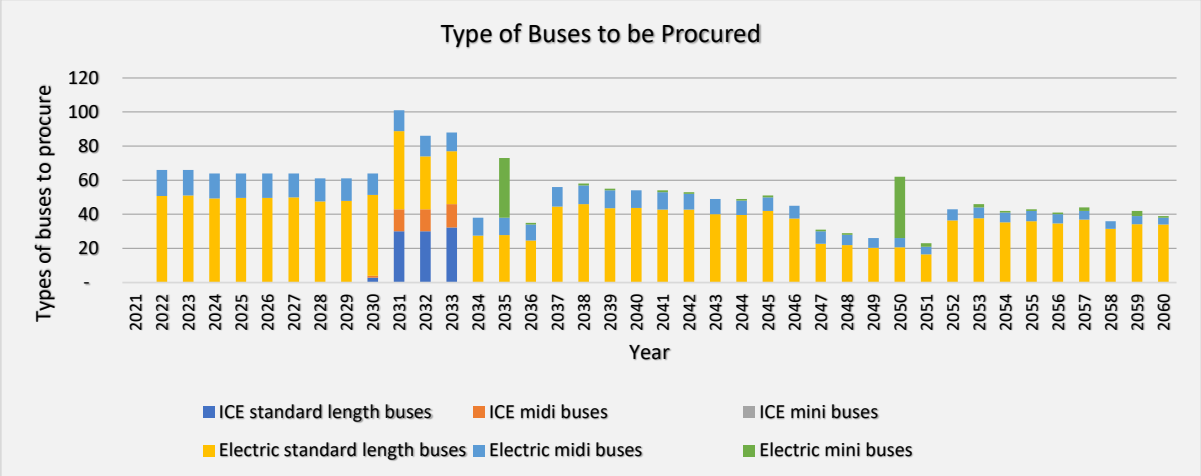
Business as Usual Scenario



Low Ambition Scenario

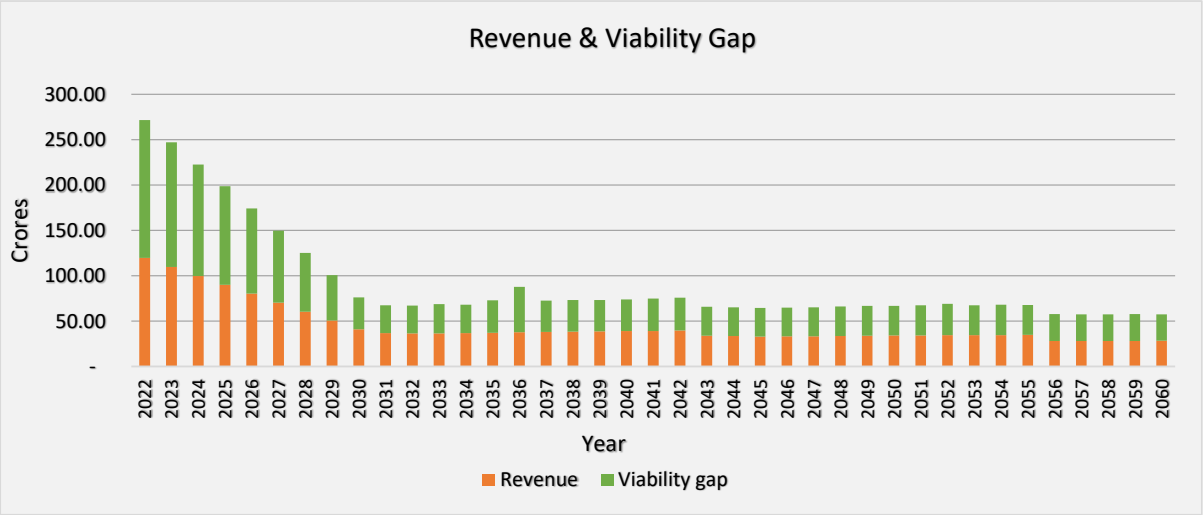


High Ambition Scenario

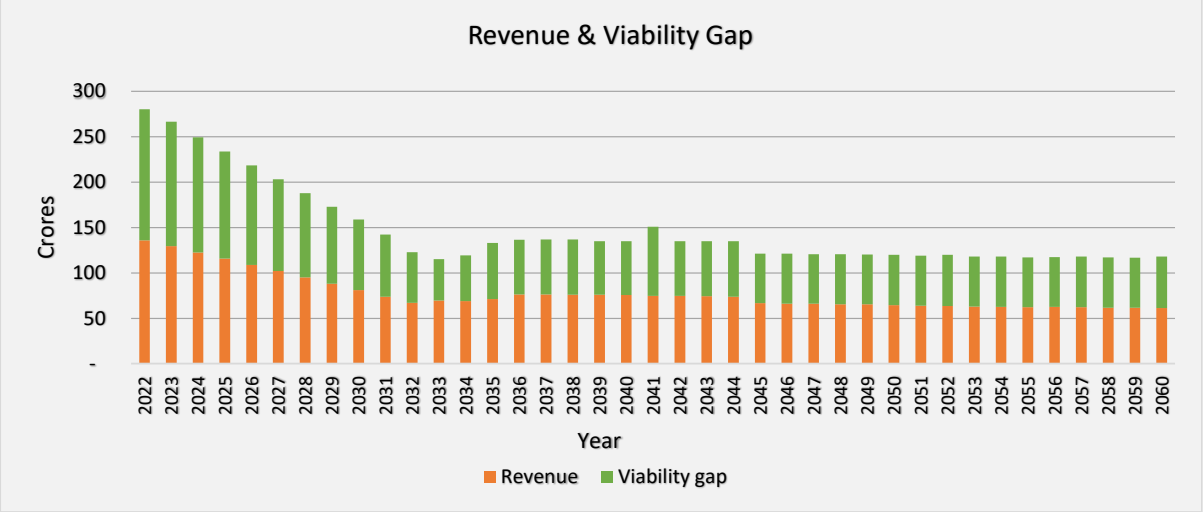


Revenue and Viability Gap: GCC Model

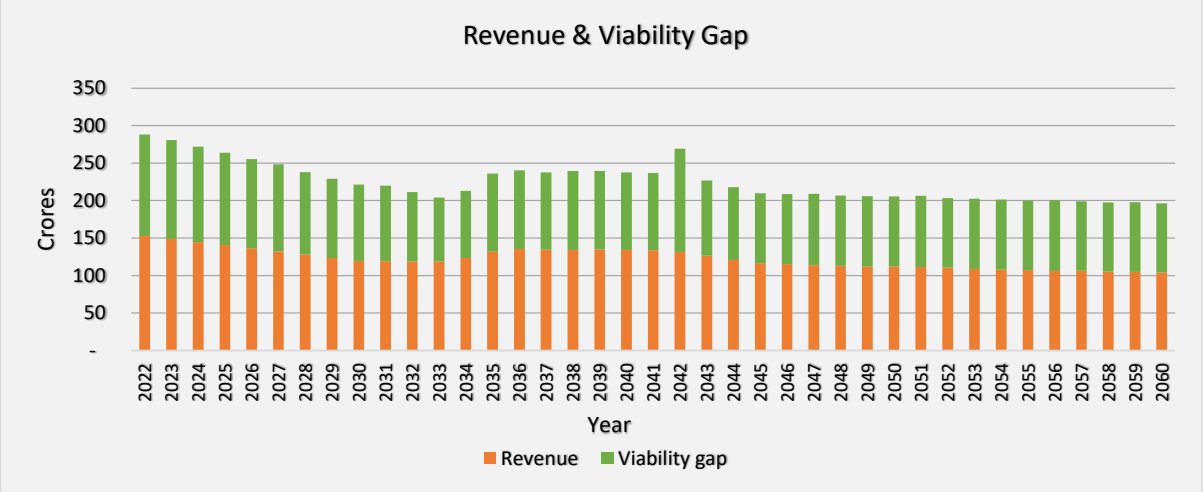
Business as Usual Scenario



Low Ambition Scenario

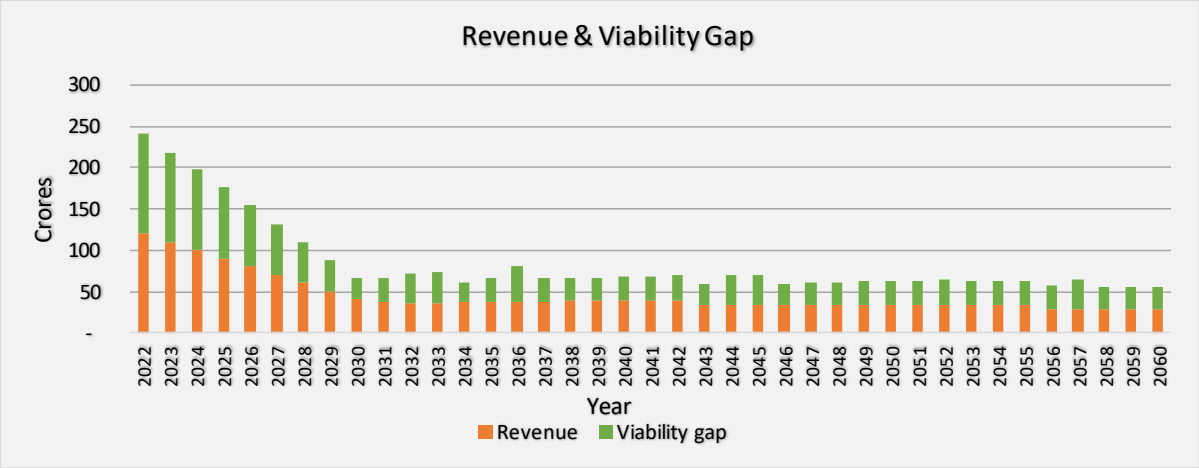


High Ambition Scenario

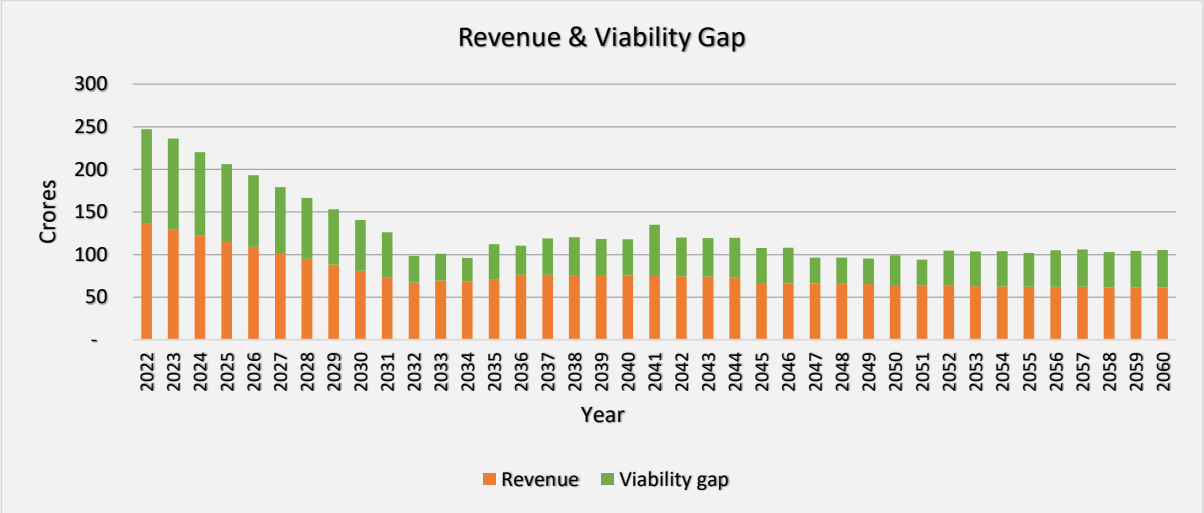


Revenue and Viability Gap: Outright Purchase Model

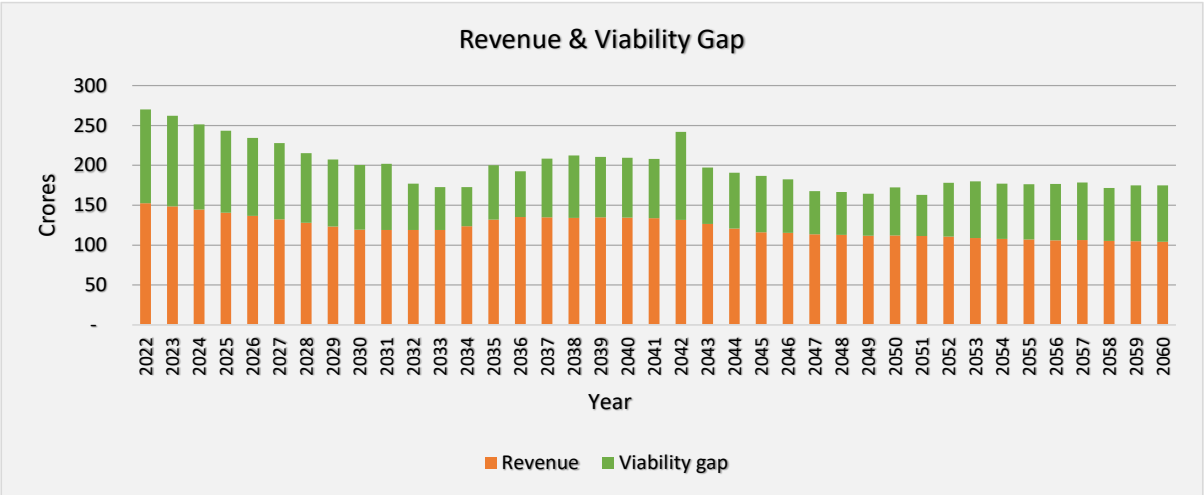
Business as usual Scenario



Low Ambition Scenario

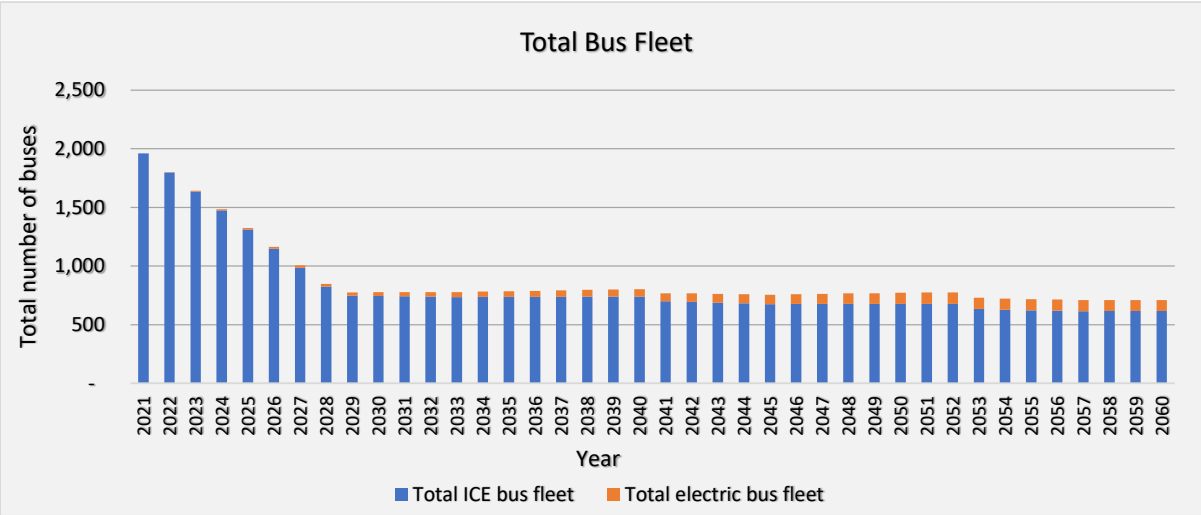


High Ambition Scenario

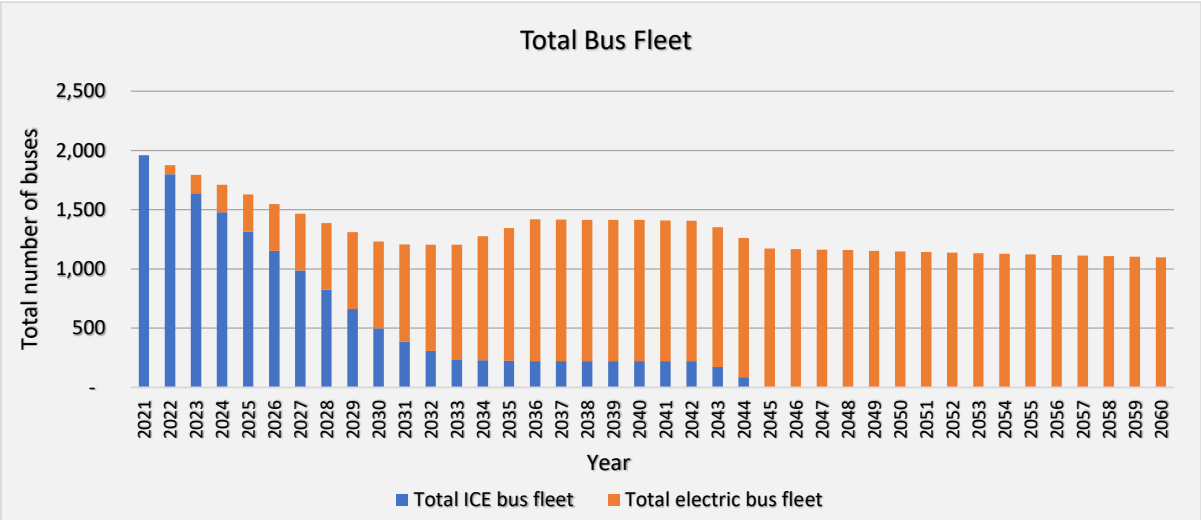


25. State / UT: Nagaland

Business as usual Scenario



Low Ambition Scenario



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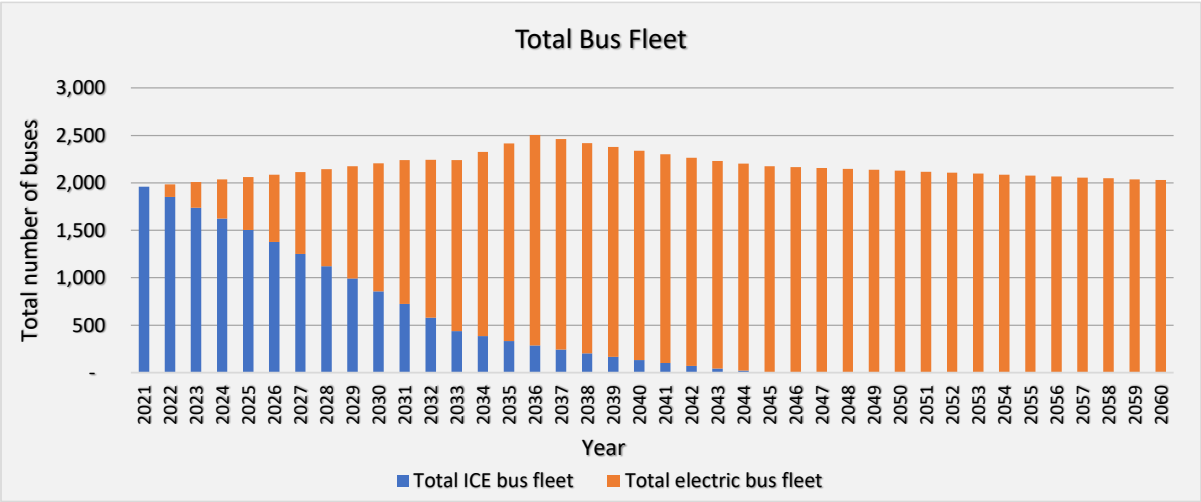
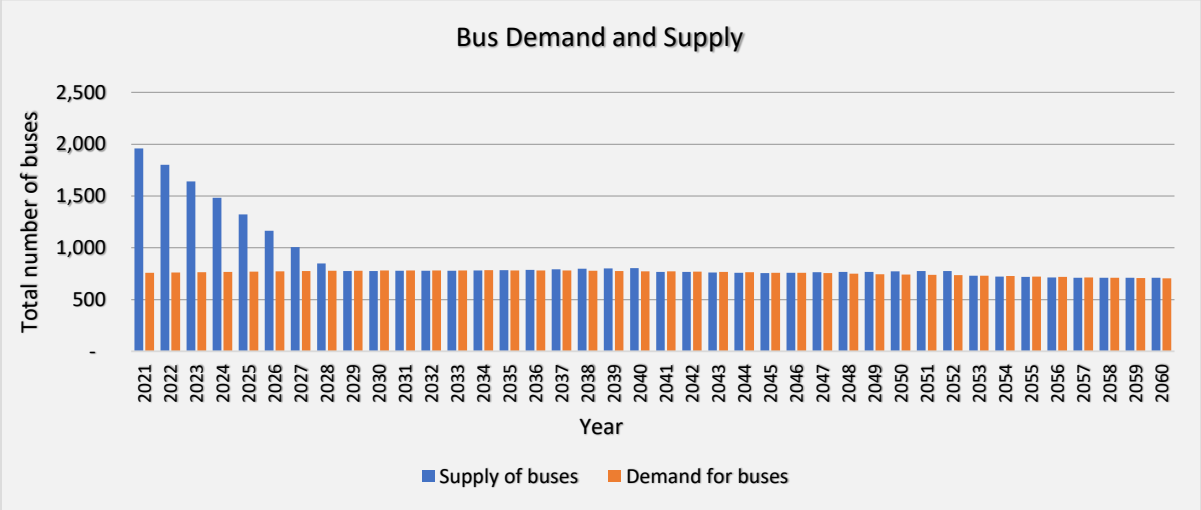
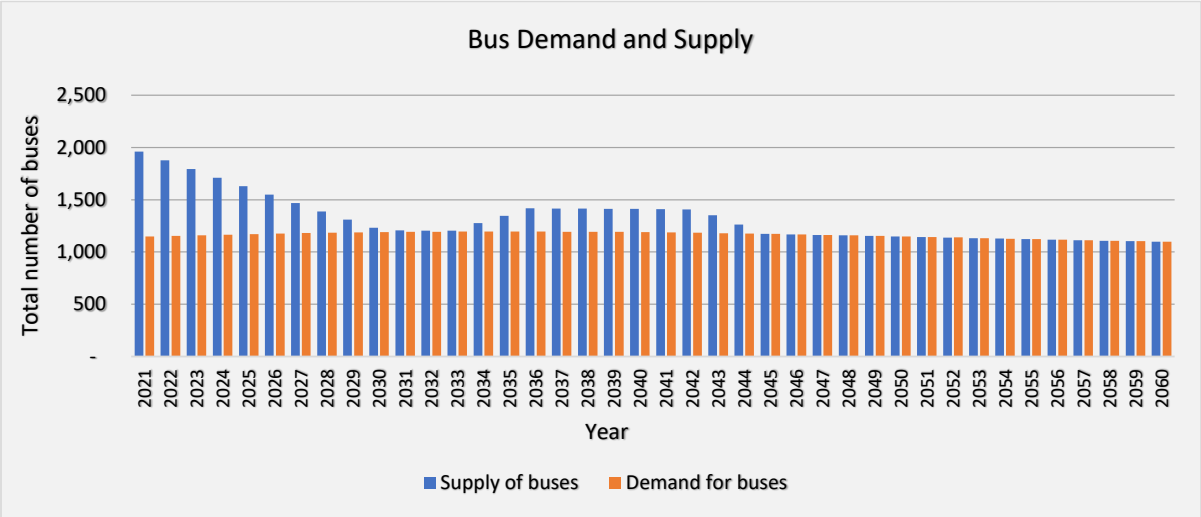


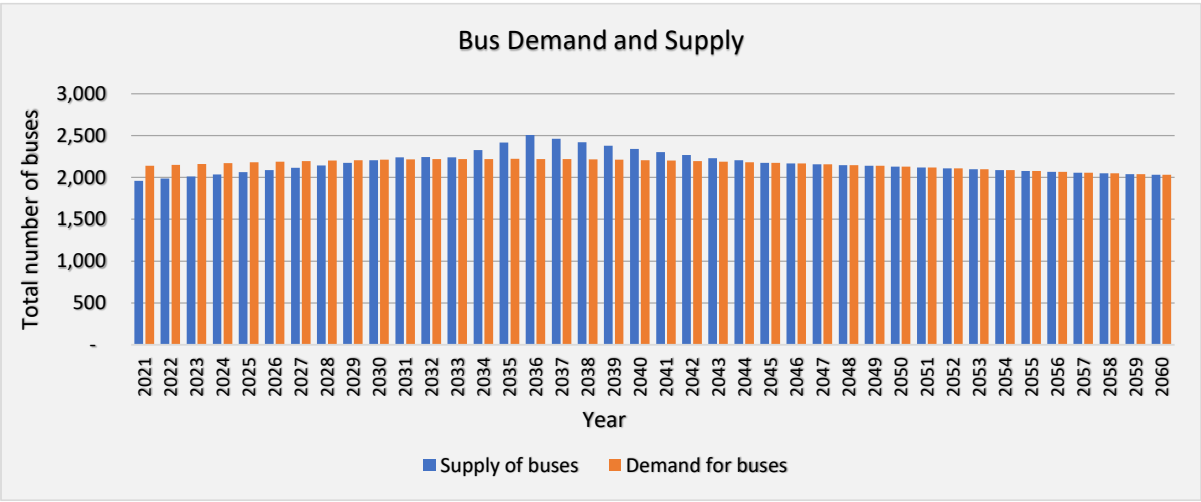
Business as Usual Scenario



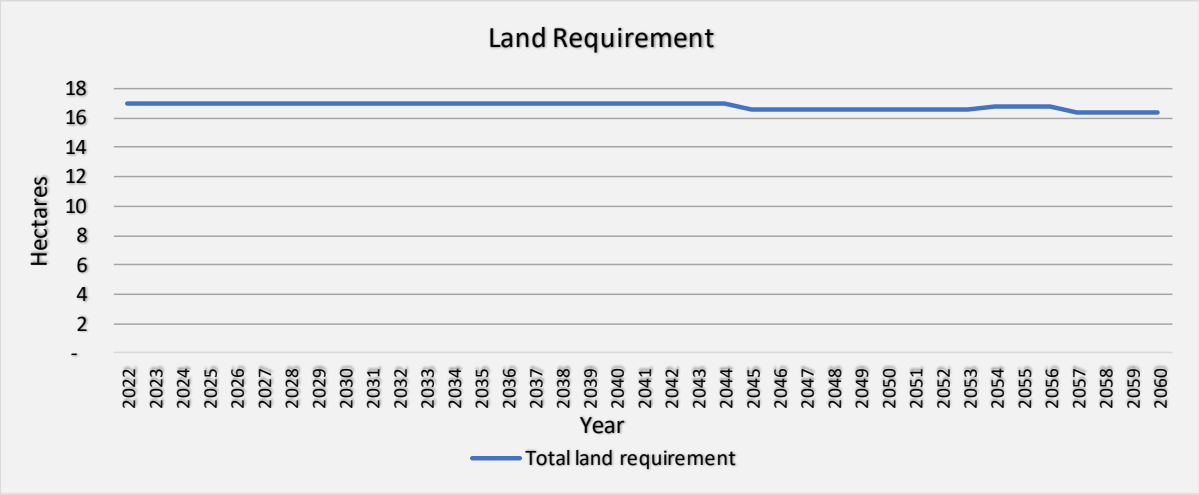
Low Ambition Scenario



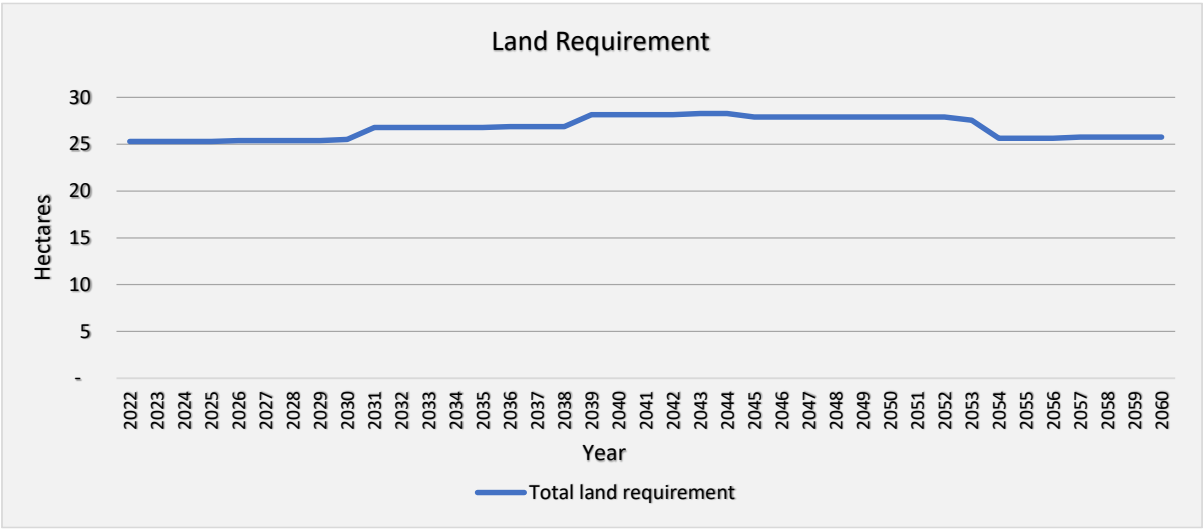
High Ambition Scenario



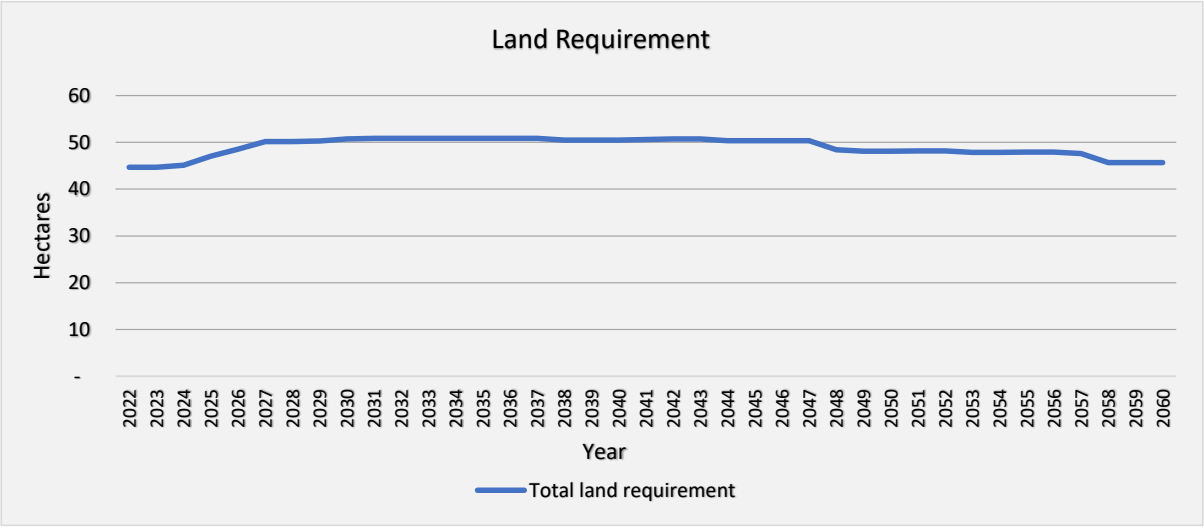
Business as Usual Scenario



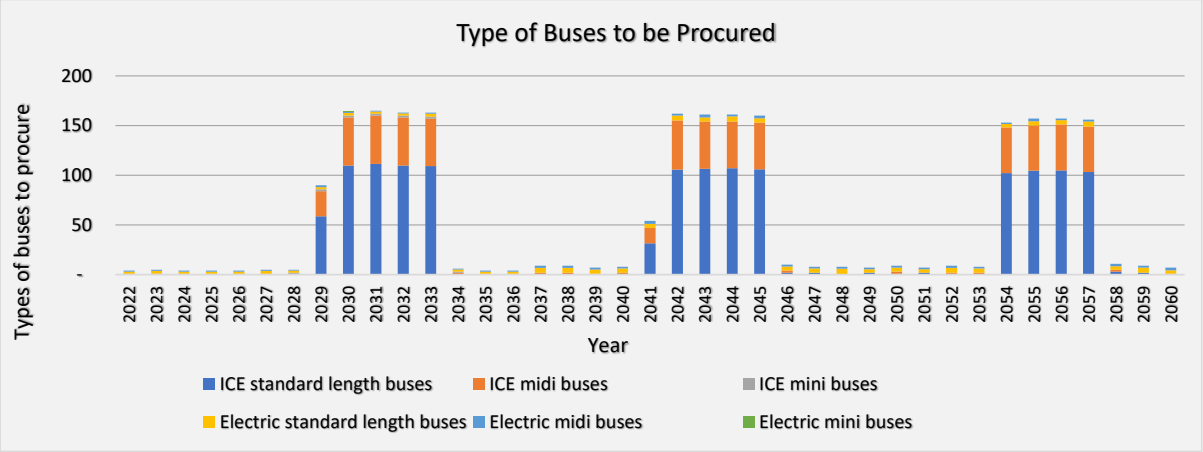
Low Ambition Scenario



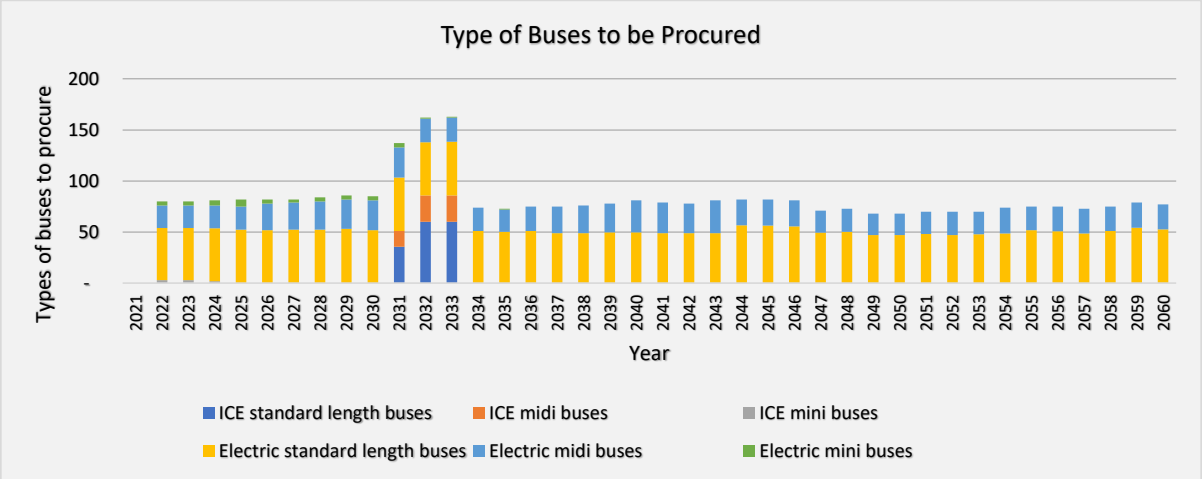
High Ambition Scenario



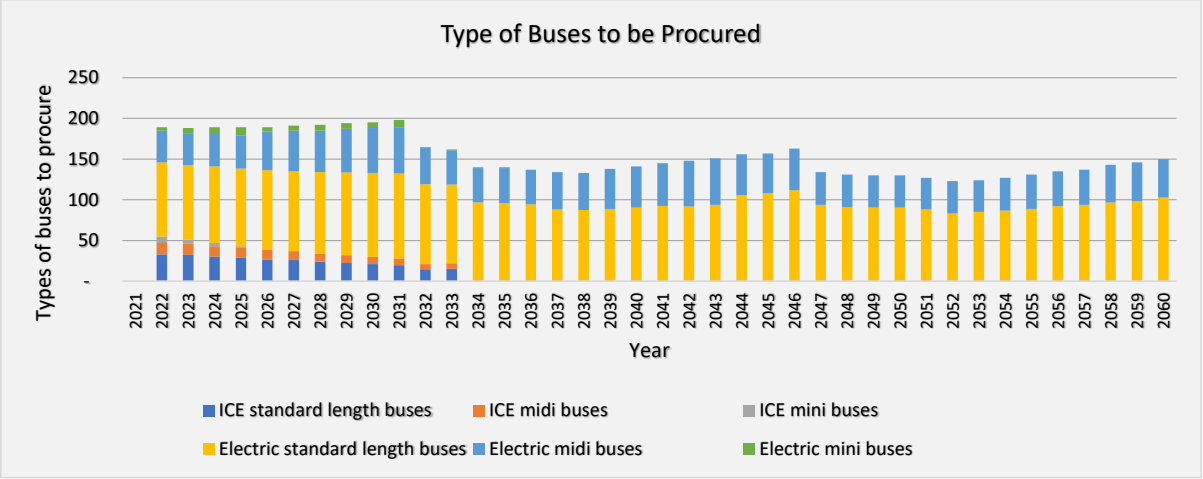
Business as Usual Scenario



Low Ambition Scenario

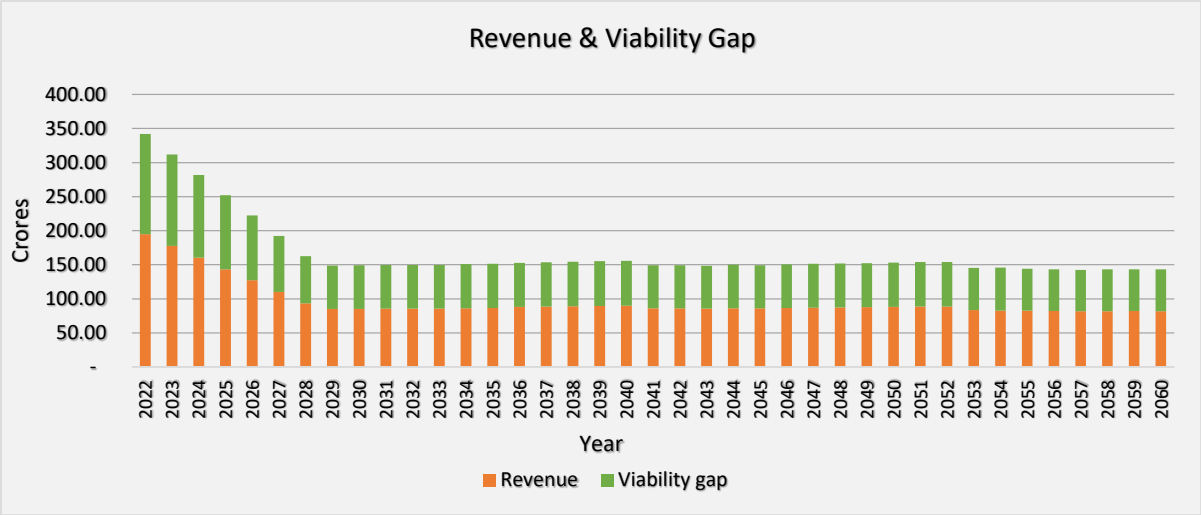


High Ambition Scenario

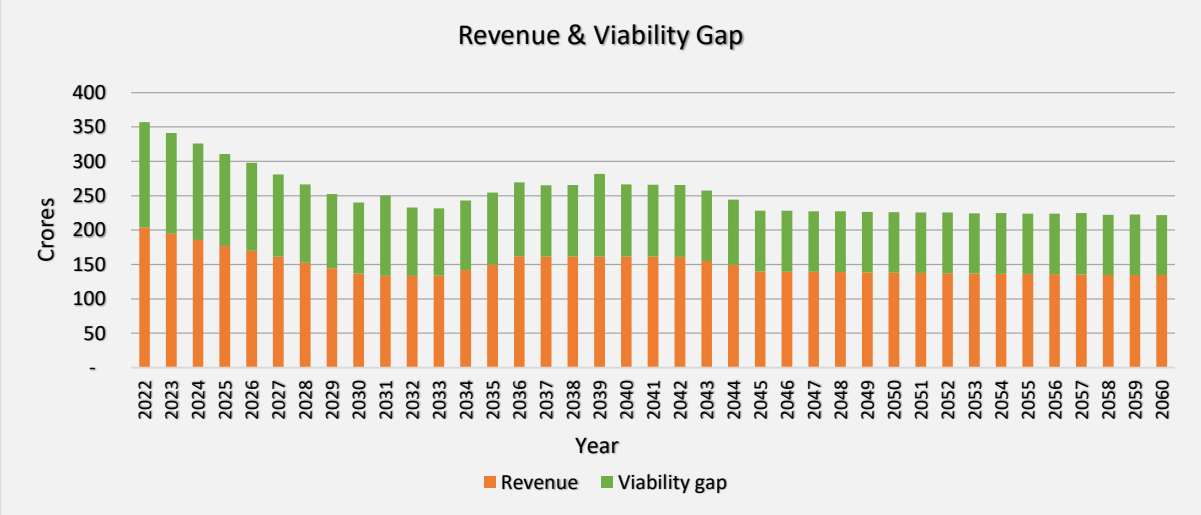


Revenue and Viability Gap: GCC Model

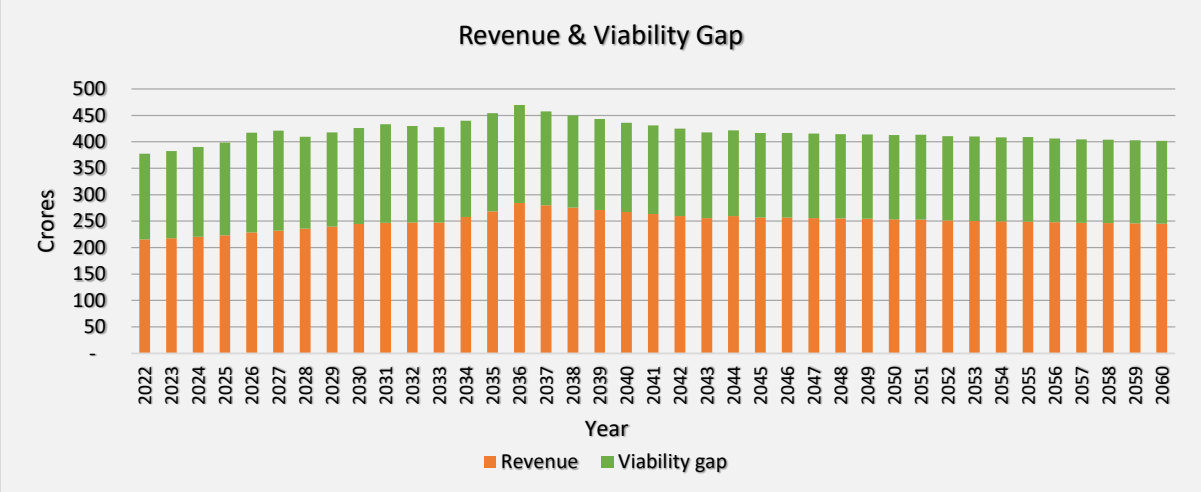
Business as Usual Scenario



Low Ambition Scenario

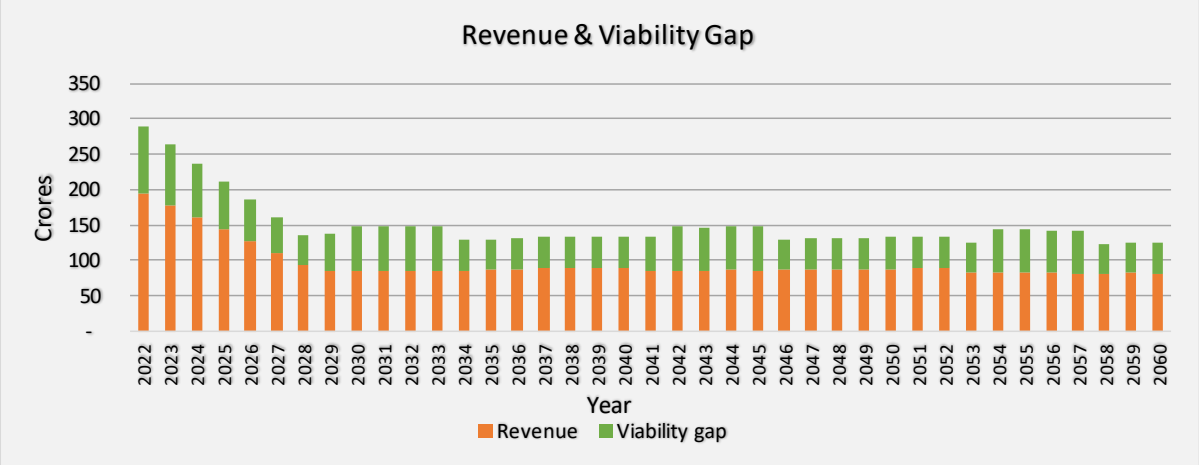


High Ambition Scenario

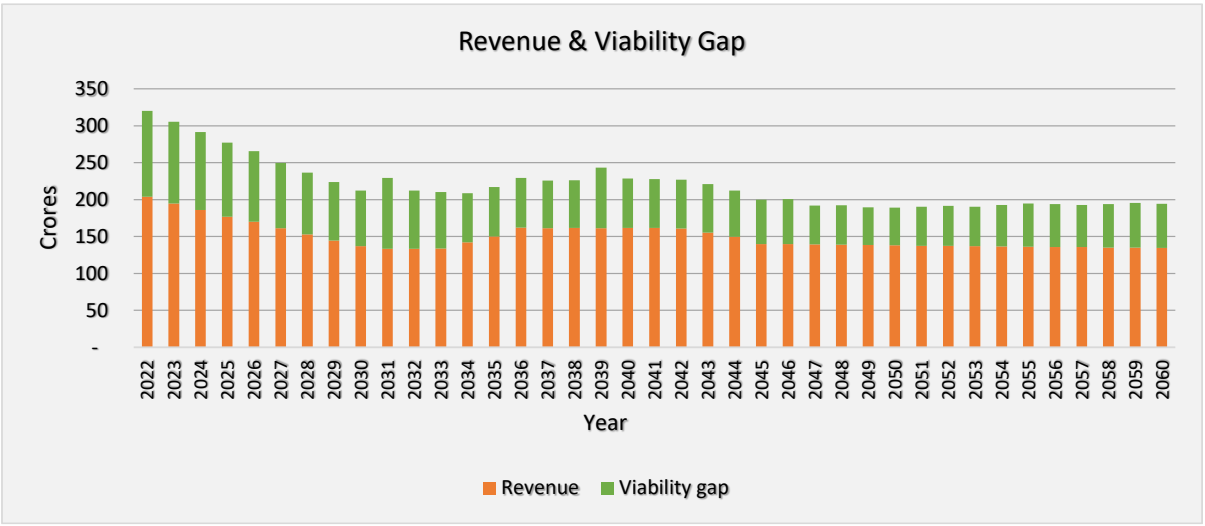


Revenue and Viability Gap: Outright Purchase Model

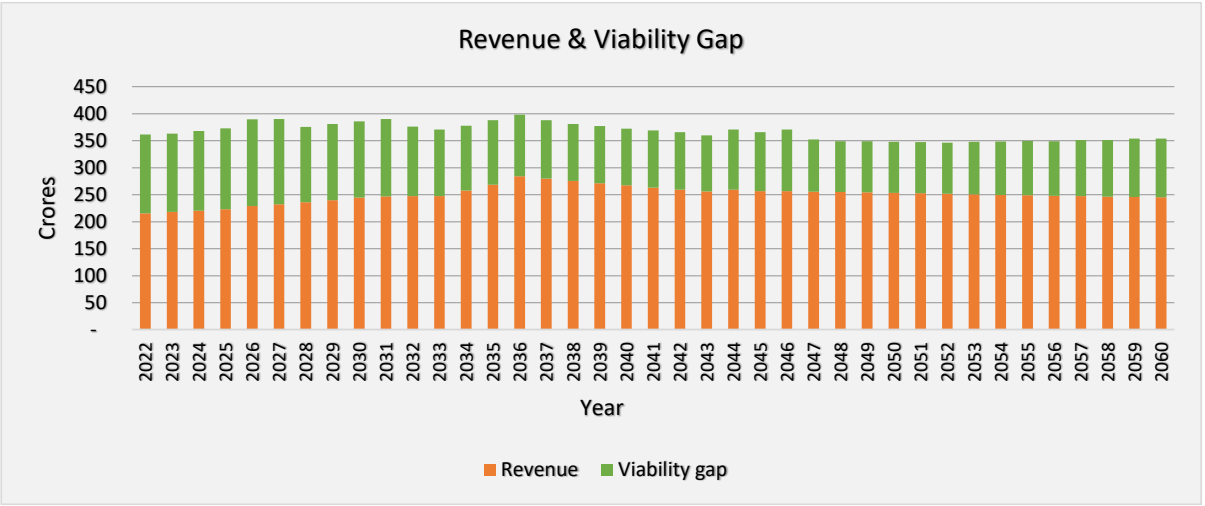
Business as usual Scenario



Low Ambition Scenario

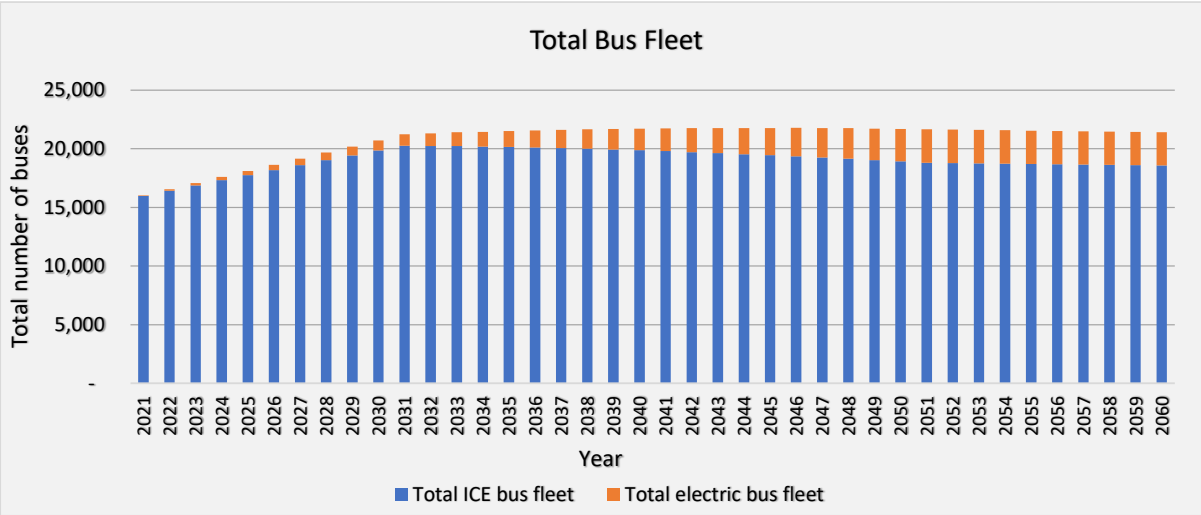


High Ambition Scenario

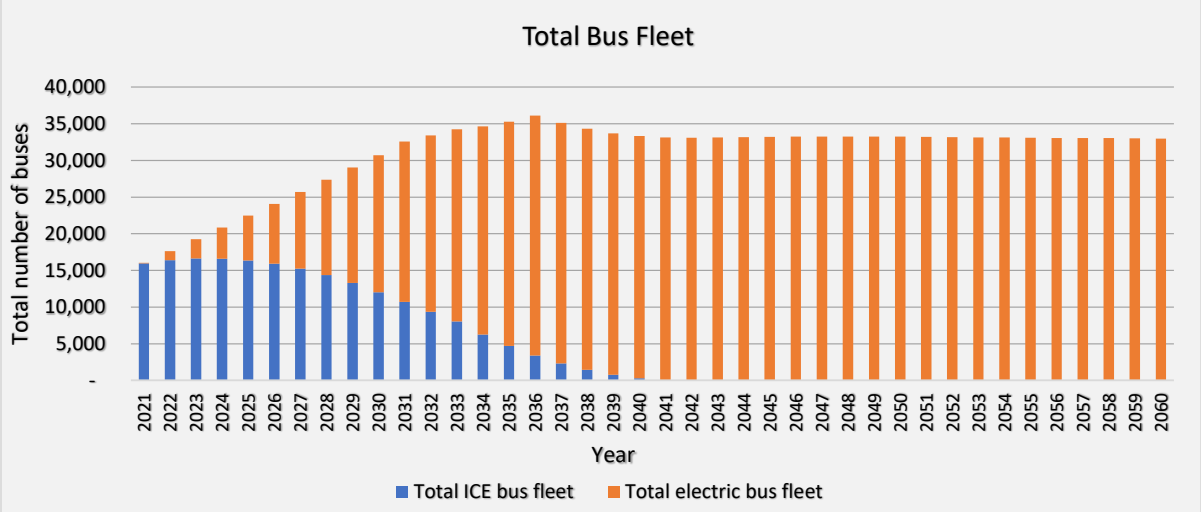


26. State / UT: Odisha

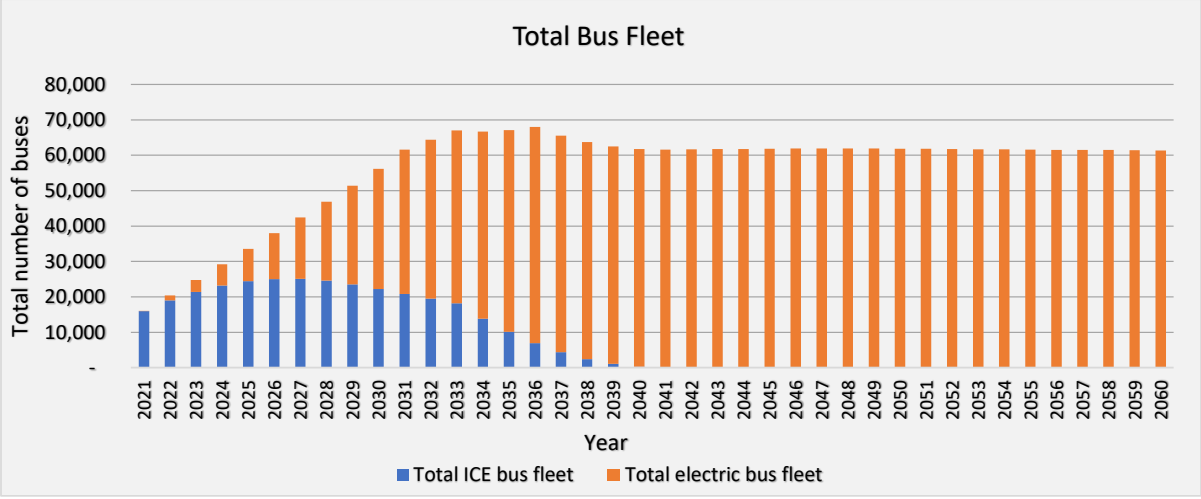
Business as usual Scenario



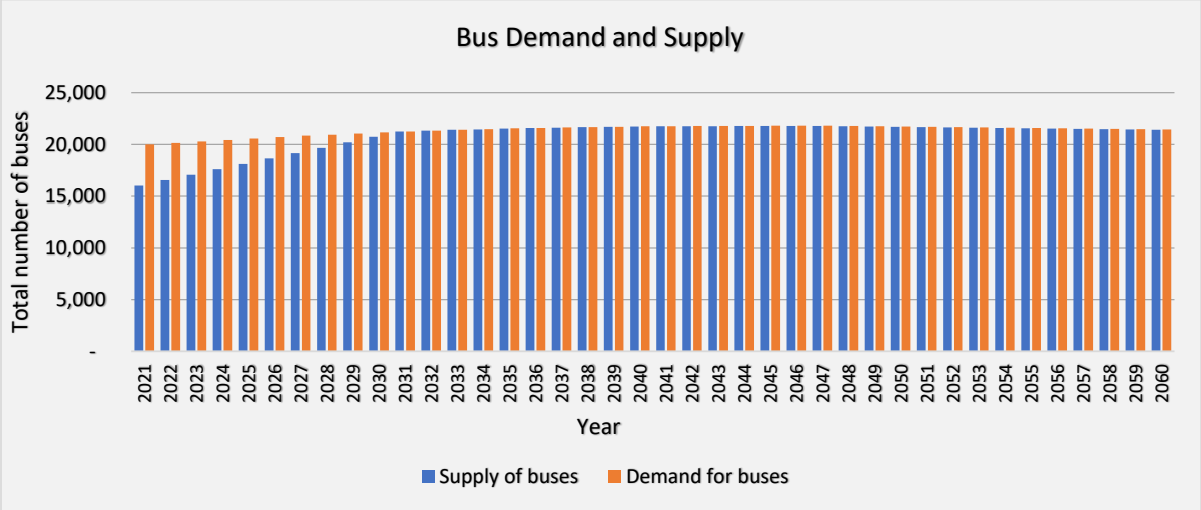
Low Ambition Scenario



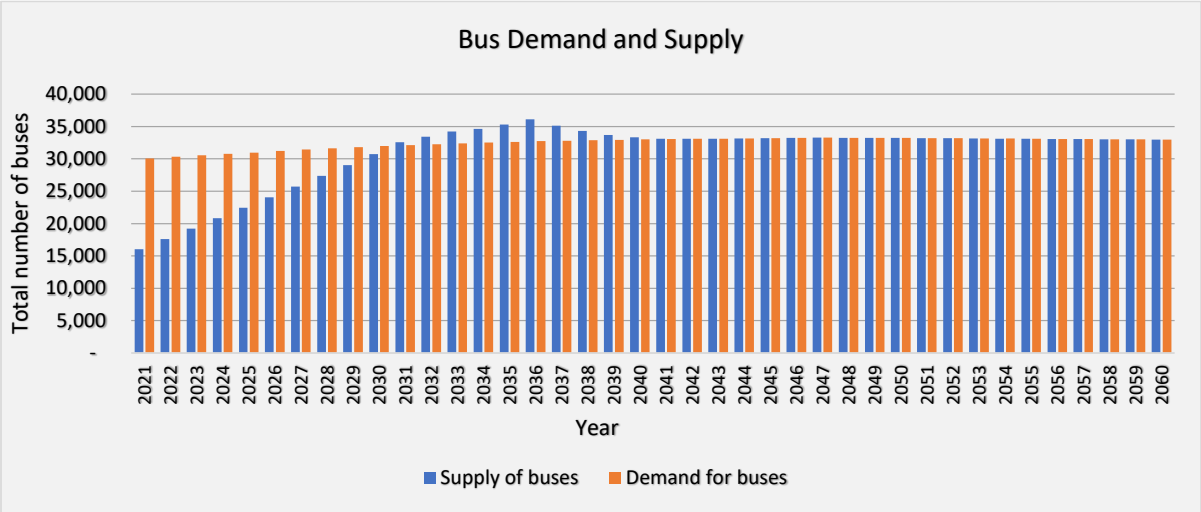
High Ambition Scenario



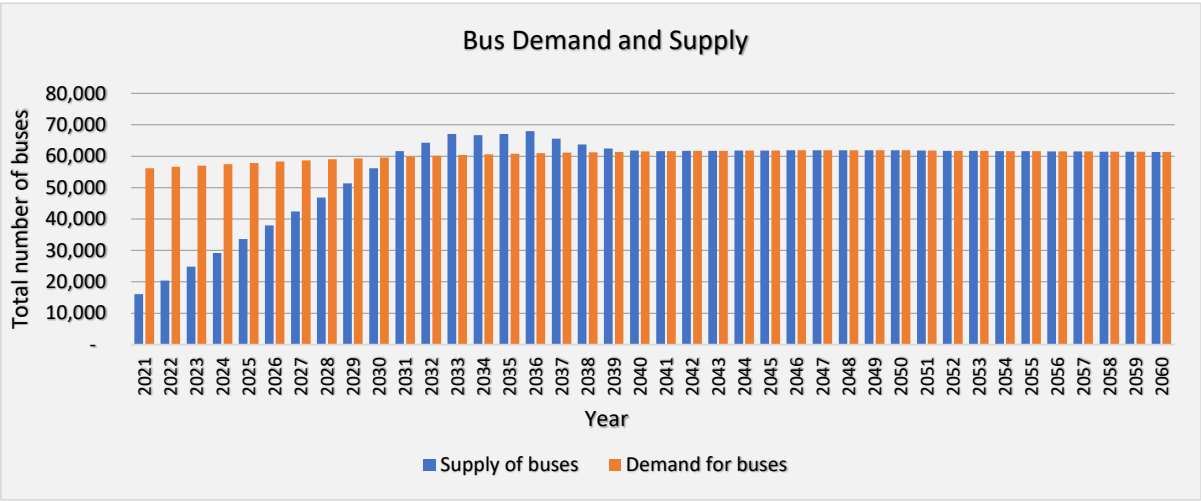
Business as Usual Scenario



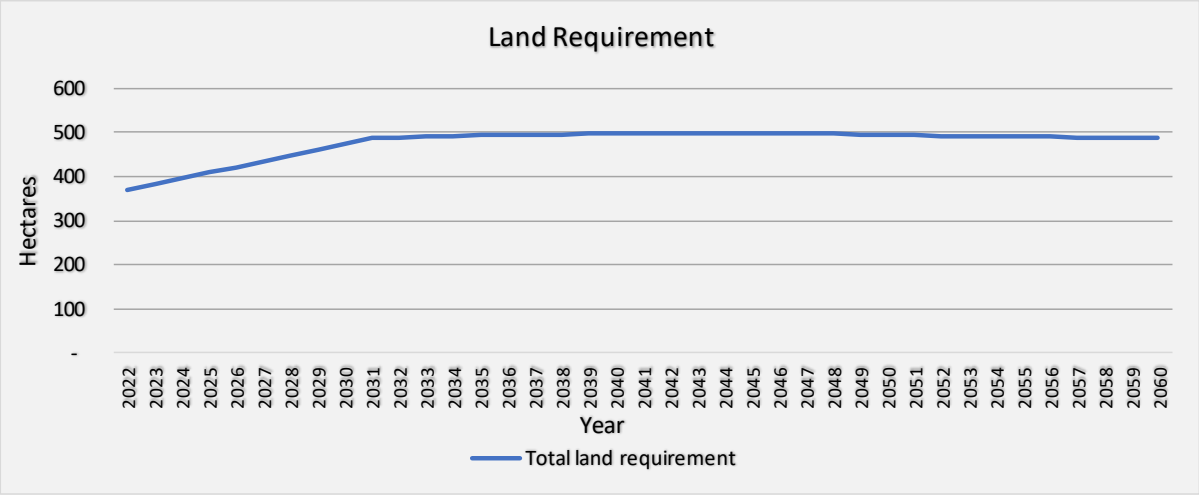
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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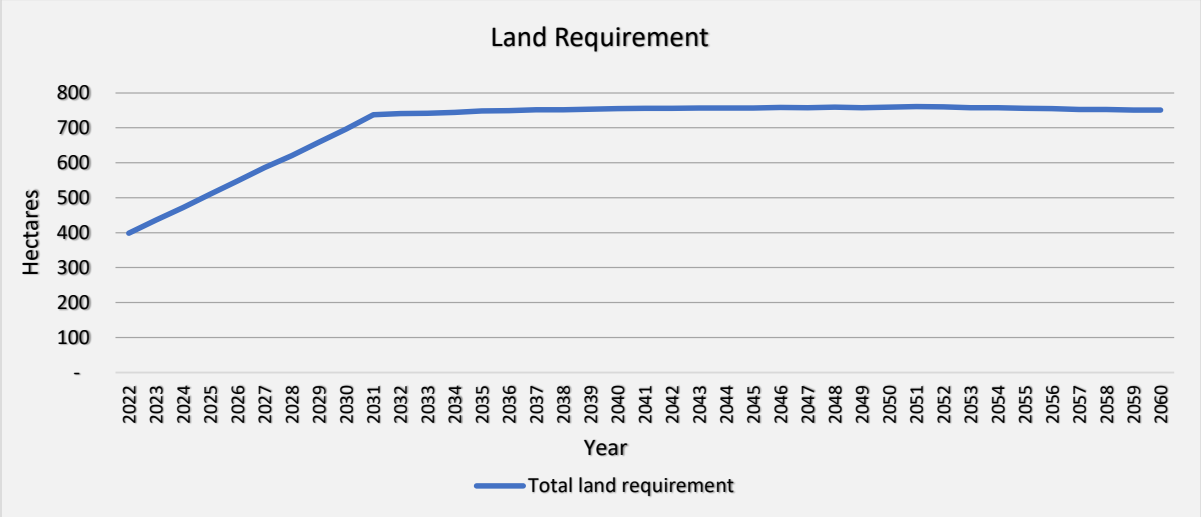
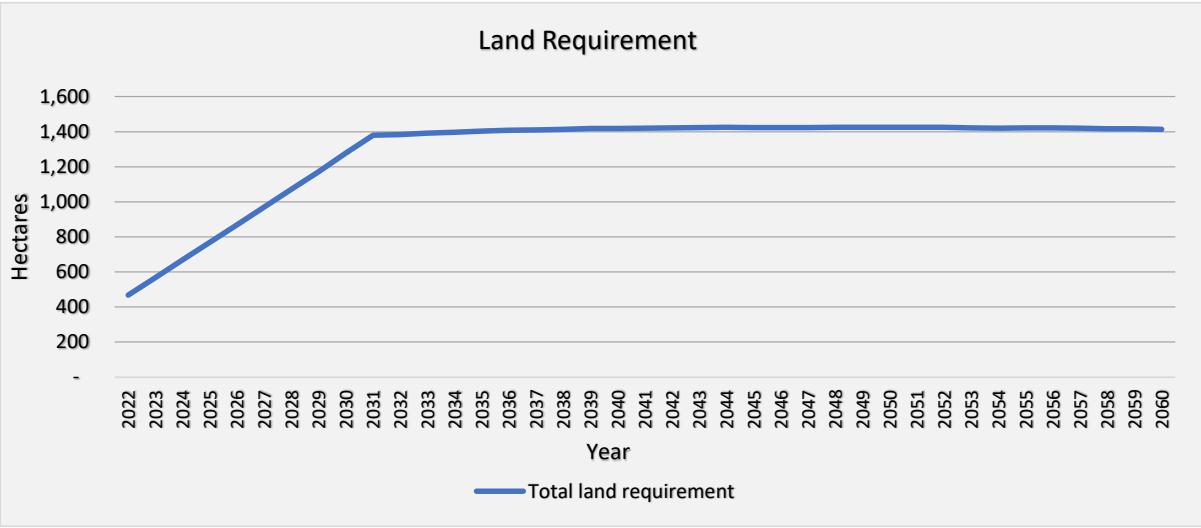
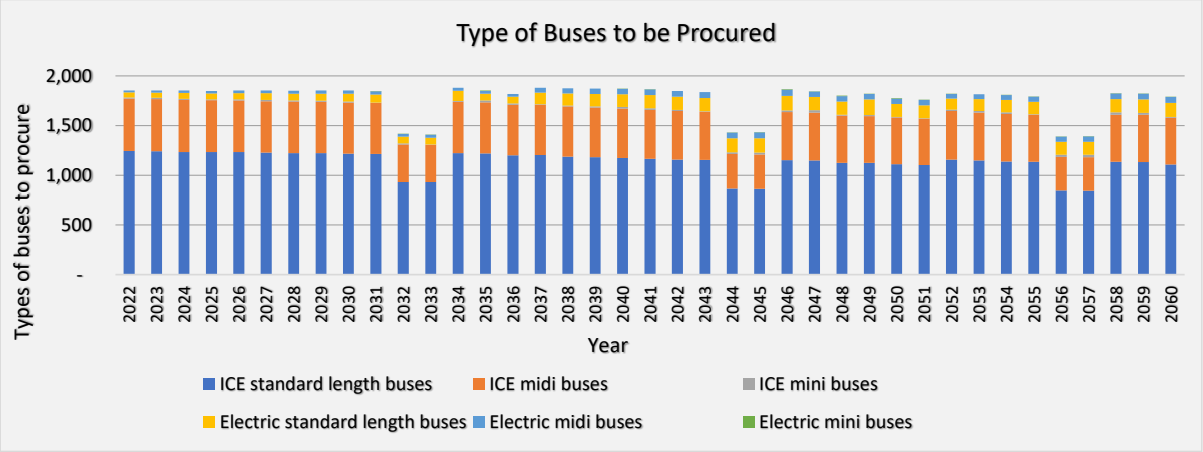


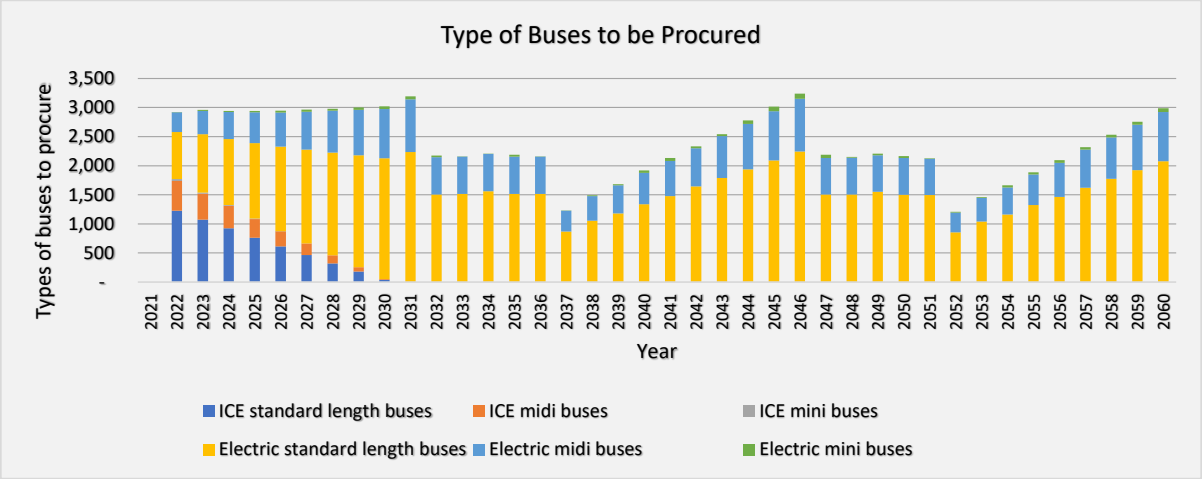
High Ambition Scenario



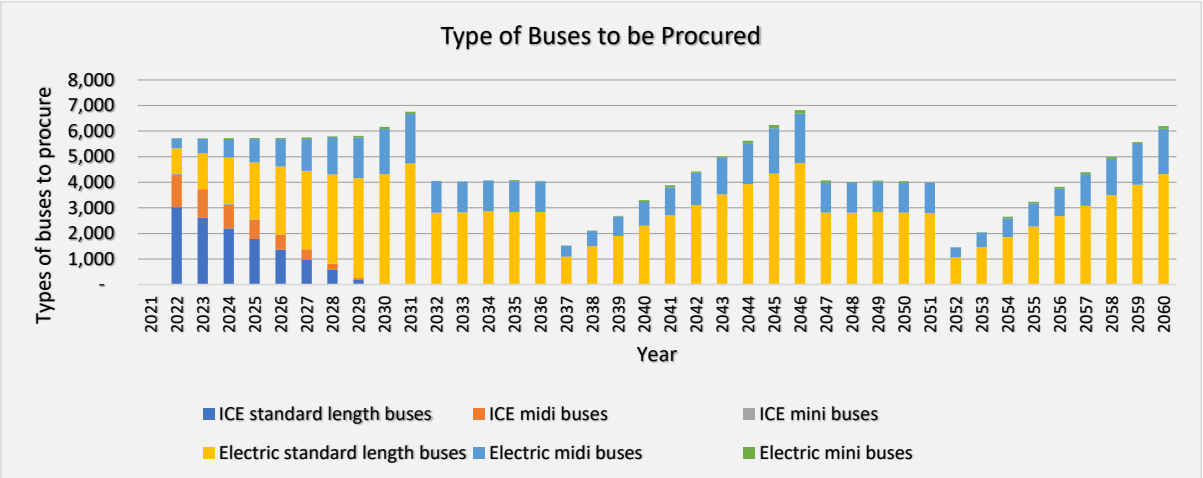
Business as Usual Scenario



Low Ambition Scenario

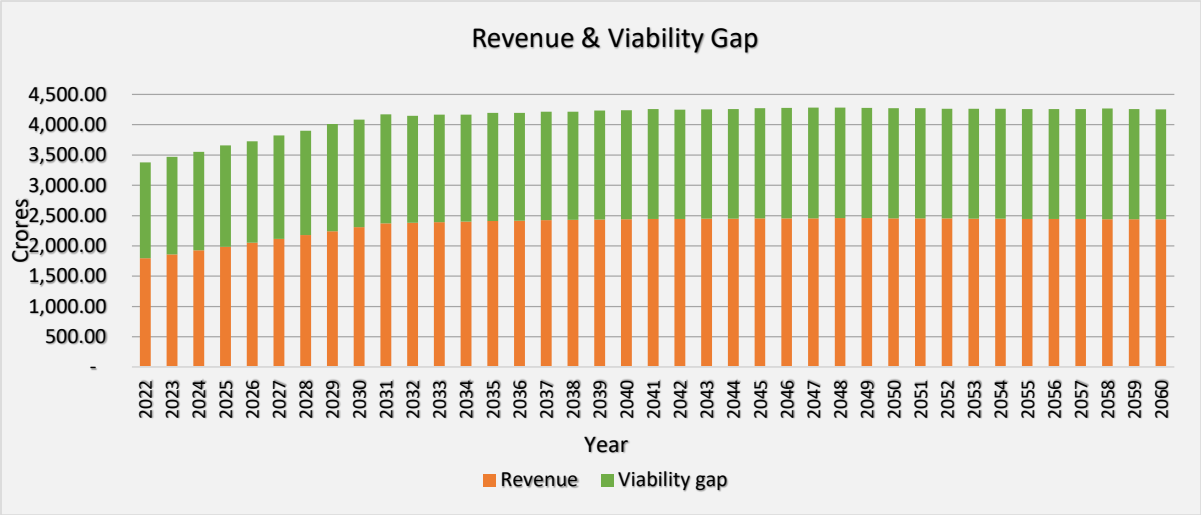


High Ambition Scenario

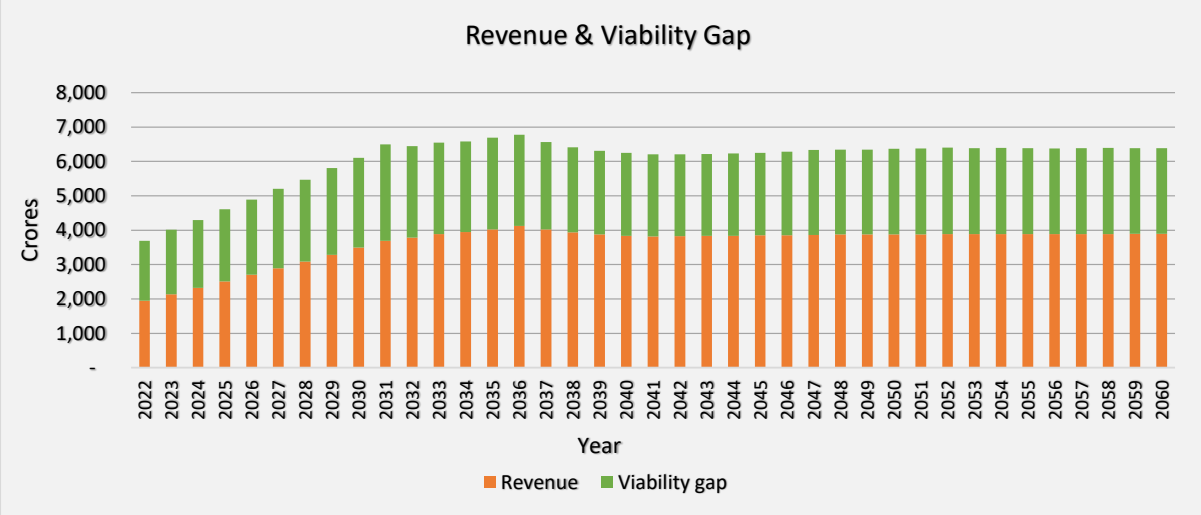


Revenue and Viability Gap: GCC Model

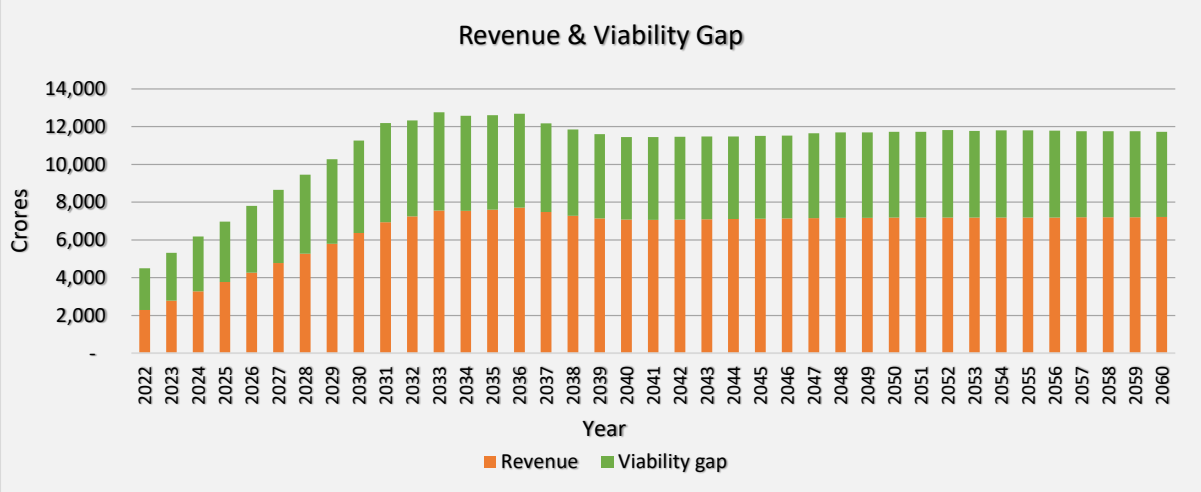
Business as Usual Scenario



Low Ambition Scenario

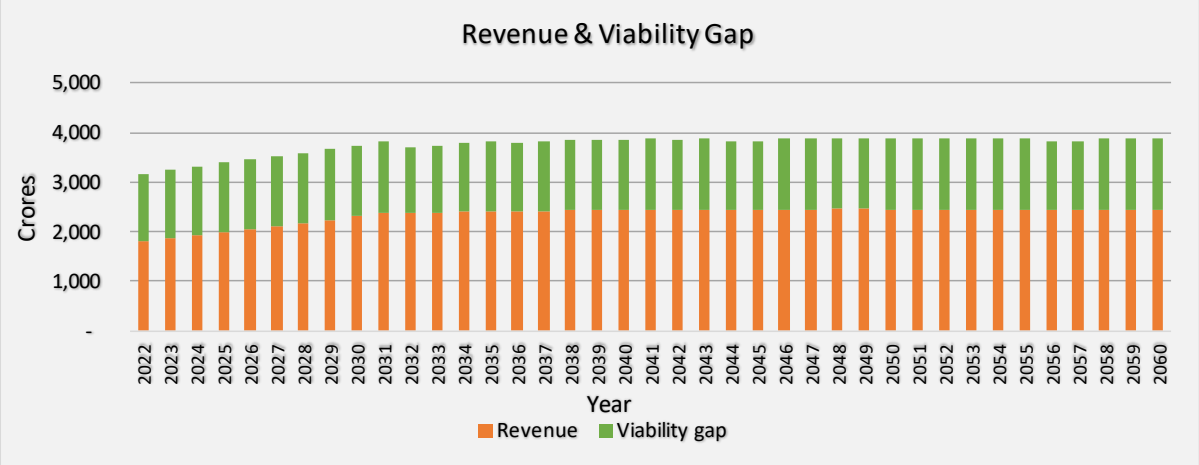


High Ambition Scenario

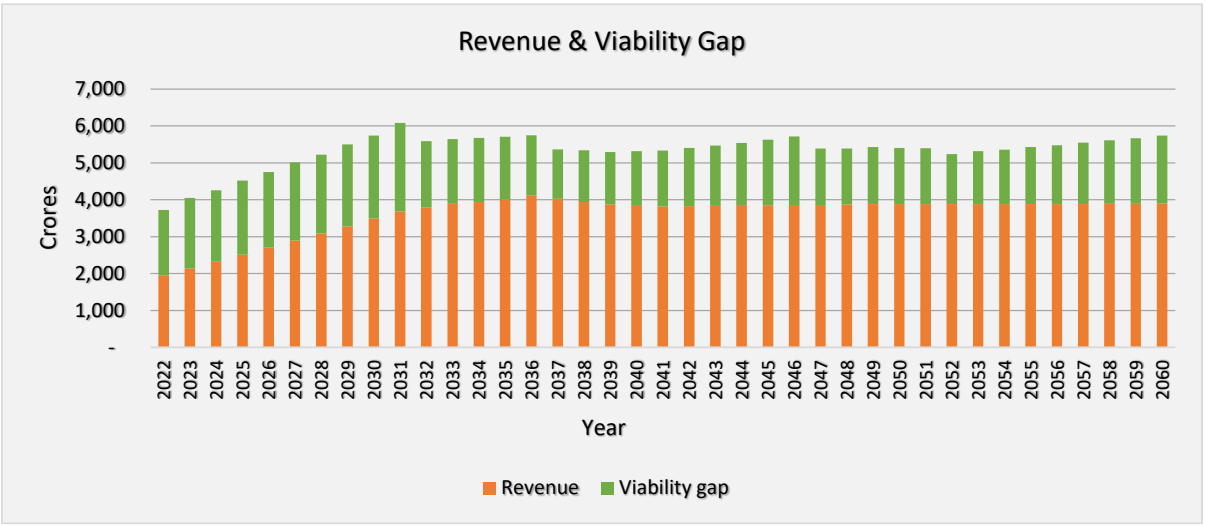


Revenue and Viability Gap: Outright Purchase Model

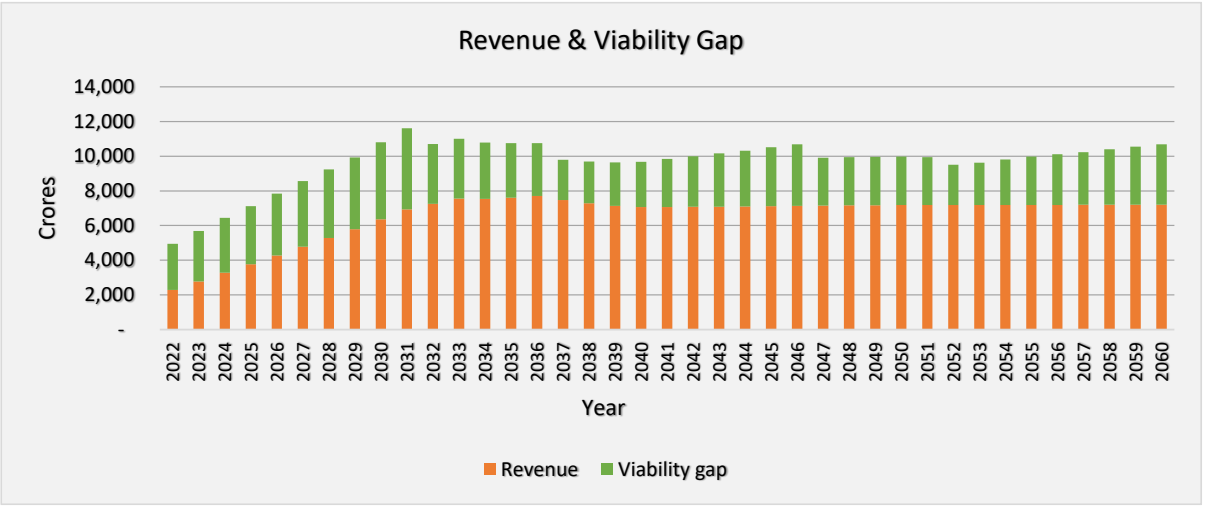
Business as usual Scenario



Low Ambition Scenario

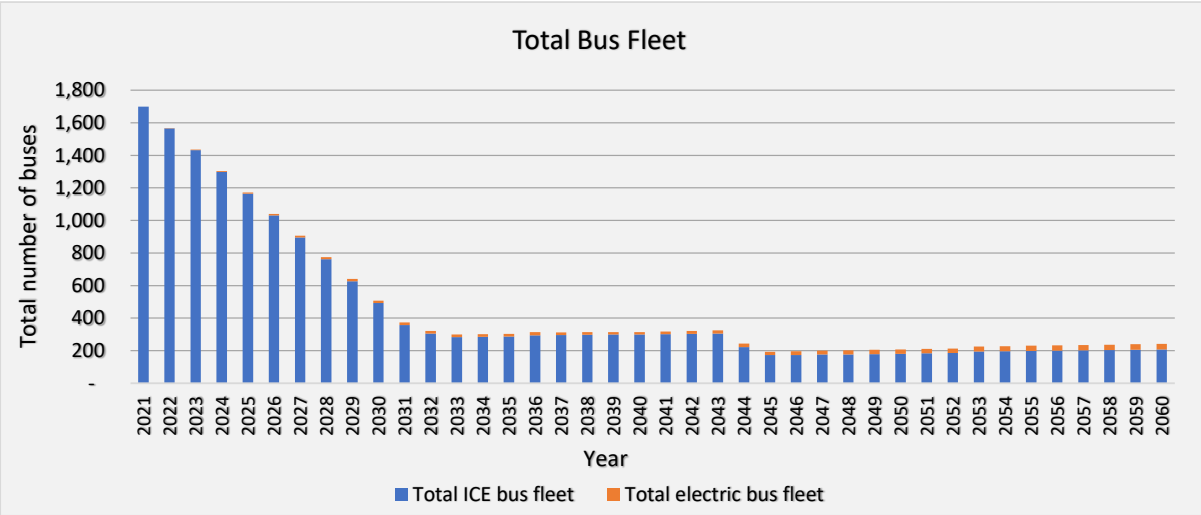


High Ambition Scenario

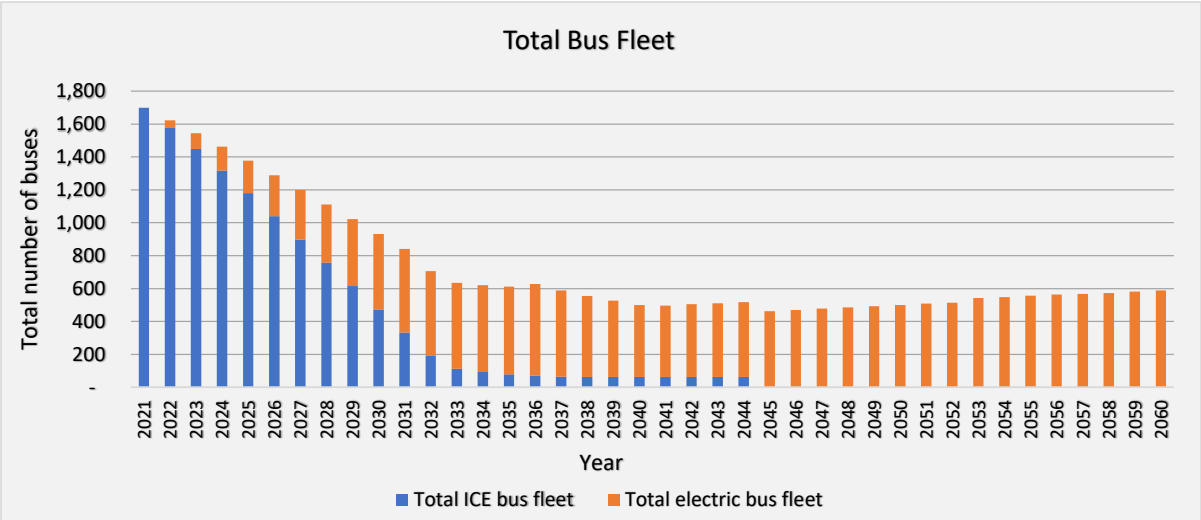


27. State / UT: Puducherry

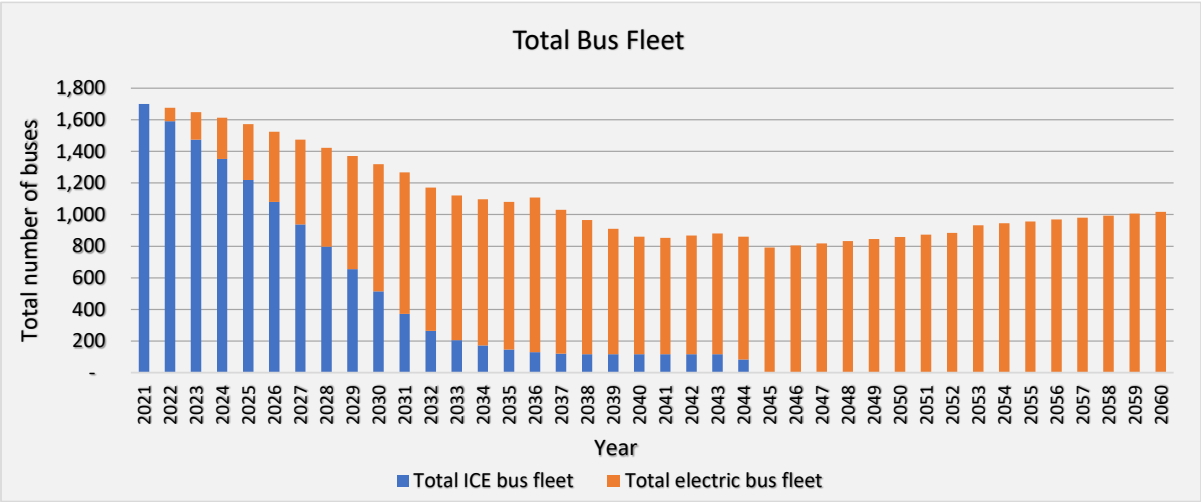
Business as usual Scenario



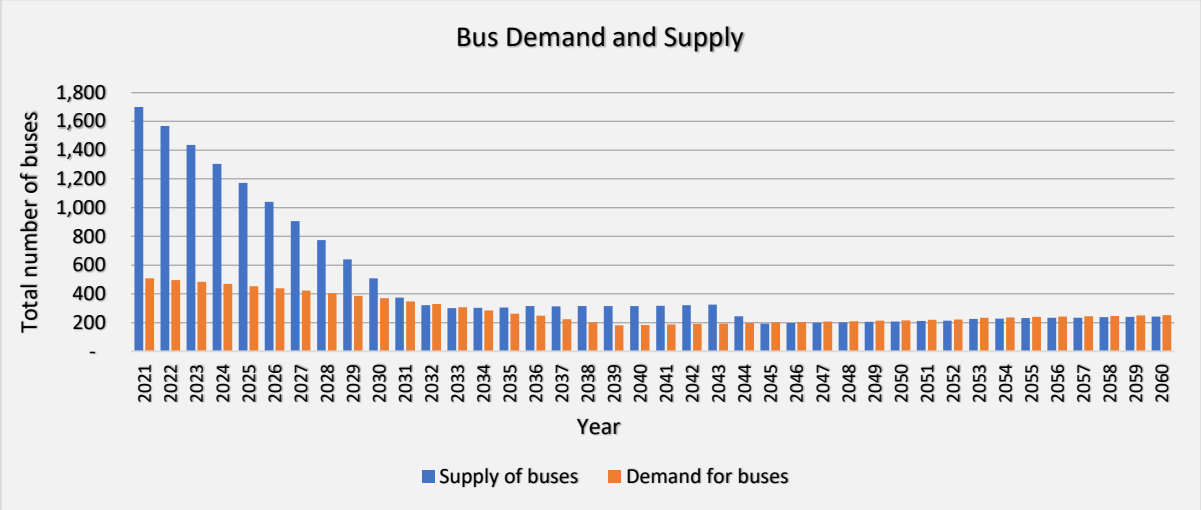
Low Ambition Scenario



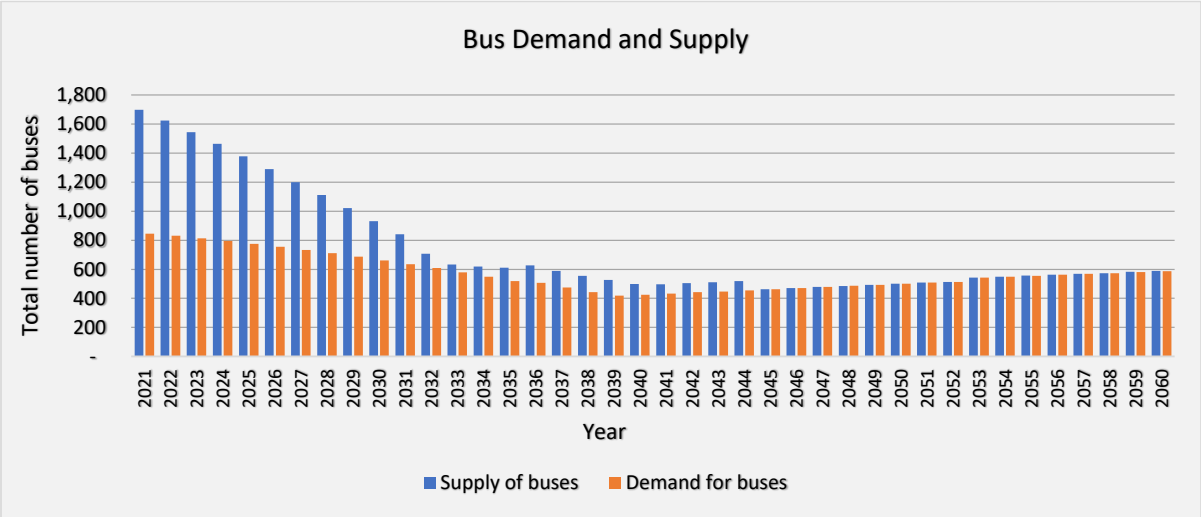
High Ambition Scenario



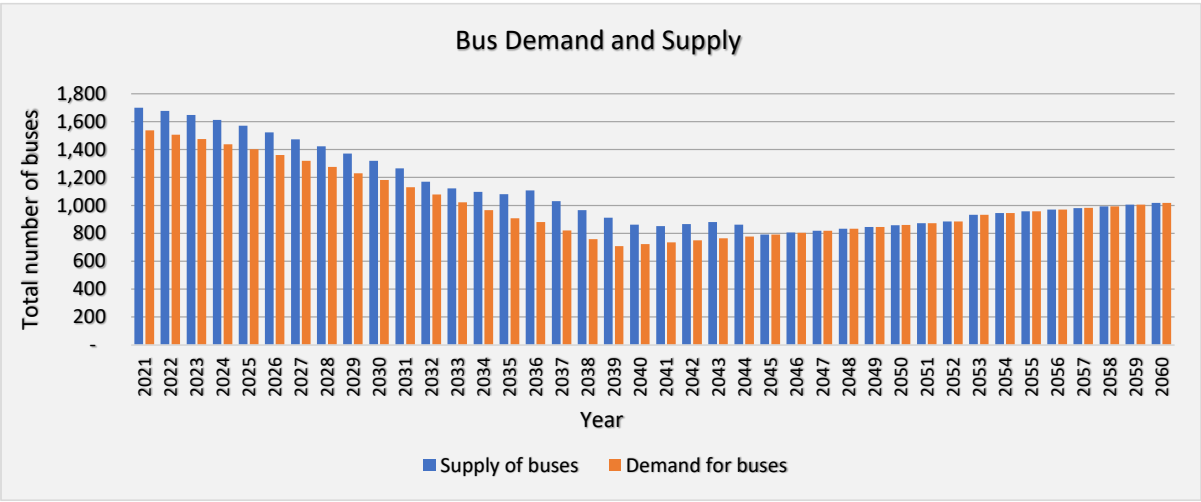
Business as Usual Scenario



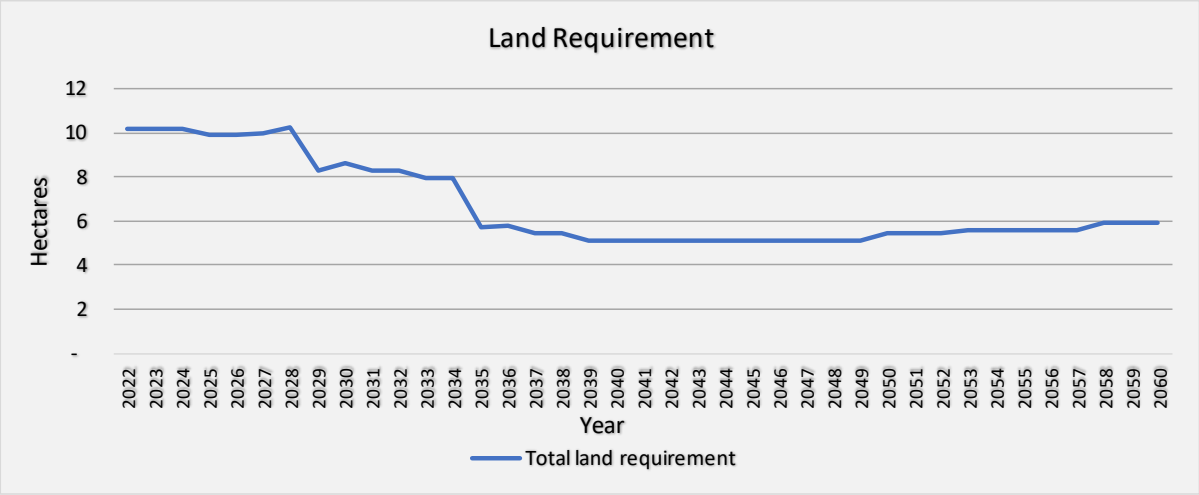
Low Ambition Scenario



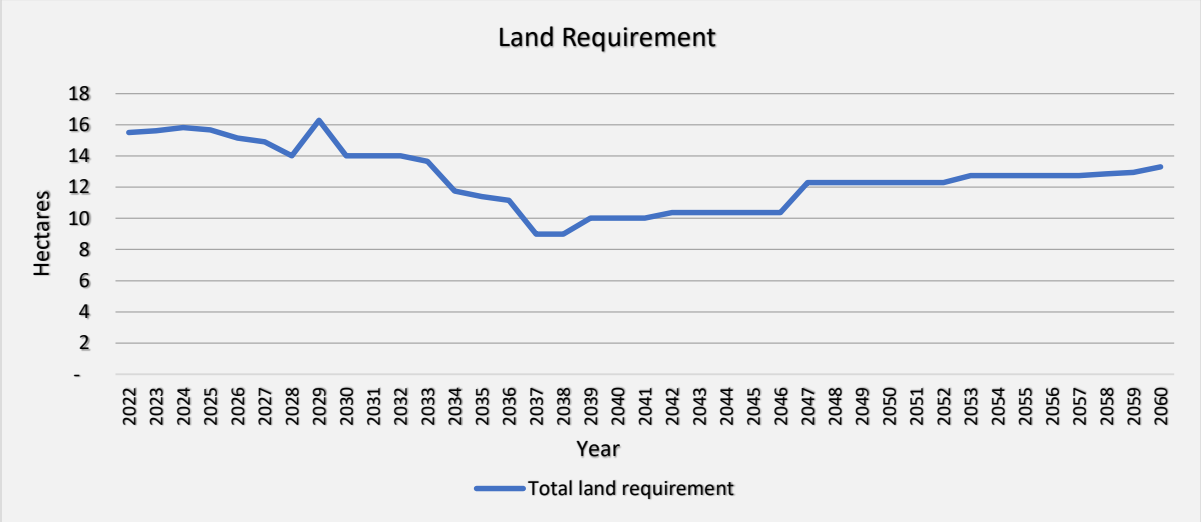
High Ambition Scenario



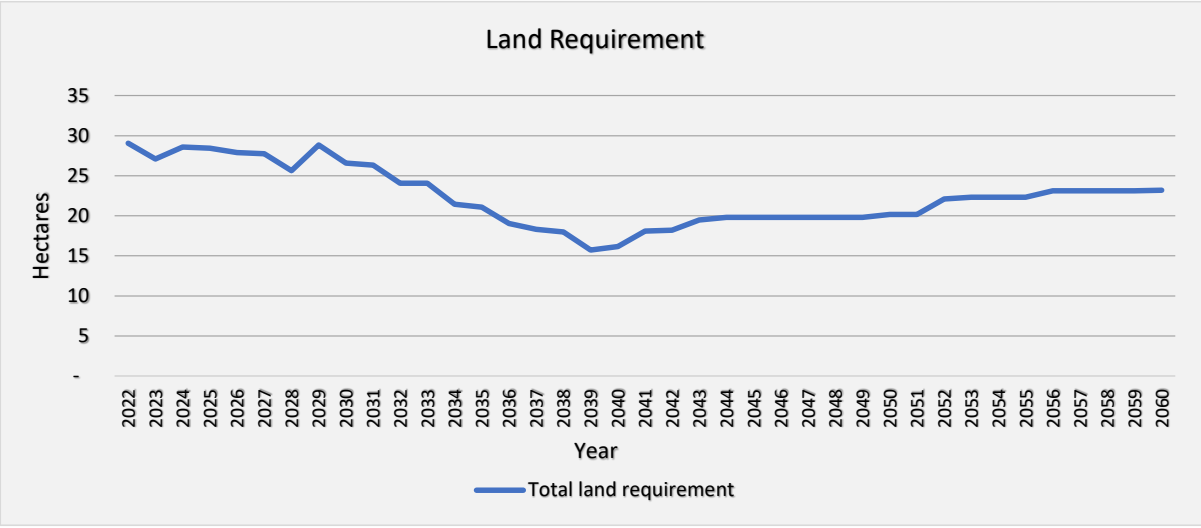
Business as Usual Scenario



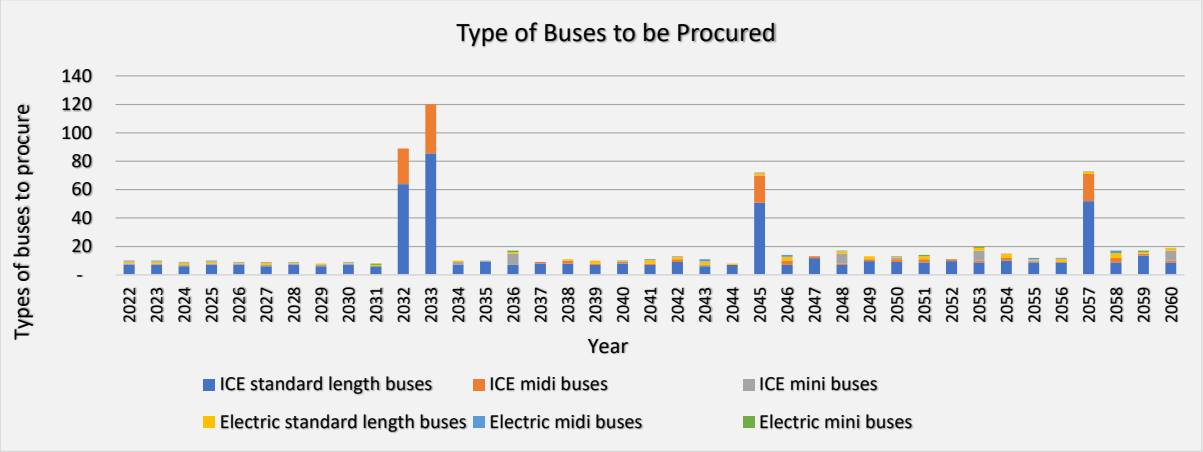
Low Ambition Scenario



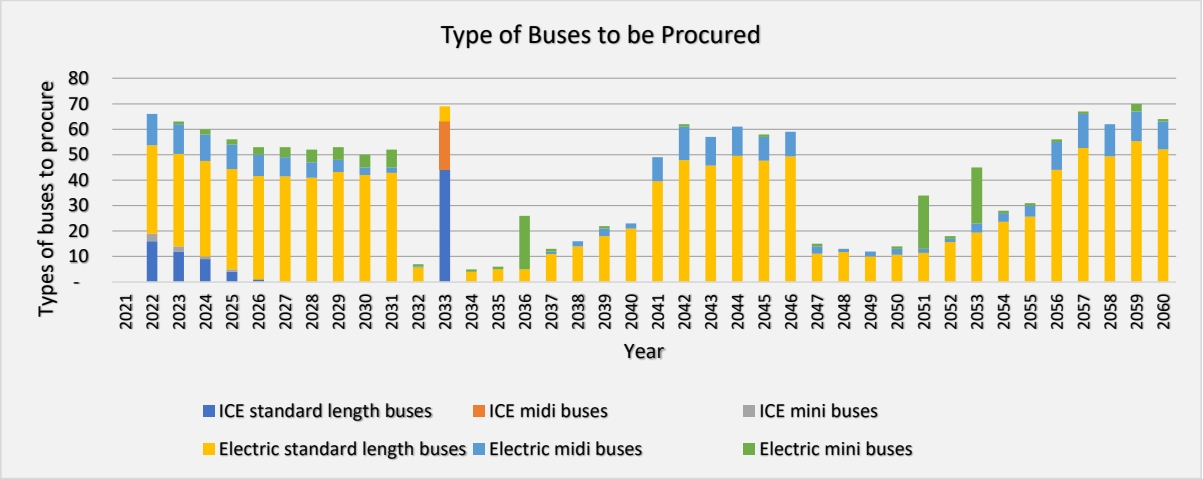
High Ambition Scenario



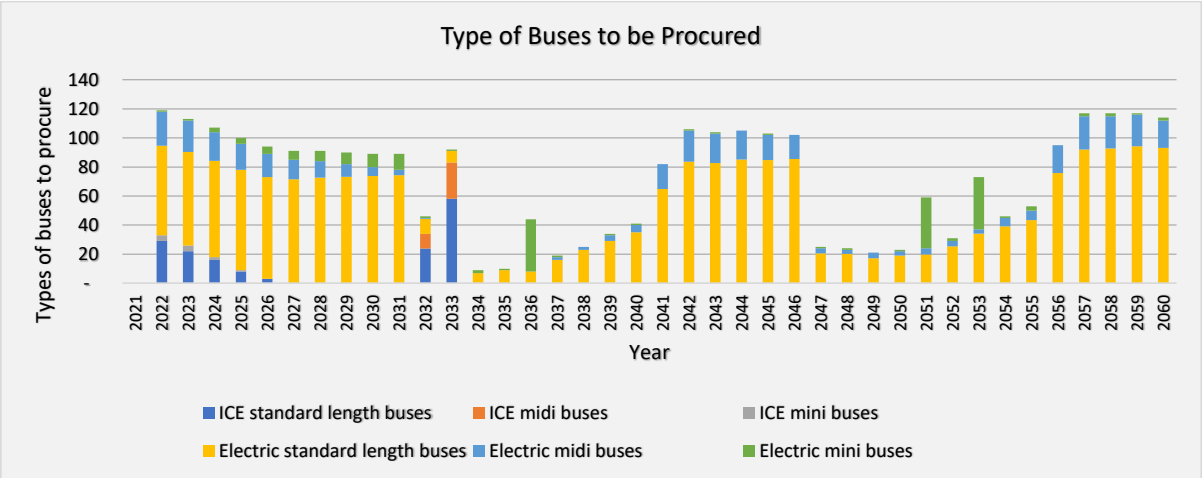
Business as Usual Scenario



Low Ambition Scenario

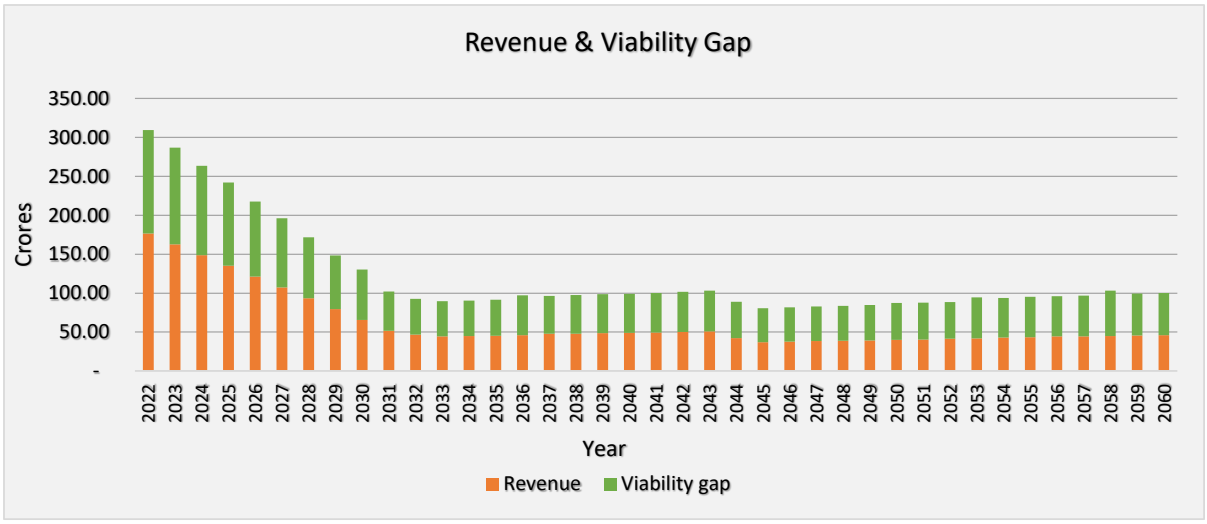


High Ambition Scenario

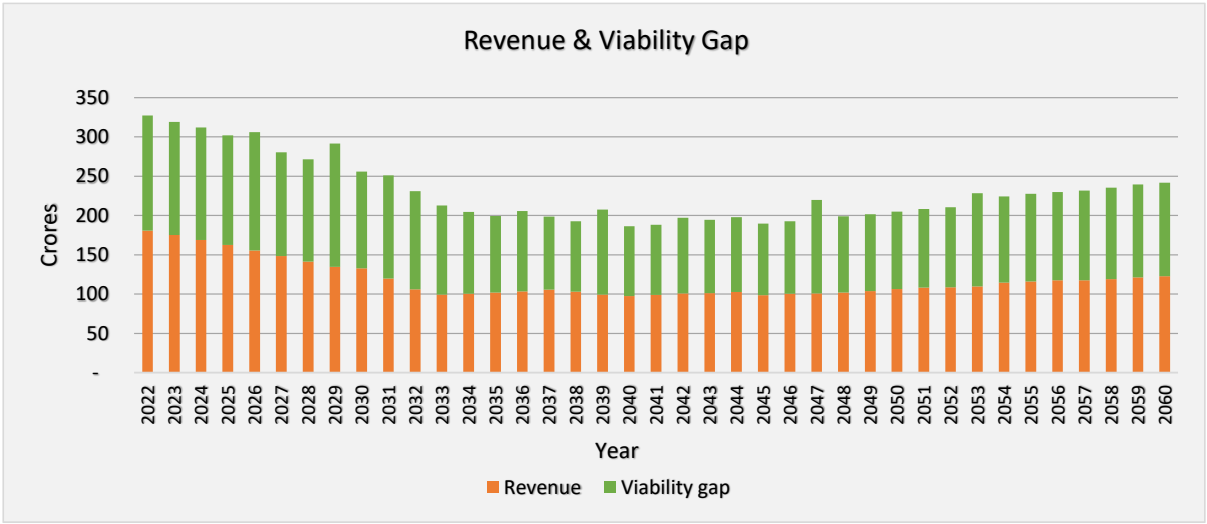


Revenue and Viability Gap: GCC Model

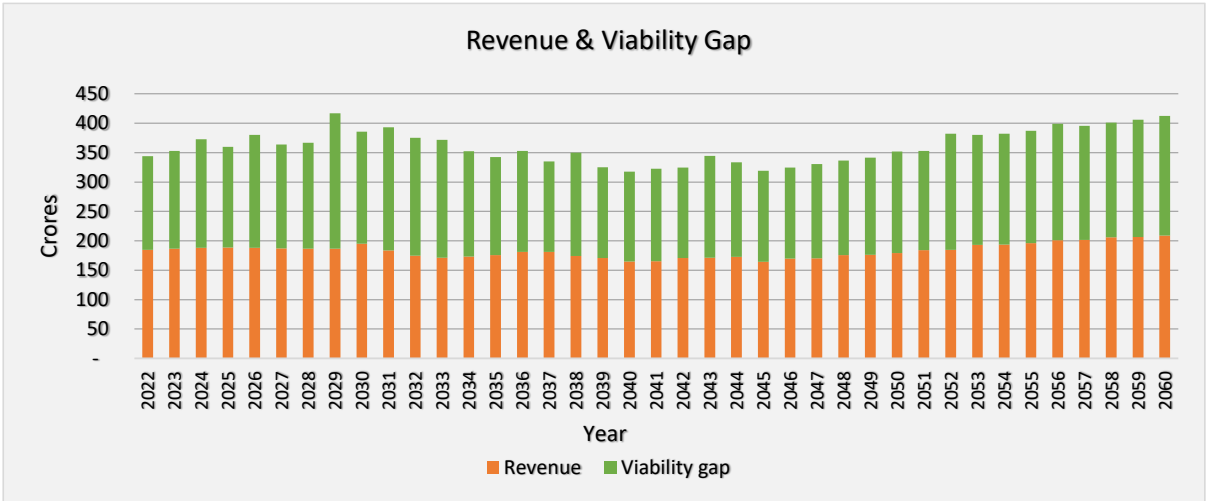
Business as Usual Scenario



Low Ambition Scenario

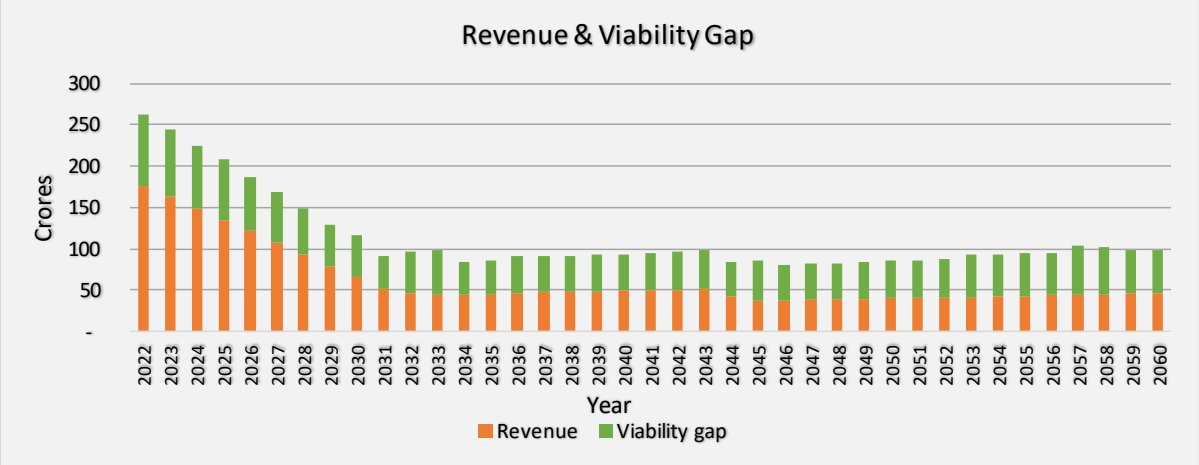


High Ambition Scenario

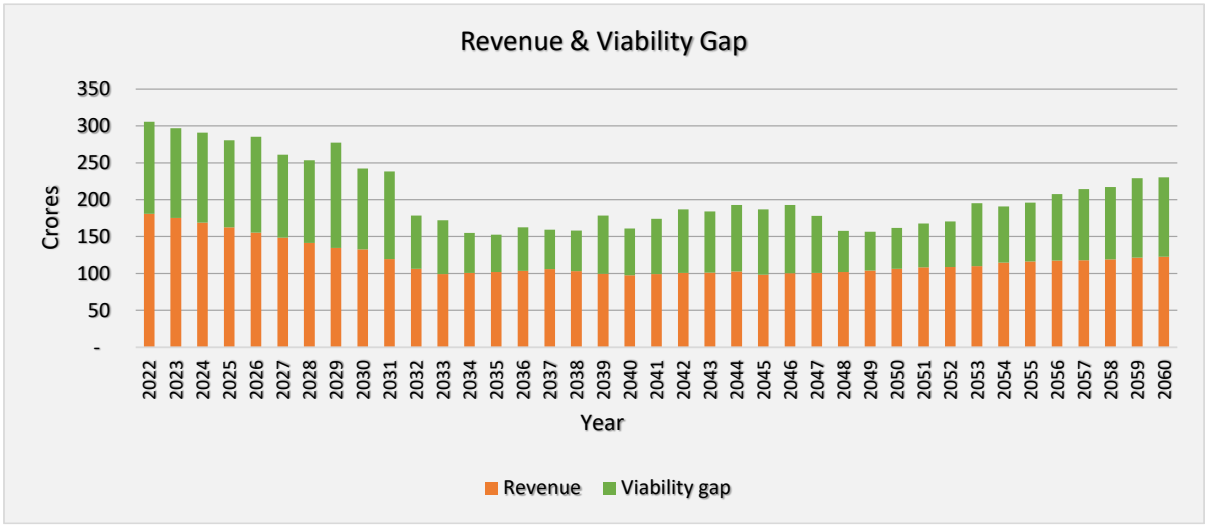


Revenue and Viability Gap: Outright Purchase Model

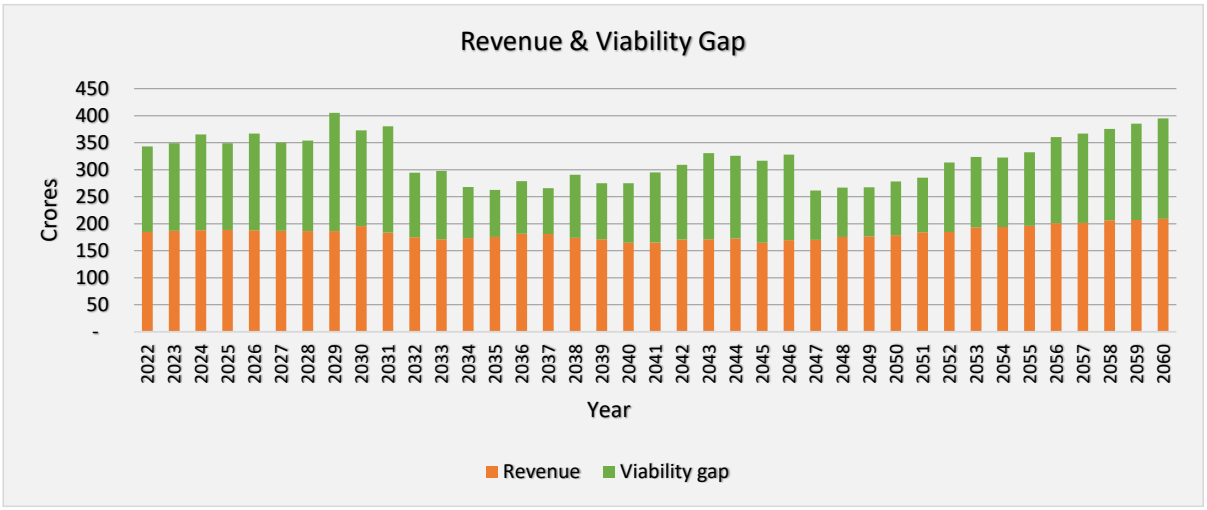
Business as usual Scenario



Low Ambition Scenario

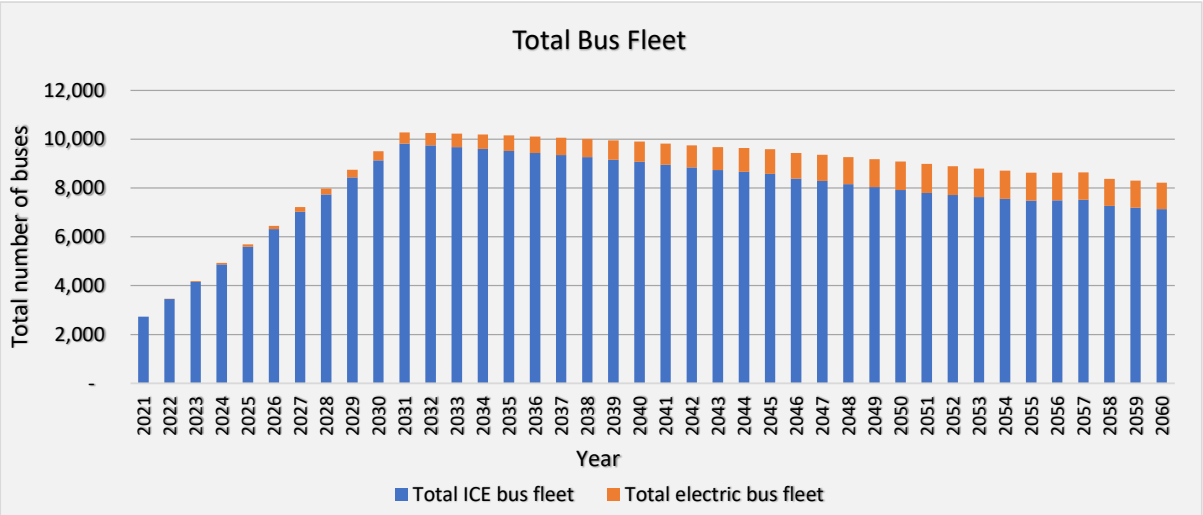


High Ambition Scenario

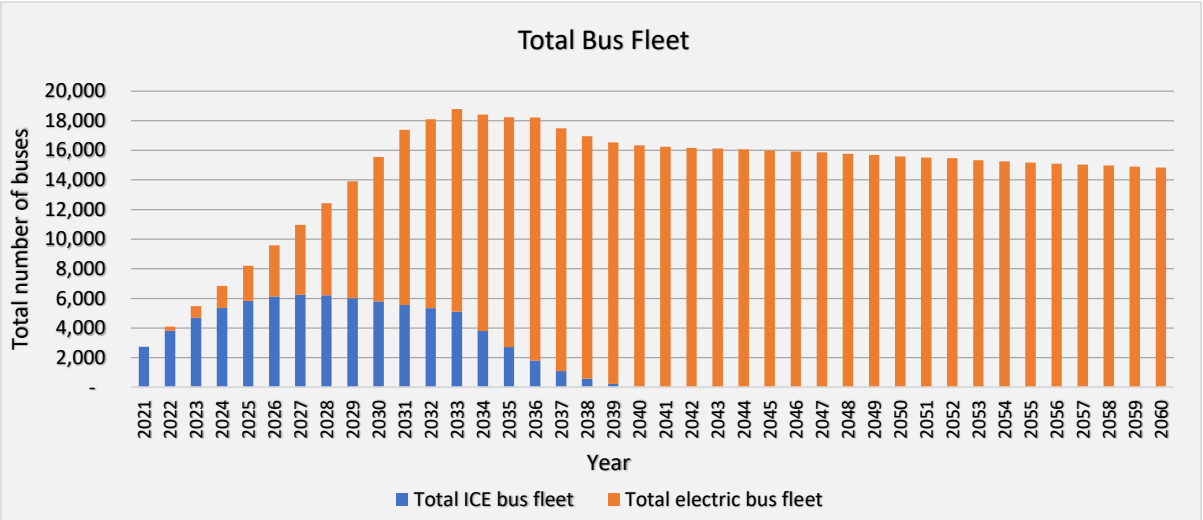


28. State / UT: Punjab

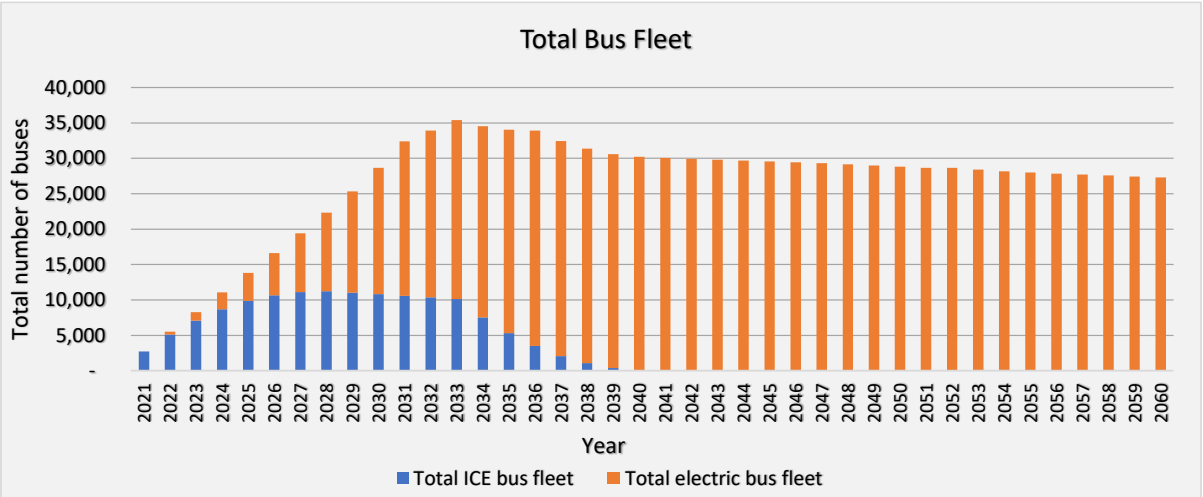
Business as usual Scenario



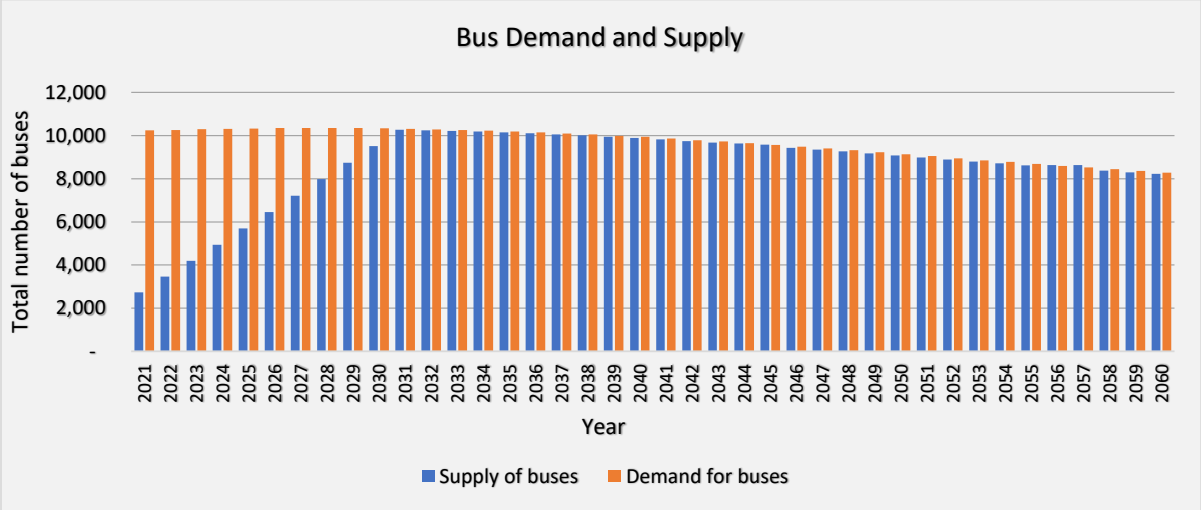
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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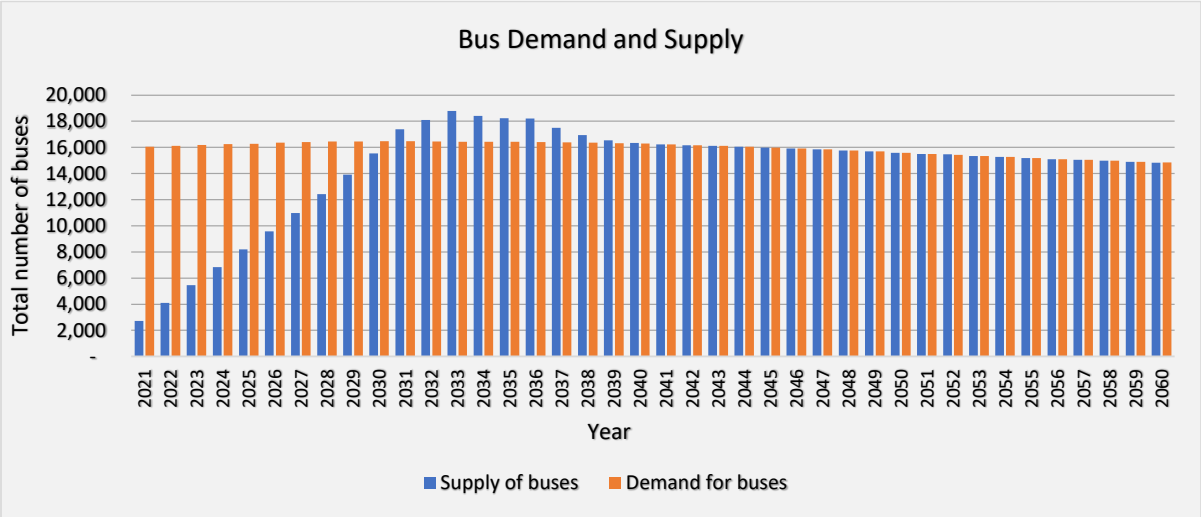
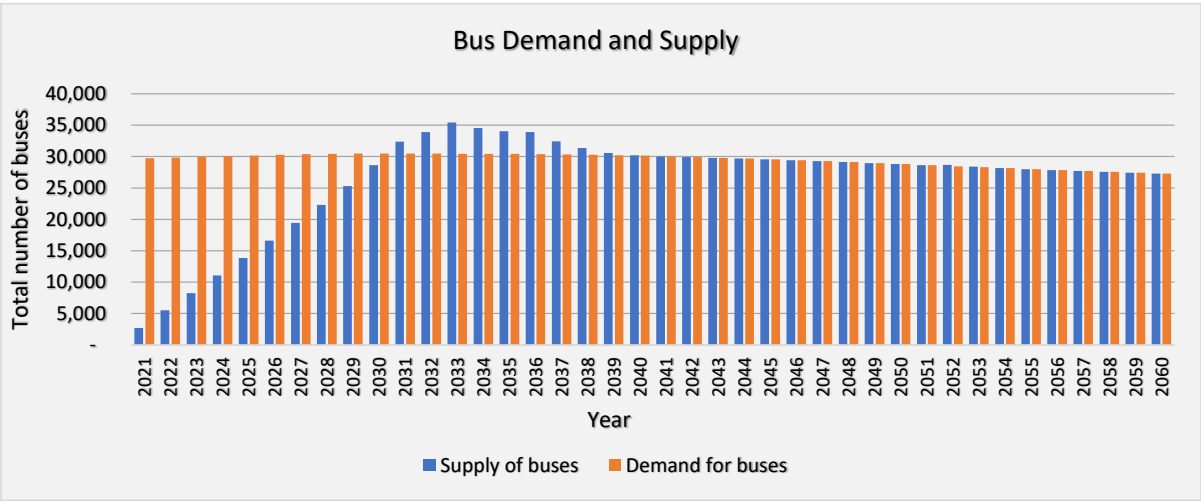
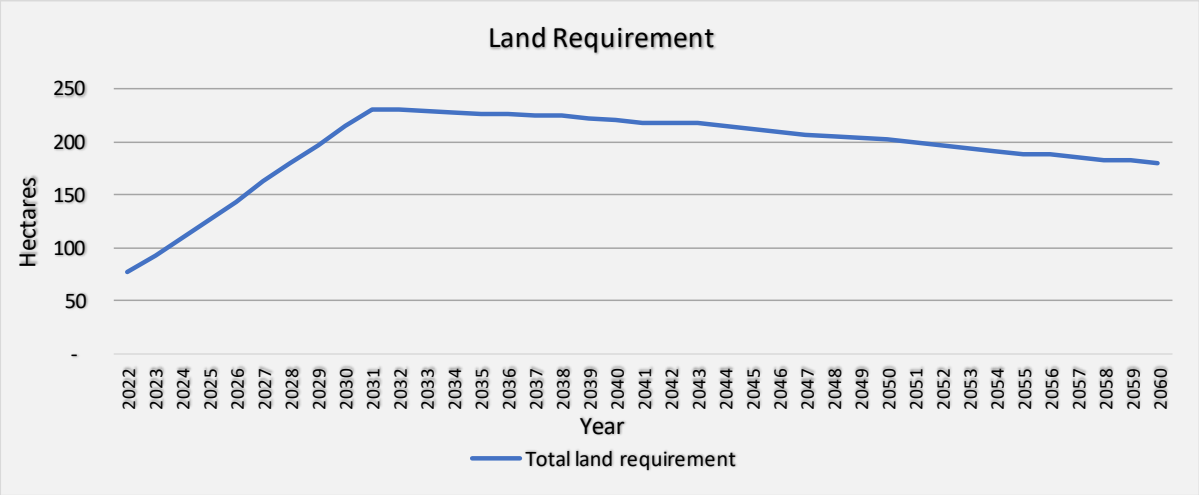


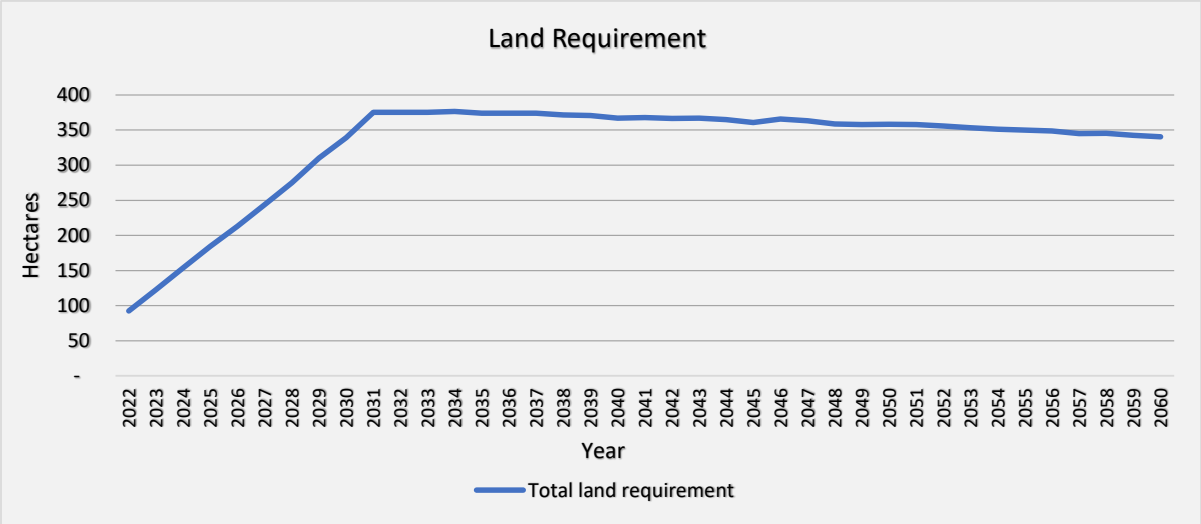
High Ambition Scenario



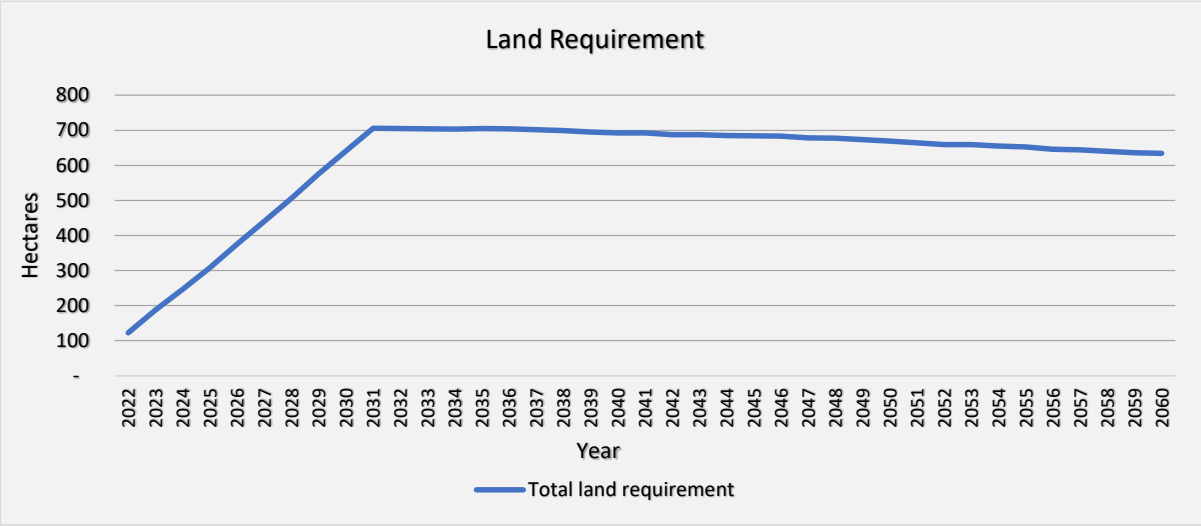
Business as Usual Scenario



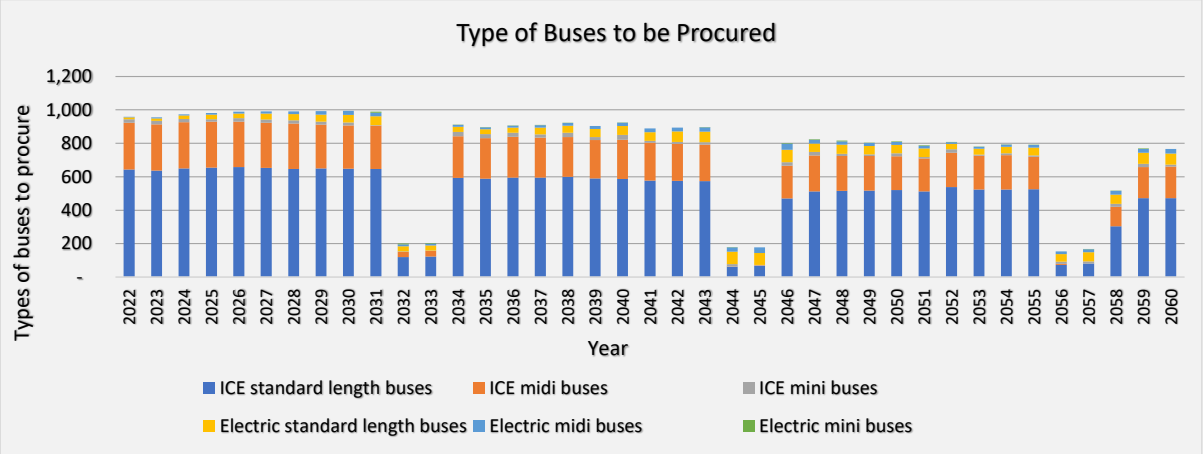
Low Ambition Scenario



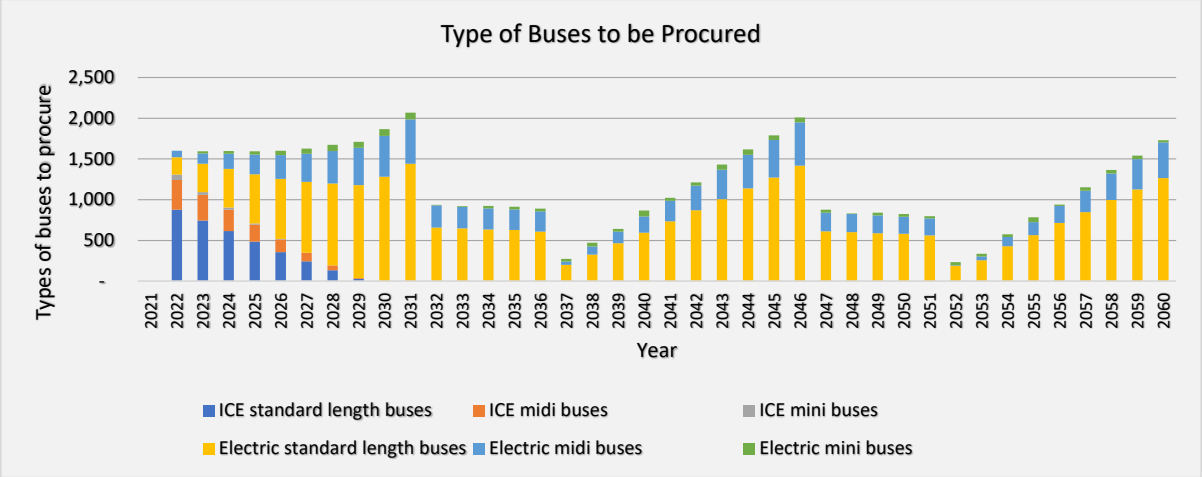
High Ambition Scenario



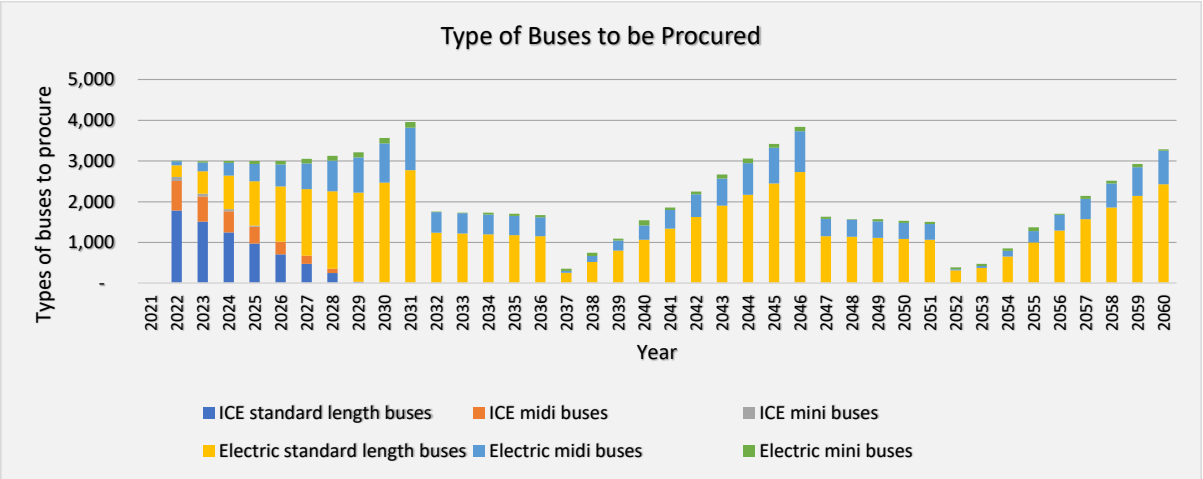
Business as Usual Scenario



Low Ambition Scenario

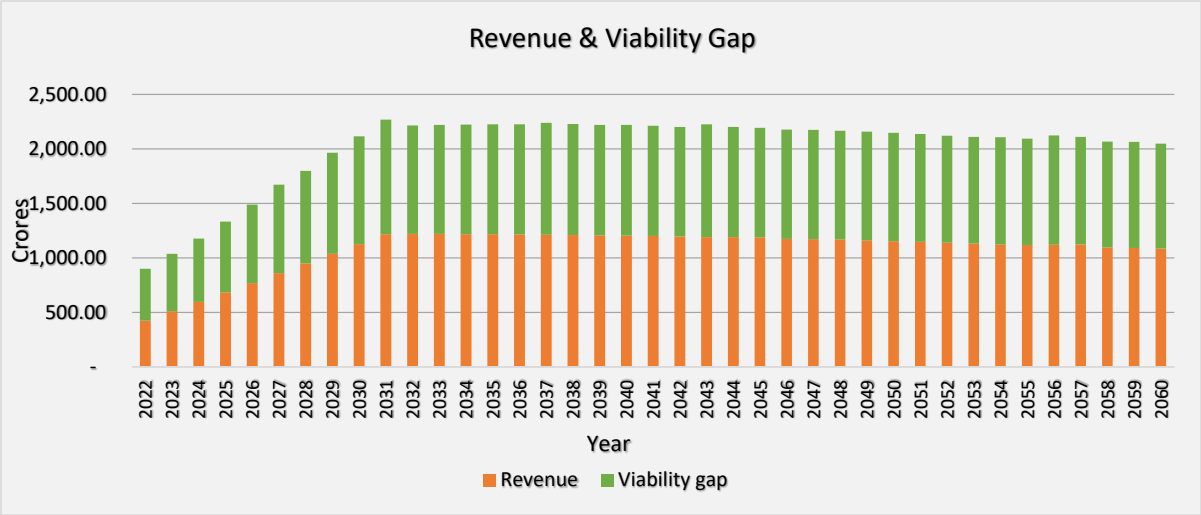


High Ambition Scenario

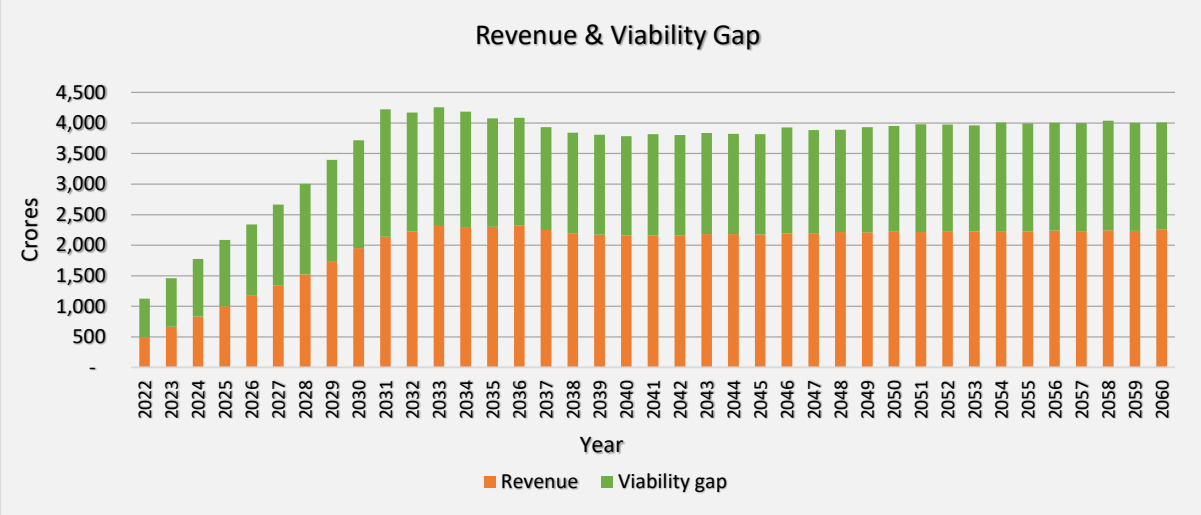


Revenue and Viability Gap: GCC Model

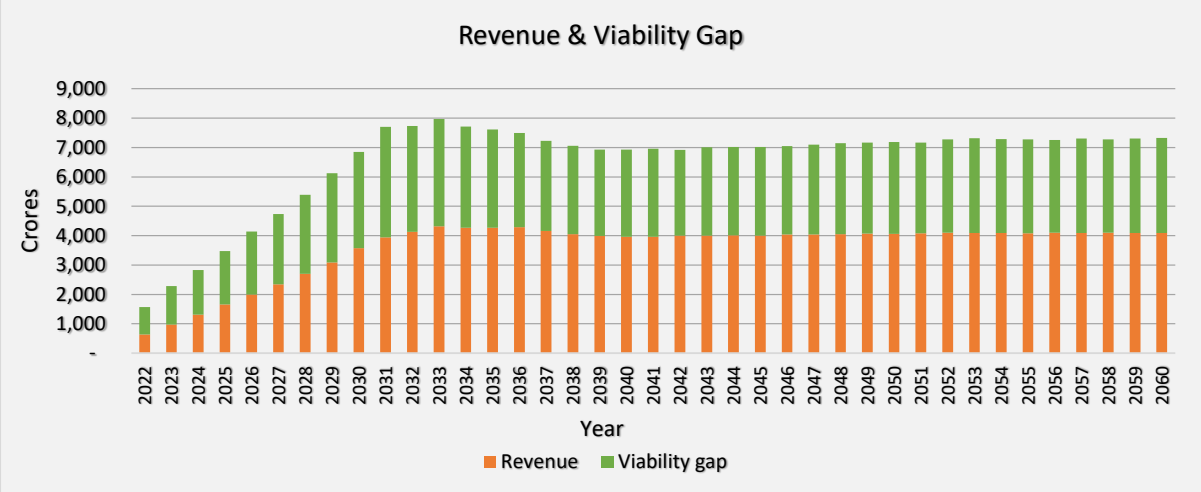
Business as Usual Scenario



Low Ambition Scenario

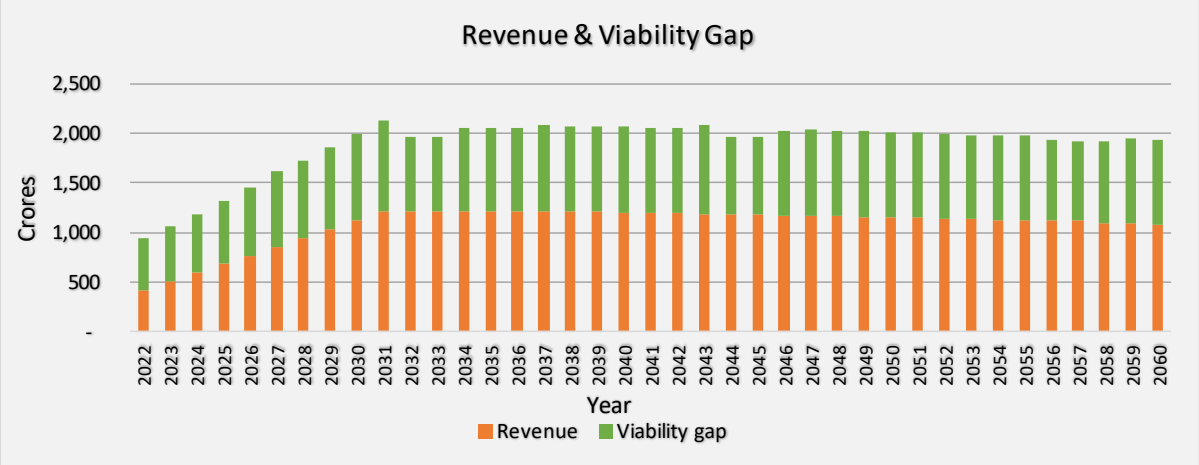


High Ambition Scenario

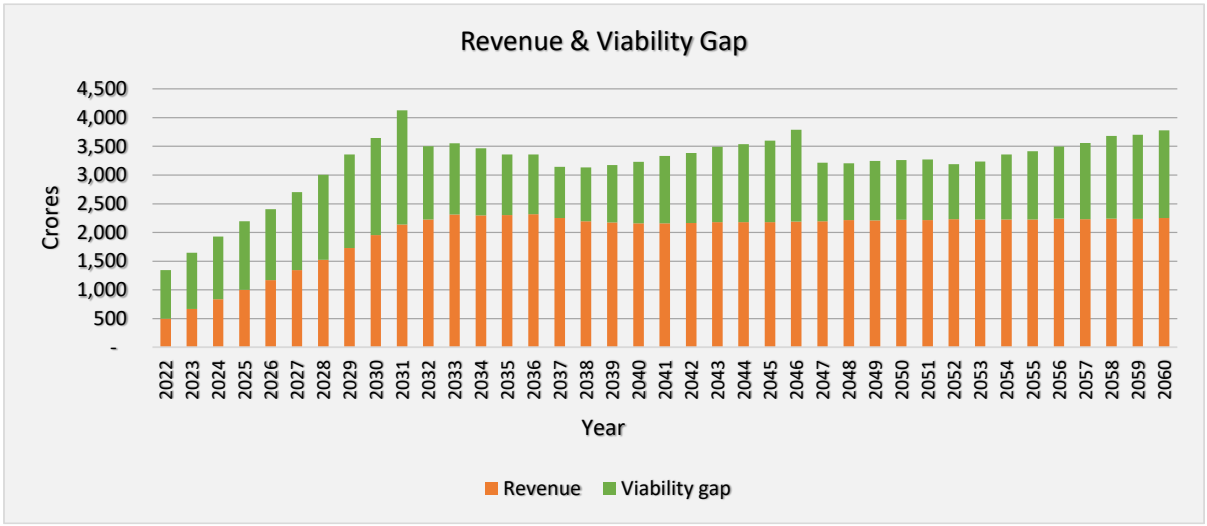


Revenue and Viability Gap: Outright Purchase Model

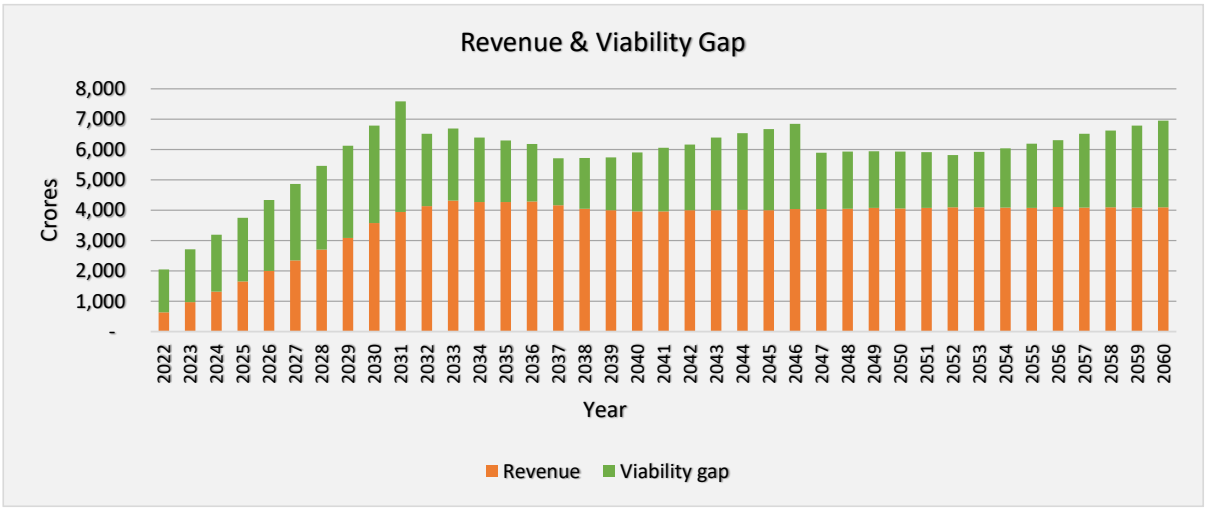
Business as usual Scenario



Low Ambition Scenario

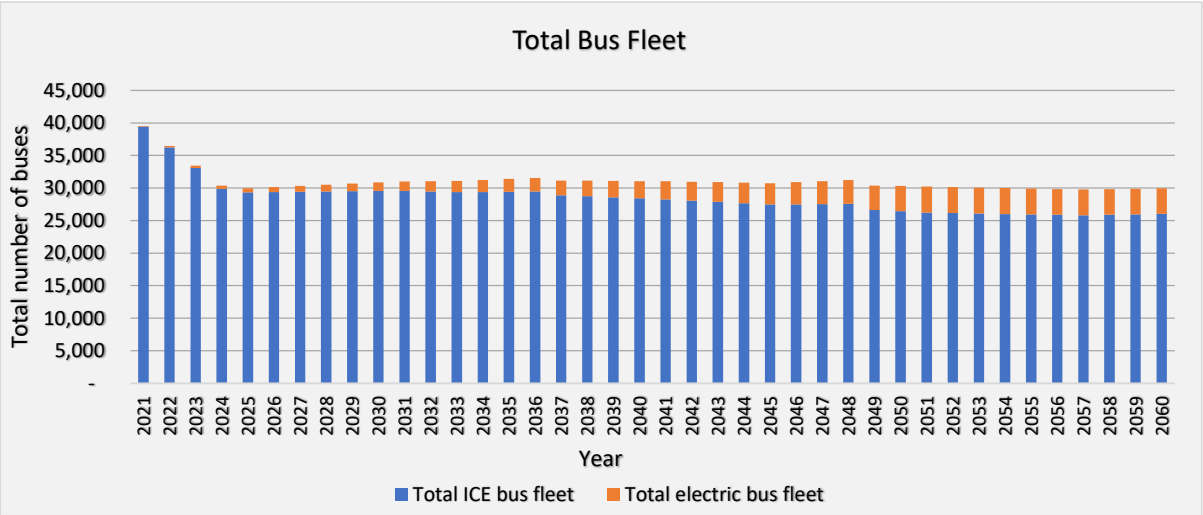


High Ambition Scenario

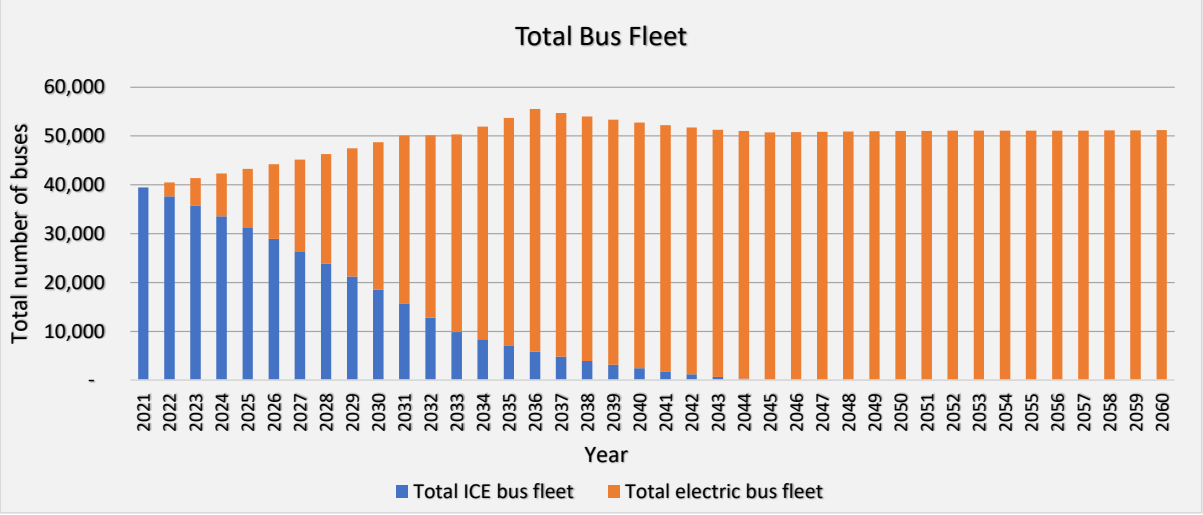


29. State / UT: Rajasthan

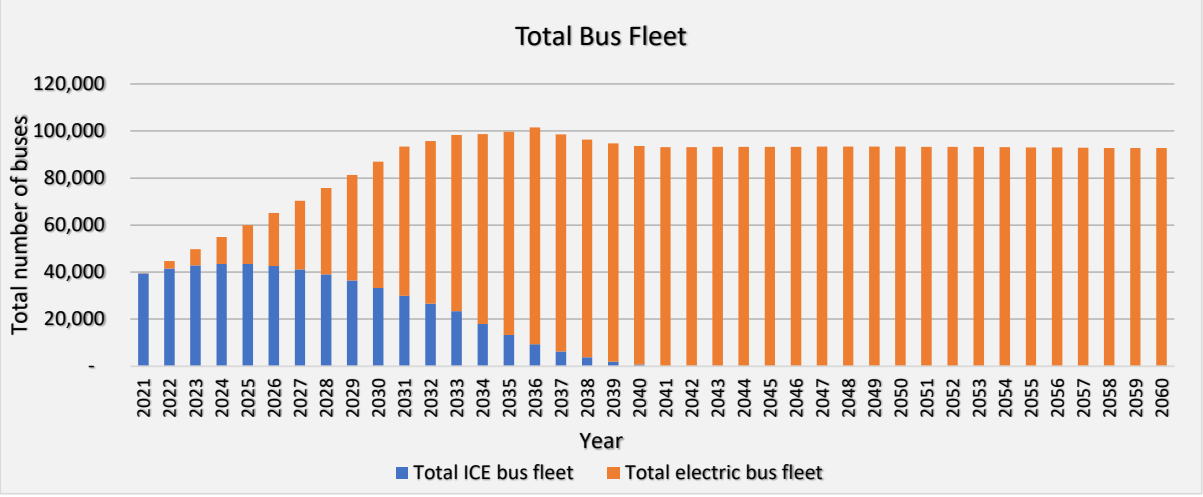
Business as usual Scenario



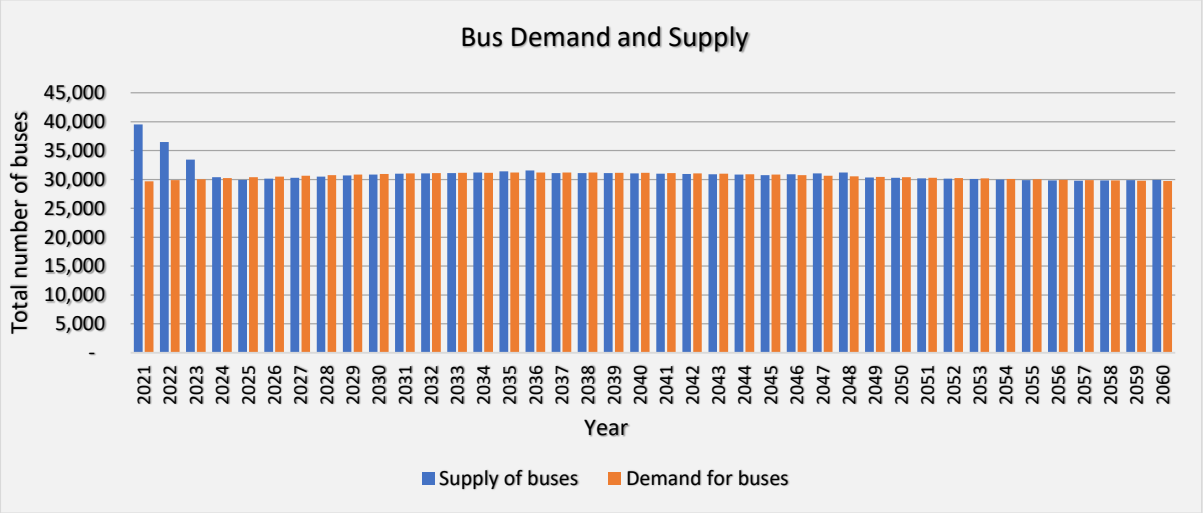
Low Ambition Scenario



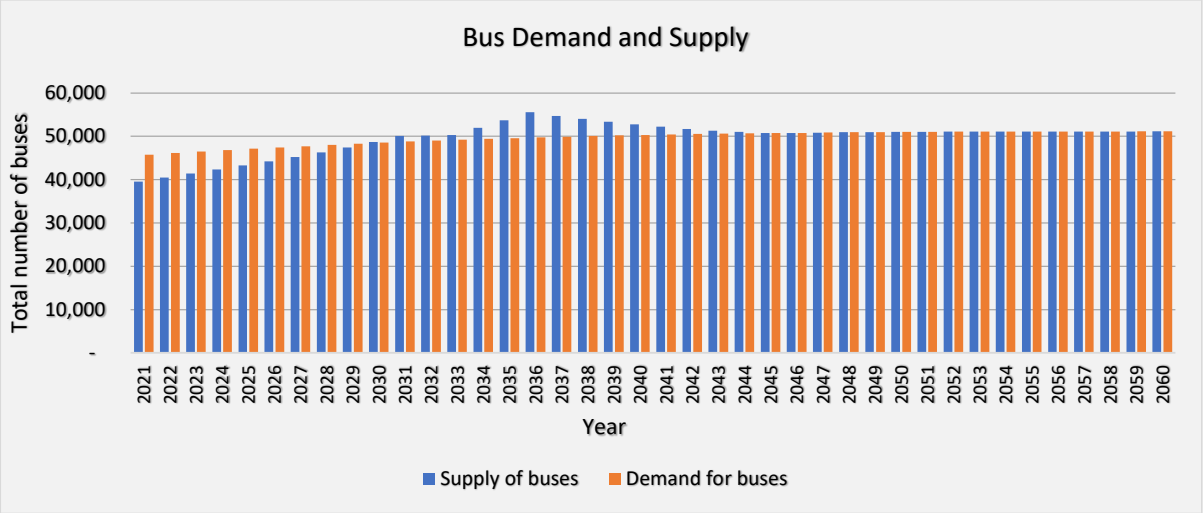
High Ambition Scenario



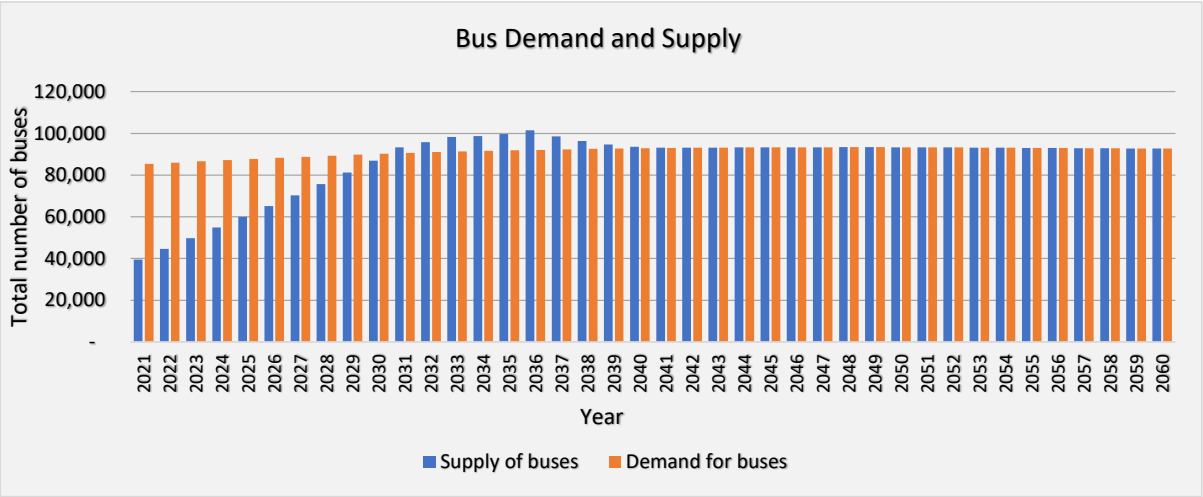
Business as Usual Scenario



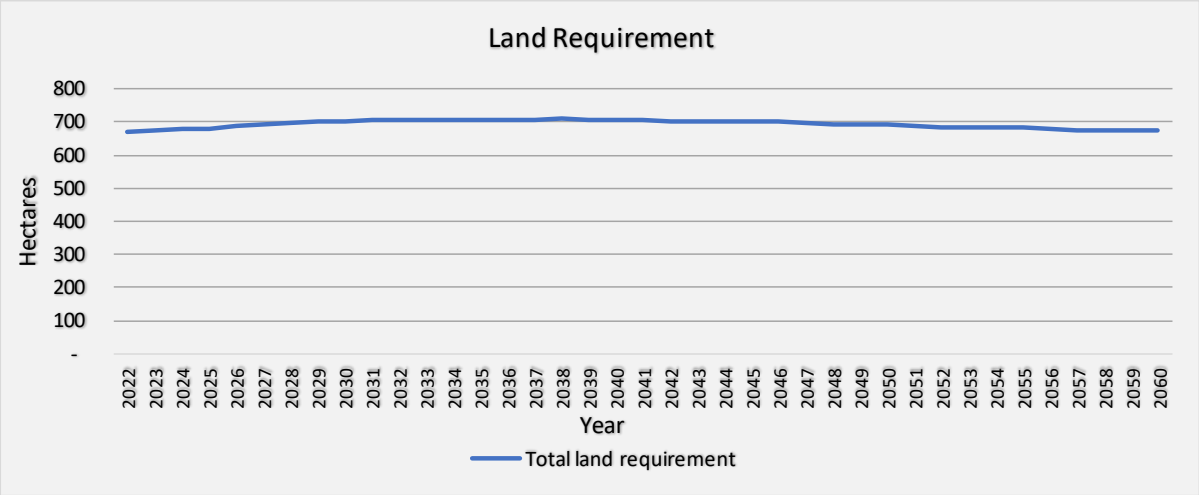
Low Ambition Scenario



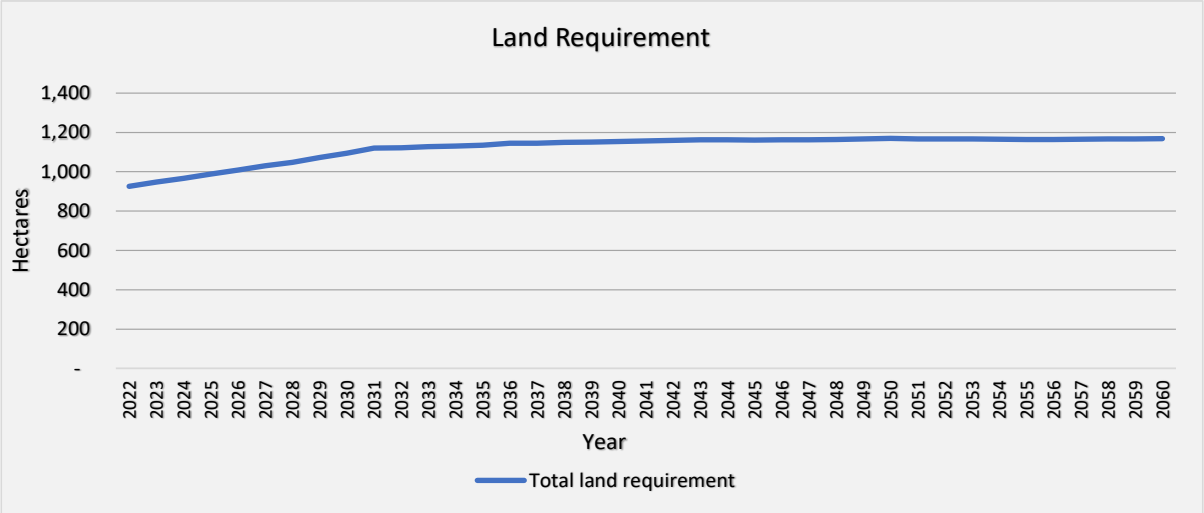
High Ambition Scenario



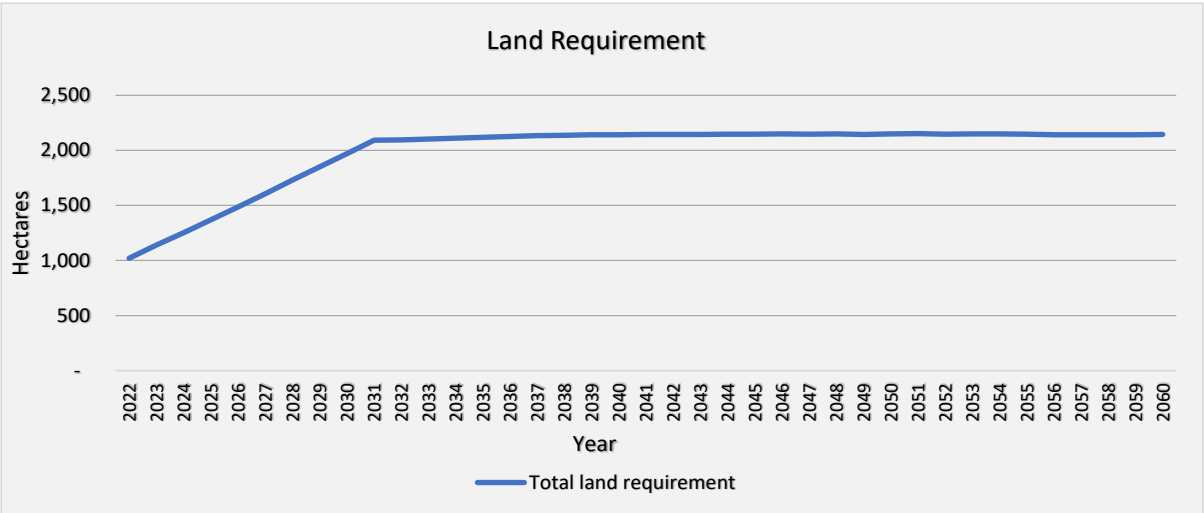
Business as Usual Scenario



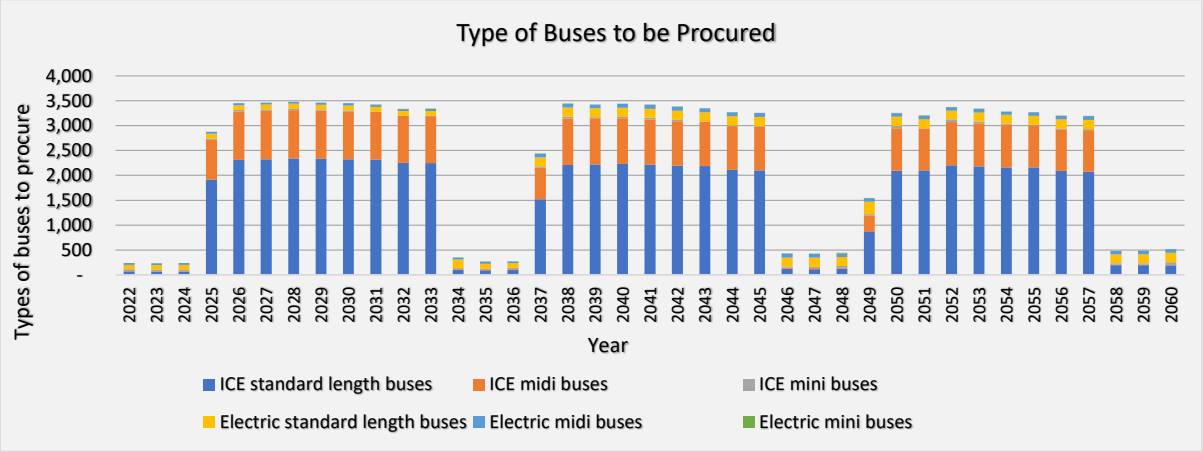
Low Ambition Scenario



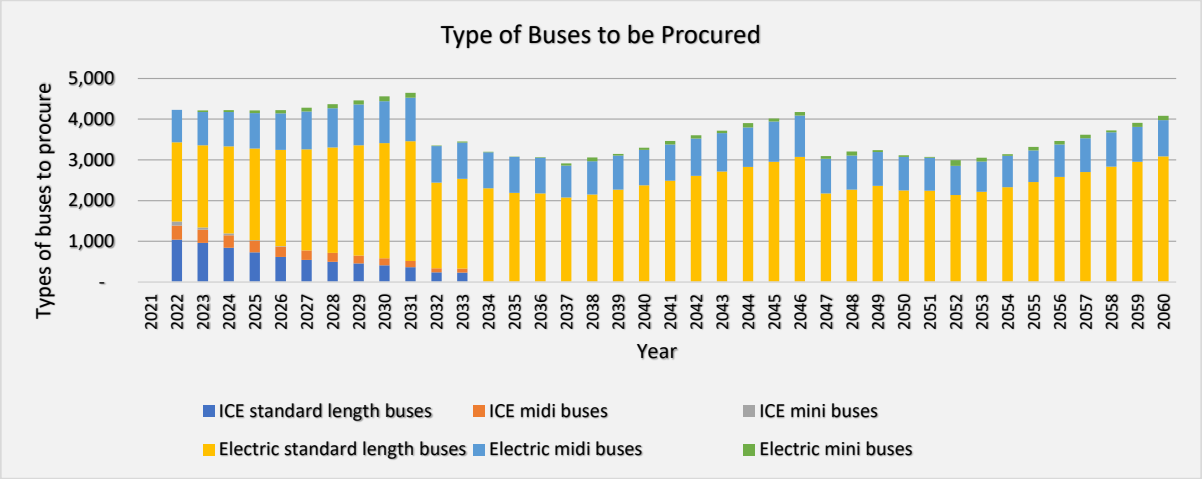
High Ambition Scenario



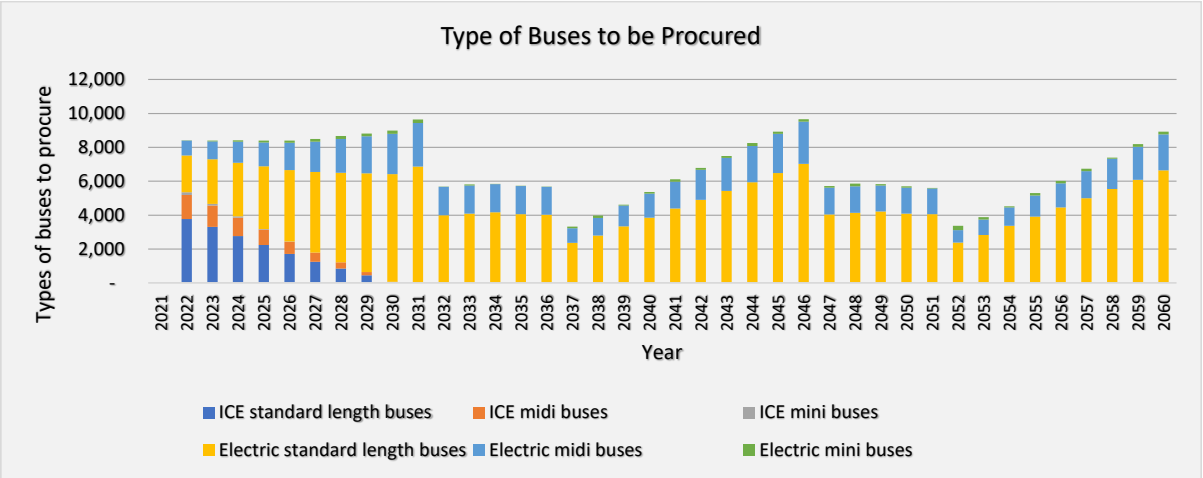
Business as Usual Scenario



Low Ambition Scenario

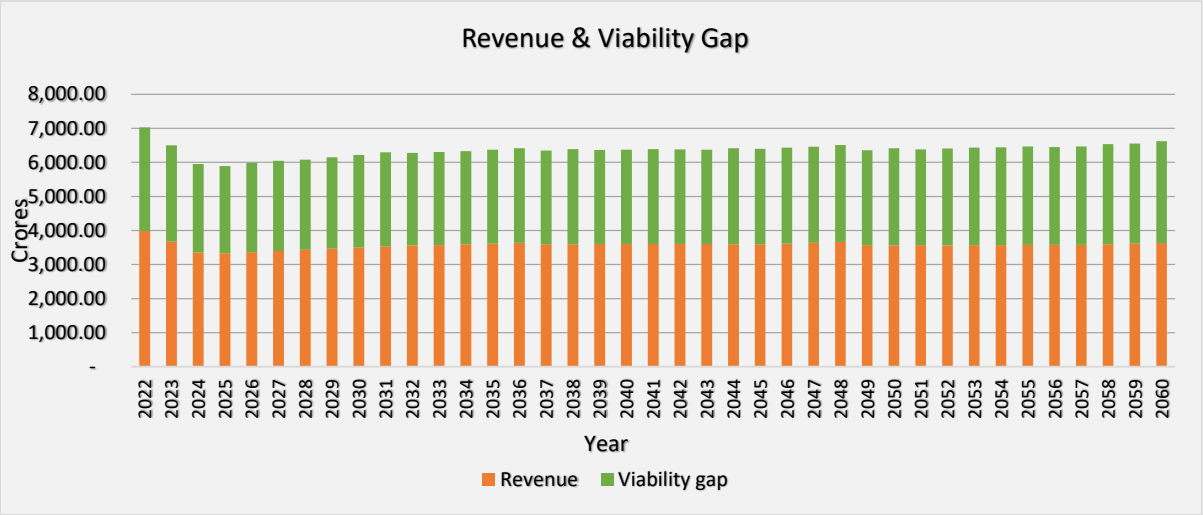


High Ambition Scenario

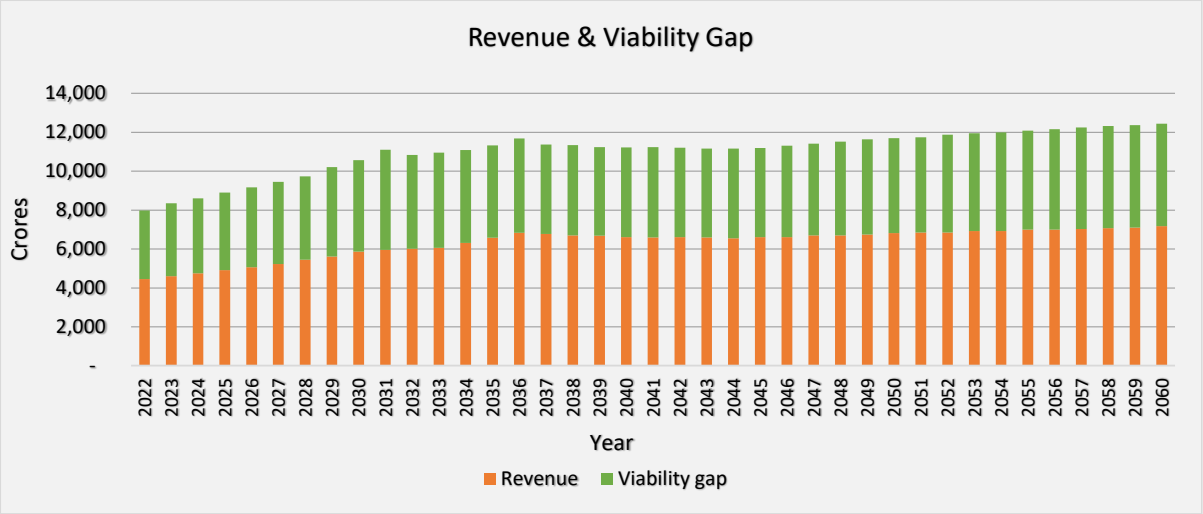


Revenue and Viability Gap: GCC Model

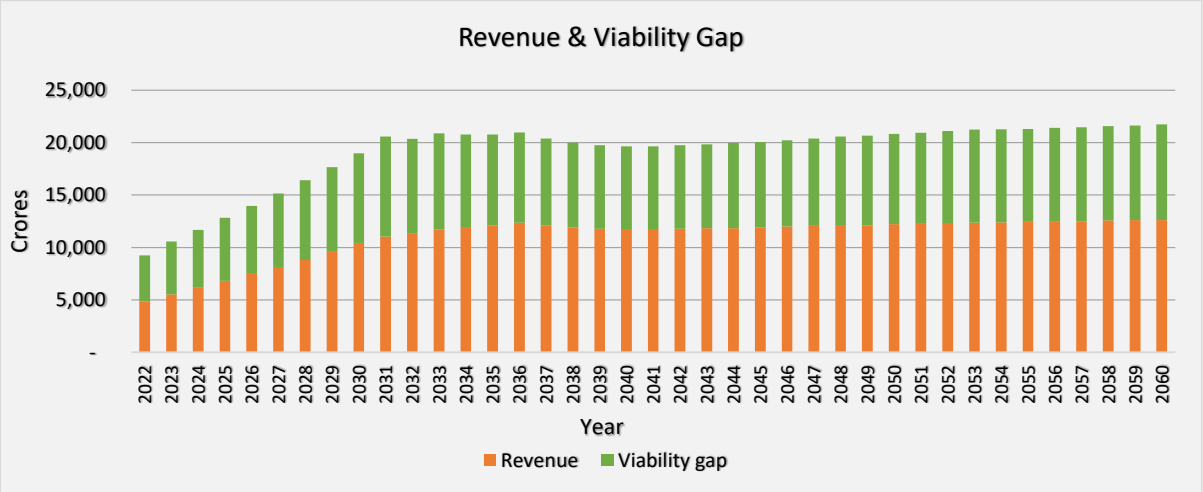
Business as Usual Scenario



Low Ambition Scenario

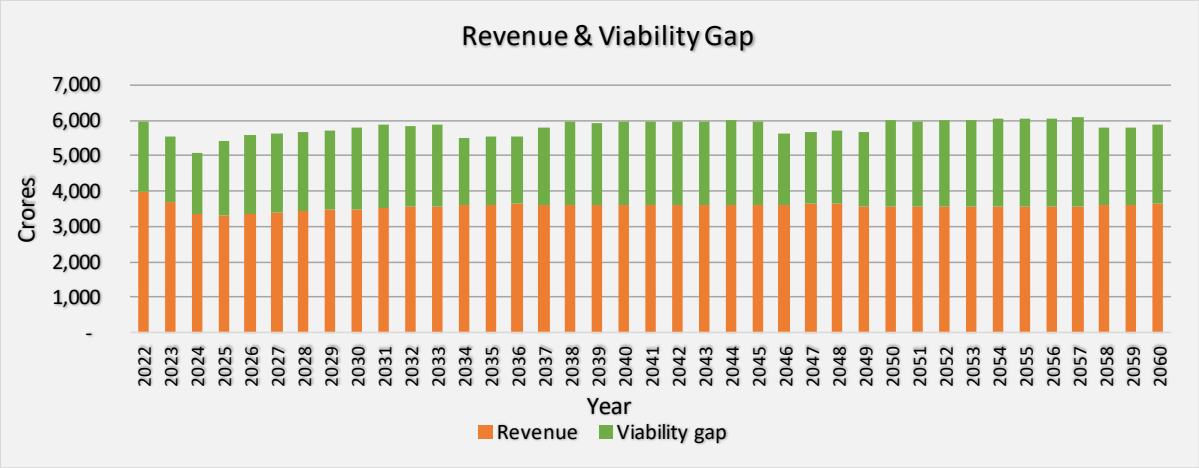


High Ambition Scenario

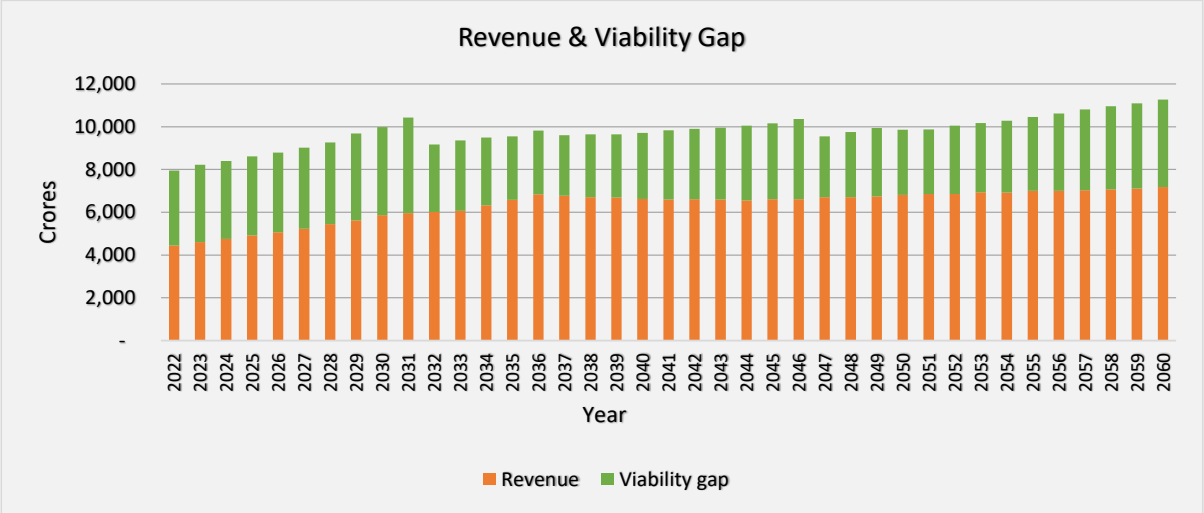


Revenue and Viability Gap: Outright Purchase Model

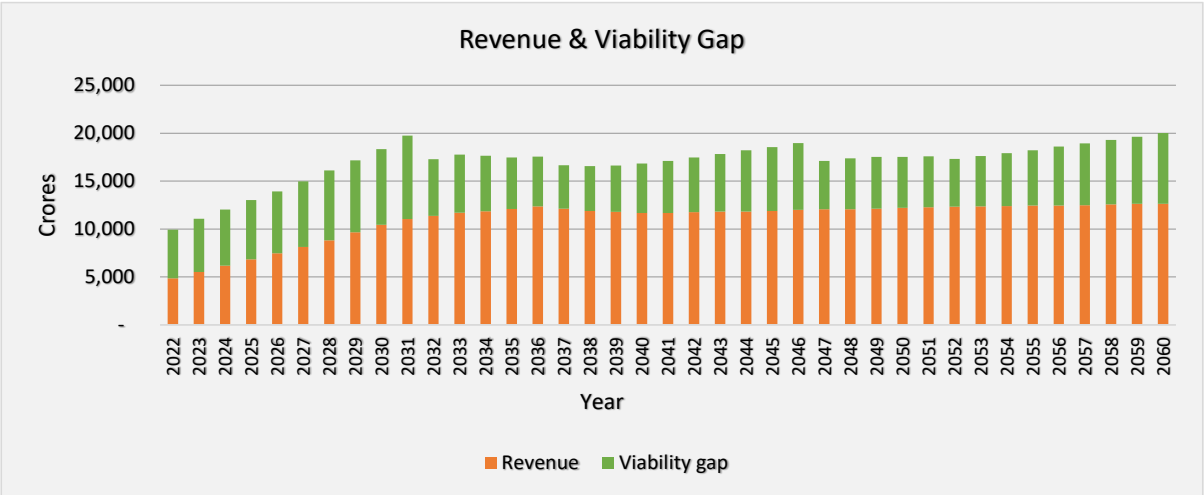
Business as usual Scenario



Low Ambition Scenario

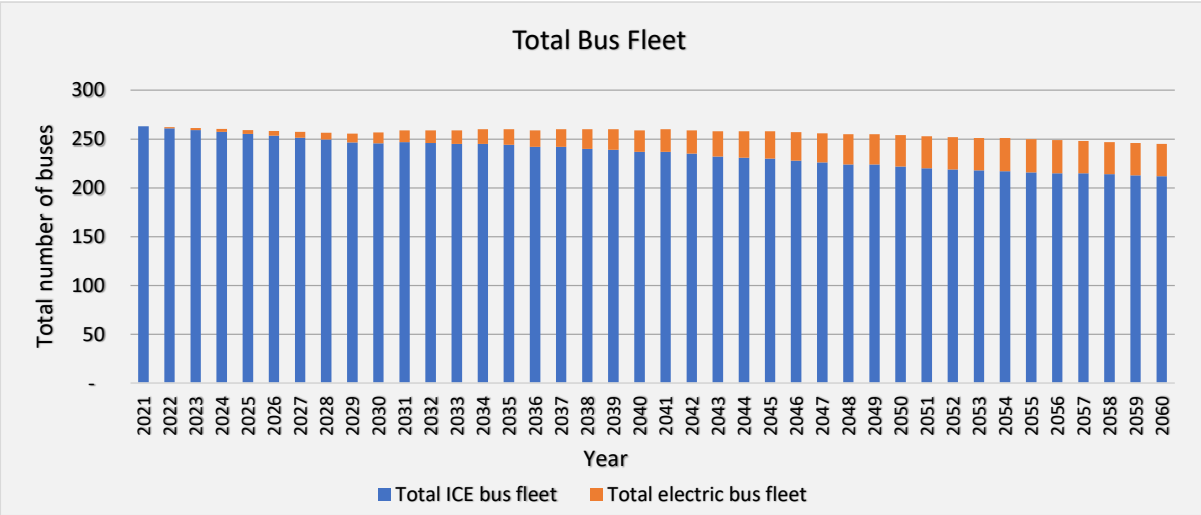


High Ambition Scenario

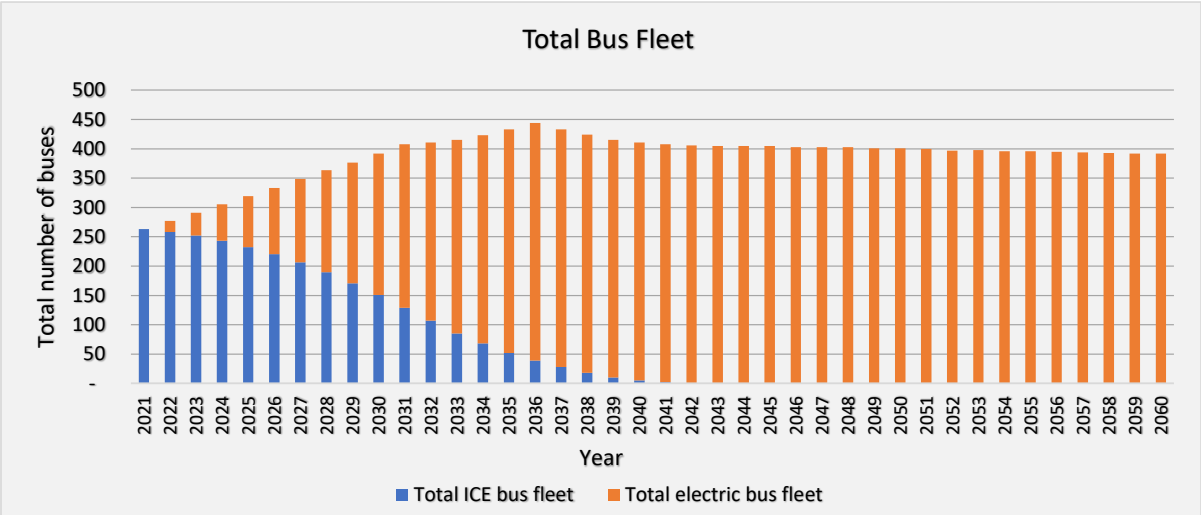


30. State / UT: Sikkim

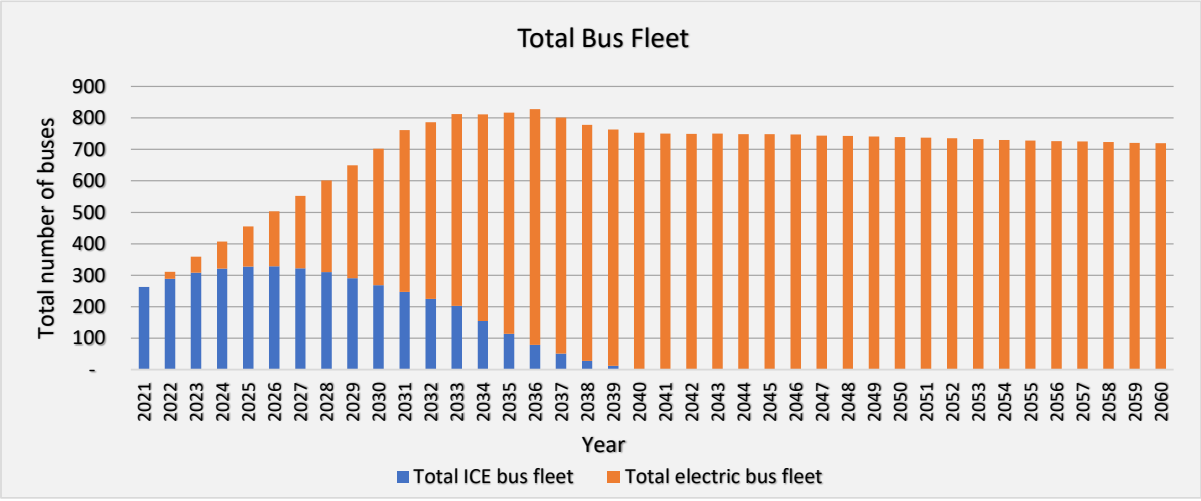
Business as usual Scenario



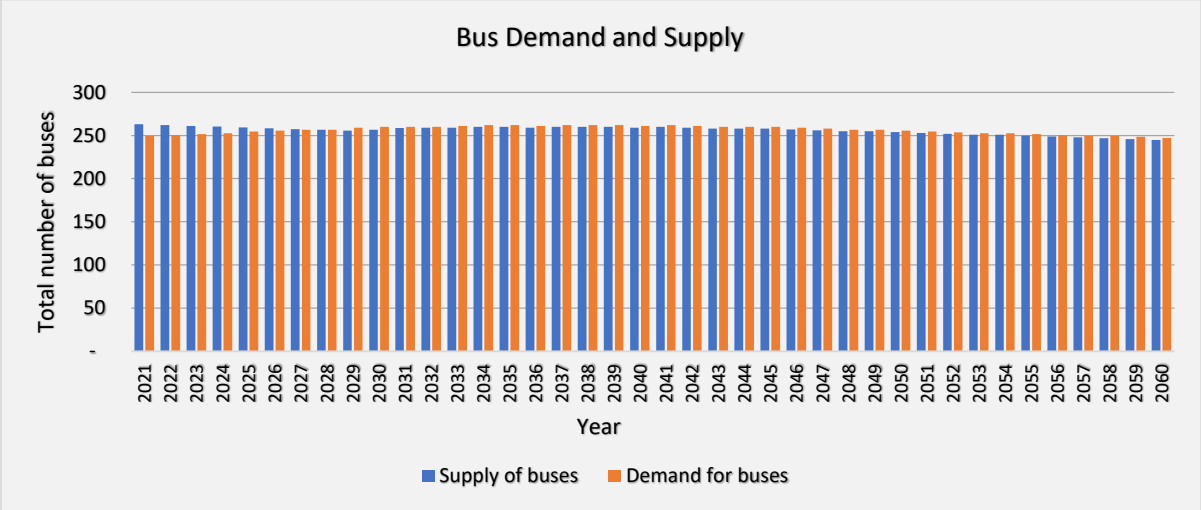
Low Ambition Scenario



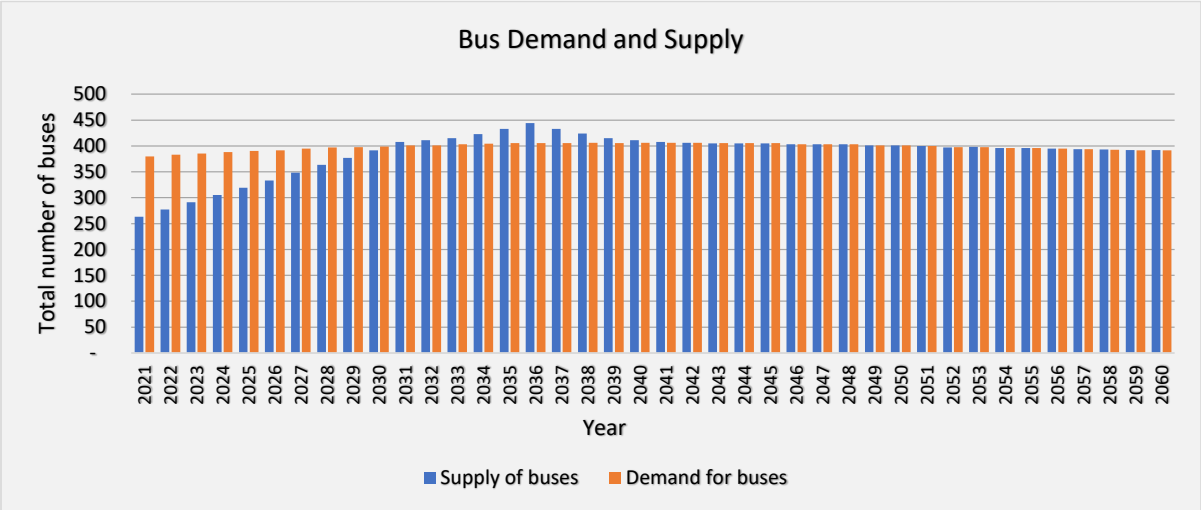
High Ambition Scenario



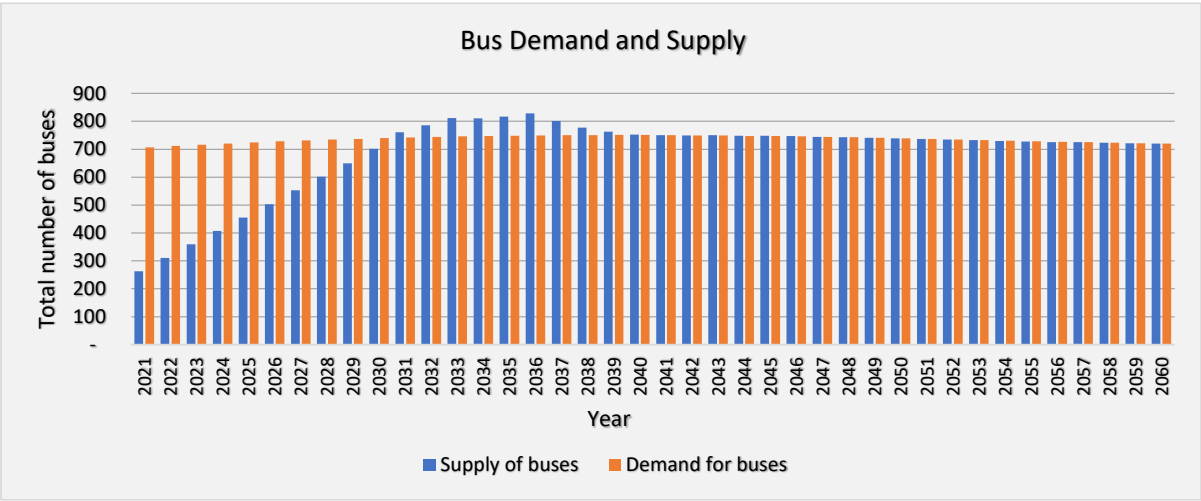
Business as Usual Scenario



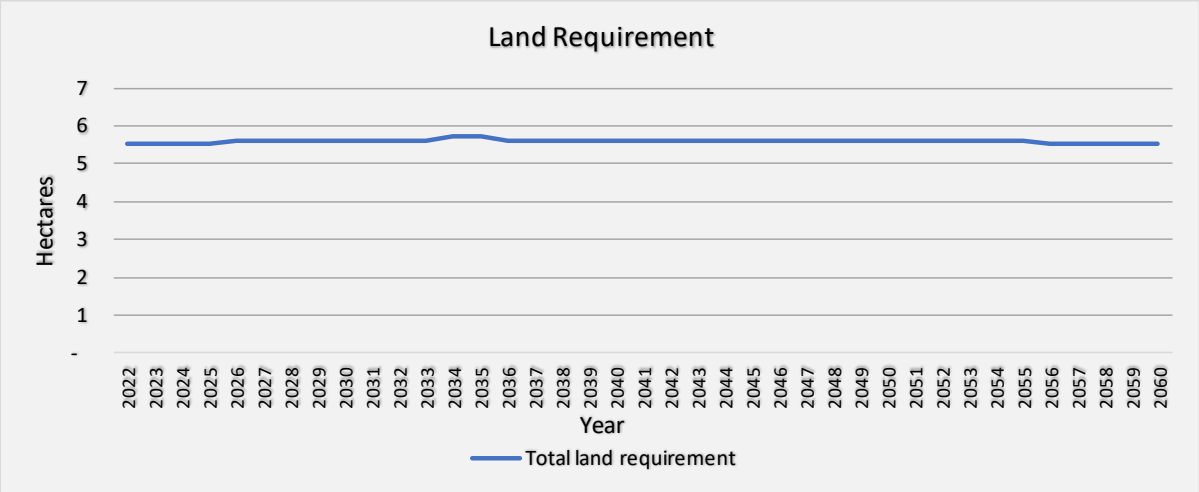
Low Ambition Scenario



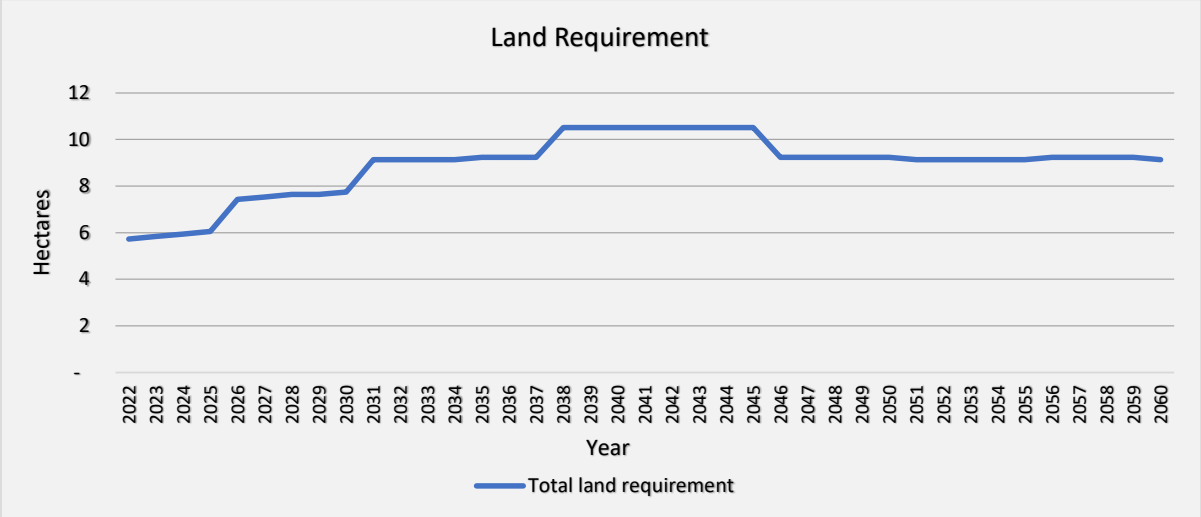
High Ambition Scenario



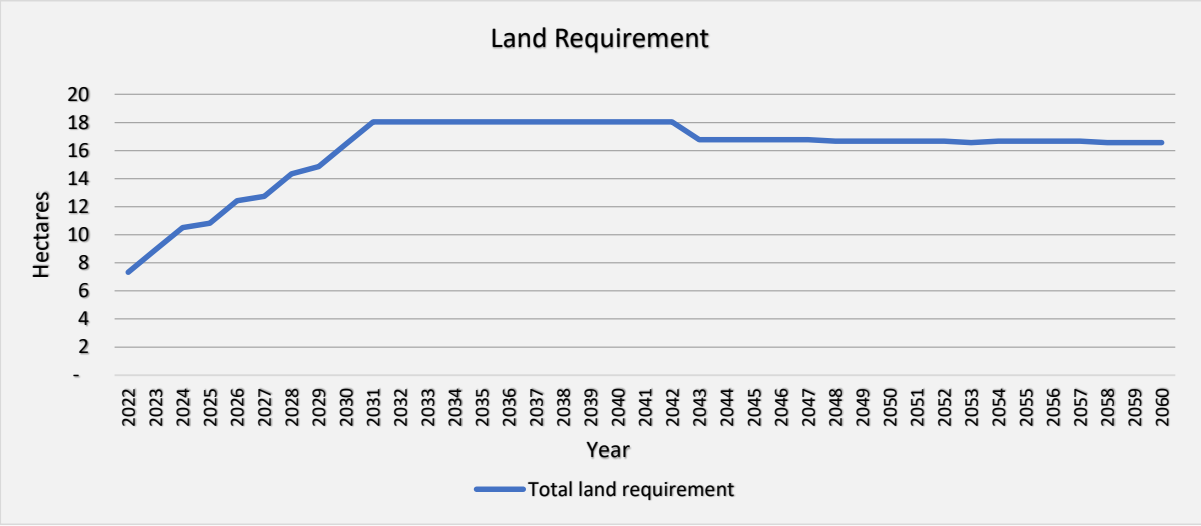
Business as Usual Scenario



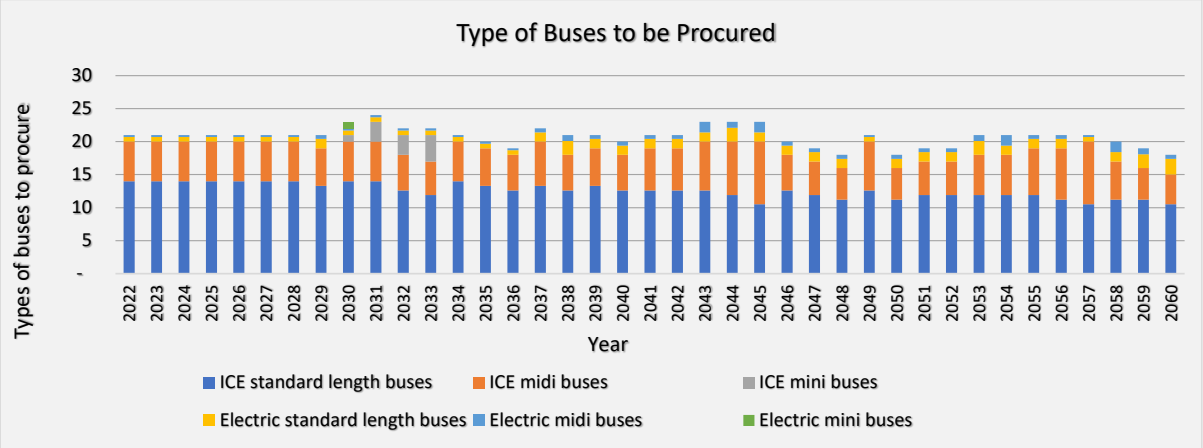
Low Ambition Scenario



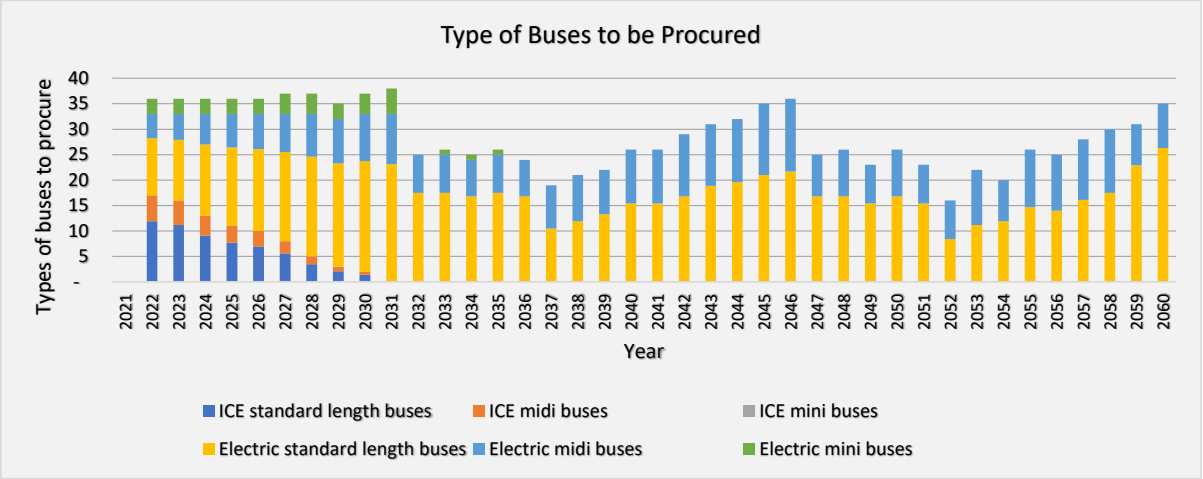
High Ambition Scenario



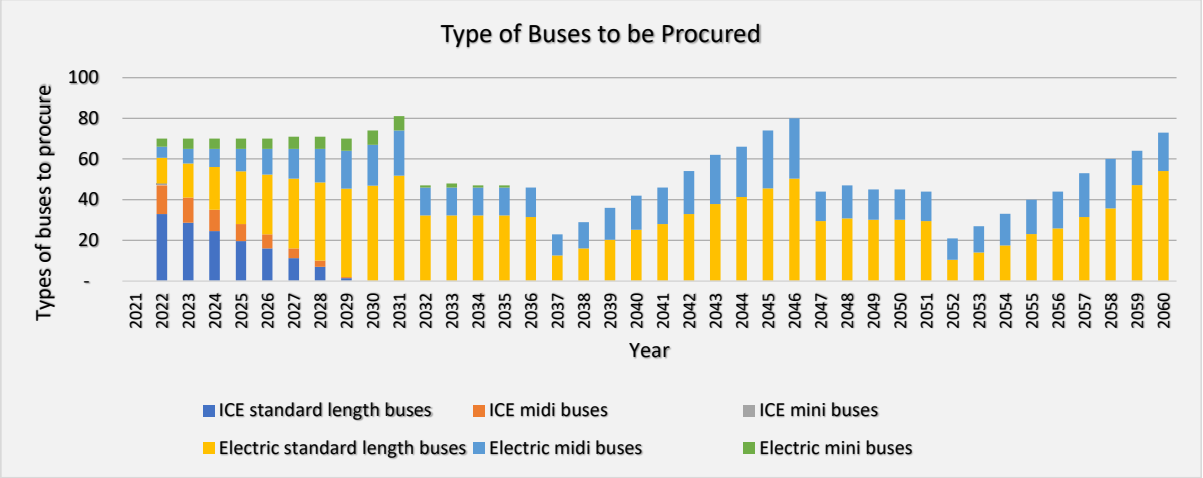
Business as Usual Scenario



Low Ambition Scenario

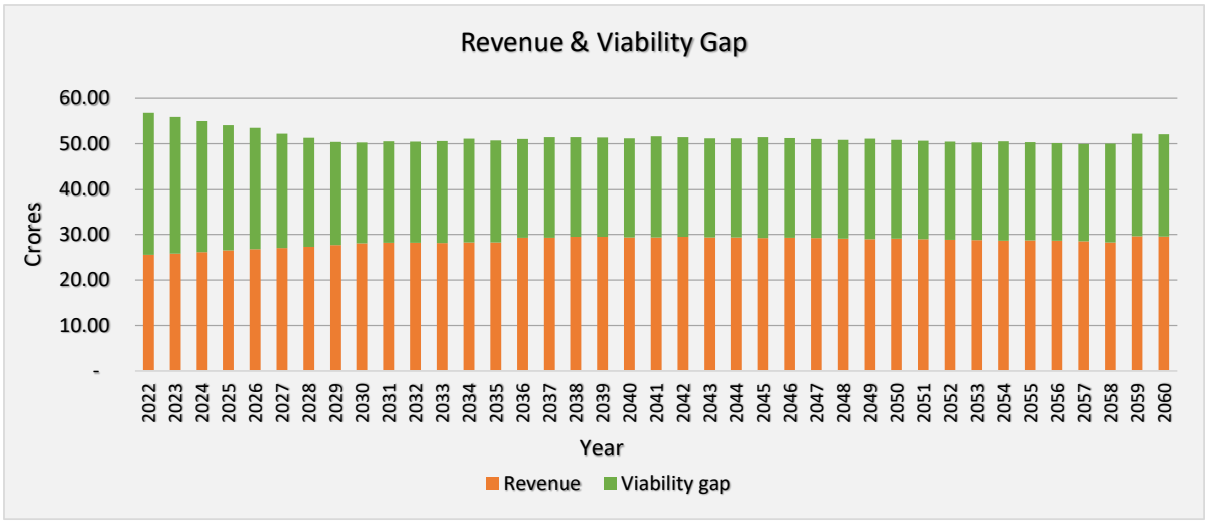


High Ambition Scenario

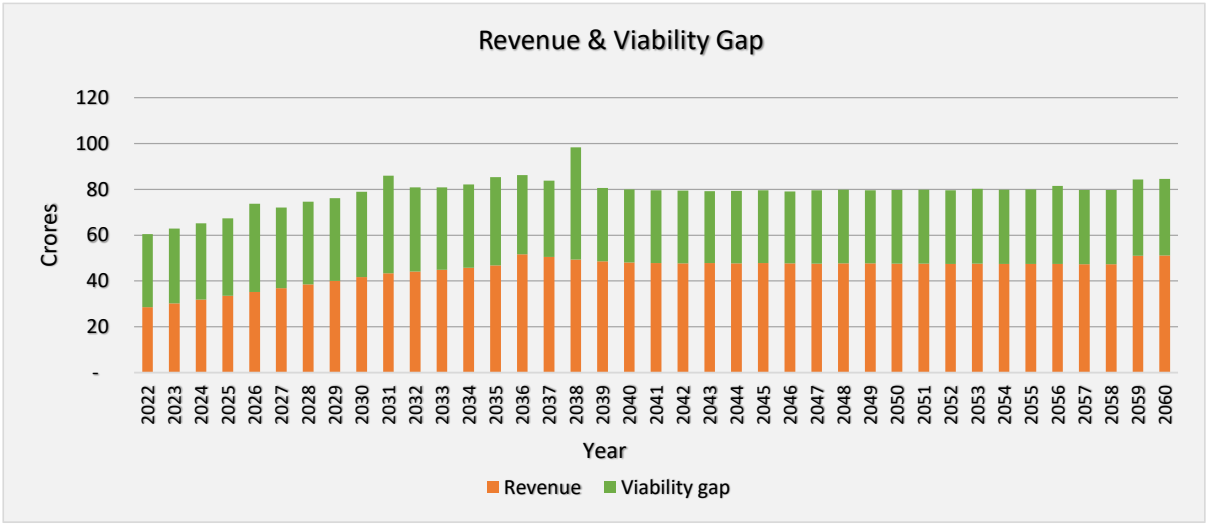


Revenue and Viability Gap: GCC Model

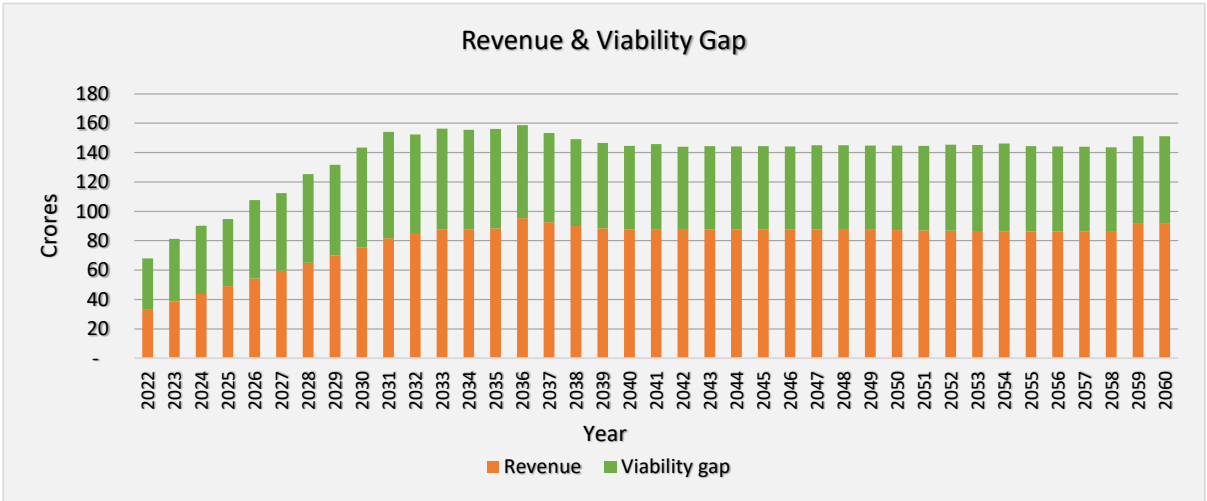
Business as Usual Scenario



Low Ambition Scenario

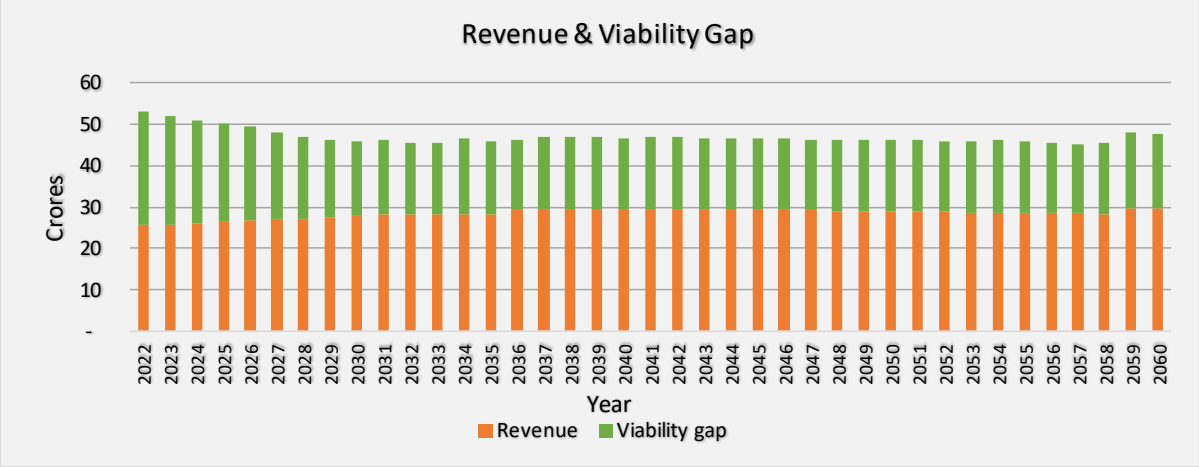


High Ambition Scenario

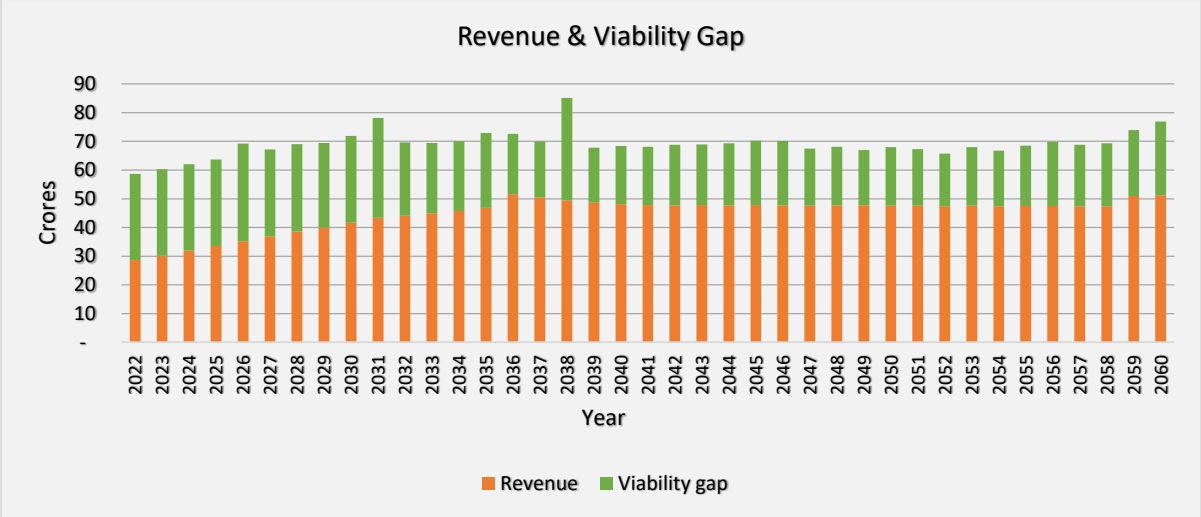


Revenue and Viability Gap: Outright Purchase Model

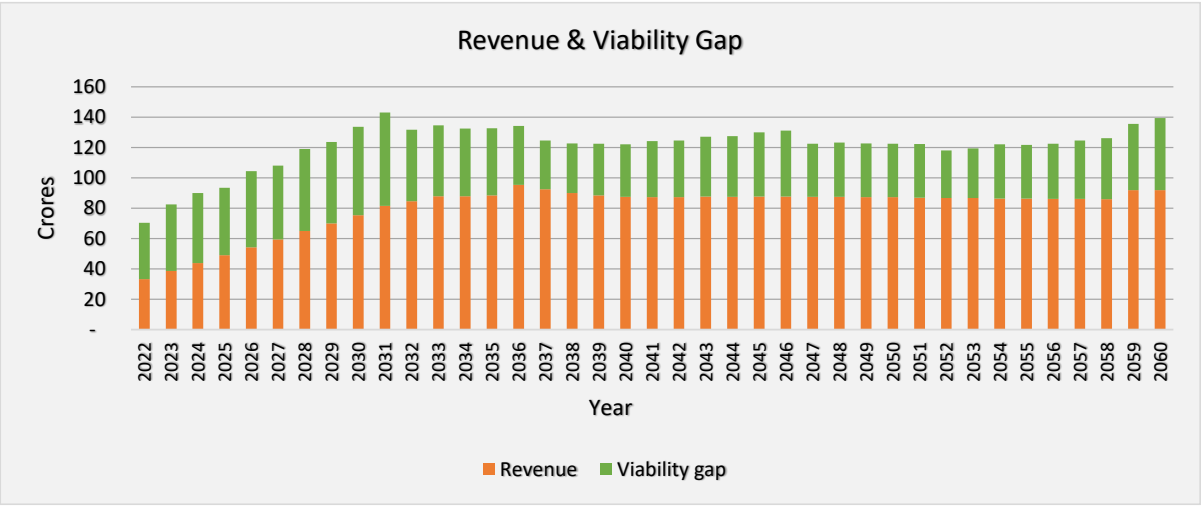
Business as usual Scenario



Low Ambition Scenario

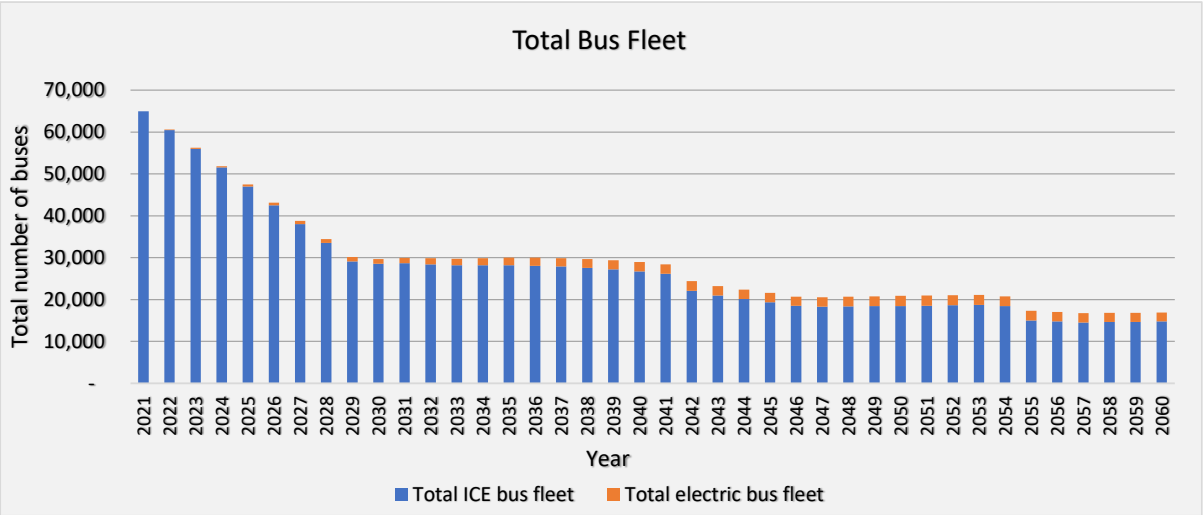


High Ambition Scenario

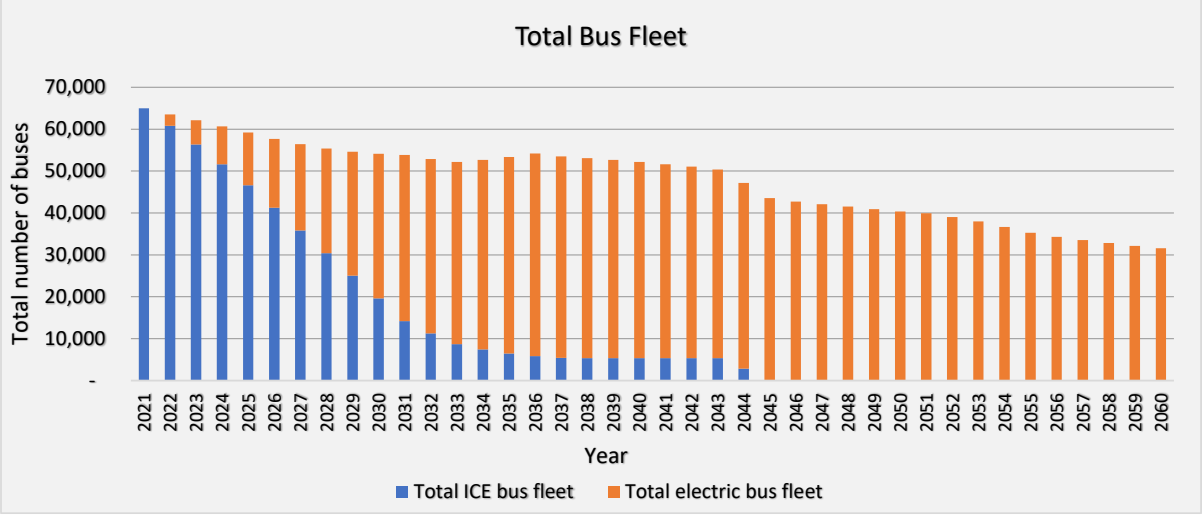


31. State / UT: Tamil Nadu

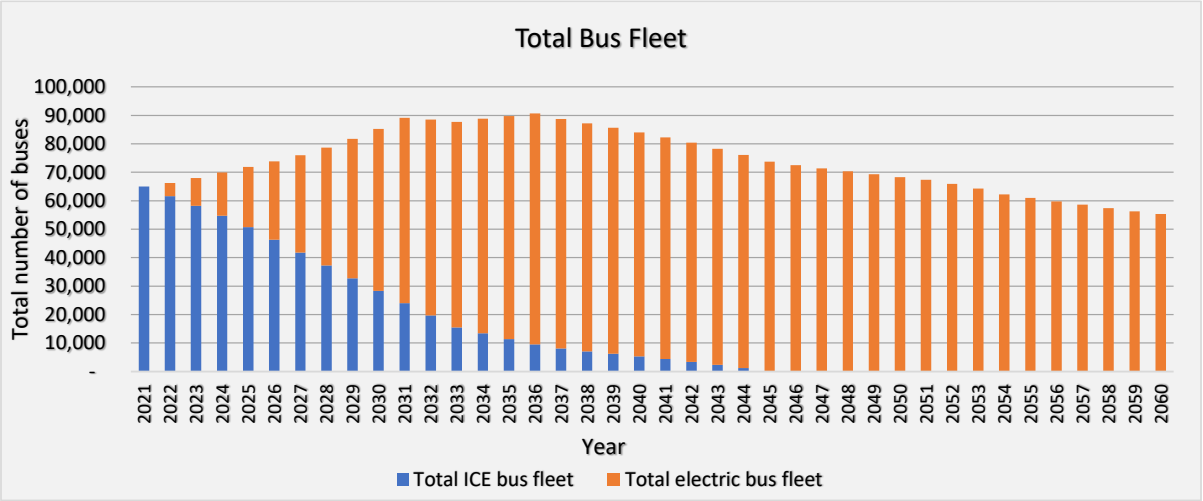
Business as usual Scenario



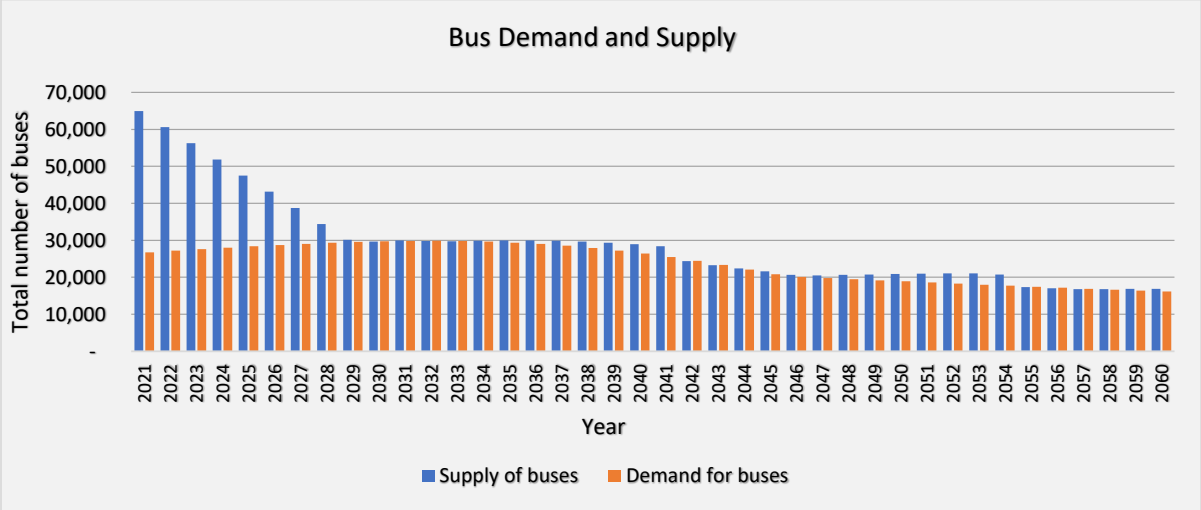
Low Ambition Scenario



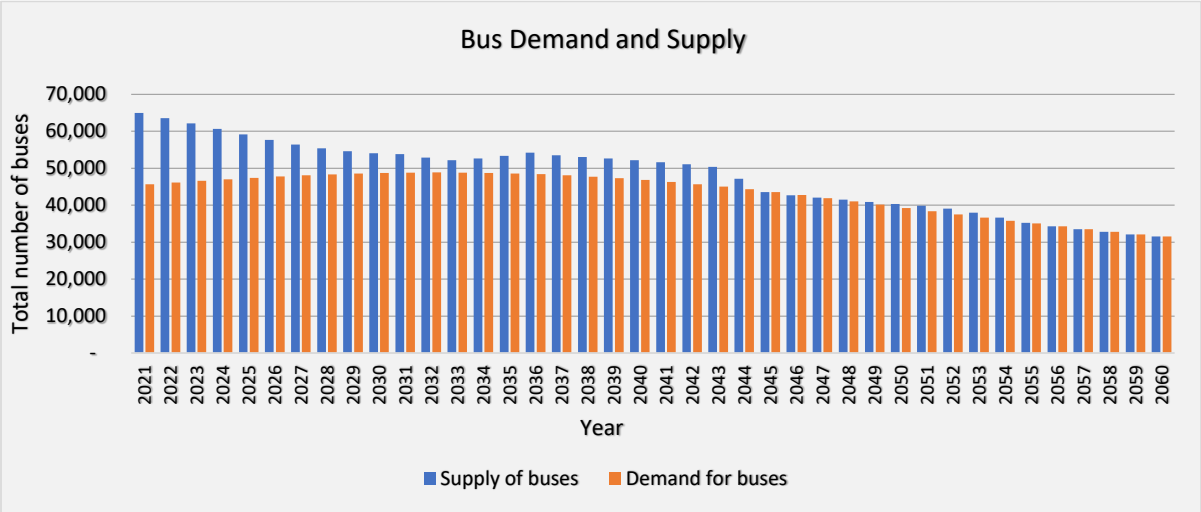
High Ambition Scenario



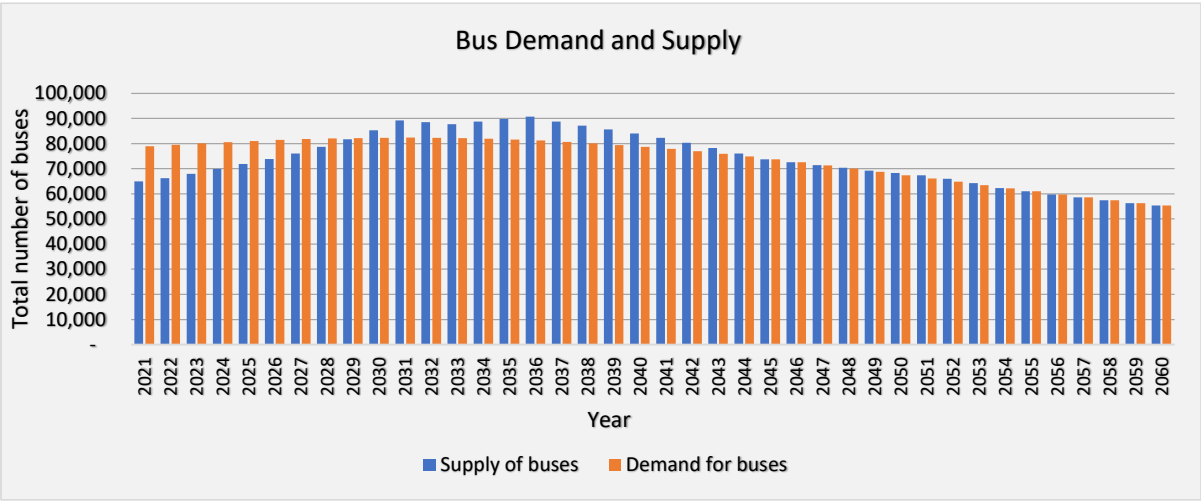
Business as Usual Scenario



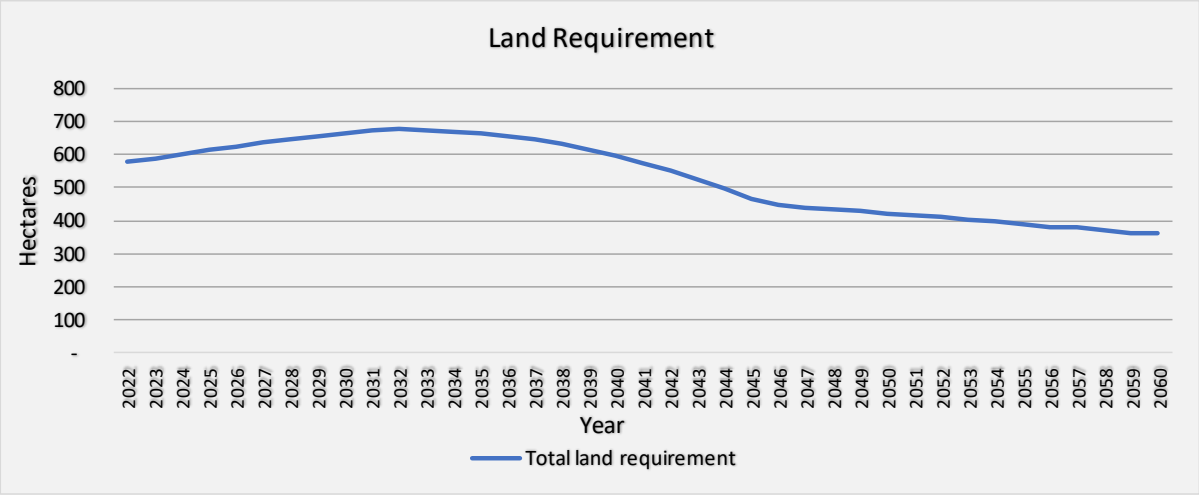
Low Ambition Scenario



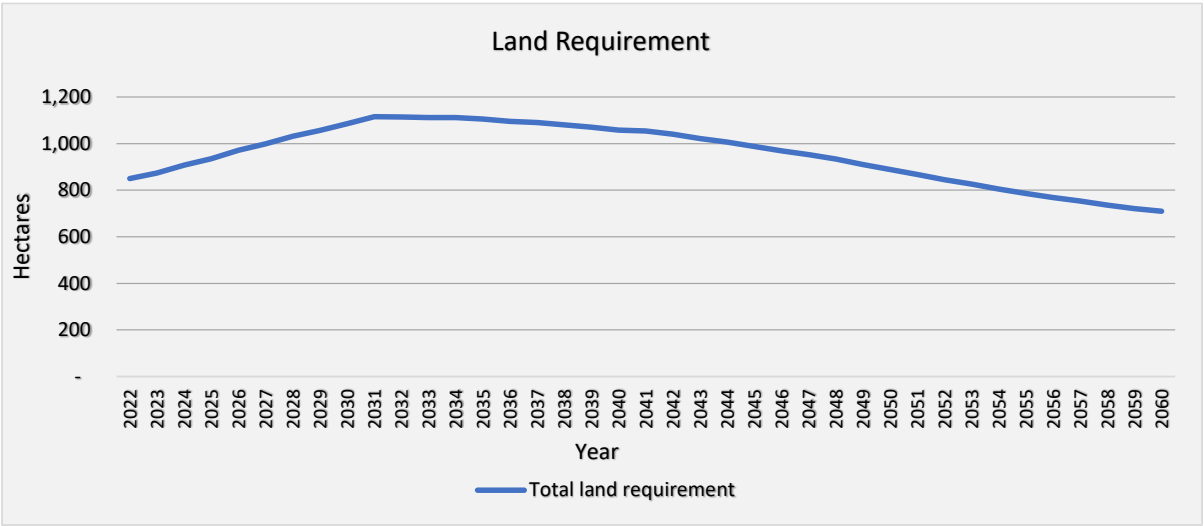
High Ambition Scenario



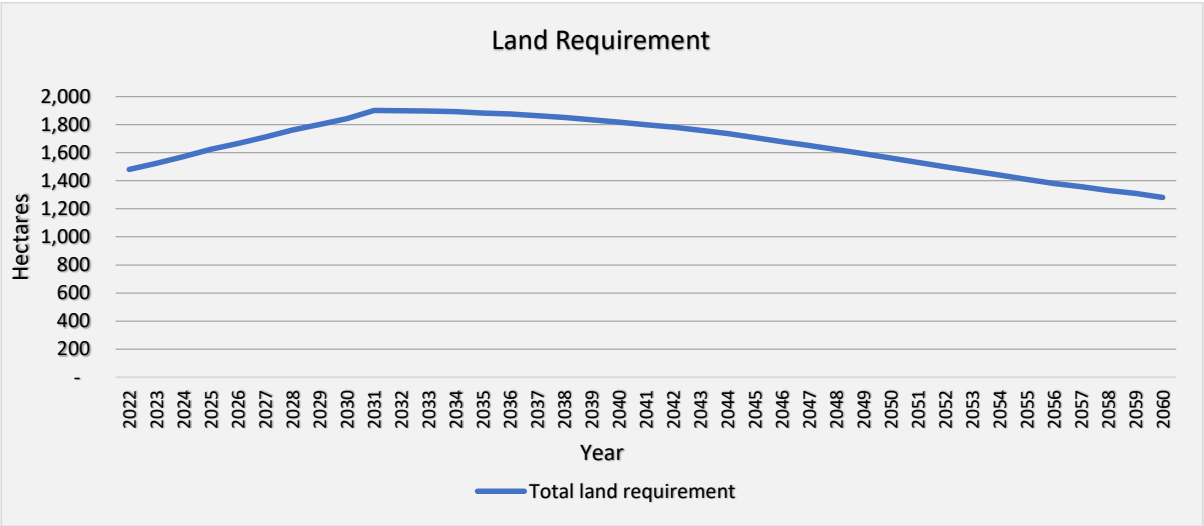
Business as Usual Scenario



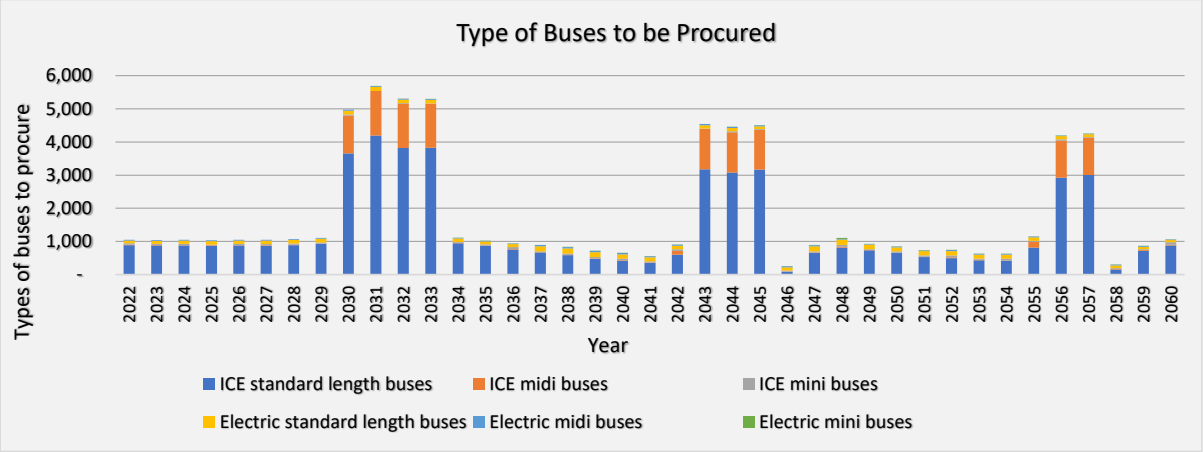
Low Ambition Scenario



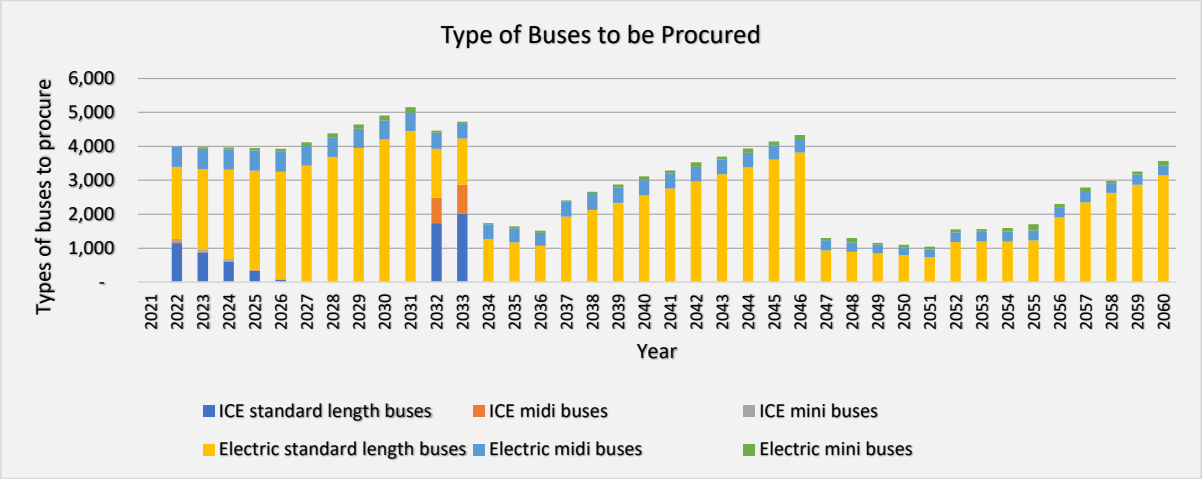
High Ambition Scenario



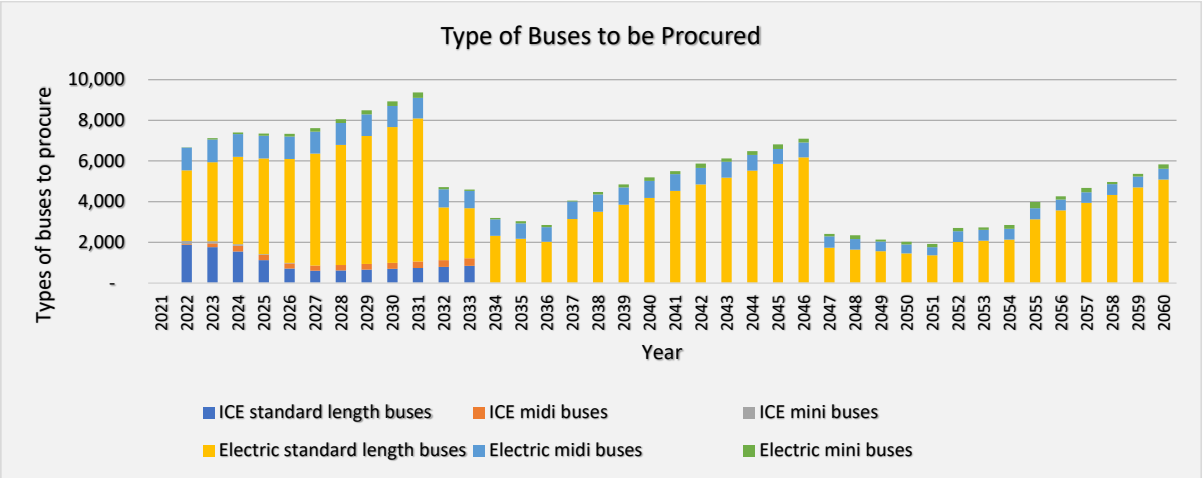
Business as Usual Scenario



Low Ambition Scenario

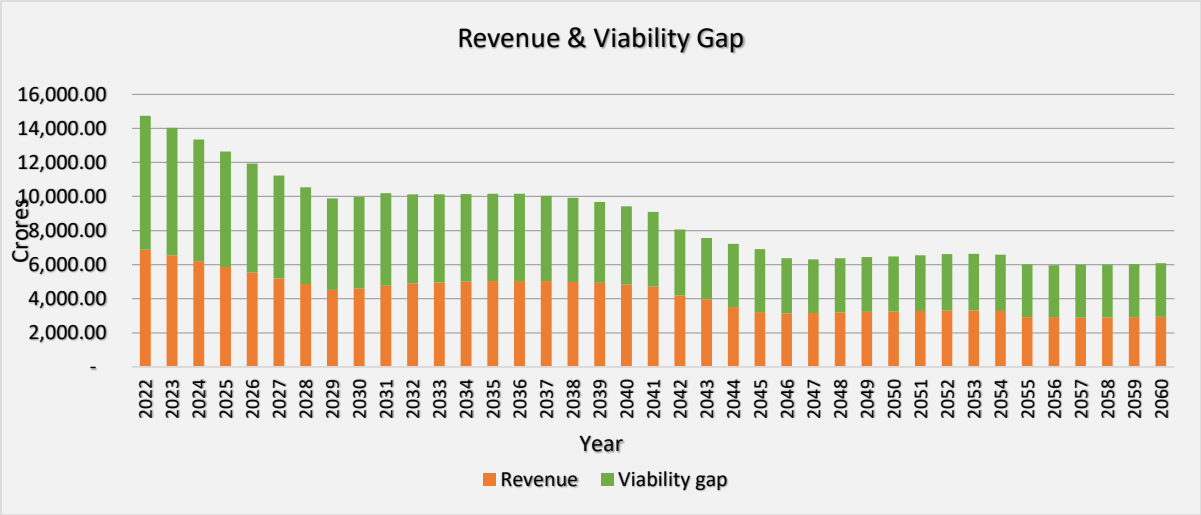


High Ambition Scenario

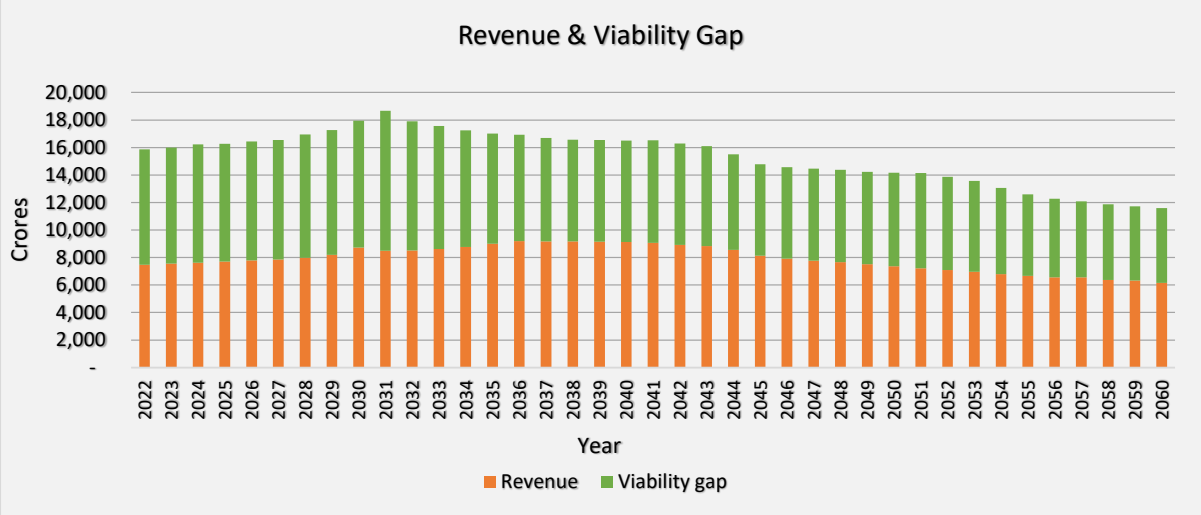


Revenue and Viability Gap: GCC Model

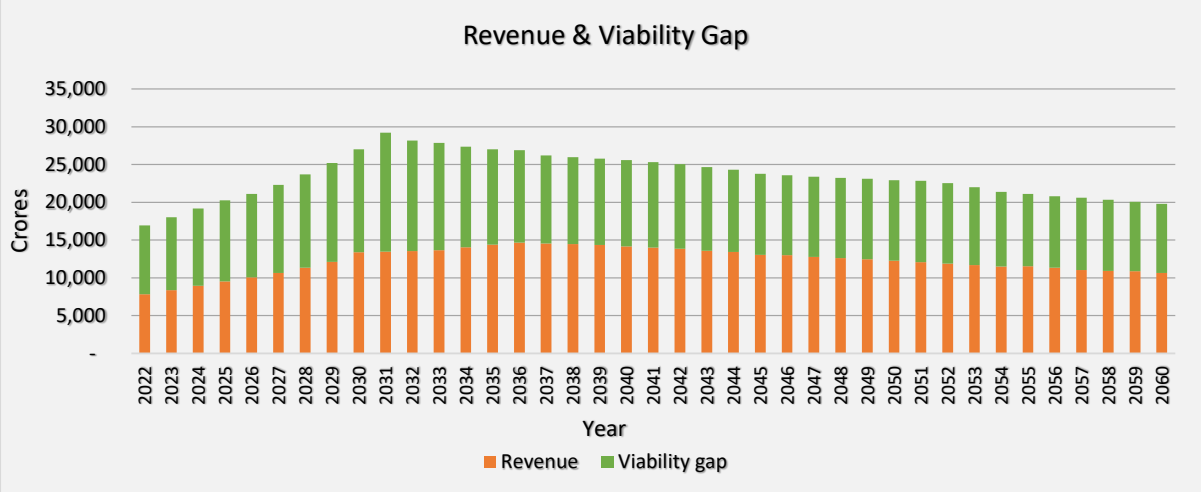
Business as Usual Scenario



Low Ambition Scenario

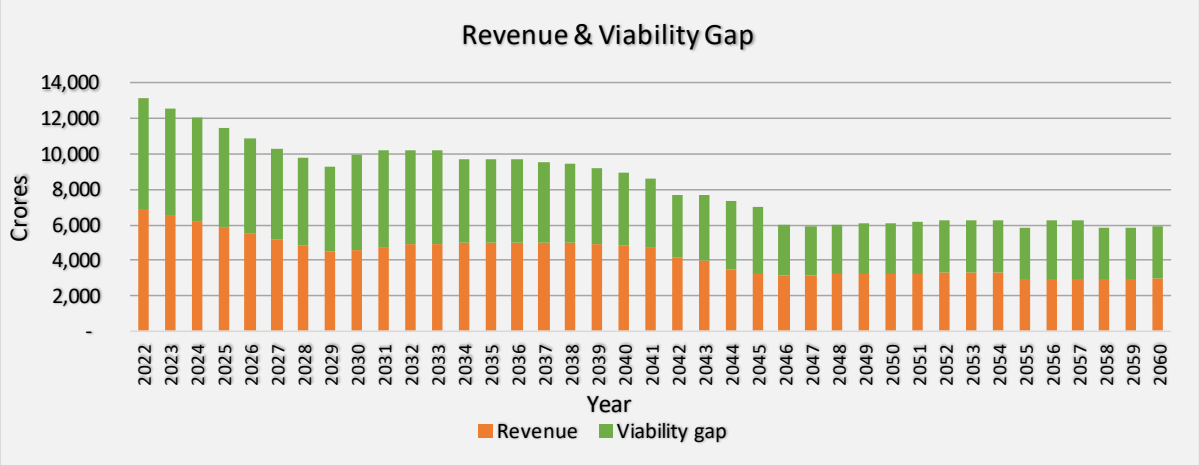


High Ambition Scenario

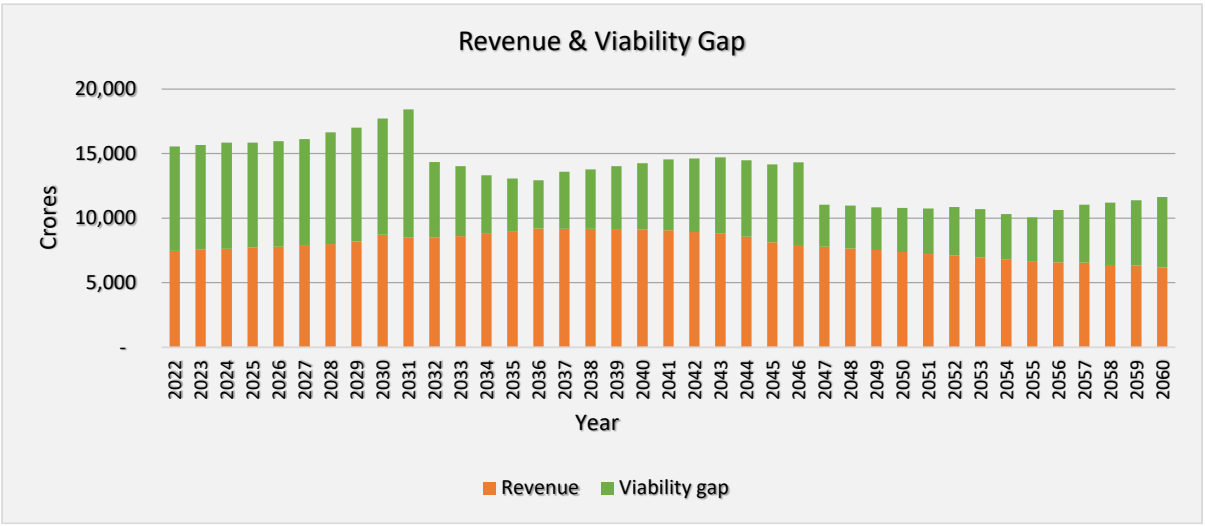


Revenue and Viability Gap: Outright Purchase Model

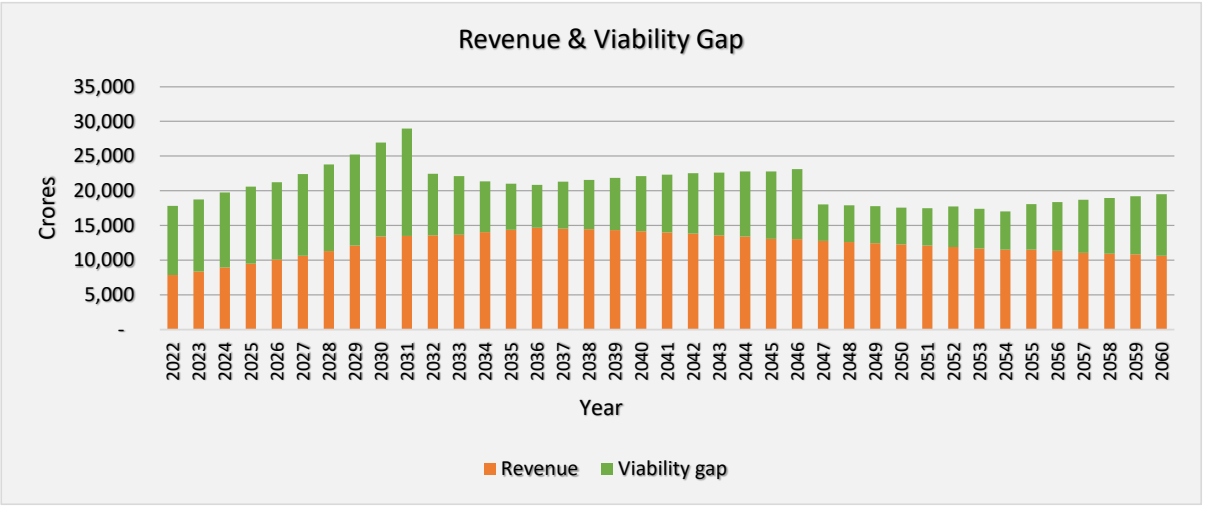
Business as usual Scenario



Low Ambition Scenario

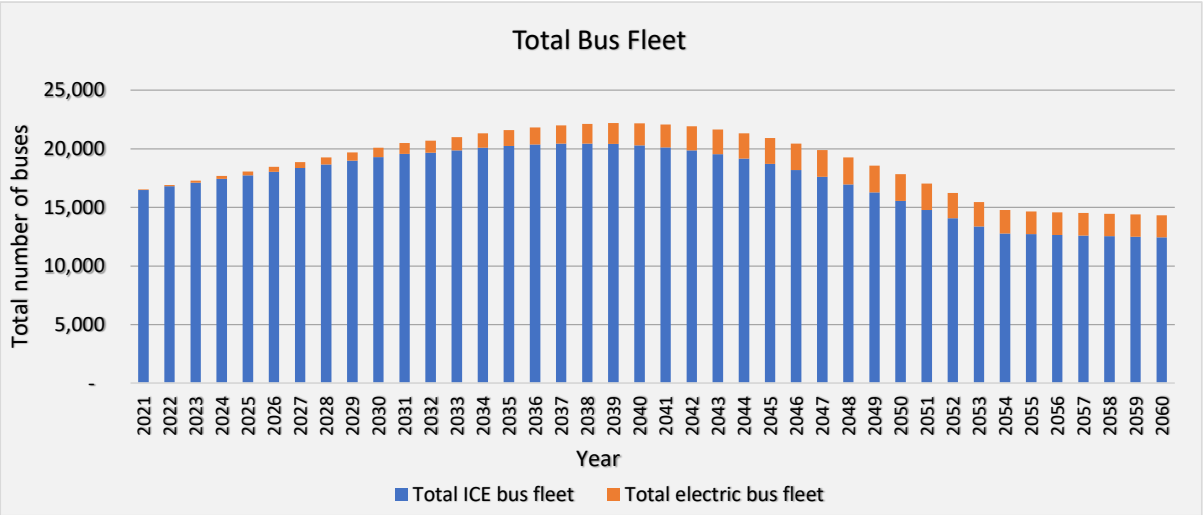


High Ambition Scenario

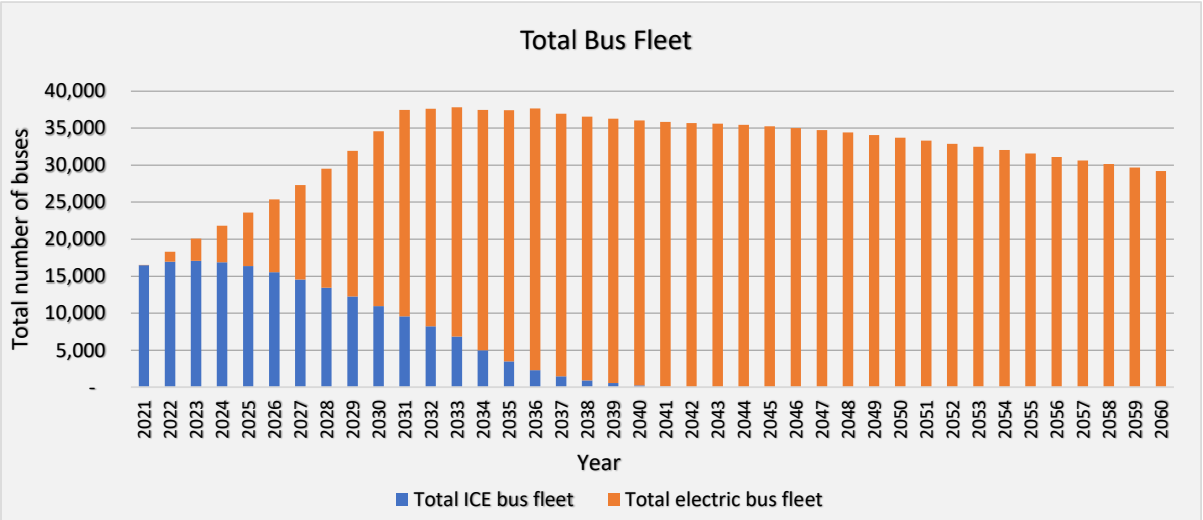


32. State / UT: Telangana

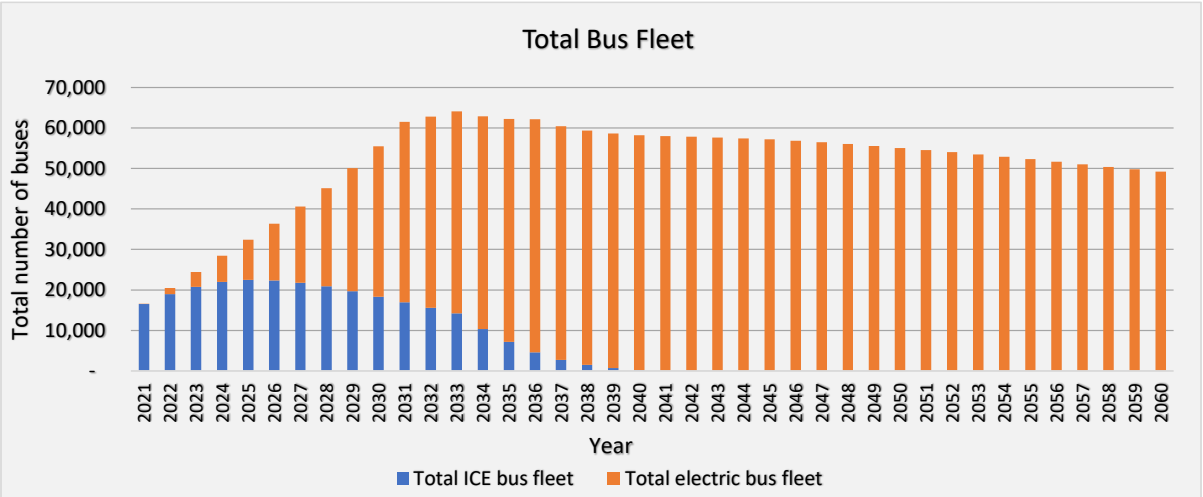
Business as usual Scenario



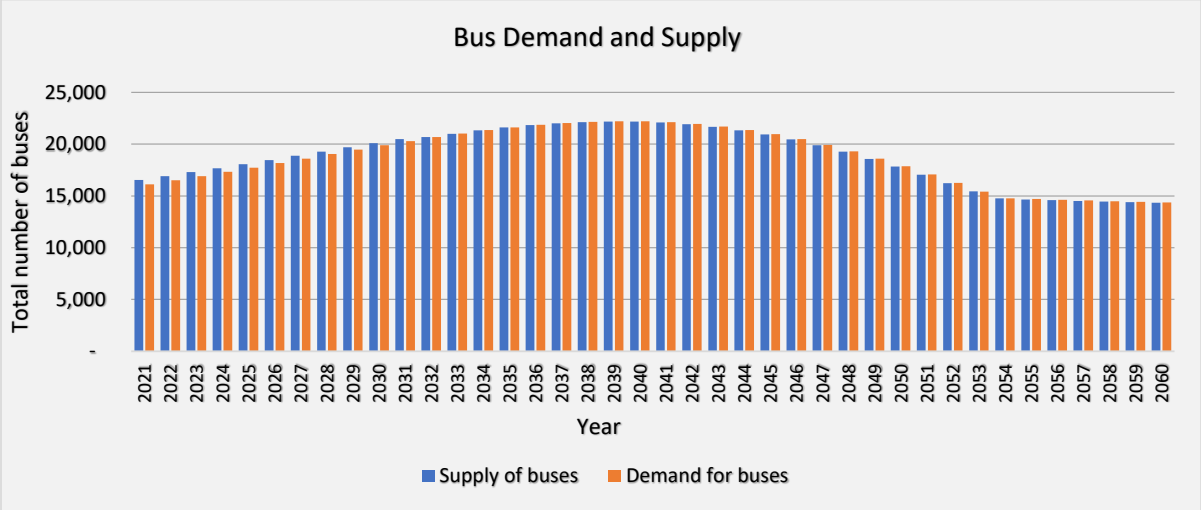
Low Ambition Scenario



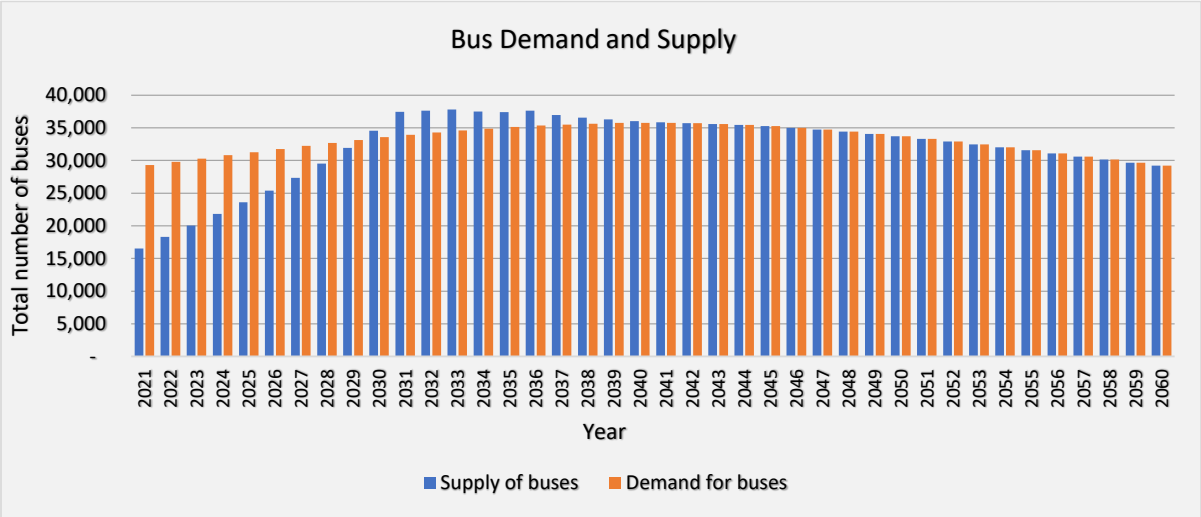
High Ambition Scenario



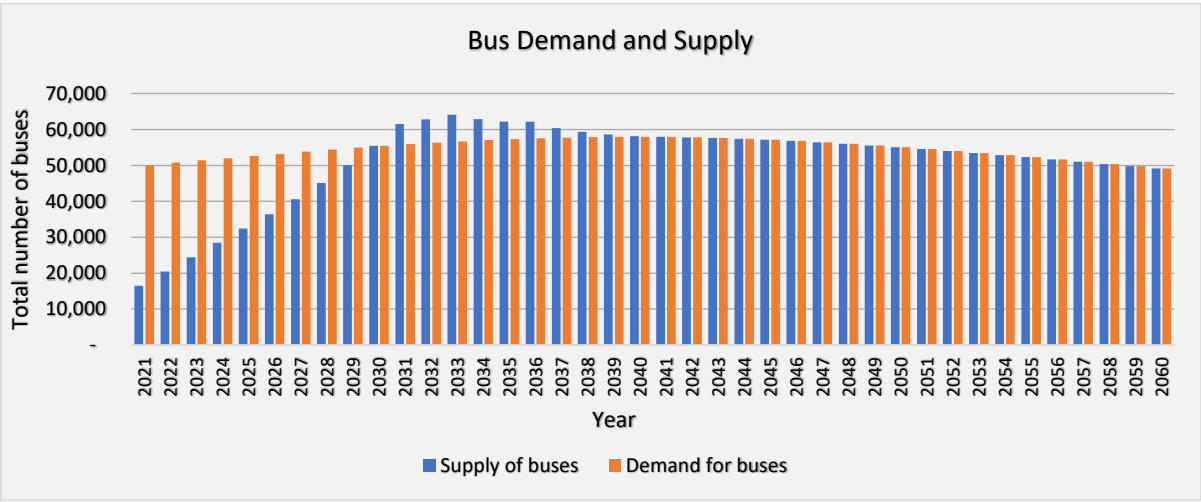
Business as Usual Scenario



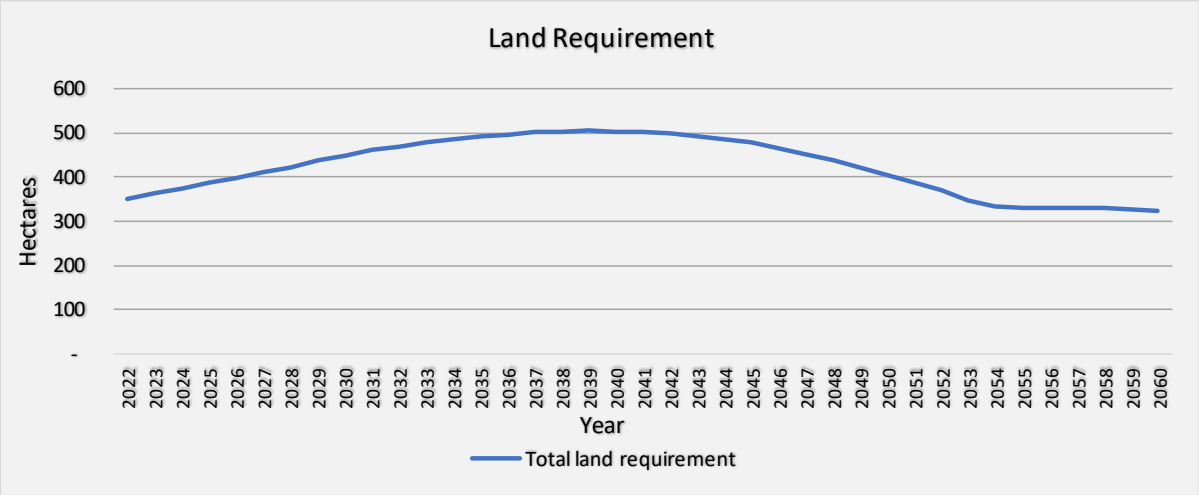
Low Ambition Scenario



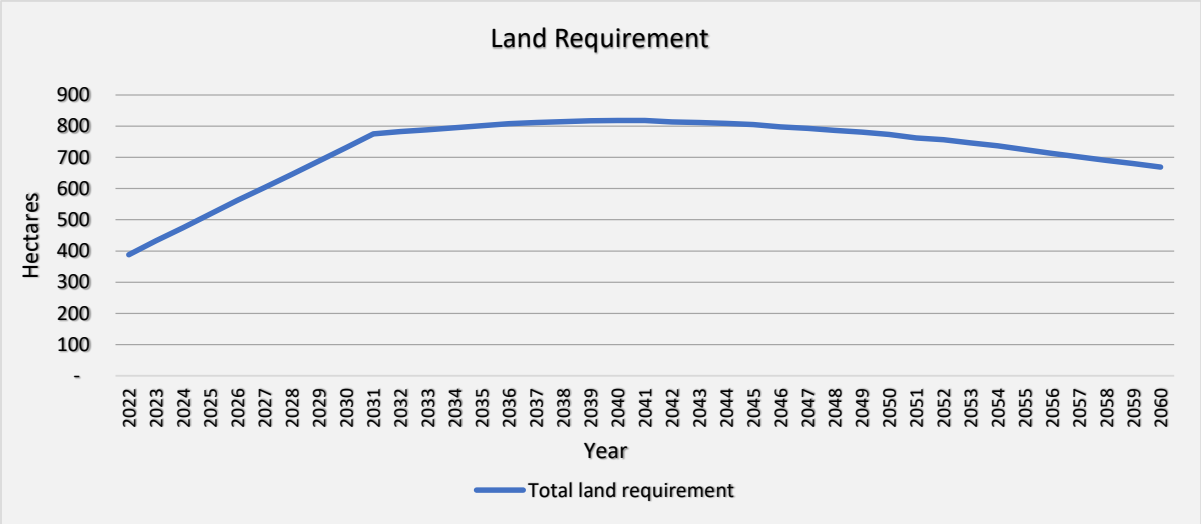
High Ambition Scenario



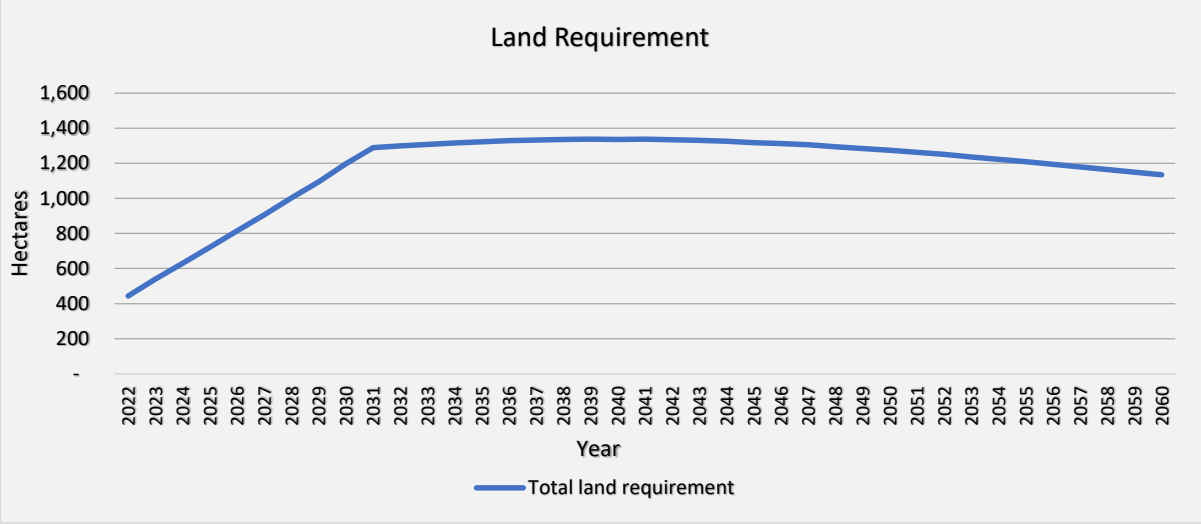
Business as Usual Scenario



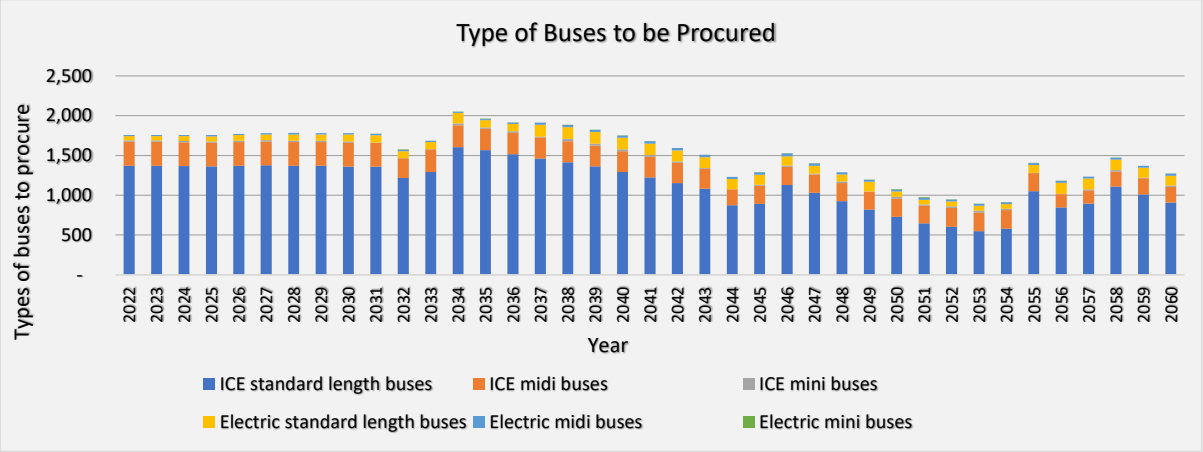
Low Ambition Scenario



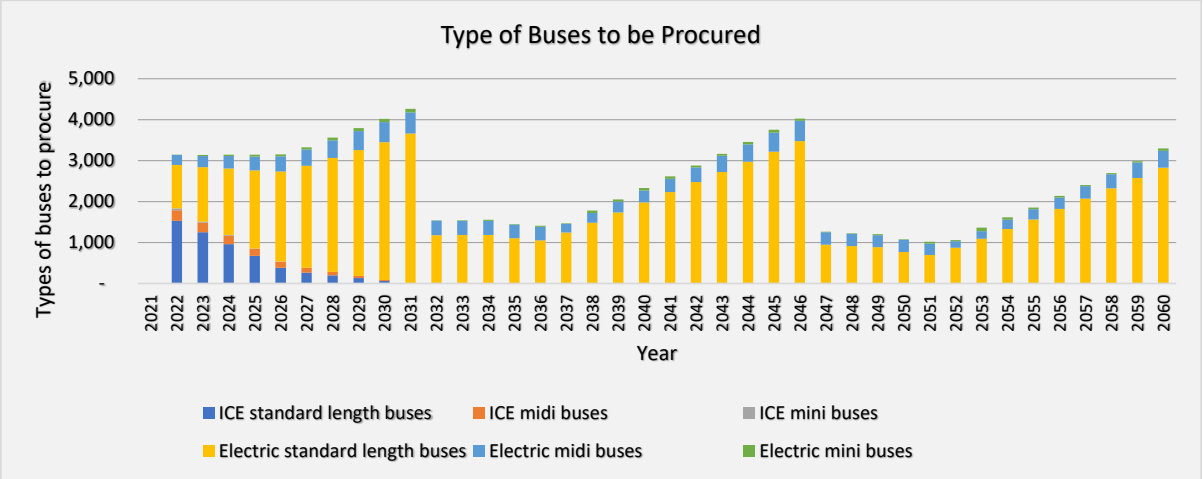
High Ambition Scenario



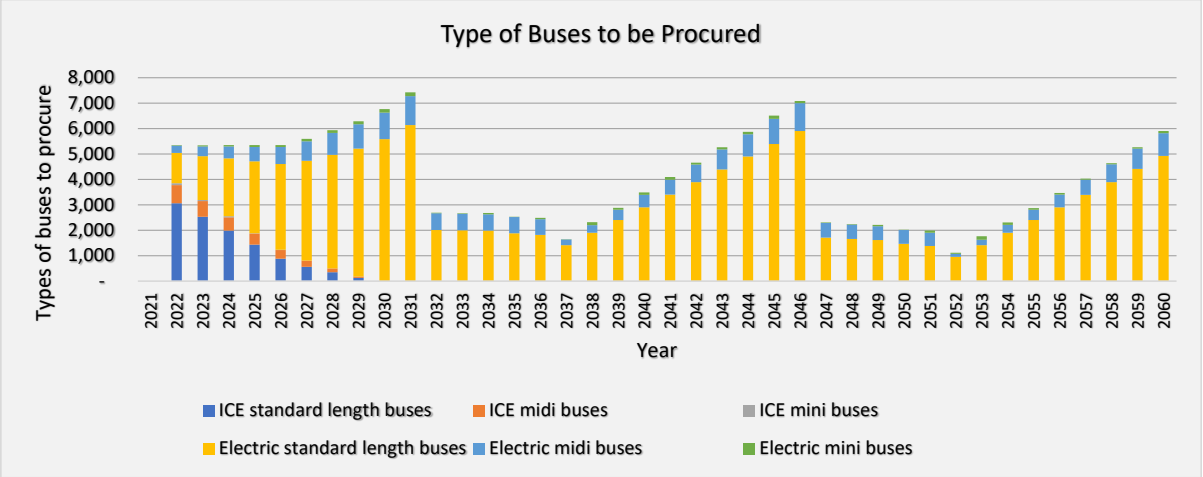
Business as Usual Scenario



Low Ambition Scenario

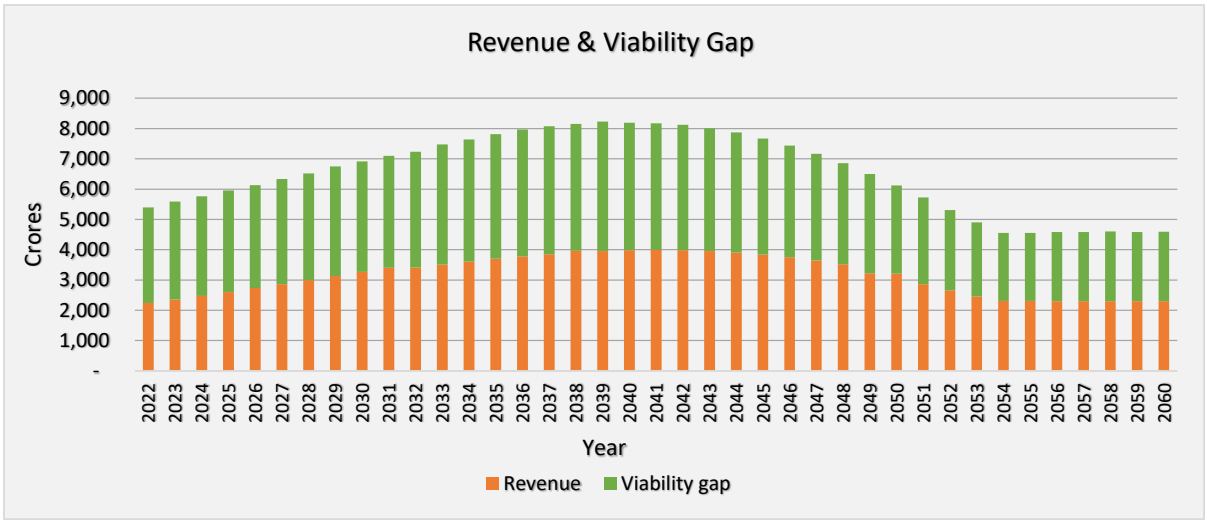


High Ambition Scenario

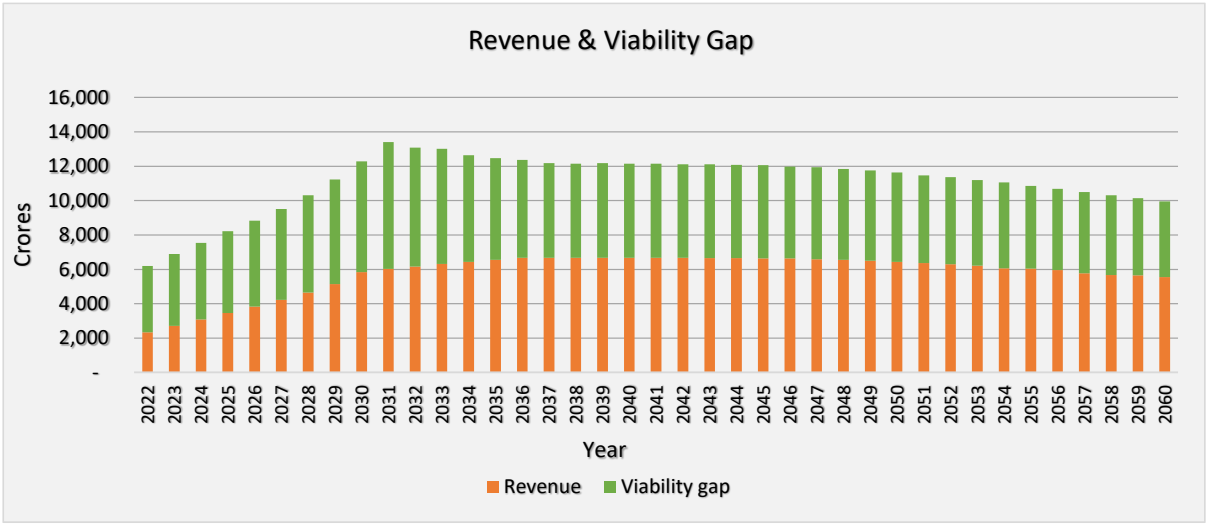


Revenue and Viability Gap: GCC Model

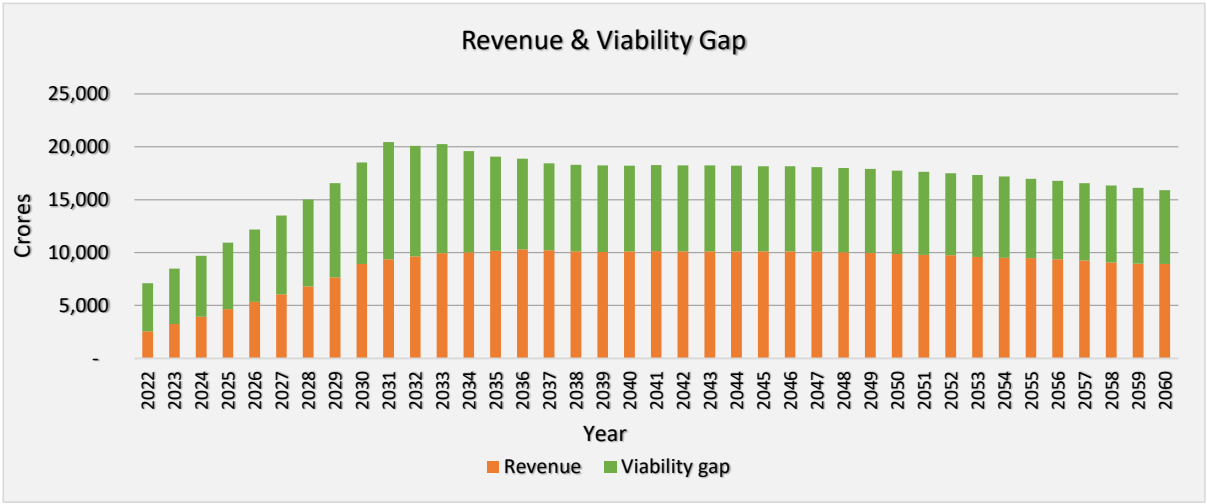
Business as Usual Scenario



Low Ambition Scenario

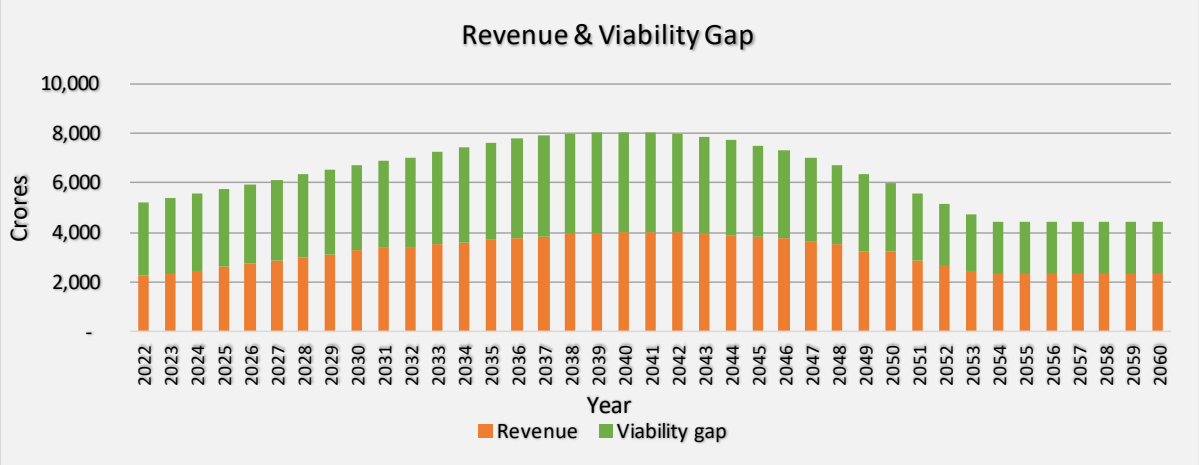


High Ambition Scenario

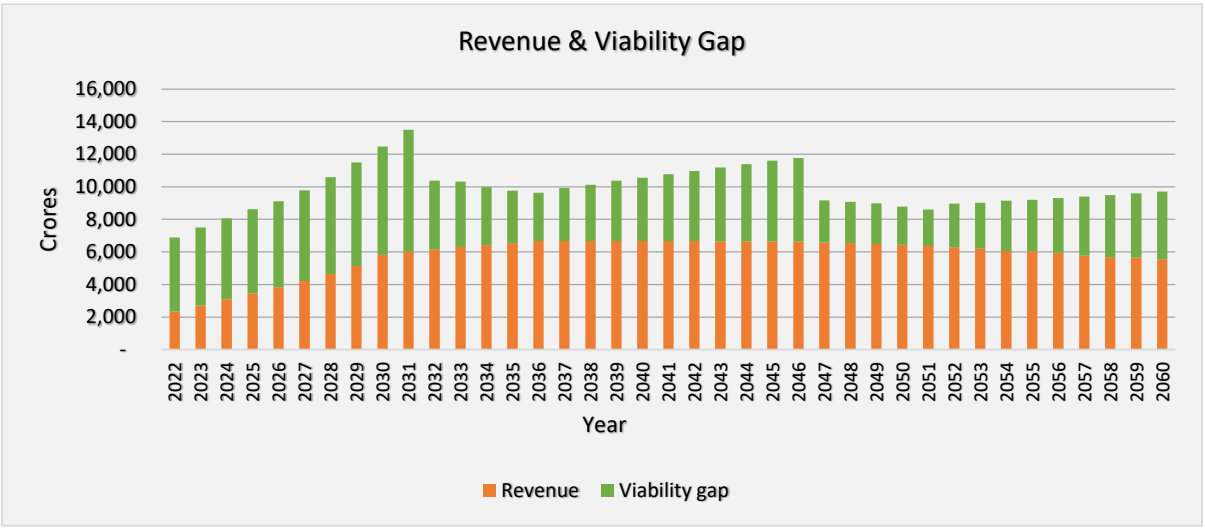


Revenue and Viability Gap: Outright Purchase Model

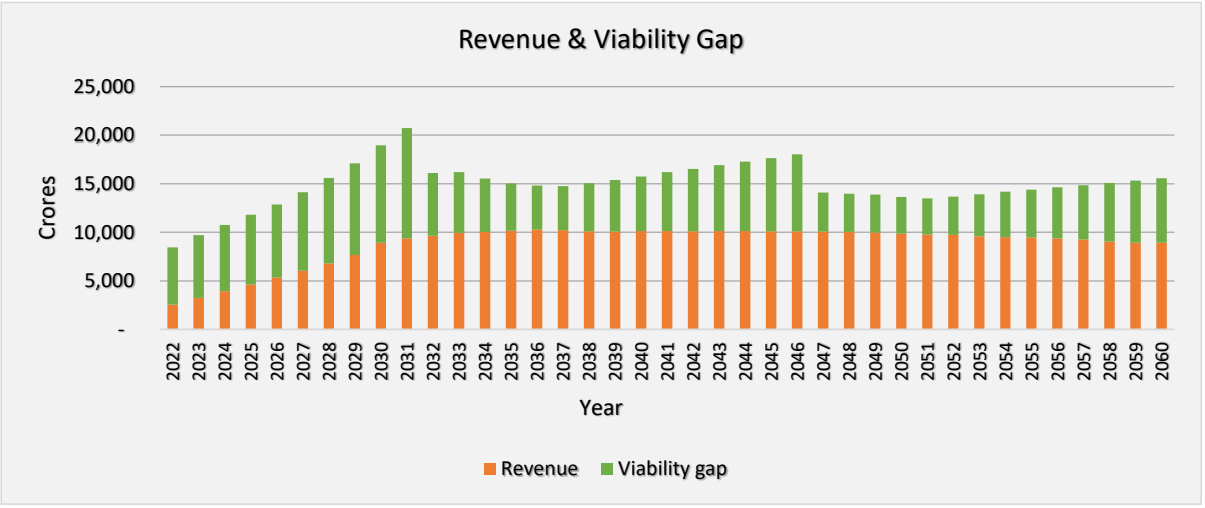
Business as usual Scenario



Low Ambition Scenario

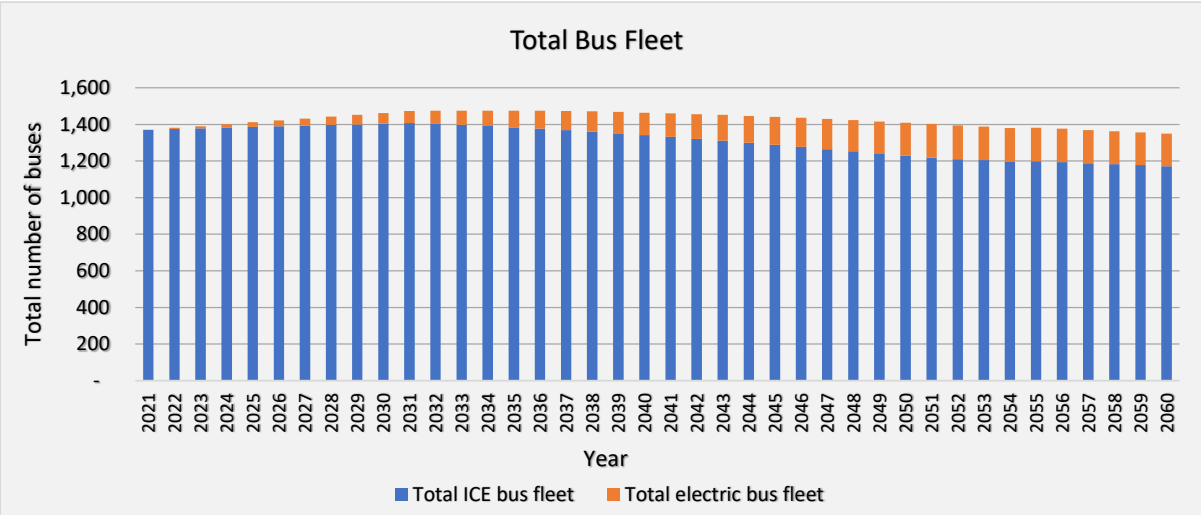


High Ambition Scenario

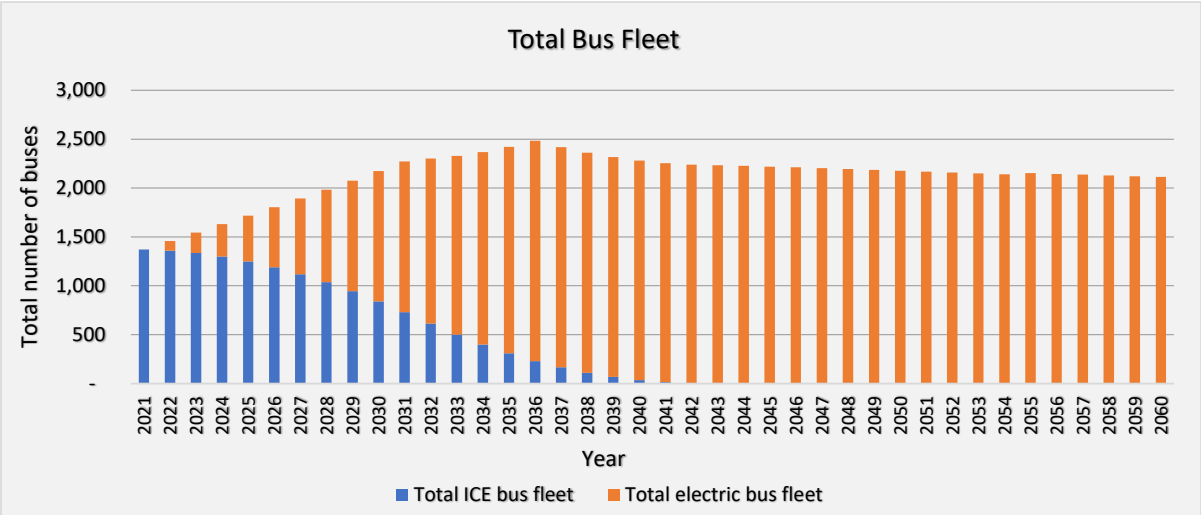


33. State / UT: Tripura

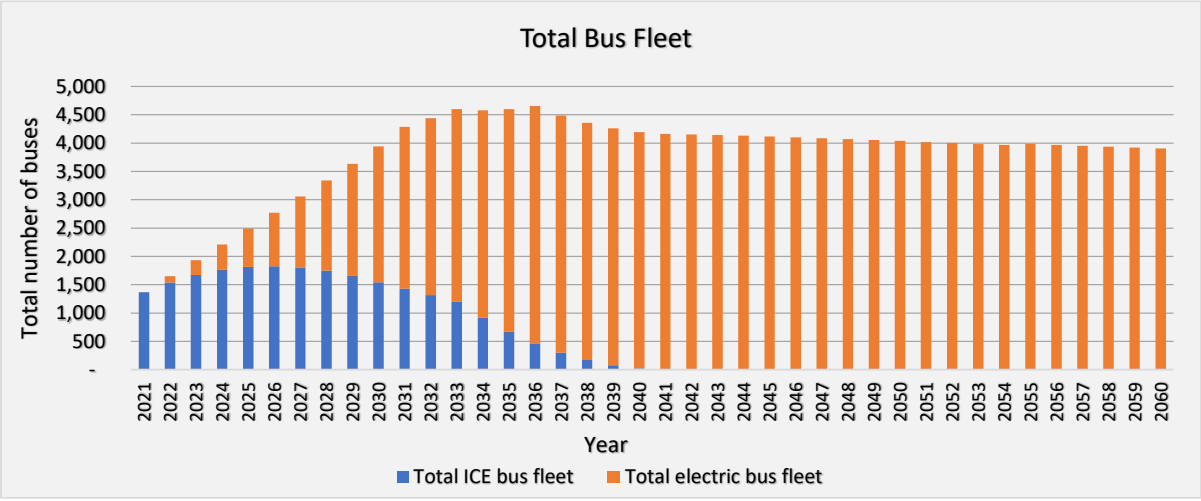
Business as usual Scenario



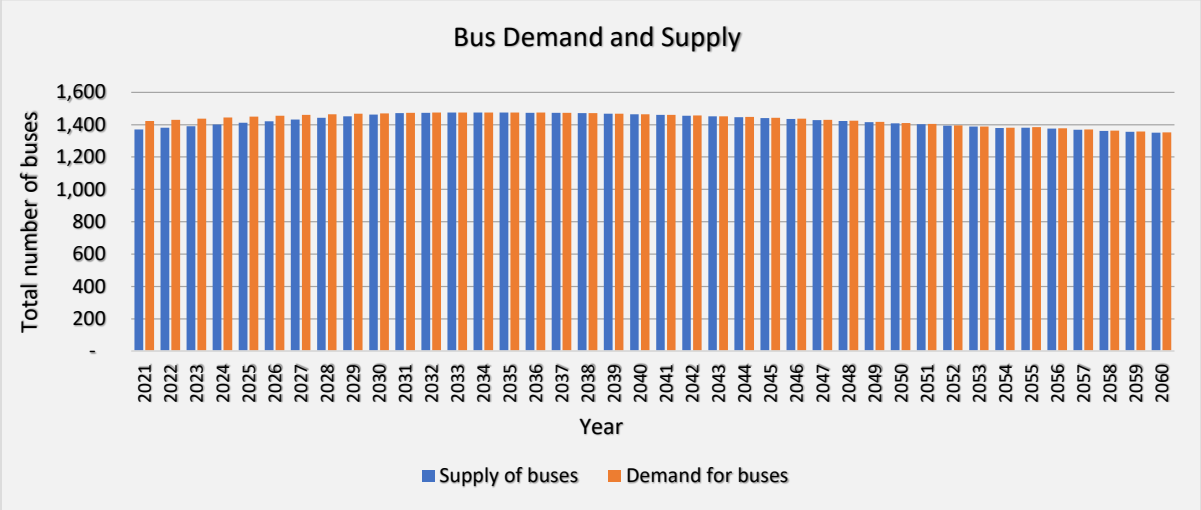
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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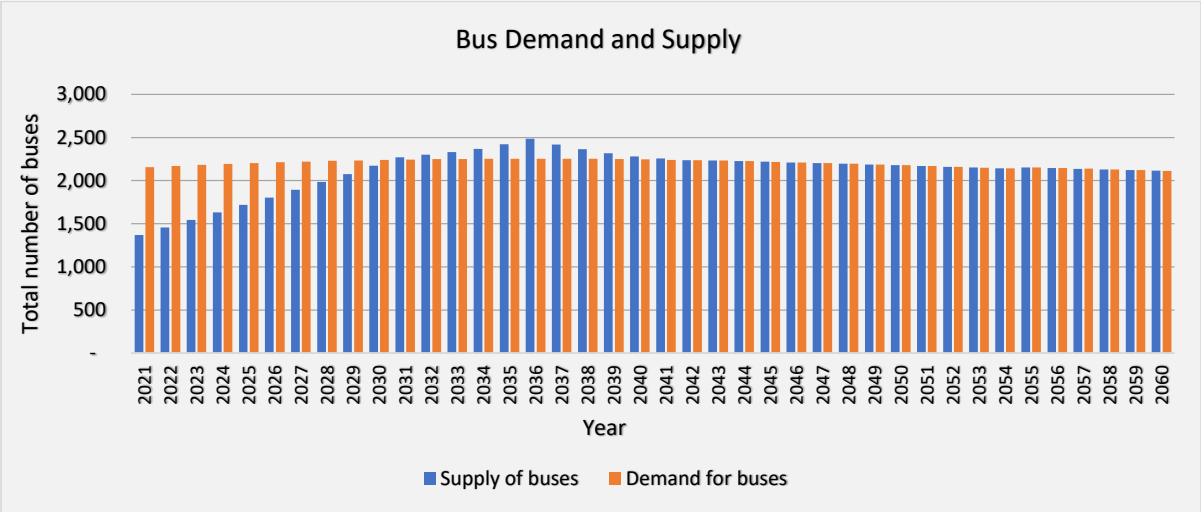
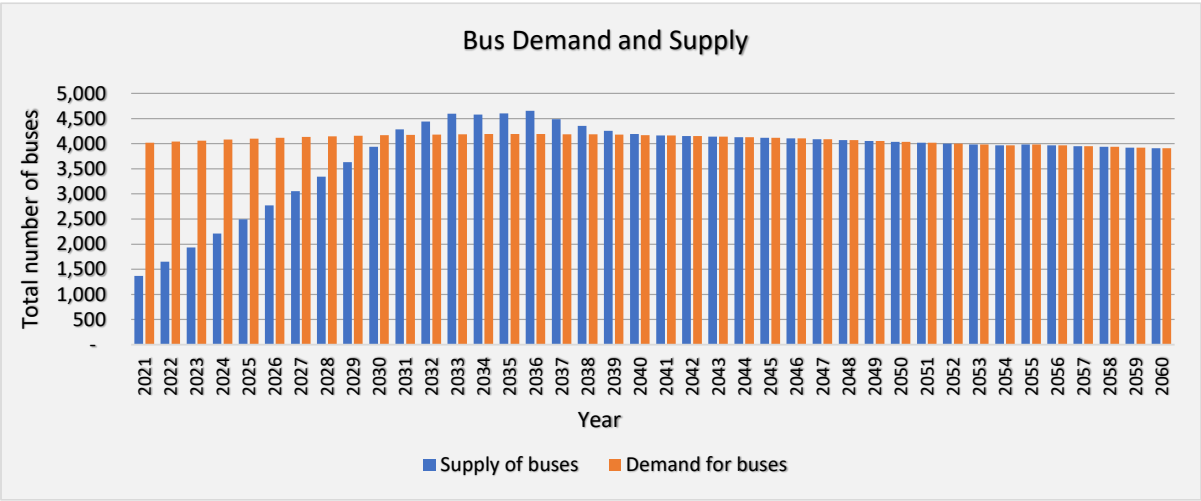
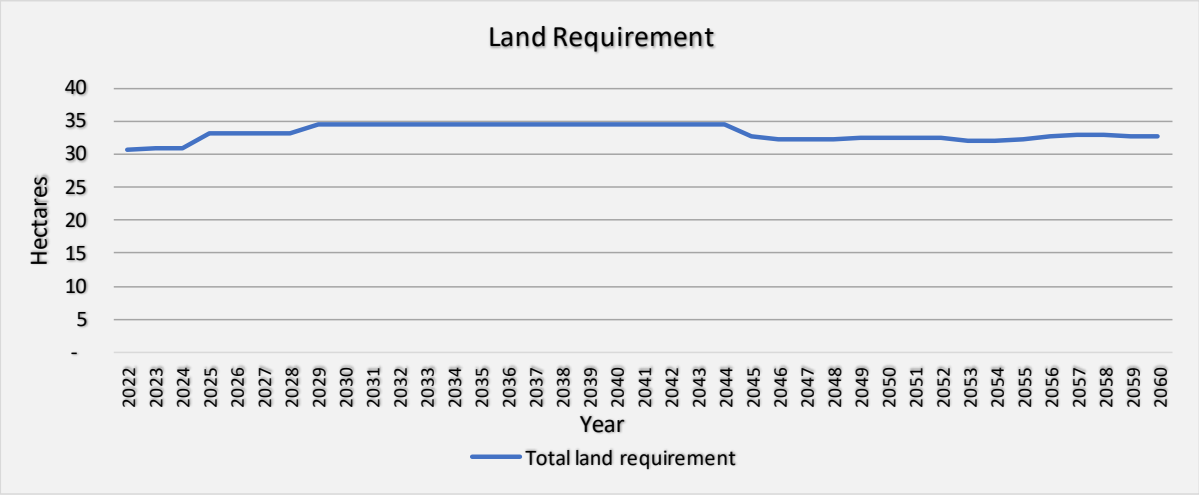


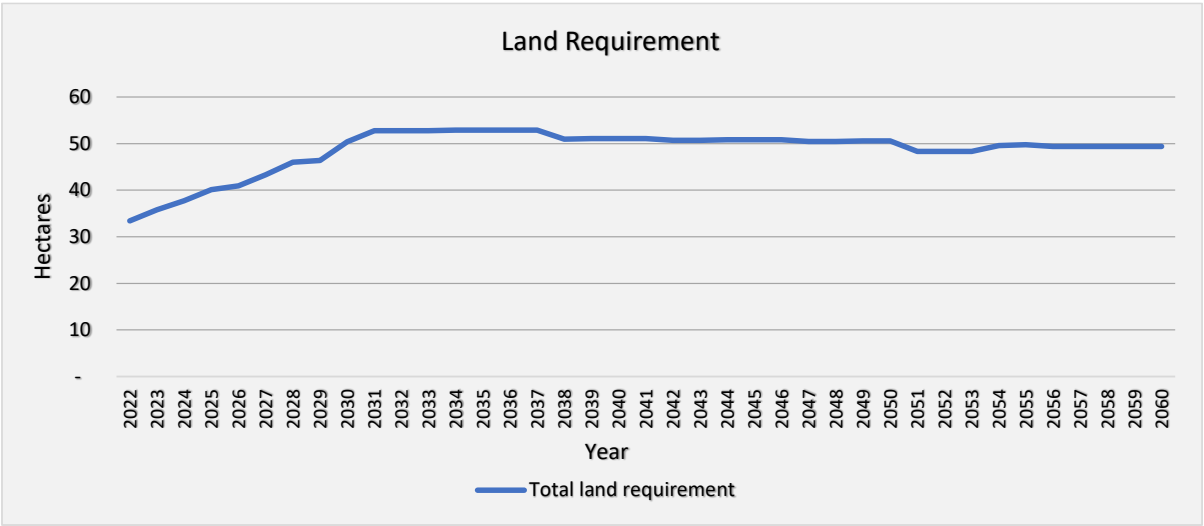
High Ambition Scenario



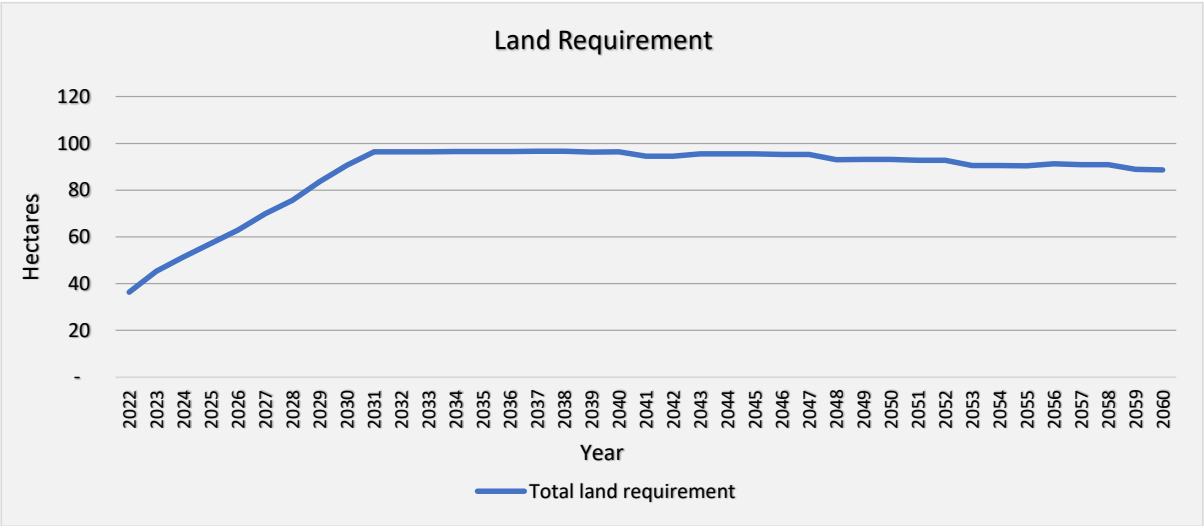
Business as Usual Scenario



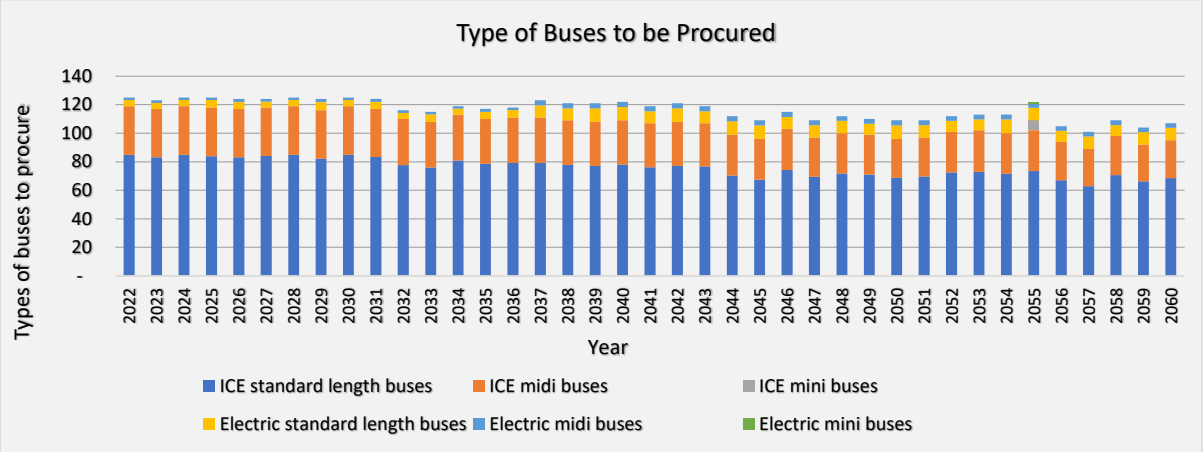
Low Ambition Scenario



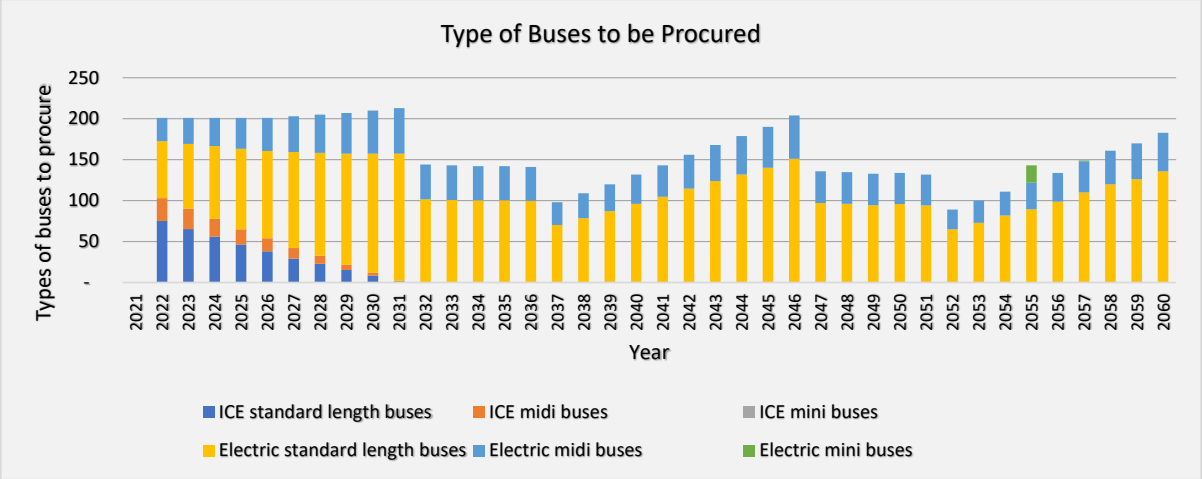
High Ambition Scenario



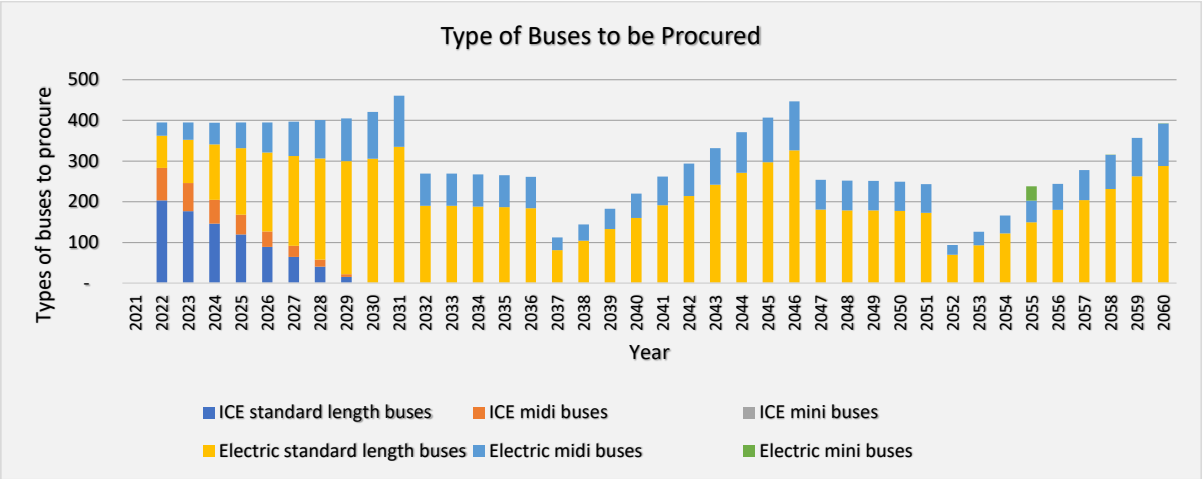
Business as Usual Scenario



Low Ambition Scenario

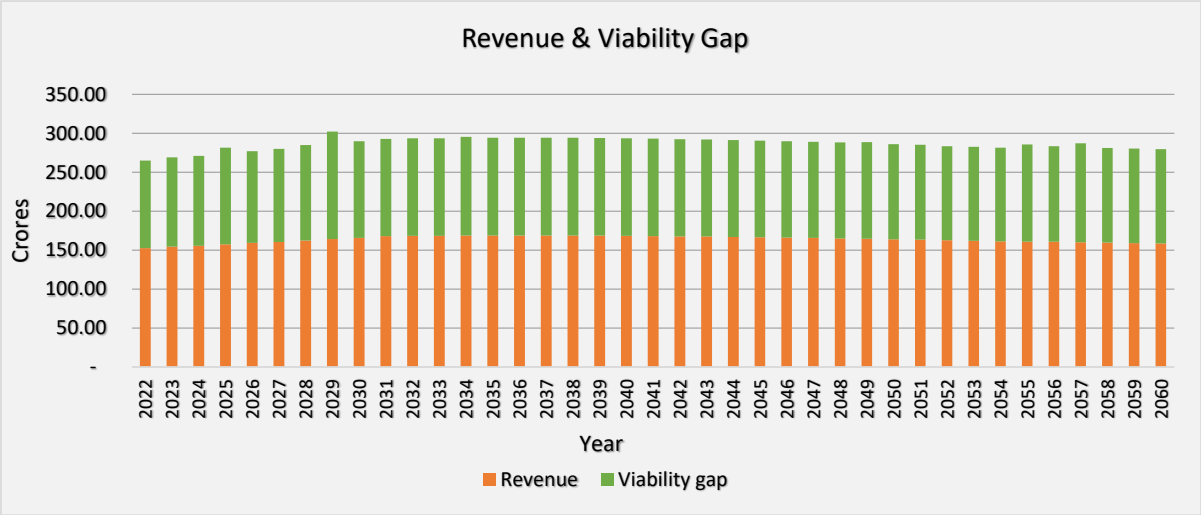


High Ambition Scenario

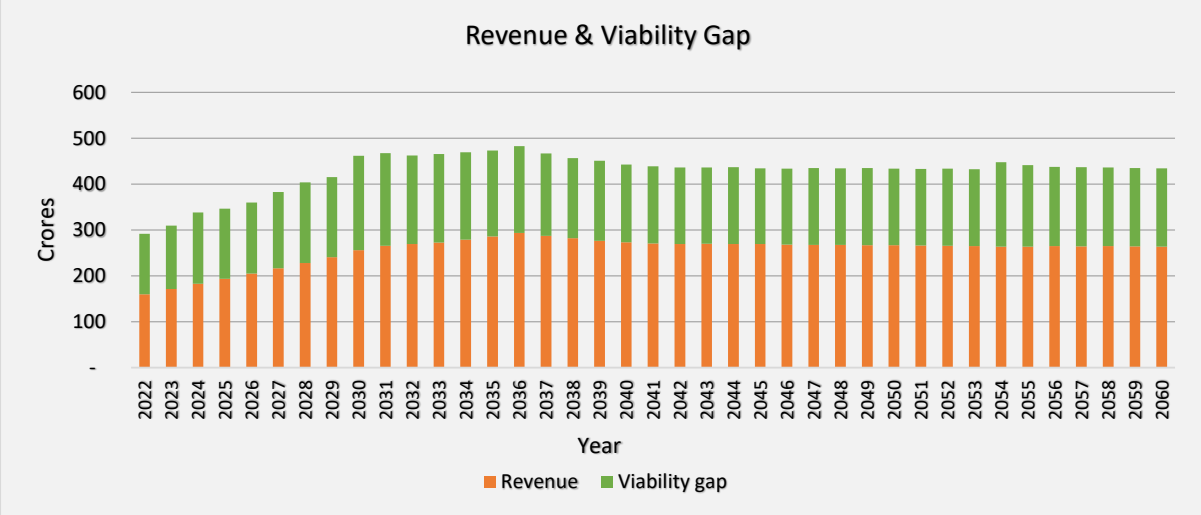


Revenue and Viability Gap: GCC Model

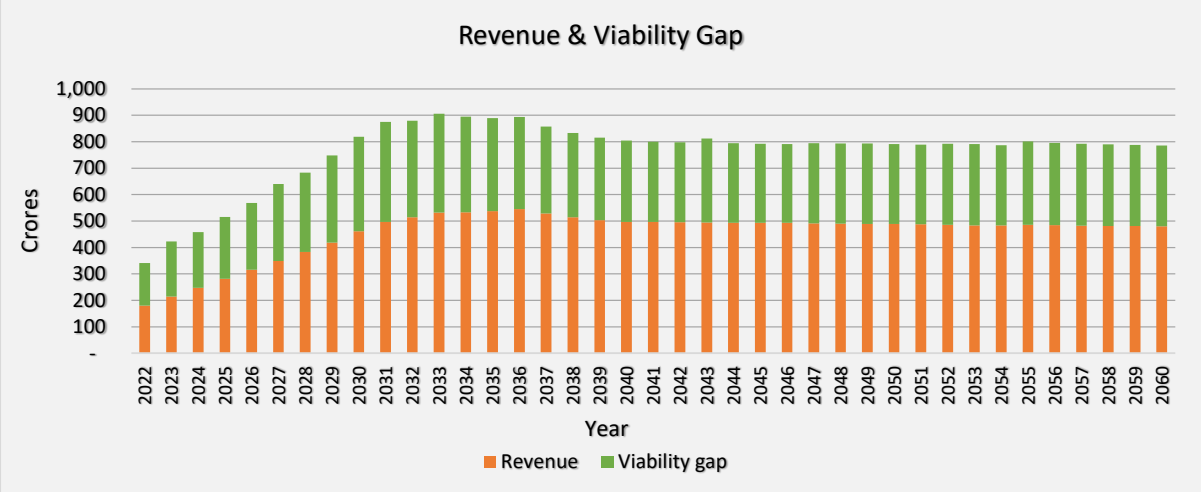
Business as Usual Scenario



Low Ambition Scenario

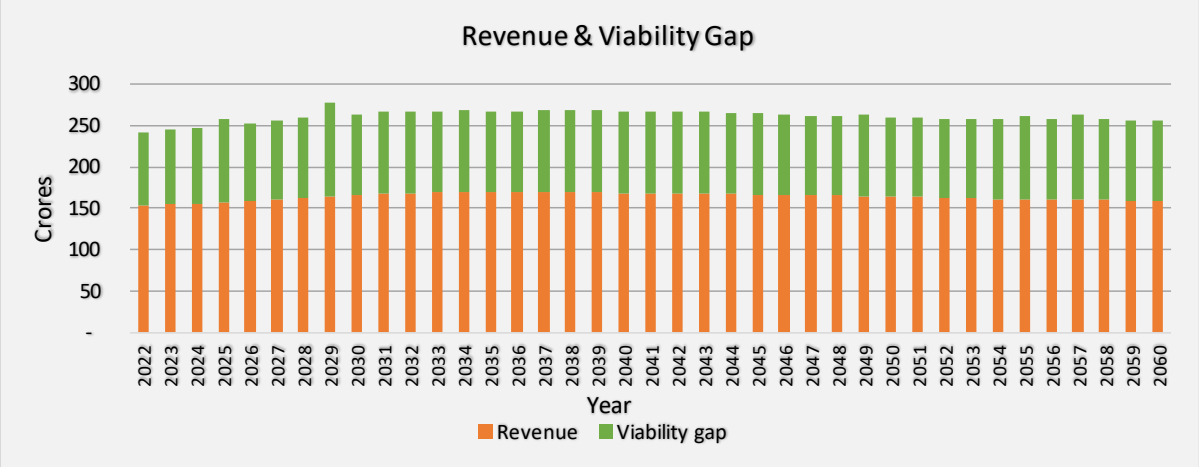


High Ambition Scenario

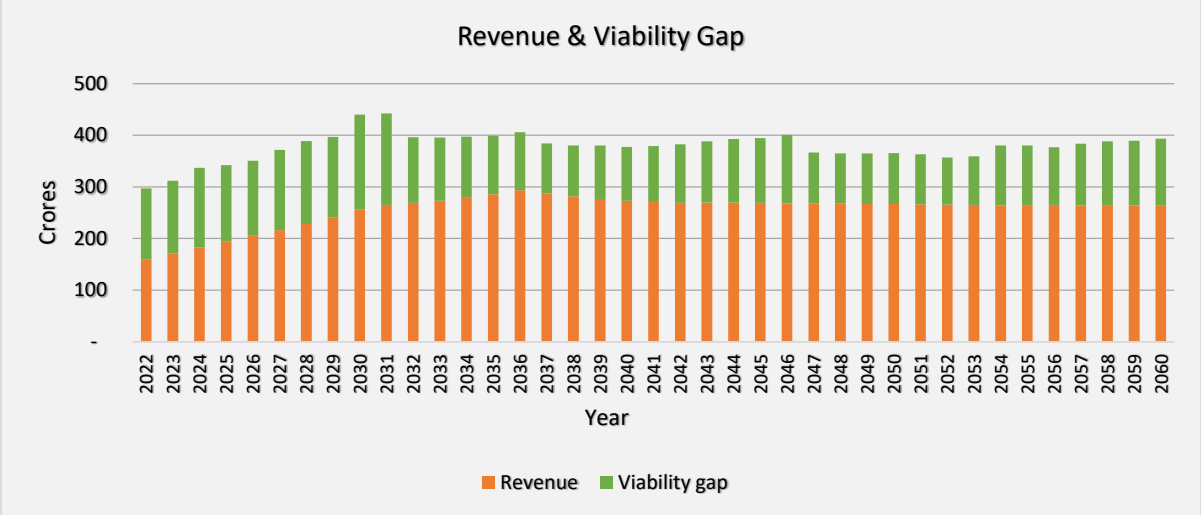


Revenue and Viability Gap: Outright Purchase Model

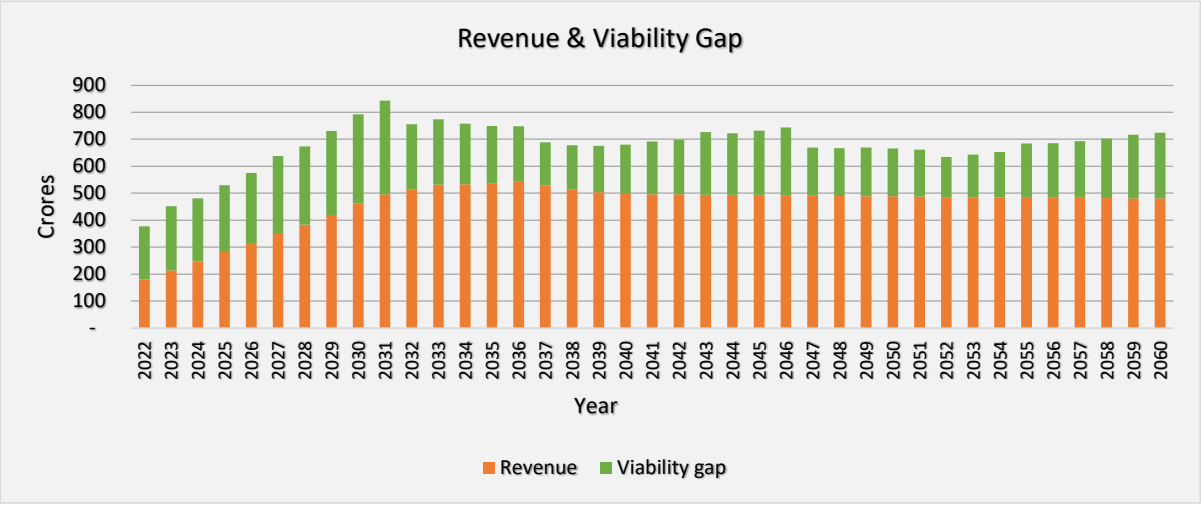
Business as usual Scenario



Low Ambition Scenario

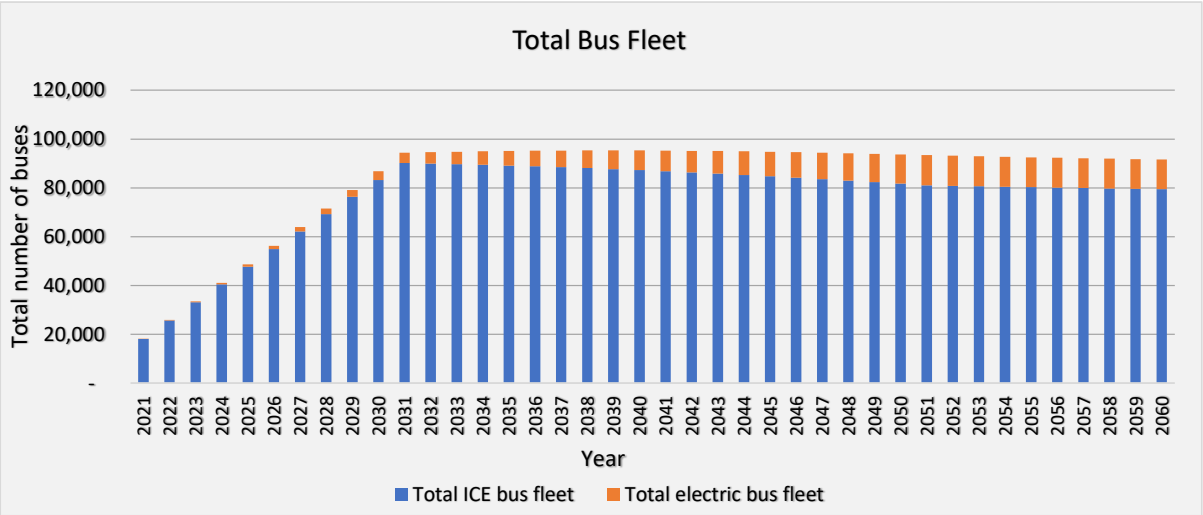


High Ambition Scenario

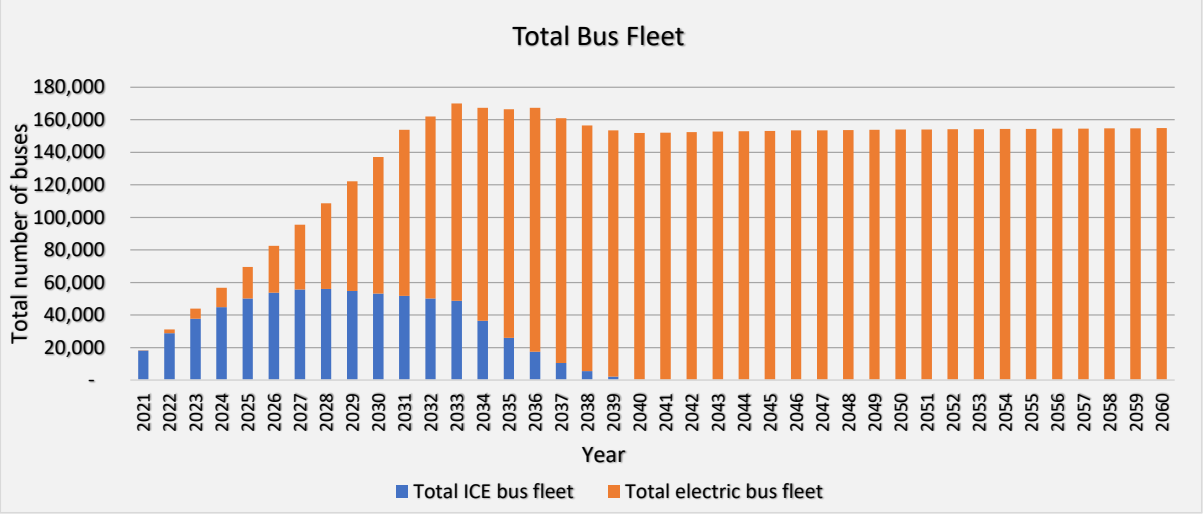


34. State / UT: Uttar Pradesh

Business as usual Scenario



Low Ambition Scenario



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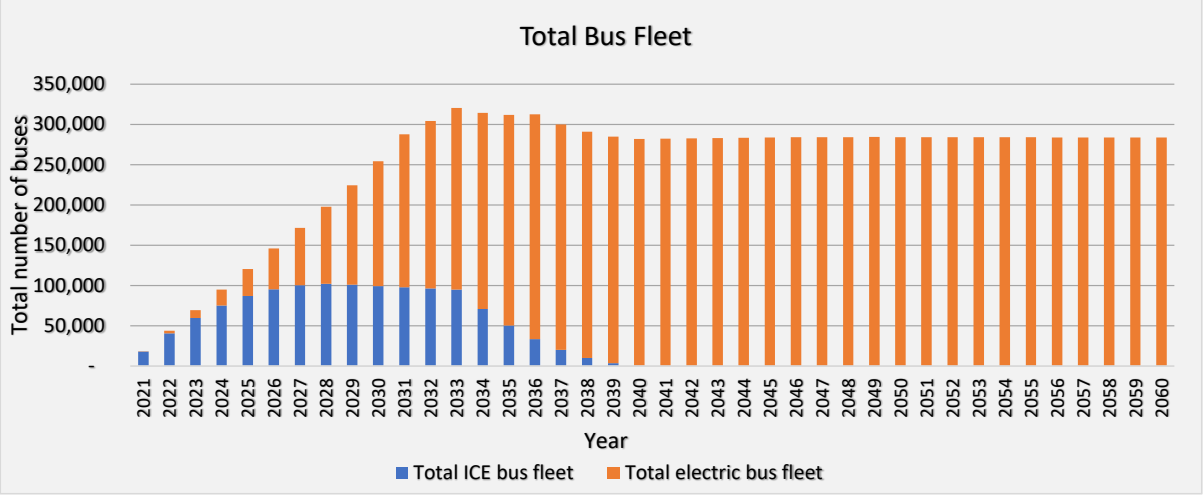
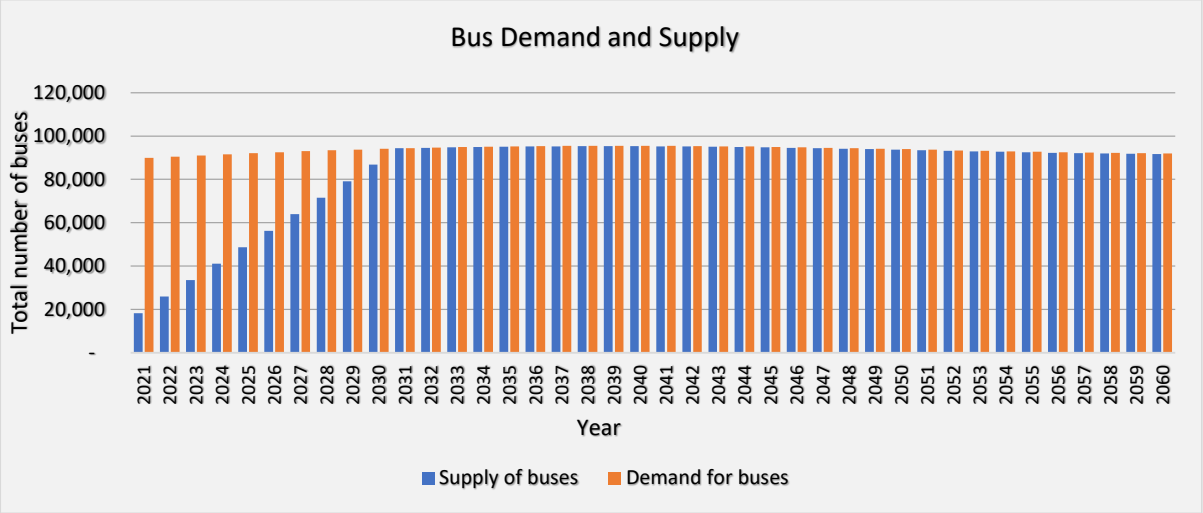


Business as Usual Scenario



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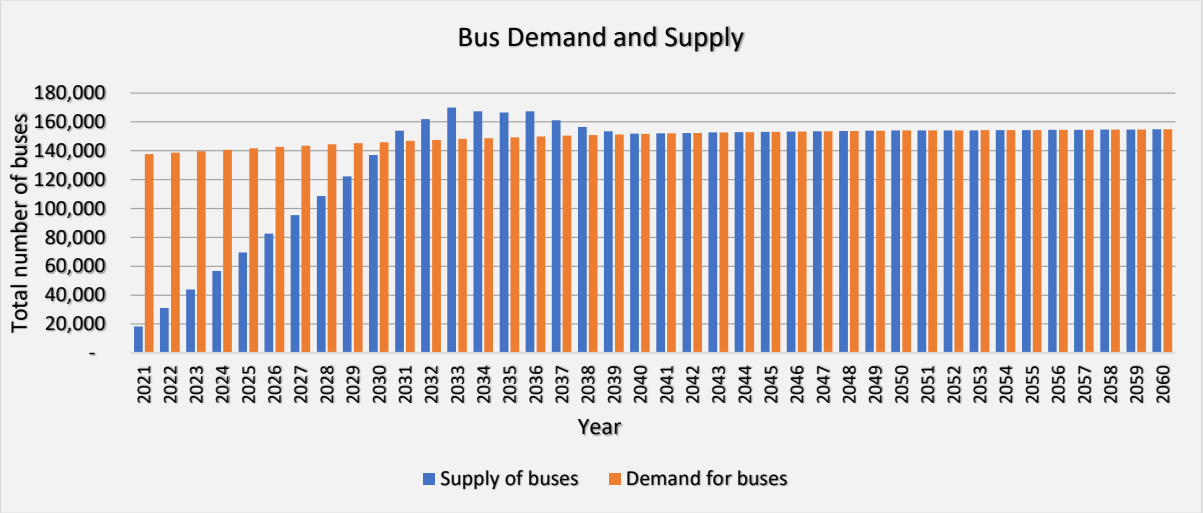

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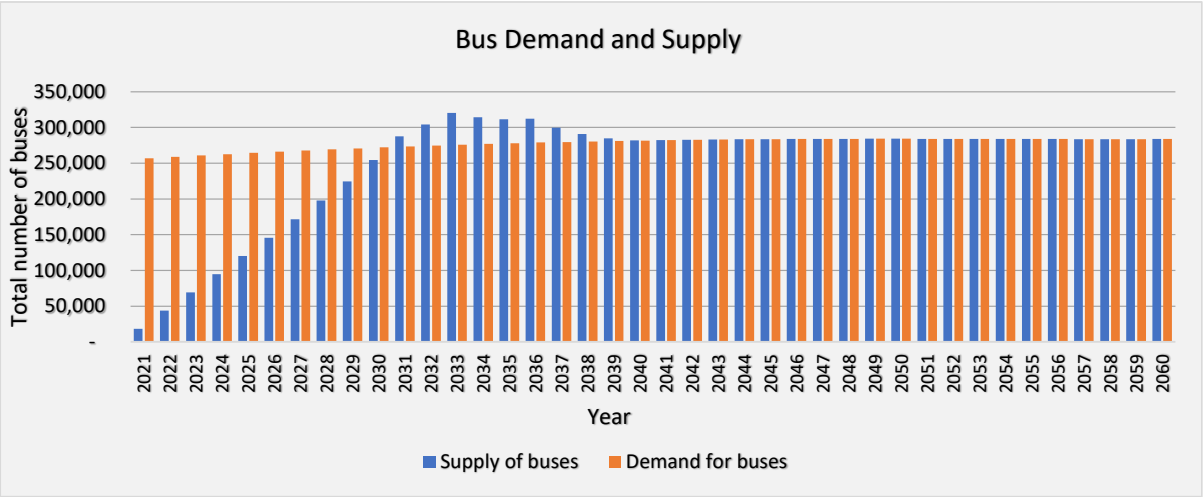
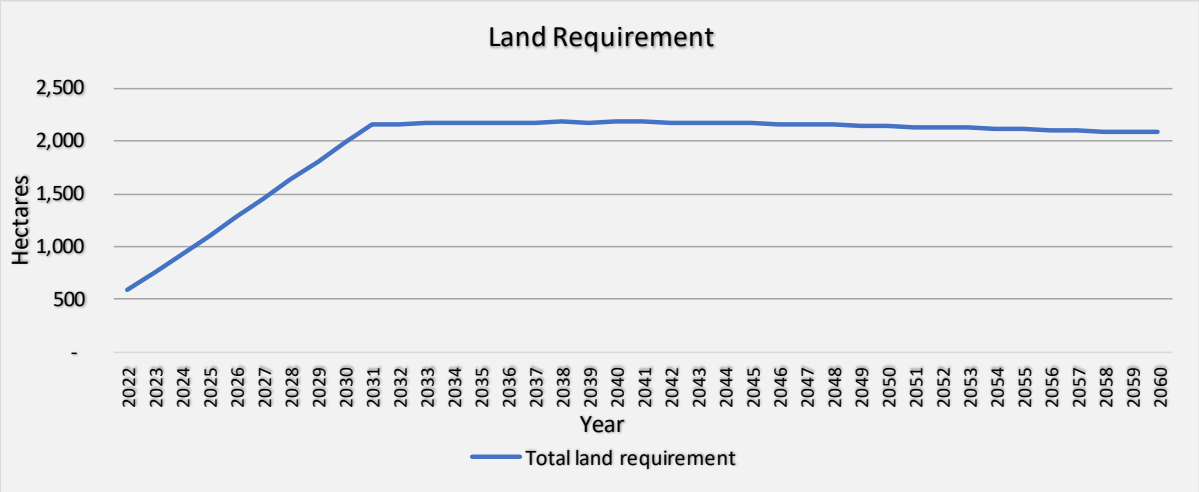


Business as Usual Scenario



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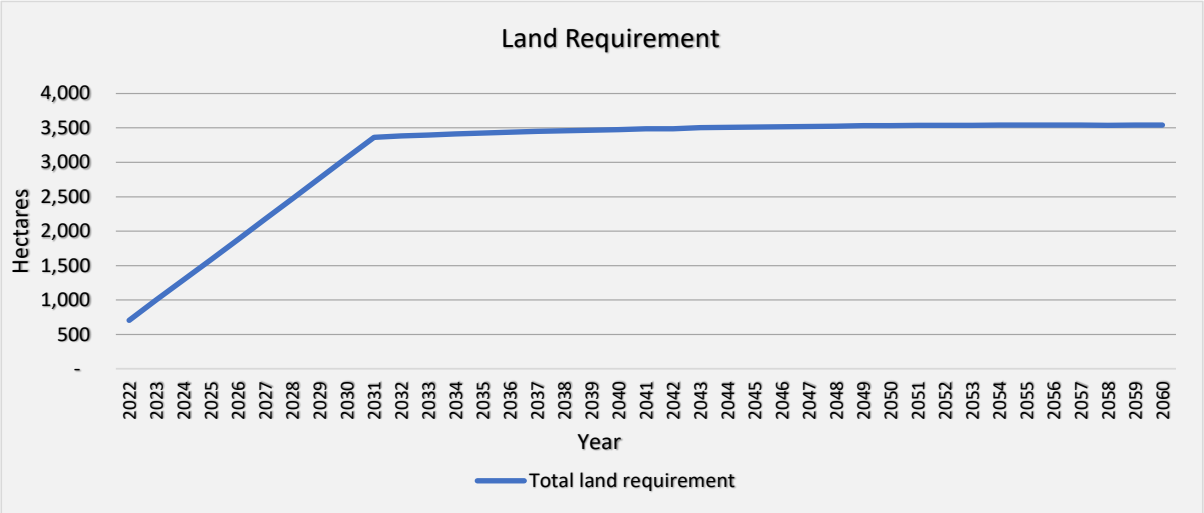

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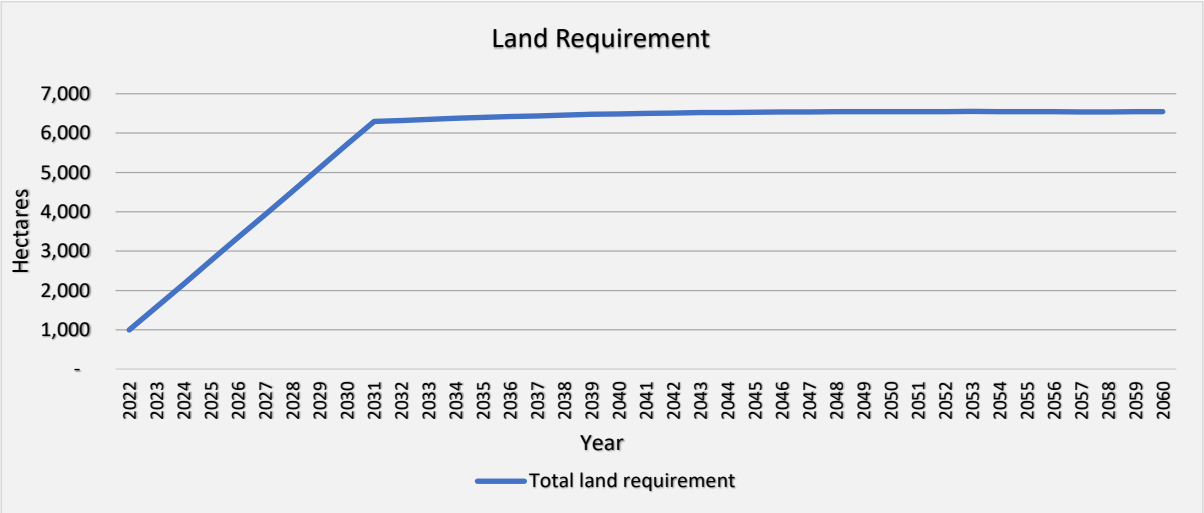
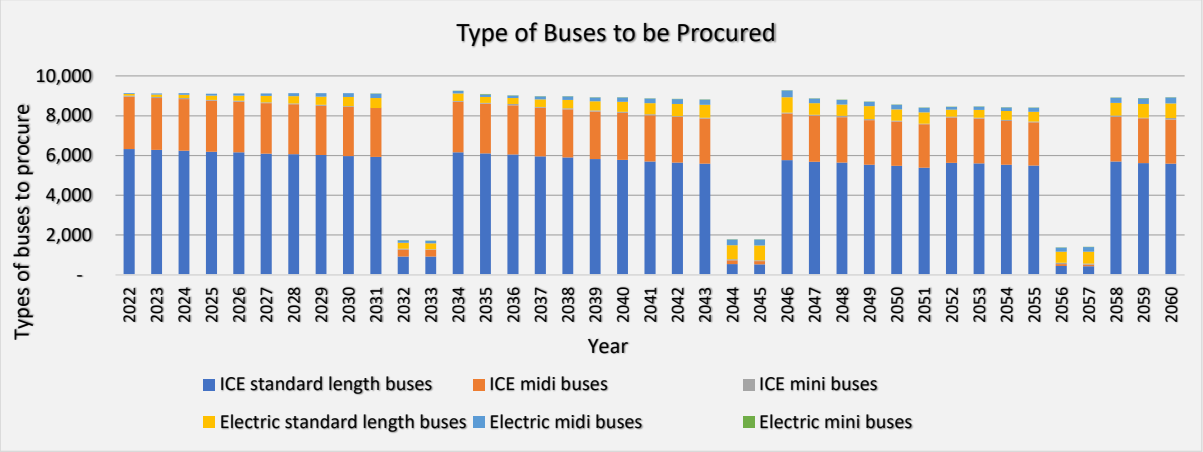


Business as Usual Scenario



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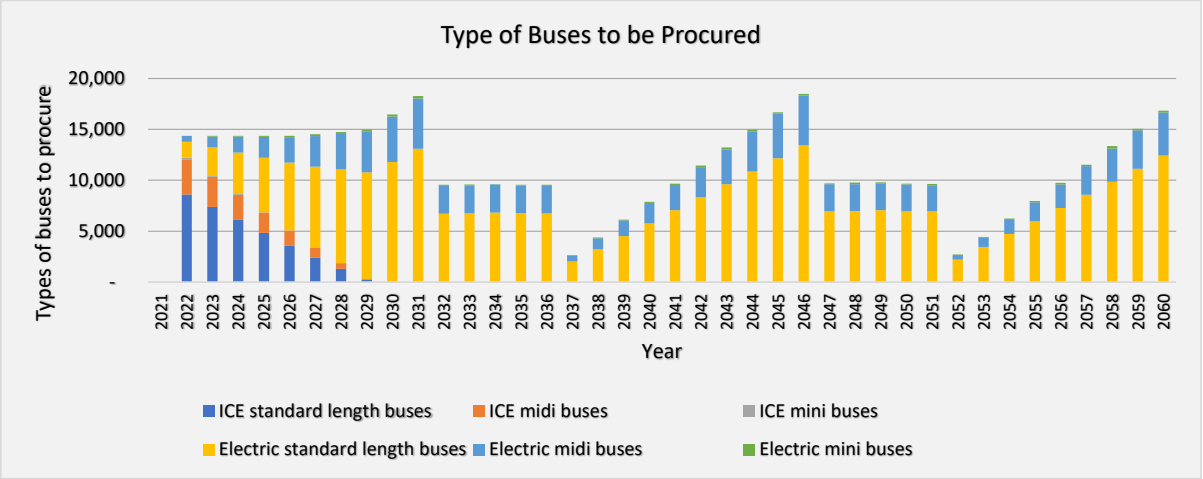

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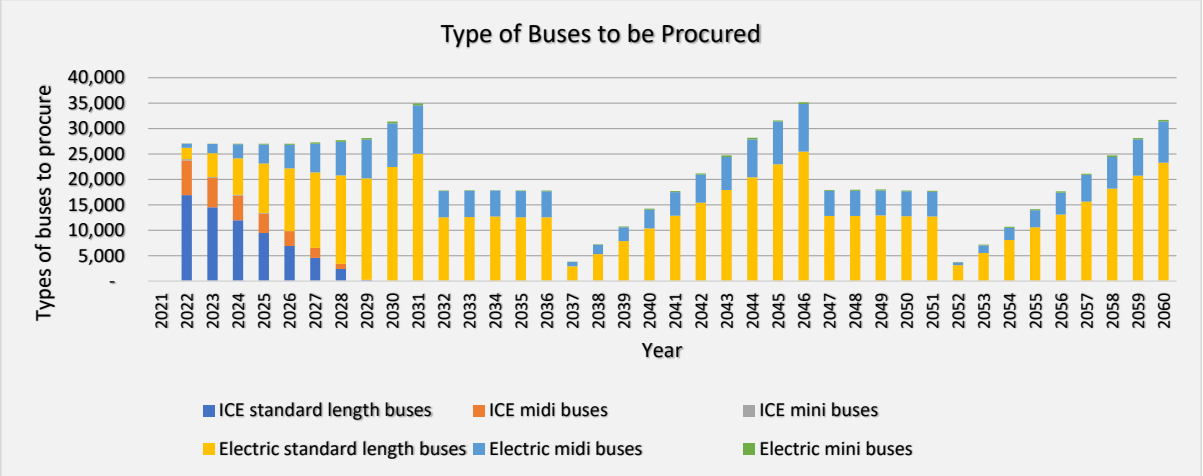
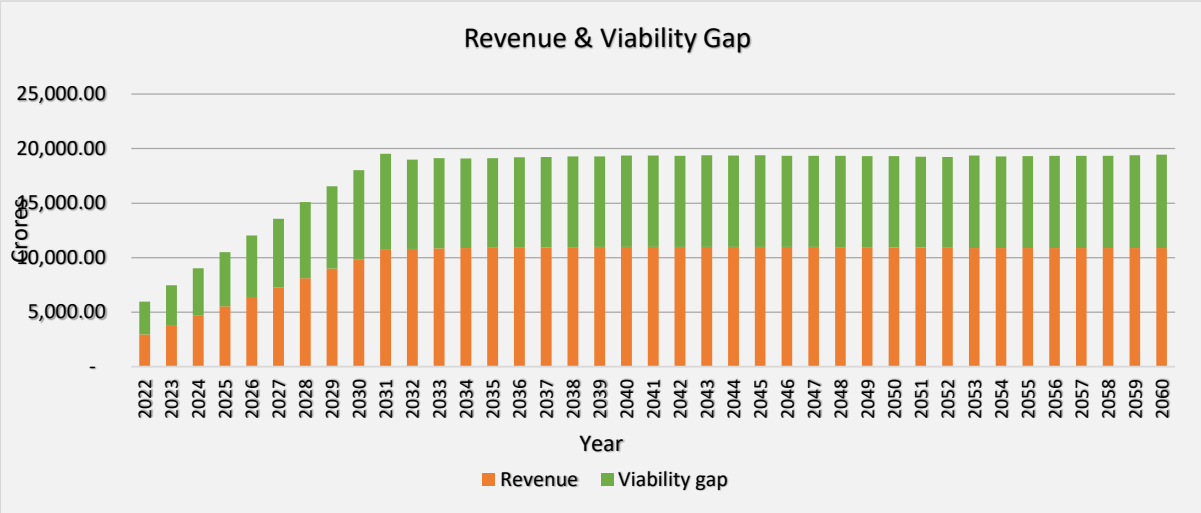


Revenue and Viability Gap: GCC Model

Business as Usual Scenario



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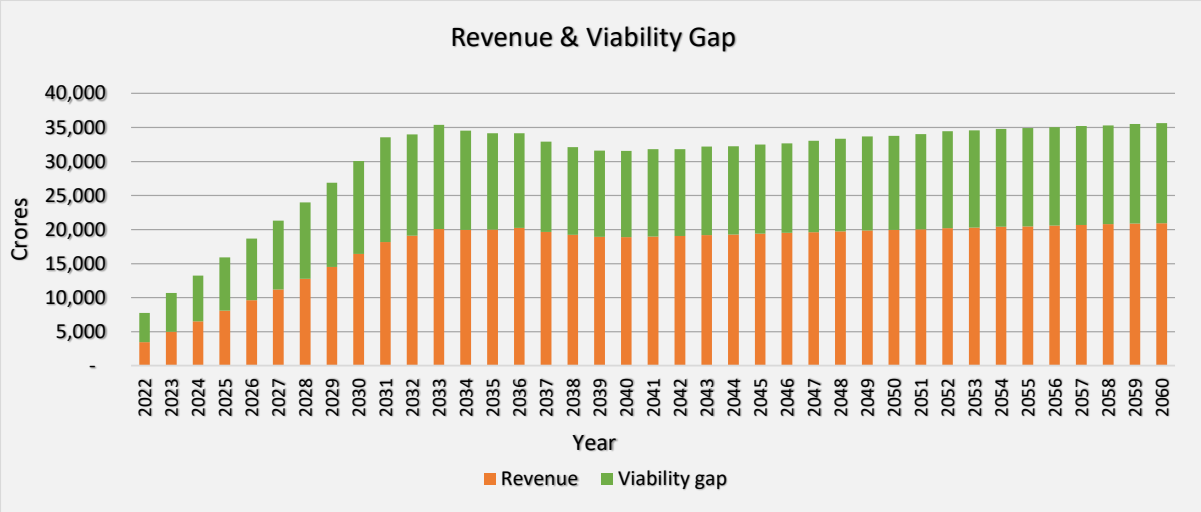
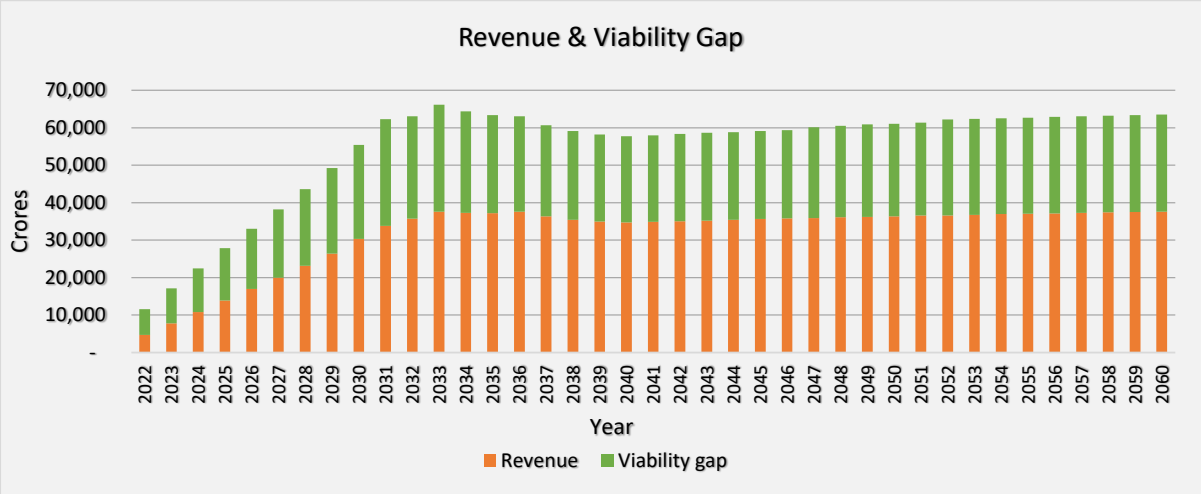
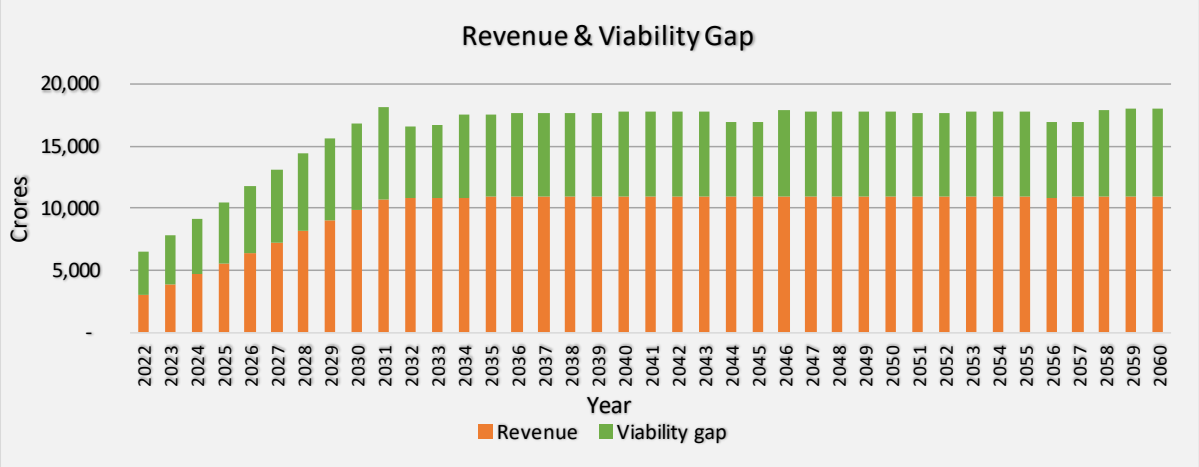


High Ambition Scenario

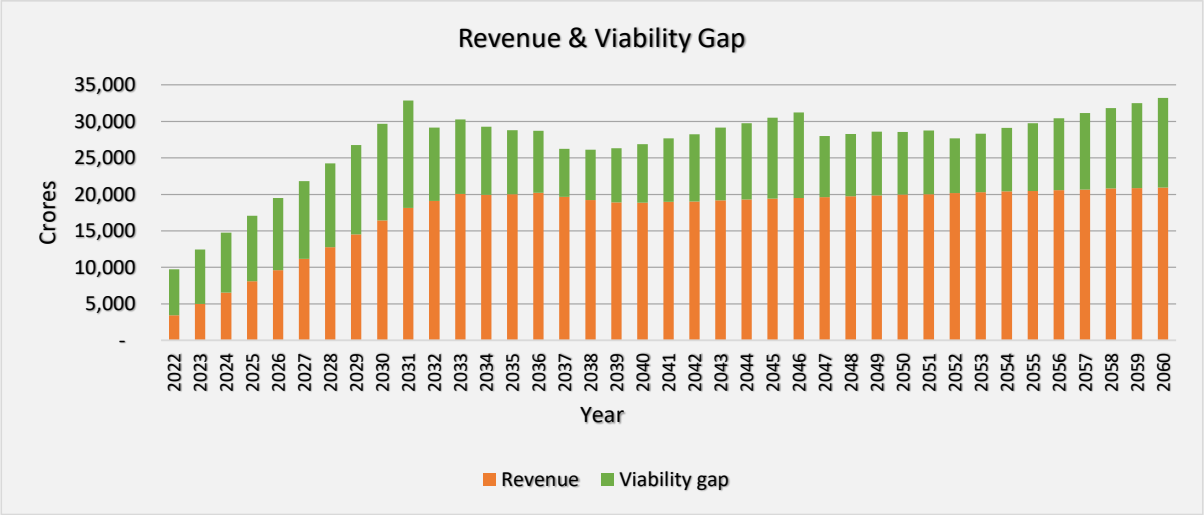


Revenue and Viability Gap: Outright Purchase Model

Business as usual Scenario



Low Ambition Scenario



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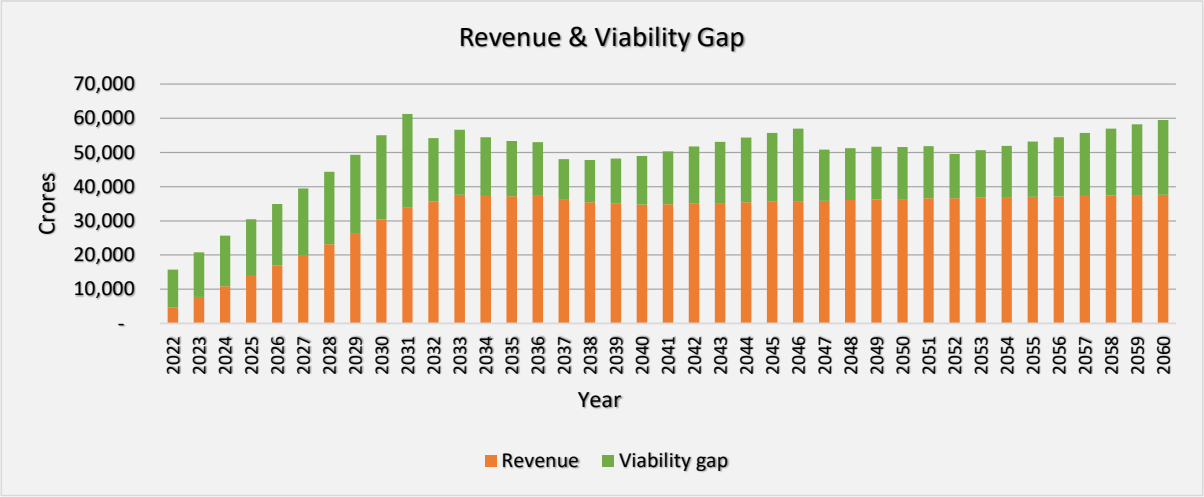
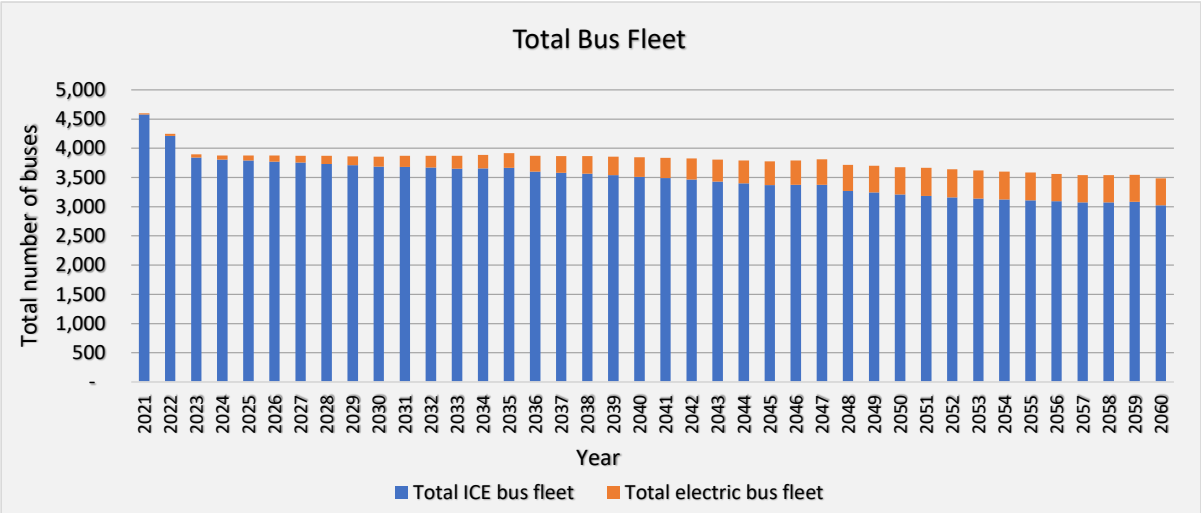


35. State / UT: Uttarakhand

Business as usual Scenario



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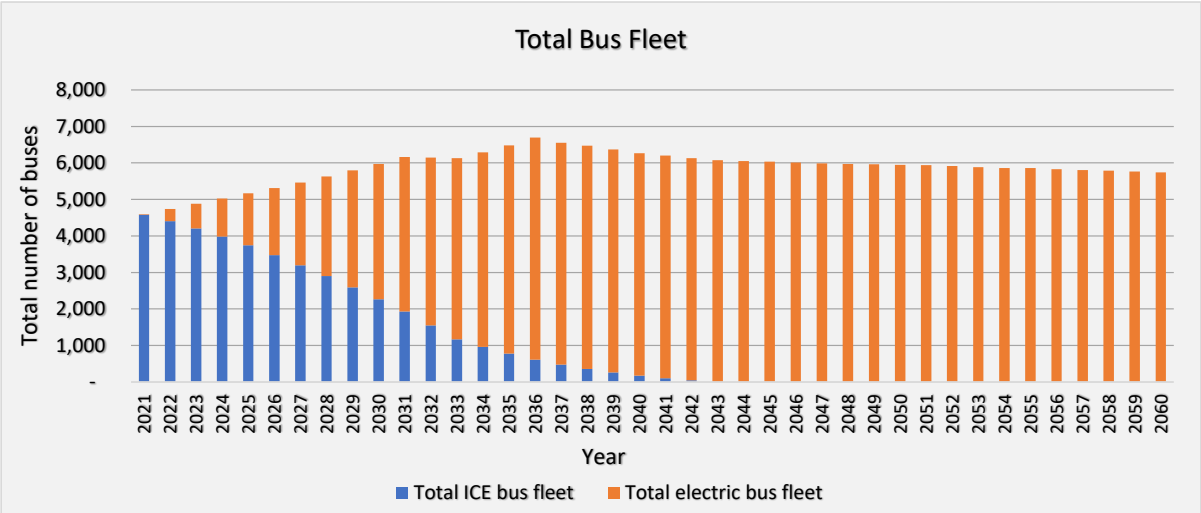

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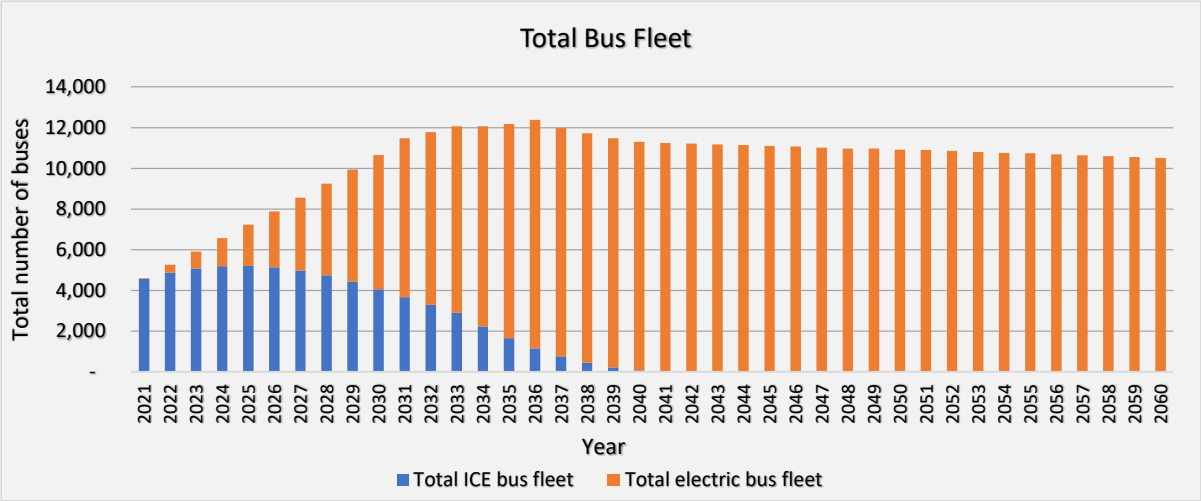
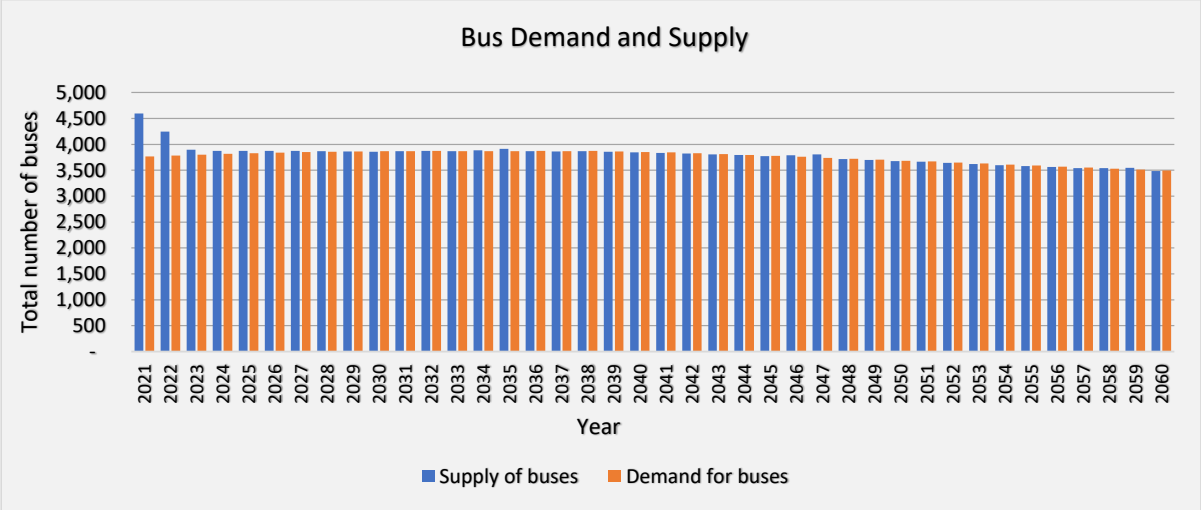


Business as Usual Scenario



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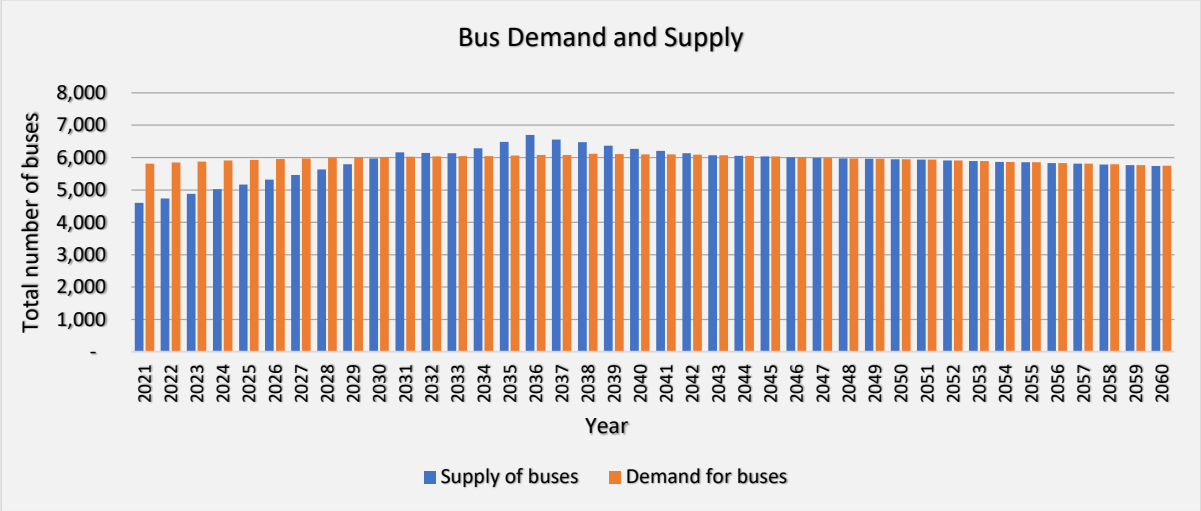
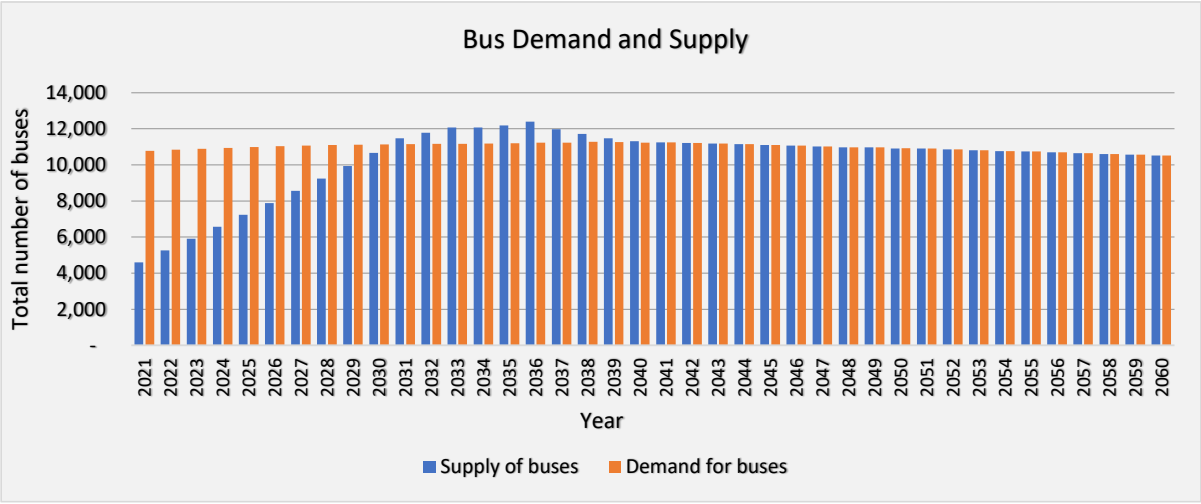
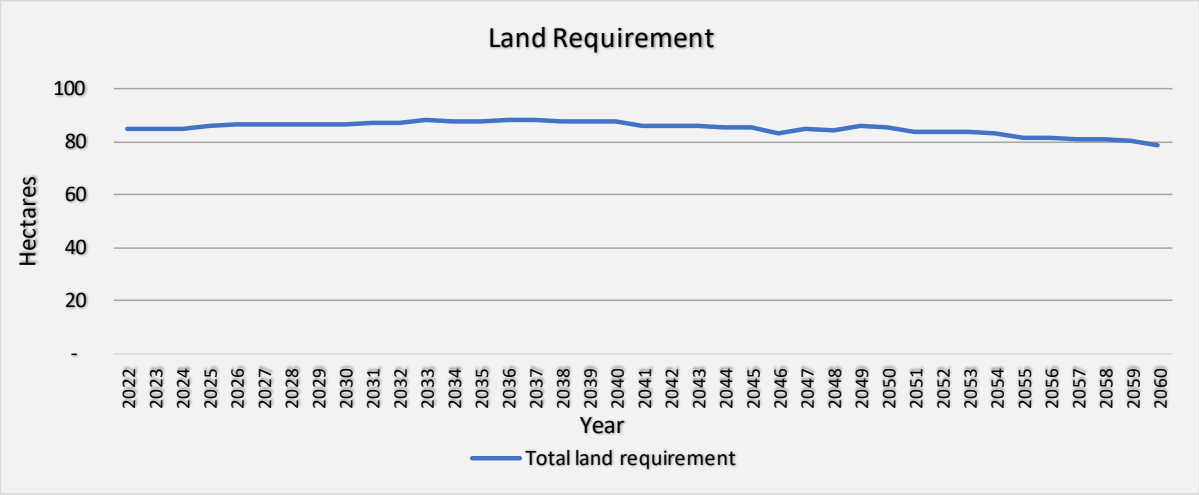


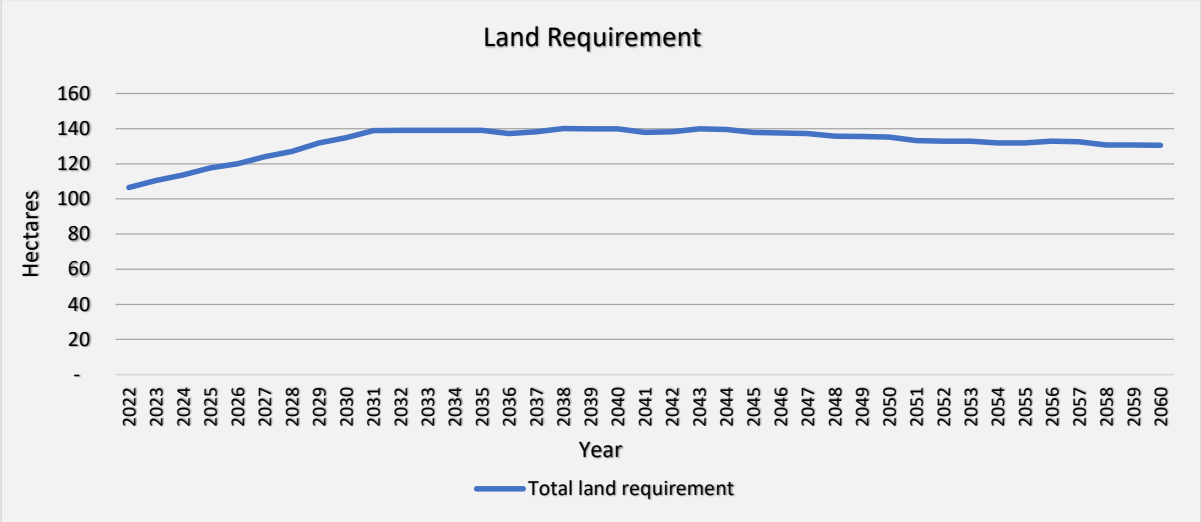
High Ambition Scenario



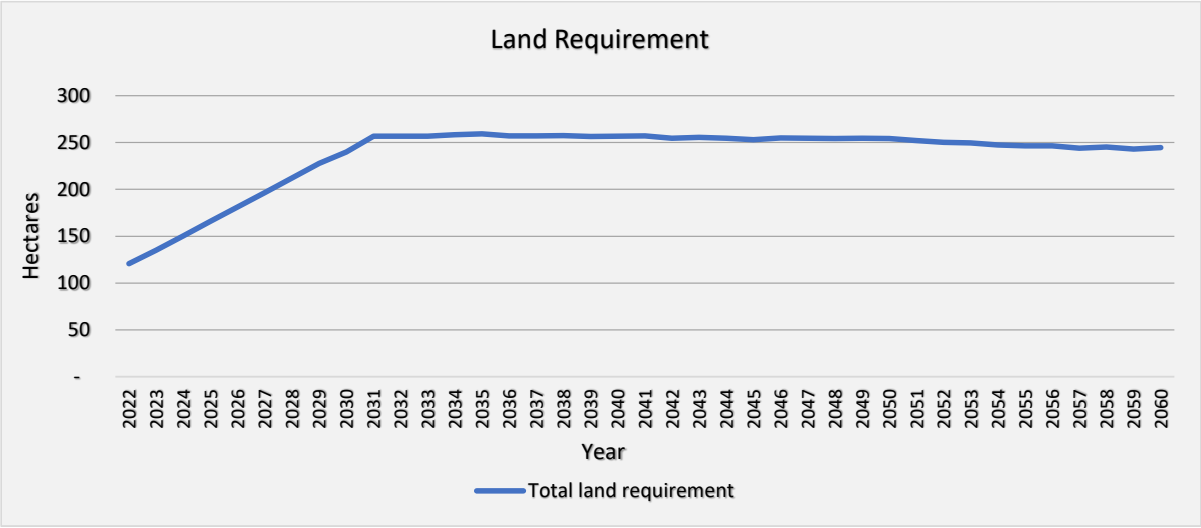
Business as Usual Scenario



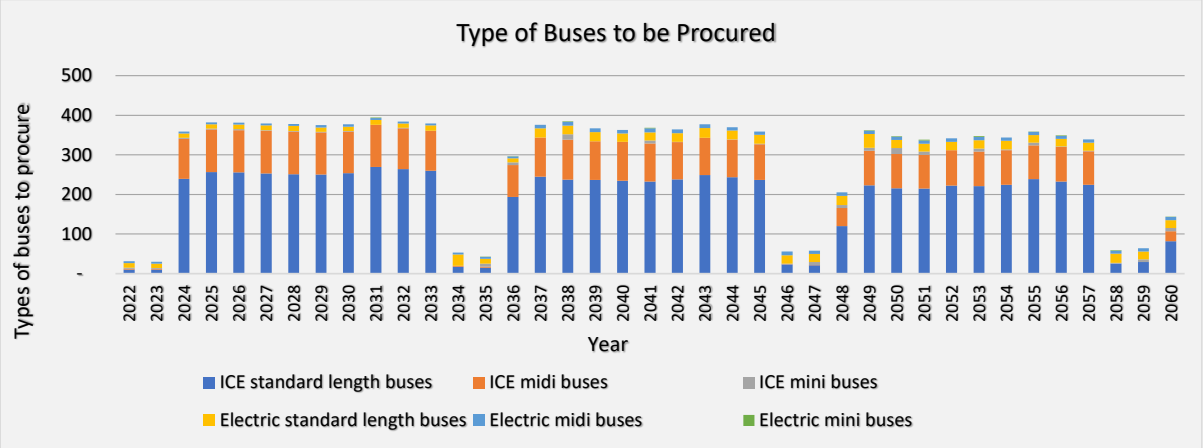
Low Ambition Scenario



High Ambition Scenario



Business as Usual Scenario



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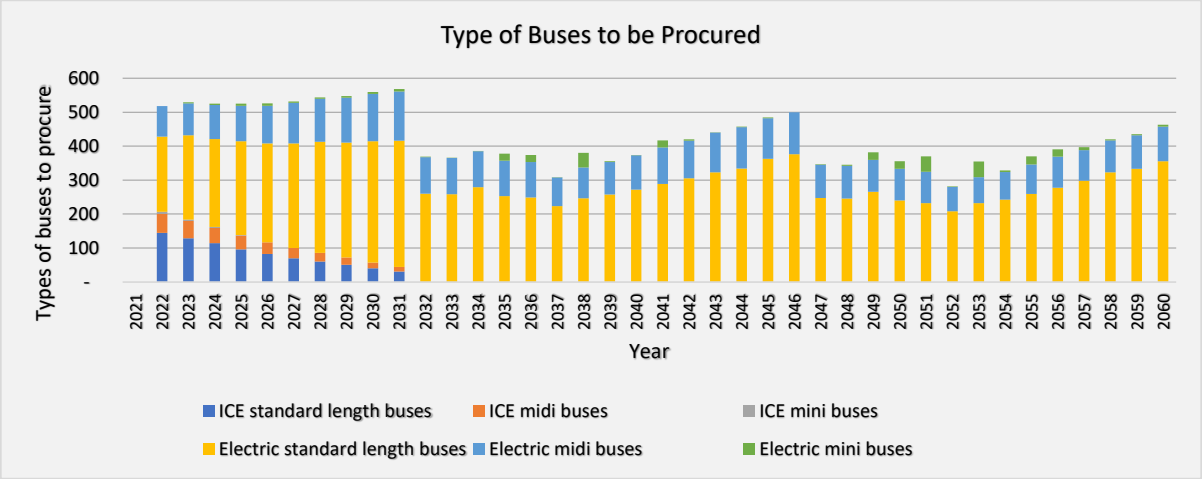
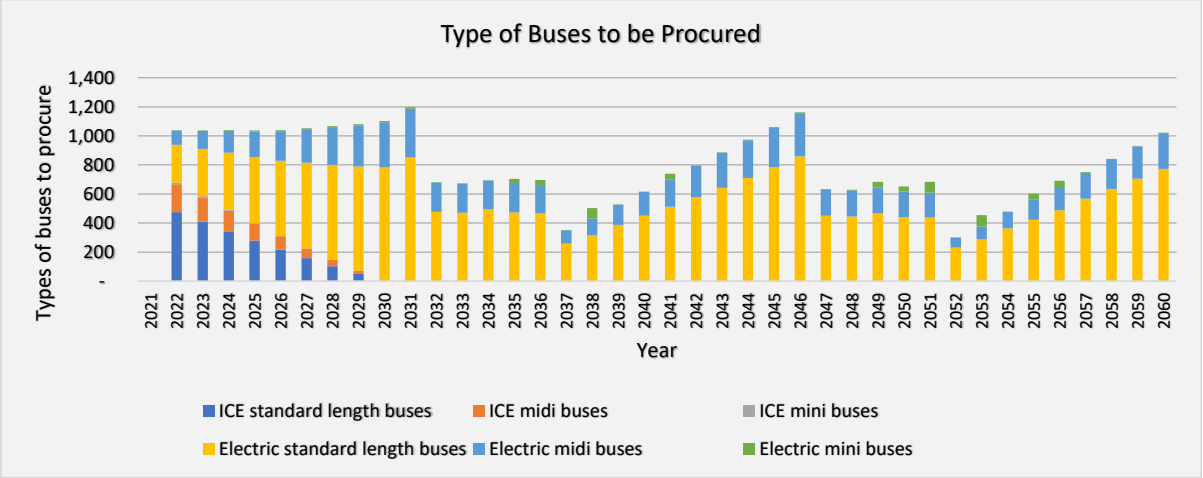
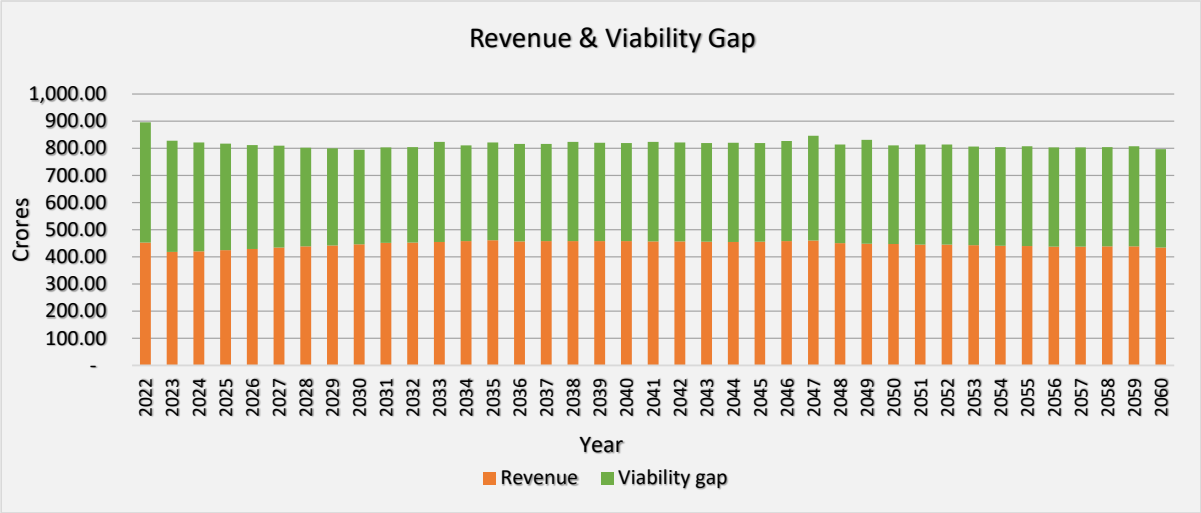


High Ambition Scenario

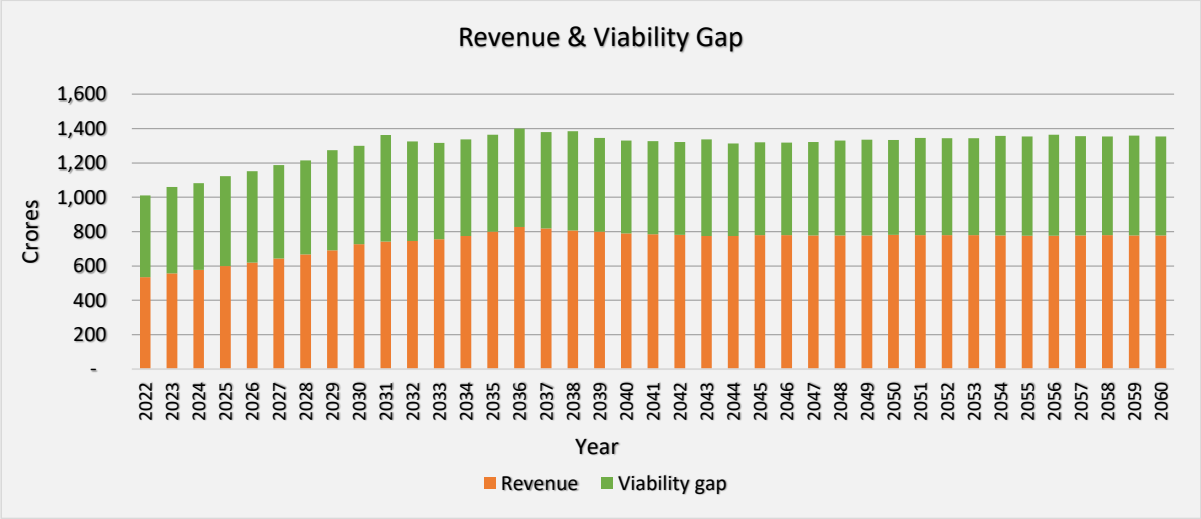


Revenue and Viability Gap: GCC Model

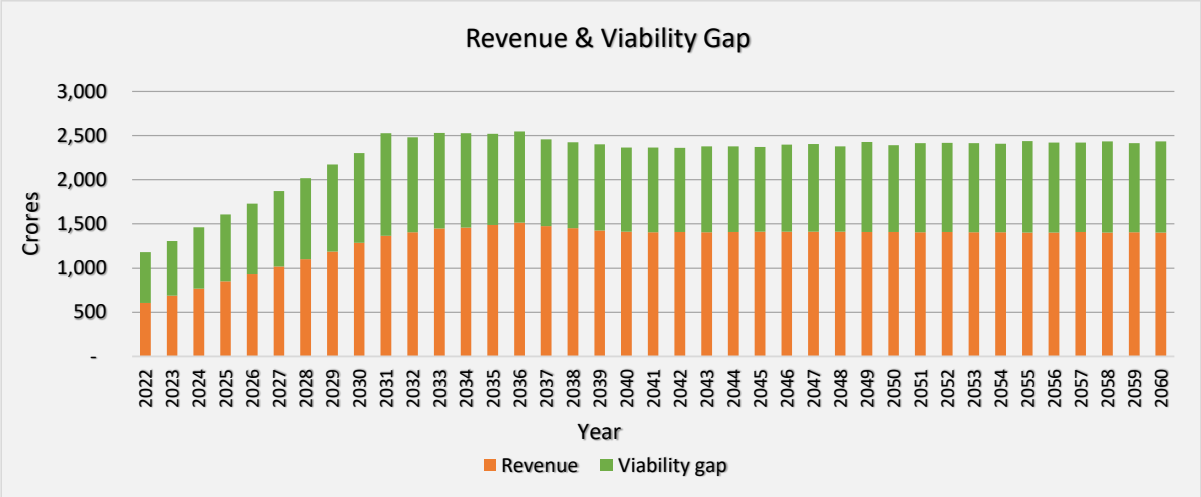
Business as Usual Scenario



Low Ambition Scenario

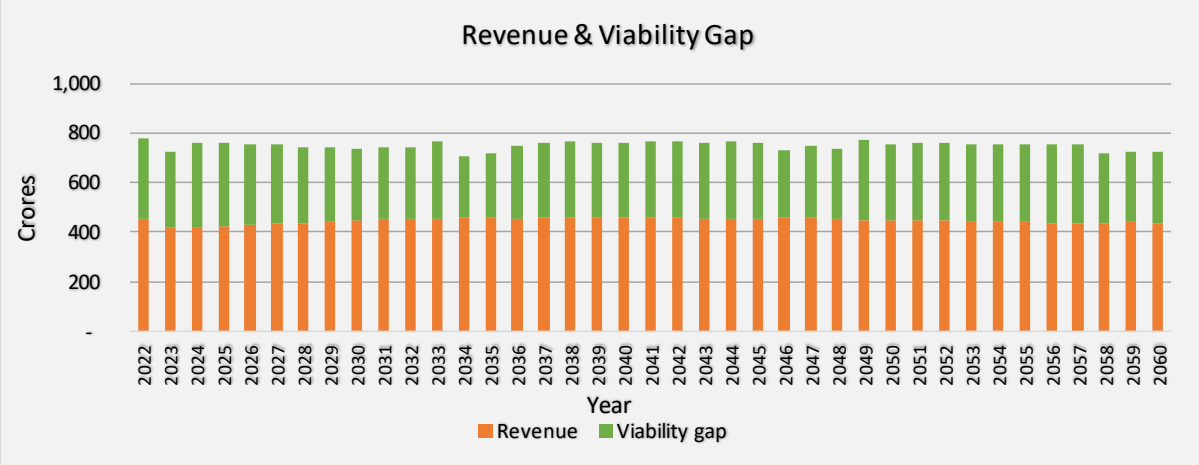


High Ambition Scenario

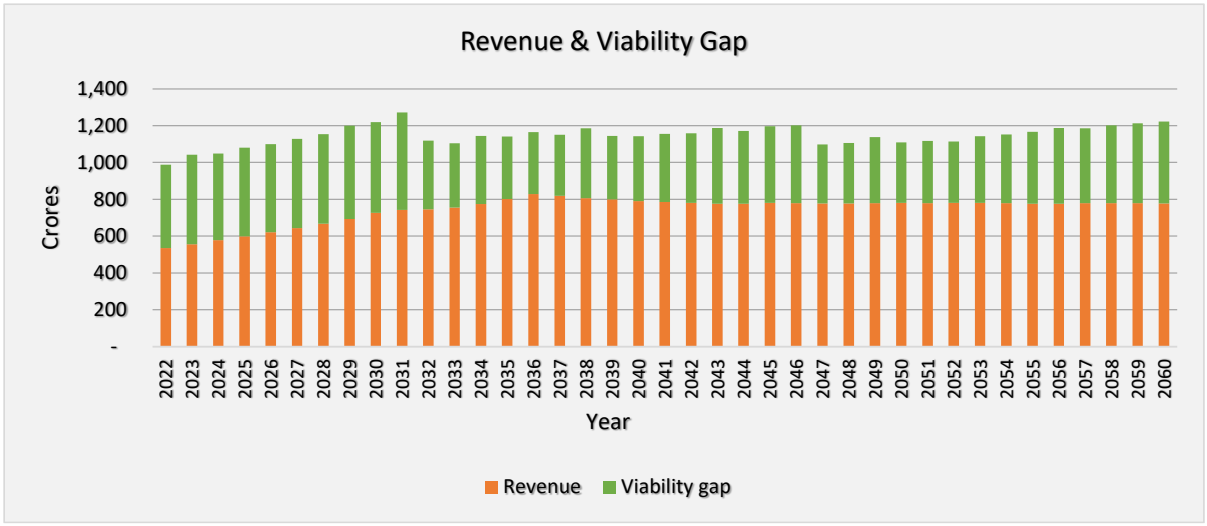


Revenue and Viability Gap: Outright Purchase Model

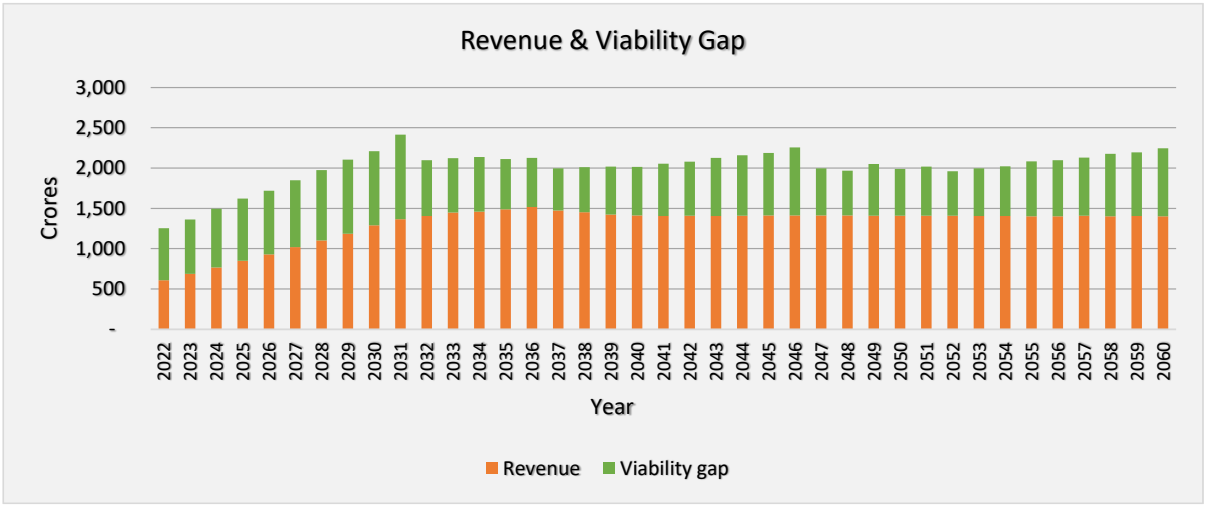
Business as usual Scenario



Low Ambition Scenario

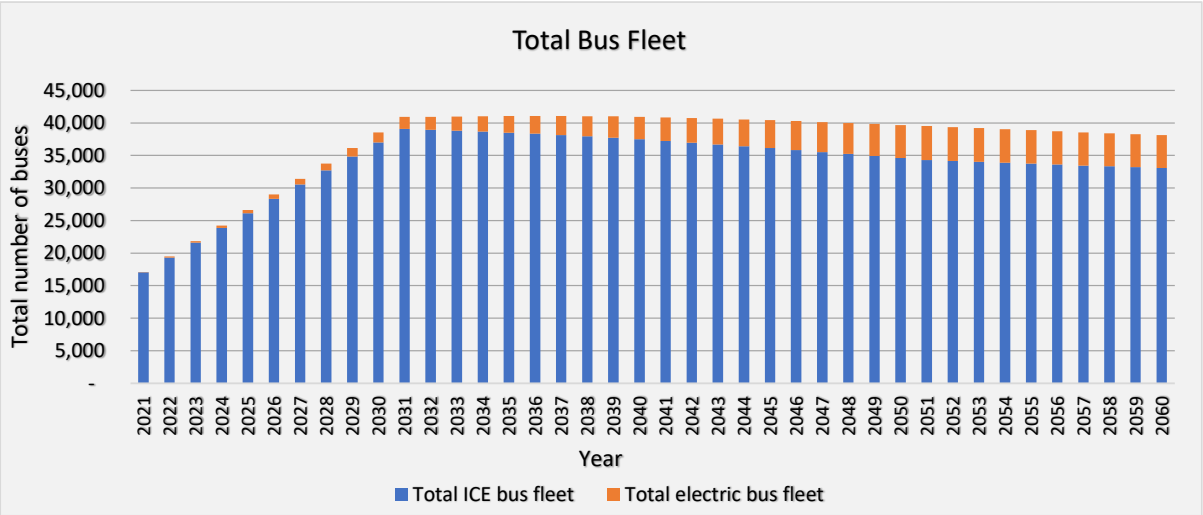


High Ambition Scenario



36. State / UT: West Bengal

Business as usual Scenario



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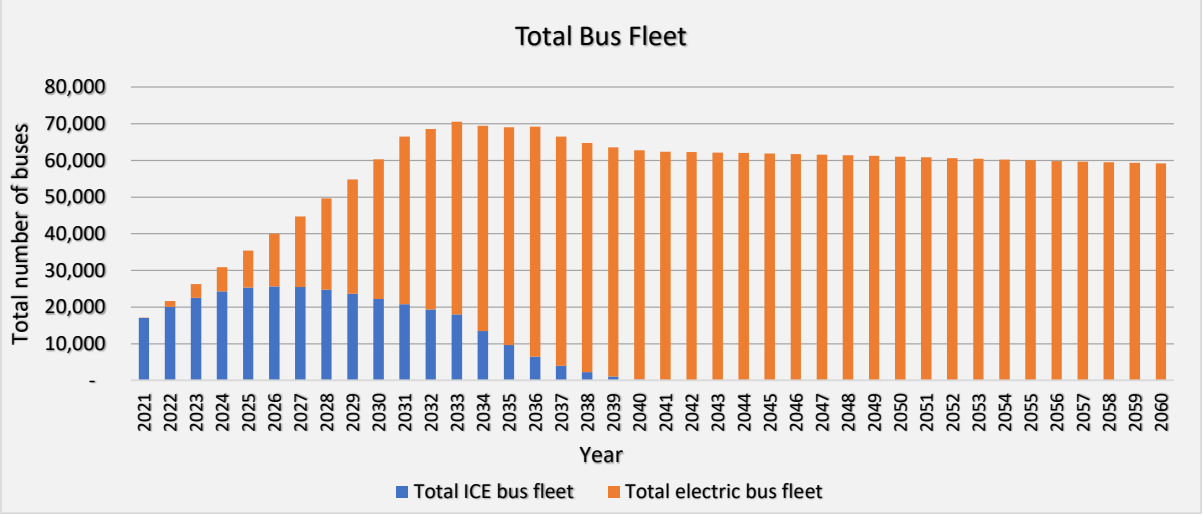

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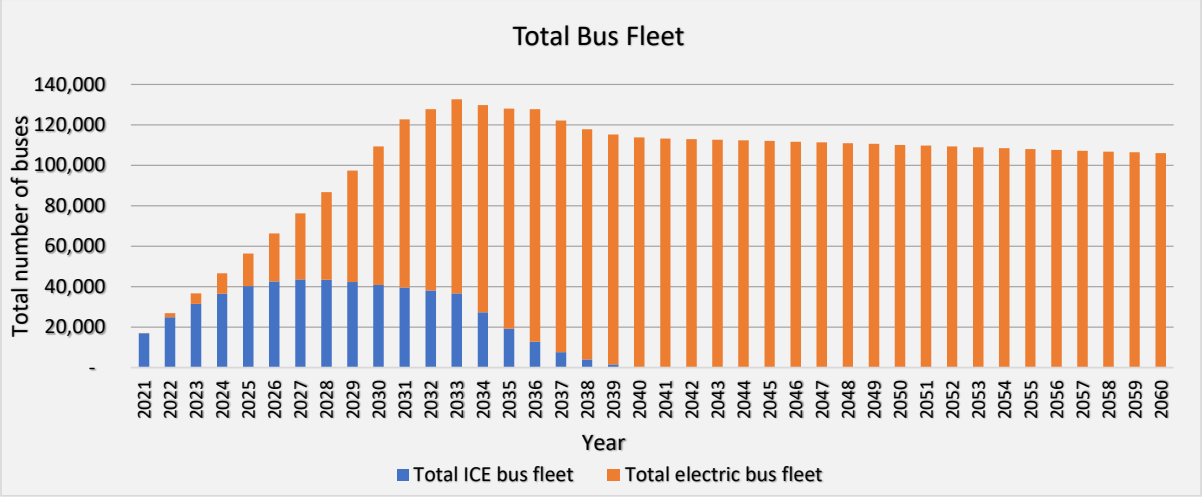
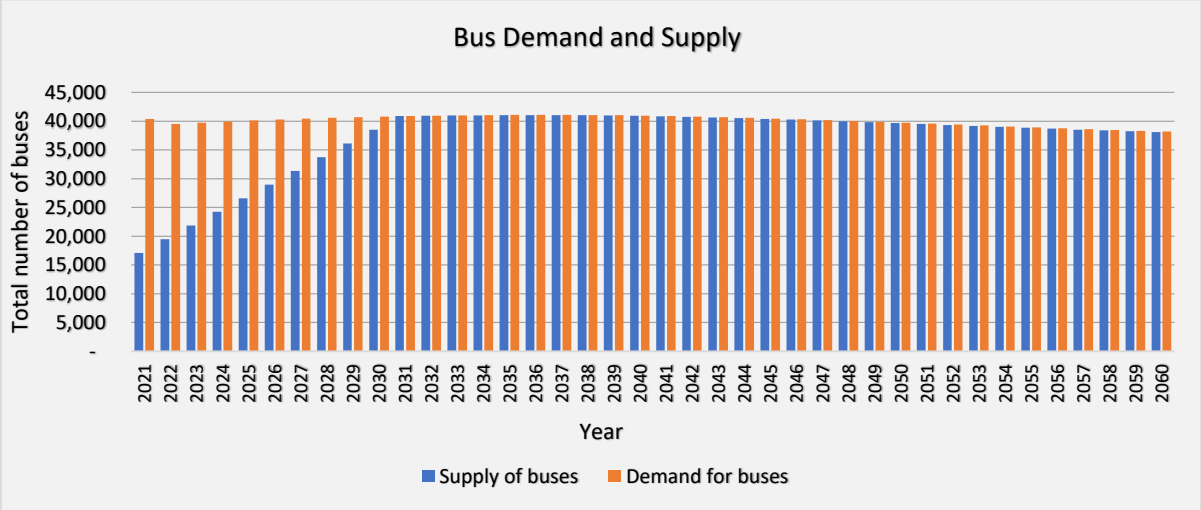


Business as Usual Scenario



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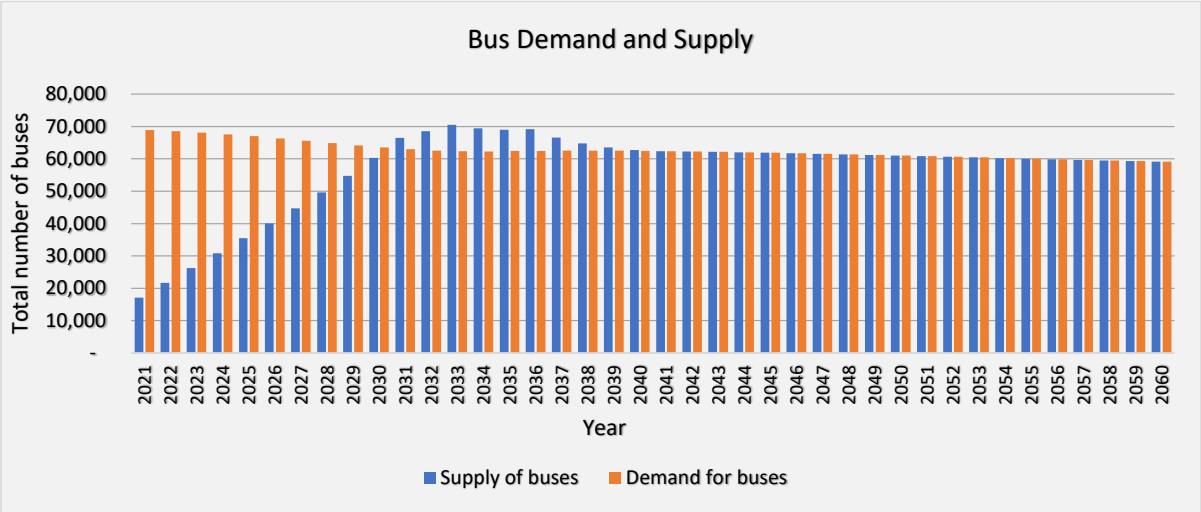

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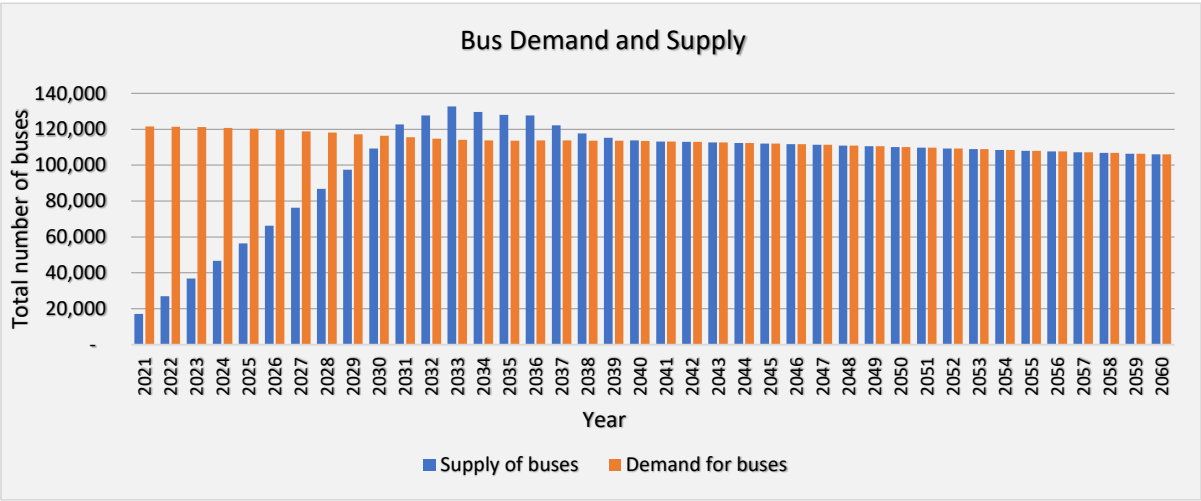
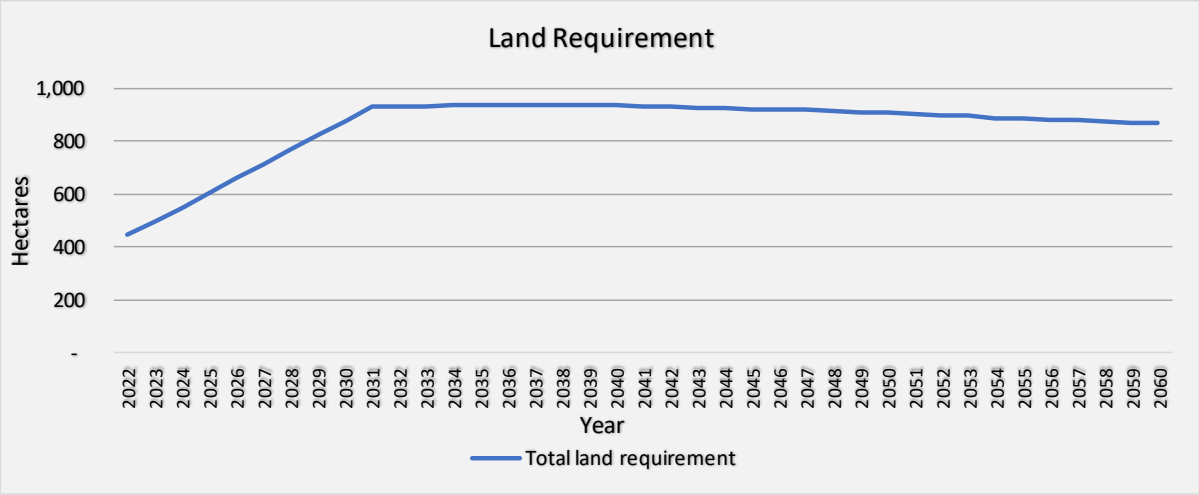


Business as Usual Scenario



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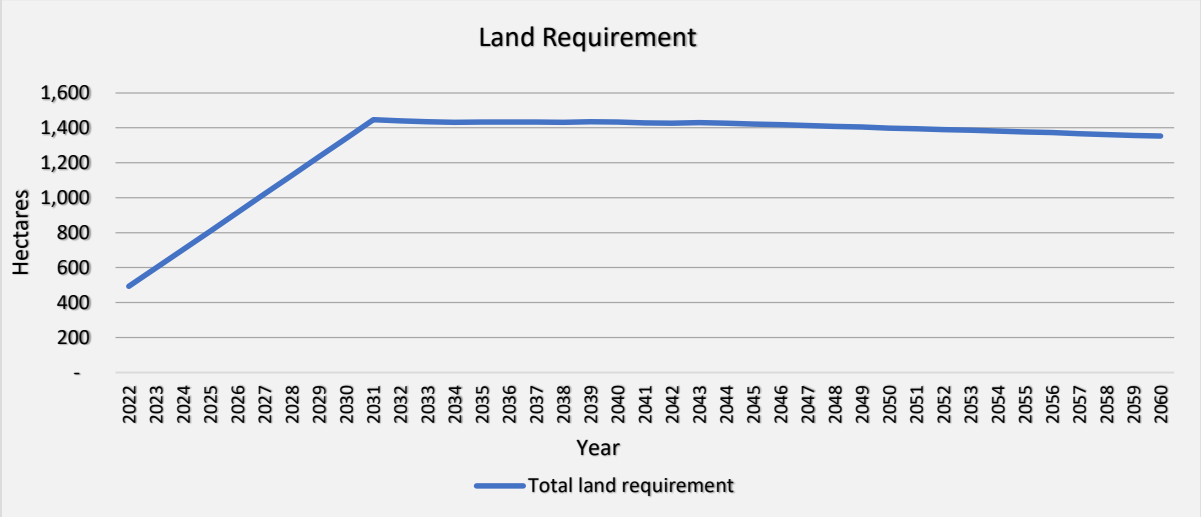

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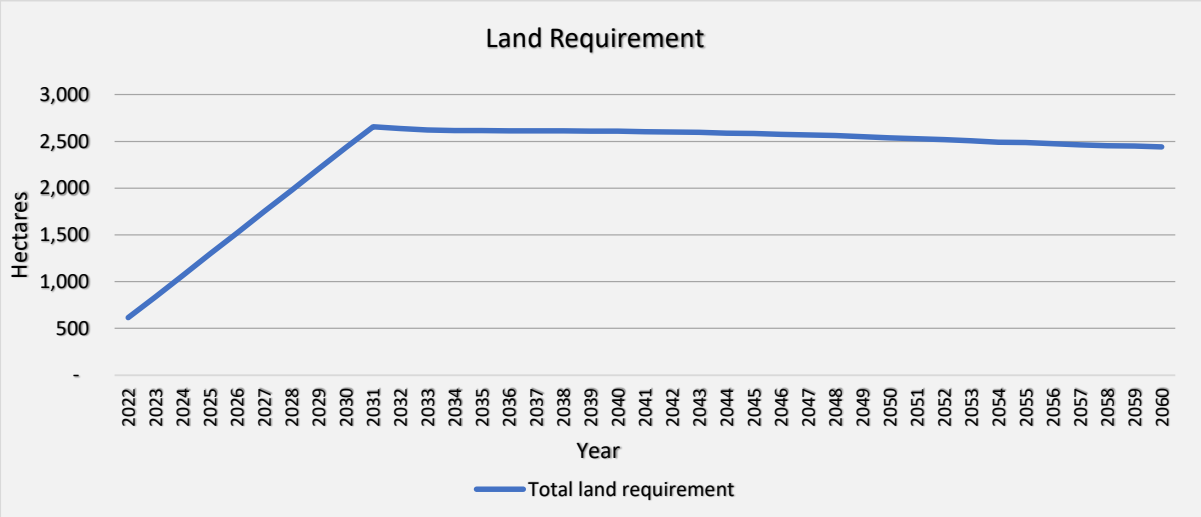
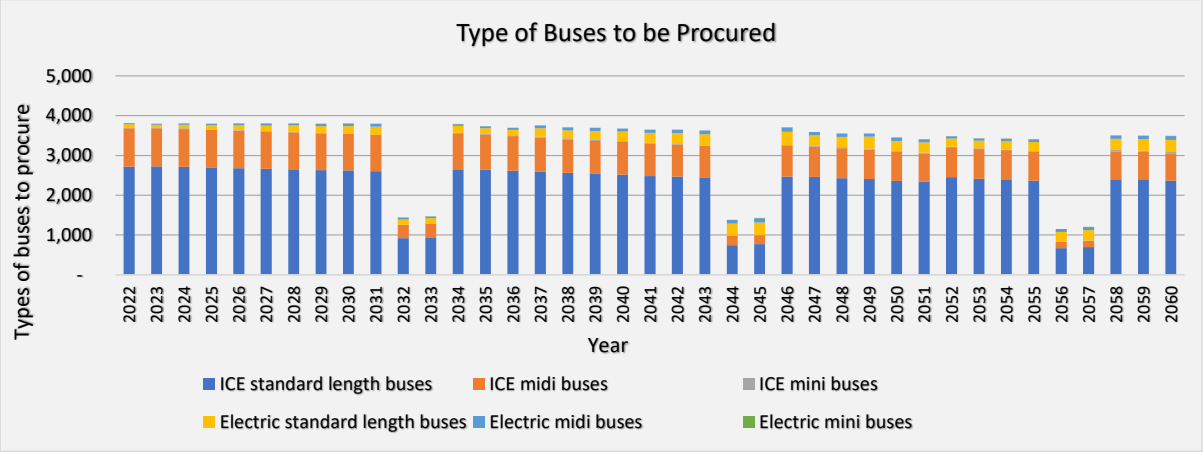


Business as Usual Scenario



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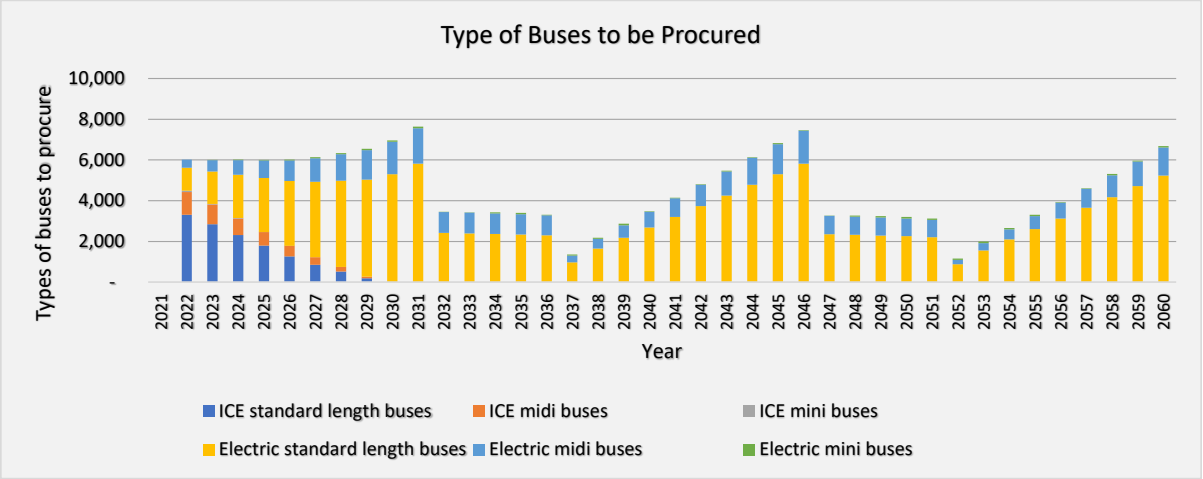
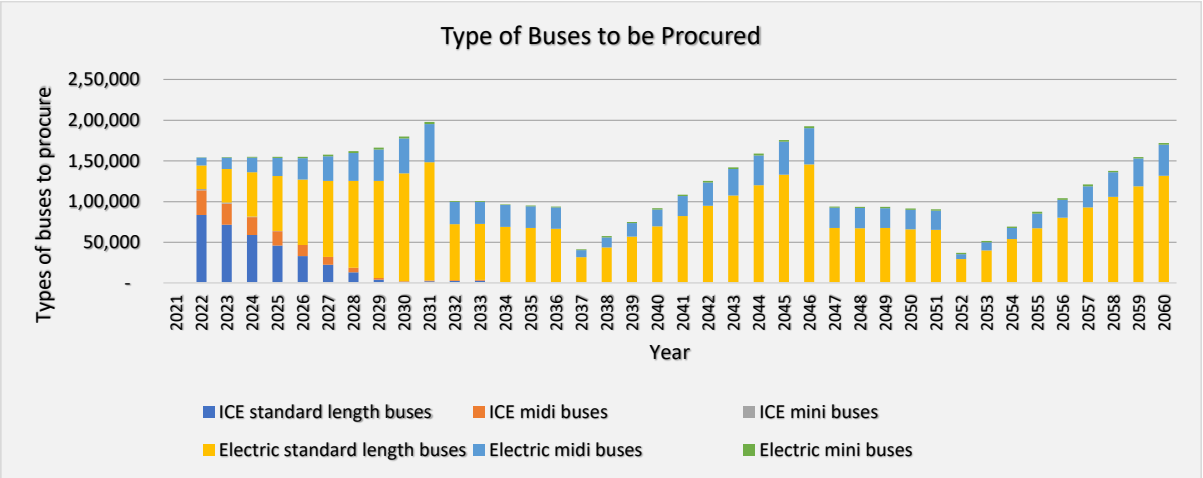
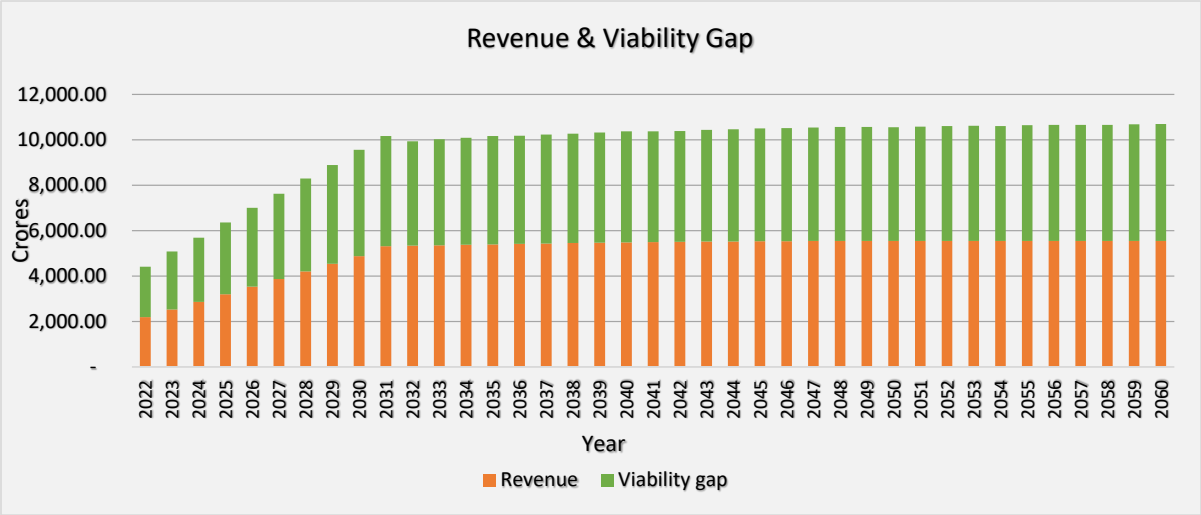


High Ambition Scenario



Revenue and Viability Gap: GCC Model

Business as Usual Scenario



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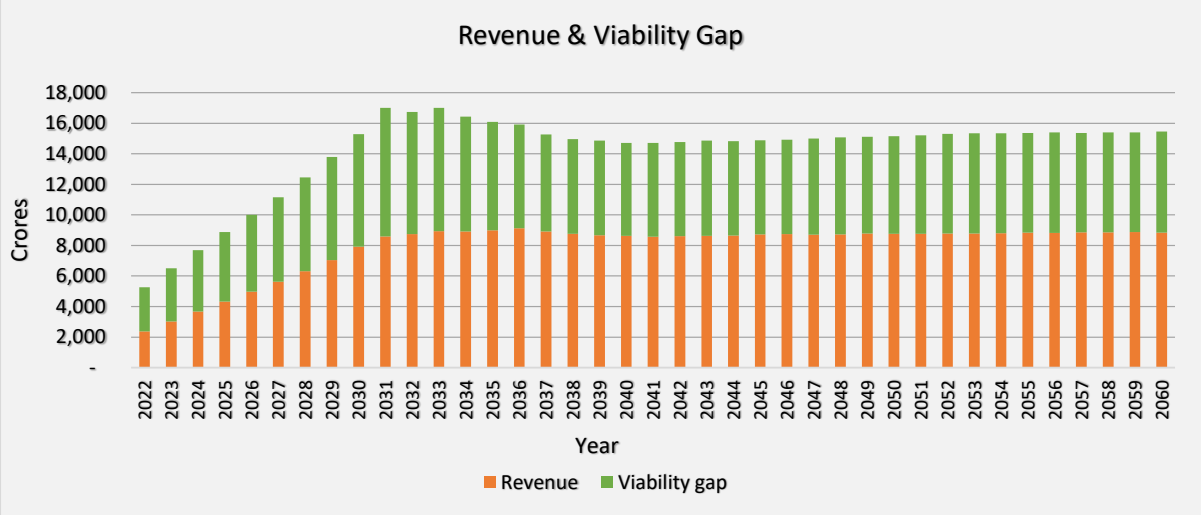
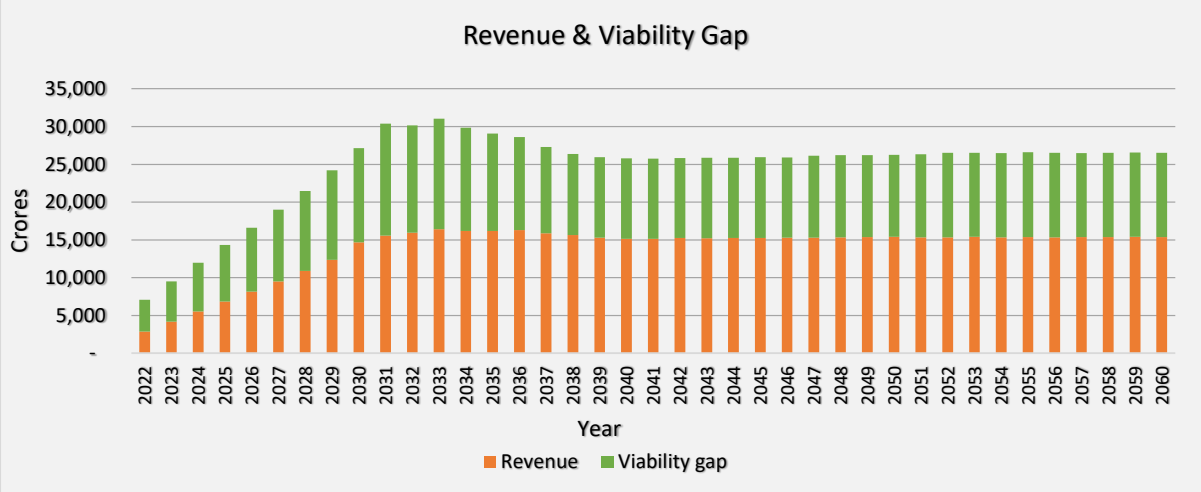
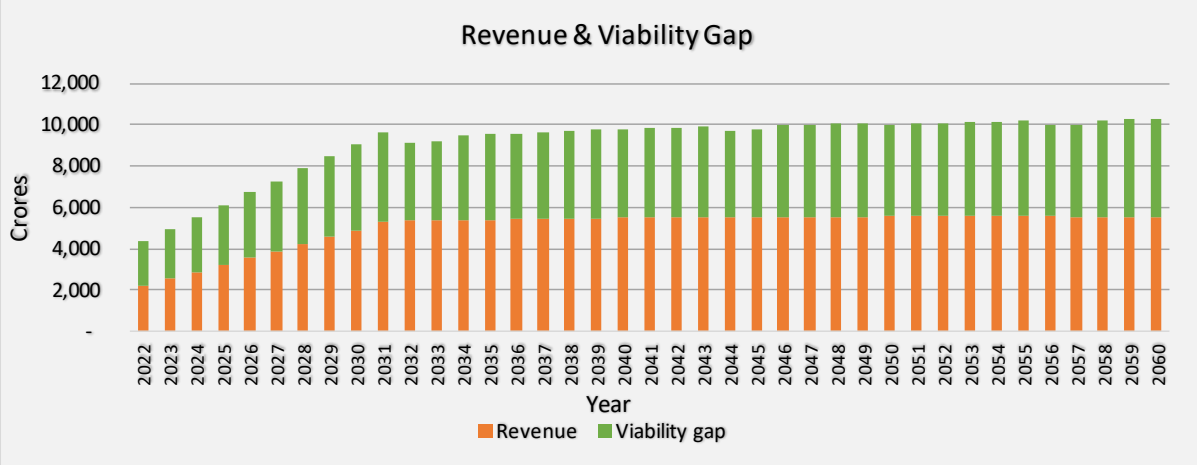


High Ambition Scenario

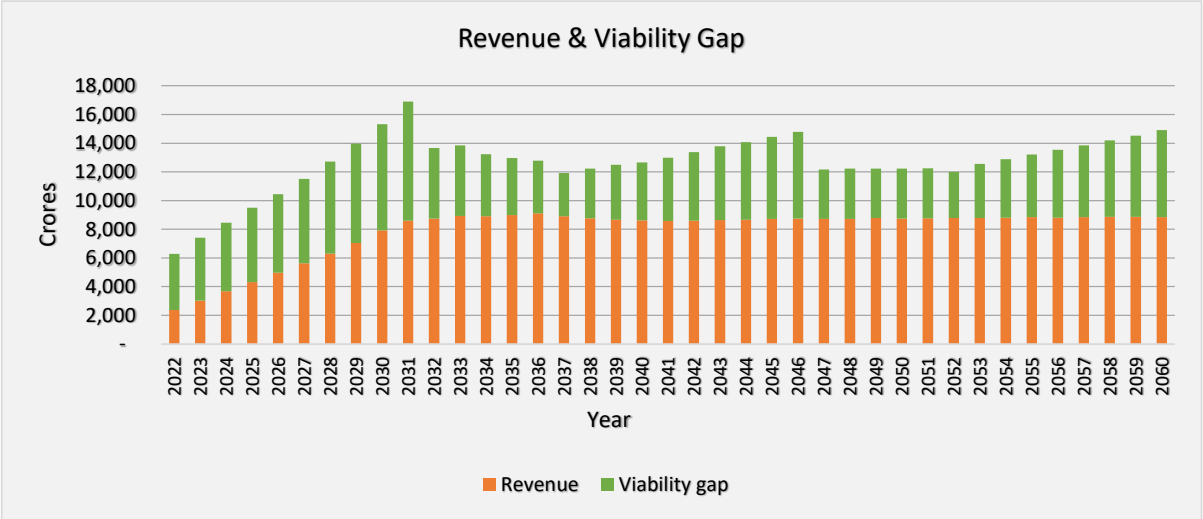


Revenue and Viability Gap: Outright Purchase Model

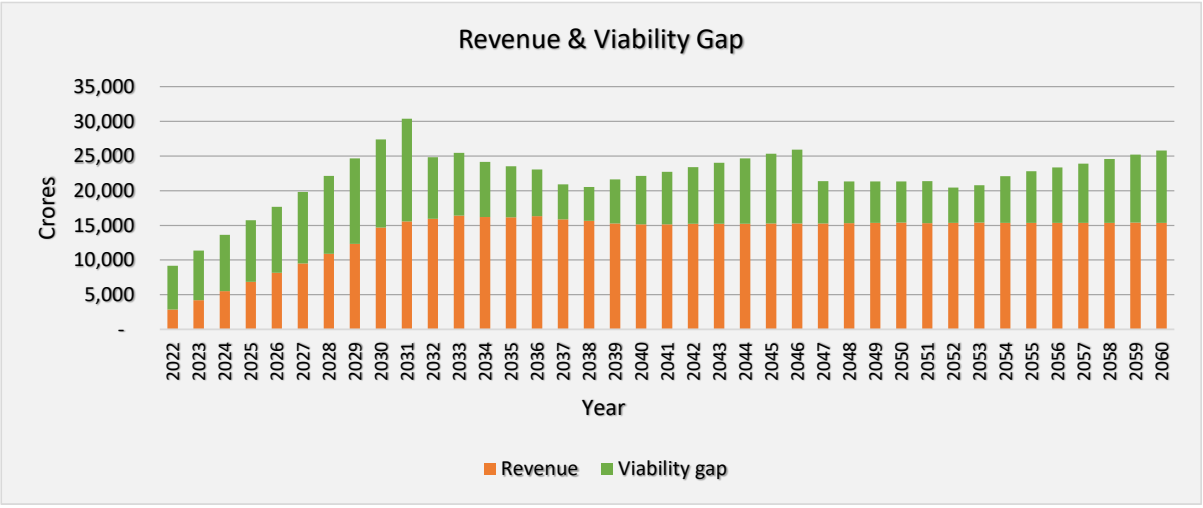
Business as usual Scenario



Low Ambition Scenario



High Ambition Scenario



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Shakti Sustainable Energy Foundation seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the areas of clean power, energy efficiency, sustainable urban transport, climate change mitigation and clean energy finance.

SGArchitects was established in 2006 and provides consultancy services in the field of sustainable urban transport including public and non-motorized transport. We provide expertise in research, planning and implementation for all forms of sustainable urban transport projects, including developing toolkits, guidelines, and other resource material.