LOGIOS

Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City

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Deliverable 3.1
Evaluation of the Electric Bus Innovation System: Barriers to Adoption

Prepared for the United Nations Industrial Development Organization and the Climate Technology Centre & Network

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Cover photograph: Electric bus in Casco Viejo, Panama City, Panama (2018). © LOGIOS.

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Executive Summary

Introduction

This report is concerned with the analysis of the electric vehicle innovation system in Panama, with a focus on the market segment of buses for public transportation. The objective is to identify potential barriers to adoption and strategies to improving conditions for adoption. The analysis for Panama is complemented with case studies of two countries in the region namely Costa Rica and Colombia. Also experiences from the United States are at times integrated.

In October 28, 2019, Panama approved, via Cabinet Resolution 103, a National Strategy of Electric Mobility and instituted the Interagency Commission of Electric Mobility. The strategy proposed achieving the following goals by 2030:

- 25% to 40% share of electric vehicles in car sales.
- 10% to 20% of electric cars in the private vehicle fleet.
- 25% to 50% of electric cars in the Government fleet.
- 15% to 35% of electric buses in the fleets with authorized concession.

The national strategy has 24 action areas to support electric mobility, mapped into four pillars, namely:

- Governance
- Regulation
- Strategic Sectors, and
- Knowledge and Education.

The present analysis uses a theoretical framework known as Technology Innovation Systems (TIS), to define the factors that will help first characterize, and ultimately explain the status of electric vehicle markets. TIS recognizes that new technology adoption is not adequately supported with individual, disconnected measures, programs, or policies, and instead it takes a broad and integrated perspective on the process of technology adoption. The general logic behind using TIS is to start from an understanding of the conditions needed for innovation to flourish,

evaluate the existing conditions in a given market (Panama, in this case), identify the missing parts (deterrents to innovation), and apply domain expertise to evaluate the central areas for future work.

To adequately support electric vehicle market adoption, eight areas of activity, known as *functions*, are necesary. These functions are described in Table ES 1, including examples of indicators that could be looked at, for the case of electric mobility. Data to evaluate these functions were obtained from public documents, publicly available information, and interviews with local stakeholders.

Table ES 1. TIS function definitions and high-level operationalizations

Function name	Function description	Example function indicators
Entrepreneurial Experimentation	Function related to probing new ideas to support technology innovation. New ideas can relate to technologies, methods, and institutions.	• Test programs (trials, pilots, etc.) • Local EV-related industry • Regulatory & business models • Variety in vehicle offering • Exceptional champions
Knowledge Development	Function related to the creation of new knowledge about technology, methods related to the technology, or institutions that support the technology.	• Feasibility studies or similar • Identification of factors driving adoption • Government reports • Research groups • Technical assistances • Time since market entry
Knowledge Diffusion	Function that disseminates knowledge within organizations and/or through	• EV working groups • Legislative activity • Interagency collaboration • Industry-government networks

	networks in the innovation system.	• Guidance documents
Influence on the Direction of the Search	Function concerned with creating endogenous pressures for actors, institutions and networks to invest resources to innovation in the technology.	• Institutional roadblocks • Public expressions of support • EV in NDCs • EV plans/strategy • EV-related legislation/ordinances • Articulation of expectations (market share, socio-environmental benefits, etc.) • EV-affecting regulation
Market Formation	Function that relates to all activities that can have a positive impact on technology adoption and that would not happen naturally or spontaneously under established institutions.	• EV adoption requirements • Incentives and magnitude • EV-affecting fiscal instruments and magnitude • Program duration/stability • Marketing campaigns • Investment in infrastructure
Legitimation	Function that relates to activities directed to making the technology more accepted by the public, policymakers, and the private sector.	• Level of public information • Level of public acceptance • Level of political information • Level of political acceptance/political divide over EV • Competitive credit conditions • Retail price relative to alternatives • Electricity price differential • Investment in infrastructure

Resource Mobilization	Function concerned with the allocation of capital, labor, and assets toward supporting technology innovation.	• Public funding appropriations to support EV adoption • Private investment • Credit availability • Dedicated staff • Executive office involvement • Industry product supply
Development of Positive Externalities	Function concerned with the creation of spillovers from the technology system to other technology systems, or vice versa.	• Job creation • Environmental benefits • Intersectoral links • Electric utilities involvement

For electric vehicles to materialize their full carbon-mitigation potential and make a significant impact to combat climate change, market uptake will need to increase continuously and fast toward scale. As with any emerging technology, there is a set of actors, institutions, and policies that can and should work together to support the adoption and use of electric vehicles. Failure to find these collaborations will deter market growth.

Evaluation of the Technology Innovation System Functions for Panama

Entrepreneurial Experimentation

The development of and experimentation with new ideas play an important role in the transition to electric mobility. Experimentation is not a goal in itself, but rather a means to strengthen other

innovation functions. For example, experimentation helps develop new information, increasing exposure to and familiarity with the technology, etc.

As part of the experimentation process, several stakeholders in Panama have deployed electric mobility assets; initiatives that could probably be best characterized as trials or proofs of concept. These are summarized in the report.

As part of an intention to transition the public transport system cleaner technologies, the City of Panama decided to implement a trial of an electric bus BYD K7M to serve the old town of Panama City. This initiative included a partnership with MiBus, the Ministry of Environment, the Secretary of Energy, and the Authority of Transportation and Terrestrial Transit (ATTT). A detailed evaluation of this trial was presented in a separate report of this technical assistance.[1]
Following up on the trial of the BYD K7M, a proof of concept as implemented with a larger 12-meter model, the BYD K9FE, with overnight charging technology. This was a collaboration among MiBus, ENSA Services, and BYD with the purpose of assessing opportunities to incorporate electric buses to the public transport system in Panama City.

Knowledge Development

The importance of knowledge development, not just about technology but also about policy design, etc., was recognized in the National Strategy, which includes many proposed actions in this area. As mentioned above, both private and public sectors have been taking some steps to test technologies, and this work has in turn yielded, as expected, information that might be useful for next steps. For example, building upon vehicle trials, MiBus is developing interest in exploring shorter 9-meter electric buses, which might adapt better to the characteristics of the road infrastructure in parts of Panama City. Indeed, it is *critical that experimentation develops into information* that can be used to advance the market. While several actors in Panama have participated in the deployment and trial of rolling and charging assets, the extent to which these

[1] LOGIOS (2019) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 2.2. https://www.ctc-n.org/content/d22report-recommendation-most-appropiate-technology-panama

have been methodically planned and evaluated is not too clear. This arises as an area of opportunity for stakeholders in Panama, to seek further collaboration, data collection, and program evaluation, thus taking full advantage of these opportunities for knowledge creation.
As many countries, just like Panama, are taking their first steps in electric mobility, it would be natural to look for potential lessons from countries and regions with a longer trajectory in this space. Elements of experiences from other countries, such as the Zero-Emission Vehicle (ZEV) program in California,[2] have been loosely referenced in the National Strategy document. Conversations with stakeholders, however, suggest that there has been a limited effort to studying regions with longer experience in electric transportation and debating how they could apply to Panama. At a regional level, there has been some activity around sharing lessons learned.

Panama has started work on some of knowledge gap areas. For example, the present technical assistance includes components directly aligned with the needs for information described the National Strategy. Also, a series of webinars was agreed upon between MiBus and C40 Cities Finance Facility, for capacity building relative to operations of electric buses, the first of which took place in July 2020. MiAmbiente is leading an evaluation of strategies for carbon pricing, including the transport sector, expecting some results toward the later part of 2020.

Knowledge Diffusion

The national government has communicated clearly where Panama stands in regard to electric mobility, highlighting the importance of this transition to achieve energy efficiency and environmental goals. Before getting the final version of the National Strategy of Electric Mobility (ENME) officially approved in October 28, 2019, via Cabinet Resolution 103, it presented a report explaining the situation at the time, as part of the elaboration process of the national strategy, particularly the situation of transportation, infrastructure of the industry legal and regulatory framework, and gaps and opportunities.

[2] Collantes, G. and D. Sperling (2008) The origin of California's zero emission vehicle mandate. *Transportatioin Research Part A: Policy and Practice* **42**(10: 1302-1313.

The National Strategy gives little attention to knowledge diffusion. The focus currently is in the dissemination of existence and results of test programs (including pilot projects). As discussed in the section on experimentation, the exchange of ideas and information needs to start at the planning stage, even before implementation of test programs; this is an area on which Panama could focus more.

Influence on the Direction of the Search

Panama's National Determined Contributions (NDCs), while recognizing that transportation is the main national source of greenhouse gas emissions, are focused on the sectors of energy, efficiency in transportation, land use-land use change and forestry. The reference to electric mobility in Panama's NDC is centered on the expansion of the Metro (electric railroad) system, while it also includes a broader objective of moving toward energy-efficient public transport, though not explicitly setting goals on electric mobility.

Panama's document *Strategic Guidelines: Energy Transition Schedule 2020-2030* includes consideration of sustainable mobility and envisions a transition to electric mobility as a means to mitigate carbon emissions, while proposing that fiscal incentives are the key policy instrument to support this transition.

The National Strategy of Electric Mobility includes a number of action areas related to influencing the direction of the search.

Market Formation

Actions that impact directly the competitiveness of electric vehicles, helping them penetrate a market institutionally and economically dominated by incumbent technologies and fuels are a key component of health innovation systems. Such action might include electric vehicle adoption requirements (e.g. directives for the procurement of electric vehicles for public fleets, etc.), fiscal incentives, non-monetary benefits, publicity and promotional campaigns have a key role on determining the pace at which the transition into electric mobility takes place.

Electric vehicle model offering in Panama is still limited. Sales in the last few years have concentrated in the luxury segment, and the retail price of these vehicles is still significantly higher than in other markets, such as the United States.

As one early policy step toward supporting the market entrance of electric vehicles, Law 69 of October 2012 granted exemptions from the *selective tax* on the importation of electric and hybrid vehicles, regardless of the cost of the vehicle, until 2017. The tax level would rise to 5% starting on 2018. The alignment of incentives along the supply chain foster market development, as all economic agents will see reductions in the cost associated with participation in the electric vehicle market.

Electricity generation, transmission, and distribution companies have a central stake in the development of electric mobility markets. Distribution companies are supportive of the development of dedicated rates for the charging of electric vehicles. The administrative processes for the revision of rate structures have to be initiated by the Secretariat of Energy and submitted to the Public Services National Authority (ASEP).

The services arms of the electric distribution companies (ENSA Servicios, Naturgy Servicios) can participate in the installation of charging equipment, although this participation has remained relatively low. In the U.S., many utilities have created incentive programs to support financially the installation of charging infrastructure in private and public spaces.

Given that the capital requirements are large and financial resources are constrained, finding creative ways to maximize the cost-effectiveness and bankability of projects is key. Traditional financing mechanisms have been loans from multilateral financial institutions and bilateral from commercial banks. In Latin America there has been a growing interest in having investment grade and liquid securities. In this context, Panama could assess the possibility of issuing a Green Bond in the capital markets, taking advantage of the economic performance of Panama in recent years. An example of Sovereign Green Bonds is found in Chile, where the bond was a key instrument in financing the 2017-2022 National Action Plan for Climate Change, as well as other measures including the electrification of buses and trains.

Stakeholders express concern about the likelihood of meeting the goals set in National Strategy of Electric Mobility for electric vehicle market uptake by 2030. In this sense it is perceived as important to start moving toward the electrification of public transport fleets in Panama City and

other regions, to deploy a solid network of charging stations in urban public places and in interurban roads. Also, the consideration of fiscal incentives is believed to be vital to stimulate enough the private sector to import more electric vehicles.

Legitimation

Communications with stakeholders revealed a universal concern about the high market prices of electric vehicles and uncertainty regarding the financial models that could be used to elicit a strong market uptake in the short term. Almost universally, stakeholders agreed that incentives will be needed, which strengthens the legitimation function, as it shows support across the board for electric-mobility policies. At the same time, uncertainties around financial pathways make stakeholders cautious.

Research of media outlets in Panama reveals that electric mobility is of some interest to the general public. Key media outlets are giving good coverage to electric mobility, which is a symptom of public reception of the technology. This coverage has been in general positive, highlighting primarily the environmental benefits of electric transportation. The media exposure of public officials speaking about electric mobility has been relatively limited.

Consumer awareness is critical for the market uptake of electric vehicles. There are a range of strategies that have been implemented globally to this end. Research of government and utility websites in Panama showed relatively little information dedicated to electric mobility, and only a fraction of this was dedicated to consumer information. This is an area where work could be expanded, perhaps in partnership with groups with expertise and experience in communications with the broader public. Ultimately, the participation of car companies and retailers in the marketing effort will be critical.

Resource Mobilization

Panama has taken steps to mobilize financial and human resources to support the development of local electric mobility markets. A starting point was the multi-stakeholder effort, with support from the United Nations Environment Program and Euroclima+ to develop a national strategy for the sector. Also, there have been projects elaborated by a consulting firm in technical, economic

and financial areas, providing a reference framework to analyze the country current situation, as well as feasibility studies in economic and financial terms considering the technology of electric vehicles, in particular, electric buses. In addition, Panama recently started to work with the World Bank Group with a Technical Assistance project to find different alternatives to financing of the electric buses that MiBus is planning to buy for its fleet. [3]

Stakeholders agree on the need to develop a package of incentives to support the market uptake of electric vehicles. A legislative proposal is being developed in this regard. Experiences around financial incentives have been globally diverse. In the United States, a dual approach was observed, with incentives at the federal and state levels. Empirical evidence from the U.S. shows that incentives do work. Experience also shows that incentive program effectiveness and, importantly, *efficiency* strongly depends on the structure of the incentives, which should be related to local conditions. When it comes to financial incentives, analyses suggest that incentive effectiveness increases with the proximity to the point of sale. Importantly, the least effective incentive is that of which consumers are not aware. Evidence showed that consumers were often unaware of incentives. Accounting for these questions will be important as Panama moves toward allocating fiscal resources to an incentive package.

Positive Externalities

The existence of a legal framework in related areas, such as the environmental conservation, has facilitated the introduction of policy and regulatory initiatives in energy transformation and electric mobility. Panama has set goals for the growth in unconventional renewable generation. Non-dispatchable wind and solar parks will increasingly supply power during day hours that are now considered peak hours, where demand is high and supply surplus is tighter. Electric mobility can benefit from these developments by negotiating contracts to absorb the new capacity.

Barriers to the Growth of Electric Mobility in Panama

[3] Gathered from meetings with MiBus. July 2020.

The identification of gaps or barriers to the growth of electric mobility, to present an assessment of the work that lies ahead to create the basic platform from where a market can flourish, are assessed by looking at how the TIS areas (or functions) are fulfilled in Panama. The evaluation of the TIS functions necessarily relies on expert judgment, based on an understanding of the fundamentals of innovation and knowledge of previous experiences whenever available.

The *health* of each of the TIS functions can be quantified on a soft scale, based on an articulation of strengths and weaknesses. Such quantification is presented for each of the functions in Figure ES 1.

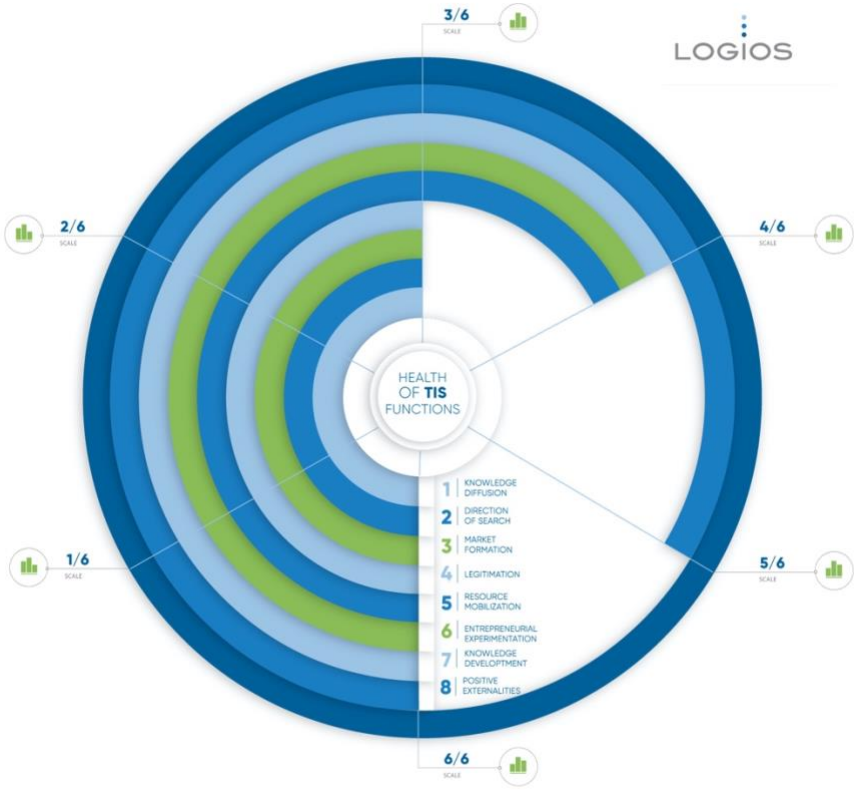

Figure ES 1. Rating of the health of the TIS functions for electric bus innovation in Panama. (Source: LOGIOS)

Entrepreneurial experimentation

While the trials/proofs-of-concept (PoC) in Panama were focused on one bus manufacturer and one charging method (overnight charging), they created opportunities to experiment with the operation of the technology. Experimentation, however, aims at creating conditions where ideas can be tested, and data can be generated, so that eventually lessons can be distilled, and knowledge be developed. Experimentation requires planning and methodic data collection.

Specific areas where Panama could strengthen its experimentation include the following:

- Expand trials/PoC to include vehicles with overhead charging capability
- Expand trials/PoC to include vehicles from a variety of suppliers
- Plan one or more prototypes or pilot projects *following*, and *integrating the results* from, the technical evaluations currently underway
- Implement prototypes/pilot projects including:
    - A data collection plan that yields reliable data
    - Experimentation with variables beyond the technology, such as dedicated energy rates, strategies to mitigate demand charges, operation on dedicated lanes, optimization of depot location/design, etc.

Though this discussion focuses on the market segment of buses, it is worthwhile noting that there is an opportunity for the National Strategy to give more attention to experimentation, particularly in the light duty vehicle segment.

Knowledge creation

While the National Strategy reflects that Panama is keenly aware of the importance evidence-based instruments to galvanize market adoption of electric vehicles, several areas were identified where Panama could strengthen significantly the work on knowledge creation.

Integration of processes of data creation

While the National Strategy proposes a good number of analyses and studies to inform policy, the type of studies and analyses that can be conducted will be determined by the type of data

available. Because of the very early stage of development of the electric vehicle market and the limited amount of data collected as part of trials to date, Panama should integrate a program of data generation as a first step toward the studies and analyses.

Strategies to improve conditions for bus operation

The urban system in Panama City should be the focus of analysis, to identify strategies to provide electric buses with an operational ecosystem conducive to best performance. A special focus of the analysis should be strategies to mitigate the exposure of electric buses to adverse traffic conditions.

Integrated plan of zero-emission public transportation

While a fleet of conventional fossil-fuel buses can be thought of as a sum of individual units, an electric bus fleet must be thought of as an integrated system. Neglecting the systemic nature of electric fleets and infrastructure and taking a piecemeal approach to fleet transformation would be exposed to inefficiencies and the risk of stranded assets. Panama should develop a medium-term plan for the design of an efficient electric bus system for the city.

Financing models

Capital expenditures and financing models were recurrent topics brought up by stakeholders. The development of a financing blueprint for the electrification of public transportation is an area of work that should be considered as high priority. It is strongly recommended that a study of financing models follows the development of the zero-emission public transportation plan—only a solid knowledge of the necessary assets can produce reliable inputs to the investment plans.

Influence on the direction of the search

MiBus is facing imminent decisions about the replacement of large numbers of aging buses. For this reason, it would be beneficial for the recommendation in the National Strategy to (a) include some parameters that help define the ambition of the program, and (b) be given high priority for implementation, to be sensitive to the time pressures facing the modernization of MiBus's fleet.

Market formation

The National Strategy includes a recommendation of a program for the electrification of public transportation fleets. This idea could be implemented relatively quickly and offers an opportunity for the creation of niche markets for electric buses as a part of a holistic plan that facilitates an efficient integration of electric units. This idea has two weak areas that should be addressed: (a) the lack of detail (no studies have been completed yet); and (b) the little activity toward implementing it. A market formation program for MiBus could take a number of approaches. One possible approach that could be consistent with the systems nature of electric fleets (discussed above), is to plan niche deployments centered on shared opportunity charge infrastructure.

Legitimation

The questions related to legitimation of the technology are different for the markets of buses and personal vehicles. For the case of public transportation, the relevant question is *Who needs to have a positive stance on the technology for a sustainable market to evolve?* The answer resides in an understanding of the procurement cycles (flow of financial resources) and the strategic partnerships that can influence operating costs (including city government and electric utilities). The key to generate successful investments, to maintain the continued engagement that will be needed to move to scale, is to ensure that projects are correctly evaluated from a technical and financial perspective (technical and financial evaluations should be integrated, not done separately), that engineering studies are conducted for successful implementation, and that a process of monitoring and performance evaluation be adopted feed new information for future procurement cycles. Understanding that MiBus has responsibility for the implementation of the bus procurement process, the national government, MiBus, the Alcaldía, the ATTT, and the electric companies, should try to coordinate on the planning of investments in fleet electrification.

Resource mobilization

Stakeholders consistently expressed in interviews their concern with the retail cost of electric vehicles and financial models to attract the necessary capital. The National Strategy is proposing the evaluation of financial incentives. As important as identifying effective and efficient incentive

structures, is determining how the incentives will be funded. Experience shows that it is important for incentives to be perceived as stable over time, so that business models can develop around them. It is recommended that both an analysis of incentives and analysis of carbon pricing strategies be integrated into a sustainable financial support mechanism.

Positive externalities

A large fleet of electric buses constitutes a significant additional load which could peak at different times in the day, depending on the fleet configuration and the charging strategy. The addition of this load can be beneficial to existing plans relative to the deployment of now-hydro renewable sources of power. Regulatory frameworks in Panama already allow for parties to enter into long-term contracts for power supply. Panama should develop policy interventions that further support synergies between the deployments of electric buses and renewable capacity.

1. Introduction

1.1 Context - The National Strategy of Electric Mobility

The Secretaría Nacional de Energía adopted Resolution 4169(i),[4] on February 2019, creating the Comisión Intergubernamental de Movilidad Eléctrica (Governmental Commission of Electric Mobility). This is considered as the first step toward *Línea de Acción 1* (Action Area 1) of the National Strategy of Electric Mobility (ENME for its acronyms in Spanish).[5] This commission was tasked with coordinating and monitoring the implementation of the National Strategy of Electric Mobility. The membership of this commission includes one person from each of the following institutions:

- Secretaría Nacional de Energía (SNE)
- Ministerio de Ambiente (MiAmbiente)
- Municipio de Panamá
- Autoridad de Tránsito y Transporte Terrestre (ATTT)
- Autoridad de los Servicios Públicos (ASEP)
- Transporte Masivo de Panamá (MiBus)

ENME[6] addresses the benefits of the electric mobility transition, the methodology used mainly through a participative process with principal actors of urban mobility and the energy sector, and goals to achieve by 2030, through 4 strategic reference pillars, namely; governance, regulations, strategic sectors, and knowledge and education. Specific objectives for each of these pillars are associated to different groups, institutional, public and private.

As for the goals of the National Strategy of Electric Mobility by 2030:

[4] Available at https://www.gacetaoficial.gob.pa/pdfTemp/28713_A/GacetaNo_28713a_20190213.pdf

[5] Estrategia Nacional de Movilidad Eléctrica, June 2019. Available in the Web at http://movelatam.org/wp-content/uploads/2019/07/ENME-Panama-Estrategia.pdf

[6] Republic of Panama, Estrategia Nacional de Movilidad Eléctrica, 10/29/2019. Available at https://www.gacetaoficial.gob.pa/pdfTemp/28892_A/75497.pdf

- 25% to 40% share of electric vehicles in car sales.
- 10% to 20% of electric cars in the private vehicle fleet.
- 25% to 50% of electric cars in the Government fleet.
- 15% to 35% of electric buses in the fleets with authorized concession.

The national strategy has 24 action lines, within the electric mobility context, mapped to each of the pillars and these action lines have received a level of priority of high or medium:

- The Governance strategic pillar wants to create interinstitutional arrangements for the transport sector and promote private sector, academia and civil society involvement in the electric mobility transition. Action lines 1 and 2.
- Regulation as strategic pillar has a key role in defining market conditions from a legal perspective, in order to promote electric mobility and discourage the use of fossil fuels. Action lines go from item 3 through 17, 15 in total.
- The pillar of Strategic Sectors is made of 4 transportation subsectors; government fleets, private fleets, fleets of taxi services, delivery, industrial and heavy equipment, and public transportation. Action lines are 4 from item 18 to 21.
- The last pillar is Knowledge and Education, which concentrates in Outreach in particular, the areas of Research, Technology and Innovation (I+D+i), technical professional training, and outreach campaign. Action lines are from item 22 to 24.

1.2 Objectives

This report is concerned with the analysis of the electric vehicle innovation system in Panama, with a focus on the market segment of buses for public transportation. The objective is to identify potential barriers to adoption and strategies to improving conditions for adoption. The analysis for Panama is complemented with case studies of two countries in the region namely Costa Rica and Colombia. Also experiences from the United States are at times integrated.

The remainder of the report is organized as follows: Section 2 presents the methodological framework for the analysis; Section 3 presents the analysis of the factors that support innovation in Panama; Section 4 presents an analysis of deterrents to innovation and strategies to address them.

2. Framework for the Analysis

In order to define the factors that will help first characterize, and ultimately explain the status of electric vehicle markets, a theoretical framework known as Technology Innovation Systems (TIS) is adopted. TIS recognizes that new technology adoption is not adequately supported with individual, disconnected measures, programs, or policies, and instead it takes a broad and integrated perspective on the process of technology adoption. It acknowledges that barriers to technology innovation arise not only at the interface between actors and markets, but also within institutions and networks. The general logic behind using TIS is to start from an understanding of the conditions needed for innovation to flourish, evaluate the existing conditions in a given market (Panama, in this case), identify the missing parts (deterrents to innovation), and apply domain expertise to evaluate the central areas for future work. This framework has been employed in past studies concerned with clean technology innovation in general and with transportation electrification in particular.[7] [8]

A technology innovation system has been defined as "the interrelated set of actors, networks and institutions that contribute – in a supporting or detracting way – to the development, diffusion and applications of knowledge and/or products related to a given technology".[9] TIS postulates that there are seven functions that an innovation system should develop, if it is to create conditions conducive to the adoption of a new technology. Figure 1 shows the names of these functions and schematically illustrates that, as functions of a system, they are interconnected.

[7] Vergis and Mehta (2012) Technology innovation and policy: A case study of the California ZEV mandate; Vergis (2014) The Norwegian electric vehicle market: A Technology Innovation Systems analysis.

[8] Collantes, G., J. Kessler, and E. Cahill (2017) Structural Determinants of Electric Vehicle Market Growth.

[9] Ibid.

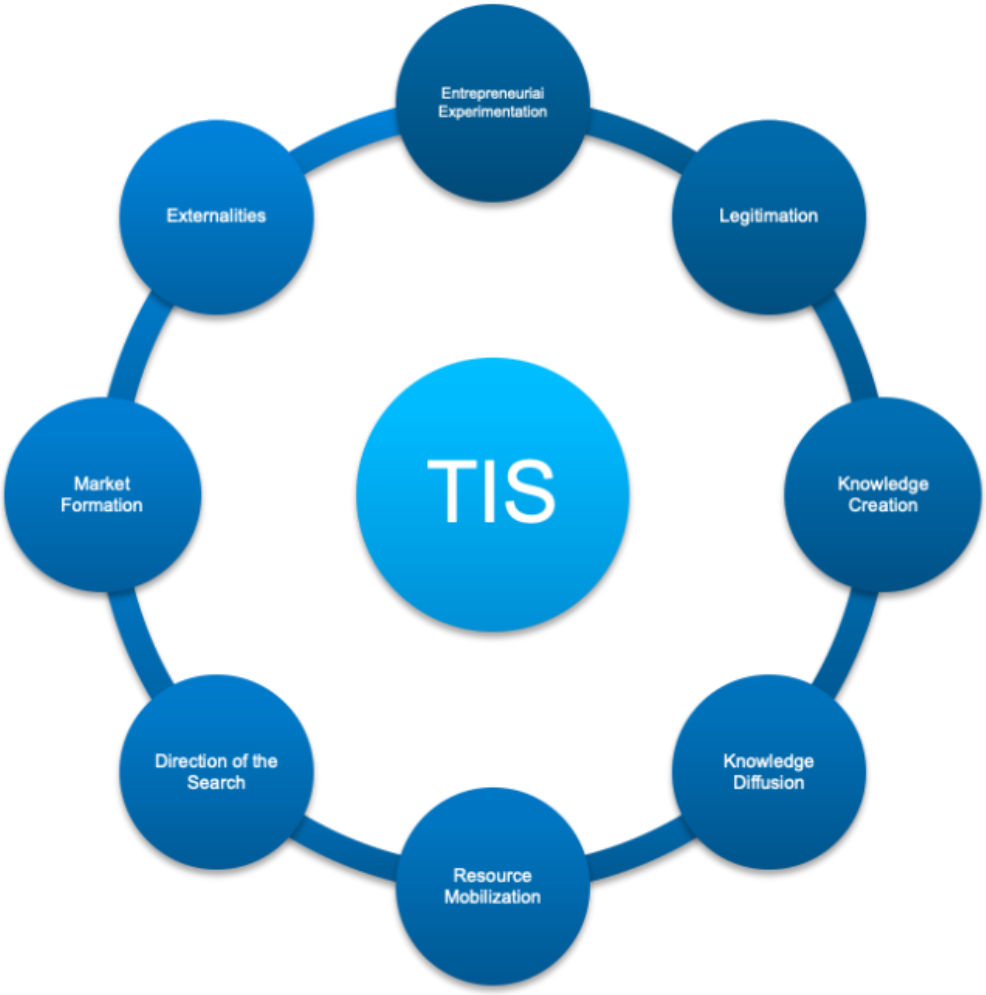

Figure 1. Schematic of the functions of the Technology Innovation Systems framework

2.1. Conceptual Definitions of the TIS Functions

Entrepreneurial Experimentation

Function of the TIS related to probing new ideas to support technology innovation. New ideas can relate to technologies, methods, and institutions.

Knowledge Development

Function of the TIS related to the creation of new knowledge about technology, methods related to the technology, or institutions that support the technology. Knowledge differs from data and

information, though these can be a condition toward knowledge creation. Knowledge should be a consequence of the probing that happens as part of entrepreneurial experimentation.

Knowledge Diffusion

The function of the TIS that disseminates knowledge within organizations and/or through networks in the innovation system. In a strong innovation system, knowledge diffusion and knowledge creation are intimately connected, although neither warranties the other.

Influence on the Direction of the Search

The function of the TIS concerned with creating endogenous pressures for actors, institutions and networks to invest resources to innovation in the technology. Pressures may arise from regulations, market demand, expectations and beliefs, and others.

Market Formation

The function that relates to all activities that can have a positive impact on technology adoption and that would not happen naturally or spontaneously under established institutions. These activities can range from public intervention, to the implementation of an ingenious market application, to many others.

Legitimation

Function that relates to activities directed to making the technology more accepted by the public, policymakers, and the private sector. Legitimacy is better understood on the background of established competing technologies, which are accepted by the market and supported by economic and/or political groups. Legitimacy grows when is less resisted by the public and established groups of power.

Resource Mobilization

Function concerned with the allocation of capital, labor, and assets toward supporting technology innovation.

Development of Positive Externalities

Function concerned with the creation of spillovers from the technology system to other technology systems, or vice versa. Such benefits can take many forms, including technological, symbolic, economic, and political.

2.2. Utilizing TIS to Analyze Electric Vehicles Adoption

Electric mobility is an interesting technology to analyze with the help of the TIS framework. For electric vehicles to materialize their full carbon-mitigation potential and make a significant impact to combat climate change, market uptake will need to increase continuously and fast toward scale. This in turn will require continued innovation, both at a product level, as well as across the entire supply chain. As with any emerging technology, there is a set of actors, institutions, and policies that can and should work together to support the adoption and use of electric vehicles. Failure to find these collaborations will deter market growth.

TIS analysis can reveal obstacles to adoption that might remain uncovered with other means of analysis, for example using innovation modeling methods. As a specific example from earlier work, TIS research revealed fundamental differences between how electric vehicles and conventional vehicles were sold at dealerships in the United States, and then highlighting retail practices that would be more effective at supporting the adoption of electric vehicles.[10] With a TIS analysis, it might, for instance quickly become apparent that functional fulfillment is weak for *legitimation* in Latin America. Addressing this weakness adequately could efficiently improve uptake of electric vehicles. Strategies to address legitimation would be a very different than policy instruments such as tax rebates or fleet composition requirements, which would serve to strengthen other functions of the TIS.

Table 1 is included to summarize the meaning of each TIS function, including example indicators for their evaluation.

Table 1. TIS function definitions and high-level operationalizations

[10] Cahill, E., Davis-Shawhyde, J., & Turrentine, T. S. (2014). New Car Dealers and Retail Innovation in California's Plug-In Electric Vehicle Market. In D. University of California (Ed.). University of California, Davis: Institute of Transportation Studies.

Function name	Function description	Example function indicators
Entrepreneurial Experimentation	Function related to probing new ideas to support technology innovation. New ideas can relate to technologies, methods, and institutions.	• Test programs (trials, pilots, etc.) • Local EV-related industry • Regulatory & business models • Variety in vehicle offering • Exceptional champions
Knowledge Development	Function related to the creation of new knowledge about technology, methods related to the technology, or institutions that support the technology.	• Feasibility studies or similar • Identification of factors driving adoption • Government reports • Research groups • Technical assistances • Time since market entry
Knowledge Diffusion	Function that disseminates knowledge within organizations and/or through networks in the innovation system.	• EV working groups • Legislative activity • Interagency collaboration • Industry-government networks • Guidance documents
Influence on the Direction of the Search	Function concerned with creating endogenous pressures for actors, institutions and networks to invest resources to innovation in the technology.	• Institutional roadblocks • Public expressions of support • EV in NDCs • EV plans/strategy • EV-related legislation/ordinances • Articulation of expectations (market share, socio-environmental benefits, etc.) • EV-affecting regulation

Market Formation	Function that relates to all activities that can have a positive impact on technology adoption and that would not happen naturally or spontaneously under established institutions.	• EV adoption requirements • Incentives and magnitude • EV-affecting fiscal instruments and magnitude • Program duration/stability • Marketing campaigns • Investment in infrastructure
Legitimation	Function that relates to activities directed to making the technology more accepted by the public, policymakers, and the private sector.	• Level of public information • Level of public acceptance • Level of political information • Level of political acceptance/political divide over EV • Competitive credit conditions • Retail price relative to alternatives • Electricity price differential • Investment in infrastructure
Resource Mobilization	Function concerned with the allocation of capital, labor, and assets toward supporting technology innovation.	• Public funding appropriations to support EV adoption • Private investment • Credit availability • Dedicated staff • Executive office involvement • Industry product supply
Development of Positive Externalities	Function concerned with the creation of spillovers from the technology system to other technology systems, or vice versa.	• Job creation • Environmental benefits • Intersectoral links • Electric utilities involvement

2.3. Data collection

The data collection process was structured around two central components: (a) research of publicly available information, and (b) interviews with local stakeholders. In all cases, the search for data and information was guided by the TIS framework. Interviews were sought with key local actors. Interviews included, among others, the National Secretariat of Energy (SNE), Mass Transport of Panama (MiBus), Ministry of Environment (MiAmbiente), electricity generation and distribution companies, and financial institutions. Interviews were conducting on digital platforms and typically lasted between 45 minutes and 75 minutes. In some cases, stakeholders were consulted multiple times.

3. Evaluation of the TIS functions for Panama

Table 2 shows the areas of action that ENME has identified as *high-priority* and their correlation with the TIS functions. Table 3 shows the same, for areas of action identified as *medium priority*.

Table 2. Correlation between high-priority action items in the National Strategy of Electric Mobility and TIS functions

Areas of Action	Market Segment	Entrepreneurial Experimentation	Knowledge Creation	Knowledge Diffusion	Influence on the Direction of the Search	Market Formation	Legitimation	Resource Mobilization	Development of Positive Externalities
Develop specific objectives, indicators, and timetables for the implementation of the Areas of Action	All				■			■	
Identify areas to improve legal and regulatory frameworks in the transport sector, to enable the implementation of the National Strategy of Electric Mobility	All				■			■	
Implement a working group for the sustained dialogue amongst public and private entities relative to electric mobility.	All						■	■	
Do economic and market analyses of fiscal incentives for electric vehicles	All		■						
Analysis of non-monetary incentives	All		■						
Implement vehicle emission standards and emissions testing procedures	All				■	■			
Review and revise extant law relative to procedures for vehicle emissions testing	All		■		■				
Implement mechanisms for the modernization of vehicle emission testing workshops	All				■				
Commission a study of pathways for the implementation of carbon pricing mechanisms	All		■		■				
Specify requirements around homologation, safety, and interoperability of imported electric vehicles	All		■		■				
Include requirements for charging stations in new buildings in the Sustainable Building Rule (Reglamento de Construcción Sostenible)	Personal vehicles				■	■	■		
Conduct studies about the need for dedicated EV charging rates	Personal vehicles		■		■				
Conduct studies about the need for dedicate charging rates for public transportation fleets	Buses		■		■				
Review a list of studies and technical assistances needed, seek collaborations with multilateral banks, and move expeditiously to formalize contracts	All		■		■				
Develop NAMAs and request funding from green funds	All							■	
Coordinate conversations between the Commission of Electric Mobility and multilateral banks, about the incorporation of electric buses	Buses							■	
Conduct an analysis of the feasibility to replace government vehicles with electric vehicles	Public fleets		■		■				
Evaluate opportunities for the replacement of light-duty and medium-duty government trucks with electric vehicles	Public fleets		■						
Include emission and efficiency standard requirements in the procurement process related to government fleets	Public fleets					■			
Establish goals and a timetable for the replacement of internal combustion vehicles in government fleets with electric vehicles	Public fleets					■			
Encourage private fleet to adopt electric vehicles and support their access to green funds	Private fleets				■		■		
Conduct analyses of the operational conditions of public transport buses and determine the technical, financial, and environmental feasibility of integrating electric buses	Buses		■						
Include emission and efficiency requirements in MiBus's procurement processes	Buses					■			
Establish a program for the electrification of public transport fleets	Buses				■	■			
Broad dissemination of the pilot projects that are being implemented	All			■					

Table 3. Correlation between medium-priority action items in the National Strategy of Electric Mobility and TIS functions

Implement new-vehicle efficiency standards	Personal vehicles								
Adopt certification of emissions and efficiency for imported vehicles	All								
Develop a congressional bill relative to the implementation of carbon pricing mechanism	All								
Include charging infrastructure requirements in urban development plans	Personal vehicles								
Create innovative business models for charging infrastructure	Personal vehicles								
Encourage methods of payment for the use of charging infrastructure that support the growth of electric mobility	Personal vehicles								
Evaluate projected grid load from electric vehicles and determine "optimal" charging sites	All								
Development regulations for charging sites	Personal vehicles								
Support pilot tests and disseminate results, to mitigate concerns about range limitation	All								
Regulate the installation of commercial EV charging stations	Personal vehicles								
Conduct feasibility studies about the integration of electric vehicles to government fleets	Public fleets								
Invite the input of local commercial banks and insurance companies on the implementation of the National Strategy	All								
Conduct lifecycle analyses of the proposed fleet modernization projects	All								
Review and revise Law 33 relative to vehicle waste management	All								
Disseminate results from private fleet pilot projects	Private fleets								
Implement incentives for the electrification of taxi fleets	Private fleets								

3.1 Entrepreneurial Experimentation

The development of and experimentation with new ideas play an important role in the transition to electric mobility. Panama is no exception. Not only the number of experiments but also their quality and commitment to them are foundations to the pace and success of the transition. Experimentation is not a goal in itself, though. It rather is a means to strengthen other function in the innovation system, for example by developing new information, increasing exposure to and familiarity with the technology, etc. In this sense, test programs, new technology developments, incursions into subjects related to new business models and policy instruments, are the engines moving the transition.

Table 4. Areas of action related to entrepreneurial experimentation in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	None
Medium priority	Create innovative business models for charging infrastructure
	Encourage methods of payment for the use of charging infrastructure that support the growth of electric mobility
	Support pilot tests and disseminate results, to mitigate concerns about range limitation

As part of the experimentation process, several stakeholders in Panama have deployed electric mobility assets. To help with later discussions, it is important to correctly characterize these initiatives. Terms such pilot project, proof of concept, trial, demonstration project, and others are often confusing to those unfamiliar with the innovation jargon and are often used incorrectly. A few concepts are next defined:

Trial: A trial involves putting the product, service, or solution in the hands of the prospective customer and allow them to experience it first-hand in their own environment, with the goal of validating the characteristics advertised by the supplier.

Proof of concept (POC): A proof of concept is a small-scale targeted exercise to test the *potential* of a service, product, or solution to be applied by the prospective customer in the real world. The focus of the POC is to show if a feature or system *can* be developed.

Prototype: A prototype is employed when there is a clear hypothesis about a service or solution, but it is still uncertain how it would work and feel. Prototypes can evolve; by incorporating lessons, the prototype of the service or solution can be refined and improved.

Pilot project: Pilot projects are the first phase of implementation of a service or solution that is expected to be rolled out at scale. Pilot projects are used when there is strong evidence that the service or solution is effective, and it is of interest to test it with a small sample of real users, to identify and, hopefully, fix any final issues.

These types of initiatives, particularly pilot projects, need to be participatory. Involving the range of relevant stakeholders will help identify key factors for scaling up, build ownership, generate political interest, and overall increase the chances of success of larger deployments.[11] [12]
While electric mobility is only starting in the region, the view of electric utilities is that it will eventually grow, and for this, it is important to develop attractive business models. The challenges tend to be at the regulatory level and seek avenues of reform that enable the market to accelerate.[13]

In Panama a few initiatives have taken place that could probably be best characterized as trials or proofs of concept. Three of these have taken place in the city of Panama, led by the Panama Canal Authority (ACP), ENSA, and MiBus. ACP incorporated nine hybrid electric vehicles in 2009 and then added an electric vehicle in 2012. ENSA acquired two electric vehicles to be used at its corporate offices in order to evaluate the technology since early 2018. [14] Seven BYD e6 electric taxis were deployed in the city of Colón in 2019, as pilot project, of a partnership between ENSA Services, TRASERVI, and BYD. As announced, the fleet of electric taxis was expected to reach 60 units by the end of 2019, and eventually 1,500 units, although at the time of this writing no information could be obtained about deployments beyond the initial. The companies built a charging infrastructure for EVs in Colon. [15]

As part of an intention to transition the public transport system cleaner technologies, the City of Panama decided to implement a trial of an electric bus BYD K7M to serve the old town of Panama City. This initiative included a partnership with MiBus, the Ministry of Environment, the Secretary

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[11] World Health Organization (2011) Beginning with the End in Mind: Planning Pilot Projects and Other Programmatic Research for Successful Scaling Up.

[12] Ryghaug, M., M. Ornetzeder, T. Skjolsvold, and W. Throndsen (2019) The role of experimentation and demonstration projects in efforts of upscaling: An analysis of two projects attempting to reconfigure production and consumption in energy and mobility. *Sustainability* 11, 5771.

[13] Gathered from meetings with energy companies serving Panama City. July 2020.

[14] ONU Medio Ambiente, Informe de situación nacional – Estrategia Nacional de Movilidad Eléctrica, 2019. Available at https://movelatam.org/wp-content/uploads/2019/06/ENME-Panama-Informe-de-Situacion.pdf

[15] CleanTechnica, “BYD delivers the first of 1,500 taxis to Colon, Panama”, 07/08/2019. Available at https://cleantechnica.com/2019/07/08/byd-delivers-the-first-of-1500-taxis-to-colon-panama/

of Energy, and the Authority of Transportation and Terrestrial Transit (ATTT). [16] A charging station was installed by BYD at one of MiBus's depots. The program was backed up by UN Environment on August 2018 as an important step towards a more sustainable mobility alternative to reduce polluting emissions. UN Environment stated that: "If the entire current fleet of buses and taxis in Panama City were replaced by electric vehicles, almost $500 million would be saved in fuels by 2030 and emissions of 8.5 million tons of carbon dioxide equivalent would be avoided." [17] A detailed evaluation of this trial was presented in a separate report of this technical assistance.[18] Following up on the trial of the BYD K7M, a proof of concept as implemented with a larger 12-meter model, the BYD K9FE, with overnight charging technology. This was a collaboration among MiBus, ENSA Services, and BYD with the purpose of assessing opportunities to incorporate electric buses to the public transport system in Panama City. The bus was operated for periods of time ranging from a few days to three weeks on 12 different routes.

Bavarian Motors, a BMW dealership and service center, has installed five 7 kW public-access charging stations in dealerships (2), malls (1), the offices of UN Environment Program (1), and the electric distribution company Naturgy (1). BYD has also installed three charging stations in Panama City, one at its distribution center, another in the business district of Santa Maria, and one 40 kW station in Colon at TRANSERVI, a bus and taxi transport enterprise.[19] Some of these stations have connectors complying with the SAE J1772 American standard, while others comply with the Mennekes European standard.

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[16] E&N, "Panamá: La alcaldía de Ciudad de Panamá pone a prueba buses eléctricos."06/08/2018. Available at https://www.estrategiaynegocios.net/centroamericaymundo/1204457-330/panam%C3%A1-la-alcald%C3%ADa-de-ciudad-de-panam%C3%A1-pone-a-prueba-buses-el%C3%A9ctricos

[17] Busworld, "Ciudad de Panamá tendría autobuses eléctricos," 08/08/2018. Available at https://www.busworld.org/articles/detail/3964/ciudad-de-panam-tendra-autobuses-elctricos

[18] LOGIOS (2019) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 2.2. https://www.ctc-n.org/content/d22report-recommendation-most-appropiate-technology-panama

[19] ONU Medio Ambiente, Informe de Situación Nacional – Estrategia Nacional de Movilidad Eléctrica, 02/21/2019. Available at https://movelatam.org/wp-content/uploads/2019/06/ENME-Panama-Informe-de-Situacion.pdf

Celsia, an energy company, installed a 7.2 kW charging station in a mall in Panama City, that opened to the public in February 2019. It was expected that, for the first year, the public could use the station free of cost. [20]

Cervecería Nacional partnered with Truckslogic y Banistmo, supported by MiAmbiente, to integrate an electric vehicle for urban logistics. The BYD T3 unit, which costed $32,000, started rolling on January 2020, serving the old town of Panama City, operating three journeys per day. For this project, a charging station was installed at Cervecería Nacional in Sábana, Vía España. [21] At the time of starting this initiative, Truckslogic anticipated that at least another five units would be incorporated in the second trimester of 2020.

Reference case: Colombia

Colombia has had many opportunities for experimentation considering the number of trials and proof of concept projects it hosted over the years. These projects were led by both the public and private sectors, ranging public transportation fleets, taxi fleets, and freight vehicles. There is no clear evidence that early deployments were taken as opportunities for collection of data and testing of ideas. Rather deployment, in general, started with fleets of scores of buses.

Experimental electric buses were developed and deployed in the city of Cali starting in 2014. They used older battery technology but provided exposure to zero-emission vehicles for public transport. Cali was the first city in Colombia to deploy a fleet of electric buses; in 2019 a partnership between the Major's Office, Metro Cali, Blanco y

[20] ElCapitalFinanciero.com, "Celsia inaugura su primera estación de recarga para autos eléctricos en Panamá," 02/07/2019. Available at https://elcapitalfinanciero.com/celsia-inaugura-su-primera-estacion-de-recarga-para-autos-electricos-en-panama/

[21] Ministerio del Ambiente de Panamá, "MiAMBIENTE APOYA EL LANZAMIENTO DEL PRIMER AUTO ELECTRICO PARA TRANSPORTAR CARGA", 01/27/2020. Available at https://www.miambiente.gob.pa/miambiente-apoya-el-lanzamiento-del-primer-auto-electrico-para-transportar-carga/

Negro Masivo, and Celsia, introduced 26 units. Another 109 units are in the plans. No evidence could be found of technical or engineering studies leading to the investment.

The city of Bogota embarked in a process that included experimentation with few units, which helped the city identify issues prior to procurement. A trial involving an 18-meter articulated electric bus was conducted in Bogota starting on June 2017. A tender in September 2019 for the procurement of 594 electric buses was declared void, because of a variety of reasons, including a high perceived financial risk of the Sistema Integrado de Transporte Público (SITP), and the failure of some intended bidders to secure adequate insurance.

Later in 2019, Bogota awarded a concession for operation and maintenance of the electric buses fleet to Somos Operación S.A.S and Empresa Operadora de Transportes Gran Américas S.A.S., and for the provision of 379 electric buses to Plural Structure Electribus Bogotá and Empresa de Energía del Pacífico S.A. ESP. These new electric buses will be part of Transmilenium fleet, the Sistema Integrado de Transporte Público (SITP). ENEL Codensa is responsible for the provision of charging infrastructure, including 177 charging stations. The depots will have an

[22] Sistema Integrado de Transporte Masivo de Cali, “MIO puts into service the first electric fleet of an integrated mass transportation system in Colombia,” 09/09/2019. Available at https://www.metrocali.gov.co/wp/el-mio-pone-en-servicio-la-primera-flota-electrica-de-un-sistema-integrado-de-transporte-masivo-en-colombia/

[23] Sistema Integrado de Transporte Masivo de Cali, “Cali metro opens tender to acquire 109 electric buses under concession,” 05/27/2019. Available at https://www.metrocali.gov.co/wp/metro-cali-abre-licitacion-para-adquirir-en-concesion-109-buses-electricos/

[24] Transmilenio, "Con 379 buses, Bogotá tendrá la flota eléctrica más grande del país," 11/14/2019. Available at https://www.transmilenio.gov.co/publicaciones/151495/con-379-buses-bogota-tendra-la-flota-electrica-mas-grande-del-pais/

installed capacity of 8-10 MW to charge the fleet at the same time, and it is expected to be online by the second half of 2020.

In April of 2018 the first electric bus arrived in Medellin. A collaboration between Empresas Públicas de Medellin (EPM), Metroplus, the City of Medellin, and Metro, the bus was an 18-meter articulated BYD bus. In December that same year, Medellin granted a contract for the provision of 64 electric buses to the consortium Green Medellin, composed of BYD Industry Company and BYD Colombia. Only limited planning was done prior to deployment, and some of the buses remained out of service because of insufficient charging capacity.

Medellin also experienced the introduction of electric taxis in 2019, a joint project of the City of Medellin and EPM that gave economic incentives to taxi owners of old units. The project involves two vehicle models: the BYD e5 and the Renault Zoe.

Renting Colombia SA delivers financing and leasing services. The Company offers vehicle acquisition, maintenance, insurance, rental assistance, satellite procedures and licenses, vehicle and fleet administration, and stand-by vehicles services. They have started few pilot projects with several companies, including Nutresa, Colombina, Exito, and Cervecería Bavaria. The latter conducted a proof of concept in Medellin in 2019, involving one electric truck for urban logistics. Positive results led to a decision

[25] Revista Auto Crash, "Enel-Codensa construirá las electrolineras de los buses del SITP eléctricos," 11/18/2019. Available at https://www.revistaautocrash.com/enel-codensa-construira-las-electrolineras-de-los-buses-del-sitp-electricos/

[26] Alcaldía de Medellín, Secretaria de Movilidad de Medellín, Por las calles de Medellín ruedan los taxis eléctricos, 09/19/2019. Available at https://www.medellin.gov.co/movilidad/component/k2/por-las-calles-de-medellin-ruedan-los-taxis-electricos

[27] Bloomberg, Company profile Renting Colombia. Available at https://www.bloomberg.com/profile/company/SURENT:CB

[28] Grupo BanColombia, Sala de Prensa, "Grupo Bancolombia pondrá en circulación 1.000 camiones eléctricos para mejorar la movilidad sostenible del país,", 03/12/2019. Available at https://www.grupobancolombia.com/wps/portal/acerca-de/sala-prensa/noticias/responsabilidad-social-ambiental/circulacion-1000-camiones-electricos

to increase the fleet, in partnership with Renting (Grupo BanColombia), bringing 200 electric vehicles in a period of 2 years, in the cities of Bogotá and Medellin.

Reference case: Costa Rica

Costa Rica has conducted pilots and planning for developing infrastructure in the transportation sector, specifically for electrifying public transportation, buses and train. For this purpose, the country has developed alliances and partnerships with other governments, multilateral organizations, and private sector with specific knowledge of electric mobility market, as well as prepared the legal and regulatory terrain for electric mobility, so the stakeholders have a better understanding of the landscape for establishing business in the sector. Here are some of the entrepreneurial initiatives that Costa Rica has experienced so far.

The first test program with electric buses for public transport system, took place as a collaboration between BYD, the Office of the First Lady of the Republic, ICE, the National Force and Light Company (CNFL) and the University of Costa Rica (UCR). UCR researchers participated in the data collection process for a detailed evaluation of the performance.

A Public Private Partnership known as IETP-Bus was started, to introduce electric buses, starting with three units donated by the German Cooperation Agency GIZ. The pilot project was expanded with 12 units contributed by different operators. The project

[29] Cervecería Bavaria, Noticias. “Bavaria tendrá la flota más grande de camiones eléctricos del país gracias a su alianza con Grupo Bancolombia.” Available at https://www.bavaria.co/camiones-electricos-bavaria

[30] Energía Limpia para todos, "República China impulsa buses 100% eléctricos no contaminantes en Costa Rica y América del Sur," 10/27/2019. Available at https://energialimpiaparatodos.com/2019/10/27/republica-china-impulsa-buses-100-electricos-no-contaminantes-en-costa-rica-y-america-del-su/

is the result of a collaboration between the public sector (Ministry of Public Works and Transport (MOPT), Ministry of Environment and Energy (MINAE), and The Costa Rican Electricity Institute (ICE)), the private sector and international organizations. The First Lady Claudia Dobles led the opening of the project, highlighting the importance of experimentation and data collection, to develop metrics of performance in a wide variety of operational conditions. Various key stakeholders were engaged as part of the project, which enabled broader experimentation—for example, with dedicated electricity tariffs.

Charging infrastructure at Grupo ICE, an electricity and telecommunications company, has experience a positive trend in the last 4 years, starting with semi-fast chargers: One in 2016, two in 2017, and thirty-four in 2019, and then with eight fast-chargers in 2019. During this year, the company acquired 100 electric vehicles.

In November 2019, the company of Correos de Costa Rica, S.A. (CCR) announced the electrification process of its fleet for deliveries that would be carried out in the medium term with the aim of equipping it with 348 electric motorcycles. NPP Recently, the enterprise added 44 electric motorcycles to the already 5 in its fleet with a cost of approximately US$360,000. Also, CCR in partnership with Euradvance S.A.

[31] Government of Costa Rica, Presidency, "Costa Rica amplía plan piloto de buses eléctricos como parte de la modernización del transporte público," 03/05/2020. Available at https://www.presidencia.go.cr/comunicados/2020/03/costa-rica-amplia-plan-piloto-de-buses-electricos-como-parte-de-la-modernizacion-del-transporte-publico/

[32] Grupo ICE, Available at https://www.grupoice.com/wps/portal/ICE/Electricidad/carga-elect/estaciones-carga/estaciones+de+carga+nuevo

[33] Government of Costa Rica, "Correos de Costa Rica anuncia la transformación eléctrica de su flota de motocicletas," 11/21/2018. Available at https://www.presidencia.go.cr/comunicados/2018/11/correos-de-costa-rica-anuncia-transformacion-electrica-de-su-flota-de-motocicletas

is incorporating 2 electric vehicles with more capacity for packaging delivery in the metropolitan area.

3.2 Knowledge Development

Developing knowledge, not just about the technology but also about policy, economics, etc. is a fundamental block to enable evidence-based initiatives. As shown in Table 5, the National Strategy of Electric Mobility recognized this importance, including numerous action areas related to the development of knowledge.

Table 5. Areas of action related to knowledge development in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	Do economic and market analyses of fiscal incentives for electric vehicles
	Analysis of non-monetary incentives
	Review and revise extant law relative to procedures for vehicle emissions testing
	Commission a study of pathways for the implementation of carbon pricing mechanisms
	Specify requirements around homologation, safety, and interoperability of imported electric vehicles
	Conduct studies about the need for dedicated EV charging rates

[34] Government of Costa Rica, "46 motocicletas y 2 vehículos eléctricos se suma a la flotilla cero emisiones de Correos de Costa Rica," 05/16/2020. Available at https://www.presidencia.go.cr/comunicados/2020/05/46-motocicletas-y-2-vehiculos-electricos-se-suman-a-la-flotilla-cero-emisiones-de-correos-de-costa-rica/

	Conduct studies about the need for dedicated charging rates for public transportation fleets
	Review a list of studies and technical assistances needed, seek collaborations with multilateral banks, and move expeditiously to formalize contracts
	Conduct an analysis of the feasibility to replace government vehicles with electric vehicles
	Evaluate opportunities for the replacement of light-duty and medium-duty government trucks with electric vehicles
	Conduct analyses of the operational conditions of public transport buses and determine the technical, financial, and environmental feasibility of integrating electric buses
Medium priority	Create innovative business models for charging infrastructure
	Evaluate projected grid load from electric vehicles and determine "optimal" charging sites
	Development regulations for charging sites Support pilot tests and disseminate results, to mitigate concerns about range limitation
	Conduct feasibility studies about the integration of electric vehicles to government fleets
	Conduct lifecycle analyses of the proposed fleet modernization projects

Electric mobility is a technology that public institutions and private companies are starting to integrate in their planning as a way to incorporate sustainable practices. As described in the discussion of Entrepreneurial Experimentation, both private and public sectors have been taking some steps to test technologies. Their work has yielded some information that might be useful for next steps. For example, building upon vehicle trials, MiBus is developing interest in exploring shorter 9-meter electric buses, which might adapt better to the characteristics of the road infrastructure in parts of Panama City. [35] Indeed, it is *critical that experimentation develops into information* that can be used to advance the market. While several actors in Panama have

[35] From working sessions between MiBus and LOGIOS.

participated in the deployment and trial of rolling and charging assets, the extent to which these have been planned and methodically evaluated is not too clear. This arises as an area of opportunity for stakeholders in Panama, to seek further collaboration, data collection, and program evaluation, thus taking full advantage of these opportunities for knowledge creation.

As many countries, just like Panama, are taking their first steps in electric mobility, it would be natural to look for potential lessons from countries and regions with a longer trajectory in this space. Elements of experiences from other countries, such as the Zero-Emission Vehicle (ZEV) program in California,[36] have been loosely referenced in the National Strategy document. Conversations with stakeholders, however, suggest that there has been a limited effort to studying experiences from regions with a longer history in electric transportation and debating how they could apply to Panama. At a regional level, there has been some activity around sharing lessons learned. For example, Panama's Secretary of Energy met with the Vice Minister of Energy of Costa Rica to share experiences relative to regulatory strategies for the support of energy efficiency, electric mobility, and distributed generation. [37]

Table 5 illustrates that there are important knowledge gaps in Panama, but importantly, Panama went through the process of identifying these gaps and incorporated in the National Strategy action items to address them. This is a very healthy process that will help get Panama in the right action track for the support of electric mobility uptake. Furthermore, Panama has started work on some of these areas. For example, the present technical assistance includes components directly aligned with the needs for information describe in Table 5. A study led by the World Bank, entitled *Analysis of Electromobility Solutions for Public Transport in Panama* was started in July 2020. Also, a series of webinars was agreed upon between MiBus and C40 Cities Finance Facility, for capacity building relative to operations of electric buses, the first of which took place in July 2020. MiAmbiente is leading an evaluation of strategies for carbon pricing, including the transport sector, expecting some results toward the later part of 2020.

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[36] Collantes, G. and D. Sperling (2008) The origin of California's zero emission vehicle mandate. *Transportatioin Research Part A: Policy and Practice* **42**(10: 1302-1313.

[37] MiAMbiente, "Panamá y Costa estrechan vínculos comerciales," 02/27/2020. Available at http://www.energia.gob.pa/2020/02/panama-y-costa-rica-estrechan-vinculos-politicos-y-comerciales/

Case study: Colombia

Colombia has good technical universities that have produced a variety of research initiatives related to transportation electrification.

The National Strategy recognizes the importance of creating knowledge on a few areas. It does not explicitly recommend the commissioning of studies to identify most effective, most efficient regulatory and fiscal instruments to support electric vehicle adoption and use.

Case study: Costa Rica

Costa Rica's Autoridad Reguladora de los Servicios Públicos (ARESEP) in partnership with the World Bank, contracted with Deloitte to do an economic study of electric buses. The study included a benefit cost analysis of electric buses, an estimation of operating costs, costs of charging infrastructure, etc. Of the conclusions proposed by Deloitte, one that got widely reported is that the integration of electric buses should be done in a stepwise manner, mainly due to the higher capital cost of the rolling assets. Another proposed conclusion is that battery technology limits viability of electric fleets for daily distances over 300km.

The Universidad de Costa Rica, with funding from the Interamerican Development Bank, conducted an analysis of the location of DC fast charge infrastructure in Costa Rica.

3.3 Knowledge Diffusion

The national government has communicated clearly where Panama stands in regard to electric mobility, highlighting the importance of this transition to achieve energy efficiency and environmental goals. Before the issuance of Cabinet Resolution 103, approving the National

Strategy of Electric Mobility (ENME) and instituting the Interagency Commission of Electric Mobility (Comisión Interinstitucional de Movilidad Eléctrica), a government report explained the situation at the time, including issues of transportation, infrastructure, legal and regulatory framework, and gaps and opportunities.[38]

The establishment of the Comisión Interinstitucional de Movilidad Eléctrica, described above, is an important step toward promoting communication and exchange of information across key government stakeholders. Capacity building is a critical area for the successful integration of electric buses to MiBus's fleet. Panama in general and MiBus specifically have recognized this and have been actively looking for opportunities to train their staff. This has involved webinar sessions with C40, a capacity building workshop as part of the present technical assistance, and others.

As suggested by the summary in Table 6, the National Strategy gives little attention to knowledge diffusion. The focus currently is in the dissemination of existence and results of test programs (including pilot projects). As discussed in the section on experimentation, the exchange of ideas and information needs to start at the planning stage, even before implementation of test programs; this is an area on which Panama could focus more. There are important areas for knowledge diffusion that Panama has not yet initiated in depth. One key example is the engagement of local electric utilities, to proactively identify areas of work, opportunities for mitigating operating costs, plan for prospective infrastructure needs, etc. The importance of electric utility engagement is discussed in a separate report.[39]

[38] MiAmbiente, SNE, ONU Medio Ambiente, WEC Panama, Eurclima+, Informe situación Estrategia Nacional de Movilidad Eléctrica de Panamá, 02/21/2019. Available at https://movelatam.org/wp-content/uploads/2019/06/ENME-Panama-Informe-de-Situacion.pdf

[39] LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.3. Sustainable Public Transportation Mobility Plan.

Table 6. Areas of action related to knowledge diffusion in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	Broad dissemination of the pilot projects that are being implemented
Medium priority	Support pilot tests and disseminate results, to mitigate concerns about range limitation
	Disseminate results from private fleet pilot projects

Case study: Colombia

Colombia's National Strategy establishes the creation of a permanent working group on zero-emission vehicle technology, as a participatory forum for stakeholders to debate of ideas around policies, regulatory instruments, and capacity building.

Pilot projects involving the deployment of electric buses in Colombia have generally involved several partners, such as city governments, fleet operators, and energy companies. This practice promotes joint learning and the exchange of ideas and knowledge.

[40] https://www1.upme.gov.co/DemandaEnergetica/ENME_2019_V16Oct19.pdf

Case study: Costa Rica

Costa Rica has implemented pilot projects involving partnerships of several actors, which is conducive to learning and diffusion of information among partners.

Costa Rica has a number of institutions with electric mobility as part of their academic training offering. One example is the National Institute of Learning (INA), which has a specialization in this field for technicians. The institute has a special course for light electric and hybrid vehicles, and it has been updated with a component of conversion of internal combustion cars into electric vehicles.

3.4 Influence on the Direction of the Search

Panama's National Determined Contributions (NDCs), while recognizing that transportation is the main source of greenhouse gas emissions (59% contribution) are focused on the sectors of energy, efficiency in transportation, land use-land use change and forestry. The reference to electric mobility in Panama's NDC is centered on the expansion of the Metro (electric railroad) system, while it also includes a broader objective of moving toward energy-efficient public transport. Electricity generation in Panamá is relatively clean, with a 60% share from renewable sources, predominantly hydro, contributing 52%, followed by wind, with about 7%, and then solar, with about 1%. NDCs for the energy sector are oriented to increasing the installed capacity from non-conventional renewable sources, such as solar, wind, and biomass by 30% by the year 2050.[42] In the near future, the country is considering the inclusion of the transportation sector, a

[41] ASOMOVE, "INA actualiza cursos para atender nueva demanda," 07/17/2019. Available at https://asomove.org/noticias/7802513

[42] Republic of Panama, Nationally Determined Contribution to Climate Change Mitigation (NDC) of the Republic of Panama before the United Nations Framework Convention on Climate Change (UNFCCC), April 2016. Available at https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Panama/1/Panama_NDC.pdf

central contributor to carbon emissions in Panama, as a component of the NDCs and then be presented as an appropriate mitigation action (NAMA).

The *Lineamientos Estratégicos: Agenda de Transición Energética 2020-2030* (Strategic Guidelines: Energy Transition Schedule 2020-2030) includes consideration of sustainable mobility. It recognizes that the transport sector bears much responsibility for the growth in greenhouse gas emissions, with a share of 65% of the national emissions. It further envisions a transition to electric mobility as a means to mitigate these emissions and sees fiscal incentives as a key policy instrument to support this transition. The document adopts as a metric of progress having a draft legislative bill ready, with the following timetable, starting on July 2020:

- Month 1: Establish the Comisión Interinstitucional para la Movilidad Eléctrica, chaired by the Secretariat of Energy;
- Month 2: Identify a set of prospective fiscal and non-fiscal incentives;
- Month 3: Consultations with the Ministry of Finance about the viability of different incentives;
- Month 4: Drafting and submittal of draft legislative bill. [43]

It should be noted that a draft bill was introduced to the Legislature on September 16, 2019, proposing a number of measures to support the market uptake of electric vehicles.[44]

The National Strategy of Electric Mobility includes a number of action areas related to influencing the direction of the search, as shown in Table 7.

Table 7. Areas of action related to influence on the direction of the search in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	Develop specific objectives, indicators, and timetables for the implementation of the Areas of Action

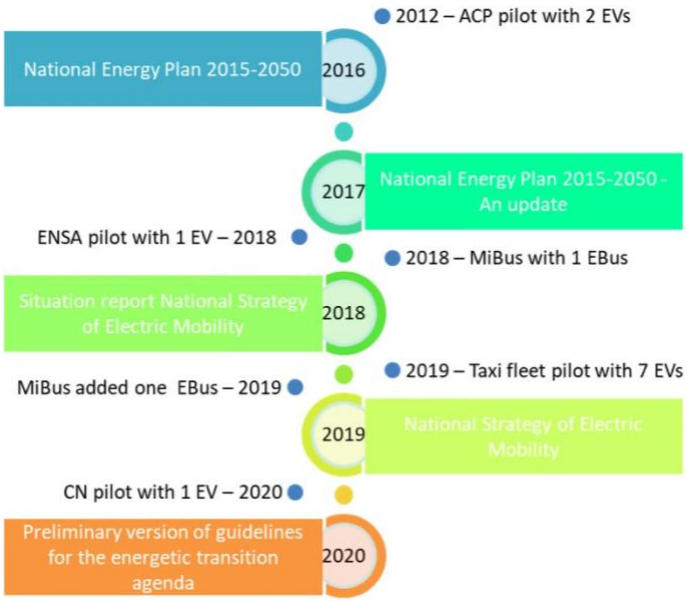
[43] Republic of Panama, Preliminary version of the strategic guidelines for the energy transition agenda, 06/11/2020. Available at https://www.gacetaoficial.gob.pa/pdfTemp/29045_A/GacetaNo_29045a_20200611.pdf

[44] As of the time of this writing, draft bill No162 is pending debate in the Committee on Communications and Transport of the Legislature.

Priority level	Areas of action
	Identify areas to improve legal and regulatory frameworks in the transport sector, to enable the implementation of the National Strategy of Electric Mobility
	Implement vehicle emission standards and emissions testing procedures
	Review and revise extant law relative to procedures for vehicle emissions testing
	Implement mechanisms for the modernization of vehicle emission testing workshops
	Commission a study of pathways for the implementation of carbon pricing mechanisms
	Specify requirements around homologation, safety, and interoperability of imported electric vehicles
	Include requirements for charging stations in new buildings in the Sustainable Building Rule (Reglamento de Construcción Sostenible)
	Conduct studies about the need for dedicated EV charging rates
	Conduct studies about the need for dedicate charging rates for public transportation fleets
	Review a list of studies and technical assistances needed, seek collaborations with multilateral banks, and move expeditiously to formalize contracts
	Conduct an analysis of the feasibility to replace government vehicles with electric vehicles
	Encourage private fleet to adopt electric vehicles and support their access to green funds

Priority level	Areas of action
	Establish a program for the electrification of public transport fleets
Medium priority	Include charging infrastructure requirements in urban development plans
	Implement new-vehicle efficiency standards
	Develop a congressional bill relative to the implementation of carbon pricing mechanism

The National Energy Plan 2015-2050 that was official in 2016, setting the goal of reaching 70% of the energy supplied through renewable sources by 2050. Later in 2017 there was a revision of the document given the significant increase in installed capacity for electric generation of wind and solar. [45, 46]



The timeline of policy-related actions relevant to energy in general and to electric mobility more specifically, has set an initial start for all stakeholders in Panama, from the public sector (Presidential Office, National Energy Secretary, Environment Ministry, ATTT), the private sector (Electric distribution

[45] Secretaría Nacional de Energía, Plan Energético Nacional 2015-2050, 04/05/2016. Available at http://www.energia.gob.pa/energia/wp-content/uploads/sites/2/2017/06/Plan-Energetico-Nacional-2015-2050.pdf

[46] Secretaría Nacional de Energía, Actualización PEN 2015-2050, 2017. Available at http://www.energia.gob.pa/energia/wp-content/uploads/sites/2/2018/04/PEN-2017-Versi%C3%B3n-Final.pdf

companies, Association of Automobile Dealers of Panama, other related businesses), as well as private citizens. Not only the electric mobility policies but also environmental awareness and potential economic drivers are motivating important market players (e.g. Panama City's town hall, ENSA), who are planning to include electric vehicles as part of their organizational culture, a reflection observe in pilot programs since 2012, and most recently with MiBus.

Case study: Colombia

Colombia's National Strategy of Electric Mobility aims to generate the regulatory and policy framework necessary to promote electric and sustainable mobility, review and generate the necessary economic and market mechanisms, and establish the technical guidelines to be developed to promote electrical technologies in the different market segments. The Strategy was authored by key ministries, and wide participation across government offices, starting with the President. The document is a clear signal that Colombia takes electric mobility as a matter of national importance.

Colombia has committed to reduce its greenhouse gas emissions by 20% by 2030 and it has taken the Nationally Determined Contributions as an opportunity to strengthen and build on measures to mitigate and adapt to climate change as well as to use them as a reference flag for future policies, programs, and projects among different sectors with the participation of public and private sectors and civil society. However, there is no specific mention of electric mobility as a way to help reduce pollution; they specify prioritized actions in the country, highlighting six priority sectors of the economy (transport, energy, agriculture, housing, health, and trade, tourism and

[47] ONU Programa para el Medio Ambiente, Estado de la Movilidad Eléctrica. América Latina y el Caribe, 2019. Available at https://movelatam.org/wp-content/uploads/2020/06/Reporte-Movilidad-ele%CC%81ctrica-LAC-2019-HQ-3.pdf

[48] https://www1.upme.gov.co/DemandaEnergetica/ENME_2019_V16Oct19.pdf

industry) that will include climate change considerations in their planning instruments and will be implementing innovative adaptation actions. .

COPES 3934 - Green Growth Policy – 07/10/2018. The objective of the Green Growth policy (CONPES 3934) is to define the actions that allow accelerating the transition towards electric mobility, with the goal of incorporating 600,000 electric vehicles by 2030.

Case study: Costa Rica

Costa Rica, with support from the Interamerican Development Bank, developed a National Strategy for the Support of Electric Vehicles.

Costa Rica passed into law legislation on incentives for electric vehicles.

Costa Rica's National Decarbonization Plan 2018-2050 includes the following goals:

- Public transportation – 70% of buses has to be electric buses by 2035 and 100% by 2050.
- Private vehicles – 25% of the fleet, private or institutional, has to be electric by 2035.
- Freight transportation – decrease in 20% of the emissions from this sector by 2050 with the introduction of new technologies.

[49] Government of Colombia, Intended Nationally Determined Contribution (iNDC), Available at https://www.minambiente.gov.co/images/cambioclimatico/pdf/colombia_hacia_la_COP21/iNDC_ingles.pdf

[50] Republic of Colombia, CONPES 3934, 07/10/2018. Available at https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/3934.pdf

3.5 Market Formation

Actions that impact directly the competitiveness of electric vehicles, helping them penetrate a market institutionally and economically dominated by incumbent technologies and fuels are a key component of health innovation systems. Such action might include electric vehicle adoption requirements (e.g. directives for the procurement of electric vehicles for public fleets, etc.), fiscal incentives, non-monetary benefits, publicity and promotional campaigns have a key role on determining the pace at which the transition into electric mobility takes place, and could set the path to achieve ENME goals by 2030.

The draft bill introduced to the Legislature on September 16, 2019, included a proposal on a number of market formation measures. These included:

- Establishing requirements for the installation of charging stations in buildings 50-meter or higher, shopping malls, and gas stations;
- Establishing requirements on charging stations for the permitting of new buildings;
- Stopping all renewals of concession contracts to suppliers of fossil-fueled buses to be used in public transport; and
- Requiring the Autoridad de Tránsito y Transporte Terrestre (ATTT) to establish minimum quotas of electric vehicles for taxi fleets.

Electric vehicle model offering in Panama is still limited. Sales in the last few years have concentrated in the luxury segment, where two plug-in hybrid electric vehicle models have seen the higher market uptake: the Porsche Cayenne SE and the BMW X5, with 70 and 34 units sold, respectively. BMW offers one all-electric model, the i3, of which few units have been sold. LOGIOS visited Bavarian Motors in March 2019 to discuss aspects of the commercialization of this model. The retail price of these vehicles is still significantly higher than in other markets, such as the United States.

Previous to the approval of ENME, there were conversations among public institutions, private sector, academia and international organizations that help to create the document, resulting in a Report on the National Situation regarding the National Strategy of Electric Mobility, in February,

2019. [51] This document, led by the United Nations Environment Program, discussed the state of the transport sector in Panama, from climate and institutional perspectives, and discusses challenges and opportunities for the transition to electric mobility. The document shows historical carbon emissions per kilometer from transport in Panama are consistent with other countries in the region, and between those in Colombia and Costa Rica. Sales of new passenger cars are comparable for Panama and Costa Rica (Figure 2), while sales in Colombia are 4-5 times bigger. The number of passenger cars on the road remains larger in Costa Rica (Figure 3).[52]

The Report on the National Situation argued, based on discussion among stakeholders and input elicited during the workshop that launched the National Strategy of Electric Mobility, that the central areas that need attention to support electric vehicle market growth are

- Retail prices
- Training programs for technicians and engineers
- Consumer education
- Charging infrastructure
- Mitigation of vehicle emissions
- Governance
- Fleets
- Studies

[51] MiAmbiente, SNE, ONU Medio Ambiente, WEC Panama, Eurclima+, Informe situación ENME, 02/21/2019. Available at https://movelatam.org/wp-content/uploads/2019/06/ENME-Panama-Informe-de-Situacion.pdf

[52] Based on World Bank's data, Costa Rica's population was about 4.8 million in 2015, while Panama's was about 4 million.

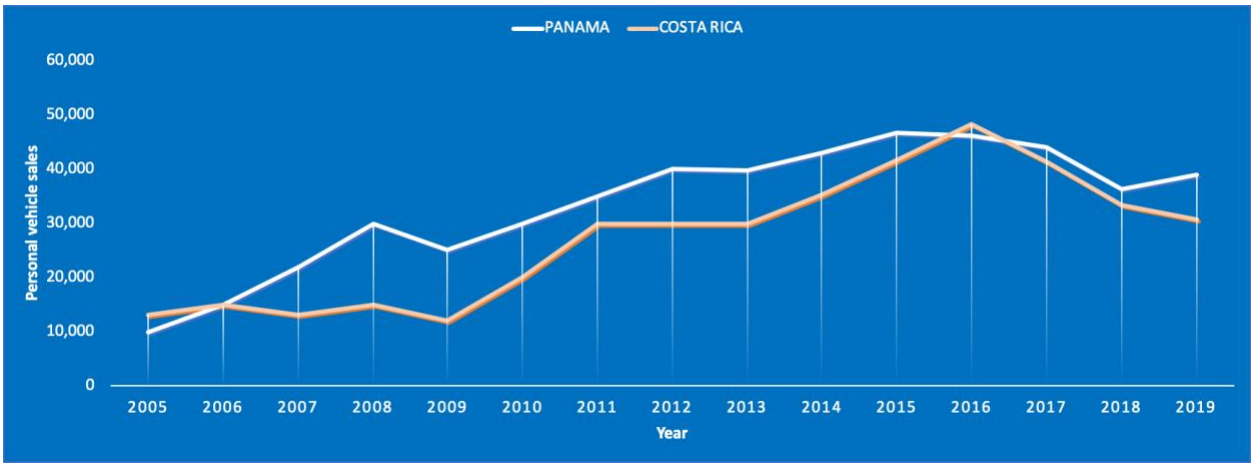


Figure 2. Historical annual sales of personal vehicles for Panama and Costa Rica (Data source: OICA chart: LOGIOS)

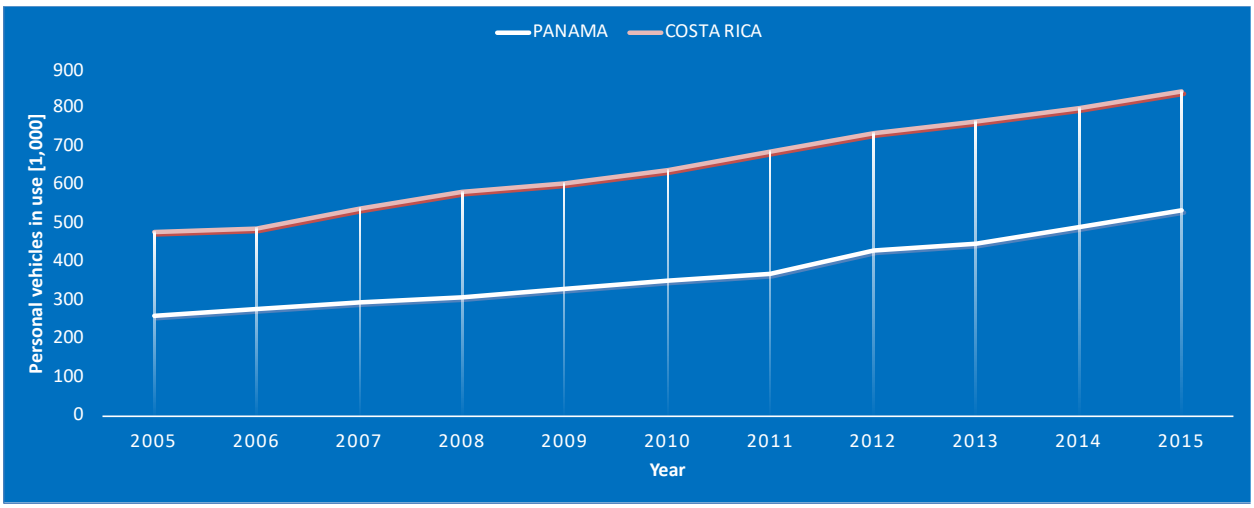


Figure 3. Personal vehicles in use in Panama and Costa Rica, 2005-2015 (Data source: OICA; chart: LOGIOS)

The National Strategy of Electric Mobility describes the benefits of electric mobility and action lines in four strategic areas, namely governance, regulations, strategic sectors,[53] and knowledge and education. The document highlights the importance to Panama of having an efficient

[53] Strategic sectors: Government fleets, Private fleets, Fleets of taxi services, delivery, industrial and heavy equipment, and Public transportation.

transportation system that uses cleaner energy sources.[54] The National Strategy of Electric Mobility includes a number of action areas related to market formation, as shown in Table 8.

Table 8. Areas of action related to market formation in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	Implement vehicle emission standards and emissions testing procedures
	Include requirements for charging stations in new buildings in the Sustainable Building Rule (Reglamento de Construcción Sostenible)
	Include emission and efficiency standard requirements in the procurement process related to government fleets
	Establish goals and a timetable for the replacement of internal combustion vehicles in government fleets with electric vehicles
	Include emission and efficiency requirements in MiBus's procurement processes
	Establish a program for the electrification of public transport fleets
Medium priority	Implement new-vehicle efficiency standards
	Adopt certification of emissions and efficiency for imported vehicles

As one early policy step toward supporting the market entrance of electric vehicles, Law 69 of October 2012 granted exemptions from the *selective tax* on the importation of electric and hybrid vehicles, regardless of the cost of the vehicle, until 2017. The tax level would rise to 5% starting

[54] Republic of Panama, National Strategy of Electric Mobility, 10/29/2019. Available at https://www.gacetaoficial.gob.pa/pdfTemp/28892_A/75497.pdf

on 2018.[55] One of the recommendations in the National Strategy of Electric Mobility is to consult with the Panama Automobile Supplier Association (ADAP, for its name in Spanish) and other market players, to evaluate what the best incentives may be to increase imports of electric vehicles. The alignment of incentives along the supply chain foster market development, as all economic agents will see reductions in the cost associated with participation in the electric vehicle market.

Electricity generation, transmission, and distribution companies have a central stake in the development of electric mobility markets. Distribution companies are supportive of the development of dedicated rates for the charging of electric vehicles. Rate structures are approved for periods of four years, and the current structure expires in 2022. There are however administrative processes for the revision of rate structures. These have to be initiated by the Secretariat of Energy and submitted to the Public Services National Authority (ASEP). A public consultation process would ensue, which would typically take about four months. Thus, establishing dedicated electricity and power rates for electric vehicles (possibly with differentiated rates for public transport buses and other public transportation modes) is a step that could be completed in the short term.[56] The electric vehicle rate structure can take several forms, and the best option/s for Panama can surface from close consultation between the Secretariat of Energy and the electricity companies. As one example, Pacific Gas & Electric, in California, has adopted two electric vehicle rate plans for private customers, both of which are time-of-use (ToU) rates. In one structure, costs from vehicle charging are integrated with those from the residence, while in the other a separate meter is installed to apply dedicated rates only to the charging of the vehicle. Meanwhile, Southern California Edison has decided to support the transition in public transportation by granting exemptions from demand charges (cost of access to power) for electric buses.

The services arms of the electric distribution companies (ENSA Servicios, Naturgy Servicios) can participate in the installation of charging equipment, although this participation has remained relatively low. In the U.S., many utilities have created incentive programs to support financially

[55] Republic of Panama, https://www.gacetaoficial.gob.pa/pdfTemp/27145_A/GacetaNo_27145a_20121018.pdf

[56] From interview with electricity generating and distributing companies serving Panama City. July 2020.

the installation of charging infrastructure in private and public spaces. In the case of the State of California, these incentives take the form of rebates, and range from $1,000 to $8,000 for a level 2 charging station, and from $3,000 to $10,000 for a DC fast charging station. These incentives are complementary of the rebate programs implemented by the state and air quality districts. The state offers rebates of $5,000-$7,500 for level 2, and $80,000 for DC fast charging stations.

Given that the capital requirements are large and financial resources are constrained, finding creative ways to maximize the cost-effectiveness and bankability of projects is key. Traditional financing mechanisms have been loans from multilateral financial institutions and bilateral from commercial banks. MiBus is now a public company and is financed from the national budget, although MiBus has discretion on the implementation of procurement processes.

In Latin America there has been a growing interest in having investment grade and liquid securities. In this context, Panama could assess the possibility of issuing a Green Bond in the capital markets, taking advantage of the economic performance of Panama in recent years. An example of Sovereign Green Bonds is found in Chile, where the bond was a key instrument in financing the 2017-2022 National Action Plan for Climate Change, as well as other measures including the electrification of buses and trains. The Chilean government issued the first green bond in June 2019 with an amount in Euros equivalent to US$1,418, 30-year maturity and an interest rate of 3.53%. Worth mentioning is the fact that the investor demand was 12.8 times the debt offer. In January 2020, the Chilean government decided to add an additional green bond in US dollars, this time for US$750 million, with 12-year maturity, at 2.571% interest rate, and the operation also included a reopening of the previous bond 2019 of US$900 million with an interest rate of 3.275%.[57]

As for the general public interested in buying electric vehicles, there is interest in the conditions at which they will access credit from local banks. The experience so far, in some of the banks, has been characterized by an organic growth of credit applications from current clients who have expressed interest in acquiring EVs. The criterion the bank has implemented is a simple one,

[57] Chile Reports, “Chile obtains record rate on issuance of green bonds in dollars,” 01/30/2020. Available at https://chilereports.cl/en/news/2020/01/30/chile-obtains-record-rate-on-issuance-of-green-bonds-in-dollars#:~:text=The%2012%2Dyear%20bond%20achieved,obtained%20for%20a%20similar%20maturity.

evaluating clients' credit quality and the characteristics of the electric vehicle technology and the local network of dealers and maintenance.[58]

Stakeholders express concern about the likelihood of meeting the goals set in National Strategy of Electric Mobility for electric vehicle market uptake by 2030. In this sense it is perceived as important to start moving toward the electrification of public transport fleets in Panama City and other regions, to deploy a solid network of charging stations in urban public places and in interurban roads. Also, the consideration of fiscal incentives is believed to be vital to stimulate enough the private sector to import more electric vehicles.[59]

Case study: Colombia

Decree 1116 seeks to stimulate the use of efficient vehicle technologies, with the purpose of protecting human health and reducing dependence on fossil fuels. It includes a reduction to 5% of the tariff for hybrid vehicles, 0% for electric vehicles, and 5% for electric charging systems. The tariff reduction will apply until 2027 for specific quotas.

Decree 2051/2019 partially modifies Decree 1116/2016 to eliminate restrictions on the imports of electric vehicles.

Law 1819 of 2016 grants a differentiated value added tax of 5%, for parts and charging centers of electric and hybrid vehicles, vehicles parts and chargers for Plug-in hybrid,

[58] From interview with local bank in Panama City. July 2020.

[59] Gathered from meetings with different actors in the transportation, energy, and banking sectors. July 2020.

[60] Republic of Colombia, Decree 1116, 06/29/2017. Available at http://es.presidencia.gov.co/normativa/normativa/DECRETO%201116%20DEL%2029%20DE%20JUNIO%20DE%202017.pdf

[61] Republic of Colombia, Decree 2051, 11/13/2019. Available at https://www.mincit.gov.co/getattachment/5d28532c-84a3-43a7-b4db-8054b6029d12/Decreto-2051-del-13-de-noviembre-por-el-cual-se-mo.aspx

hybrid and electric vehicles., as well as for electric motorcycles (87.11), electric 2- and 3-wheeled vehicles and non-motorized 2- and 3-wheeled vehicles (87.12).

Law 1964 promotes the use of electric vehicles. Article 8th specifies that government fleets, including municipalities and public transportation, must be at least 30% of electric vehicles by the year 2025. For cities that have public transportation, it is required that the acquisition of new vehicles for public transportation be at least 10% by 2025, 20% by 2027, 40% by 2029, 60% by 2031, 80% by 2033, and 100% by 2035.

The incentives, fiscal and non-monetary, for the use of electric vehicles covered in Law 1964 are:

- Exemption from *pico y placa* restrictions to operate
- Degrees of freedom for the Municipalities - these may develop economic incentives such as discounts on registration or vehicle tax, differentiated parking rates or tax exemptions
- 10% discount on *SOAT* (mandatory insurance for road accidents)
- Preferential parking - Min 2% of its capacity must be destined to VEs
- Within six years, 30% of the vehicles procured for the fleet of the national government and municipalities (with exceptions) must be electric

[62] Republic of Colombia, Law 1819, 12/29/2016. Available at http://es.presidencia.gov.co/normativa/normativa/LEY%201819%20DEL%2029%20DE%20DICIEMBRE%20DE%202016.pdf

[63] Republic of Colombia, Law 1964, 07/11/2019. Available at https://colaboracion.dnp.gov.co/CDT/Prensa/Ley1955-PlanNacionaldeDesarrollo-pacto-por-colombia-pacto-por-la-equidad.pdf

- Within three years, municipal governments (with exceptions) must install at least five public-access fast charging stations. For Bogota, this requirement is increased to 20 stations.

At the municipal level, as described above, the city of Medellin in partnership with EPM developed a plan to integrate 1,500 electric vehicles to the city's taxi fleet, which included a rebate of COP 17 million to the first 200 vehicles. The recipient of this rebate was not the new vehicle owner but the dealership.

Case study: Costa Rica

Costa Rica's National Strategy of Decarbonization sets a goal that 70% of the public transportation buses should be electric by the year 2035.

The Grupo Instituto Costarricense de Electricidad (ICE), with financial assistance from the Interamerican Development Bank, incorporated 100 electric vehicles to its corporate fleet, replacing 100 conventional combustion vehicles.

The National Decarbonization Plan 2018-2050 of Costa Rica includes the following relevant goals:

- Public transportation – 70% of buses has to be electric buses by 2035 and 100% by 2050.
- Private vehicles – 25% of the fleet, private or institutional, has to be electric by 2035.

64 https://dapre.presidencia.gov.co/normativa/normativa/LEY%201964%20DEL%2011%20DE%20JULIO%20DE%202019.pdf

65

- Freight transportation – decrease in 20% of the emissions from this sector by 2050 with the introduction of new technologies.

Law 9518 promotes the use of electric transportation, taking into account economic incentives, credit access, and non-monetary benefits of circulation. The incentives include:

- Exemption from vehicle property tax for electric vehicles. Electric vehicles will be exempt from paying the vehicle property tax for a period of five years in a gradually de-escalation rate of 20% less each year after the first one until the fifth one.
- Exemption from general sales tax, selective consumption tax and customs value tax depending on the CIF value
- Depreciation acceleration for transport fleet replacement, at least ten percent (10%) per year, with a minimum of three vehicles.

The National Plan for Electric Transport 2018-2030 further promotes electric mobility. Based on the Law 9518 and the National Decarbonization Plan. There are three relevant axes of action:

- Replace the national fleet of conventional vehicles with electric vehicles.
- Incorporate electric vehicles in the State fleet.
- Develop the electrification of public transport

[65] Government of Costa Rica, MINAE, MOPT, Plan de Descarbonización 2018-2050, 02/20/2019. Available at https://minae.go.cr/images/pdf/Plan-de-Descarbonizacion-1.pdf

[66] Government of Costa Rica, Ley 9518 Incentivos y promoción para el transporte eléctrico, 01/25/2018. Available at http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?nValor1=1&nValor2=85810

[67] Government of Costa Rica, MINAE, MOPT, Plan Nacional de Transporte Eléctrico 2018-2030, 2019. Available at https://sepse.go.cr/documentos/PlanTranspElect.pdf

Executive Decree No. 41642 – MINAE that establishes the constructive and operating conditions needed that charging stations should have.

3.6 Legitimation

Communications with stakeholders revealed a universal concern about the high market prices of electric vehicles and uncertainty regarding the financial models that could be used to elicit a strong market uptake in the short term. Almost universally, stakeholders agreed that incentives will be needed, which strengthens the legitimation function, as it shows support across the board for electric-mobility policies. At the same time, uncertainties around financial pathways make stakeholders cautious.

Research of media outlets in Panama reveals that electric mobility is of some interest to the general public. The media is giving good coverage to electric mobility, relative to the level of activity on the ground. Outlets such as MiDiario, La Prensa,[69] La Estrella,[70] and El Siglo[71] have reported on events in Panama related to electric vehicles. This coverage has been in general positive, highlighting primarily the environmental benefits of electric transportation. The media exposure of public officials speaking about electric mobility has been relatively limited. The apparent consensus of key media outlets on the benefits of electromobility is a symptom of public reception of the technology and helps strengthen the legitimation function. At the same time, there

[68] Government of Costa Rica, Reglamento para la construcción y el funcionamiento de la red de centros de recarga eléctrica para automóviles eléctricos por parte de las empresas distribuidoras de energía eléctrica, 04/02/2019. Available at http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=89191&nValor3=116987&strTipM=TC

[69] https://www.prensa.com/impresa/economia/largo-camino-hacia-los-autos-electricos/

[70] https://www.laestrella.com.pa/nacional/200211/crearan-comite-multisectorial-impulsar-movilidad-electrica-panama

[71] http://elsiglo.com.pa/panama/electrico-circulara-casco-antiguo-panama-partir-6-agosto/24076032

may be room for an increased presence of stakeholders in the media helping educate the general public about electric mobility.

Consumer awareness is critical for the market uptake of electric vehicles. There are a range of strategies that have been implemented globally to this end. Marketing campaigns typically start with governmental entities, although the participation of the private sector is ultimately essential. Opportunities should be sought to direct consumers to information and education resources, such as webpages. In turn, resources should be readily available to consumers seeking information. Often, electric utilities are a key ally in this regard, as they have direct communication lines with consumers. Research of government and utility websites showed relatively little information dedicated to electric mobility, and only a fraction of this was dedicated to consumer information. This is an area where work could be expanded, perhaps in partnership with groups with expertise and experience in communications with the broader public. Ultimately, the participation of car companies and retailers in the marketing effort is important.

Strategic alliances involving government, electric utilities, and other stakeholders can thus be important to communicate to consumers opportunities to transition to electric mobility. One strategy that proved extremely successful in the U.S. was the implementation of ride and drive events, in which consumers are exposed to the technology and given an opportunity to test vehicles. This strategy, informally known among practitioners as *butts in the seat*, is based on the premise that, when it comes to familiarizing oneself with a new technology, there is no good substitute to actually experiencing it. Field surveys have shown that this type of event does have an impact on consumers' perception of and interest in adopting electric vehicles.

An important step is the already approved National Strategy of Electric Mobility that promotes the transition to a more sustainable approach of modernizing, expanding vehicular fleets: Governmental, privates, public transportation and private citizens, looking forward to contributing to less pollutant emissions and at the same time improving Panama's transit and environmental quality. The Strategy has set electric vehicle penetration goals by 2030 in terms of *ranges* of market shares, namely: 20%-40% for new car sales, 10%-20% for private fleets, 25%-50% for government fleets, and 15%-35% for buses. These goals should be made more precise and ambitious. Setting low expectations for market penetration send weaker signals to the market and decisionmakers, thus weakening legitimation.

Electric mobility is interconnected through the National Energy Plan the Strategic Government Plan 2019-2024, as it is a component of one of the strategic pillars: Competitive economy that generates employment in the Environment area with main work of promoting a pilot program electrifying public transportation (electric buses, Metro Line 3).

The National Strategy of Electric Mobility includes few action areas related to legitimation, as shown in Table 9

Table 9. Areas of action related to legitimation in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	Implement a working group for the sustained dialogue amongst public and private entities relative to electric mobility.
	Include requirements for charging stations in new buildings in the Sustainable Building Rule (Reglamento de Construcción Sostenible)
	Encourage private fleet to adopt electric vehicles and support their access to green funds
Medium priority	Include charging infrastructure requirements in urban development plans
	Support pilot tests and disseminate results, to mitigate concerns about range limitation
	Implement incentives for the electrification of taxi fleets

Case study: Colombia

Colombia's main media outlets have covered extensively new relative to electric buses. Reports are generally objective and highlighting the environmental benefits of electric mobility. It may be inferred that the general public is relatively well informed about electric buses for the stage of market development.

The National Strategy of Electric Mobility was authored by key ministries, and wide participation across government offices, starting with the President. The document is a clear indication that electric mobility has political support.

The public transportation operators in the main urban areas, including Bogota, Medellin, and Cali, have been actively pursuing the integration of electric buses, signaling interest in the technology.

Case study: Costa Rica

Costa Rica's First Lady Claudia Dobles has been outspoken about the importance of decarbonizing the public transportation system transitioning to electric buses.

Organizations dedicated to advance electric mobility and educating the public include ASOMOVE, the non-profit Costa Rican Association of Electric Mobility. They provide detail information on how to acquire, manage, charge and maintain electric vehicles. ASOMOVE lists charging station centers, and as electric mobility offer, they have available information of used electric vehicles dealerships, charging station companies, etc.

Another initiative from civil society is Costa Rica Limpia, created in 2014 with the idea of having a country free of fuel oil and resilient to climate change. Their approach to promote these ideals is through public consultations and disseminating news, and increase public awareness of electric mobility. They launched the first festival of electric mobility in 2017, provided analysis on environment proposals from presidential candidates in for the 2018-2022. Costa Rica Limpia teamed up on the National Decarbonization Plan to implement a campaign targeting the general public and using videos, articles, and activities. They collaborate with media news on the decarbonization issue from a non-governmental perspective.

3.7 Resource Mobilization

Panama has taken steps to mobilize financial and human resources to support the development of local electric mobility markets. A starting point was the multi-stakeholder effort, with support from the United Nations Environment Program and Euroclima+ to develop a national strategy for the sector. Also, there have been projects elaborated by a consulting firm in technical, economic and financial areas, providing a reference framework to analyze the country current situation, as well as feasibility studies in economic and financial terms considering the technology of electric vehicles, in particular, electric buses. In addition, Panama recently started to work with the World Bank Group with a Technical Assistance project to find different alternatives to financing of the electric buses that MiBus is planning to buy for its fleet. [72]

Stakeholders agree on the need to develop a package of incentives to support the market uptake of electric vehicles. It was reported that the Secretariat of Energy is working with the Ministry of Economy and Finance to develop a legislative proposal for this package. According to the Secretary of Energy, Panama is giving consideration to the experience of Chile, Mexico, Costa Rica, and Colombia in this regard.[73] Experiences around financial incentives have been globally diverse. In the United States, a dual approach was observed, with incentives at the federal and state levels. Empirical evidence from the U.S. shows that incentives do work.[74] Experience also shows that incentive program effectiveness and, importantly, *efficiency* strongly depends on the structure of the incentives, which should be related to local conditions. States in the U.S. adopted a variety of incentive structures, from sales rebates, to sales tax exemptions, to others. Quantitative studies showed that they were all effective, though not necessarily equally effective. When it comes to financial incentives, analyses suggest that incentive effectiveness increases

[72] Gathered from meetings with MiBus. July 2020.

[73] La Prensa, February 15, 2020: https://www.prensa.com/impresa/economia/largo-camino-hacia-los-autos-electricos/

[74] Collantes, G. and A. Eggert (2014) The effect of monetary incentives on sales of advanced clean cars in the United States: Summary of the evidence. Policy Institute for Energy, Environment, and the Economy. University of California, Davis.: https://policyinstitute.ucdavis.edu/files/ZEMAP-Policy-Memo-Vehicle-Incentives.pdf

with the proximity to the point of sale. Thus, sales tax exemptions, sales rebates, and tax incentives would rank in that order on effectiveness.[75] While the evaluation of the effectiveness and efficiency of incentives is not an easy quantitative exercise, it is critical that it is included as part of a program, and to keep programs flexible for adjustments over time.[76] Additionally, there is a balance to be sought between complexity and transparency – consumers are not always able to understand incentives when these are complex, while simple incentive structures may run into inefficiencies. Finally, the least effective incentive is that of which consumers are not aware. Evidence showed that consumers were often unaware of incentives, and this may be due to multiple reasons, including ineffective communication, limited incentive among car sellers to communicate them, and others. Accounting for these questions will be important as Panama moves toward allocating fiscal resources to an incentive package.

Contrary to the case of fossil fuels, electricity markets, particularly on the distribution side, are heavily regulated. This means that the public sector has some discretion in the treatment of electric mobility as a consumer of electricity, which in turn creates opportunities for the mobilization of resources. The city of Panama has sufficient access to power to support the installation of high-power charging infrastructure, either centralized in patios, or decentralized as overhead chargers, or combinations thereof.[77] Thus, no upfront expenditures to upgrade the distribution system would need to be absorbed. There may still be a need for capacity access at certain locations, for which transformers and wiring will probably have to be installed. For installations under 500 kW, these would be free of charge to MiBus (or others). For installations over 500 kW, their cost would be borne by MiBus, although they would be reimbursed 90 percent of this cost by the public sector over five to seven years. The cost of a transformer could be in the order of up to $50,000. These aspects of the regulatory framework to accommodate new load support the integration of associated costs into investment plans. Similarly, the regulatory

[75] For example, Narassimhan, E. and C. Johnson (2018) The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US States. *Environmental Research Letters* **13**(7)

[76] Yasenov. V., G. Collantes, and E. Muehlegger (2015) Analysis of the effectiveness of state incentives for the adoption of plug-in electric vehicles. Unpublished.

[77] Conversations with the local distribution companies.

framework allows for clients with high energy requirements to secure this energy via long-term contracts, outside of regulated tariffs.

The National Strategy of Electric Mobility includes a number of action areas related to resource mobilization, as shown in Table 10.

Table 10. Areas of action related to resource mobilization in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	Develop specific objectives, indicators, and timetables for the implementation of the Areas of Action
	Identify areas to improve legal and regulatory frameworks in the transport sector, to enable the implementation of the National Strategy of Electric Mobility
	Implement a working group for the sustained dialogue amongst public and private entities relative to electric mobility.
	Develop NAMAs and request funding from green funds
	Coordinate conversations between the Commission of Electric Mobility and multilateral banks, about the incorporation of electric buses
Medium priority	Implement new-vehicle efficiency standards
	Adopt certification of emissions and efficiency for imported vehicles
	Include charging infrastructure requirements in urban development plans
	Development regulations for charging sites

Case study: Colombia

The Colombian government will receive €20 mill to design a program to promote the demand of electric vehicles, focused on public transportation coming from the Nationally Adequate Mitigation Action (NAMA) donation. The project will start with the design phase to later use the resources to promote the electric vehicles demand establishing penetration goals by 2024.

In October 2018, a cooperation agreement was signed between Bancóldex and Enel-Codensa to have available financial resources for regional or national projects related to electric mobility, either as structurers, bidders, funders or investors. A measure that Bancóldex took earlier this year was not to finance any more diesel buses for passenger transportation.

The National Strategy proposes allocating funds in the order of USD 1.5 M, for a variety of studies and initiatives.

Case study: Costa Rica

Costa Rica has been very active in the mobilization of financial resources to apply toward studies and implementation of initiatives for electric mobility. Some of these were discussed above.

In 2016 Costa Rica and South Korea subscribed an understanding agreement to promote charging infrastructure for electric vehicles. As a result, South Korea donated

[78] NAMA Facility, Colombia – Building an Enabling Environment to Develop Electricity-Based Mobility. Available at https://www.nama-facility.org/projects/colombia-building-an-enabling-environment-to-develop-electricity-based-mobility/

[79] Enel-Codensa, "Alianza entre Enel - Codensa y Bancóldex promueve proyectos de movilidad eléctrica en el país," 10/04/2018. Available at https://www.enel.com.co/es/prensa/news/d201810-alianza-entre-enel---codensa-y-bancldex-promueve-proyectos-de-movilidad-elctrica-en-el-pas.html

3 charging stations to the Costa Rican Electricity Institute (ICE for its acronyms in Spanish) and they were planning to install them based on a smart grid plan developed by the Ministry of Environment and Energy.

Costa Rica received a donation of electric vehicles from the government of Japan. The donation consisted of ¥300 million, equivalent to about US$2.8 million, used for 60 ecofriendly vehicles, including 20 Plug-in Hybrid Electric Mitsubishi Outlander PHEV, and 29 Mitsubishi i-MiEV electric. These vehicles were destined to 13 institutions in the public sector.

In March 2020, Costa Rica obtained a loan of US$230 million for the implementation of the National Decarbonization Plan, part of the policy-based programmatic loan of the IADB, a loan subject to implementation of the policy. The objective of this project is to support Costa Rica's transition to zero net greenhouse gas (GHG) emissions by 2050, and among the reforms proposed is increasing the use electric energy for transportation.

Also relevant is the creation of working groups related to electric mobility in public institutions. One example is the Planning Secretary Energy Subsector (SEPSE for its acronyms in Spanish), where a section is dedicated to electric transportation.

[80] El Mundo, "Tras donación de Corea del Sur, ICE valora comprar vehículos eléctricos," 10/31/2016. Available at https://www.elmundo.cr/costa-rica/tras-donacion-de-corea-del-sur-ice-valora-comprar-vehiculos-electricos/

[81] Republic of Costa Rica, Presidency, International Relations Communications, "Costa Rica recibe donación de 60 vehículos híbridos y eléctricos del pueblo y gobierno de Japón," 03/20/2018. Available at https://www.presidencia.go.cr/comunicados/2018/03/costa-rica-recibe-donacion-de-60-vehiculos-hibridos-y-electricos-del-pueblo-y-gobierno-de-japon/

[82] ASOMOVE, "Costa Rica obtiene préstamo de $230 millones para avanzar con descarbonización," 03/12/2020. Available at https://asomove.com/noticias/8861033

3.8 Positive Externalities

Having a legal framework in other areas such as the environmental conservation has facilitated the introduction of policy and regulatory initiatives in energy transformation and electric mobility. The provision of the 2016 air quality improvement law, created in 1998 with revisions in 2003 and 2010, helped the rapid progress with the ratification of the Paris Agreement of 2015 by the Republic. The National Energy Plan 2015-2050 allows for long-term planning that serves as a foundation for decision-making relative to energy efficiency and sustainable development grounded on renewable energy.[83]

As described above, Panama has set goals for the growth in unconventional renewable generation. Non-dispatchable wind and solar parks will increasingly supply power during day hours that are now considered peak hours, where demand is high and supply surplus is tighter. This will develop in motivation among renewable power developers to seek opportunities to sell any excess in power during day hours. Electric mobility, and in particular large consolidated demand such as a fleet of overhead electric buses, can benefit from these developments by negotiating long-term contracts at competitive prices, thus creating win-win situations.
The National Strategy of Electric Mobility includes a few action areas related to the creation of positive externalities, as shown in Table 11.

Table 11. Areas of action related to positive externalities in Panama's National Strategy for Electric Mobility

Priority level	Areas of action
High priority	None
Medium priority	Evaluate projected grid load from electric vehicles and determine "optimal" charging sites

[83] Republic of Panama, Ley 41 de 1 de julio de 1998 (Ley de Mejoramiento de la calidad del aire), 10/04/2016. Available at https://www.gacetaoficial.gob.pa/pdfTemp/28131_A/GacetaNo_28131a_20161004.pdf

	Invite the input of local commercial banks and insurance companies on the implementation of the National Strategy
	Review and revise Law 33 relative to vehicle waste management

Case study: Colombia

Colombia's urban areas suffer from severe air quality problems. For example, in Bogota, Emission percentage of PM2.5 particulate matter coming from mobile source represent 78%, from which 41% correspond to buses, 28% to trucks, 14% to automobiles, 13% to motorcycles (2012). There are social and regulatory pressures to address this problem. Indeed, COPES 3943 - Policy for Improving Air Quality set objectives:

- Reduce polluting emissions to air from mobile sources.
- Reduce polluting emissions to air from stationary sources.
- Improve pollution prevention, reduction and control strategies from air.

The introduction of electric buses is well aligned with these social and institutional pressures.

Case study: Costa Rica

Costa Rica has conducted pilots and planning for developing infrastructure in the transportation sector, specifically for electrifying public transportation, buses and train. For this purpose, the country has developed alliances and partnerships with

[84] Republic of Colombia, COPES 3943 - Policy for Improving Air Quality, 07/31/2018. Available at https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/3943.pdf

other governments, multilateral organizations, and private sector with specific knowledge of electric mobility market, as well as prepared the legal and regulatory terrain for electric mobility, so the stakeholders have a better understanding of the landscape for establishing business in the sector. Here are some of the entrepreneurial initiatives that Costa Rica has experienced so far.

4. Assessment of Obstacles to Electric Vehicle Market Uptake

The preceding sections were concerned with the assessment of the different factors that are necessary for the development of electric vehicle markets, for the case of Panama. The analysis was guided under a methodological framework known as Technology Innovation Systems or TIS, which was successfully used for similar analyses in other regions. In a simplified manner, TIS can be described as a frame of reference, against which the local conditions can be evaluated.

The research presented herein, based in communications with key stakeholders in Panama and other resources, shows that Panama is in a very early stage of electric vehicle market development. This not only means that electric vehicle adoption is still marginal but, more importantly, that Panama is in the early stage of developing institutional frameworks conducive to market uptake. Given this context, it may not be very productive to try to identify obstacles, as in *bottlenecks*, to market adoption. Rather, it may be more productive to present an assessment of the work that lies ahead to create the basic platform from where a market can flourish. This is the focus of the present section, with an emphasis on buses for public transportation.

These gaps or barriers to the growth of electric mobility are assessed by looking at how the TIS areas (or functions) are fulfilled in Panama. With the development of a national strategy to support electric mobility, Panama has taken a significant step toward the mobilization of institutional resources in agreed-upon directions. This is of great value in and of itself, because it helps coordinate actions across stakeholders, which will necessarily increase the efficiency of the national effort. The National Strategy also offers a good reference against which the TIS analysis can be presented.

The evaluation of the TIS functions necessarily relies on expert judgment, based on an understanding of the fundamentals of innovation and knowledge of previous experiences whenever available. The *health* of each of the TIS functions can be quantified on a soft scale, based on an articulation of strengths and weaknesses. Such quantification is presented for each of the functions in Figure 4. The quantification is meant predominantly for identification of

weaknesses and prioritization of directions, including potential items to incorporate in the National Strategy.

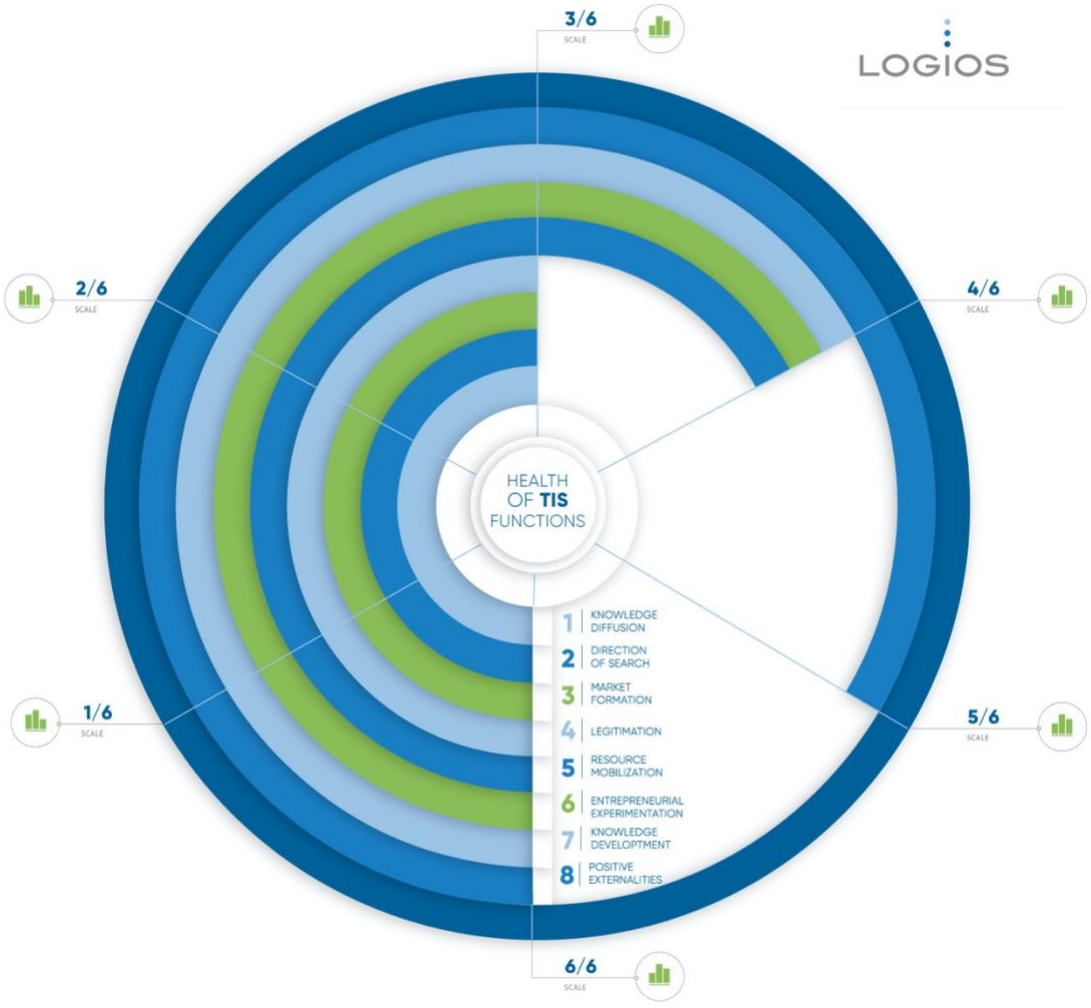


Figure 4. Rating of the health of the TIS functions for electric bus innovation in Panama. (Source: LOGIOS)

4.1. Entrepreneurial experimentation

As described above, Panama has been conducting trials and proofs of concept of electric buses on a variety of routes and conditions for about two years. While the trials/PoC were focused on

one make of bus (BYD) and one charging method (overnight charging), they created opportunities for MiBus to experiment with the operation of the technology.

The main rationale for experimentation, however, goes beyond experimentation per se. It fundamentally aims at creating conditions where ideas can be tested, and data can be generated, so that eventually lessons can be distilled, and knowledge be developed. Experimentation requires planning and methodic data collection. From this perspective, Panama's experimentation with electric buses could be improved.

The National Strategy of Electric Mobility gives relatively little attention to experimentation. To better support the transformation of the public transportation fleet, and given the timelines involved (see separate report),[85] the Strategy should be revised to include items as high priority. The items relative to charging infrastructure business models and pilot tests should be refined to include applications to public transportation, to account for the specific challenges pertaining this sector.

Specific areas where Panama could strengthen its experimentation include the following:

- Expand trials/PoC to include vehicles with overhead charging capability
- Expand trials/PoC to include vehicles from a variety of suppliers
- Plan one or more prototypes or pilot projects *following*, and *integrating the results* from, the technical evaluations currently underway
- Implement prototypes/pilot projects including:
    - A data collection plan that yields reliable data
    - Experimentation with variables beyond the technology, such as dedicated energy rates, strategies to mitigate demand charges, operation on dedicated lanes, optimization of depot location/design, etc.

Though this discussion focuses on the market segment of buses, it is worthwhile noting that there is an opportunity for the National Strategy to give more attention to experimentation, particularly

[85] LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.3. Sustainable Public Transport Mobility Plan.

in the light duty vehicle segment. This is particularly important in view of the strong emphasis that the National Strategy is giving to the implementation of studies and analyses (see section on knowledge creation). As explained above, experimentation is the space where local data can be generated, which can then be taken for empirical analysis.

4.2 Knowledge creation

As reflected in the National Strategy, Panama is keenly aware of the importance evidence-based instruments to galvanize market adoption of electric vehicles. The National Strategy includes with high priority numerous items geared toward the creation of knowledge, via studies and analyses. This is a solid place from where to start the construction of policy programs that make efficient use of public resources.

Several areas were identified where Panama could strengthen significantly the work on knowledge creation. These areas are listed below in suggested order of priority.

Integration of processes of data creation

While the National Strategy proposes a good number of analyses and studies to inform policy, the type of studies and analyses that can be conducted will be determined by the type of data available. Because of the very early stage of development of the electric vehicle market and the limited amount of data collected as part of trials to date, Panama should integrate a program of data generation as a first step toward the studies and analyses. This can take the form of experimentation with many of the factors that can influence market adoption; for example, financial and non-financial incentives of various forms, dedicated rates for electricity and power, dedicated lanes, etc.[86] The planning and implementation of these experiments should be done as a multi-stakeholder process. Data collection should be planned and implemented by a third party. The data collection plan could also be part of the analyses and studies proposed in the National

[86] For some of these topics, see companion report LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.3. Sustainable Public Transport Mobility Plan.

Strategy, however: (a) it is nevertheless important for the National Strategy to explicitly include data collection amongst its recommendations; and (b) there are potential synergies, in the sense that more than one analysis/study could require the same/similar data, and thus it may be worth considering to coordinate all analyses/studies to some extent.

Strategies to improve conditions for bus operation

As discussed in a separate report,[87] the electrification of a public transportation fleet cannot be approached solely as a technology problem. The technology is embedded in complex urban systems capable of significantly affect its performance. The urban system in Panama City should be the focus of analysis, to identify strategies to provide electric buses with an operational ecosystem conducive to best performance. A special focus of the analysis should be strategies to mitigate the exposure of electric buses to adverse traffic conditions. This analysis should be integrated or coordinated with the analysis proposed in the National Strategy about carbon pricing for transportation.

Integrated plan of zero-emission public transportation

While a fleet of conventional fossil-fuel buses can be thought of as a sum of individual units, an electric bus fleet must be thought of as an integrated system. Some of the complexities of the different electric bus technologies and how they would integrate with the supporting charging infrastructure were discussed in a separate report.[88] Neglecting the systemic nature of electric fleets and infrastructure and taking a piecemeal approach to fleet transformation would be exposed to inefficiencies and the risk of stranded assets. MiBus and the Secretariat of Energy should commission the preparation of a medium-term plan for the design of an efficient electric bus system for the city, and to the extent possible consult with key stakeholders, as the electric distribution companies, the Traffic and Road Transport Authority, and others, as applicable.

[87] LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.2. Charging Strategies for the Routes Selected for Initial Electric Bus Deployments.

[88] Ibid.

Financing models

Capital expenditures and financing models were recurrent topics brought up by stakeholders. The development of a financing blueprint for the electrification of public transportation is an area of work that should be considered as high priority. Uncertainties about the financial pathway for fleet transformation risks weakening interest amongst stakeholders and slowing down innovation. As the National Strategy recommends the commissioning of studies about carbon pricing, there is an opportunity to also recommend a study of financing models that look at revenues from fiscal instruments to mitigate emissions, revenue flows from integration with the electric grid, etc. It is strongly recommended that a study of financing models follows the development of the zero-emission public transportation plan—only a solid knowledge of the necessary assets can produce reliable inputs to the investment plans.

4.3 Knowledge diffusion

With the establishment of the Governmental Commission of Electric Mobility, described above, Panama has taken a solid and important step toward promoting communication and exchange of information across key government stakeholders. To mention the example of the United States, states with leadership in the support for electric mobility convened similar groups (generally called EV Task Force or similar). The two states that pioneered the formation of such group were California and Washington. Both the California Plug-in Electric Vehicle Collaborative (later named Veloz) and the Washington State Plug-in Electric Vehicle Task Force, convened key stakeholders from government, the private sector (primarily auto manufacturers and electric utilities), and non-profit organizations. This approach proved successful and Panama is on the right track toward that model.

Acknowledging that the type of challenges, questions, and timetables that are faced for the adoption of electric buses are, to a large degree, different from those facing the broader consumer market, Panama should consider establishing a schedule of activities for a subgroup dedicated to public transportation.

4.4 Influence on the direction of the search

The National Strategy includes numerous action items related to this function. Some of these items are preliminary evaluations and a couple of the items are implementation oriented. One of the items relates directly to public transportation: the recommendation to establish a program for the electrification of public transportation fleets. While the implementation of this item, perhaps integrated with other analytic work mentioned above, could have a significant impact in the adoption of electric buses, research as part of this technical assistance was unable to find evidence of work in that direction. The National Strategy also recommends for the program to establish goals for bus electrification, although it remains agnostic about how ambitious these goals should be.

As described and discussed in a separate report,[89] MiBus is facing imminent decisions about the replacement of large numbers of aging buses. For this reason, it would be beneficial for the recommendation in the National Strategy to (a) include some parameters that help define the ambition of the program, and (b) be given high priority for implementation, to be sensitive to the time pressures facing the modernization of MiBus's fleet.

As these action items start being implemented, they will create more tangible endogenous pressures for actors (MiBus, electric utilities, financial institutions) to invest resources to support bus fleet transformation.

4.5 Market formation

As described above, there is an electric mobility draft bill with pending debate in Panama's Legislature, that includes a proposal to stop concession renewals to suppliers of fossil-fueled buses. Should that bill become law, it would have a tangible market formation impact for electric buses. Questions may still remain around the implementation of that proposal. A requirement on

[89] LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.3. Sustainable Public Transport Mobility Plan.

the phase out of fossil fuel buses and the inclusion of electric buses, without a detailed plan, does not necessarily guarantee a positive outcome.

The National Strategy, on the other hand, includes two recommendations with market formation implications for electric buses. If emissions and efficiency standards were included in MiBus's procurement processes, the competitiveness of electric buses would be increased proportionally to the tightness of the standards. It is however unclear whether procurement processes of this form would be consistent with a strategy for the electrification of the fleet.

The other element in the National Strategy with market formation implications for electric buses is the recommendation of a program for the electrification of public transportation fleets. This idea seems to offer the best opportunity for the creation of niche markets for electric buses as a part of a holistic plan that facilitates an efficient integration of electric units. The strength of this idea is that it could be implemented relatively quickly (contingent upon the times involved in completing the pertinent analyses). The weakness of the idea is twofold: (a) it still lacks detail (no studies have been completed yet); and (b) there has been little activity toward implementing it. A market formation program for MiBus could take a number of approaches. One possible approach that could be consistent with the systems nature of electric fleets (discussed above), is to plan niche deployments centered on shared opportunity charge infrastructure.[90]

4.6 Legitimation

The questions related to legitimation of the technology are different for the markets of buses and personal vehicles. For the case of public transportation, the relevant question is *Who needs to have a positive stance on the technology for a sustainable market to evolve?* The answer resides in an understanding of the procurement cycles (flow of financial resources) and the strategic partnerships that can influence operating costs (including city government and electric utilities). In essence, it is desirable to generate successful investments, to maintain the continued

[90] LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.2. Charging Strategies for the Routes Selected for Initial Electric Bus Deployments.

engagement that will be needed to move to scale. The key in this respect is to ensure that projects are correctly evaluated from a technical and financial perspective (technical and financial evaluations should be integrated, not done separately), that engineering studies are conducted for successful implementation, and that a process of monitoring and performance evaluation be adopted feed new information for future procurement cycles.[91] Thus, understanding that MiBus is responsible for implementing the procurement of buses, it would be important for the national government (source of funding for fleet procurement), MiBus (responsible for procurement process implementation), the Alcaldía, the ATTT, and the electric companies, to try to coordinate on a form of process for the planning of investments in fleet electrification including the elements mentioned above. This will mitigate significantly the risks of inefficient investments that may stall the process of fleet electrification.

4.7 Resource mobilization

The discussion presented above on the activities related to resource mobilization suggests that Panama is working on several important fronts. Stakeholders consistently expressed in interviews their concern with the retail cost of electric vehicles and financial models to attract the necessary capital. The National Strategy is proposing the evaluation of financial incentives to mitigate the retail price differentials, although there is not much precision regarding the markets that would benefit (consumer vehicles vs. bus fleets vs. government fleets vs other). As important as identifying effective and efficient incentive structures, is determining how the incentives will be funded. Experience shows that it is important for incentives to be perceived as stable over time, so that business models can develop around them. If uncertainties arise about the stability of the incentives, stakeholder engagement will be weaker and business models will tend not to develop.

In this regard, the National Strategy is opening opportunities for the debate of both incentives and fiscal instruments (carbon pricing) that can be integrated, to construct a stable system to provide

[91] This is consistent with recommendations in World Resources Institute (2019) *Barriers to Adopting Electric Buses*, available for download at https://www.wri.org/publication/barriers-adopting-electric-buses#:~:text=Common%20obstacles%20identified%20in%20this,land%20for%20the%20adaptations%20needed.

financial support to investments in fleet electrification via the internalization of external (carbon) costs. Thus, it is recommended that both efforts — analysis of incentives and analysis of carbon pricing strategies — be integrated into a sustainable financial support mechanism. To arrive at that, however, there are important, time-demanding steps that need completing. These include design of studies, collection of data (important to enable empirical analysis of the impact of incentives and fiscal instruments), and the political/legislative process to sign these into law, and administrative process to implement them.

4.8 Positive externalities

Panama's Nationally Determined Contributions and National Energy Plan have laid out commitments to growing the share of the power generation coming from non-hydro renewable sources. A large fleet of electric buses constitutes a significant additional load which could peak at different times in the day, depending on the fleet configuration and the charging strategy.[92] These developments offer an opportunity for the efficient integration of investments in non-dispatchable renewable power capacity and electric loads for transport applications. Regulatory frameworks in Panama already allow for parties to enter into long-term contracts for power supply; the Metro is one relevant example. However, there is an opportunity for the development of policy interventions that support synergies and integrate the planning on both ends. This natural alignment of fleet electrification with ongoing efforts relative to renewable energy, gives the Positive Externalities function the highest ranking in Panama's electric bus innovation system (Figure 4).

[92] LOGIOS (2020) Accelerating the Transition to Sustainable Mobility and Low Carbon Emissions in Panama City: Deliverable 3.2. Charging Strategies for the Routes Selected for Initial Electric Bus Deployments.


LOGIOS