USAID COLOMBIA YOUNG LEADERS WORKFORCE TRAINING PROGRAM ACTION PLANS: EARLY ADOPTERS WORK TO ACCELERATE ELECTRIC VEHICLE TRANSITIONS IN BOYACÁ, COLOMBIA

La Empresa De Energía De Boyacá (EBSA) Advances Electric Mobility in the Boyacá Region

INTRODUCTION

As part of the U.S. Agency for International Development (USAID)-National Renewable Energy Laboratory (NREL) Young Leaders Workforce Training Program in Colombia,[1] Empresa de Energía de Boyacá (EBSA) participants leveraged their training and professional experience to develop an electric mobility and transition action plan for their organization. EBSA was one of four teams selected by the training program development team to receive continued technical assistance and strategic advisory support from the USAID-NREL Partnership for action plan implementation.

NREL worked in close collaboration with the EBSA action plan team to scope priorities and key decision-making metrics, gather data on fleet operations, and assess plans for an electric vehicle (EV) transition. EBSA and NREL engaged a diverse group of stakeholders to inform mobility decisions. These stakeholders included the utility Compañía Energética de Occidente, EV mobility service provider, Erco Energia, and the car rental company, Renting Colombia, that supplies EBSA with rental vehicles.

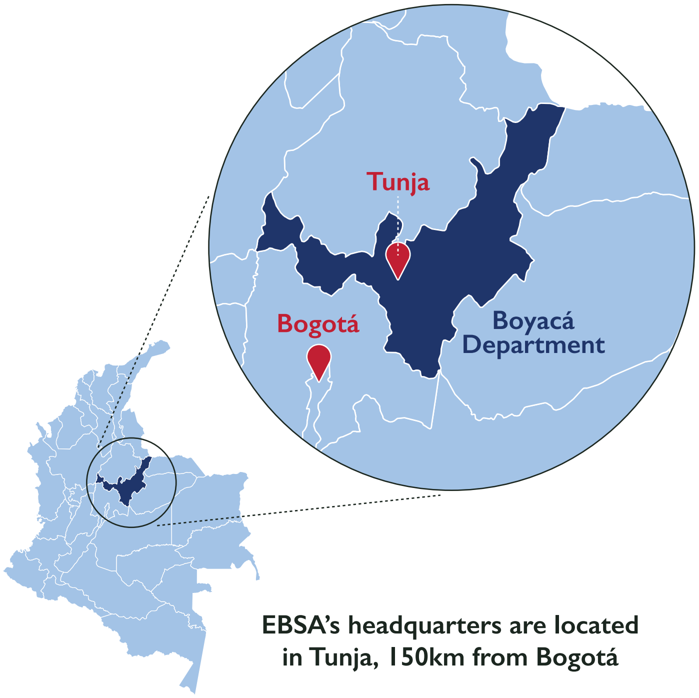

Figure 1. EBSA service area. Image by EBSA

BACKGROUND

EBSA is an integrated electricity service and retail provider in the department of Boyacá, Colombia, a mountainous region in the Eastern Cordillera range of the Andes spanning more than 23,000 square kilometers. EBSA provides power to over 520,000 consumers across Boyacá. Due to the mountainous nature of the region, EBSA relies primarily on 4x4 vehicles to navigate hilly and difficult terrain, as maintenance vehicles and drivers are dispatched daily to provide scheduled and emergency maintenance operations in mountainous and sometimes remote locations.

Table 1. EBSA's Fleet by Vehicle Type

VEHICLE TYPE	VEHICLE COUNT
Car	1
Truck	40
Crane Truck	26
Camper	190
Total	**257**

EBSA is committed to supporting the electric mobility transition in Boyacá and has set a goal to replace its service fleet of approximately 250 vehicles with EV models and install charging stations to support charging demand throughout the region.

OBJECTIVES

Based on the action plan EBSA developed through the Young Leaders Workforce Training Program, USAID-NREL collaborated with key leaders at EBSA to support their electric mobility goals.

1. English: https://www.nrel.gov/docs/fy22osti/82855.pdf; Spanish: https://www.nrel.gov/usaid-partnership/assets/pdfs/nrel-usaid-colombia-brochure-fy22.pdf.

The guiding objectives for action plan implementation and USAID-NREL technical assistance were to:

- Assess EV technical suitability and determine if EV options available on the Colombian market can adequately support EBSA driving profiles and vehicle performance requirements
- Analyze EV total cost of ownership and savings performance compared to internal combustion engine vehicle (ICE) equivalents (over a period of 5 years) to estimate the initial level of capital investment and long-term return on investment from transitioning to EVs.

DECISION-MAKING METRICS

EBSA leadership and technical advisory staff determined the following metrics were most critical to the strategy and integration of EVs in their service fleet:

- **EV Range and Performance Capabilities:** EBSA vehicles are deployed across Boyacá and must be capable of navigating difficult mountain terrain and adverse conditions. Most of the existing service and maintenance vehicles are 4x4 and, on average, travel between 50 and 60 kilometers per day.
- **Financial Comparison:** EBSA required an analysis of the economic investment associated with the transition to EVs, including the long-term costs and benefits associated with regional electric vehicle supply equipment (EVSE), or EV charging infrastructure, deployment.

DATA USED FOR ANALYSIS

EBSA provided 2 years of detailed fleet data, including:

Monthly average vehicle distance traveled (km), disaggregated by vehicle class and service area[2]
Monthly average vehicle fuel economy (km/gallon)
Monthly average fuel consumption (gallons), disaggregated by vehicle and service area
Monthly average fuel expenditures ($COP/gallon)
Electricity tariff data ($COP/kWh)
Geographical areas of operation
Terrain characteristics of service areas.

2. In this case, daily distance traveled is preferred to reduce analytical uncertainty regarding battery size and range requirements. To mitigate data gaps, EBSA was able to provide daily travel data for one vehicle in its fleet (the Compero Suzuki Jimny) to perform a sensitivity analysis and confirm model assumptions.

PERFORMANCE CAPABILITIES

Energy and cost data from EBSA's ICE vehicles were used to assess the electrification potential, or ability of available EV models to comparably meet the desired range and performance capabilities, for different types of vehicle models within the EBSA fleet. Four key elements were considered in the analysis:

(1) Calculate daily average fuel consumption for existing ICE fleet. Average fuel consumption (gallons) data, disaggregated into relevant vehicle classifications (e.g., light-duty truck or passenger vehicle), was a key starting point to assess how much energy, on average, an ICE vehicle consumes during its day-to-day operations.

(2) Convert conventional fuel energy to equivalent daily battery energy. Determining the average daily electrical energy requirement per vehicle classification was used to estimate the minimum battery size needed to electrify an ICE vehicle. Basic charging cost data were obtained by combining daily electrical energy consumption estimates (in kWh) with local electricity tariff information ($/kWh).

(3) Determine which available EV models might be suitable for required vehicle range and performance criteria When determining the minimum battery size needed to meet vehicle range and performance criteria, average daily electricity consumption is generally an accurate indicator of the minimum battery capacity requirements for a given vehicle.

(4) Calculate estimated energy costs for EVs. For this analysis, estimates of daily electrical energy requirements were compared to the nominal battery size for a suite of EV archetypes, including the Tesla Model S, Dongfeng Rich 6, Nissan Ariya, and Lightning Motors class 4 truck. Availability of comparable EV models might be influenced by market maturity, supply chain logistics, import regulations, and/or other unique factors for a given location.

Figure 2 shows the estimated range for average daily electrical energy requirement (derived from average fuel consumption and converted to kWh) by vehicle type for EBSA's current fleet. The figure also overlays the battery size for the Tesla Model S, Dongfeng Rich 6, Nissan Ariya, and Lightning Motors class 4 truck with the average daily electrical consumption, illustrating that the battery sizes can meet most of EBSA's fleet use requirements.

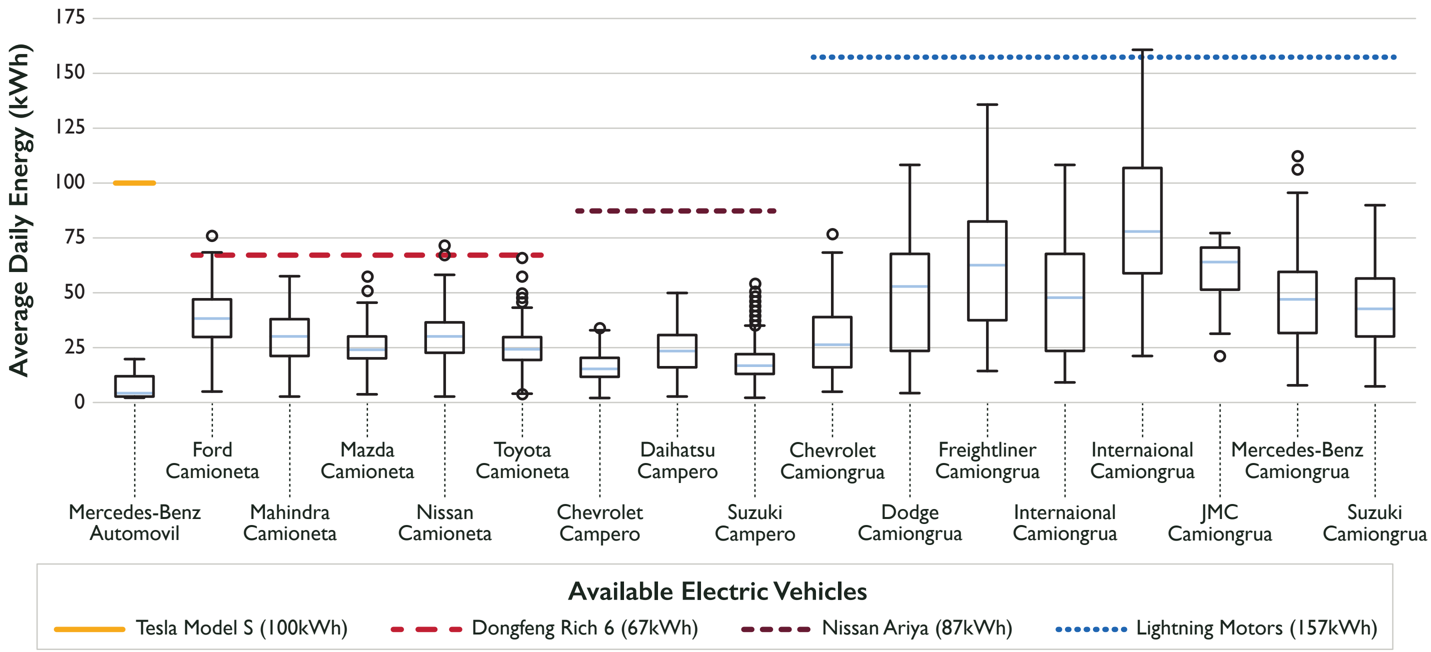

Figure 2. Distribution of average daily electrical energy by vehicle type compared to nominal battery capacity of 4 commercial EV models

REFINING THE ELECTRIFICATION POTENTIAL ANALYSIS

Month-to-month data for average vehicle distance traveled and fuel consumption can provide a good frame of reference for ICE electrification potential; however, daily or second-by-second data (if available) help reduce uncertainty in battery sizing estimations and improve confidence in EV model selection. EBSA was able to provide more detailed travel data across eight separate service zones to refine the electrification potential analysis for their Campero Suzuki Jimny fleet vehicles, which comprise nearly half of EBSA's service vehicles. These data sets were used to determine the lower and upper bounds of daily electrical energy requirements and obtain a more accurate estimate of the minimum battery energy needed to electrify these vehicles (**Figure 3**). Based on this analysis, the Compero Suzuki Jimmy appears to be well suited for electrification.

FINANCIAL COMPARISON FOR EV INVESTMENT

For the financial cost comparison for EV investment, NREL developed a list of expenditures for an EV, including operation, maintenance, purchase price, depreciation, road taxes, insurance, and administrative expenditures (**Table 2**). These were listed both for ICEs and EVs, the main difference being gasoline cost for ICEs versus electricity cost for EVs.

For the EV investment analysis, NREL developed a spreadsheet tool in Excel with several tabs, including:

1. Glossary and instructions
2. Cost for the ICE
3. Cost for the EV to replace the ICE
4. Monthly ICE cost calculation for 5 years
5. Monthly EV cost calculation for 5 years
6. Graph comparing the ICE and EV costs from initial investments to total expenditures during the 5-year comparison.

Table 2. EV Expenditures

CATEGORY	ITEM
Investment	Vehicle Cost
	Transfer, Taxes, Discounts
	Linkage to special transport
Depreciation	Depreciation of vehicle value
Insurance	SOAT
	Insurance (all risk)
	Payment of Special Transport Company Policy (Cont, Extra)
	Special Transport Company Admin
Administration	GPS
Operation	Monthly kilometers
	EV Performance (km per kWh)
	Gasoline Cost (PESOS M.CTE per gallon)
	kWh cost (PESOS M.CTE per kWh)
	Tolls and others
Maintenance	Maintenance and repair (PESOS M.CTE per km)
	Mechanical technology

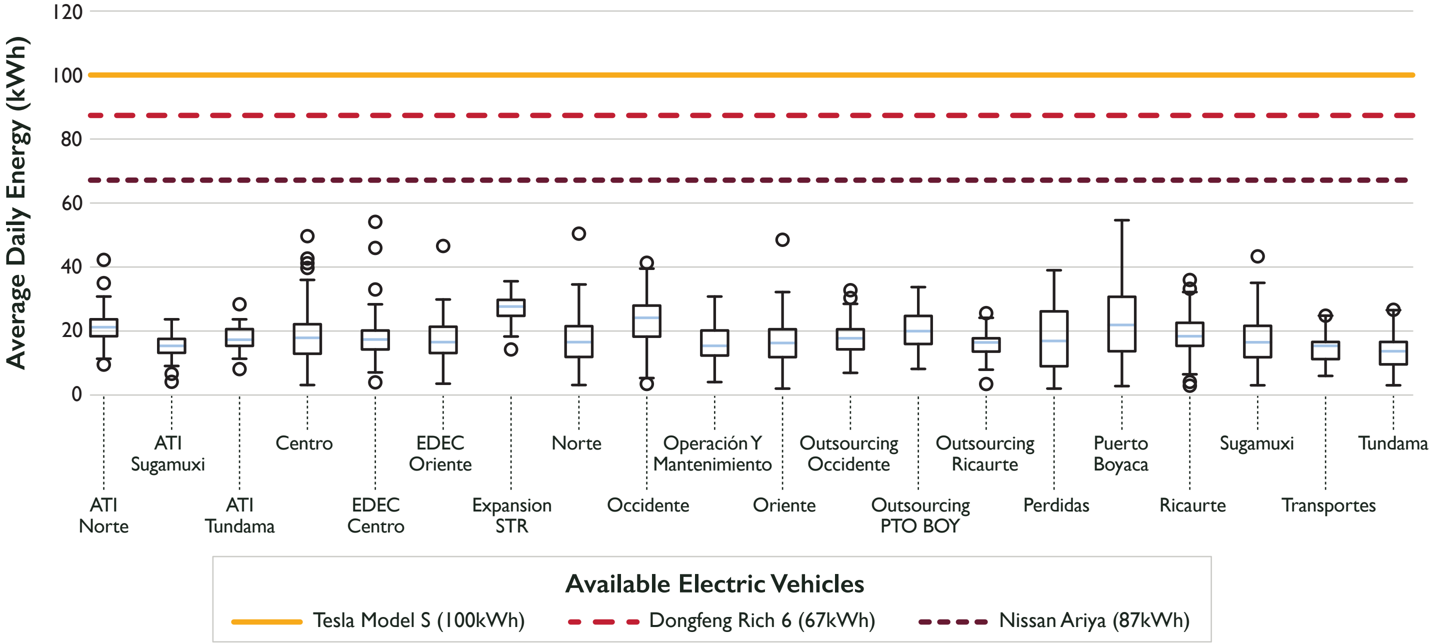

Figure 3. Daily average electrical energy consumption (kWh) of Compero Suzuki Jimny compared to EV models by zone

This tool analyzes and provides a visual comparison between EVs and ICEs on total cost of ownership and savings performance for a 5-year period. The tool is customizable for different scenarios, including kilometers traveled per month; cost (e.g., fuel or energy); specific ICE comparable to a specific EV and the vehicle characteristics such as vehicle cost, energy efficiency (kilometers per gallon, kilometers per kWh); and additional EV incentives and/or discount specific to EVs. This tool was delivered to EBSA for the continued facilitation of EV deployment planning.

KEY TAKEAWAYS

Preliminary electrification analysis indicates that it is technically feasible to replace EBSA cars, trucks, and SUV vehicles with EV equivalents. Rated battery capacity (in kWh) for four comparable EV models—Tesla Model S, Dongfeng Rich 6, Nissan Ariya, and Lightning Motors class 4 truck—exceeds estimated daily average energy consumption for EBSA cars, trucks, and SUV ICE vehicles within their fleet. Additionally, the maximum range (km) for EV equivalent models, on average, exceeds the distance driven by EBSA vehicles during a typical day (**Figure 2** and **Figure 3**). These results indicate that most EBSA vehicles can be electrified for an average day, and that there are commercially available EV models capable of meeting EBSA range requirements. NREL recommends that EBSA test drive or pilot desired EV models to confirm range and other performance capabilities on frequently driven and/or difficult service routes. Initial suggestions for potential EV equivalents were based on global examples; however, some EV models might not yet be available in Colombia. EBSA and other local stakeholder partners collected data on EV models available in the Colombian market to inform the pilot testing period.

Transitioning to EV models can generate cost savings for EBSA when compared to ICE equivalents. While the initial investments for EVs is higher, EBSA could break even, on average, after 3 years of initial investment and save significantly after this break-even time, mainly from energy cost savings compared to gasoline and diesel equivalents (**Figure 4**). Higher savings can be obtained by focusing on the vehicles that travel the most distance and with the lowest fuel efficiency (i.e., low kilometers per gallon or miles per gallon efficiency). Other main factors to consider are: (1) The variability in fuel price and potential increase in price due to fuel shocks, which would make EVs more economically attractive; and (2) Opportunities for renewable and lower energy cost.

Figure 4 presents an example comparing total investment and cost over 5 years, showing that, while the initial investment for an EV is higher than the initial investment for an ICE, after 3 years (~38 months), the total cost of ownership of EVs is lower than for ICEs

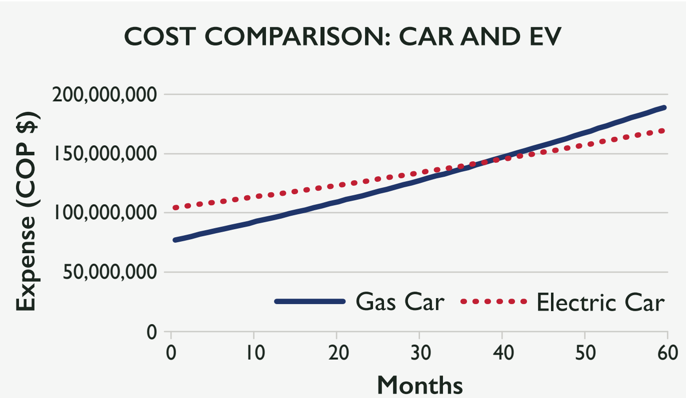

Figure 4. Five-year cost comparison ICE and EV-equivalent

CHALLENGES

- **Supply-Side Availability and Uncertainty:** Availability and cost of electric 4x4s and all-terrain EVs in the Colombian market emerged as a key concern for EBSA due to COVID-19-induced global EV supply chain disruptions, delays, and short-term price hikes.
- **Local Technology Costs:** Comprehensive data on localized EV initial capital expense and lifetime operation and maintenance costs were difficult to obtain for Colombia, as EV markets and service economies are still emerging in the Latin American region.
- **Workforce Training and Expertise:** Boyacá is located 100+ kilometers from the Colombian capital of Bogotá; as EVs and EVSEs are newly introduced to this region, EBSA leadership and technical strategists are concerned about the ability of local mechanics and technicians to provide EV service and repair. Transporting EVs to Bogotá for repair could impact vehicle downtime and maintenance costs.
- **Fleet Data Resolution:** Daily fuel usage and vehicle distance traveled data were not known or available for all vehicles in the EBSA fleet and would be difficult to ascertain without expensive and complex GPS data loggers.

MOVING FORWARD

EBSA is already engaging with several car companies (Auteco, BYD, Renting Colombia) that could supply EVs in Colombia. EBSA conducted a test trial with the Dongfeng Rich 6 EV to analyze their ability to meet daily operation requirements. The test trial found that the Dongfeng Rich 6 can meet the operational needs for some regions of EBSA's service areas, while more rugged terrain will require a four-wheel drive EV. EBSA plans to test other EV models to replace SUVs in their fleet and will use the cost comparison tool to better understand its implications, potentially complementing the comparison with additional information and tools provided by the car companies and their financial analysis and management teams.

Longer term, EBSA plans to implement and deploy its EV fleet strategy from 2022–2025. EBSA will also develop roadside EVSE infrastructure to meet charging demand for EV users. As a strategic advisor and early adopter of EVs, EBSA will emerge as both an example and leader in the regional implementation of electric mobility transitions.

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INTEGRACIÓN EFICIENTE DE ENERGÍAS RENOVABLES VARIABLES AL SISTEMA COLOMBIANO

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To learn more, visit:
www.nrel.gov/usaid-partnership/project-colombia.html

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