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LONG RANGE PLANNING FOR ELECTRIC VEHICLE CHARGING STATIONS SIZING FOR SÃO CAETANO DO SUL´S MASTER PLAN

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ABSTRACT

This study aimed to conduct discrete-event simulations using Simul8 in key locations within the city of São Caetano do Sul, Brazil (shopping mall; supermarkets; gas stations) to assess the current level of service provided by electric vehicle charging stations. Simulations are also carried out to evaluate future scenarios, considering the projected growth of electric vehicles both nationally and within the city. In partnership with municipal departments, this work is providing valuable insights to the city's master plan, currently under development, which will outline strategic guidelines for urban growth over the next ten years. In addition to assessing current infrastructure performance, the study seeks to determine the optimal number of charging stations required to ensure a satisfactory level of service under different future demand scenarios.

1 INTRODUCTION AND RELATED WORKS

Electric vehicles (EVs) are rapidly gaining market share worldwide, but in Brazil their expansion is hindered by the lack of a structured public charging network. In São Caetano do Sul, one of the cities with the highest per capita EV growth, public agencies such as SEMOB have begun strategic planning to align infrastructure with rising demand. At the same time, companies like ABB have expanded operations in Brazil, offering scalable slow and fast-charging solutions. To support these efforts and foster EV adoption, this study analyzed charging capacity at high-traffic locations in the city, considering current demand and projecting growth over the next 10 years to guide infrastructure planning and strategic decisions.

Çelik and Ok (2024) develop an optimization and simulation model for planning the location and capacity of EV charging stations, tackling key barriers to EV adoption like limited infrastructure, battery limits, and high costs. Their approach reduces travel distances and waiting times.

Ramirez-Nafarrate et al. (2021) employed discrete-event simulation to evaluate the charging capacity of electric vehicles along the interurban route between Guadalajara and Mexico City. The results showed that the existing infrastructure is insufficient for BEVs with lower range and that new stations can reduce trip failures, but also transfer congestion to neighboring locations. The study highlights the role of simulation in capturing traffic variability and revealing not only geographical coverage.

2 SIMULATION MODEL

For the simulation, charging stations were categorized into on-demand and convenience. On-demand charging occurs mainly at gas stations, requiring fast chargers up to 120 kW and averaging 30 minutes. This profile is typically associated with app-based drivers (e.g., Uber) who depend on immediate charging. Convenience charging takes place in locations such as malls and supermarkets, where slow chargers (~7 kW) allow charging during longer stays, often at no additional cost beyond parking.

For convenience charging, demand is strongly linked to charger availability: if a charger is free, EV drivers tend to use it even without urgent need. To represent this behavior, service levels of 50%, 60%, and

80% were tested. For on-demand stations, where charging is immediate and critical, higher service levels of 90%, 95%, and 99% were applied.

Demand estimation combined traffic flow data from SEMOB with current EV penetration (2% of the fleet). Two gas station profiles were modeled: high-flow stations on main avenues and local stations on secondary roads. For convenience points, demand was estimated from current daily usage patterns.

A discrete-event simulation model in Simul8 incorporated arrival rates, charger power, station capacity, and length-of-stay distributions. Current service levels are: shopping mall – 8 chargers (25%); supermarket – 2 chargers (25%); market – 1 charger (54%); high-flow gas station – no chargers; local gas station – 2 chargers (80%). Future demand scenarios (2026, 2030, 2035) were projected assuming EV fleet shares of 2%, 6.18%, and 11.78%, obtained through regression analysis. Simulation results for convenience charging are presented in Table 1, and for on-demand charging in Table 2.

Table 1: Convenience charging results.

Place	Service Level	2026 Scenario	2030 Scenario	2035 Scenario
Shopping mall	50%	18	52	84
(# of slow chargers)	60%	22	70	105
	80%	33	95	190
Super Market	50%	-	4	6
(# of slow chargers)	60%	2	5	8
	80%	3	7	13
Market	50%	-	-	2
(# of slow chargers)	60%	1	2	3
	80%	2	3	4

Table 2: On-demand charging results.

Place	Service Level	2026 Scenario	2030 Scenario	2035 Scenario
High flow Gas Station	90%	-	2	3
(# of fast charges)	95%	-	3	4
	99%	1	4	6
Low flow Gas Station - Local	90%	-	-	1
(# of fast charges)	95%	-	1	2
	99%	1	2	3

3 CONCLUSIONS AND ACKNOWLEDGEMENTS

This study highlights the importance of strategic planning for EV charging infrastructure in major cities. Simulations were based on peak usage days, repeated multiple times to ensure reliable results. The analysis considered current EV demand and projected growth over the next ten years. Results indicate a significant gap between existing charging capacity and future needs. The study offers data-driven insights for infrastructure planning and supports decision-making by public and private stakeholders aiming to expand EV adoption. We are currently providing sensitivity analysis of the key parameters to allow a broader view.

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