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Electromobility in Bus Transport Public in Latin America: A Social Network Analysis Approach in 28 Latin America cities and Metropolitan Region of Sao Paulo, Brazil

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Abstract: The electromobility of urban public transport in cities has been seen as a way to reduce local and greenhouse gas emissions, as well as improve people's health by reducing the harmful effects caused by pollution. This article aims to investigate the relationship between 28 Latin American cities and the São Paulo Metropolitan Region with the current stage of bus fleet electrification considering the types of vehicles in operation. For this purpose, data from the E-bus Radar platform project on electric buses in Latin America is used. The Social Network Analysis (SNA) tool is adopted to identify similarities between cities, the types of vehicles most used, the concentration by city and vehicle, and the main network of Latin American cities that adopt electromobility in urban public transport by bus. The study provides insights into how public managers develop public policies to improve transport policies.

Keywords: Electromobility; Public Transport; Bus Service; Latin America Cities; Environmental Pollution.

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1. Introduction

Urbanization growth and cities spreading around the world have triggered a series of challenges, among which the urgent need to reevaluate our public transport systems stands out. The exponential increase in road traffic has not only congested the roads but also led to serious environmental problems, including the emission of greenhouse gasses and air pollutants [1]. Therefore, electromobility emerges as a promising solution to mitigate these problems, especially in the context of urban public transport [2,3,4].

Several studies have been developed to analyze electromobility in public transport. Pietrzak and Pietrzak [3] analyze the effects of implementing zero-emission vehicles focusing on the city of Szczecin, Poland, and emphasize the need for public policies that encourage the adoption of zero-emission vehicles. Jerez [4] examines electromobility in Bolivia, a country with significant reserves of lithium, essential for electric vehicle batteries, and offers insights into the complexities of the narratives around electromobility, highlighting the intersections among economic, technological, political, and moral issues. López [5] conducts an analysis of the state of electromobility exploring charging strategies, types of chargers, and electric buses, and concludes the need for an integrated approach, considering both technological and operational aspects to achieve a successful transition to electric buses in urban public transport.

Given that, the research questions of this study are: (1) What is the actual stage of public transport electromobility in Latin America; (2) Which are the most e-bus vehicles

of the type used; (3) Is there a main number of cities in Latin America adopting electromobility in public transport.

This article investigates electromobility in public transport in Latin American cities and the Sao Paulo Metropolitan Region. Our study uses data from the E-bus Radar project, a platform dedicated to monitoring electric buses in the region, to analyze the current stage of bus fleet electrification. To this end, Social Network Analysis (SNA) is adopted to map the interconnections between these cities, identify patterns of adoption of electric vehicles, and evaluate the effectiveness of implemented public policies.

2. Methodology

The methodological approach of this study revolved around collecting electromobility data in 28 cities and the Sao Paulo Metropolitan Region in Latin America to analyze the relationships between the cities involved and the types of systems available. The research questions were answered using the Social Network Analysis approach.

2.1. Data Collection

Data in the study were collected from the e-bus radar platform [6], available from a study carried out by the Federal University of Rio de Janeiro (UFRJ) and the Denmark University of Technology (DUT). The period covered was the year 2021.

The relevant data selected include information on representative cities in Latin America and the types of electric vehicles in operation, such as trolleybuses, articulated buses, standard buses, and midi buses. Data was also obtained on the amount of each type of vehicle.

2.2 Data Organization and Analysis

To organize the data and make it suitable for study, Microsoft Excel v.19 ® was used to create a data matrix that allowed us to understand the relationships among the collected variables.

Network analysis was conducted using Ucinet software v.6.0®. It converted the data matrix into the network patterns. Subsequently, the NetDraw v. 2.138® software was adopted to create a graphical representation of the relationships between network nodes [7]. The thickness of the lines in the network graph was adjusted according to the number of buses by type making the relationships clearer and more noticeable. The social network metrics analyzed were "Degree Centrality" to identify the most central types of vehicles in the network and the "K-core" method to identify the main network and its distinctive characteristics [7].

3. Results and Discussion

Figure 1 presents the degree centrality results. The results indicated that e-standard buses (1,234) and trolleybus (900) are the main electric options running in Latin America. Sao Paulo - Brazil (201) and Ciudad de Mexico - Mexico (336) are the main cities to adopt trolleybus while Santiago - Chile (776) and Bogota - Colombia (285) are the main hubs of e-standard battery bus vehicles.

The city of Santiago is the main operator of electric buses in Latin America due to its problems of fine particulate matter emissions combined with the organization of its public transport system [8]. In Colombia, Medellin and Bogota present public transport systems well organized and centralized allowing the implementation of electric vehicles [8]. Both Santiago and Bogota initiated a split process of capital and operational expenditure which are a key step to electromobility insofar as the change in the energetic technology modifies the relations between capital costs and operational ones [8].

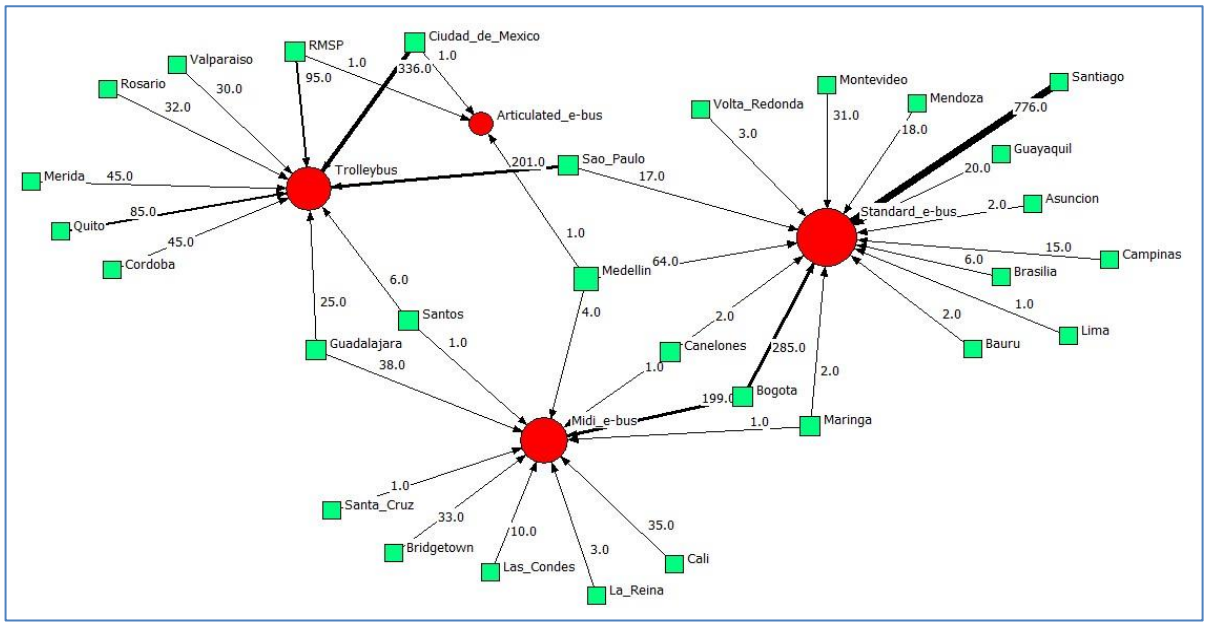

Figure 1. Degree Centrality.

Figure 2 shows the k-core analysis results. The main e-bus Latin America network is formed by the four kinds of vehicles and the cities of Sao Paulo, Santos, Maringá and RMSP (Brazil), Ciudad de Mexico, and Guadalajara (México), Medellin and Bogota (Colombia), Canelones (Uruguay). This result does not necessarily reflect the total number of vehicles (1,280 - 51,76%). However, it reflects cities and areas with more than one kind of e-bus vehicle which means different attempts to obtain a sustainable public transport city. E-bus systems are an important contribution to the future of mobility since they can overcome the existing disadvantages of using fossil fuels and support a push for a modal shift to public transport [9]. In this context, our results indicate that Latin American cities independently of size are generating efforts in this direction that can be shown in k-core analysis.

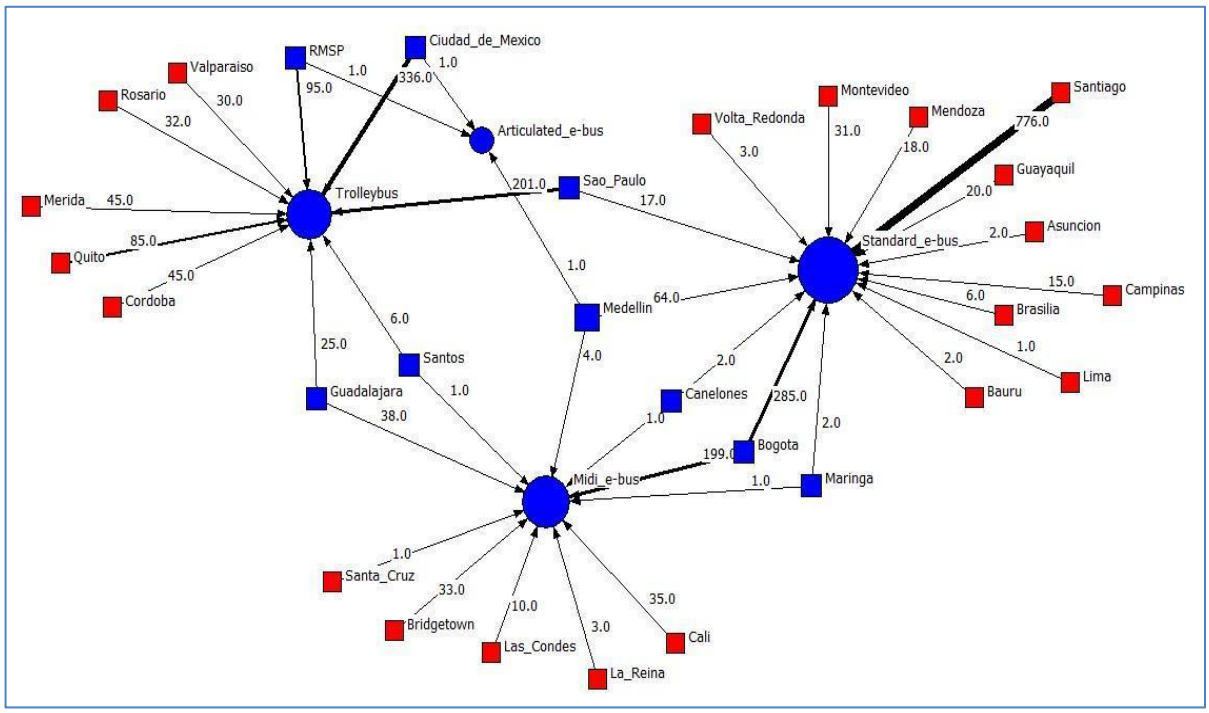

Figure 2. K-core.

4. Conclusion

This article used an SNA approach to understand the relationship between cities in Latin America and the Metropolitan Region of São Paulo – Brazil and Electromobility in Public Transport. Enabling the identification of similarities between different cities, which type of vehicle is most used, the highest concentration per vehicle and city and which Latin American cities use electromobility in urban public transport by bus.

Through this study, it was possible to identify that Mexico City and São Paulo stand out in the use of Trolleybuses. The City of Santiago, in Chile, stands out in terms of the volume of electric buses used in the fleet.

Finally, given this analysis, it is observed that the adoption of electromobility vehicles favors air quality, by reducing carbon dioxide (CO2) emissions, bringing gains to public health and sustainable urban planning, as recommended by the SDG 11 on more inclusive and sustainable cities, the agenda of the UN 2030 Agenda.

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Conflicts of Interest: The authors declare no conflict of interest.

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