Impact of the Delhi Electric Vehicle Policy-2020 on the Demand for Electric Buses in Delhi from 2020-2023

Research Question: To what extent has the Delhi Electric Vehicle Policy-2020 affected the demand for electric buses in Delhi from 2020-2023?

Word Count: 3998

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1. INTRODUCTION

1.1 Relevance of the Topic

India's national capital and industrial epicentre Delhi has undergone rapid urbanization since the 1950s, resulting in a sharp rise in population density. From 1176 persons per square kilometre in 1951, population density has risen to over 18,000 persons per square kilometre today (Economics Survey of Delhi, 2023). Alongside its rapid urbanization, Delhi has experienced escalating levels of pollution, currently ranking as the most polluted city in the world with an average AQI of 233 in 2024 (India Air Quality Index, 2024).

Carbon emissions contribute largely to Delhi's pollution, out of which 38% can be attributed to vehicular emissions produced by fuel-based vehicles (TOI, 2023). The burning of petrol and diesel releases carbon dioxide into the atmosphere, imposing multiple negative externalities on Delhi's community like pollution, respiratory problems and unnatural weather conditions. This leads to loss of productivity and higher healthcare costs for the third party, in this case, the residents of Delhi. In fact, a study found that the economic costs of air pollution in Delhi were Rs. 4.08 billion for healthcare expenditure and Rs. 31.28 billion for productivity loss (Chowdhury, 2023). A broader estimate by OECD suggests that ambient air pollution may cost India more than USD 500 billion per year (OECD, 2016).

To mitigate the impact of fuel-based vehicles, the Indian government has taken steps to promote electric vehicle adoption. One initiative is the Delhi Electric Vehicle Policy-2020, which aims to reduce vehicular air pollution, making Delhi a leader in electrification.

Electric vehicles offer multifaceted environmental benefits, producing zero tailpipe emissions and releasing nearly three times lesser carbon dioxide than petrol and diesel cars, even when production emissions are considered (e-AMRIT, 2022). They also consume 58% less energy than gas-powered vehicles, enhancing efficiency (EPA, 2019). According to a study by TERI and ARAI, electrifying 6% of Delhi's vehicular fleet, including 3% of its public transport, would improve ambient air quality by 9% (Saraf, 2018).

1.2 Outline of the Scope

Given the severe impact of vehicular emissions on Delhi's air quality, evidenced by a 25% increase in average AQI since 2014, alongside an estimated Rs. 20,000 crore yearly expenditure in public health due to pollution, evaluating the effectiveness of government policies in promoting sustainable transport is essential (Garg, 2020; Dandona, 2020). Public transport, particularly buses, is necessary to reduce congestion and pollution, making the transition to electric buses vital. However, the success of such policies depends on their ability to drive actual demand amongst commuters and operators.

Henceforth, this essay aims to answer the research question:

"To what extent has the Delhi Electric Vehicle Policy-2020 affected the demand for electric buses in Delhi from 2020-2023?".

By assessing the policy's impact on bus electrification, this essay will reveal whether policy interventions alone are sufficient or if additional measures are required to accelerate adoption, offering deeper insights into the role of policy in advancing green transportation worldwide.

2. METHODOLOGY

2.1 Analysis of Secondary Sources to evaluate effectiveness of the Delhi Electric Vehicle Policy-2020 in increasing percentage of electric buses and public acceptance in Delhi:

I. Policy Paper- Delhi Electric Vehicle Policy-2020: This policy paper serves as the foundation for this investigation, outlining the government's goals and specific implementation strategies like subsidies and tax exemptions, providing a clear framework to evaluate intended policy outcomes. However, the policy sets ambitious targets without measuring real-time progress which limits analysis.

II. Government Reports: Thus, government reports were used to obtain an official assessment of the policy's progress through statistics on adoption and future projections. The *Delhi Government Policy Progress Report*, for instance, was published in 2022 within the study period, making it relevant to analysing the policy's early impact. Additionally, *Delhi Transport Corporation* reports were used to understand existing bus regulations and tax structures, providing context for how the policy has influenced preexisting operating conditions. While these government reports are firsthand and reliable, they may reflect biases towards emphasizing positive outcomes. Thus, independent data and studies were incorporated to validate the findings.

III. Datasets from Delhi Transport Department (DTD, 2019-2023): These datasets, covering year 2019-2023, provided official records of total and electric buses in Delhi, allowing for an objective evaluation of the policy's effectiveness through numerical data. Since DTD is a government authority that oversees public transport policies, the data is officially recorded and reliable, reducing the risk of inaccuracies to ensure credibility. This data was used to logistically model the percentage of electric buses in Delhi and extrapolate a predicted value for Delhi's electric buses in 2025. But, these datasets lack insights into public acceptance and commuter preferences, indicating the need for a more holistic perspective.

IV. Research Studies: To complement the numerical analysis, research studies from credible journals like *Econometrica* and *Ecological Economics* were referenced to gain deeper insights into operator preferences, commuter behaviour and social acceptance of electric buses. The trends highlighted in these papers guided the design of survey and interview questionnaires used in this investigation. Nevertheless, academic research is based on specific samples that may not fully represent Delhi's context, suggesting the requirement for primary methods that ensure generalizability to Delhi's population.

2.2 Conducting a Quantitative Survey to determine price elasticity of demand (PED) of electric buses to analyse the effectiveness of tax exemptions: A survey was conducted with 25 private transport operators, from a population of approximately 100 operators in Delhi. The survey focused on how exemptions in road taxes and vehicle registration fees would influence their willingness to purchase electric buses. Surveying transport operators, directly affected by tax policies, reinforced the data's relevance while providing a broader perspective. Their responses were used to calculate the PED for yearly maintenance costs of electric buses, a factor influencing electric bus purchase decisions. The PED values were then used to determine the effectiveness of price exemptions in increasing electric bus demand.

2.3 Conducting a Structured Interview to measure public demand for electric buses in Delhi: A structured interview was conducted with a purposive sample of 50 daily commuters who had used both electric and conventional buses. The participants were interviewed about the factors influencing their bus choice, their preferences, and the impact of fare changes. Gathering insights from regular users ensured real-world relevance and credibility. The reliability of this method is strengthened by the structured format, which ensured consistent and focused responses from all participants. Moreover, the purposive sample ensured comprehensive feedback from participants familiar with both bus types.

3. DELHI ELECTRIC VEHICLE POLICY-2020

The Delhi Electric Vehicle Policy-2020 has been named the most progressive EV policy in India with an ambitious vision of having **1 out of every 4 vehicles sold in Delhi to be electric by 2024** (Delhi Transport, 2023). Its primary objective is to accelerate the pace of

EV adoption by supporting the electrification of buses amongst other four wheelers, good carriers and cars.

Table 1: *Revisions and Extensions to the Delhi Electric Vehicle Policy-2020*

Date	Action	Details
August 7, 2020	Initial Notification	Delhi Electric Vehicle-Policy 2020 is initially notified for August 2020-2023.
August, 2023	Extension till December, 2023	Policy extended to include more aggressive measures.

After policy revision, the Government of National Capital Territory of Delhi (GNCTD) committed to providing subsidies and tax exemptions to ensure that electric buses constitute **at least 80% of all buses in Delhi by 2025** (Switch Delhi, 2024).

Subsidy offered by Delhi Electric Vehicle Policy-2020

A subsidy is a benefit provided by the government, in the form of a payment or payment reduction, to encourage the production or consumption of a merit good (Cambridge, 2024). In this case, the policy offers a subsidy to electric bus operators (consumers) via a payment reduction of Rs. 5,000 per kWh of the battery capacity up to Rs. 30,000 on each EV. For comparison, private battery distributors and firms in India charge between Rs. 11,000 to Rs. 15,000 per kWh for electric batteries (Raizada, 2023).

Table 2: *Subsidy on electric bus batteries*

Battery Capacity (kWh)	Market Price of Battery (₹)	Subsidy (₹5,000 per kWh, up to ₹30,000)	Cost after Subsidy (₹)	% Change in Battery Price (₹)
120 kWh	1,560,000	30,000	1,530,000	-1.92%
350 kWh	4,550,000	30,000	4,520,000	-0.66%
400 kWh	5,200,000	30,000	5,170,000	-0.58%
500 kWh	6,500,000	30,000	6,470,000	-0.46%

The battery capacity 120 kWh is representative of a typical 9-meter bus, 350-400 kWh represent a typical 12-meter bus, while the 500 kWh capacity represents an 18-meter bus.

Tax Exemption offered by Delhi Electric Vehicle Policy-2020

Road tax is levied by the government on vehicles for using public roads. It is typically collected through tolls and vehicle registration (Haryana Transport, 2021). The policy proposes that road tax and registration fees be waived for all electric vehicles in Delhi during the policy period, 2020-2023. This tax exemption aims to increase electric bus demand amongst operators by reducing its cost.

Table 3: *Quarterly road tax for buses in Delhi based on seating capacity*

Seating Capacity	Quarterly Road Tax Applicable (₹)
Less than 18 passengers	1915
More than 18 passengers	1915 + 280 per additional passenger

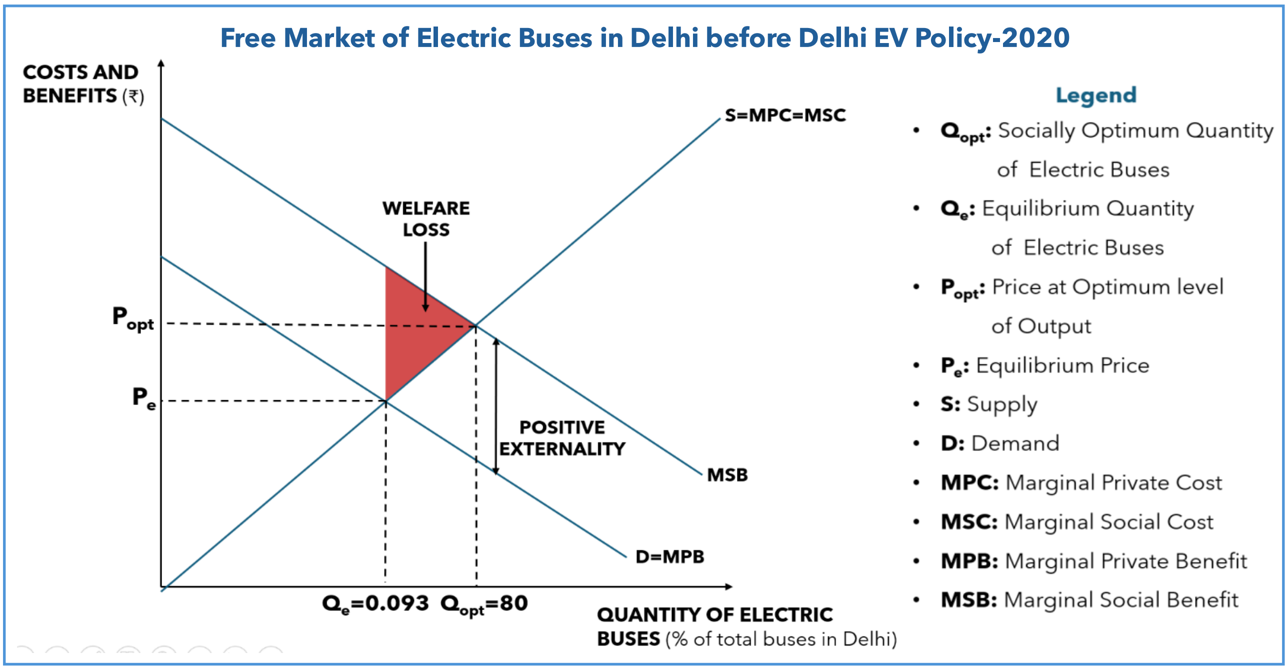
Moreover, the vehicle registration fee is Rs. 1000 for buses with less than 40 passengers and Rs. 1500 for buses with 40 or more passengers (Delhi Transport, 2023). These taxes will be exempted for all electric buses during the policy period (GNCTD, 2020).

Therefore, the focus of this essay is to **investigate the impact of subsidies and tax exemptions on demand for electric buses.** The demand for electric buses will be measured for two consumer segments: private transport operators and commuters (end users).

4. ECONOMIC BACKGROUND

Market failure occurs when the market is unable to allocate resources efficiently, leading to allocative inefficiency. In Delhi, the free market for electric buses exhibits such allocative inefficiency through **underconsumption**. Electric buses are merit goods, meaning they generate positive externalities, but consumers only focus on their private benefits and neglect broader public gain. As short-term utility maximisers, consumers demand fewer electric buses despite their long-term benefits, resulting in their under-allocation in Delhi.

Figure 1: *Free Market of Electric Buses in Delhi before Delhi Electric Vehicle Policy-2020*



The diagram represents Delhi's electric bus market in 2019, before the Delhi Electric Vehicle Policy-2020. That year, only 0.093% of buses were electric (Q_e=0.093%) (Refer to ***Table 4)***. At this quantity, marginal private benefit (MPB) equals marginal private cost (MPC) and marginal social cost (MSC), indicating that consumers focused on private benefits of electric buses, while ignoring external gains. This resulted in underconsumption as indicated by the marginal social benefit (MSB) curve that lies above the demand curve (D=MPB). This market failure (Q_{opt}>Q_e) results in lost social benefits like reduced pollution (World Bank, 2022). To incur these benefits, 80% of all buses must be electrified as (Q_{opt}=80%).

5. DATA COLLECTION, PROCESSING & ANALYSIS

5.1 Secondary Data to determine effectiveness of Delhi Electric Vehicle Policy-2020

To determine the policy's effectiveness in increasing demand for electric buses, DTD's dataset was used to compare the change in number of electric buses in Delhi, before the policy (August 2019) and during the policy (August 2020-December 2023). Upon processing this data, the percentage of electric buses in Delhi has been calculated below.

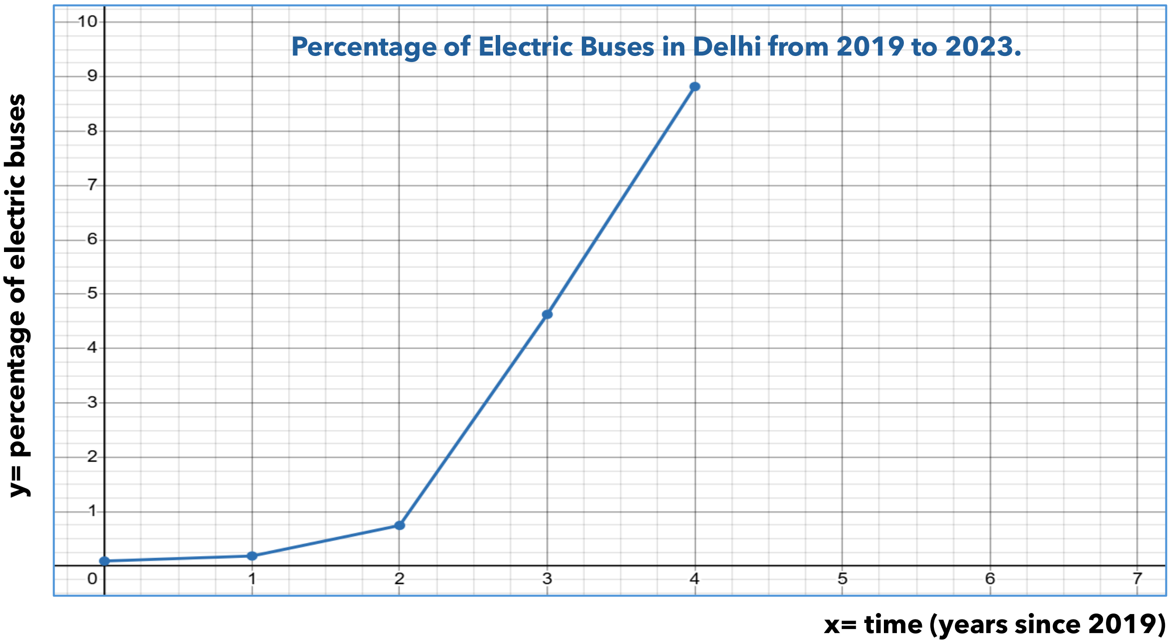
Table 4: *Quantity of electric buses before and during Delhi Electric Vehicle Policy-2020*

Year	**Quantity of Electric Buses in Delhi**	**Quantity of Total Buses** *(including fuel-based)*	**Percentage of Electric Buses of Total (%)**
2019	30	32,220	0.093%
2020	62	33,300	0.186%
2021	249	33,290	0.748%
2022	800	17,280	4.629%
2023	1650	18,700	8.82%

5.2 Analysis of Secondary Data

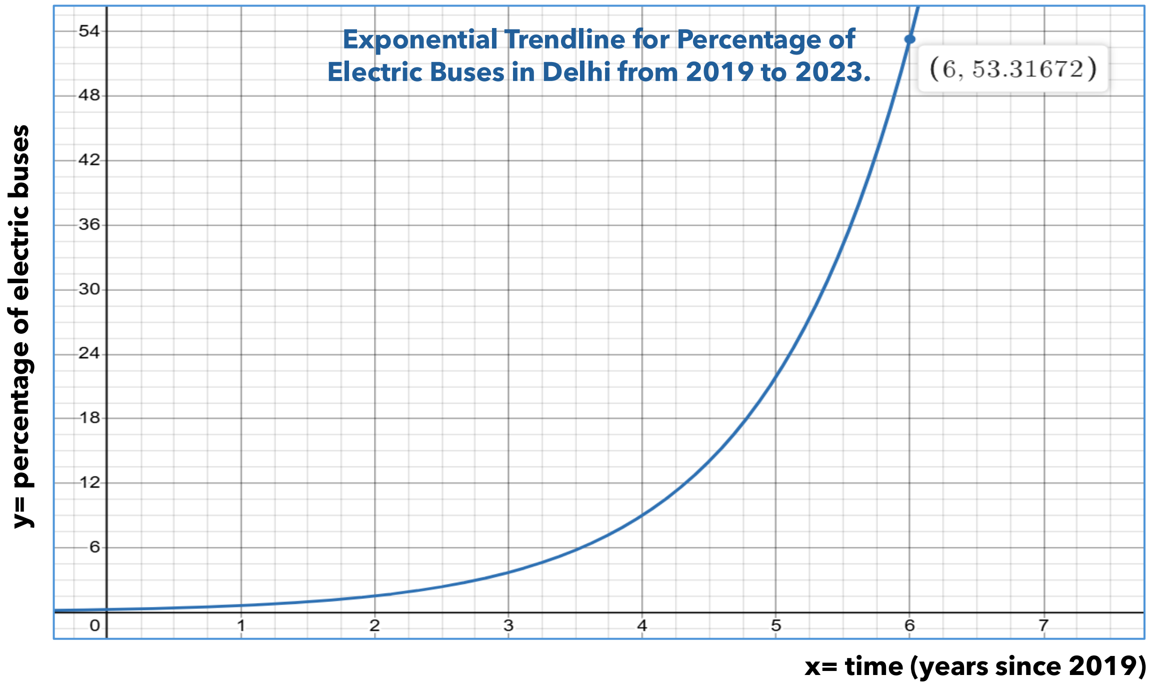
The data shows a consistent rise in the quantity of electric buses in Delhi. During the 5-year period, the number of electric buses **increased by 5400%,** from 30 to 1650. Moreover, the **percentage of electric buses** from total buses **increased from 0.093% to 8.82%** from 2019 to 2023**.** This highlights that the **Delhi Electric Vehicle Policy-2020 has been effective in increasing the demand for electric buses** to an extent. To quantify this extent, the Delhi Electric Vehicle Policy will be assessed on its potential of achieving the Delhi government's goal of **electrification of 80% buses by 2025.** This has been done by modelling a trendline:

Figure 2: *Percentage of electric buses in Delhi from 2019 to 2023*



Next, technology, specifically a Desmos Graphing Calculator, has been used to perform an exponential regression to estimate a line of best fit:

Figure 3: *Exponential trendline predicting percentage of electric buses in Delhi in 2025*



This trendline is represented by the function:

$$y = 0.258869 \times 2.43014^x,$$

where y is the percentage of electric buses in Delhi and x is the time in years since 2019.

Since 2019 is $x = 0$, 2025 will be $x = 6$. Substituting this into the function:

$$y = 0.258869 \times 2.43014^6 \approx 53.32\%$$

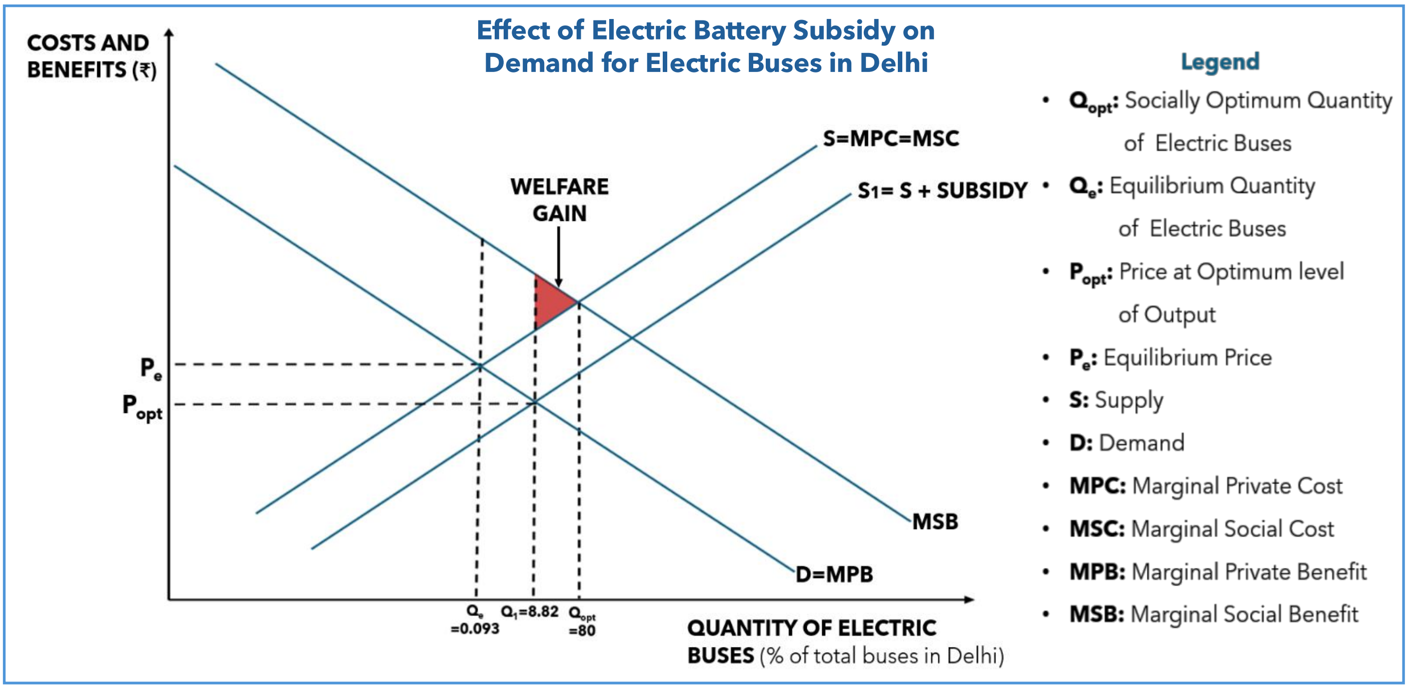
The same value $(6, 53.32)$ has been extrapolated and marked on the graph above.

The model predicts a **53.32% adoption rate of electric buses by 2025**, which, while a significant increase, is lower than the socially optimal 80%, suggesting that the **Delhi Electric Vehicle Policy-2020** alone is **insufficient** in achieving this target. However, this conclusion depends on the assumption that adoption will continue at a constant rate. In actuality, factors like infrastructure expansion and financial incentives could accelerate adoption while supply chain disruptions or lack of operator willingness could slow it down (Phuthong, 2024). This can be seen in years 2020 and 2021, where the COVID-19 pandemic introduced financial uncertainty, reducing operator spending and public transport usage. This slowdown shaped the model's exponential pattern. Comparing this policy to other cities, like Shenzhen and Oslo where an aggressive combination of subsidies and mandates led to complete electrification, we can conclude that Delhi's approach is milder due to its reliance on incentives instead of legislation (Li, 2020; Glasco, 2023). Future adjustments like mandatory electrification may be necessary to close this gap.

Economic Theory

Although multiple factors have driven the rise in electric bus demand, we will analyse the impact of the battery subsidies provided by the Delhi Electric Vehicle Policy (Refer to **Table 2**). The subsidy's effect can be seen as:

Figure 4: *Effect of electric battery subsidy on demand for electric buses in Delhi*



In the free market, electric buses were produced and consumed at Q_e (0.093% of total buses). The subsidy on electric batteries shifted the supply curve for electric buses from S to S_1, lowering the commercial price of electric buses from P_e to P_{opt}. This price reduction, ranging from 0.34%-1.43% (depending on the type of bus as calculated in ***Table 2***), likely incentivized transport operators to purchase electric buses, increasing e-bus demand. This resulted in a new market equilibrium $P_{opt}Q_1$, which reflects an increased adoption rate of 8.82% by 2023. However, this diagram isolates the subsidy's impact without considering other components of the policy like tax exemptions, making it reductive such that it may overestimate the subsidy's effectiveness alone. To address this, we will analyse the role of tax exemptions by calculating the price elasticity of demand (PED) of electric buses.

5.3 Quantitative Survey to determine price elasticity of demand (PED) of electric buses

PED is the degree of responsiveness of percentage change in quantity demanded to percentage change in price, as represented by the formula:

$$\text{PED} = \frac{\%\Delta\, Quantity\ Demanded}{\%\Delta Price}$$

The PED of a good can either be elastic or inelastic:

- PED < 1 **(Inelastic Demand)**: Change in price leads to a proportionally smaller change in quantity demanded.
- PED > 1 **(Elastic Demand)**: Change in price leads to a proportionally larger change in quantity demanded.

To assess the impact of tax exemptions on electric bus demand, we will determine the PED for the bus's annual maintenance costs which include taxes and road fees. This approach is justified as maintenance costs are a recurring expenses that directly impact an operator's financial feasibility. A study revealed that 77% of Indian bus operators are influenced by annual maintenance costs in their decision to purchase a bus (Dawda, 2024). Hence, a quantitative survey with 25 private transport operators in Delhi was conducted (Appendix 1). They were asked how changes in road taxes and vehicle registration fees would affect their decision to purchase an electric bus. For the survey, buses were categorized into two types: 18-seater and 40-seater. Their average annual maintenance costs were set at Rs. 1.5 lakhs and Rs. 2.5 lakhs respectively using existing information (Vijaykumar, 2021).

Table 5: *Quantity of 18-seater electric buses demanded at different maintenance costs.*

Percentage Change in **Maintenance Cost** of Electric Bus	**Total Quantity** of Electric Buses **Demanded** by **25 respondents**	**Average Quantity** of Electric Buses **Demanded per respondent**
+20.00%	10	0.40
+15.00%	13	0.52
+10.00%	16	0.64
+5.00%	18	0.72
0.00%	19	0.76
-5.00%	19	0.76
-10.00%	21	0.84
-15.00%	24	0.96
-20.00%	27	1.08

Table 6: *Calculation of PED for 18-seater electric buses*

$\%\Delta \boldsymbol{Price}$ $(Maintenance\ Cost)$ of Electric Bus	**Average Quantity Demanded** (Q_d) for Electric Buses	$\%\Delta\ \boldsymbol{Quantity\ Demanded}$ for Electric Buses (Initial Q_d= 0.76)	**PED**
+20.00%	0.40	$\frac{New\ Q_d - Initial\ Q_d}{Initial\ Q_d} \times 100$ $\frac{0.40-0.76}{0.76} \times 100 =$ -47.37%	$\frac{\%\Delta\ Q_d}{\%\Delta Price}$ $\frac{-47.37}{20.00} =$ -2.37
+15.00%	0.52	-31.58%	-2.10
+10.00%	0.64	-15.79%	-1.58
+5.00%	0.72	-5.26%	-1.05
0.00%	0.76	0.00%	0.00
-5.00%	0.76	0.00%	0.00
-10.00%	0.84	10.53%	-1.05
-15.00%	0.96	26.32%	-1.75
-20.00%	1.08	42.11%	-2.10

Hence, the average PED for annual maintenance costs of an 18-seater electric bus is:

$$\frac{Sum\ of\ PED\ values}{Number\ of\ PED\ values} \approx \frac{-12}{9} \approx -1.33$$

Now, the same calculations have be done for the 40-seater electric bus:

Table 7: *Quantity of 40-seater electric buses demanded at different maintenance costs.*

Percentage Change in **Maintenance Cost** of Electric Bus	**Total Quantity** of Electric Buses **Demanded** by **25 respondents**	**Average Quantity** of Electric Buses **Demanded per respondent**
+20.00%	9	0.36
+15.00%	11	0.44
+10.00%	14	0.56
+5.00%	15	0.60
0.00%	15	0.60
-5.00%	17	0.68
-10.00%	18	0.72
-15.00%	20	0.80
-20.00%	22	0.88

Table 8: *Calculation of PED for 40-seater electric buses*

$\%\Delta \boldsymbol{Price}$ $(Maintenance\ Cost)$ of Electric Bus	**Average Quantity Demanded** (Q_d) for Electric Buses	$\%\Delta$ $\boldsymbol{Quantity\ Demanded}$ for Electric Buses (Initial Q_d= 0.60)	**PED**
+20.00%	0.36	$\frac{New\ Q_d - Initial\ Q_d}{Initial\ Q_d} \times 100$ $\frac{0.36-0.60}{0.60} \times 100 =$ -40.00%	$\frac{\%\Delta\ Q_d}{\%\Delta Price}$ $\frac{-40.00}{20.00} =$ -2.00
+15.00%	0.44	-26.66%	-1.78
+10.00%	0.56	-6.67%	-0.67
+5.00%	0.60	0.00%	0.00
0.00%	0.60	0.00%	0.00
-5.00%	0.68	13.33%	-2.66
-10.00%	0.72	20.00%	-2.00
-15.00%	0.80	33.33%	-2.22
-20.00%	0.88	46.66%	-2.33

Similarly, the average PED for annual maintenance costs of a 40-seater electric bus is:

$$\frac{Sum\ of\ PED\ values}{Number\ of\ PED\ values} \approx \frac{-13.66}{9} \approx -1.52$$

Therefore, the overall PED for annual maintenance costs for all electric buses in Delhi is:

$$\frac{(-1.52)+(-1.33)}{2} \approx -1.425$$

5.4 Analysis of PED of electric buses to determine effectiveness of tax exemptions

The overall PED for annual maintenance costs of electric buses in Delhi is **1.425**, indicating that **demand** for electric buses is **responsive to changes in maintenance costs** and, thus, it is **price elastic**. Therefore, we can conclude that the Delhi Electric Vehicle Policy-2020 is effective in encouraging electric bus adoption among operators.

To deepen this analysis, the PED values for both categories of electric buses have been compared with their corresponding tax exemption rates (Refer to ***Table 3***).

For 18-seater electric buses, the quarterly tax exemption is Rs. 1915 coupled with a Rs. 1000 exemption of vehicle registration. Hence, the annual tax exemption amounts to **Rs. 8660** which is **5.77%** of the yearly maintenance cost. While the overall PED for an 18-seater bus's maintenance costs is **-1.33**, the PED at a **5% price reduction** is **0.00,** suggesting inelastic demand close to this exemption rate. Therefore, the **-5.77% exemption is insufficient in increasing demand for 18-seater electric buses,** and a larger exemption in maintenance costs around -10.00% would encourage bus operators to switch to electric buses.

For 40-seater electric buses, the quarterly road tax exemption includes Rs. 1915 for the first 18 passengers and an additional Rs. 280 per passenger for the remaining 22 passengers $(40 - 18 = 22)$. Along with the Rs. 1500 exemption on the vehicle registration fee, this results in an annual tax exemption of **Rs. 33,800,** approximately **13.52%** of the yearly maintenance cost. Given the 40-seater buses' overall PED of **-1.52** and the PED of **2.00** at a **10% price reduction,** it is clear that demand is responsive close to this rate of exemption. Thus, the **13.52% exemption is effective in driving demand for 40-seater buses.**

Conclusively, while reducing maintenance costs through tax exemptions is beneficial, it assumes that operating costs are the primary barrier to electric bus adoption. Instead, the upfront purchasing cost of electric buses influences the operator's purchase decision more significantly, as it is higher than that of fuel-based buses (Laizans, 2016). The assumption that reducing maintenance costs alone will drive e-bus demand overlooks the constraints of smaller operators struggling with initial capital investment (Rout, 2021).

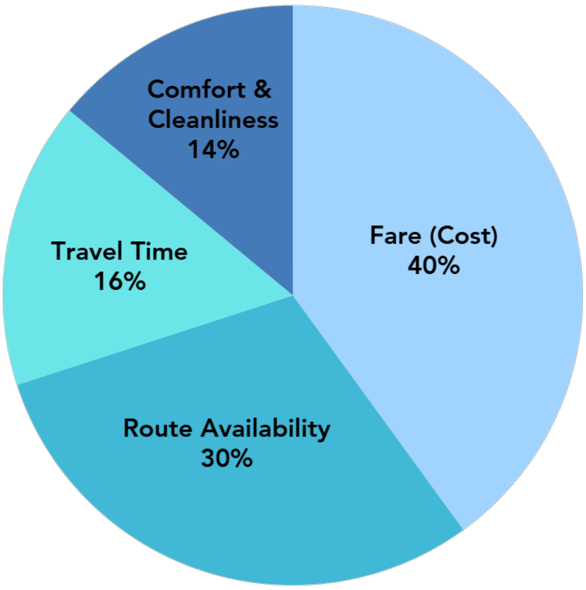
Moreover, the policy primarily benefits existing electric bus owners by lowering maintenance costs rather than incentivizing new demand. Thus, it fails to address all stakeholders in the bus operating sector. Instead, reducing the initial cost through direct subsidies or provisions may be more effective.

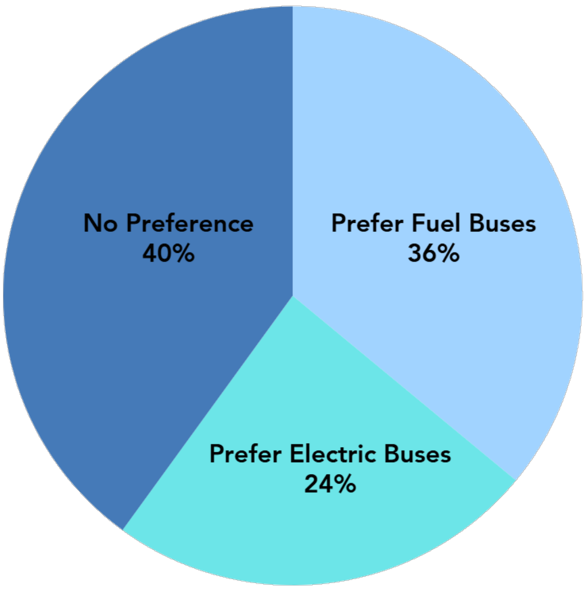
5.5 Structured Interview to measure public demand for electric buses in Delhi

These structured interviews with 50 daily commuters aimed to identify the factors influencing Delhi commuters' bus choices. These insights were used to assess the Delhi Electric Vehicle Policy-2020's effectiveness in increasing ridership, while recognizing gaps in the policy that could be closed to encourage a conscious shift towards electric buses (Appendix 3).

Structured Interview Responses

Question 1: What is the primary factor influencing your choice of bus for commute?		
Response	**Number**	**Percentage**
Fare (Cost)	20	40%
Route Availability	15	30%
Travel Time	8	16%
Comfort & Cleanliness	7	14%

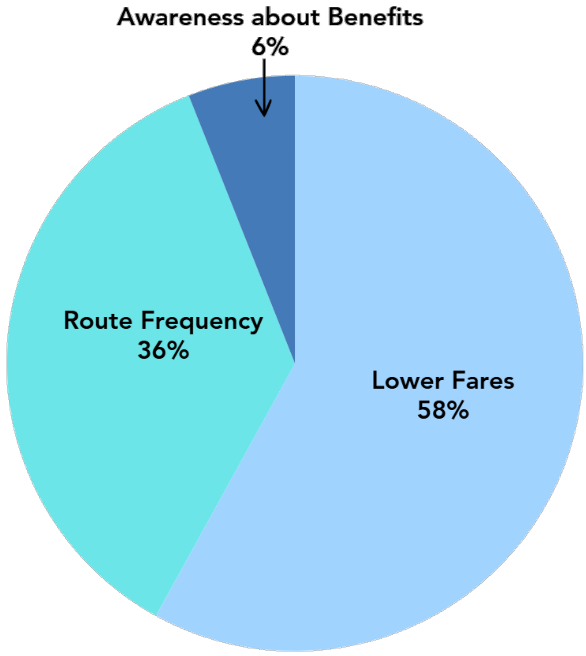




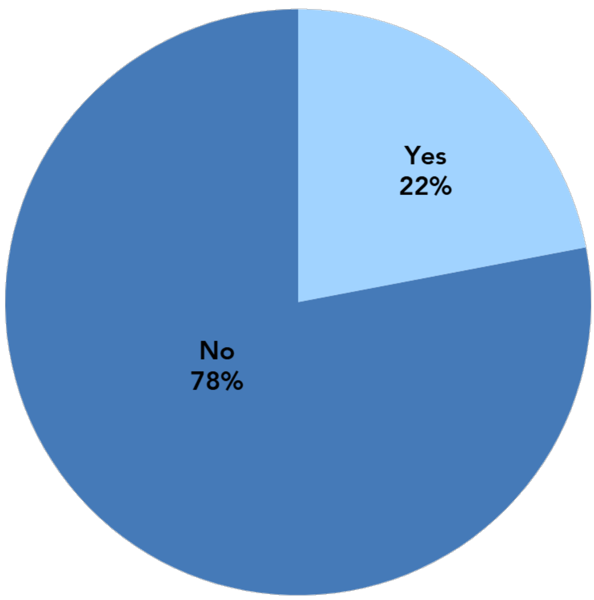
Question 2: Do you actively choose between electric and fuel-powered buses for commute?		
Response	**Number**	**Percentage**
Yes, I prefer fuel buses	18	36%
Yes, I prefer electric buses	12	24%
No preference	20	40%

Follow-up for Question 2: What drives your preference for electric/fuel-powered buses?	
Response	**Number**
Preference for fuel-powered buses due to:	**Total=** 18
• Convenience	13
• Faster travel time	5
Preference for electric buses due to:	**Total=** 12
• Cleanliness and Comfort	8
• Eco-friendliness	4
No preference	**Total=** 20

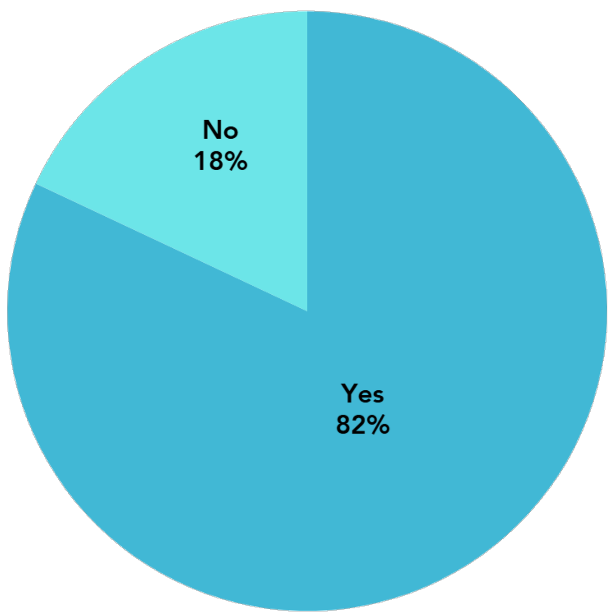
Question 3: What measures, in your opinion, would encourage more people to use electric buses?		
Response	**Number**	**Percentage**
Lower Fares	29	58%
Frequency of Routes	18	36%
Awareness Campaigns about e-bus Benefits	3	6%



Question 4: Do you consider the environmental impact when choosing to commute by bus?		
Response	**Number**	**Percentage**
Yes	11	22%
No	39	78%



Question 5: Would a 10% fare reduction influence your decision to choose a particular bus?		
Response	**Number**	**Percentage**
Yes	41	82%
No	9	18%



5.6 Analysis of structured interview to determine public demand for electric buses

36% of respondents indicated that increasing route frequency would boost demand for electric buses. Higher frequency requires more buses, a target partially achieved by the Delhi Electric Vehicle Policy, as seen in the increase from 0.093% to 8.82% electric buses (*Section 5.1)*. However, multiple factors influence demand for electric buses amongst Delhi's commuters, and the policy's effectiveness is limited by its inability to address these:

I. Low Convenience and Route Availability

An important factor influencing 30% of respondents' decision to commute is the availability of routes. With only 1650 electric buses of 18,700 total buses, the number of routes covered by e-buses is limited to only 25% of Delhi's 606 routes (DTC, 2024). Thus, while the policy has been successful in increasing the number of electric buses, it has not ensured their strategic deployment across high-demand routes, which is vital for stakeholders like daily workers who rely on public transportation to commute to work (Krishnan, 2019). This is supported by the fact that 36% of respondents believe that increasing route frequency would drive public demand for e-buses.

A majority of commuters still prefer fuel-powered buses due to their convenience, as stated by 13 respondents, and faster travel time, as mentioned by 5 respondents. This preference is driven by the inconvenience of e-bus routes. Further, newer e-buses are equipped with speed sensors and GPS tracking, which prevents reckless driving but also leads to longer travel times, which is less favourable as indicated by commuters (Switch Delhi, 2022). While maintaining these safety measures, the policy could have implemented a targeted expansion strategy to optimize route allocation, ensuring wider access to e-buses. **By failing to address route coverage, the Delhi Electric Vehicle Policy-2020 is ineffective in increasing public demand for electric buses.**

II. Knowledge Gap about e-bus Benefits

6% of respondents stated that awareness campaigns can encourage public demand for e-buses, supported by the fact that 78% of respondents fail to consider environmental impact when choosing their mode of commute. Research shows that electric buses can eliminate the social costs of fuel buses estimated at $43,800 per bus, but low awareness prevents commuters from availing these social benefits (Choma, 2024). The policy's assumption that bus expansion alone will drive adoption overlooks the importance of addressing the knowledge gap to inform commuters' decisions. To induce behavioural change, educational campaigns or nudges must be incorporated. **Therefore, the Delhi Electric Vehicle Policy-2020 is ineffective in increasing public demand for e-buses due to the lack of awareness about their social benefits.**

III. Standardized Prices

Bus fares in Delhi are standardized for both electric and fuel-powered buses (DTC, 2023). 40% of respondents indicated fare as a primary factor, with 82% agreeing that a 10% fare reduction would influence their choice of commute. By standardizing fares for fuel and electric buses, despite the lower operational cost of e-buses, many commuters found electric buses "expensive" (Anas, 2019). This pricing structure assumes that commuters will pay the same fare regardless of bus type, neglecting that lower fares could incentivize adoption. **By failing to adjust bus fares to reflect the cost advantages of electric buses, the Delhi Electric Vehicle Policy-2020 is ineffective in increasing public demand.**

6. CONCLUSION

In conclusion, the effectiveness of the Delhi Electric Vehicle Policy-2020 in increasing demand for electric buses varies for the two stakeholders: commuters and bus operators.

Analysis of secondary data revealed an 8.82% increase in electric bus adoption during the 4-year period, indicating increasing demand among transport operators. However, extrapolation shows that, at this rate, the policy will be **ineffective in achieving the socially optimal target of 80% bus electrification by 2025** and will, instead, reach an estimated 53.32% rate of electrification.

The policy has been **effective to some extent in encouraging operators to adopt electric buses**, through battery subsidies and exemptions on registration fees and taxes, which reduce maintenance costs, making e-buses more affordable for operators. This was reflected in the price elastic demand for electric buses, which responded to changes in maintenance costs. However, this only addresses one aspect of the decision-making process, neglecting larger upfront costs of e-buses that may lower demand.

On the commuter side, structured interviews revealed that the policy has been **ineffective to a great extent in addressing key factors that drive electric bus demand**, like **availability, awareness,** and **affordable fares**, leading to low ridership and public demand.

Thus, the research question, **"To what extent has the Delhi Electric Vehicle Policy-2020 affected the demand for electric buses in Delhi from 2020-2023?"** has been answered by concluding that the policy alone has had a limited impact on increasing commuter demand, due to its failure to address commuter preferences like convenience, education, and lower costs. While the Delhi Electric Vehicle Policy-2020 has been somewhat effective in incentivizing bus operators, through subsidies and tax exemptions, the **current pace of adoption will not meet the government's 80% electrification target by 2025.**

I. Potential Solutions

To overcome the policy's limitations, the government can subsidize upfront costs instead of solely batteries and maintenance costs. Drawing inspiration from China's 40,000-strong electric bus fleet, direct subsidies or low-interest loans can be offered to facilitate adoption, especially amongst smaller operators (Sovacool, 2017). Educational campaigns like billboards and real-time carbon footprint trackers, implemented in Amsterdam, can be incorporated to bridge the knowledge gap about electric transport's social benefits, encouraging commuters to actively choose e-buses (Amsterdam Smart City, 2022).

II. Limitations

The quantitative survey was limited to private transport operators, failing to reflect public agencies' purchasing decisions, such as those of the Delhi Transport Corporation. However, since these insights were used to calculate the price elasticity of demand for electric buses, this sample is appropriate here as private agencies primarily respond to tax incentives, while public agencies may not.

Moreover, the structured interview utilized a small sample of 50 daily commuters, which may not fully represent Delhi's diverse population. Nevertheless, purposive sampling ensured that participants had experience with both electric and conventional buses, making their insights relevant. Referring to secondary research studies on public perception further mitigated this limitation by providing a broader perspective on social acceptance.

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6. APPENDIX

Appendix 1: Quantitative Survey **(Questionnaire)**

Company Name:
Company Size:
You will be given two categories of buses and will be required to answer questions for each:

Category 1: An 18-seater electric bus sold at Rs. 90 lakhs with Rs. 1.5 lakhs annual maintenance cost.

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1. How many 18-seater electric buses are you willing to purchase?
2. How many 18-seater electric buses are you willing to purchase if maintenance costs increase by 5%?
3. How many 18-seater electric buses are you willing to purchase if maintenance costs increase by 10%?
4. How many 18-seater electric buses are you willing to purchase if maintenance costs increase by 15%?
5. How many 18-seater electric buses are you willing to purchase if maintenance costs increase by 20%?
6. How many 18-seater electric buses are you willing to purchase if maintenance costs decrease by 5%?
7. How many 18-seater electric buses are you willing to purchase if maintenance costs decrease by 10%?
8. How many 18-seater electric buses are you willing to purchase if maintenance costs decrease by 15%?
9. How many 18-seater electric buses are you willing to purchase if maintenance costs decrease by 20%?

Category 2: A 40-seater electric bus sold at Rs. 1.5 crore with Rs. 2.5 lakhs annual maintenance cost.

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1. How many 40-seater electric buses are you willing to purchase?
2. How many 40-seater electric buses are you willing to purchase if maintenance costs increase by 5%?

3. How many 40-seater electric buses are you willing to purchase if maintenance costs increase by 10%?
4. How many 40-seater electric buses are you willing to purchase if maintenance costs increase by 15%?
5. How many 40-seater electric buses are you willing to purchase if maintenance costs increase by 20%?
6. How many 40-seater electric buses are you willing to purchase if maintenance costs decrease by 5%?
7. How many 40-seater electric buses are you willing to purchase if maintenance costs decrease by 10%?
8. How many 40-seater electric buses are you willing to purchase if maintenance costs decrease by 15%?
9. How many 40-seater electric buses are you willing to purchase if maintenance costs decrease by 20%?

Appendix 2: Structured Interview **(Questionnaire)**

Age: Duration of Electric Bus Usage:

1. What is the primary factor influencing your choice of bus for commuting?
2. (a) Do you actively choose between electric and fuel-powered buses for commute?
   (b) **Follow Up:** What drives your preference for electric/fuel-powered buses?
3. What measures, in your opinion, would encourage more people to use electric buses?
4. Do you consider the environmental impact when choosing to commute by bus?
5. Would a 10% fare reduction influence your decision to choose a particular bus?