TRANSfer III Colombia

Promoting the Electrification of Public Transportation Fleets in Colombia

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Project Background

Transport is the highest energy-consuming sector in 40% of all countries worldwide and causes about a quarter of energy-related CO2 emissions. To limit global warming to two degrees, an extensive transformation and decarbonisation of transport is necessary. The TRANSfer project's objective is to increase the efforts of developing countries and emerging economies to bring about climate-friendly transport. The project acts as a mitigation action preparation facility and thus specifically supports the implementation of the Nationally Determined Contributions (NDC) of the Paris Agreement. The project supports several countries (including Peru, Colombia, the Philippines, Thailand, Indonesia) in developing greenhouse gas mitigation measures in transport.

The TRANSfer project is implemented by GIZ and funded by the International Climate Initiative (IKI) of the German Federal Ministry for Economic Affairs and Climate Action (BMWK). It operates on three levels.

Mobilise

Facilitating the MobiliseYourCity Partnership

The goal of the multi-stakeholder partnership MobiliseYourCity, which is currently being supported by France, Germany, and the European Commission, is to have one hundred cities and twenty national governments commit to ambitious climate action targets for urban transport and take appropriate measures.

Prepare

Preparation of Mitigation Measures

Standardized support packages (toolkits) are developed and used for the preparation of selected mitigation measures. As a result, measures can be prepared more efficiently, until they are ready for implementation and eligible for (climate) financing. Accumulated over 10 years, the targeted measures aim for a total reduction potential of 60 MtCO2.

Stimulate

Knowledge Products, Training, and Dialogue

Based on these experiences, TRANSfer is sharing and disseminating best practices. This is achieved through the development of knowledge products, the organisation of events and trainings, and the contribution to an increasing level of ambition. Personal exchange of experience and dialogue is promoted at various events, including the annual Transport and Climate Change Week in Berlin, the United Nations Climate Change Conference (COP), and the International Transport Forum.

Meet us at **www.changing-transport.org**

Disclaimer

Acknowledgements

We would first like to express our sincere gratitude to the entire Colombian Ministry of Transportation team, which was committed and supportive of our project from the beginning, starting with the Minister herself, *Ángela María Orozco*, who, during her tenure, became a champion of sustainable, low emission, inclusive mobility.

Inside the ministry, we enjoyed the constant feedback and support from *Sandra Liliana Ángel* and the entire Unit for Urban Sustainable Mobility, UMUS, including *Susana Ricaurte*, *Juan Carlos Melo*, *Juan Manuel Guzmán*, and all the colleagues who work day-to-day to make sustainable Colombian mass transportation a reality. Also, we could not have worked without the support from the Ministry's Group on Sustainable and Social Affairs – *Juan David Roldan*, and *María Jose Puello* – who were our allies in every endeavor.

We also appreciated the support provided by entire Colombian government, including the Sustainable Infrastructure and Energy Department at the National Planning Department; the Ministry of Environment and Sustainable Development, Financiera de Desarrollo Nacional, the consultants, and colleagues who collaborated with us to achieve the results presented in this Concept Note.

Finally, we would like to thank the Changing Transport team at GIZ and our donor BMWK for the opportunity to initiate transformational change in transport.

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Exchange rates

Local Currency	EUR	USD	Date
1 COP	0.00025 EUR	0.00027 USD	20.4.2022

Glossary

A

AFD: French Development Agency (French: Agence Française de Développement)

B

BAU: Business-As-Usual

BC: Black Carbon

BMWK: German Federal Ministry for Economic Affairs and Climate Action

BMZ: German Federal Ministry of Economic Cooperation and Development

BRT: Bus Rapid Transit

C

CAF: Development Bank of Latin America

CAPEX: Capital Expenditure

CONPES: National Council for Social and Economic Policy (Spanish: Consejo Nacional de Política Económica y Social)

D

dB: Decibels

DNP: National Planning Department (Spanish: Departamento Nacional de Planeación)

F

FET: Fare Stabilisation Fund (Spanish: Fondo de Estabilización Tarifario)

G

GCF: Green Climate Fund

GHG emissions: Greenhouse Gas Emissions

GIZ: German cooperation agency (German: Gesellschaft für Internationale Zusammenarbeit)

H

HFC: Hydrofluorocarbons

I

IADB: Inter-American Development Bank

ICE: Internal Combustion Engine

IPCC: Intergovernmental Panel on Climate Change

K

KfW: German development bank

M

ME: Management Entities

MinAmbiente: Colombia's Ministry of Environment

MinHacienda: Colombia's Ministry of Finance

MinMinas: Colombia's Ministry of Mines and Energy

MinTic: Colombia's Ministry of Information and Communications Technologies

MinTransporte: Colombia's Ministry of Transport

MITS: Interinstitutional Board for Sustainable Transport (Spanish: Mesa Interinstitucional de Transporte Sostenible)

MRV: Monitoring, Reporting, and Verification

$MtCO_2$ e: Million Tons of Carbon Dioxide Equivalent

N

NDC: Nationally Determined Contribution

NUTP: National Urban Transport Program

O

OPEX: Operational Expenditure

P

PM: Particulate matter

R

RENARE: National Registry for the Reduction of GHG Emissions (Spanish: Registro Nacional de Reducciones de Emisiones)

RUNT: National Unique Transit Registry

S

SENA: National Training Service (Spanish: Servicio Nacional de Aprendizaje)

SETP: Strategic Public Transport System (Spanish: Servicio Estrategico de Transporte Público)

SISETU: Information, Monitoring, and Evaluation System for Urban Transport (Spanish: Sistema de Información y Evaluación del Transporte Urbano)

SITM: Integrated Mass Transit System (Spanish: Sistema Integrado de Transporte Masivo)

T

TCO: Total Cost of Ownership

TDM: Transportation Demand Management

U

UPME: National Unit for Mining and Energy Planning (Spanish: Unidad de Planeación Minero Energética)

W

WB: World Bank

WTT Emissions: Well-to-Tank Emissions

Executive Summary

Table 1. Activities of TRANSfer III Colombia at a glance (Source: GIZ)

<table>
<tr><td>Contribution to NDC implementation</td><td colspan="3">TRANSfer III supports the Colombian government in decarbonizing its public transport sector. As Colombian transport is responsible for 12% of total country emissions and 40% of fossil fuel consumption, transport must make a key contribution to fulfilling the ambitious national pledge of achieving a 51% reduction in emissions by 2030, as formulated by the Colombian government in its revised NDC.

To this end, the Colombian Minister of Transportation has presented seven national policies for reducing GHG emissions, which will abate 4.9 Mton CO_{2e}/year by 2030 across the sector in comparison to a business-as-usual scenario (BAU).

Among the targeted measures, electric mobility has the largest reduction potential, accounting for 65% of projected emissions savings. TRANSfer III assisted the Colombian government with developing a framework for electrifying the public bus fleet in cities in order to harness this potential. This work included the development of a fund that will facilitate a partial replacement of the fleet with electric buses during the 2020-2030 period. In total, 2735 buses will be replaced, as detailed below.

<table>
<tr><th colspan="7">Fleet substitution scenario – Total number of buses replaced per year</th></tr>
<tr><th></th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>Total</th></tr>
<tr><td>Feeder 10m</td><td>0</td><td>379</td><td>266</td><td>0</td><td>769</td><td>1414</td></tr>
<tr><td>Feeder 12m</td><td>0</td><td>55</td><td>39</td><td>0</td><td>112</td><td>206</td></tr>
<tr><td>Pretrunk 10m</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Pretrunk 12m</td><td>0</td><td>39</td><td>29</td><td>0</td><td>81</td><td>149</td></tr>
<tr><td>SETP 10m</td><td>200</td><td>20</td><td>24</td><td>0</td><td>41</td><td>285</td></tr>
<tr><td>SETP 7m</td><td>292</td><td>0</td><td>15</td><td>0</td><td>0</td><td>307</td></tr>
<tr><td>Trunk 12m</td><td>0</td><td>12</td><td>9</td><td>0</td><td>24</td><td>45</td></tr>
<tr><td>Trunk 18m</td><td>0</td><td>88</td><td>61</td><td>0</td><td>180</td><td>329</td></tr>
</table>

The electrification of the public bus fleet is anticipated to achieve mitigation up to 0.312 Mton CO_{2e}/year in comparison to business as usual by 2030, with a total aggregate mitigation of 1.8 Mton CO_{2e} during the 2020-2030 period.</td></tr>
<tr><td>Type of action</td><td>Program</td><td>Subsector</td><td>Public transport</td></tr>
<tr><td>Geographical scope</td><td>The program encompasses the entire country, but is focused on 15 Colombian cities with formal public transportation systems, namely:

Bogotá, Medellín, Cali, Barranquilla, Cartagena, Bucaramanga, Pereira, Santa Marta, Pasto, Montería, Popayán, Armenia, Valledupar, Sincelejo, and Neiva.</td><td>Type of policy instruments</td><td><u>Regulations:</u> yes

<u>Economic instruments:</u> yes

<u>Public spending/ investments:</u> no

<u>Communication and information:</u> yes</td></tr>
<tr><td>Organization</td><td colspan="3">Responsible organization: Colombian Ministry of Transportation

Involved national partners: National Planning Department (DNP), Colombian Ministry of Environment and Sustainable Development, National Training Service (SENA).</td></tr>
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<table>
<tr><td></td><td>Involved international organizations: GIZ, KfW, AFD</td></tr>
<tr><td>Main mitigation measures</td><td>(A) Public investment fund to help cover the incremental cost of e-buses in Colombia

(B) Proposal development for the Green Climate Fund to promote a large-scale regional transition towards e-mobility in Latin America</td></tr>
<tr><td>Schedule</td><td>Phase 1:

Project design (2019-2022) led by TRANSfer III in Colombia, including:

Financial analysis of potential bus electrification in Colombia
Gap analysis of technical and regulatory framework for e-mobility
Proposal of a governance structure for e-mobility policy

Phase 2:

Preparation and approval of legal framework to set and operate Public Investment Fund for technological renewal of public transport fleets (2021).
Preparation of GCF project proposal E-MOTION (2022).

Phase 3: Full scale construction and implementation of the investment fund and fleet renewal of public transportation systems (2024)</td></tr>
<tr><td>GHG mitigation effect and other benefits</td><td><u>GHG mitigation:</u> 1.8 MtCO2eq of aggregate direct mitigation between 2020 and 2030, with mitigation of up to 0.32 MtCO2eq in 2030 in comparison to a business-as-usual scenario, resulting from the implementation of the investment fund and projected fleet replacement.

<table>
<tr><th>Difference between scenarios CO2e (mitigation vs. business as usual scenarios)</th><th>Million-ton CO_2e mitigated, 2020-2030 (cumulative)</th></tr>
<tr><td>Fleet fuel combustion</td><td>1.8</td></tr>
<tr><td>Electricity generation</td><td>-0.2</td></tr>
<tr><td>Fuel transport and production</td><td>0.2</td></tr>
<tr><td>Air conditioning systems</td><td>0.03</td></tr>
<tr><td>Total</td><td>1.8</td></tr>
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<u>Other benefits:</u> Abatement of 345 tons of black carbon and 341 tons of $PM_{2.5}$.</td></tr>
<tr><td>Feasibility</td><td>
<table>
<tr><th>Product to be offered by the fund</th><th>COP millions</th><th>EUR millions</th></tr>
<tr><td>Contributions to cover the CAPEX: 70% national government, 30% municipalities</td><td>1,397,612</td><td>349</td></tr>
<tr><td>Soft financing conditions</td><td>1,297,777</td><td>324</td></tr>
<tr><td>Total fund resources</td><td>2,635,389</td><td>659</td></tr>
<tr><td>Equity from concessionaires or municipalities</td><td>530,476</td><td>133</td></tr>
<tr><td>Total investment</td><td>3,165,865</td><td>791</td></tr>
</table></td></tr>
<tr><td>Type of support required</td><td><u>Technical support:</u> Capacity building with a view to project and electrification planning and technical operations.

<u>Financial support:</u> Provision of a financial instrument portfolio to facilitate the procurement of electric fleets, from a national fund for technological promotion.</td></tr>
</table>

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Core concept and motivation

In the largest Colombian cities, the transport sector accounts for a high share of greenhouse gas emissions and also makes a major contribution to air pollution, with attendant negative impacts on the climate and human health. It is therefore crucial to implement measures to address the mitigation of emissions and pollutants, especially in public transport. This document describes TRANSfer III program activities to support e-bus deployment in Colombian public transport systems. The goal of the program was to reduce GHG emissions from the transport sector by identifying and tackling the most important barriers to the electrification of public bus fleets. These barriers had not previously been addressed by the national government or other programs.

The Columbian transport sector emitted 28.2 MtCO_2 eq in 2012. Furthermore, sector emissions are anticipated to increase to 55.8 MtCO_2 eq by 2030 given a business-as-usual scenario due to the rapid growth of cities and motorized transport. This trend of rising transport emissions represents a major challenge to the fulfilment of the country's Nationally Determined Contribution (NDC) targets. In addition to GHG emissions, in the largest cities, transport accounts for 25% of $PM_{2.5}$ emissions, making it the most relevant source of air pollution harmful to human health. In the revised NDC, as part of the pledge to achieve a 51% reduction in emissions by 2030, the Columbian Ministry of Transport presented seven national policies to abate GHG emissions. Among the proposed measures, electric mobility has the largest reduction potential (65%). Reducing the sector's emissions is crucial for complying with climate change mitigation goals and for improving air quality and public health in Colombia's cities.

As public transport accounts for 48% of daily trips it is one of the most important starting points for electrification. Municipal efforts to transform public transport fleets can be supported at the national level. Current Columbian regulations, for example, permit the national co-financing of mass transport systems, with the federal government covering up to 70% of required investment volumes. At the start of the TRANSfer III project, it was recognized that a national bus electrification program that sought to bridge the cost gap between conventional and electric buses could build on this co-financing mechanism. However, various barriers that inhibit electric mobility in public transport would have to be overcome, including first and foremost the higher price tag of electric buses.

TRANSfer III cooperation with the Colombian sought to develop a comprehensive approach to reducing these barriers. At the outset of the project, the project participants conducted an in-depth inventory of formal transport systems in the country, and also quantified the costs required to upgrade fleets with e-buses alternatives. Based on these findings, the project identified possible instruments and investment scenarios while also ensuring alignment with the Columbian NDC and sustainable mobility goals.

Approach for transformational change

An important first step in the project was to identify and evaluate barriers to the adoption of electromobility. This was followed by the planning and implementation of activities to reduce barriers and spur the electrification of public transport fleets.

TRANSfer III project activities in Colombia consisted of two direct mitigation actions and three supportive measures, which fell under four categories (financial; institutional/regulatory; technical; and monitoring, reporting and verification).

GHG mitigation actions

The main outcome of the TRANSfer III project was to address the barriers to fleet electrification by designing and implementing the legal framework for the construction of a Public Investment Fund that could address that cost gap between electric and ICE vehicles, including the costs related to charging infrastructure and other required investments. In this connection, the project developed specialized financial instruments that could be accessed by fleet owners and operators in order to support the transformation of their fleets.

The fund, which is expected to function as a dedicated investment fund, will be managed by the Colombian Ministry of Transport, and will be able to channel not only public funds to promote fleet electrification, but also private resources to build specialized investment portfolios for the Colombian cities.

In addition, Changing Transport, which serves as the umbrella initiative for the global sustainable mobility projects sponsored by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), including TRANSfer III, collaborated with AFD, CAF, and KFW to develop a proposal for the Green Climate Fund, with the aim to promote a large-scale regional transition towards electro-mobility in Latin America. This proposed project is called E-MOTION.

Supportive actions

In addition to setting up the Public Investment Fund and developing the E-MOTION proposal, TRANSfer III included activities to help strengthen the institutional framework for e-mobility, including: Building capacities among operators, managing entities, and the national government to plan electric public transportation systems; identifying capacity gaps and preparing the curriculums for training personnel to operate and maintain e-mobility equipment and vehicles (with a gender approach), and establish methodologies and institutional arrangements to monitor, report, and verify (MRV) the program's progress.

TRANSfer III worked on four supporting actions for capacity building:

1. Supporting transport sector stakeholders to understand potential business models for electrifying their fleets and participating in the e-mobility market: An international three-month course on transport systems based on e-buses was developed and offered in a partnership between TRANSfer III and MOVING Chile, both funded by BMWK. The course was delivered by Universidad de Chile with professors from Universidad de los Andes.

   During its first session the course was attended by 54 students, and the course is currently being offered as part of non-formal summer school classes by both universities.

2. Teaching operators, public transport managing entities, and city planners about e-mobility, e-buses, and about the process for planning and implementing e-bus corridors and services: First, an analysis of the Colombian electricity market and business models that e-buses operators can use to contract electricity was conducted. As a result of this work, a guide was offered on business contracting schemes, value chains for charging services, and processes, assets, and costs. Second, TRANSfer III organized a study in Bogotá to identify electric-vehicle charging demand and support the development of procurement documentation.

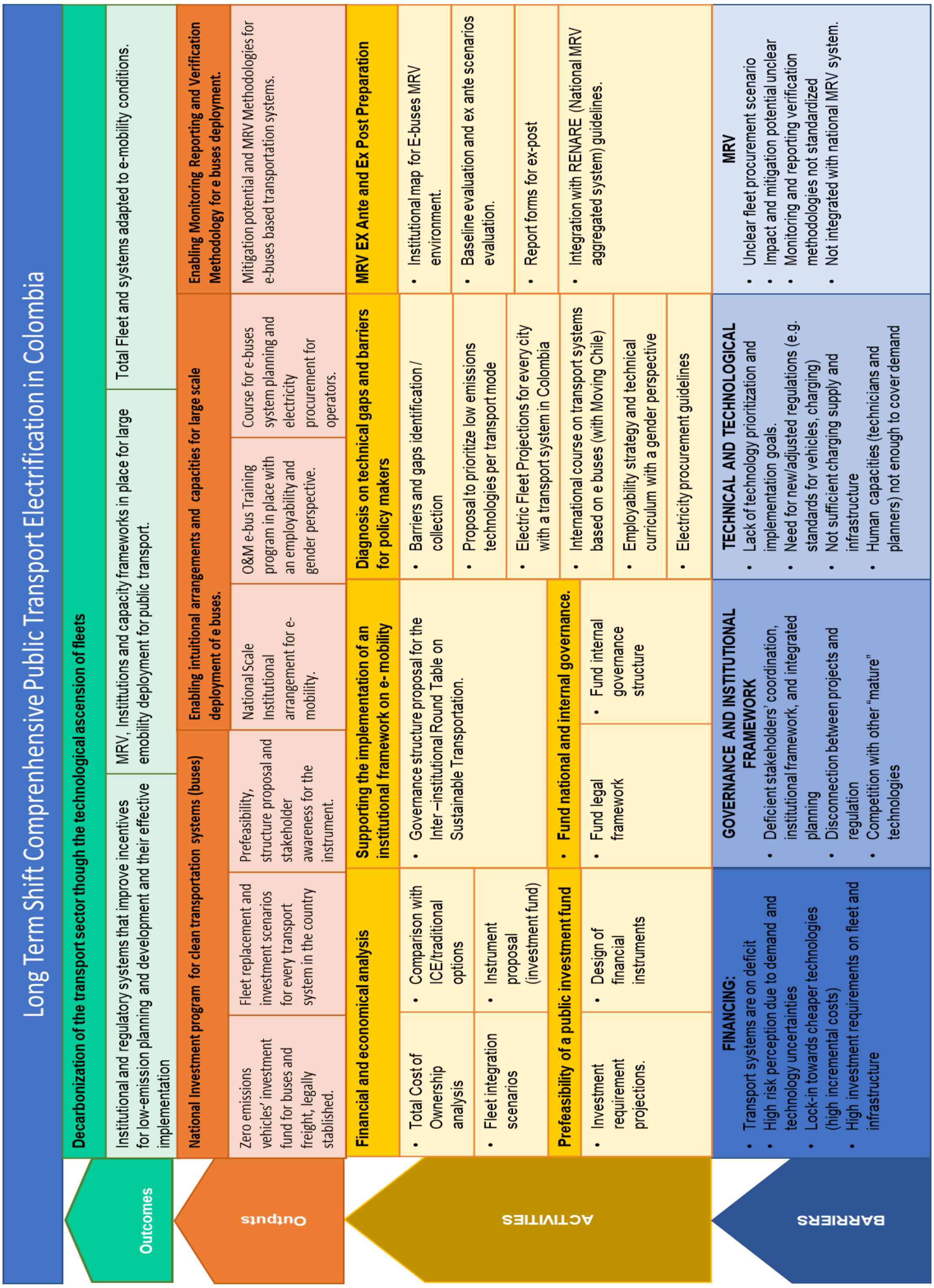


Figure 1. Logical framework for electrifying public transportation in Colombia (Source: GIZ)

3. Training people to operate and maintain public e-bus fleets: An employee training curriculum was developed for the National Training Service, thus responding to the short and medium term need for qualified e-bus personnel. The study addressed four topic areas: the value chain in

public transport systems; the qualification of human talent in e-mobility; gender issues; and the guiding principles for sustainability defined in the UN 2030 Agenda.[1]

4. Developing a MRV for the electrification of public fleets: Following the national guidelines set to report and harmonize mitigation actions, as well as the goal set by the Colombian Ministry of Transportation to position electromobility as a main driver of transport decarbonization, TRANSfer III developed ex-ante emissions projections for the business-as-usual and mitigation scenarios, as well as an ex-post methodology for evaluating the emissions and energy impacts of fleet electrification.

Institutional framework and governance arrangements

TRANSfer III participated in the construction of two organisational framework and governance measures to to further the adoption of e-mobility in public transport. Specifically, TRANSfer assisted with the formulation of a National Strategy for Sustainable Transport, and also helped to implement a National Strategy for Electric Mobility. In addition, TRANSfer assisted with the development of impact monitoring and evaluation systems for e-bus projects; this included proposals for the information flow and organizational structure required to coordinate among the public and private entities an effective evaluation of the electrification measures.

Financing concept

It was estimated that, in a scenario of total fleet renovation, the fifteen main Colombian cities would need to purchase 13,422 buses. In a scenario assuming only minimum compliance with Law 1964 of 2019, they will need to procure 2,735 buses, necessitated investment of COP $3.2 billion (for vehicles and charging infrastructure). The price differential between Euro VI diesel buses and e-buses was estimated at COP $1.7 billion.

Table 2. Fleet substitution scenario (summation for GIZ TRANSfer III, 2020)

Fleet substitution scenario						
	2022	2023	2024	2025	2026	Total
Feeder 10m	0	379	266	0	769	1414
Feeder 12m	0	55	39	0	112	206
Pretrunk 10m	0	0	0	0	0	0
Pretrunk 12m	0	39	29	0	81	149
SETP 10m	200	20	24	0	41	285
SETP 7m	292	0	15	0	0	307
Trunk 12m	0	12	9	0	24	45
Trunk 18m	0	88	61	0	180	329

The Public Investment Fund shall bridge the financing gap between conventional and electric buses and thereby promote the deployment of the latter in Colombia. The Fund itself needs financial.

To meet the financial objective to implement the Fund, the design of four products was proposed:

(i) Non-refundable contributions (grants) for the purchase of the fleet and its charging systems.

[1] The United Nations 2030 agenda for Sustainable Development "sets out a vision for sustainable development grounded in international human rights standards, putting equality and non-discrimination at the centre of its efforts and encompassing not only economic and social rights but also civil, political, and cultural rights, and the right to development" (UN, 2022), therefore the agenda considers 3 main principles to guarantee that all its actions are inclusive: 1. Follow a humans rights based approach; 2. Leave no one behind; 3. Gender Equality and Women Empowerment.

(ii) Soft financing conditions: Financing municipalities or mass transport system concessionaires with more flexible and competitive rates and term conditions than that offered by financial markets.

(iii) Guarantees issued by the fund to e-mobility investors to facilitate financing.

(iv) Technical support for technology adoption (e.g., studies for the specification of buses, estimation and monitoring of operating costs, maintenance requirements, operator training, etc.).

Table 3. Resources needed by the fund based on the pre-feasibility study

Product to be offered by the fund	COP millions	EUR millions
Contributions to cover the CAPEX: 70% national level, 30% municipalities	1,397,612	349
Soft financing conditions	1,297,777	324
Total fund resources	2,635,389	659
Equity from concessionaires or municipalities	530,476	133
Total investment	3,165,865	791

Scale of investment and support needs for different ambition levels

Before the fund can provide financial resources for purchasing and operating electric bus fleets through one of the four products described above, it needs to gather funding from various sources.

Resources from the national government and from local public entities

Colombian legislation allows the national government to invest in mass transport systems at the local level. To direct resources, co-financing agreements have been signed between national and local entities. However, the remaining resources from these co-financing agreements were redirected towards the reduction of the operational deficits which were highly increased by the low demand during the COVID-19 pandemic. As these agreements did not provide for funding increases, they could not be used for investment in new fleets.

Third-party resources

Since a high percentage of the investments required are non-reimbursable, the inclusion of resources from international organizations and multilateral banks was considered. The goal is to cover the gap between the resources required and those provided by national and municipal governments. Considering the nature and investment policies of those organizations, the capital acquired by the fund will mostly take the form of soft loans.

Private parties

There are manufacturers, utilities, energy distributors, charging system manufacturers, and other actors interested in e-bus deployment in Colombia. However, current business and cost structures prevent profitable small-scale operations. Nevertheless, the fund has been designed to permit contributions from private companies.

Potential benefits: GHG mitigation and more

TRANSfer III conducted a modeling exercise with the aim of calculating the potential emission savings (and other benefits) that would result from replacing a certain share of the currently active diesel bus fleet in Colombia with electric buses. Table 4 shows the boundaries that were chosen for the assessment, including timeframes, emission sources, and the national GHG inventory categories based on IPCC standards. Two scopes were defined for the purpose of estimating the impacts resulting from the replacement of diesel buses with e-buses on GHG emissions and beyond, considering the weight of each source in GHG emissions, and the difficulties and uncertainty associated with their estimation at this stage of the program.

Table 4. Assessment boundaries (Source: Hill for GIZ TRANSfer III, 2021)

Limits	Scope 1	Scope 2	
Analyzed system	GHG emissions from energy combustion in the operation of buses that are part of the SITM (Integrated Massive Transportation Systems) and SETP (Strategic Public Transportation Systems)[2]	GHG emissions from producing and transporting energy used by SITM and SETP	GHG emissions from using air conditioning systems in SITM and SETP buses[3]
Temporary	Base year: 2020 Analysis period: 2020-2030	Base year: 2020 Analysis period: 2020-2030	
Process generating emissions	Combustion	Combustion and fugitive emissions	Fugitive emissions
GHGs considered	Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Black Carbon (BC)*	Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Black Carbon (BC)*	Hydrofluorocarbons (HFCs)
Type of mitigation	Energy substitution: replacing internal combustion engine buses with electric buses, and natural gas vehicles with electric fleet	Reducing emissions from producing and transporting diesel that is no longer used; the increase in emissions from electricity generation is also considered	Leakage reduction due to more efficient systems and/or switch to compounds with lower global warming potential
IPCC 2006 categories	1A3biii. Heavy-duty trucks and buses	1A1ai. Electricity generation 1.B.2. Oil and natural gas	2F1bii. Mobile air conditioning

GHG mitigation impact

The calculation of the ex-ante GHG mitigation potential and the estimation of the sustainable development benefits are based on the following scenarios and main assumptions (further details are provided in section 6):

- **Baseline Scenario (BAU):** Considering existing plans for service coverage, fleet management, and operational improvement and assuming no new mitigation actions are introduced over the timeframe of the analysis, the most likely GHG emission trends were estimated for public transport systems in 15 locations:[4]

  - Bogotá
  - Medellín
  - Cali
  - Barranquilla
  - Cartagena

[2] This refers only to the monitoring of emissions caused during operation, with a high degree of uncertainty as to upstream and fugitive emissions. It should be used in contexts where there is insufficient information to perform Well-To-Wheels analysis.

[3] This refers to a more ambitious scope that includes upstream emissions (Well-to-Tank) and evaporative emissions associated with cooling systems.

[4] The systems are the Integrated Mass Transit Systems (SITMs) in Bogotá/Soacha, the Barranquilla Metropolitan Area, Cali, the Valle de Aburrá Metropolitan Area, the Centro Occidente Metropolitan Area, the Bucaramanga Metropolitan Area, and Cartagena; and the Strategic Public Transportation Systems (SETPs) in Pasto, Sincelejo, Santa Marta, Valledupar, Montería, Armenia, Popayán, and Neiva.

- Bucaramanga
- Pereira
- Santa Marta
- Pasto
- Montería
- Popayán
- Armenia
- Valledupar
- Sincelejo
- Neiva

Base year emissions were projected forward based on the 2020 bus fleet size, fleet composition, fleet activity, and fuel consumption factors while considering estimated future fleet size and future demand.

- **Mitigation scenario:**

For the baseline and mitigation scenario, it was assumed that SITMs will grow in the years up to 2030 in accordance with the national goals and projections set for passenger coverage by UMUS – namely, by 4.2% annually.

In the mitigation scenario, once the fleet substitution initially supported by the fund is finished by 2026, the e-bus penetration rate is kept constant up to 2030. This assumption is based on the expectation of price parity between technologies by 2026, especially given fund financing of required infrastructure for e-buses fleets, thus reducing entry barriers and fixed costs for additional buses. The fleet composition figures for the business-as-usual and mitigation scenarios are as follows:

Table 5. Baseline scenario, energy source share in national fleet (Source: Own, 2023)

Year	Bus (10m)			Microbuses (7m)			Padron (12m)				18m +		
	Dsl	GNV	Elec	Dsl	GNV	Elec	Dsl	GNV	Elec	Hyb	Dsl	GNV	Elec
2020-2026	92%	8%	0%	100%	0%	0%	53%	4%	37%	5%	72%	28%	0%

Table 6. Mitigation action scenario, energy source share in national fleet (Source: Own, 2023)

Year	Bus (10m)			Microbuses (7m)			Padron (12m)				18m +		
	Dsl	GNV	Elec	Dsl	GNV	Elec	Dsl	GNV	Elec	Hyb)	Dsl	GNV	Elec
2020	92%	8%	0%	100%	0%	0%	53%	4%	37%	5%	72%	28%	0%
2021	92%	8%	0%	100%	0%	0%	53%	4%	37%	5%	72%	28%	0%
2022	90%	8%	2%	87%	0%	13%	53%	4%	37%	5%	72%	28%	0%
2023	85%	8%	7%	87%	0%	13%	51%	4%	40%	5%	69%	28%	3%
2024	82%	8%	10%	87%	0%	13%	49%	4%	42%	5%	67%	28%	5%
2025	82%	8%	10%	87%	0%	13%	49%	4%	42%	5%	67%	28%	5%
2026-2030	73%	8%	19%	87%	0%	13%	44%	4%	46%	5%	60%	28%	12%

The adoption of e-buses will slash GHG emissions from public transport, achieving 1.8 MtCO2eq of aggregated direct mitigation between 2020 and 2030, with an annual mitigation up to 0.32 MtCO2eq in 2030 in comparison to the business-as-usual scenario.

Table 7. CO2 eq in the baseline and mitigation scenarios (Source: Own, 2023)

Cumulative difference between mitigation scenario vs business as usual	Million-ton CO_2e mitigated
Cumulative (2020 -2030) Fleet fuel combustion	1.8
Cumulative (2020 -2030) Electricity generation	-0.2
Cumulative (2020 -2030) Fuel transport and production	0.2
Cumulative (2020 -2030) Air Conditioning Systems	0.03
Total	**1.8**

The program also has the potential to reduce 228 tons of black carbon (BC) and 345 tons of $PM_{2.5}$ during the analysis period.

2023 UPDATE NOTE:

This report was updated in April 2023 as part of final reporting for the Changing Transport and TRANSfer III project. Although the technology upgrade fund in Colombia has been approved and is currently being elaborated by the Ministry of Transportation and Ministry of Budget with the support from the Inter-American Development Bank (IADB), fund operations have not yet started, and there will be at least a two year delay in implementation from the original expected launch in 2022.

As a result of this delay, aggregate anticipated mitigation between 2020 and 2030 now stands at 1.6 Mton CO_2e, down from 1.8 Mton CO_2e.

Table 8. Cumulative change in CO2 emissions by source

Difference between scenarios CO2e, 2023 Update	Million-ton CO2e
Fleet fuel combustion	1.6
Electricity generation	-0.2
Fuel transport and production	0.1
Air conditioning systems	0.03
Cumulative total change, 2020-2030	**1.6**

1. Introduction

The objective of the TRANSfer III project in Colombia was to promote the mass adoption of electric vehicles in public transport systems, with the goal of reducing GHG emissions in the transport sector. This is a highly relevant objective given the share of GHG emissions attributable to public transport in Colombia and the benefits of such electrification in abating emissions in urban travel and slowing motorization growth rates.

In 2012, the transport sector was responsible for 11% of total national greenhouse gas (GHG) emissions (specifically, 28.2 $MtCO_2$ eq of 258.8 $MtCO_2$ eq in energy-related emissions) (IDEAM, 2016). In a business-as-usual scenario, transport emissions are expected to nearly double to 55.8 $MtCO_2$ eq by 2030 (Hill, 2021) due to rapid urbanization and growth in individual motorized transport.

Aside from GHG emissions, emissions inventories in large Colombian cities show that transport is an important contributor to particulate matter (PM) emissions (AMVA, 2017b), with the sector being responsible for 25% of $PM_{2.5}$ emissions in surveyed cities (mainly because of diesel-fuelled freight and public transport), making $PM_{2.5}$ the most relevant air pollutant from transport (Cuellar y Belalcázar, 2016).[5] Public awareness for the negative impact of particulate emissions on human health has increased dramatically in recent past years. It is estimated that in Columbia, urban air pollution is responsible for over ten thousand premature deaths annually and 75% of the national health costs of environmental degradation; those costs represent almost 2% of GDP (DNP, 2018). Thus, reducing the transport sector's emissions is not only crucial for complying with climate change mitigation goals, but also for improving air quality and public health in Colombia's cities.

In the revised Colombian NDC, MinTransporte presented seven national-level policies with a total estimated reduction potential of 4.9 MtCO2eq in 2030. Of those proposed policies, the promotion of electrical mobility has the largest reduction potential, representing 65% of projected abatement, followed by the scrapping or retrofitting of old freight vehicles, which has the second largest reduction potential (12%).

Currently, several barriers inhibit the integration of electric mobility in public transport systems in Colombia. Four main barriers were identified; they are described in greater detail in section 3:

- Economic and financial barrier: high initial costs and risks make it difficult for investors and operators to switch to electric buses.
- Governance and institutional barrier: due to lack of a legal and financial framework, necessary regulations are not yet in place and the collaboration of actors at different levels is impeded.
- Technical and technological barrier: existing vehicles need to be retrofitted, new infrastructure needs to be put in place, and personnel lack expertise to plan and operate e-bus fleets and infrastructure.
- and monitoring, reporting and verification barriers: without a functioning MRV system it is difficult to enhance trust in the measures.

[5] Particulate Matter (PM) is a mixture of solid and liquid particles suspended in the air. These are categorized into coarse, fine, and ultrafine. $PM_{2.5}$ are fine particles that have a diameter less than 2.5 micrometres (more than 100 times thinner than a human hair) and remain suspended in the air for longer durations. They pose an acute health risk because they can pass directly through the lungs into the blood stream (Indoor Hygiene Institute, 2022).

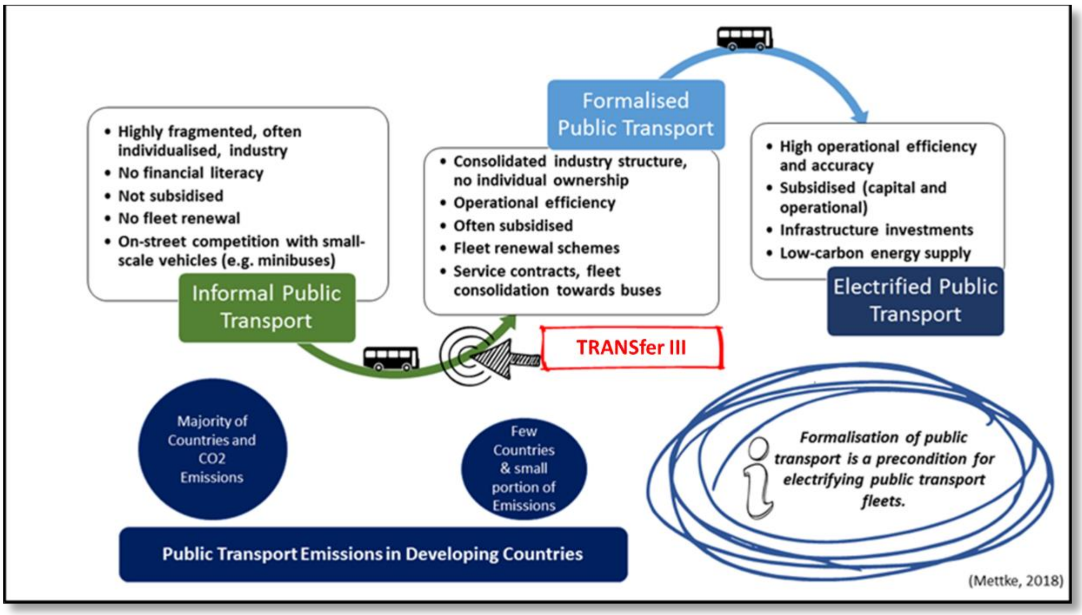


Figure 2. Public transport emissions in developing countries (Source: adapted from Mettke, 2018).

Considering the main objective of the project and the barriers to its realization, TRANSfer III project activities in Colombia focused on:

- Developing national investment programs for e-bus public transportation systems,
- Enabling institutional arrangements and capacities for large scale deployment of e-buses,
- Building technical capacity among key stakeholders to manage bus fleet electrification,
- Developing an MRV methodology to monitor and verify compliance with emission reduction goals for the deployment and operation of e-buses.

TRANSfer III supported the development of a national financing instrument that aims to bridge the gap between the total cost of ownership between electric and conventional buses, and, by this means, to increase the share of e-buses in public transport fleets in Colombia. A Public Investment Fund created with TRANSfer III support was included in the Climate Action Law of 2021 (Law 2169). Operating as a stand-alone fund under the management of MinTransporte, the Public Investment Fund will facilitate investment by cities to update their public transportation fleets with zero-emission alternatives.

Implementation of the fund is anticipated during the second semester of 2022 or first semester of 2023. It will draw on resources allocated by DNP as well as funding provided through cooperation with IADB. Technical implementation will be supported on a continuous basis by GIZ in Colombia as part of the latest DKTI transport initiative funded by the German Federal Ministry of Economic Cooperation and Development (BMZ). It is expected that the 2022-2026 National Development Plan adopted by the incoming national government will provide for the operation and financing of the fund.

In addition to the assistance provided in preparing and setting up the fund, TRANSfer III worked on the following three supportive actions for capacity building:

1. Development of an international training course on transport systems based on e-buses.
2. Generation of technical capacities at the intersection of the public transport and electric vehicle markets, to allow stakeholders and project designers to plan infrastructure, procurement, and contract mechanisms.

3. Development of a labor training curriculum for the National Training Service (SENA) to responded to the short- and medium-term need for qualified personnel to operate and maintain e-buses.

Also, two organizational measures were developed:

- The first measure was to establish the institutional arrangements necessary for the formulation of a National Strategy for Sustainable Transport, in order to ensure a holistic and coherent approach to sustainable transport policy.

  To this end, TRANSfer III, along the MinTransporte, MinEnergía, MinAmbiente, and DNP, developed a proposal for an Interinstitutional Roundtable for Sustainable Transport (abbreviated MITS in Spanish). The goal of this forum is to enable Columbian departments of government to discuss and develop integrated sustainable mobility policy.

- The second measure was to support the development of impact monitoring and evaluation systems for e-bus projects; this included proposing monitoring, reporting, and validation methods, and associated informational flows and organizational structures required for coordinating public and private entities for an effective evaluation of electrification measures.

Furthermore, Changing Transport (the global initiative that serves as the umbrella for global sustainable mobility projects sponsored by BMWK, including TRANSfer III) worked with AFD, CAF, and KfW to develop a proposal for the Green Climate Fund, with the aim of promoting a large-scale regional transition towards electric mobility in Latin America; this proposal was titled E-MOTION.

This report first aims to present the results of the TRANSfer III project, in order to document the work and impacts of the project in Colombia during its third stage. In addition, this report aims to support the work of practitioners and policymakers who are concerned with sustainable mobility and climate change. Specifically, we hope the activities and issues discussed herein are of value to actors in other countries as they go about developing policies to promote the transformation of their transport sectors.

2. Sector overview: Public transport in Colombia

2.1. Structure of the transport sector

The transport and logistics sector represents about 6% of Colombia's GDP, with ground transport accounting for almost 70% of the sector's GDP. From 2007 to 2016 the sector grew by 39.61% with an average annual growth rate of 3.6%. By 2021, Colombia's total vehicle fleet stood at seventeen million vehicles (RUNT, 2021). Figure 3 shows the motorization rate in Colombia from 2017 to 2020. The number of vehicles per 1,000 inhabitants is growing faster than the population; annual automobile and motorcycle growth have trended at 3% and 5%, respectively, compared to annual population growth of 1%. While the motorization rate in Colombia is still low compared to other countries in the region, such as Chile and Mexico, this growth poses a challenge to the country's Nationally Determined Contribution (NDC) goals.

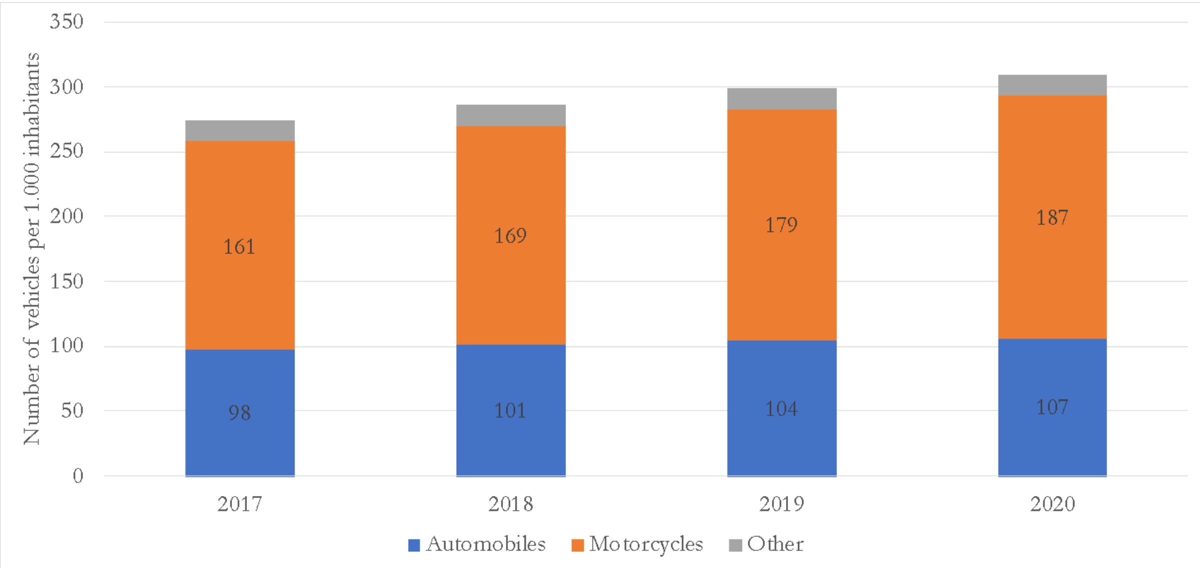


Figure 3. National motorization rate, 2017 to 2020 (Source: RUNT, 2022)

Public transport vehicles comprise just 1.4% of the total national vehicle fleet, yet account for 48% of daily urban passenger trips (RUNT, 2022).

Overall, in Colombia, there are two categories of urban public transport systems:

1. Integrated Mass Transit Systems (abbreviated SITM in Spanish), which are designed as bus rapid transit (BRT) systems, based on main trunk lines and feeder routes. SITMs have been implemented in cities with over 600,000 inhabitants, including Bogotá/Soacha, Cartagena, and Cali, and in the metropolitan areas of Barranquilla, Bucaramanga, Medellín, and Pereira.
2. Strategic Public Transport Systems (abbreviated SETP in Spanish) have been implemented in cities with populations between 300,000 and 600,000 inhabitants, including Popayán, Pasto, Santa Marta, Armenia, Valledupar, Sincelejo, and Montería (DNP, 2016).

SITMs provide for 5.3 million daily trips, which corresponds to almost 36% of all daily urban passenger trips in Colombia. In the three largest cities, the modal share for public buses, including both conventional buses and SITMs, is 16.7% in Cali, 35% in Medellin, and 35.8% in Bogotá (Figure 4); by contrast, the SITM modal share is 48% in Medellin, 73% in Cali, and 81% in Bogotá. In the figure 4 below, "conventional bus" refers to old buses that have operating permits from local transport authorities, but are not managed within an integrated transport system (because they operate on different routes, use other payment systems, or do not comply with certain standards).

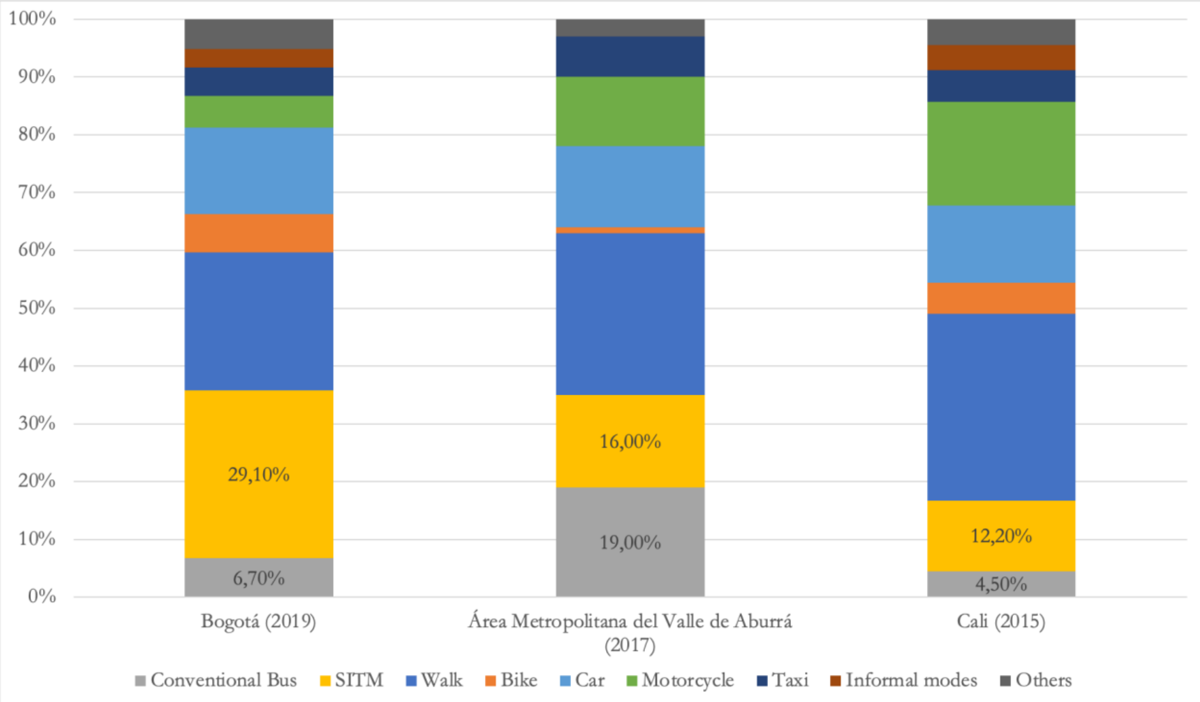


Figure 4. Modal share in Colombia's three largest cities (Source: mobility surveys in Bogotá, Valle de Aburrá, and Cali, supplemented with data collected by the authors)

In 2012, the Columbian transport sector was responsible for 11% of total greenhouse gas emissions (specifically, 28.2 $MtCO_2$ eq of 258.8 $MtCO_2$ eq in energy-related emissions; see IDEAM, 2016). Under a business-as-usual scenario the sector is projected to emit 55.8 $MtCO_2$ eq by 2030 due to rapid urbanization and growth in individual motorized transport (Hill, 2021).

Apart from climate-damaging GHG emissions, transport is a major source of particulate emissions in Colombian cities (AMVA, 2017b), accounting for 25% of $PM_{2.5}$ emissions. The majority of these $PM_{2.5}$ emissions, which are highly damaging to human health, are attributable to diesel-powered freight and public transport vehicles (Cuellar y Belalcázar, 2016). It has been estimated that urban air pollution is responsible for over ten thousand premature deaths annually in Columbia and 75% of the national health costs of environmental degradation; those costs correspond to nearly 2% of GDP (DNP, 2018). Thus, reducing the transport sector's emissions is not only crucial for complying with climate change mitigation goals, but also for improving air quality and public health in Colombia's cities.

The following section addresses why the transformation of public transport in Columbia represents an important opportunity for clean mobility, and discusses the role that electric vehicles can play in this regard.

2.2. Transport and climate policy context

Colombia has enacted various policies and regulations that aim to mitigate the transport sector's contribution to GHG emissions. Most of these policies and regulations seek in part to promote the adoption of electric mobility.

The idea of promoting electric mobility to address climate change in Colombia was first mentioned in the Ministry of Transport's Sectoral Action Plan for Mitigation, in 2014, and since the ratification of the Paris Agreement by the Colombian Congress in 2017, the country has progressively adopted various policies for its promotion. Table 9 summarizes the main regulations and public policies that are relevant to the promotion of electric mobility and, by extension, the e-bus program.

Table 9. Main regulations and public policies related to electric mobility in Colombia

YEAR OF ADOPTION	DOCUMENT	CONTENT
National Regulations		
2017	Resolution 1988 of MinAmbiente	Establishes the reduction of 5.49% of the energy consumed by the transport sector by 2022 as an environmental goal. To achieve this, projects that promote the adoption of electric vehicles in government fleets, taxis, and public transport fleets, as well as for private motorcycles and automobiles, can be certified by MinAmbiente to obtain an exemption from the national value-added tax.
2018	Law 1964 (E-mobility Law)[6]	Promotes the use of electrical and zero emissions vehicles, to contribute to sustainable mobility and to the reduction of GHG emissions. It established tax benefits for electric vehicles, defined goals for the number of these vehicles in nationally co-financed public transport systems, and distributed responsibilities among national government entities for the promotion of e-mobility.
2019	Law 1955 (National Development Plan 2018-2022)[7]	Requires local governments to adopt Sustainable and Safe Mobility Plans, which must seek to implement the Sustainable Development Goals (SDG) in their urban transport systems and should prioritize low and zero emission technologies for public transport. Additionally, it requires nationally co-financed public transport systems to adopt zero or low emissions technologies, allowing for total or partial financing of the acquisition of said technologies by the national government.
	Resolution 5304 MinTransporte[8]	Grants an economic incentive for replacing old public and private freight vehicles with newer vehicles that use clean or low emissions technologies.
	Presidential Decree 2051[9]	Permanently reduces import tariffs for electrical vehicles to 0% as an incentive for their mass-scale deployment.[10]

[6] Available at: https://www.suin-juriscol.gov.co/viewDocument.asp?id=30036636
[7] Available at: https://www.suin-juriscol.gov.co/viewDocument.asp?ruta=Leyes/30036488
[8] Available at: https://www.runt.com.co/sites/default/files/normas/Resoluci%C3%B3n%20No.%200005304%20del%2024-10-2019.pdf
[9] Available at: https://www.suin-juriscol.gov.co/viewDocument.asp?id=30038341
[10] Previously, Presidential Decree 1116 of 2017 established this tariff reduction with the exception of a limited number of vehicles to be imported between 2017 and 2027.

YEAR OF ADOPTION	DOCUMENT	CONTENT
2021	Resolution 40223 of MinMinas[11]	Establishes minimum conditions for the standardization of charging infrastructure for electrical and plug-in hybrid vehicles. It requires new charging stations to have at least one Type 1 connector for charging levels 2 and 3 of alternate current, and at least one CCS Combo 1 connector for a charging level 3 of direct current.
National Public Policy Documents		
2017	National Climate Change Policy[12]	Establishes an action line to provide efficient and low-carbon public transport alternatives as well as incentives for low-emission vehicles, and to promote non-motorized transport modes. This puts MinAmbiente (with the support of the National Planning Department and MinEnergía) as well as local authorities, in charge of identifying and evaluating emission reduction measures.
2018/ 2021[13]	Comprehensive Climate Change Management Plan of the Mines and Energy Sector[14]	Establishes a "Zero and low emissions mobility" action within the "Cooperation for resilient and low-carbon development" line, which puts MinMinas in charge of establishing policy guidelines for the development of the required infrastructure, for the commercialization and operation of electric mobility, and for the promotion of a technological upgrade program for public fleets.
2019	National Electric Mobility Strategy[15]	Defines the necessary actions to accelerate the adoption of electric mobility and sets the goal of incorporating 600,000 electrical vehicles by 2030, in accordance with the National Council of Economic and Social Policy's (CONPES) documents 3934, "Green Growth Policy" and 3943, "Air Quality Improvement Policy." To achieve this, it prioritizes four types of actions: actions that ease the adoption of zero and low GHG emission technologies; specific approximations to the market; creation and strengthening of a regulatory framework; and development of charging infrastructure to anticipate future demand.

[11] Available at: https://www.minenergia.gov.co/documents/10180//23517//48995-40223.pdf
[12] Available at: https://www.minambiente.gov.co/wp-content/uploads/2022/01/9.-Politica-Nacional-de-Cambio-Climatico.pdf
[13] The Mining and Energy Sector's PIGCC was originally published in 2018, but it was updated in 2021. The mentioned policy action is present in both versions.
[14] The updated 2021 version is available at: https://www.minenergia.gov.co/documents/10192/24309752/21261021_Plan_Modifica+el+Plan+Integral+de+Gesti%C3%B3n+del+Cambio+Clim%C3%A1tico+-+Sector+Minero+Energ%C3%A9tico.pdf/dbb68213-3ac3-48fb-9638-08ab42e74e83
[15] Available at: https://www1.upme.gov.co/DemandaEnergetica/ENME.pdf

YEAR OF ADOPTI ON	DOCUMENT	CONTENT
	National Energy Plan 2020-2050[16]	Within its planning assumptions, it estimates an increase in the electricity consumption of the transport sector from less than 0.1% in 2019 to 8-16% in 2050.

In 2015, MinTransporte created as one of its working units the Environmental and Sustainable Development Group (abbreviated GAAD in Spanish), which is composed of a multidisciplinary group of professionals with direct coordination from the ministerial office. GAAD is tasked with the formulation, implementation, and monitoring of strategies, programs, and projects that seek to mitigate the effects of the transport sector on the environment.

With the adoption of the Paris Agreement, Colombia was obliged to pursue domestic mitigation measures to achieve its NDC goals. The reduction of GHG emissions from the transport sector is particularly relevant for NDC fulfilment.

In terms of NDC goals, in 2015 the national government pledged to reduce GHG emissions based on a two-track approach: It committed to achieving a 20% reduction in 2030 emissions on its own, and a 30% reduction given international support.

However, in 2020 the national government raised the bar with a more ambitious pledge to reduce 51% of emissions by 2030 (expecting international support but without a concrete requirement), based on MinAmbiente's projections, in a revised NDC (Minambiente, 2021). Table 10 summarises the 2020 NDC goals.

Table 10. Current Colombian national and transport sector NDC goals (Source: MinTransporte, 2020)

Element	Content
All economic sectors	
Type of goal	Absolute GHG emissions by 2030
Goal value	Maximum national emissions of 169.4 MT CO_2eq
Equivalent metrics	95.7 Mt CO_2eq / 51% reduction in 2030 emissions in relation to baseline
Baseline	Base year: 2015

[16] Available at: https://www1.upme.gov.co/DemandayEficiencia/Documents/PEN_2020_2050/Plan_Energetico_Nacional_2020_2050.pdf

Element	Content
	Annual growth rate of emissions (2015-2030): 2.65%
	Accumulated emissions (2015-2030): 4,236 Mt CO_2eq
	Emissions level in 2030: 345.8 Mt CO_2eq
Transport sector	
Goal value	Twenty percent reduction with respect to 2030 emissions[17]
Equivalent metrics	9.72 Mt CO_2eq reduction with respect to 2030 emissions
Baseline	Base year: 2015
	Annual growth rate of emissions (2015-2030): 3.58%
	Accumulated emissions (2015-2030): 691 Mt CO_2eq
	Emissions level in 2030: 55.8 Mt CO_2eq

In Columbia's revised NDC, the Columbian Ministry of Transport (MinTransporte, for short) presented seven national-level transport policies with a total estimated reduction potential of 4.9 MtCO2eq in 2030, as shown in Figure 5. Of the proposed policies, the promotion of electrical mobility has the largest reduction potential (accounting for 65% emission reductions), followed by the scrapping and retrofitting of old freight vehicles, which has the second largest reduction potential (12%). The remaining policies account for 23% of the reduction potential. Additional private sector-led and regional/local government-level mitigation measures were also identified but not quantified. These measures could augment emission reductions in the transport sector.

[17] In 2015, the Intersectoral Commission for Climate Change published guidelines mandating a 20% GHG emissions reduction in each economic sector. These guidelines were not altered by the 2020 NDC revision, which instead focuses on listing concrete sectoral policies at the national level, with their corresponding mitigation potential. Thus, the 20% reduction goal remains valid for the transport sector, even though the national level policies introduced by MinTransporte only account for about half of that goal.

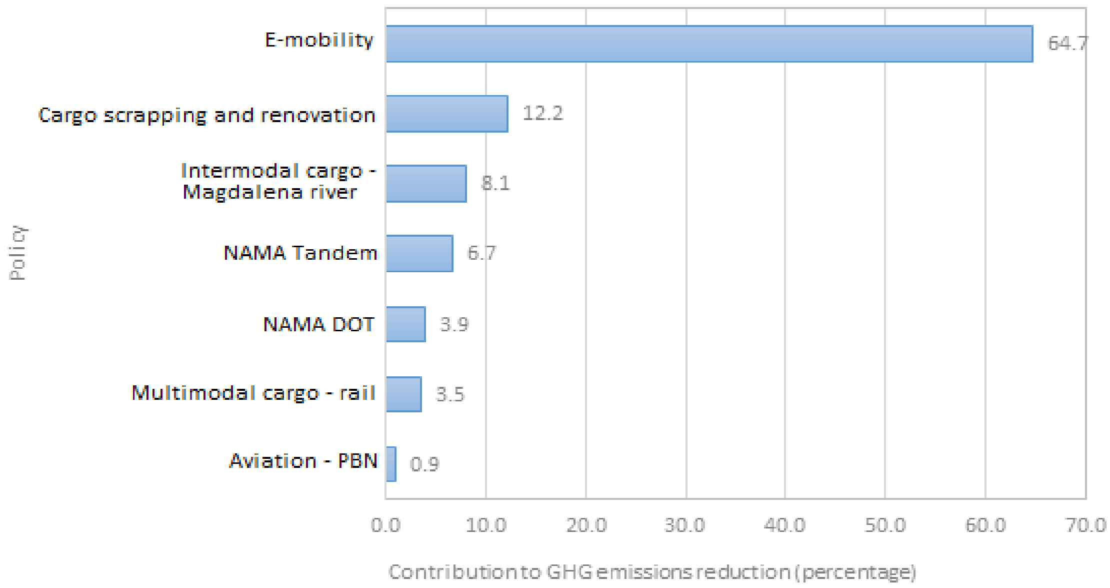


Figure 5. Contribution to GHG emissions reduction by policy (Source: Revised NDC, 2020)

Regarding the implementation of e-buses in Colombia, the pioneer city was Cali with the incorporation of 26 e-buses in its fleet in 2019 and 9 more in 2021. The model implemented in Cali for those 35 e-buses involved the participation of energy distribution companies, infrastructure providers and private bus operators as investors. In 2020, the city of Medellín acquired 65 e-buses for the publicly owned Metro de Medellín. Bogotá started its run to become the e-bus leader in Colombia in 2020, with the purchasing of 483 e-buses and the procurement of an additional 1,002, reaching 1,485 e-buses to be in operation by the end of 2022. The model used in Bogotá is similar to the one used in Cali.

2.3. Governance and institutional arrangements in public transport

Formal urban public bus transport services are generally provided by private companies in Columbia; there are only two cases of public companies directly providing and operating such services (in Medellín and Cartagena). Accordingly, the role of the public sector is to design transport plans and regulations; adopt guidelines; advise managing entities and operators; award contracts and permits; and supervise operations.

The provisioning of transport services by private companies is generally formalized through two types of legal arrangements: through the signing of contracts and the granting of operating permits. The first is characterized by establishing the terms and conditions a company must fulfill in terms of technical and financial prerequisites. Contracts also allow for tighter control by the public company in charge of managing the system (i.e. the “management entity”; more information below) and for delegating activities that traditionally have been in the public sector, such as the provision and maintenance of public infrastructure. The granting of operating permits is the traditional means of assigning routes or services to private companies who carry out transport service provisioning.

The institutions and actors involved in public transport and their primary responsibilities are presented in Figure 6.

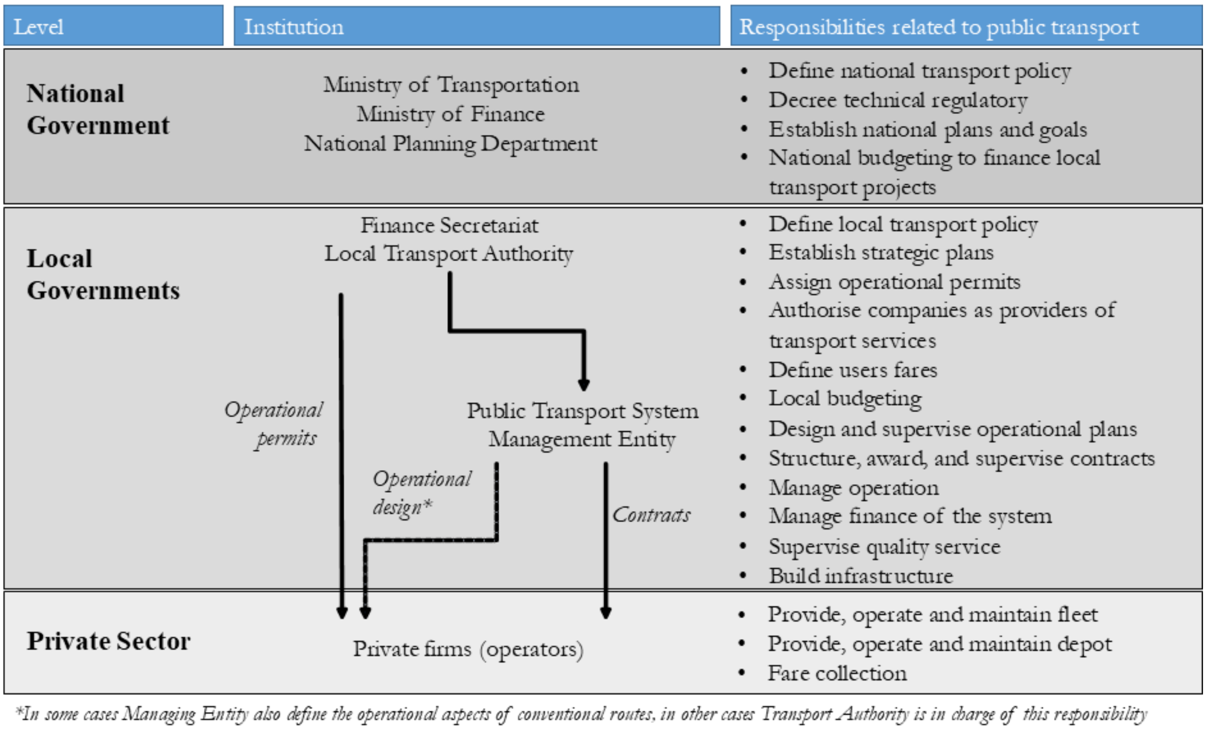


Figure 6. Governance of public transport in Colombia

At the city level, the key players are the Management Entities (ME), which are the public companies that receive funds from national and local governments through a trust fund for infrastructure projects. MEs are also in charge of developing and tendering fleet provision and operations, as well as fare collection contracts. As an example, Transmilenio S.A., Bogotá's ME, currently contracts 42 private fleet operators for Bus Rapid Transit (BRT) trunk corridors, feeders, and complementary routes, and contracts a private company called Recaudo Bogotá to provide fare collection services. However, due to the local autonomy in each city, the role of the private stakeholders may vary. For example, in contrast to Bogotá, both Medellín and Cartagena have publicly owned bus fleets and private operators.

Table 11 presents an overview of the current market for public bus transport in Colombia.

Table 11. Composition of market for public bus transport in Colombia

City	Type of System	Management Entity	Number of Private Operators	Legal Authorization
Armenia	SETP	Amable S.A.S.	Owner-operator	Operational Permits
Barranquilla	SITM	TransMetro S.A.	2	Contracts
Bogotá	SITM	TransMilenio S.A.	42	Contracts
Bucaramanga	SITM	Metrolínea S.A.	2	Contracts and Operational Permits

City	Type of System	Management Entity	Number of Private Operators	Legal Authorization
Cali	SITM	MetroCali S.A.	3	Contracts and Operational Permits
Cartagena	SITM	TransCaribe S.A.	3	Contracts and Operational Permits
Medellín	SITM	Metroplus S.A.	3	Contracts and Operational Permits
Montería	SETP	Amable S.A.S.	2	Contracts and Operational Permits
Neiva	SETP	Transfederal S.A.S.	Owner-operator	Operational Permits
Pasto	SETP	Avante S.A.S.	Owner-operator	Operational Permits
Pereira	SITM	Megabús S.A.	2	Contracts and Operational Permits
Popayán	SETP	Movilidad Futura S.A.S.	2	Operational Permits
Santa Marta	SETP	SETP Santa Marta S.A.S.	1	Operational Permits
Sincelejo	SETP	Metro Sabanas S.A.S.	Owner-operator	Operational Permits
Valledupar	SETP	SIVA S.A.S.	Owner-operator	Operational Permits

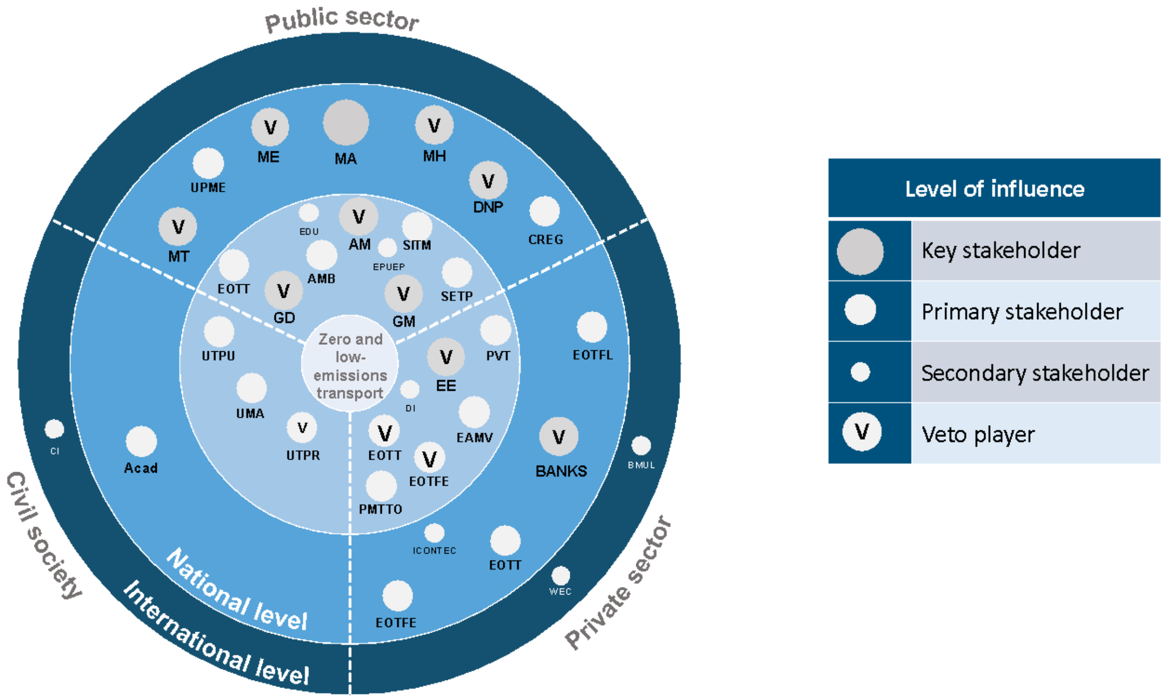
An important consideration in terms of market configuration is that there are several informal services that compete with the formal systems, including informal buses, vans, private cars, collective taxis, motorcycle taxis, and pedicabs, all of which lack operating permits. Such services fill a gap in the market that formal systems either do not cover or cover with inadequate quality. Nevertheless, informal services are a growing concern for authorities, because they cannibalize demand from formal systems and they do not necessarily comply with all legal standards and regulations, thus potentially posing a risk to passengers and drivers in terms of road safety and personal security. The obligation to monitor such informal services lies with the local transport authorities.

The fares charged by public transport systems in Colombia are regulated and there are subsidies for vulnerable user groups (elderly, low-income, students, etc.), depending on local regulations. Contributions from local governments are provided to cover the difference between the system costs and revenues – that is, they provide direct subsidies to the company operating the system.

2.4. Stakeholders in e-bus projects

In terms of organizational arrangements, Bogotá, Medellín, and Cali were subjected to closer analysis, since they are the only cities with e-buses. The relevant stakeholders for e-bus projects were identified and classified based on the following categories (Figure 7):

- **Key stakeholders:** those with a power position that grants them the capacity to either influence or participate directly in the project decision making.
- **Primary stakeholders:** those directly affected by the project's results, either positively or negatively.
- **Secondary stakeholders:** those who participate in the project temporarily or indirectly.
- **Veto players:** those whose participation or support is required to achieve the project's expected results and whose lack of participation or support, can veto the project. They can simultaneously be key, primary, or secondary stakeholders.



Acronym	Entity
AM	Metropolitan Areas
AMB	Environmental authorities
BMUL	Multilateral banking
CI	International cooperation
CREG	Energy and Gas Regulation Commission
DI	Infrastructure developers
DNP	National Planning Department
EAMV	Vehicle maintenance companies
EDU	Entities involved in the development of urban and public space projects
EE	Energy companies
EOTFE	Rail transport operating companies
EOTFL	River transport operating companies
EOTT	Land transport operating companies
EPUEP	Urban planning entities and public space
GD	Departmental (regional) governments
GM	Local governments
ICONTEC	Colombian Institute of Technical Standards and Certification
MA	Ministry of Environment
ME	Ministry of Mines and Energy
MH	Ministry of Finance
MT	Ministry of Transport
PMTTO	Suppliers of spare parts for vehicle maintenance
PVT	Vehicle providers
SETP	Strategic Public Transport System
SITM	Integrated Mass Transit System
UMA	Active mode users
UPME	Energy Mining Planning Unit
UTPR	Private transport user
UTPU	Public transport user
WEC	World Energy Council

Figure 7. Stakeholder map, –Colombian e-bus market

One key finding of the analysis is that, in addition to the transport sector stakeholders, energy sector players are highly relevant, including energy companies with the financial capacity to invest in fleet provision and/or infrastructure. Additional considerations include:

- Both the private and public sectors play an especially important role in the e-bus market.
- Fleet and charging technology providers are both key stakeholders and veto players.
- Energy sellers and banks are both key stakeholders and veto players.
- Public transport operators are veto players.
- Some regional public entities are key actors and veto players, but others have a smaller level of influence.
- The national government entities involved in electric mobility are veto players, except for the Information and Communications Technologies Ministry (MinTic).

Table 12. List of the main stakeholders from each category that are present in Colombia

Fleet Operator	Fleet Provider	Energy Company	Automotive Company	Charging Infrastructure Provider
Gran Américas Fontibón 1 S.A.S.	Celsia Move S.A.S.	Enel	BYD	ABB
E-Somos Alimentación S.A.S.	Electribús Bogotá Fontibón II S.A.S.	Celsia	Sunwin	Enel
E-Somos Fontibón S.A.S.	Electribús Bogotá Usme I S.A.S.	EPM	Yutong	Engie
ZMO Fontibón Iii S.A.S.	ZMP Fontibón III S.A.S.	Andesco	Mitusui	Terpel
ZMO Fontibón V S.A.S.	ZMP Fontibón V S.A.S.	Engie	Zhongtong	Celsia
Mueve Fontibon S.A.S.	Fontibón ZE S.A.S.	Terpel		
Mueve Usme S.A.S.	Usme ZE S.A.S.			
Blanco y Negro	Vgmobility Perdomo S.A.S.			
GIT Masivo				
Metro de Medellín				

2.5. Finance and current business models

In 1993, Congress authorised the National Government to support local authorities in implementing SITMs through the co-financing of infrastructure investments such as terminals, maintenance depots, roads, and BRT corridors, among others. This was formalised by the National Urban Transport Program (NUTP), which began in 2002, with Bogotá as its first SITM beneficiary.

In 2009, the NUTP was amended by Presidential Decree 3422, allowing it to also co-finance SETPs. The NUTP program grants 40 to 70% of the infrastructure costs of public transport systems to its beneficiary cities. Since June 2019, Law 1955 has allowed national investments in the acquisition of new rolling stock for zero and low emission technologies. However, so far, the national government has not co-financed fleets. In terms of infrastructure, by 2017, the total investment from the national government was USD $4.7 billion for SITMs and USD $1.4 billion for SETPs. Most of the national funding comes from loans by development banks, such as the Latin-American Development Bank (CAF), the Inter-American Development Bank (IADB), and the World Bank (WB). Local funding usually comes from surtaxes on gasoline.

As laid out in the previous chapter, partnerships between the public and private sectors play an integral role in Colombian public transport policy. The public sector oversees the delivery of infrastructure, bus corridors and stations, as well as the planning and oversight of operations, while the private sector is primarily responsible for the acquisition and operation of vehicles, including maintenance depots, and fare collection. Figure 8 shows how the NUTP funds flow for financing infrastructure and operations.

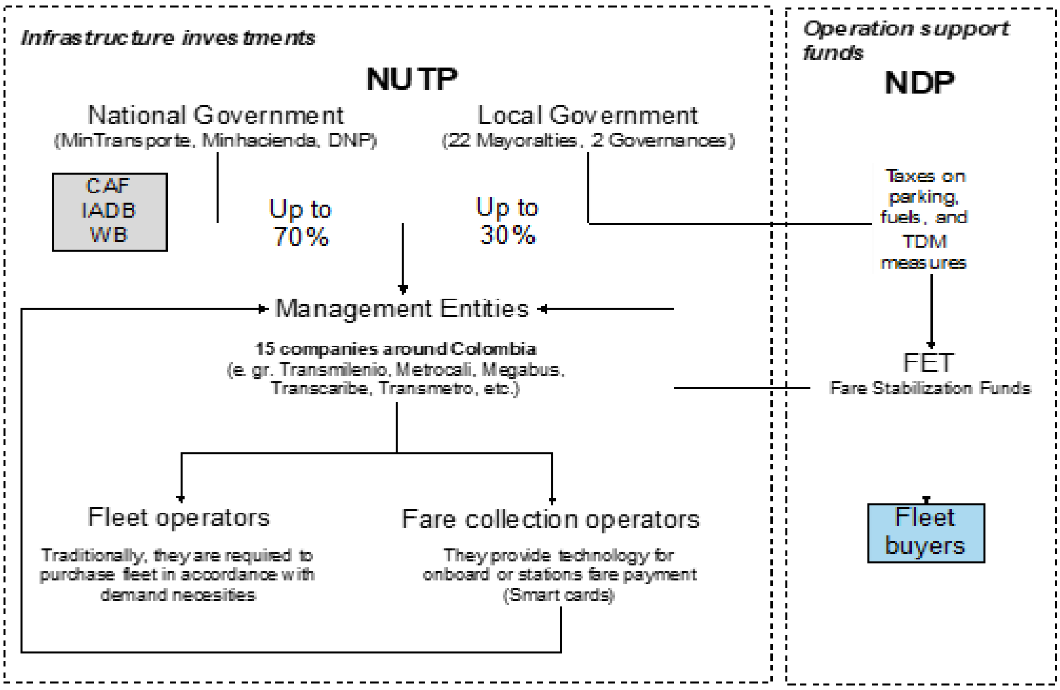


Figure 8. NUTP funding flows (Source: GIZ)

NUTP's financial and institutional arrangements have allowed several local authorities to improve the efficiency, affordability, safety, and environmental sustainability of public transport services, as they provide clear nationwide guidelines but keep implementation and contract management in the hands of local government.

Regarding costs, before 2015 the national government had determined that transport systems needed to be "self-sustainable," meaning that the operations and capital costs of the fleets had to be entirely covered by fares. However, this has proven to be unfeasible given the goal offering passengers a high level of service in terms of comfort, frequency, safety, security, etc.

The fares paid by passengers are set independently by each city based on political negotiations and associated regulations. Usually, they do not cover the system's costs ("technical tariff"). As a result, there is a gap, usually ranging between 20% and 50%, between revenues and costs. This gap has been widening due to increased motorization rates, especially for motorcycles, which has resulted in lower passenger demand. This dynamic was worsened by vehicle occupation restrictions imposed during the COVID-19 pandemic.

Various mechanisms are used to cover this cost gap, including the Fare Stabilisation Fund (Fondo de Estabilización Tarifaria, or FET); direct funding from municipalities using gasoline surtaxes; and other mechanisms authorised by the national government. The FET program was created to allow cities to cover operational costs while maintaining affordable fares for users. Bogotá, Medellín, Cali, and Barranquilla have established FETs, funded by gasoline surcharges and in some cases by traffic fines.

In relation to the other mechanisms that the national government has authorised cities to implement, including Transportation Demand Management (TDM) schemes, there has been an overall failure to implement them and capture revenues. Some of those measures include:

- Surcharges from parking/garage services,
- Charging for on-street parking,
- Congestion charging schemes,
- Environmental charging schemes, and
- Land value capture.

The current National Development Plan (2018-2022) emphasizes that national co-financing for SITMs or SETPs will remain up to 70% of investment costs, depending on the availability of funding resources, in accordance with the country's medium-term fiscal planning. This may include funds for fleet purchasing, specifically for zero or low emission vehicles.

The success of Colombia's investment programs shows that national efforts can enhance the implementation of sustainable transport measures at the city level. A logical next step to guide urban transport onto a decarbonization pathway is to implement a national vehicle electrification program. In combination with a further shift to sustainable transport modes and increasing shares of renewables, battery electric vehicles are currently considered the most effective technological option (in comparison to liquefied natural gas, compressed natural gas, and hybrid electric vehicles) and the most efficient (compared to fuel cell vehicles).

2.6. Related initiatives

Promoting electric mobility is, and has been, the goal of several past and current programs and projects in Colombia. Table 13 summarizes the most relevant initiatives.

Table 13. Relevant e-mobility initiatives in Colombia

Initiative	Involved Agencies	Duration	Initiative Details	Budget[18]
E-MOTION Regional GCF E-Mobility Program for Latin America	Accredited Agency: AFD Implementing Agency: GIZ (for technical assistance), CAF and KfW Proparco for private sector cooperation	2021–present (ongoing)	This program aims to enable a regional transition towards electromobility in Latin America and to provide tools for the transition. The program focuses on the electrification of intensively used high-mileage vehicles in cities, such as buses, taxis, utility vehicles for urban freight, and mobility-as-a-service/car sharing providers, since the electrification of such vehicles will have a major impact on GHG mitigation. The program components include financial incentives for e-vehicles and charging infrastructure through grants and loans. The project is still to be approved by the GCF board.	Up to USD 855 million
TUMI e-BUS Mission	GIZ	2019–present (ongoing)	This program seeks to provide electrification plans for Barranquilla and Valledupar, with Bogotá as a mentor city for the region.	Not defined
City GAP Fund	European Development Bank	2020–present (ongoing)	This program seeks to evaluate the feasibility of electrifying Bogotá's school buses fleet.	USD 75,000
Accelerating Electric Bus Adoption in Colombia	WRI UK Pact	2019–present (ongoing)	This project involves pre-feasibility studies for transport systems in three cities (Pasto, Neiva, Montería)	USD 600,000
C40 procurement of e-buses for Medellín	External support: C40 Cities and WRI Local stakeholders: Alcaldía de Medellín, Metroplús, Metro de Medellín, EPM, Área Metropolitana del Valle de Aburrá	2019	This project involved the purchase of 64 e-buses and sixteen charging stations from the Chinese manufacturing firm BYD by the city of Medellín. The buses have a capacity of eighty passengers and their use is expected to prevent the emission of 3,274 Mt CO_2e and 79 kg $PM_{2.5}$. The structuring study was carried out by C40 and WRI. WRI also provided technical support for the operational planning, and during the manufacturing and delivery of the e-buses by BYD.	USD 20,000

[18] Given the high volatility of the Colombian peso over the last decade, current values are listed.

	BYD: Production and delivery of e-buses			
Ecologistics: Low Carbon Freight for Sustainable Cities	Executing partner: ICLEI Local Partner: MinTransporte City Governments: Bogotá, Manizales y Área Metropolitana del Valle de Aburrá.	2018–present (ongoing)	This project involves nine cities in Argentina, Colombia, and India. It seeks to involve governmental and non-governmental stakeholders in the building of strategies and policies to promote low-carbon and more sustainable urban freight through local action and national support.	IKI- BMWK EUR 3.2 million
Sustainable Transport for Intermediate Cities (STIC Program)	Implementing agency: CAF Local Partners: MinTransporte	2018–present (ongoing)	This program's main goal is to reduce GHG emissions by adopting more efficient, less carbon-intensive modes of public and private transport in four mid-sized cities in Colombia (Pasto, Pereira, Montería, and Valledupar). This is to be achieved through a combination of strategic interventions to trigger: (i) a modal shift from low-capacity private vehicles to fewer larger public vehicles; (ii) a modal shift from motorized vehicles to non-motorized modes; and (iii) lower travelled distance per activity because of better urban planning and transport demand management. PPF support will be used to carry out preparatory studies for each city. Similarly, investments will also be used to develop and deploy a strategy for transport demand management, as well as urban transit-oriented development (TOD) strategies. This program also encompasses road safety, communications, gender issues, and environmental and social management.	USD 1.4 million Funding Proposal: up to USD 50 million
UrbanLEDS II	Led by: ICLEI South America Secretariat. Supported by: UN-Habitat Regional Office for Latin America and the	2018–present (ongoing)	The program helps local governments to implement integrated low-emission and resilient development by (1) offering guidance, tools, and technical assistance; (2) mobilising cities to commit to the Global Covenant of Mayors for Climate & Energy (GCoM); (3) exploring access to financing; and (4) supporting multilevel governance. The project will also support the improvement of effective monitoring and reporting systems through an integrated MRV	Not defined

	Caribbean City Governments: Cali, Ibagué, Área Metropolitana del Valle de Aburrá, Cartago, Tópaga, Valledupar y Manizales		process, which is vital for tracking progress and accelerating climate action within cities.	
Building an Enabling Environment to Develop Electricity-Based Mobility	Local Partners: MinTransporte and MinMinas Supporting organisation: FINDETER Implementing Partner: WWF	2017–present (ongoing)	This NAMA Support Project (NSP) will set the course for the development of electromobility in Colombia by building an enabling regulatory and financial environment for the mass adoption of electric vehicles, creating substantial demand by 2024, when electric vehicles are expected to achieve price parity with fossil technologies.	NAMA Facility USD 3 million
World Bank's Partnership for Market Readiness (PMR)	World Bank Local Partners: MinTransporte and MinAmbiente	2014–present (ongoing)	This program is developing carbon market instruments to achieve GHG mitigation in the transport sector. Under PMR, Colombia is assessing the market readiness of the transport sector; identifying market instruments suitable for transport sector; improving a "carbon market" instrument; conducting a carbon tax study; designing an Emissions Trading System; and helped with the planning and implementation of Colombia's Nationally Determined Contribution (NDC).	USD 3 million
The Emerging and Sustainable Cities Program (ESC)	Implementing agency: FINDETER, within the framework of the BID Initiative Allies: CAF, AFD[19]	2012–present (ongoing)	This program pursues an interdisciplinary approach to address the most urgent challenges faced by medium-sized cities. Following a thorough analysis of the needs of participating cities, the program defines an action plan and prioritizes topics, one of them being electric mobility.	USD 500 million

[19] CAF supports the programme with the development of studies; AFD co-finances projects under this initiative via the French Global Environment Facility.

3. Barriers to electrifying mass public transport

In recent years, electric vehicles have become a major technological disruptor, establishing themselves as the primary medium-to-long term competitor to vehicles that rely on fossil fuels. Electric vehicles are one of the most important decarbonization options in urban areas.

Currently, several barriers inhibit the adoption of electric vehicles in Columbian public transport systems (see Figure 9). These barriers include cost differentials and risks; the lack of a suitable legal and financial framework; and a lack of capacities for planning, operating, and monitoring e-buses in municipal public transport. The existing barriers can be subdivided into four overarching categories: economic and financial; governance and institutional; technical and technological; and monitoring, reporting and verification.

3.1. Economic and financial barriers

The successful incorporation of e-buses in public transport fleets depends in no small part on operating conditions and associated cost structures. While e-buses have higher upfront costs than traditional internal combustion engine (ICE) options (80-160% higher), they also have lower maintenance and operating costs (due to fewer moving parts and lower energy prices). These are just two of the cost factors that need to be taken into account when comparing the economic feasibility of e-buses in relation to conventional alternatives.

The substantial upfront cost differential usually results in a higher overall Total Cost of Ownership (TCO) for e-buses. This may negatively impact the liquidity of fleet providers and public transport managing entities and/or exacerbate the deficits being run by Columbia's public transport systems. TCO is higher not only because of higher vehicle procurement costs, but also due to necessary investment in charging infrastructure.

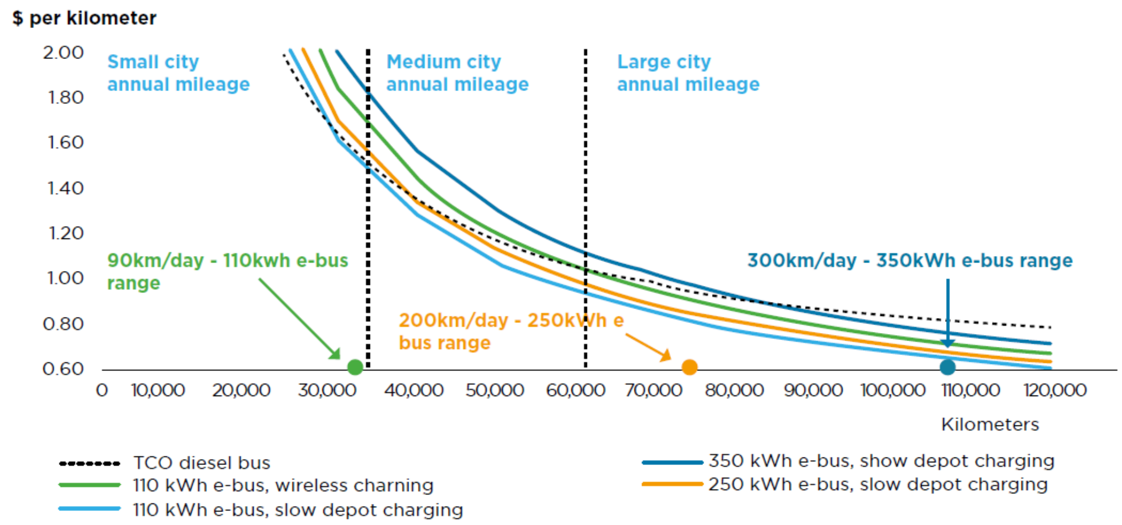


Figure 9. Total cost of ownership comparison for electric buses and diesel buses at different annual operating distances (Source: BloombergNEF, 2018)

Assumptions: Diesel price USD 0.66/liter – 2450 COP/liter (USD 2.5/gallon), electricity price: USD 0.10/kWh – 370 COP/kWh. Distance travelled is not solely dependent on city size and may vary depending on transport network design.

The higher costs barrier requires a constant process to try to level the lower operations and maintenance costs of e-buses, with the demand and the depreciation time of each project, assuming that the amount and sources of income are the same, therefore, the cost structure depends only on the specific characteristics of each technology. This may help decision makers to have a better comparison framework against lock-in traditional technologies which are better known but have higher incremental costs and less environmental benefits.Although some cities in the region, especially Bogotá and Santiago, have managed to upgrade substantial portions of their fleets to e-buses, showing that it is technically and financially feasible, the Latin American and Caribbean markets still have a long way to go to reduce risk perceptions related to e-mobility.

Several factors contribute to the perception that electric public transport systems pose financial risks:

- uncertainties related to required civil engineering and electrical infrastructure capacities and their implementation;
- divergence between the theoretical performance rates stated by Original Equipment Manufacturers and the actual operational conditions in Latin American cities (Table 14); and
- battery lifespans, including aftermarket battery availability and replacement costs.

Additionally, operators face uncertainty in relation to lifespans of e-buses, as there is little experience with their long-term use, and no reliable data are available.

Table 14. Operational performance of e-buses in Latin America (Source: IDB, 2021)

Lima	0.78km/kWh	Pilot
	1.09 km/kWh	Manufacturer
Montevideo	0.78km/kWh	Pilot
Bogotá	0.95km/kWh	Operation
	1.20km/kWh	Manufacturer
Medellín	1.03km/kWh	Manufacturer
Santiago	0.89km/kWh	Operation
	1.00km/kWh	
Buenos Aires	1.07km/kWh	Pilot

In addition, project owners and financial institutions have little knowledge on how to best assess e-bus business models. Combined with the existing perception that the public transport sector is a high risk environment for investment, this leads to reluctance by banks to offer loans to operators.

Finally, transport sector decision-makers lack an adequate understanding of power markets, as well as possible business models that could be used to procure electricity for their fleets, in order to achieve more competitive conditions for e-bus adoption.

3.2. Governance and institutional barriers

Another important set of barriers relate to the institutional environments that govern the implementation of e-mobility in Colombian cities. When TRANSfer III started working in Colombia, the most important barrier to adequate institutional and working arrangements was the pronounced fragmentation of actors involved in the electrification of transport.

This fragmentation is specifically acknowledged in the National Electric Mobility Strategy, which was formulated by Colombia's national government in cooperation with the ministries of Transport, Environment, and Energy, as well as the National Planning Department (DNP). The strategy, which aims to promote electric vehicles and thus reduce pollutants and improve air quality, highlights the need for players from various sectors and institutions to cooperate on a regular basis. Among other things, the strategy recommends establishing a steering structure so that national and international organizations can effectively coordinate e-bus projects and allocate resources efficiently.

The existing weaknesses in institutional arrangements translate into disparate public policies and implementation plans for the adoption of e-buses in cities. Some cities have plans for e-bus adoption, but often they do not include clear objectives or economic incentives. A lack of genuine interest on the part of policymakers and stakeholders is one main reason for the failure to adopt effective implementation guidelines and policies. If incentives are limited and political support is insufficient, it becomes difficult for cities to issue tenders for the purchase of electric buses.

The national public policy documents (abbreviated CONPES in Spanish) provide generic guidelines on regulations and management practices for promoting e-mobility. However, they do not provide for comprehensive coordination between the different ministries, nor are they adapted to the needs of the local entities that execute projects. As a result, cities and states have failed to implement concrete mechanisms for adopting electric vehicles in public transport.

3.3. Technical and technological barriers

In work conducted to determine the primary barriers to the wide-scale deployment of e-buses in Colombian cities, the lack of charging infrastructure emerged as a key concern among public transport management entities and operators. One challenge in implementing charging infrastructure is that actors have difficulty identifying infrastructure development locations, as various criteria must be fulfilled, including suitable power grid connectivity and sufficient road access.

Another important barrier is the small variety of e-bus models available in Colombia, especially in the sub-segment of smaller 8-10 meter buses. Demand for such buses greatly outstrips supply, leading to soaring prices. E-bus owners must also depend on manufacturers for spare parts, but manufacturers have been slow to ensure reliable and rapid spare-part provisioning. In addition, after-sale services still need to be further established in the region.

While the aforementioned barriers are major impediments to the electrification of public bus transport systems, they will likely be addressed with the growth of the e-bus market.

From a regulatory standpoint, standards for charging infrastructure, building codes, and battery disposal are required, and it is necessary to establish appropriate guidelines and processes for the homologation of electric vehicles. The setting of standards and norms for e-vehicles will improve the safety and confidence in the technology.

Finally, a frequently overlooked but crucial barrier that must be resolved is the lack of human and organizational capacities to plan, operate, and maintain e-buses. As e-buses are a novel technology in Colombia, technical experience with managing e-bus fleets is limited. Consequently, it is important for transit agencies and operators to acquire the expertise necessary to the plan, operate, and maintain e-bus fleets and associated infrastructure.

3.4. Monitoring, reporting, and verification barriers

Colombia reports on its progress in mitigating GHG emissions through National Communications and Biennial Update Reports (BUR). Additionally, Law 1753 of 2015 requires each government sector to implement mitigation plans; NDC compliance is overseen by the National Registry for the Reduction of Greenhouse Gas Emissions (abbreviated RENARE in Spanish).

However, Columbia has yet to establish a Monitoring, Reporting, and Verification (MRV) system for public e-buses. Such a system is crucial for the ex-ante analysis of mitigation potential, for reporting on implementation and operation, and for the ex-post evaluation of mitigating performance. Accordingly, the adoption of an MRV system is needed not only for monitoring the impact of public and private investments in electric mobility and ensuring compliance with NDC mitigation commitments, but also for accessing international funding.

4. The mitigation action

4.1. Objective and concept

The objective of the TRANSfer III project in Colombia was to promote the mass deployment of electromobility in public transport systems, with the goal of reducing GHG emissions and air pollution originating from the transport sector. To achieve this objective, TRANSfer III project consisted of two direct mitigation actions, and three supportive measures. The actions addressed four domains: financial; institutional/regulatory; technical; and monitoring, reporting and verification (MRV).

Work conducted as part of the TRANSfer III project in Colombia focused on:

- Developing national investment programs for public e-bus transportation systems.
- Enabling institutional environments and capacities for large scale deployment of e-buses.
- Building capacities among key stakeholders for managing bus fleet electrification.
- Developing an MRV methodology to verify and document compliance with emissions reduction goals as part of the deployment and operation of e-buses.

The main indicators for measuring progress toward the above goal over the 2022-2030 period are:

- The share of e-buses in public transport fleets
- The GHG emissions of urban public transport
- Cumulative reductions in CO2 emissions
- Cumulative public and private investment in e-buses

The development of the program was supported by a Logical Framework (see

Figure **10).**

The first step consisted in the identification and evaluation of the **barriers for the deployment of electromobility** in the country, as mentioned in the previous chapter. It was found that the most important barriers were not being addressed by the national government or by other programs, and that additional support was required to create an enabling framework that could lead the country to the electrification of public transport systems, either from programs that were already in progress or from those that were being developed at the start of TRANSfer III. As stated previously, the most important barrier detected were the costs associated with the acquisition of electric buses, which were higher than those of traditional buses.

The second step consisted in the **planning and execution of different activities to address those barriers**, and thus spur a change in the conditions that lead to the electrification of the bus fleets. The main measure consisted in supporting the Colombian national government in the construction of a **public investment fund** to help cover the incremental cost between electric fleets and ICE traditional technologies, including infrastructure, and the financial instruments to promote the transition.

Additionally, other activities were undertaken to help **strengthen the institutional framework** for e-mobility promotion policies, including **building the necessary capacities** so that operators, managing entities, and the national government can develop the systems, identifying curriculums necessary for training the personnel who operate or maintain e-mobility equipment and vehicles (with a gender approach that aims to employ mostly women), and establishing clear **methodologies and institutional arrangements** that allow for the effective monitoring, reporting, and verification of the program's progress.

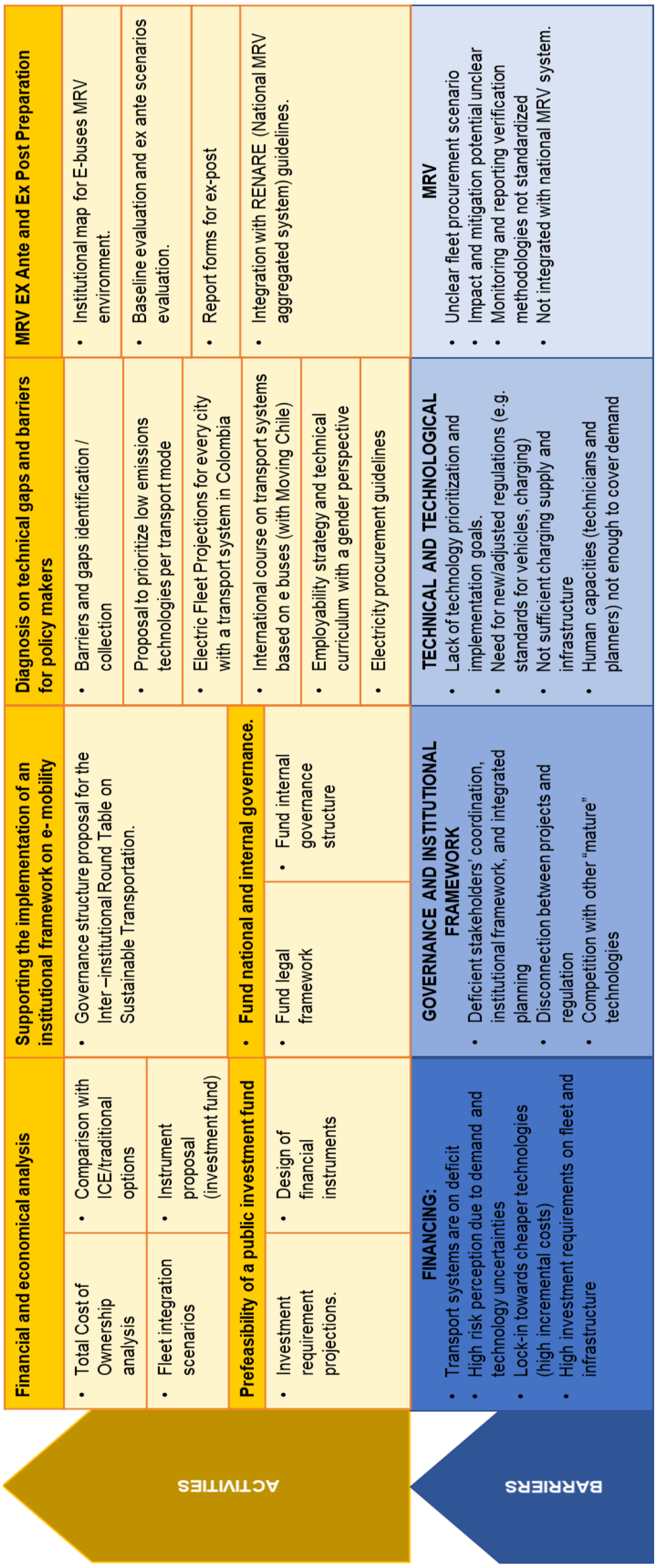


Figure 10. Logical Framework of barriers, and activities to overcome them. (Source: GIZ)

4.2. GHG mitigation actions (direct mitigation measures)

This mitigation action consisted of the development of a national financial instrument to facilitate the mass deployment of e-buses in public transport fleets in Colombia, to close the total cost of ownership gap between e-buses and their conventional counterparts.

The first step in designing this mitigation action was to conduct a financial and economic analysis of electric bus implementation. Based on the findings of this analysis, a feasibility study was prepared. This study proposed the establishment of an investment fund that would cover the procurement cost differential between fossil and electric vehicles and thus spur the electrification of public transport.

4.2.1. Financial and economic analysis of e-bus adoption in Colombian transport systems

The first step in the development of this mitigation action was to conduct an economic and financial study. This study, which was contracted by GIZ in 2019 (LAT GLOBAL for GIZ TRANSfer III, 2019), evaluated market conditions and identified instruments necessary to promote bus electrification in Colombia, given the economic factors governing the adoption of this technology.

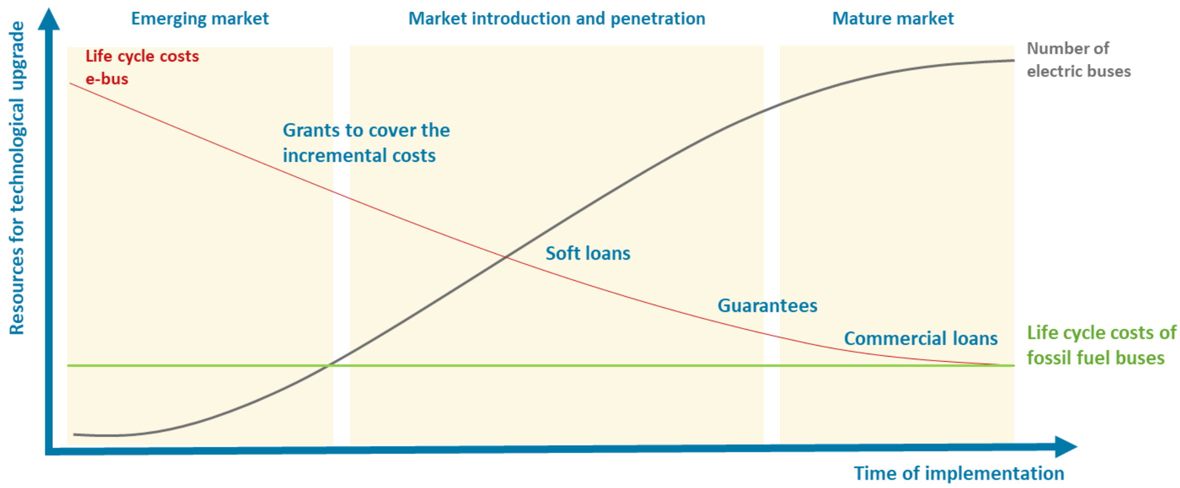


Figure 11. E-bus market introduction lifecycle

The objectives of the study were to develop a financial and economic model with sensitivity analyses to estimate the monetary impact of an investment in e-buses at the operator level, as well as to evaluate which funding mechanisms would be the necessary for a sustainable implementation of e-buses in Colombia. Based on a Total Cost of Ownership (TCO) methodology, the study analyzed four types of vehicles and four types of services available in Colombia.

To evaluate the impacts that would result from adopting clean transport technologies from a policymaker's perspective, in addition to the financial TCO, the incremental economic costs of the externalities resulting in each case were added to the total.

This assessment method yields the Total Cost of Ownership in each case, including the total costs that accrue to investors and society overall. In this way, even if a technology is not financially viable from an individual investment perspective, it may generate important benefits for society that argue in favor of implementation. In such cases, there is a justification for covering the cost differential with public subsidies.

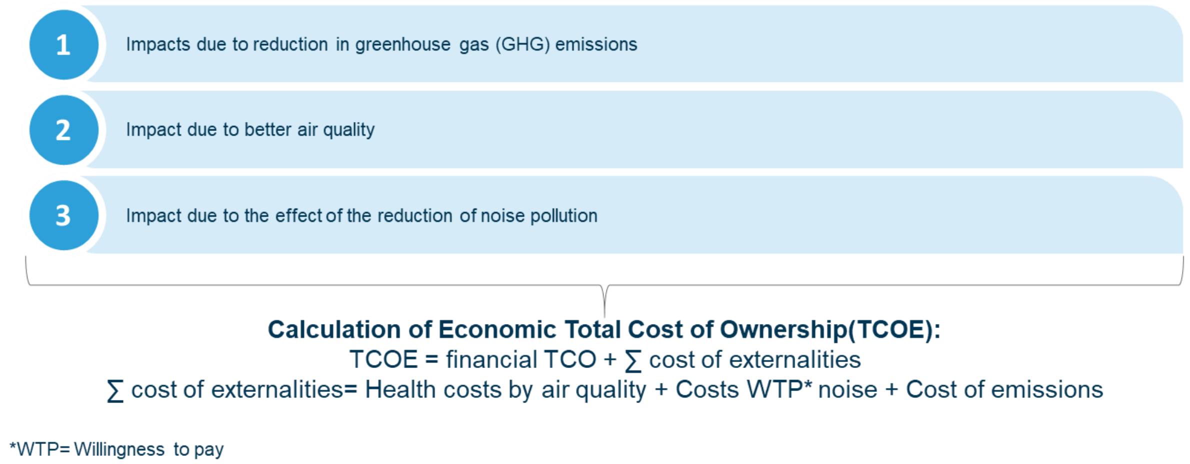


Figure 12. TCO methodology (Source: LAT-Global for GIZ TRANSfer III, 2020)

From the financial point of view, the results showed similar conditions to those found in other countries; e-buses have a higher total cost of ownership (TCO) than traditional technologies, including much larger capital expenditures (CAPEX) but lower operating expenditures (OPEX).

There are two key factors that explained the large CAPEX for e-buses: (1) the initial investment in rolling stock, including the cost of the first and the second battery packs; and (2) the required investment in charging infrastructure for operation. This means that, for bus electrification to be financially viable, it is necessary to cover or close the cost differential between e-buses and their conventional counterparts.

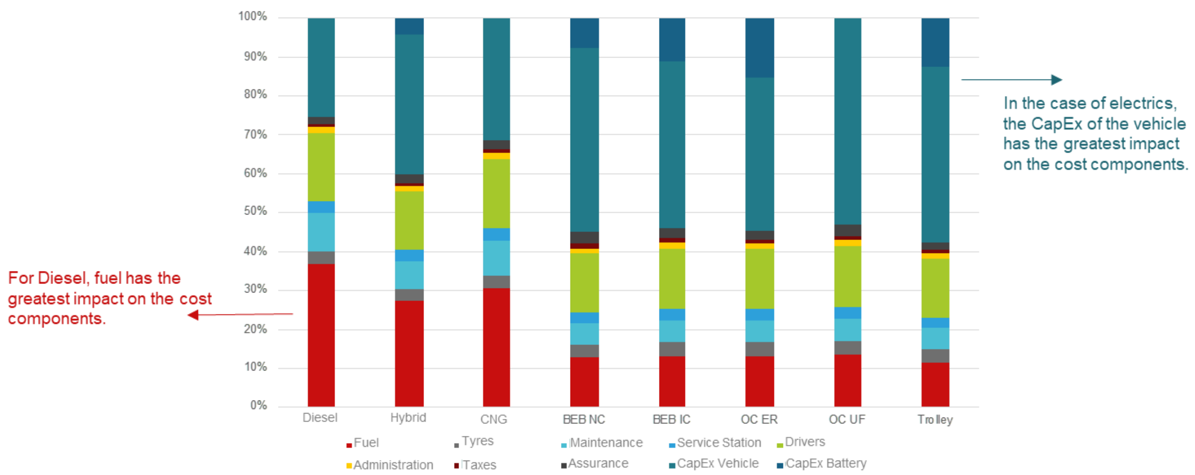


Figure 13. Total cost comparison between ICE and electric technologies (Source: LAT-Global for GIZ TRANSfer III, 2020)

From the economic perspective, the study concluded that:

- The reduction in GHG emissions would be significant for 12-metre electric buses. One electric bus would produce 2.20 tCO2e less than a 12m diesel bus over a 15-year period.
- The emissions of particulate matter from one 12m diesel bus have an estimated health cost of USD $13,710 (over 15 years). By contrast, an electric bus does not emit local pollutants and therefore does not generate health costs related to air quality.

- An electric bus produces approximately 67 decibels (dB) while in operation, compared to the approximately 74 dB produced by a diesel bus. This corresponds to an80% reduction in noise exposure.

The study also found that, in most analyzed cases, the most economically efficient option for replacing old diesel buses would be to switch to natural gas-powered models. Nevertheless, for larger buses with higher usage demands and journey lengths (around 215km/day), the TCO of e-buses moves closer to that of ICE options. The journey length has a significant impact on the TCO of each technology.

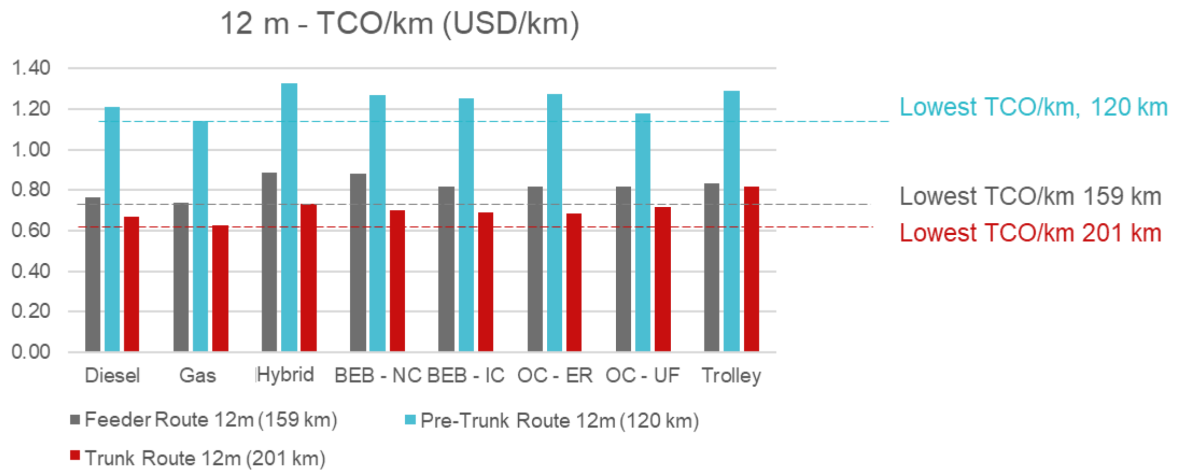


Figure 13. TCO comparison among technologies for a 12m bus, operating on feeder, pre-trunk, and trunk services (Source: LAT-Global for GIZ TRANSfer III, 2020)

The study also suggested that the most efficient way to promote e-buses in Colombia is through CAPEX compensation, a finding that is in line with international experiences. The CAPEX subsidy could be awarded directly to cover vehicle purchase or financing. The analysis showed that a subsidized leasing scheme would be more expensive than CAPEX subsidies and concessional loans. However, the feasibility of the last option is inhibited by the poor financial situation of the operators, which limits their access to commercial banks and makes the transaction costs remarkably high.

4.2.2. Public investment fund feasibility design

Establishing a dedicated fund that can serve as a financing mechanism is a known solution for reducing the cost gap between different technologies. As an additional benefit, such a fund could generate economies of scale, with larger procurement volumes spurring cost declines. While the greatest benefits would likely be attained by focusing on the promotion of larger vehicle types with higher operational intensities, the fund could also be used to enable the purchase of low-capacity types. Although such bus types are more expensive from a financial point of view, they are the most utilized in intermediate cities in Colombia, due to the geographic characteristics of the country, which often features with high slopes and sharp corners that require a narrow turning radius.

However, as many conditions that affect the competitiveness of e-buses, a comprehensive e-bus promotion program must go beyond mere financial support. In this connection, it is necessary to support the development of the most efficient systems in the context of each city.

Against the backdrop, TRANSfer undertook a **prefeasibility study for a public investment fund**, in close coordination with MinTransporte and the DNP.

The study estimated that the bus-fleet renewal needs of Colombia's 15 largest cities over the next 5 years amounted to 13,422 buses. Based on the electrification scenario foreseen by Law 1964 of 2019, Columbia's "Electric Mobility Law," out of the total bus fleet, the potential for electric fleet renewal amounts to 2,735 buses (see Table 15), which would require investment of COP $3.2 billion for the purchase of buses and charging infrastructure. To achieve this scenario, Colombia would require COP $1.7 billion in CAPEX subsidies to cover the procurement cost difference between Euro VI diesel buses and their electric counterparts.

The fleet renewal scenario mandated by the law was developed based on conservative assumptions in light of the fleet growth that occurred from 2000 to 2019. Therefore, only 20% of the total buses need to be electric.

Table 15. Colombian mass transport total fleet renewal estimation (Source: Summary for GIZ TRANSfer III, 2020)

City	Type of service and bus type	Estimated number of buses required
Bogotá	Trunk line 18m	240
	Trunk line 12m	30
	Feeder bus 12m	171
	Feeder bus 10m	1207
	Total (all type of services)	1648
Medellín	Trunk line 18m	9
	Pre trunk line 12m	15
	Feeder bus 10m	33
	SETP 10m	75
	Total (all type of services)	132
Cali	Trunk line 18m	38
	Trunk line 12m	11
	Pre trunk line 12m	79

City	Type of service and bus type	Estimated number of buses required
	Pre trunk line 10m	0
	Feeder bus 12m	19
	Feeder bus 10m	37
	Total (all type of services)	184
Barranquilla	Trunk line 18m	18
	Trunk line 12m	4
	Feeder bus 12m	16
	Feeder bus 10m	21
	Total (all type of services)	59
Cartagena	Trunk line 18m	11
	Pre trunk line 12m	35
	Feeder bus 10m	86
	Total (all type of services)	132
Bucaramanga	Trunk line 18m	2
	Pre trunk line 12m	20
	Feeder bus 10m	12
	Total (all type of services)	34

City	Type of service and bus type	Estimated number of buses required
Pereira	Trunk line 18m	11
	Feeder bus 10m	19
	Total (all type of services)	30
Santa Marta	SETP 10m	25
	SETP 7m	63
	Total (all type of services)	88
Pasto	SETP 10m	95
	SETP 7m	0
	Total (all type of services)	95
Montería	SETP 10m	29
	SETP 7m	27
	Total (all type of services)	56
Popayán	SETP 10m	0
	SETP 7m	77
	Total (all type of services)	77
Armenia	SETP 10m	61
Valledupar	SETP 7m	56

City	Type of service and bus type	Estimated number of buses required
Sincelejo	SETP 7m	17
Neiva	SETP 7m	66
All cities	Total (all type of services)	2735

Table 16. Bus quantities, fleet substitution scenario (Summary for GIZ TRANSfer III, 2020)

Fleet substitution scenario						
	2022	2023	2024	2025	2026	Total
Feeder 10m	0	379	266	0	769	1414
Feeder 12m	0	55	39	0	112	206
Pretrunk 10m	0	0	0	0	0	0
Pretrunk 12m	0	39	29	0	81	149
SETP 10m	200	20	24	0	41	285
SETP 7m	292	0	15	0	0	307
Trunk 12m	0	12	9	0	24	45
Trunk 18m	0	88	61	0	180	329

To implement the fund it was necessary, as a first step, to create the legal framework that would allow the National Government and regional authorities to endow the fund with resources. To this end, it was noted that the regional authorities could implement new funding mechanisms, such as those authorized by the National Development Plan.

When analyzing the options for the creation of the legal framework, several alternatives were considered and compared, including:

Patricia Gómez – FDN

"GIZ had the flexibility many of these governmental agencies lacked and provided necessary leadership to achieve the required interagency coordination."

- Adapting existing funds for infrastructure development and energy efficiency by changing their provisions and investment policies.
- Modifying the Law 310 of 1996 (i.e., Article 100 of Law 1955 of 2019) to allow resources to be added to current co-financing agreements set by the policy documents (CONPES) for creating and co-financing regional public transportation systems.
- Creating a new climate change investment fund, which should include portfolio or subfund dedicated to upgrading public transport with electric/zero-emission technologies.
- Creating a stand-alone fund with the capacity to invest directly into the technological modernization of public transport fleets.

After one year of deliberations between MinTransporte, DNP, and MinHacienda, the fund was created as part of the Climate Action Law (Law 2169 of 2021) as a stand-alone fund, coordinated by MinTransporte.

Starting 2022, the detailed design and subsequent implementation of the fund should begin, drawing on funding allocated by the DNP and from cooperative undertakings. It is foreseen that its funding and operation will be included in the National Development Plan approved by the national government elected to serve the term between 2022 and 2026.

It is expected that the fund will create a dynamic market for public transport e-buses in the country. The fund's prefeasibility study considered two investment scenarios, which have a total mitigation potential of some 200,000 tons of CO2e per year. The details of the study, including cost calculations, are presented in section 5.

Figure 14. Main scenario for public transport improvement fund (Source: Summary for GIZ TRANSfer III, 2021)

4.3. Supportive actions on framework conditions and capacity development)

To ensure the successful implementation of the e-bus program and to overcome the barriers outlined in section 3, TRANSfer III identified three action areas to support capacity building:

1. Support actors in the transport sector to understand potential business models for electrifying their fleets and to participate in the e-mobility market.
2. Teach operators, public transport managing entities, and city planners about electric mobility in general, and about the characteristics of e-buses in particular, as well as about the process for planning and implementing e-bus corridors and services.
3. Assist development of the human capital required for operating and maintaining public e-bus fleets.

The first action was the development of an international training course on transport systems based on e-buses. Chile and Colombia are the leading countries in integrating e-buses into public transport fleets. In a strategic alliance between the BBMWK-financed GIZ projects TRANSfer III Colombia and MOVING Chile, a training course was created and offered to authorities, city planners, operators, and managing entities concerned with bus transport systems. The course was designed to strengthen capacities for planning, acquiring, designing, maintaining, and operating e-bus fleets, and also to help participants make the best technical decisions in the transition towards e-mobility.

The course was run by the Department of Mechanical Engineering of the Universidad de Chile with professors from Universidad de los Andes in Colombia, between October and December of 2021. The course was organized into nine modules, consisting of eighteen biweekly sessions of 1.5 hours each. It was attended by a total of 54 students from six Latin America countries; of the 54 students who enrolled, 45 successfully completed the course.

The main topics taught in the course were:

- Review of international and national experiences in electromobility.
- Description of the technology, including advantages, limitations, and trends.
- Design and configuration of e-buses.
- Electrical infrastructure and characteristics of charging equipment.
- Business models.
- Telemetry and monitoring.
- Technical and financial risks.
- Gender approach and opportunities.
- Charging strategies and route planning.

The second action led by TRANSfer III aimed to develop expertise on energy procurement for public transport in Colombian cities. Lack of knowledge among actors in the transport sector concerning and power and infrastructure procurement was viewed as a major hurdle to program implementation.

The work undertaken during this process was divided in two parts. The first consisted in analyzing the electricity market and identifying possible business models that e-bus operators could use to procure electricity from energy providers. The main product of this study was a guide[20] that included information on contracting schemes for public, commercial, and private spaces; the value chain for charging services; and the processes, assets, and cost baskets involved in a project. The findings are applicable to players in a city like Bogotá in particular, and to Latin America and the Caribbean region in general.

Figure 15. Screenshots, Guide to Procuring Energy for E-Mobility. (Source: Transconsult for GIZ TRANSfer III, 2022)

The second part consisted in a study developed for the specific case of Bogotá. The objective was to study demand for charging infrastructure, specifically for taxis as a first potential source of demand for electric vehicle charging services, as well as to support the development of procurement documents the installation of public charging stations.

As part of this process, the following activities were conducted:

[20] https://changing-transport.org/publications/proveeduria-de-energia-para-vehiculos-electricos-en-colombia/

- Analysis of international experiences.
- Identification of applicable business models for the installation and operation of public charging stations.
- Identification of charging supply schemes, assets, supplies, processes, and players involved in the energy value chain.

Julián Diaz – SDM

"I commend GIZ's flexibility. The public sector tends to be too rigid, but flexibility is needed for innovation and the promotion of new businesses, because new information is constantly obtained. GIZ was able to adapt and act on new information".

"The business model guide was very complete and informative, and its usefulness is not limited to Bogotá".

The main recommendation for Bogotá was to adopt a public charging system in which a private party (an individual firm or consortium) installs the charging infrastructure in a public space (streets, platforms, parking bays, etc.) so that the infrastructure can be freely accessed as a paid service. In this way, the economic activity of exploiting public space could be conceived as a complementary activity to the city's on-street parking scheme.

Various business models were identified, and it was determined that the Charging as a Service model was the most suitable for the operation of the public charging stations in public spaces, since it offers a comprehensive solution that includes all the assets, processes, and supplies required for the provision of electrical energy, including space adequacy assessment and the development of required civil infrastructure, among other service aspects.

To estimate the number of charging stations needed, fifteen scenarios were proposed while considering various projections concerning electric taxi growth, access to home charging, charging station capacity (11, 22, 50, 70 and 150 kW), and vehicle range (250 and 400 km).

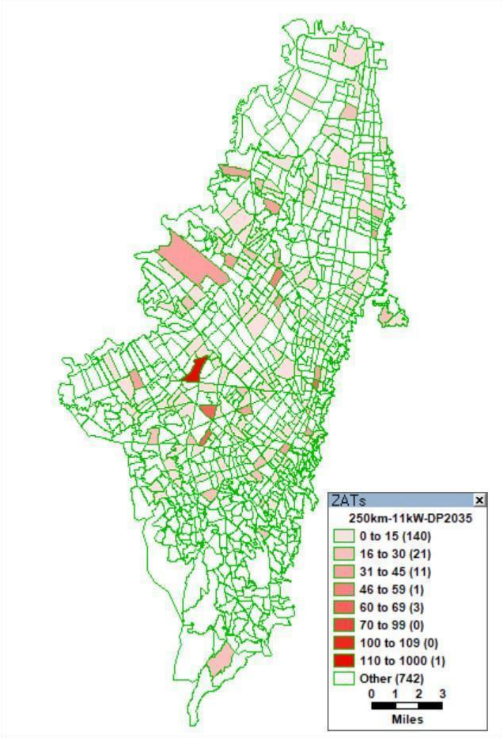


Figure 16. Distribution of charging stations in Bogotá in 2035 for a projected taxi fleet assuming 250 km range and 11 kW chargers (Source: Transconsult for GIZ TRANSfer III, 2022)

Thanks to the study, Bogotá's Secretary of Mobility aims to undertake a procurement process for the implementation of twenty public charging stations under the model, focusing on the areas prioritized in the analysis, and using the contracting documents developed as a guide.

The cooperation included both the technical analysis and preparation as well as the legal support and preparation of tender documents for the bidding.

The third action was the development of a training curriculum for the National Training Service (abbreviated SENA in Spanish). This curriculum aimed to respond to the short- and medium-term need for qualified e-bus operators. Accordingly, this action responded to another barrier to the adoption of e-bus fleets: the lack of skilled labor to operate and maintain this vehicle type.

The study was based on four concepts:

1. **Value chain in public transport systems:** Mapping the value chain of public transport based on e-bus fleets, to identify future market demand for qualified personnel.

2. **Qualification of human talent in electric mobility:** Based on the characterization of future demand, a gap analysis was performed to estimate the future personnel needs of the market. Subsequently, in light of SENA's existing training capacities and anticipated future needs, three different curriculums were designed for SENA for training portfolio inclusion.

3. **Gender approach:** Once the basic structure of the curricula were defined, various strategies and topics were integrated with the aim of encouraging women to enroll in the training programs, considering the usual barriers that would limit their participation in such domains.

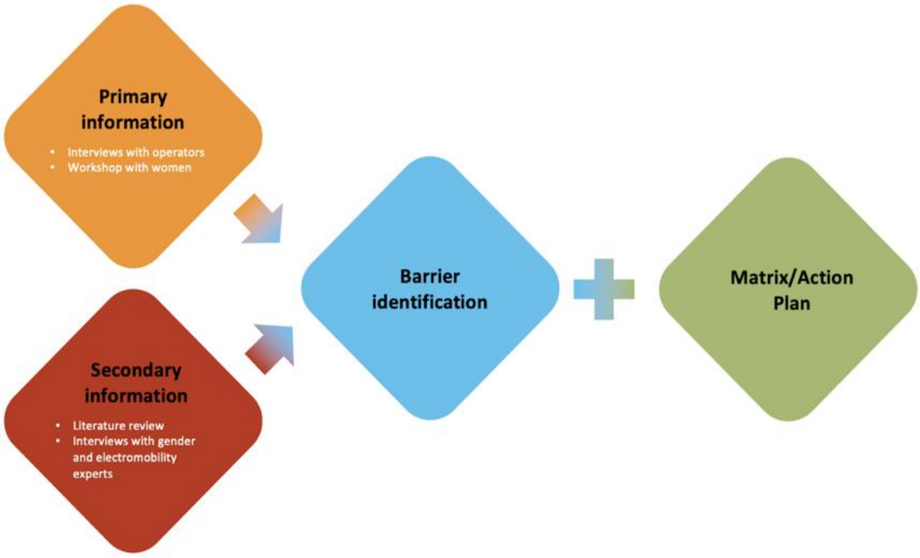


Figure 17. Process for generating strategies to promote gender equality (Source: GIZ)

The process also considered the development of a training and awareness-raising program based on a public-private partnership, through the DeveloPPP mechanism, with international inter-institutional cooperation facilitated between Germany (through GIZ) and a Colombian private company (preferably a public service operator of a mass transportation system). In this project, SENA would oversee the channeling of resources, would provide the educational services, and would coordinate the awareness-raising work.

The objective of the DeveloPPP proposal would be to overcome the gender barrier in electric public transport using two approaches: one technical and one social. The technical approach consists in the creation of a robust knowledge base that enables people to operate e-buses and to conduct vehicle maintenance and repair work. The social approach focuses on developing a communications campaign that:

I. Raises public awareness of the advantages of gender inclusion in electro-mobility,
II. sensitizes and informs employees and employers on gender inclusion strategies to create a work environment where women feel welcome, safe, and comfortable, and
III. motivates women to actively participate in the electro-mobility value chain as vehicle mechanics, feeling safe and able to perform representative tasks in these processes.

Paula Pinilla – Ministry of Transportation

"The project helped us to identify barriers that affect women's access to e-mobility jobs and careers. We must encourage women to work in e-mobility, help them to acquire the necessary qualifications and help them to land jobs in the business."

Figure 18 presents the necessary process for the development of the proposed public-private partnership.

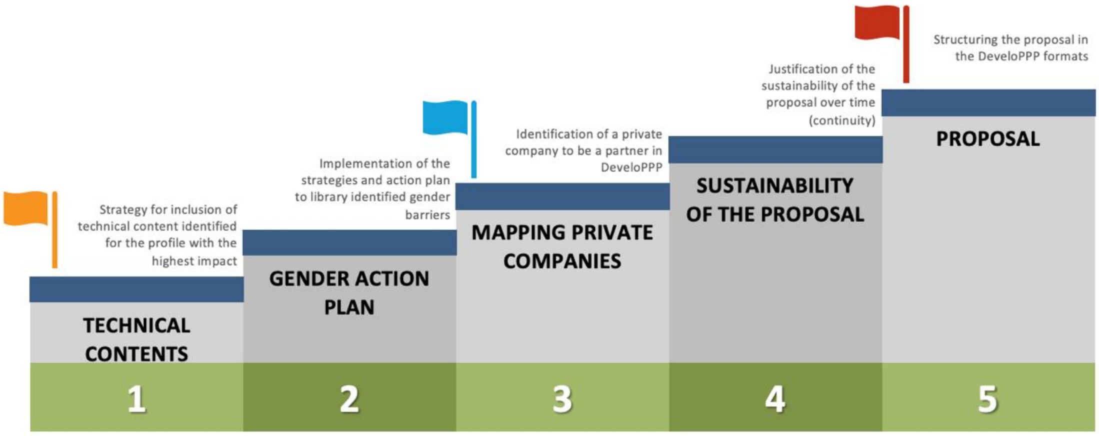


Figure 18. Development process of the DeveloPPP proposal (Source: GIZ)

4.5. Implementation arrangement (organisational measures)

To ensure that the direct GHG mitigation measures do in fact lead to the projected emission reductions, TRANSfer III participated in the construction of two organisational measures to support the adoption of electric mobility in the public transport sector.

The first organisational measure was to create the institutional arrangements necessary for the formulation of a National Strategy for Sustainable Transport and for the implementation of the National Strategy for Electric Mobility, which shared the following objectives:

- Promoting the transition to zero emission technologies.
- Facilitating the entry of electric vehicles into the market.
- Developing standards for charging infrastructure.
- Creating and strengthening the regulatory, political, and institutional framework.
- Setting up the regulatory, policy, economic, market, technical and technological conditions for low-emission sustainable mobility.
- Achieving the goals defined in Law 1964 of 2019 (Electric Mobility), Law 1972 of 2019 (Health and environmental protection by improving air quality), and Law 1955 of 2019 (National Development Plan 2018-2022), to have 600,000 electric vehicles in Colombia by 2030.

This institutional arrangement included setting up national entities that communicated with civil society in general and transport sector actors in particular to integrate them in the implementation of the Strategies' goals and instruments.

One such entity is the Interinstitutional Board for Sustainable Transport (abbreviated MITS in Spanish), which aims to enable key government actors to coordinate and plan policy recommendations, regulatory instruments, strategies, programs, actions, and projects. The structure of the MITS was developed and proposed by MinTransporte, MinAmbiente, DNP, and the National Unit for Mining and Energy Planning (UPME) with support from TRANSfer.

Susana Ricaurte – MinTransporte

"GIZ positioned itself as an integrator agency which connects key e-mobility stakeholders with one another and facilitates dialogue between them."

"The legal creation of the Fund is the key for the future of the program. The Fund will be the main tool with which the next government will promote e-mobility across the country."

Sandra Ángel – MinTransporte

"GIZ members were truly a part of the team and worked with us as such. They also helped us a lot with contacting and securing alliances with key stakeholders."

TRANSfer III led the collaboration that aimed to support and strengthen the institutional arrangements for the implementation of the MITS and of other policy instruments to promote zero-emissions transport. The collaboration between MinTransport, MinAmbiente, DNP, and UPME with support of TRANSfer III sought to:

- Analyze national and international experiences on institutional schemes for the promotion of low-emissions transport.
- Evaluate the current institutional arrangements and decision-making scenarios in Colombia regarding low-emissions transport, including strengths, barriers, and improvement opportunities.
- Propose a governance scheme for the MITS (justification, scope, roles, and main functions).
- Analyze the implementation costs for the MITS.
- Propose a legal implementation instrument (MOU, decree, or other).

The main recommendation was to establish the MITS as a legally binding entity with shared responsibilities among the different ministries that have policy agendas related to sustainable mobility, along with a secretariat in charge of coordinating, communicating, and following up on a national action plan for sustainable mobility. The proposed structure for the MITS is shown in Figure 19:

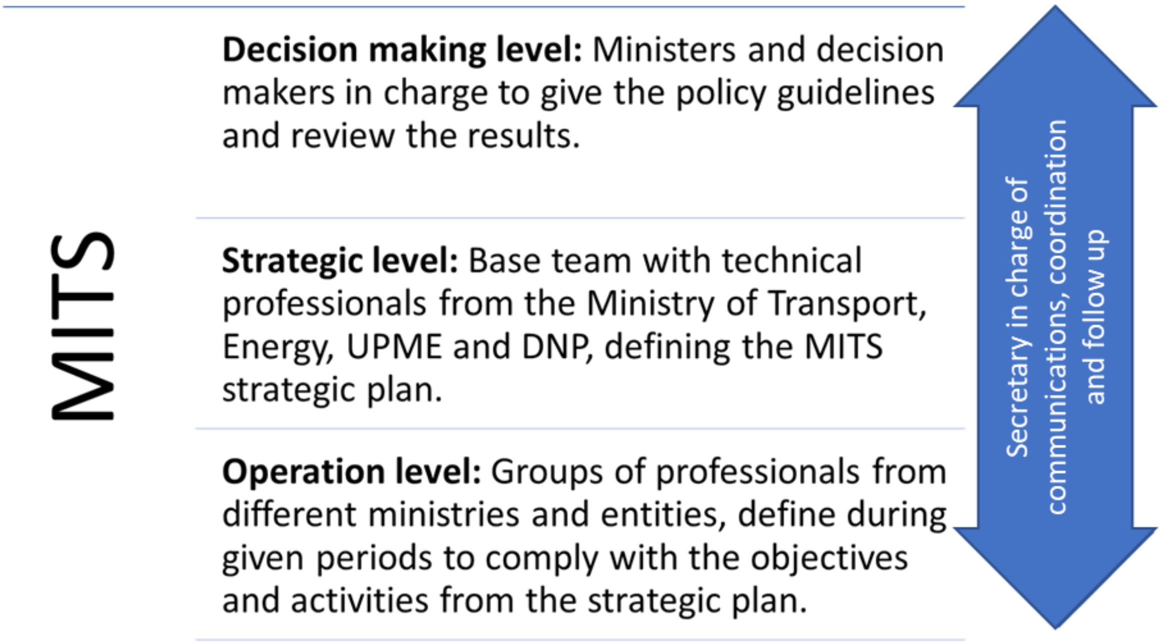


Figure 19. Proposed MITS structure

The second organizational measure was helping to guide the development of impact monitoring and evaluation systems for electric bus projects. With this objective the TRANSfer program hired a consultant to design of a monitoring, reporting and verification (MRV) system for the National Electric Bus Program in Colombia.

The result was a methodological guide, based on the Colombian case study, which considers the most relevant activities when structuring an MRV system. Those activities are described in Figure 20 and detailed in the MRV section of this report.

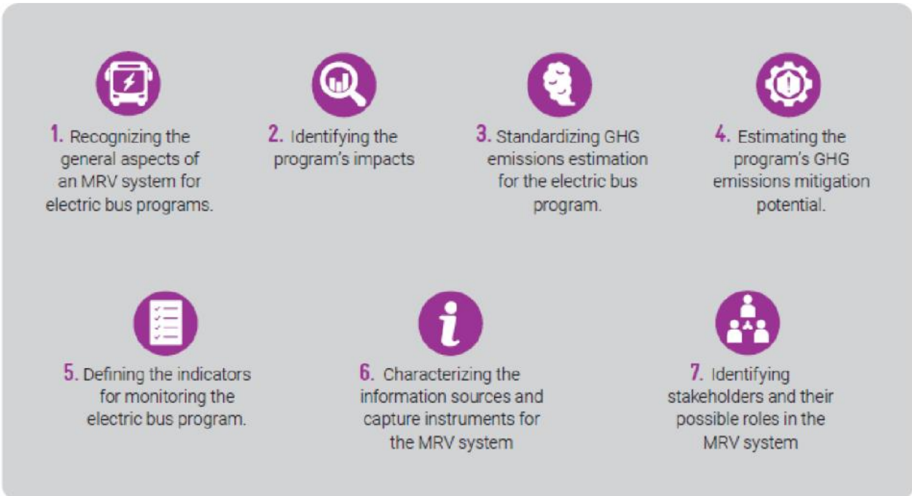


Figure 20. Activities involved in structuring an MRV system (Source: Hill for GIZ TRANSfer III, 2021)

An MRV system designed and implemented based on these seven components allows for the definition of coordination mechanisms between public and private stakeholders, and for interconnection between government actors at the local and national level. It also serves to improve information methodologies and standardization, such that analyses at a lower aggregation level (bottom-up methodologies) are consistent with established larger-scale activities (e.g., national emission inventories, biennial reports).

Therefore, an MRV system, such as the one defined by the TRANSfer III program, is expected to help advance bus fleet electrification in Colombia and become a model for other countries in the region to follow.

5. Financing concept

The goal of the direct mitigation action was to help bridge the financing gap between the costs for internal combustion engine buses and e-buses, considering that the financial analysis showed that the TCO for the electric technology will be around 30% higher than that of Euro VI diesel buses (Sumatoria for GIZ TRANSfer III, 2021). Therefore, financial mechanisms are required for the public transport system to comply with the electric fleet law requirements without increasing their current operational deficits.

5.1. Overview of costs and revenues

As part of the prefeasibility study for the Public Investment Fund (Summary for GIZ TRANSfer III, 2021), it was estimated that, in a scenario of total fleet renovation, the 15 main Colombian cities will need to purchase 13,422 buses in the following five years; in a second scenario, assuming only the compliance of the minimum share of e-buses established by Law 1964 of 2019, the cities will need to buy 2,735 new buses, as presented in Table 15 of section 4.3.1.

Purchasing 2,735 new buses would require an estimated total investment of COP $3.17 billion (791 million EUR), including the cost of vehicles and of charging infrastructure. If only the investment differential between replacing the fleet with Euro VI diesel buses and e-buses is covered, the cost is COP $1.7 billion.

5.2. Financing mechanism and structure

To meet the financial needs to implement the Public Investment Fund, the design of four financing schemes was proposed for a subsequent phase (feasibility study and comprehensive fund structuring):

(i) Non-refundable contributions for the purchase of the fleet and its charging system.

(ii) Soft financing conditions. Financing municipalities or mass transport systems concessionaires with more flexible and competitive rates and terms than that offered by the market.

(iii) Guarantees issued by the Fund to e-mobility investors to facilitate financing.

(iv) Technical support for adoption of innovative technology by a mass transport system (e.g., studies for the technical specifications of buses, estimation and monitoring of operating costs, maintenance requirements and programs, operator training, etc.).

In the following, the four financing schemes will be explained in more detail. In addition, the project work generated a road map for implementation and list of funding sources for investment.

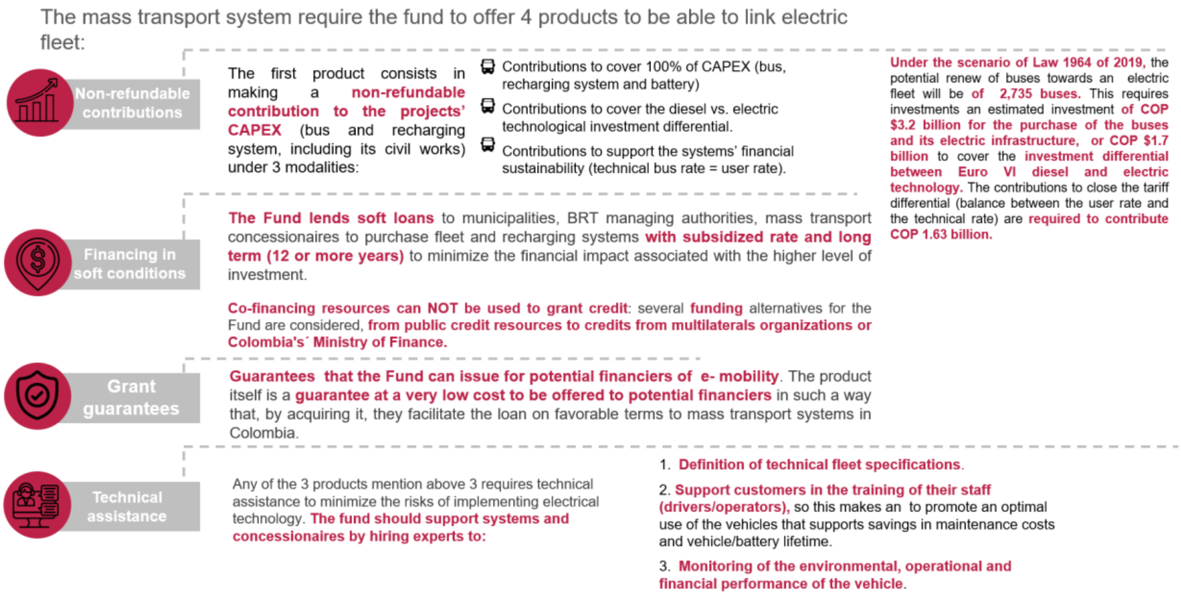


Figure 21. Public Investment Fund, Summary Description (Summary for GIZ TRANSfer III, 2021)

5.2.1. Non-refundable contributions

The first product foreseen for the Fund consists in making non-refundable contributions to the projects' CAPEX (vehicles and charging system, including civil works) under three modalities:

(i) Contributions to cover 100% of CAPEX.

(ii) Contributions to cover the CAPEX differential between Euro VI diesel buses and e-buses.

(iii) Contributions to cover the difference between users' fares and system costs. The value of this depends on the financial and legal structure of each public transport system.

5.2.2. Soft financing conditions

For the second product, the Fund would provide credit resources to municipalities and/or to mass transport system concessionaires to purchase fleet and charging systems on much more favorable terms than those offered by the financial market. Several alternatives are being considered, ranging from non-refundable resources where only an "administration fee" is paid, to funding through credits in pesos from the Colombian Ministry of Finance or from multilateral banking with promotional rates.

In the event the Fund offers direct financing to private concessionaires to facilitate their purchase under much more favorable conditions (term, rate, and grace period), the cost of capital, which represent 35-55% of CAPEX, can be reduced.

To implement this product, the Fund must obtain resources from the Colombian central government, multilateral banks, or from third parties that offer favorable conditions to promote environmental initiatives (such as the Green Climate Fund or Clean Technology Fund).

5.2.3. Guarantees

The third product consists of guarantees that the Fund could issue to potential investors in e-bus projects. Such guarantees will allow investors such as banks to offer better loan conditions (rates, grace periods) to municipalities and transport operators. Lenders can acquire the guarantee at an exceptionally low cost.

This product was designed based on the assumption that the Fund would guarantee the purchase of 2,735 buses and their charging infrastructure. The assumptions for modeling the guarantee are as follows:

Table 17. Guarantee assumptions (Source: Summary for GIZ TRANSfer III, 2020)

Debt financing as % of total vehicle cost	70%
Share of total debt guaranteed by Fund	60%
Guarantee period (Debt term)	15 years

5.2.4. Technical support for structuring e-bus projects

The fourth product seeks to offer the technical support necessary to define the best operational conditions (routes, technical specifications, charging systems, etc.) for e-bus fleets, in order to mitigate the technological and operational risks associated with e-bus implementation while also deriving the greatest possible benefits. This product can also be geared to decision-makers and operational staff (drivers/mechanics) to promote operation of the vehicles in a manner that supports reduced maintenance costs and increased vehicle/battery lifetimes.

Table 18. Resources needed by the fund (base scenario) based on the pre-feasibility study (Source: Summary for GIZ TRANSfer III, 2020)

Product to be offered by the Fund	COP millions	EUR millions
Contributions to cover the CAPEX: 70% national government / 30% municipalities	$1,397,612	349
Soft financing conditions	$1,297,777	324
Total Fund resources	$2,635,389	659
Equity from concessionaires or municipalities	$530,476	133
Total investment	**$3,165,865**	**791**

5.3. Scale of investment and support needs for different ambition levels

The Fund requires resources not only to finance fleet purchase and operation, but also to operate and meet the objectives of scaling up the number of e-buses in Colombia's mass transport systems. To determine the best funding strategy, it is important to clarify three issues: (i) the nature of the resources (public or private); (ii) restrictions on their use; and (iii) the source of funding.

The restrictions that apply to fund disbursements will depend on the source of funding (public or private), relevant legal frameworks, and the conditions signed with resource contributors. As part of the funding strategy, it is necessary to define whether the Fund resources should be paid back to the lender/investor or are non-refundable.

5.3.1. Resources from the national government and from local public entities

Law 310 of 1996 established the guidelines under which the National Government can invest in mass transport systems, establishing that: "The Nation and its decentralized entities can invest, within their Medium-Term Fiscal Frameworks, a minimum of 40% and up to 70% in mass or collective public transport system projects" (translated from Spanish). As a mechanism to direct these resources, co-financing agreements were signed between the national government and local entities.

Article 100 of Law 1955 of 2019 (National Development Plan 2018-2022) modified Law 310 of 1996 and included the possibility to utilize the resources from co-financing agreements to fund the purchase of e-buses for projects to implement public transportation systems "without changing the initial amount of resources approved in the CONPES that started each project" (translated from Spanish).

Nonetheless, Decree 575 of 2020 modified Article 100 of Law 1955 of 2019 and allocated the remaining resources from the co-financing agreements to the reduction of the operational deficits that had accrued in mass transport systems because of the COVID-19 pandemic. This further reduced the remaining resources available under the co-financing agreements.

Unfortunately, because all available resources already have a designated use, there are few resources available from the co-financing agreements that could be used for fleet purchases.

As part of the drafting of the 2022-2026 National Development Plan, policymakers are examining the financing of new investments in public transport systems. However, the 2022-2026 National Development Plan has not yet been adopted.

Table 19. Required resources for fleet purchase in Colombian cities (Source: UMUS, 2020)

City	Required resources for fleet purchase	EUR Millions
Bogotá	COP $ 225.362 MM	56.3
Medellín	COP $77.412 MM	19.4
Cali	COP $ 86.272 MM	21.6

City	Required resources for fleet purchase	EUR Millions
Barranquilla	COP $45.198 MM	11.3
Cartagena	COP $ 4.275 MM	1.1
Bucaramanga	COP $5.169 MM	1.3
Pereira	COP $26.863 MM	6.7

Consequently, the Fund requires two measures to be undertaken:

(i) The national government should assign additional resources for fleet purchase, either through *vigencias futuras* (future budget allocations) and/or by providing credits to the Fund of between COP $1.7 billion and COP $3.17 billion.

(ii) The national government should enact a law that allows it to make contributions to the Fund for the purchase and/or financing of the fleet. These contributions should be supplementary to the commitments under the co-financing agreements for funding mass transport systems.

By defining the resources that will be contributed by the national government to fleet purchase, municipalities and other jurisdictions will be incentivized to contribute their own resources (as counterpart contributions) or funds from alternative sources as authorized by Law 1955 of 2019 (e.g. revenues from parking services, congestion charging schemes, land value capture, fuel surcharges, carbon taxes, etc.)

The costs to implement these supportive and organisational actions for the successful implementation of the measure in 2022-2026 are as follows:

Table 20. Costs for implementing supportive and organizational actions (Source: GIZ TRANSfer III, 2022)

Action	Cost (COP)	Cost (EUR)
Detailed design and launch of the investment fund	$ 386,858,472	400,000 EUR
Establishment and operation of the Interinstitutional Roundtable on Sustainable Transport (MITS)	$ 386,858,472	96,742 EUR
Implementing an MRV System for the Ministry of Transportation, to follow up on NDC commitments, including follow up on CONPES 3991, Software platform and operation (Source: GIZ TRACS	$ 832,626,911	208,157 EUR

Action	Cost (COP)	Cost (EUR)
2021)		
Development of training course for e-bus drivers and maintenance technicians. Expert estimate.	$440,000,000	110,000 EUR

5.3.2. Third-party resources

Since a high percentage of the investments required by the Fund are non-reimbursable, the pre-feasibility study considered the possibility of including resources from international organizations and multilateral banks under the funding strategy. The rationale for involving third parties is to cover the gap between the resources required for electrifying the bus systems and those provided by the national and municipal governments.

Likewise, considering resource availability, efficiency mandates, and ministerial investment policies, the capital they contribute to the Fund will be mostly through soft loans. It is important to mention that most of the government agencies require a sovereign guarantee to deliver the non-refundable contributions to municipalities, BRT managing authorities, mass transport system concessionaires, and private financiers of e-buses.

5.3.3. Private parties

The program identified that there are vehicle manufacturers, energy providers, charging system manufacturers, and foundations that are interested in the deployment of e-buses in Colombia's mass transport systems. Therefore, the Fund is contemplating a structure that allows not only public resources, but also funding sources from private companies to make contributions to the different projects based on their needs and policies.

6. Monitoring, Reporting and Verification methodology and its expected benefits

A monitoring, reporting, and verification (MRV) system is a fundamental component of any GHG emissions mitigation action, as it allows one to systematically verify and report on compliance with emission reduction goals.

There are four stages to implementing an MRV system:

I. Design and Planning
II. Pilot Phase
III. Deployment and Implementation
IV. Evaluation and Follow-up

The study contracted by the TRANSfer III program focused on the Design and Planning stage, and specifically focused on the first four activities of this stage, as shown in Figure 22.

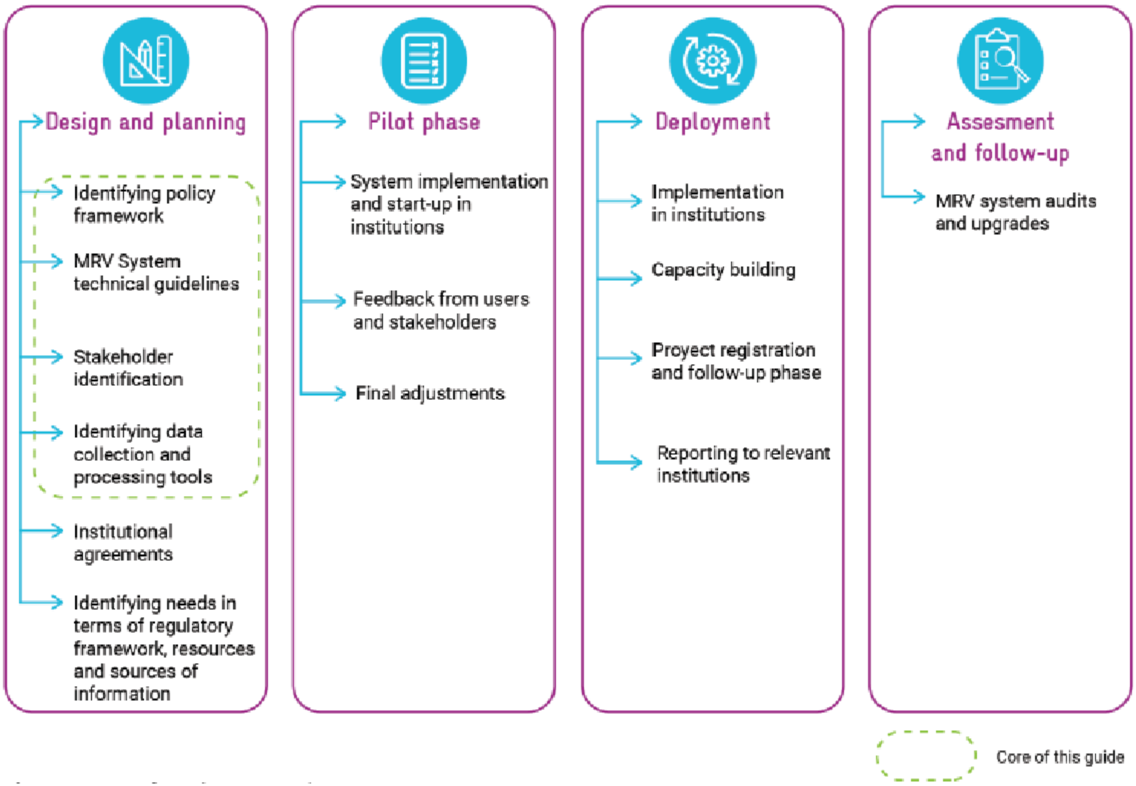


Figure 22. Roadmap for implementing an electric bus MRV system (Source: Hill for GIZ TRANSfer III, 2021)

6.1. Cause-effect impact chain

To develop a clear understanding of the process being monitored by an MRV system, it is necessary to identify its mechanisms of action and associated impacts. This is done by performing a cause-and-effect impact chain analysis.

Before public authorities decide which mitigation measures to implement, they need to know what the most effective mitigation measures are based on their costs and mitigation effects. In the present case, the stakeholders are interest in the mitigation effect that will result from the electrification of the Colombian bus fleet. To this end, two scenarios need to be compared: (1) the baseline or business-as-usual (BAU) scenario, which forecasts how emissions will develop without mitigation efforts, and (2) the mitigation scenario, which forecasts how emission levels will develop given the adoption of the mitigation measure. The difference in emissions between the scenarios represents the net impact of the mitigation action. Both scenarios are projections based on current conditions (Kooshian et al., 2017). Thus, it is crucial to determine the factors conditioning future trends as well as the mechanisms through which the mitigation scenario will change the BAU scenario. More information on this topic is available in section 6.3.

After implementation of the mitigation action, financiers and authorities will want to know what has been achieved, not only in terms of emissions savings, but also in terms of other benefits, such as reduced air pollution. To this end, it is necessary to select an appropriate set of indicators. Section 6.4 provides an overview of MRV system design.

When developing scenarios, it is crucial to determine the factors conditioning future trends as well as the mechanisms through which the mitigation scenario will change the BAU scenario. To this end, it is important to develop a causal chain analysis and define system limits.

The causal chain for bus fleet electrification in Colombia identifies the program's estimated impacts on GHG emissions. This sets the basis for defining the methodology that will be used to quantify emissions from the bus fleet under various scenarios.

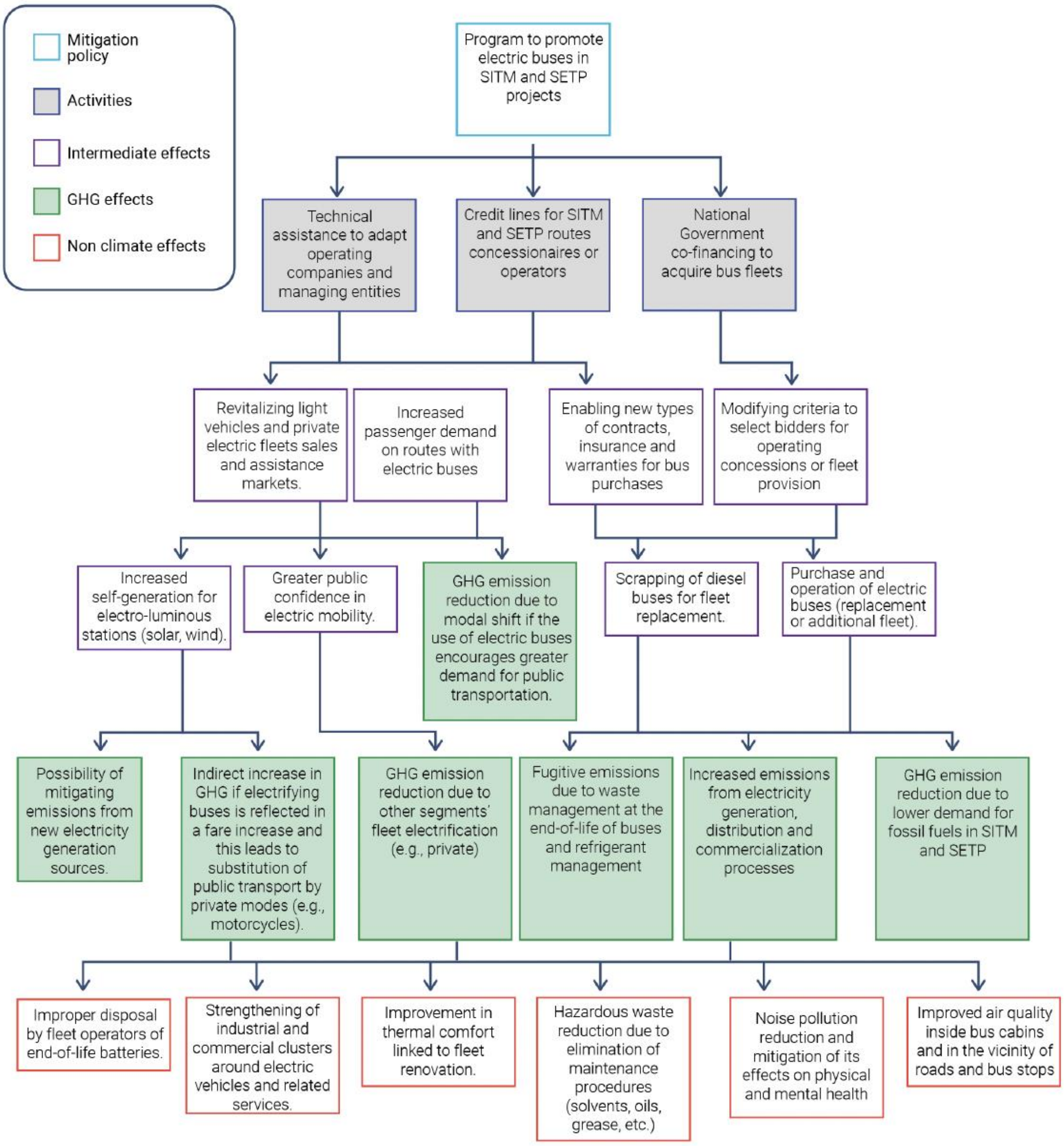


Figure 23. Electric bus program causal chain map (Source: Hill for GIZ TRANSfer III, 2021)

In terms of GHG emissions, the causal chain map becomes the main input for identifying system limits when assessing the program. This process requires the identification of the most relevant effects, so that resources for measuring the impacts of the program can be prioritized.

Table 21 shows a qualitative evaluation of climate effects included in the causal chain map for the electric bus program.

The MRV system takes into account effects with a "likely" and a "highly likely" probability of occurrence, and with "moderate" and "high" climate effects. The column on the right indicates whether an effect is included in the MRV system.

Table 21. Assessment of climate effects' probability and magnitude (Source: Hill for GIZ TRANSfer III, 2021)

Climate effect	Probability of Occurrence*	Relative Magnitude**	Inclusion in MRV
Change in emissions from operation phase of diesel buses			
CO_2	Highly likely	High	Included
CH_4	Highly likely	Moderate	Included
N_2O	Highly likely	Moderate	Included
BC	Highly likely	High	Included
Change in emissions from using refrigerants in bus air conditioners			
HFSc	Likely	Moderate	Included
Change in emissions from producing and transporting batteries and electric vehicles			
CO_2	Highly likely	Moderate according to literature. No local life cycle analysis available.	Excluded
CH_4	Likely	Low	Excluded
N_2O	Likely	Moderate according to literature. No local life cycle analysis available.	Excluded
Change in emissions from electricity generation and distribution			
CO_2	Highly likely	Moderate	Included
CH_4	Highly likely	Moderate	Included
N_2O	Highly likely	Moderate	Included
SF_6	Likely	Low	Excluded
BC	Highly likely	Low	Included
Change in emissions from modal shift to public transport			
CO_2	Unlikely	Low	Excluded
CH_4	Unlikely	Low	Excluded
N_2O	Unlikely	Low	Excluded
Change in emissions from synergistic effect of replacing private cars with electric vehicle			
CO_2	Possible	Low	Excluded
CH_4	Possible	Low	Excluded
N_2O	Possible	Low	Excluded

***Probability of occurrence**: Likelihood from highest to lowest probability on 4-point scale
****Relative magnitude:** Effect significance, classified as high, moderate, or low.

Fine particulate matter ($PM_{2.5}$) was included in the MRV analysis due to its relevance for public health in Colombian cities (IDEAM, 2018). Black carbon (BC) is also considered in the MRV system because it has negative implications for both human health and the climate. BC is a short-lived climate pollutant with a $PM_{2.5}$ share that can be close to 90% (Miller & Jin, 2018).

6.2. Assessment boundaries

When designing an MRV system, one must set the limits of the analysis that will be undertaken. In other words, one must define the activities that will be monitored.

Table 22 shows the analysis system limits, including timeframes, emission sources, and national GHG inventory categories, which are based on Intergovernmental Panel on Climate Change (IPCC) standards. Two different scopes were defined for the purpose of estimating impacts, considering the weight of each source in GHG emissions, and the difficulties and uncertainty associated with their estimation at this stage of the program. The proposed system is consistent with Colombia's NDC, national emissions inventory guidelines, the causal chain map, and guidelines issued by the IPCC and international funders such as GCF, GEF, and NAMA Facility for evaluating the ex-ante and ex-post mitigation potential of projects.

Table 22. Assessment boundaries (Source: Hill for GIZ TRANSfer III, 2021)

Limits	Scope 1	Scope 2	
Analyzed system	GHG emissions from energy combustion in the operation of buses that are part of the SITM and SETP systems.	GHG emissions from producing and transporting energy used by SITM and SETP systems.	GHG emissions from using air conditioning systems in SITM and SETP system buses.
Temporary	Base year: 2018 Analysis period: 2020-2030	Base year: 2018 Analysis period: 2020-2030	
Process generating emissions	Combustion	Combustion and fugitive emissions	Fugitive emissions
GHGs considered	Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Black Carbon (BC)*	Carbon dioxide (CO_2) Methane (CH_4) Nitrous oxide (N_2O) Black Carbon (BC)*	Hydrofluorocarbons (HFCs)
Type of mitigation	Energy substitution: replacing internal combustion engine buses with diesel buses, and VGN with electric fleet.	Reducing emissions from producing and transporting diesel that is no longer used. The increase in emissions from electricity generation is also considered.	Leakage reduction due to more efficient systems and/or switch to compounds with lower global warming potential.
Categories IPCC 2006	1A3biii. Heavy-duty trucks and buses.	1A1ai. Electricity generation. 1.B.2. Oil and natural gas.	2F1bii. Mobile air conditioning.

*Currently, BC is not considered in the National GHG Emission Inventory.

6.3. Ex-ante impact assessment

6.3.1. Baseline scenario

A program's ex ante contribution to GHG emission reductions is estimated as the difference between emissions in the baseline scenario (BAU) and the mitigation scenario (which presumes program implementation).

For the baseline scenario, the GHG emission trends of the country's fifteen public transport systems were estimated. The systems are: the Integrated Mass Transit Systems (SITMs) in Bogotá/Soacha, the Barranquilla Metropolitan Area, Cali, the Valle de Aburrá Metropolitan Area, the Centro Occidente Metropolitan Area, the Bucaramanga Metropolitan Area, and Cartagena; and the Strategic Public Transportation Systems (SETPs) in Pasto, Sincelejo, Santa Marta, Valledupar, Montería, Armenia, Popayán, and Neiva.

Baseline emissions were determined based on current bus fleet size, bus types, future fleet size, future demand, fuel consumption factors, and fleet activity using 2020 reference data. The baseline scenario was projected considering plans for service coverage, fleet management, and operational improvement, which results in an average passenger demand increase of 4.2%/year.

6.3.2. Mitigation scenario

The proposed mitigation scenario for Colombia involves increasing the share of electric vehicles up to 30% by 2030 for each bus type. In this scenario, a one-to-one substitution of buses is assumed, i.e., one e-bus replaces one diesel bus.

6.3.3. Calculation methodology

As mentioned before, considering the weight of each source in GHG emissions and the difficulties and uncertainty associated with their estimation, two scopes were defined for estimating the impacts of the program:

i. GHG emissions from energy combustion in the operation of buses that are part of the SITMs and SETPs[21]

ii. GHG emissions from producing and transporting energy used by SITMs and SETPs and GHG emissions from using air conditioning systems in SITM and SETP buses[22]

6.3.3.1. Methodology for estimating GHG emissions

To estimate the emissions of each GHG pollutant identified in the analysis of system limits, total CO_2eq emissions were estimated each year, using the following equation:

[21] This refers only to the monitoring of emissions caused during operation, with a high degree of uncertainty as to upstream and fugitive emissions. It should be used in contexts where there is insufficient information to perform WTW (Well-To-Wheels) analysis.

[22] This refers to a more ambitious scope that includes upstream emissions (Well-to-Tank) and evaporative emissions associated with cooling systems.

Table 23. Equation and terms for total GHG emissions (Source: Hill for GIZ TRANSfer III, 2021)

Term	Meaning	IS units
$ECO_2eq_{P,i} = ECO_2eq_{C,i} + ECO_2eq_{A,i} + ECO_2eq_{E,i} + ECO_2eq_{T,i}$		
$ECO_2eq_{P,i}$	CO_2eq emissions associated with the program fleet in year *i*.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{C,i}$	CO_2eq emissions from fuel combustion during fleet operation* in year *i*.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{A,i}$	CO_2eq evaporative emissions from using refrigerants in Mobile Air Conditioning systems in the fleet in year *i*.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{E,i}$	Total CO_2eq emissions associated with WTT emissions of the electricity consumed.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{T,i}$	Total CO_2eq emissions associated with Fuel WTT emissions (extraction, refining, transport, and distribution) in year *i*.	$\frac{tCO_2eq}{year}$

*According to ICCT (2020) 81%-88% of GHG emissions form Mobile Air Conditioning systems are associated with the energy required to run the AC system. This extra fuel consumption is accounted for in this equation.

6.3.3.2. CO_2eq emissions from fuel combustion during fleet operation

CO_2eq emissions were calculated using a bottom-up methodology, as a function of fuel consumption, according to the equation presented in Table 24. This equation applies to emissions generated by the internal combustion fleet. No CO_2eq emissions are generated by the electric fleet.

Table 24. Equation and terms for CO2eq as a function of fuel consumption (Source: Hill for GIZ TRANSfer III, 2021)

Term	Meaning	IS units
$ECO_{2C,i} = \sum_t a_{t,i} \sum_c k_i * \frac{1}{r_{t,c,i}} * NCV * FC * fe_c$		

Term	Meaning	IS units
$ECO_{2C,i}$	CO_2 emissions in year *i*	$\frac{tCO_2}{year}$
$a_{t,i}$	Average annual activity by type of bus *t*, in year *i*	$\frac{VKTs}{year}$
k_i	Proportion of fleet by type and fuel in year *i*	Dimensionless (Ratio)
$r_{t,c,i}$	Fuel efficiency by type of bus *t* and fuel *c*, in year *i*	$\frac{km}{gal\ diesel};\frac{km}{m^3\ NGV}$
NCV	Net Calorific Value of fuel *c*	$\frac{TJ}{gal\ diesel};\frac{TJ}{m^3\ NGV}$
FC	Unit Conversion Factor	From kg to t
fe_c	CO_2 emission factor by type of fuel *c*	$\frac{kg\ CO_2}{TJ}$

Under current national GHG emission inventory guidelines, CH and N_2O emissions are also estimated based on fuel consumption using default emission factors for each fuel type. To the extent that cities have calculated fleet-specific emission factors, they may use these instead. CO_2eq emissions are calculated considering the global warming potential of the pollutants, according to:

Table 25. Equation and terms for CO2eq considering global warming potential of the pollutants (Source: Hill for GIZ TRANSfer III, 2021)

Term	Meaning	IS units
$ECO_2eq_i = ECO_{2C,i} + (I_{GWP-CH_4} * ECH_{4,i}) + (I_{GWP-N_2O} * EN_2O_i)$		
ECO_2eq_i	CO_2eq emissions associated with the program fleet in year *i*	$\frac{tCO_2eq}{year}$
$ECO_{2C,i}$	CO_2 emissions from fleet	$\frac{tCO_2}{year}$

Term	Meaning	IS units
	operation phase in year *i*	
$ECH_{4,i}$	CH_4 emissions from fleet operation phase in year *i*	$\frac{tCH_4}{year}$
EN_2O_i	N_2O emissions from fleet operation phase in year *i*.	$\frac{tN_2O}{year}$
I_{GWP-CH_4}	Global Warming Potential (GWP) for methane	Dimensionless
I_{GWP-N_2O}	Global Warming Potential (GWP) for nitrous oxide	Dimensionless

6.3.3.3. Hydrofluorocarbon emissions from air conditioning usage

Air conditioning (AC) systems generate indirect emissions from the additional fuel consumption required for their operation (these emissions are already accounted for in the previous section) and are a direct source of refrigerant leaks. Hydrofluorocarbon (HFC) leaks are generated during fleet operation and in the procedures associated with the maintenance of these systems. HFC emissions from buses depend on the type of AC system and, to a lesser degree, on the type of bus, the energy used for its operation, and its age.

According to local information (CAEM - CCB, 2016), by 2015 in Colombia 40% of the national bus fleet had an AC system.[23] The predominant refrigerant gas in the bus fleet is HFC-134a.[24]

To estimate baseline emissions, an average emissions factor from an international study was used, as shown in Table 26.

Table 26. Emissions factor for HFC-134a (Source: Hill for GIZ TRANSfer III, 2021)

HFC-134a emissions (kg/year)	
Fugitive emissions in operation phase by bus	0.92 ± 0.4

The selected value is consistent with the figures reported by different bus studies (Baker, 2010; EC, 2007; New Zealand Ministry of Environment, 2017) and represents a conservative estimate. This is a first

[23] According to the study, 40% of the national fleet in 2015 was equivalent to 82,375 buses. The SITM and SETP fleet totalled 15,272 buses in the base year (2018). Thus, it was assumed that the entire SITM and SETP fleet had air conditioning systems.

[24] There are some R-437a consumption reports (CAEM - CCB, 2016).

approximation, as there is lack of local information on these systems for public transport buses. The shortcomings include: the type of AC systems installed in the SITM and SETP fleets, the refrigerants used, associated maintenance practices, and refrigerant leakage rates.

Additionally, CO_2eq from fugitive emissions due to air conditioning usage are estimated according to:

Table 27. Equation and terms for CO2eq fugitive emissions due to AC usage (Source: Hill for GIZ TRANSfer III, 2021)

Term	Meaning	IS units
$$ECO_2eq_{A,i} = \sum_a (FE_{a,t,i} * I_{GWP-HFC} * F_i)$$		
$ECO_2eq_{A,i}$	CO_2eq emissions from air conditioning use in year *i*	$\frac{tCO_2eq}{year}$
$FE_{a,t,i}$	HFC emissions factor for leakage, according to type of air conditioning system *a*, and bus type *t*	$\frac{kg\ HFC}{year}$
$I_{GWP-HFC}$	Global Warming Potential (GWP) for HFCs, in this case corresponding to R-134a	Dimensionless
F_i	Number of buses in operation in year *i* with air conditioning system *a*	$\frac{tN_2O}{year}$

The literature indicates that in the short to medium term, it will be possible to make significant efficiency improvements to AC systems, and to adopt new refrigerant compounds with lower global warming potential compared to R-134a. Electric bus programs could include guidelines on AC systems to increase their efficiency.

6.3.3.4. CO_2eq emissions from electricity generation

CO_2eq emissions from electricity generation and from the use of fossil fuels in the thermal electricity component are estimated according to:[25]

[25] The National Unit for Mining and Energy Planning from MinMinas estimates the electricity emission factor annually based on the electricity generation basket and total electricity generation in Colombia's National Interconnected System.

Table 28. Equation and terms for CO2eq emissions from electricity generation and fossil fuels in thermal electricity (Source: Hill, for GIZ TRANSfer III 2021)

Term	Meaning	IS units
$$ECO_2eq_{E,i} = FE_{E,i} * DE_{E,i}$$		
$ECO_2eq_{E,i}$	Total CO_2eq emissions from electricity generation in year *i*	$\frac{tCO_2eq}{year}$
$FE_{E,i}$	Emissions factor for electricity generation by the national energy system, in year *i*	$\frac{kgCO_2eq}{kWh}$
$DE_{E,i}$	Electricity demand due to the electric fleet in year *i*	$\frac{kWh}{year}$

6.3.3.5. CO_2eq emissions from fuel well-to-tank emissions

A comprehensive bottom-up calculation of emissions factors during the production and transport of each energy carrier (ECO_2 eq in Table 23) was determined to be beyond the scope of this study, given the complexity of the necessary calculations. Accordingly, approximate emissions factors were instead estimated by drawing on other studies.

Cuellar & Belalcazar (2016) estimate that upstream emissions contribute 9% to WTT emissions in the case of diesel and 17% in the case of natural gas. These values are consistent with figures reported in international studies (Howarth & Santoro, 2011; Tong et al., 2015). In this way, CO_2 eq emissions from producing and transporting fossil fuels are calculated using the following equation:

Table 29. Equation and terms for Well-to-Tank Emissions (Hill for GIZ TRANSfer III, 2021)

Term	**Meaning**	**IS units**
$$ECO_2eq_{T,i} = \sum_c ECO_2eq_{WTT,c,i}$$ $$ECO_2eq_{WTT,c,i} = (\alpha_c) * ECO_2eq_{T,c,i}$$		
$ECO_2eq_{T,c,i}$	Total CO_2eq emissions from producing and transporting fossil fuels in year *i*	$\frac{tCO_2eq}{year}$

Term	Meaning	IS units
$ECO_2eq_{WTT,c,i}$	CO_2eq emissions from producing and transporting fossil fuel *c* in year *i*	$\frac{kgCO_2eq}{kWh}$
α_c	Proportion of CO_2eq emissions generated in the energy production and transportation phase, by fuel type	Dimensionless

Finally, in the interest of developing a rigorous MRV system, it was recommended that Black Carbon (BC) emissions be quantified and reported separately, given that this pollutant is not currently included in national GHG emission reports (and does not have an officially adopted global warming potential). Nevertheless, the negative impact of BC on human health and urban microclimates justifies its monitoring and quantification.

6.3.4. Modeling assumptions and data

The assumptions below supported the development of the program's baseline scenario:

Fleet size

The SITM and SETP fleets consisted of 32,300 buses in 2021. Of this, 2,143 were articulated buses (up to 190 passengers, max. 18m); 2,590 were feeder or "padrón" buses (up to 120 passengers, max. 13.5m); 7,730 were minibuses (up to nineteen passengers, max. 7.5m); and nearly 21,300 were buses and vans (20 – 50 passengers, max. 12m). These figures do not include conventional public transport fleets.

Bus type

Vehicles in the SITM and SETP fleets are classified as: standard, articulated, or bi-articulated, with the following subtypes:

- Microbuses: 7m
- Buses: 10m
- Padron: 10m
- Articulated: 18m+

Future demand scenario for public transportation systems

Despite a trend towards lower ridership in public transportation observed in Latin American cities, all SITMs have plans for expansion, according to MinTransporte.

For the baseline and mitigation scenarios, it was assumed that SITMs will grow in the years up to 2030 in accordance with the goals and projections set for passenger coverage nationally by UMUS – namely, by 4.2% annually.

Assumed future bus fleet size and composition

Fleet size is estimated annually based on two factors. First factor is passenger demand, assuming efficiency remains constant (that is, the ratio of passengers to fleet size); the second factor is the composition of the fleet in terms of bus types. Additionally, the composition of the fleet by fuel types must be considered to estimate the BAU and mitigation scenarios.

In the mitigation scenario, the share of e-buses in public fleets changes between 2020 and 2030 (as explained in section 4) in line with anticipated bus procurement volumes (as shown in **Table 16**), based on the guidelines of Law 1964 of 2019.

Once the fleet substation initially supported by the fund is finished by 2026, the technology share is kept constant until 2030. This assumption is supported by the expectation of price parity between technologies by 2026, especially since the fund would facilitate the transition and installment of the required infrastructure for e-buses fleets, reducing entry barriers and fixed costs for additional buses.

The bus type distributions in the business-as-usual and mitigation scenarios are as follows:

Table 30. Baseline scenario, energy carrier share in national fleet

Year	Bus (10m)			Microbuses (7m)			Padron (12m)				18m +		
	Dsl	Gas	Elec	Dsl	Gas	Elec	Dsl	Gas	Elec	Hyb	Dsl	Gas	Elec
2020-2026	92%	8%	0%	100%	0%	0%	53%	4%	37%	5%	72%	28%	0%

Table 31. Mitigation scenario, energy carrier share in national fleet

Year	Bus (10m)			Microbuses (7m)			Padron (12m)				18m +		
	Dsl	Gas	Elec	Dsl	Gas	Elec	Dsl	Gas	Elec	Hyb	Dsl	Gas	Elec
2020	92%	8%	0%	100%	0%	0%	53%	4%	37%	5%	72%	28%	0%
2021	92%	8%	0%	100%	0%	0%	53%	4%	37%	5%	72%	28%	0%
2022	90%	8%	2%	87%	0%	13%	53%	4%	37%	5%	72%	28%	0%
2023	85%	8%	7%	87%	0%	13%	51%	4%	40%	5%	69%	28%	3%
2024	82%	8%	10%	87%	0%	13%	49%	4%	42%	5%	67%	28%	5%
2025	82%	8%	10%	87%	0%	13%	49%	4%	42%	5%	67%	28%	5%
2026-2030	73%	8%	19%	87%	0%	13%	44%	4%	46%	5%	60%	28%	12%

Fuel consumption factors

The proposed values were based on information from multiple sources, including academic literature, SITM and SETP data, and data published by fleet providers, as shown in Table 32. Greater emphasis was given to values that are local and representative of actual operating conditions.

Table 32. Assumed performance factors by vehicle type (Source: Hill for GIZ TRANSfer III, 2021)

Vehicle category	Value	Fuel Efficiency							
		Diesel	Units	Nat Gas	Units	Electric	Units	Hybrid	Units
Minibus (6-7.5m)	Average (n=4)	16.06	1/100km	5.22	Km/m³	0.5	Kwh/m³	N.A	N.A
	Standard deviation	2.88	Dl	0.00	Dl	0.04	Dl	N.A	N.A
		18%	Pct	0%	Pct	7%	Pct	N.A	N.A
Bus/Van (10.6-12m)	Average (n=5)	36.26	1/100km	2.84	Km/m³	0.92	Kwh/m³	N.A	N.A
	Standard deviation	3.05	Dl	0.22	Dl	0.06	Dl	N.A	N.A
		8%	Pct	8%	Pct	6%	Pct	N.A	N.A
Padron (12m)	Average (n=9)	43.99	1/100km	1.70	Km/m³	1.06	Kwh/m³	31.50	1/100km
	Standard deviation	4.83	Dl	0.12	Dl	0.26	Dl	2.12	Dl
		11%	Pct	7%	Pct	25%	Pct	7%	Pct
Articulated (18m)	Average (n=9)	71.01	1/100km	1.22	Km/m³	1.73	Kwh/m³	N.A	N.A
	Standard deviation	15.07	Dl	0.02	Dl	0.12	Dl	N.A	N.A
		21%	Pct	2%	Pct	7%	Pct	N.A	N.A
Bi-Articulated (22m)	Average (n=2)	61.75	1/100km	1.50	Km/m³	N.A	N.A	N.A	N.A
	Standard deviation	4.97	Dl	0.18	Dl	N.A	N.A	N.A	N.A
		8%	Pct	12%	Pct	N.A	N.A	N.A	N.A

*N.A: Not Applicable
**Dl: Dimensionless
***Pct: Percentage

Fleet activity

The applied values were selected according to the following prioritization:

1) Values reported by cities in surveys conducted as part of the study.
2) Values reported in the LatGlobal (2020) study conducted for this program.
3) Cities' own reference values.
4) For cities where data was unavailable from the aforementioned sources, an average value from other cities was employed as a substitute.

Table 33 shows the values used for the different metropolitan areas and cities with SITM and SETP.

Table 33. Annual activity factors used to estimate program impacts in Colombia (Source: Hill for GIZ TRANSfer III, 2021)

City or Metropolitan Area (MA)	Average activity, 2018 (km/year-vehicle)			
	Bus-Van	Minibus	Padron	Articulated/Bi-Articulated
Barranquilla MA	72,635	58,035	51,100	82,490
Bogotá MA	57,800	57,800	73,365	102,200
Bucaramanga MA	8,220	58,400	58,400	125,925
Cali MA	57,700	57,500	73,365	78,475
Medellin MA	56,739	58,765	58,765	102,200
Pereira MA	46,600	46,600	46,600	29,400
Cartagena	44,100	44,100	44,100	40,150
Armenia	55,845	55,845	55,845	N.A.
Monteria	64,496	65,116	64,806	N.A.

City or Metropolitan Area (MA)	Average activity, 2018 (km/year-vehicle)			
	Bus-Van	Minibus	Padron	Articulated/Bi-Articulated
Neiva	66,795	66,795	66,795	N.A.
Pasto	81,030	81,030	81,030	N.A.
Popayan	73,000	77,015	75,008	N.A.
Santa Marta	80,300	63,510	71,905	N.A.
Sincelejo	23,200	23,200	23,200	N.A.
Valledupar	60,225	60,225	60,225	N.A.
Weighted average by fleet	59,998	66,971	67,816	97,480

***N.A.:** Not Applicable

Calculation Incertitude

- 7%

6.3.5. Expected benefits

6.3.5.1. GHG mitigation impact

Based on the scenario estimates, aggregate CO_2 eq emissions from all Colombian SITMs and SETPs will rise to 2.34 million tons in 2030, up from 1.542 million tons in 2020. Figure 24 shows baseline GHG emissions and the estimated contribution by fleet type.

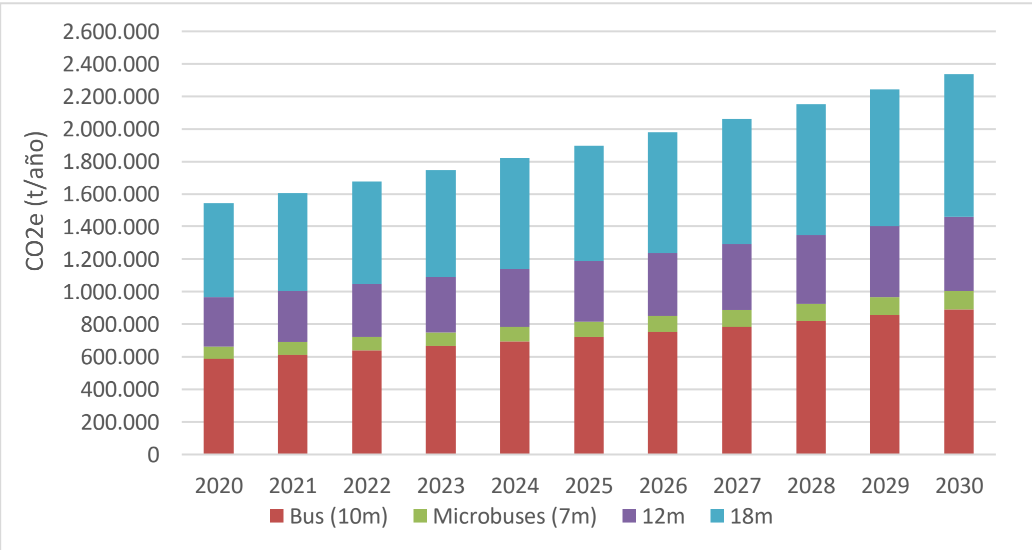


Figure 24. GHG emissions and the estimated contribution by fleet type (Source: GIZ with data from MinTransporte UMUS, WRI and TRANSfer III, 2020)

Compared to the baseline scenario, the program's implementation would lead to approximately 12,967 additional e-buses during the analysis period. Figure 25 shows the distribution of e-buses that would be adopted with the implementation of the program.

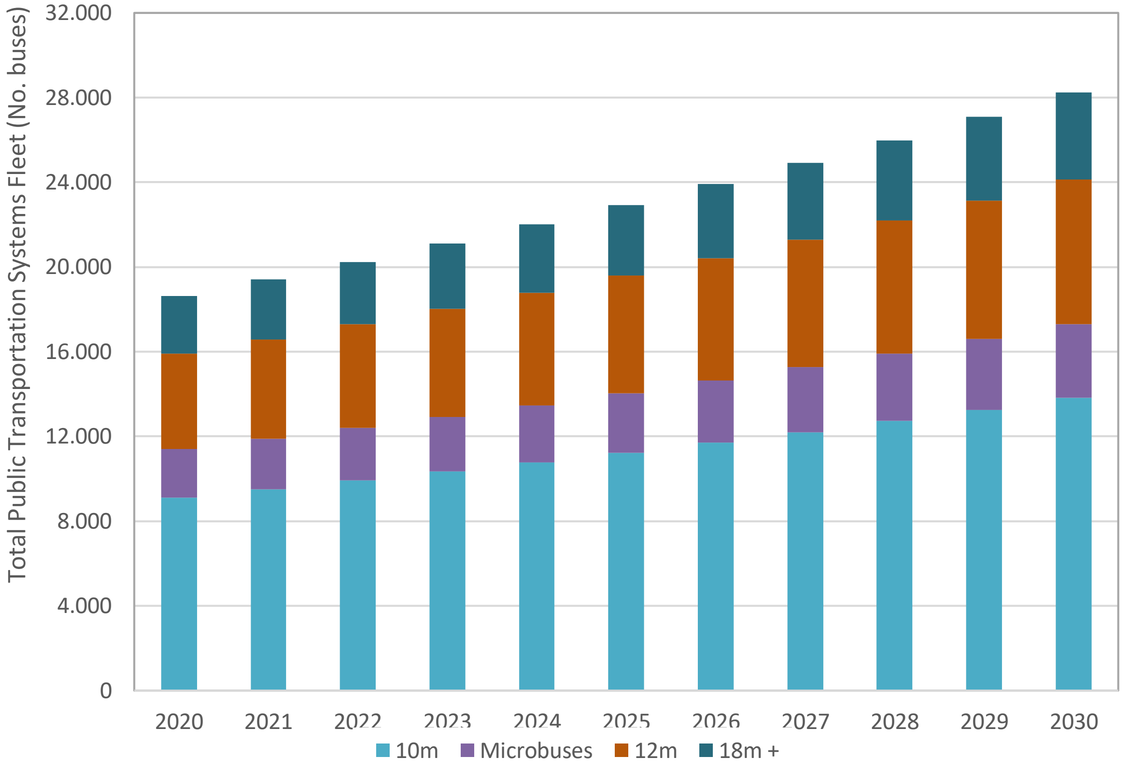


Figure 25. Distribution of e-buses in Colombia between 2020 and 2030 (Source: GIZ with data from MinTransporte UMUS, WRI and TRANSfer III, 2020)

This scenario is associated with the avoidance of 1.80 million tons of CO_2 eq emissions over the analysis period, given the defined system limits, as shown in Table 34.

Table 34. Aggregated mitigation results

Emissions $CO_{2\,eq}$ (t 10^6)	Scenario	
	Baseline	Mitigation
Year 2020	1.36	1.36
Year 2030	2.07	1.76
Cumulative 2020-2030	18.65	16.85

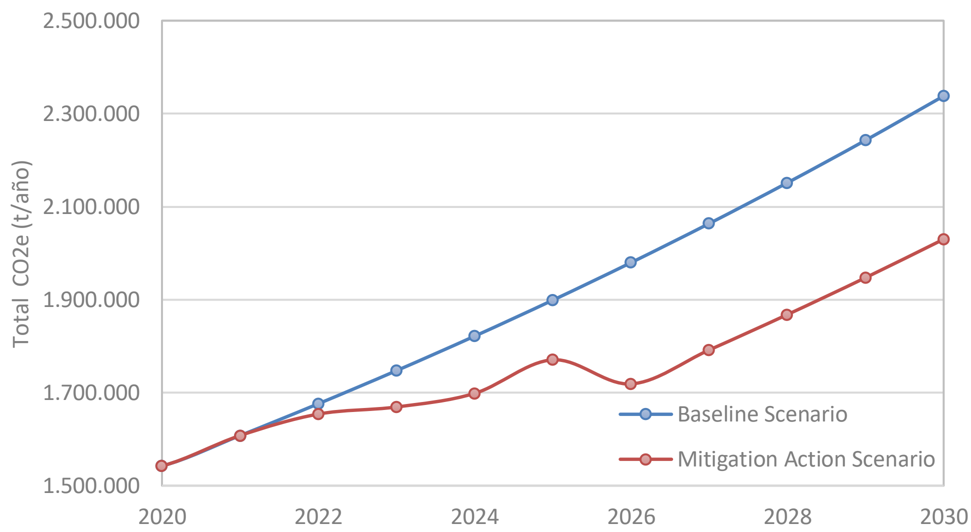


Figure 26. Total CO2 equivalent emissions between baseline and mitigation scenario

The mitigation corresponds to 10% of the cumulative emissions during the same period in the baseline scenario. The program's impact by emission source is presented in Table 35.

Table 35. Cumulative change in CO2 emissions by source, 2020-2030

Difference between scenarios in CO2e	Impact	Million-ton CO2e, cumulative over 2020-2030
Fleet fuel combustion	Reduction	1.8
Electricity generation	Increase	-0.2
Fuel transport and production	Reduction	0.2
Air conditioning systems	Reduction	0.03
Total cumulative change (2020-2030)	**Reduction**	**1.8**

Thanks to the e-bus program, the magnitude of GHG emissions stemming from SITMs and SETPs would be significantly lower. Annual GHG emissions would be 27% lower than that of the BAU scenario in 2030.

Additionally, the program has the potential to reduce 225 tons of black carbon (BC) and 341 tons of $PM_{2.5}$ during the analysis period (see Table 36). BC emissions in the year 2030 are equivalent to a 33% reduction with relation to the baseline scenario.

Table 36. Cumulative change in Black Carbon emissions by source type

BC Emissions	Tons of BC, cumulative over 2020-2030	
Combustion from fleet operation	Reduction	228.1
Combustion from electricity generation	Increase	(0.034)
Total	Reduction	228.1

2023 UPDATE NOTE:

This report was updated in April 2023 as part of Changing Transport and TRANSfer III project final reporting. Although the technology upgrade fund in Colombia has been approved and is currently being designed by the Ministry of Transportation and Ministry of Budget with the support from the Inter-American Development Bank (IADB), fund operations have not yet started, and there will be at least a two year delay in implementation from the original expected launch in 2022.

As a result of this delay, aggregate anticipated mitigation between 2020 and 2030 now stands at 1.6 Mton CO_2e, down from 1.8 Mton CO_2e.

Table 37. Cumulative change in CO2 emissions by source, 2020-2030 (2023 Update)

Difference between scenarios CO2e	Impact	Million-ton CO2e, cumulative over 2020-2030
Fleet fuel combustion	Reduction	1.6
Electricity generation	Increase	-0.2
Fuel transport and production	Reduction	0.1
Air conditioning systems	Reduction	0.03
Total cumulative change (2020-2030)	Reduction	**1.6**

6.3.5.1. Sustainable development benefits

The mitigation action is expected to generate benefits for sustainable development aside from GHG emission reductions. Specifically, the improvement of public transport services is expected to result in cleaner air, improved public health, reduced noise pollution, better quality of service to public transport users, and improved working conditions for public transport service operators.

One of the main reasons for the mounting interest in electrifying the public transport fleet is its beneficial effect on the air quality of cities. Particulate matter is considered the most critical pollutant in Colombian cities because it is the one that most frequently exceeds the air quality standards established by local regulations (IDEAM, 2018). Its negative impact on human health is considered the main environmental problem in Colombian urban centers (IDEAM, 2017).

The public transport fleet is not only an important source of this pollutant in Colombian cities, but also the main mode of transport in many urban centers, thus underscoring the magnitude of the benefits that will be obtained by migrating to cleaner solutions and improving air quality in transport-related microenvironments (Morales-Betancourt et al., 2017).

$PM_{2.5}$ emissions from the bus fleet operations phase are calculated using the following equation:

Table 38. Equation and terms for PM2.5 emissions (Source: Hill for GIZ TRANSfer III, 2021)

Term	Meaning	Units in IS
$$EPM_{2.5,i} = \sum_t a_{t,i} * FE_{PM2.5,t}$$		
$EPM_{2.5,i}$	$PM_{2.5}$ emissions per fleet operation phase in year i	$\frac{t\ PM_{2.5}}{year}$
$a_{t,i}$	Average annual activity by bus typology t in year i	$\frac{Veh/km}{year}$
$FE_{PM2.5,t}$	$PM_{2.5}$ emissions factor per vehicle/km, according to bus typology	$\frac{g\ PM_{2.5}}{km}$

It is estimated that the e-bus program will achieve an aggregated reduction of 345 tons of fine particulate matter during the period under consideration.

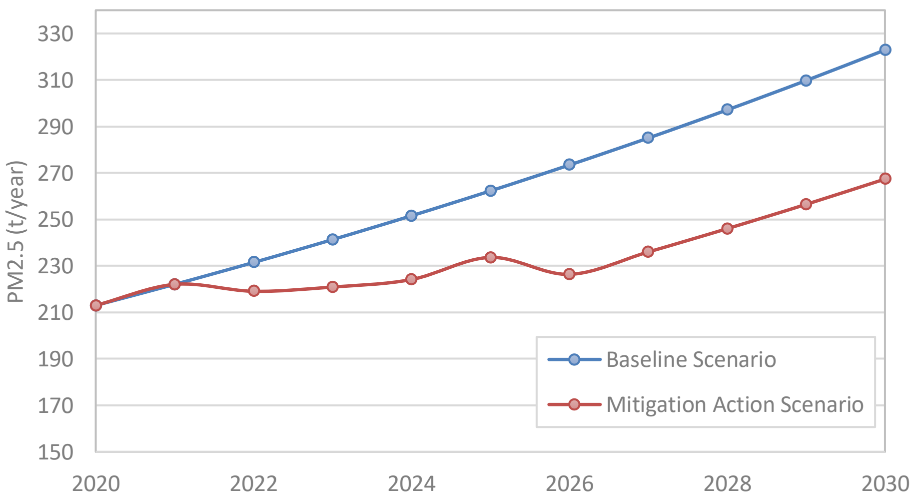


Figure 27. PM2.5 emissions from fleet operation

Although air quality in urban centers depends on multiple factors, it would be expected that a change in the public transport fleet toward cleaner options, as part of a comprehensive sustainable transport strategy, would result in reductions in particulate matter concentrations in cities. For black carbon, the estimated aggregate reduction over the same period is 228.1 tons.

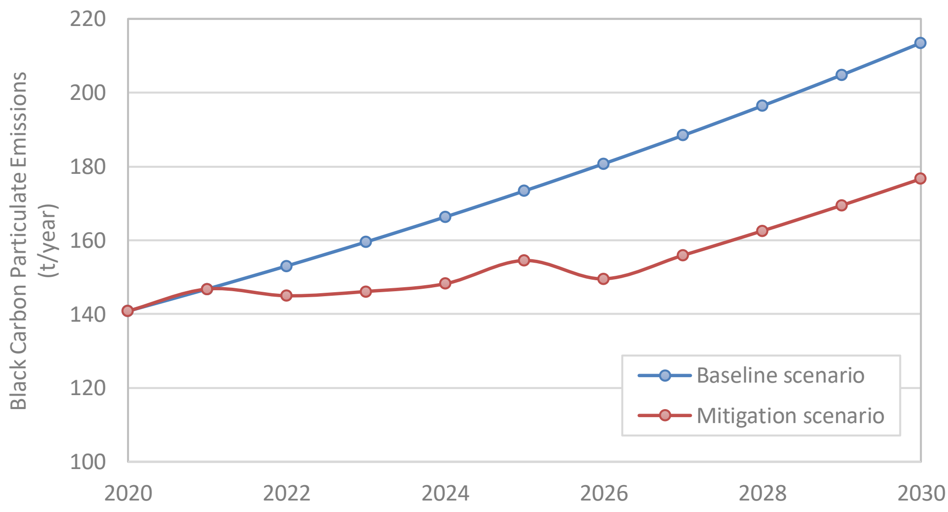


Figure 28. BC emissions from fleet operation

6.4. Monitoring and reporting plan

6.4.1. Monitoring indicators for the electric bus program

This section presents recommendations concerning the types of data that should be monitored by the MRV system, based on input from practicing professionals and in light of existing local monitoring capacities. The adopted MRV system should consider not only climate impacts, but also the progressive implementation of investment projects, and key environmental, social, and economic co-benefits.

The proposed indicators cover the following aspects:

1. GHG emission reductions
2. Progress in implementing the program
3. Financing sources for the program
4. Co-benefits in reducing emissions and $PM_{2.5}$/PM_{10} concentrations

Table 39 shows the indicators and their descriptions. They have been classified into primary and secondary indicators, according to their relevance. The main variables used to monitor them are also presented.

Table 39. Recommended indicators for monitoring the electric bus program (Source: Hill for GIZ TRANSfer III, 2021)

Type of indicator	Indicator	Description	Monitoring variables	To whom it is reported
Follow-up (Primary)	Annual CO_2eq emissions reduction (ton CO_2eq/year)	Reduction of CO_2eq emissions generated annually by SITM and SETP buses linked to the electric bus program in comparison to baseline scenario	Number of buses by fuel type and bus category* Fleet activity (km) by fuel type and bus category Fuel consumption by fuel type and bus category (l/m³/kWh/100k) Fuel efficiency factors per bus category and fuel.	Climate Financier RENARE
Follow-up (Primary)	Annual $PM_{2.5}$ emission reduction (kg $PM_{2.5}$/year)	Reduction of $PM_{2.5}$ emissions generated annually by SITM and SETP buses linked to the electric bus program.	Number of fleets by type (same as above) Fleet activity (same as above)	Climate Financier
Follow-up (Primary)	Annual BC emission reduction (kg BC/year)	Reduction of BC emissions generated annually by SITM and SETP buses linked to the electric bus program	Number of fleets by type (same as above) Fleet activity (same as above)	Climate Financier
Follow-up (Secondary)	Annual concentration of particulate matter ($PM_{2.5}$ and/or PM_{10}) (ug/µ³)	Annual PM concentration level at air quality monitoring stations in each	Average annual concentrations of particulate matter	Climate Financier

Type of indicator	Indicator	Description	Monitoring variables	To whom it is reported
		city		
Implementation (Primary)	Number of electric buses linked (#/year)	Total number of SITM and SETP electric buses linked to the program	Number of electric buses operating	Climate Financier
Management (Primary)	Annual resources leveraged by GCF with respect to total financing (%GCF)	Percentage of investment with resources obtained from GCF with respect to the program's total investment	Amount financed by GCF to purchase electric buses and charging infrastructure Total resources for the purchase of electric buses and charging infrastructure	DNP Climate Financier Financial MRV

6.4.2. MRV information sources and data collection tools

For an MRV system to work properly, it is crucial to define accurately the data sources used and the entities responsible for reporting. The definition process requires a detailed understanding of existing local and national data collection tools and mechanisms, both for aggregating information and for verifying reports.

Currently, different monitoring processes are conducted in Colombia by local and national entities to monitor the operation of public transport systems. Although the objective of current monitoring is not related to GHG mitigation, a study conducted by TRANSfer III recommended harnessing the existing capacities and practices for the establishment of the program's MRV system.

Figure 29 shows existing options for collecting data, producing reports, and conducting audits while considering opportunities for MRV system improvement. These components are classified into three levels of accuracy: level 1 being the most basic and level 3 being the most sophisticated.

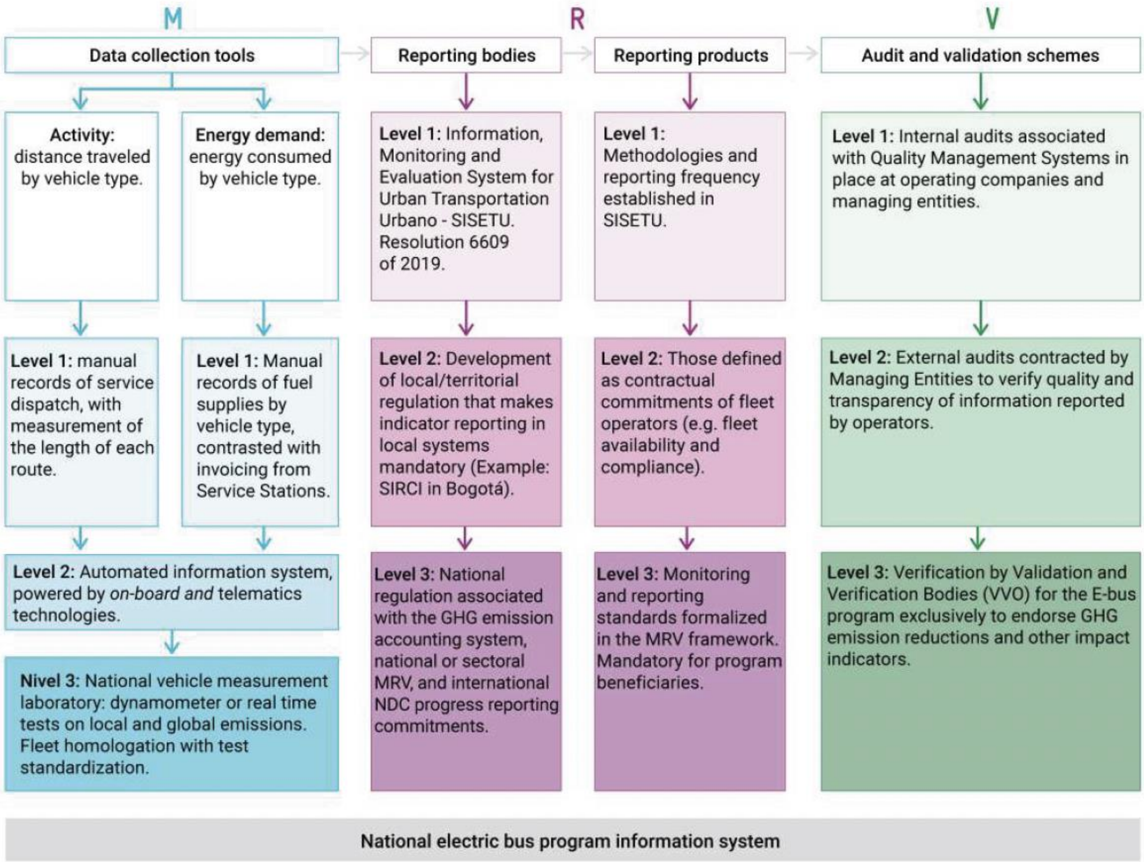


Figure 29. Existing options for collecting data, producing reports, and conducting audits (Source: Hill for GIZ TRANSfer III, 2021)

The identification of data collection tools may reveal technical gaps that can be addressed to improve the relevance of the data. For example, by merging data from the Information, Monitoring and Evaluation System for Urban Transportation (SISETU) (e.g., regarding fleet size, type, annual activity factors) with information contained in the National Unique Transit Registry (RUNT) (e.g., on the fleet's mechanical characteristics), it would be possible to estimate the annual GHG emissions of each public transport system by simply adding some additional values (e.g., fuel efficiency factors). However, the study identified that SISETU data was not up-to-date, and RUNT data was not public.

On the other hand, information collected by local transport authorities is restricted to vehicle fleet size and vehicle characteristics. Data on the level of fleet activity (which depends on citizens' travel patterns and operating efficiency) and the consumption of different energy sources are not contained in standardized and publicly accessible databases. However, since this information is linked to the productivity and finances of fleet operating companies, they have their own records of this data, stored in a format determined by their administrative systems. The existence of these systems shows that monitoring and reporting at the national level is not an unknown endeavor for public transport authorities or national institutions and that improvements as well as ownership are needed.

6.4.2.1. MRV information record forms

Creating data collection forms that allow for homogeneous and verifiable reports is a best practice for reducing uncertainty, improving data representativeness, and guaranteeing the progressive standardization of calculations in an MRV system. Therefore, three data collection forms were built by the study, to allow operating companies or concessionaires, and SITM and SETP managing entities, to monitor operations, calculate emission reductions, and implement reporting and verification procedures along the information chain of custody. Figure 30 shows a flow chart for information reporting in an MRV system.

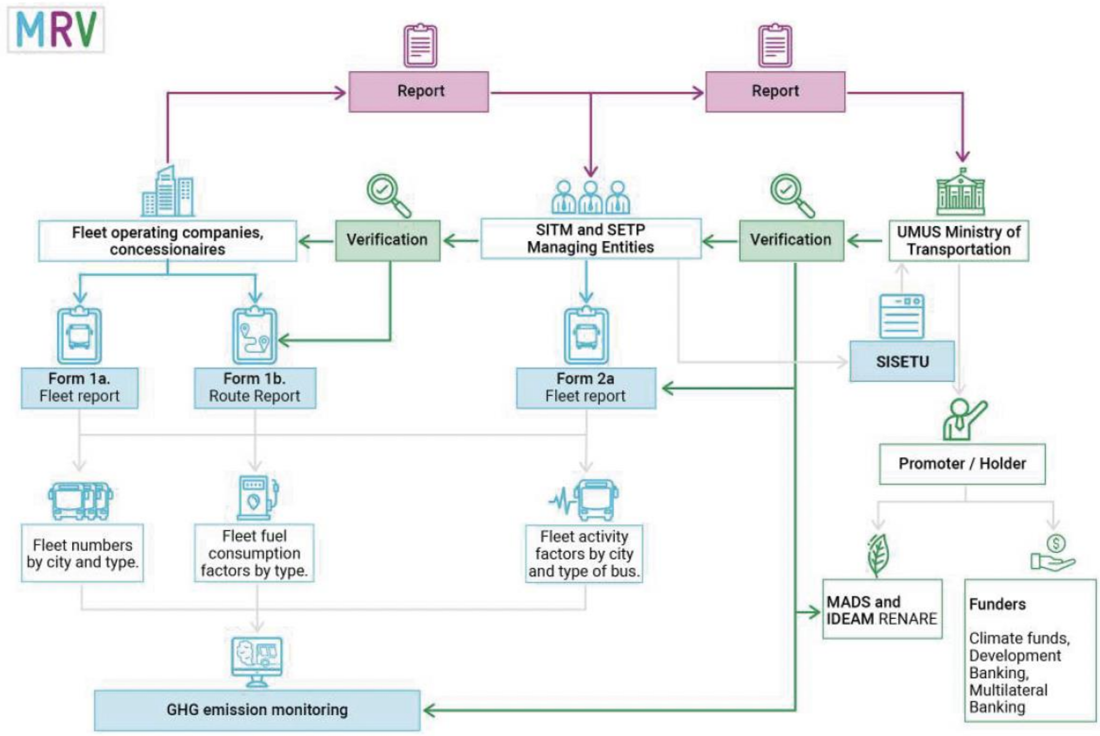


Figure 30. MRV information reporting flow chart (Source: Hill for GIZ TRANSfer III, 2021).

6.4.3. Identification of the MRV system's key stakeholders

The acquisition and operation of public bus fleets is governed by overlapping systems of financing, supervision, management, and assessment, which are in turn conditioned by local institutional arrangements, local business conditions and stakeholders, and each jurisdiction's regulatory framework.

To implement an MRV system it is essential to identify stakeholders and their responsibilities in each part of the system, as well as the flow of information required between the different stakeholders involved in the bus program, from the local transport company up to the national level, so that data can be reported in an aggregated manner to the corresponding institutions.

Figure 31 shows a relations map between stakeholders, identifying local and regional stakeholders and national and international reporting bodies that must be considered when implementing an MRV system for bus-fleet electrification in Colombia. With a view to the TRANSfer III project in Colombia, the Green Climate Fund was identified as one possible funder during the project planning phase. Figure 31 also includes elements proposed as part of the E-MOTION project proposed by AFD, CAF, KfW, and GIZ. This stakeholder analysis must be conducted anew for each project that aims to upgrade public transport fleets, as the details will vary on a case-by-case basis.

The figure showcases the possible informational and financial flows that will arise as part of the formal launch of the program. Regarding finances, two main alternatives are foreseen for channeling resources from international climate funds or multilateral banks to fleet operators:

1. One option for channeling funds is to establish an administrative organization that jointly represents the national government and territories. This organization should be established within the framework of the National Policy on Urban Transport. Within the same framework,

the entities that manage the SITMs and SETPs will take the lead on infrastructure development and plan the operation of the transport systems. Provided the national government has the monetary leeway to co-finance the acquisition of the fleet, the international resources are to be disbursed to the fiduciary accounts of the managing entities, with disbursements coordinated by the Ministry of Finance, the National Planning Department, and MinTransporte. The managing entities' fiduciary committees and boards of directors would authorize the use of resources to purchase buses under contracts for fleet operation or provision.

2. A second option is to have local commercial banks reach out directly to operating companies. Under this option, the operating companies manage the purchase of buses based on mandates from local authorities, local environmental regulations, and financial considerations.

In either case, local governments should take a leading role in fostering the adoption of zero-emission bus fleets. While national governments may offer public policy guidelines or provide financial incentives, it is at the local level where the actual transformation takes place. The international experience has shown that in places where electric vehicle adoption rates are the highest, a crucial factor has been local governments setting more ambitious goals and standards than those set by national governments.

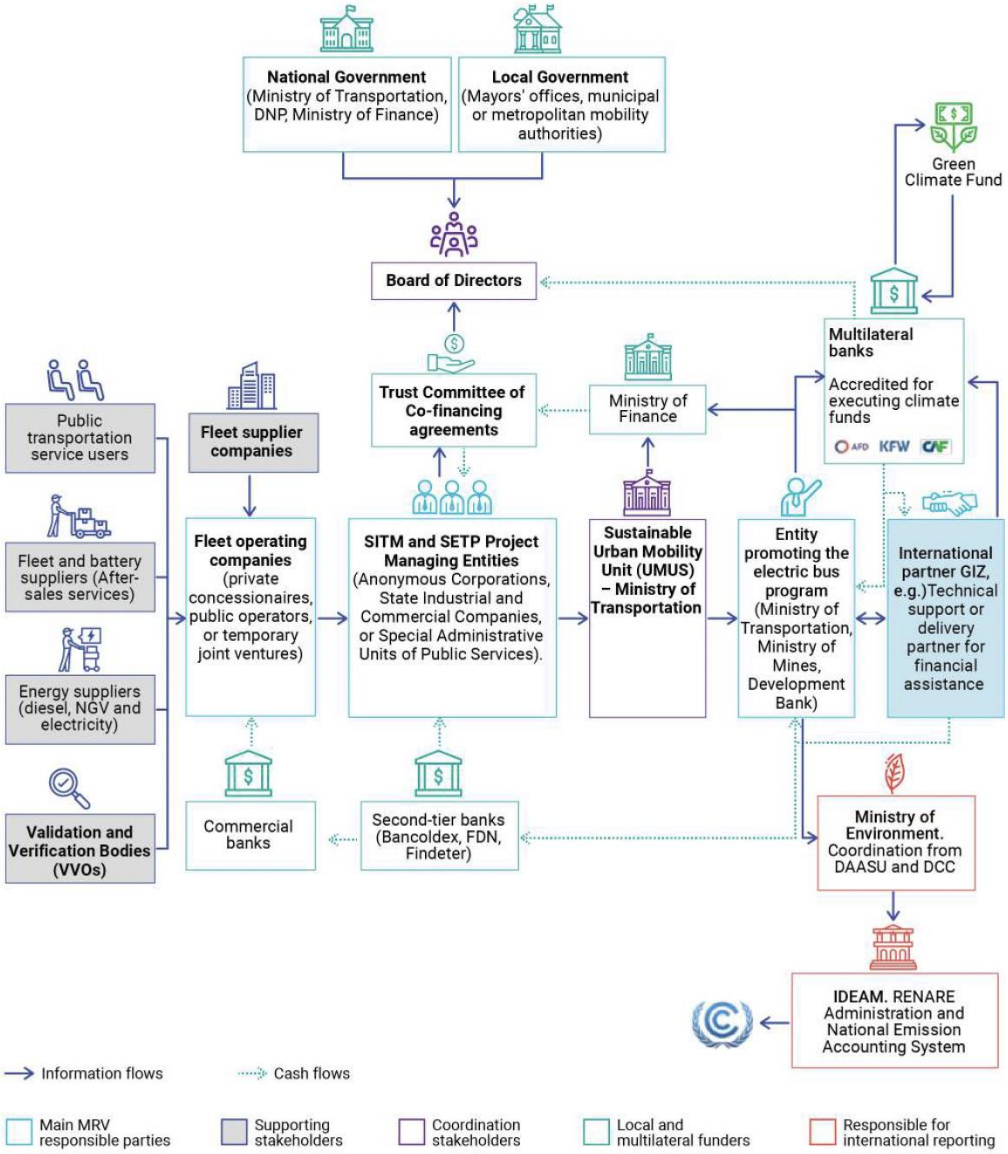


Figure 31. Map of stakeholder relations for electric bus program and MRV system (Source: Hill for GIZ TRANSfer III, 2021)

7. Lessons learned

Based on the experience gathered in the TRANSfer III project and the input provided by involved individuals at the Colombian Ministry of Transport, National Planning Department, and development banks, we present the following summary of lessons learned during the project:

- International cooperation organizations can serve as excellent partners to local institutions given the aim of ambitious change, such as the transformation of public transport systems, since these outside organizations furnish novel capacities, including in particular international experience and perspectives, thus greatly augmenting the momentum for transformation.

  In particular, the resources provided by international organizations enable the entities in charge of public transport, who usually have limited budgets and staff, to rethink and explore new alternatives for pursuing policy goals. The foreign experts involved in the cooperative endeavor also provide valuable expertise, thus accelerating the capacity development process.

  Nonetheless, to obtain the best results from joint projects it is essential for international organizations to really understand the context of each country, to learn from previously acquired cooperative undertakings – whether successful or unsuccessful – and to adapt their programs and initiatives to the needs of the partner country, even when local needs may be in flux.

  In the case of the TRANSfer III project in Colombia, the involved actors, such as Ministry of Transport staff, were highly appreciative of the contributions made by the TRANSfer team as part of the very important but complicated activities required to promote a national program for the electrification of public transport systems. Ministry of Transport staff also commended the flexibility of the TRANSfer team in adapting the project to Columbia's changing requirements.

- While the technical prerequisites for implementing the program were successfully fulfilled, there is still a great deal of work to be done, not only with regard to the passage of necessary law but also for actual implementation of the program. Seeing an undertaking of this nature through to the end requires persistent institutional collaboration and a strong political will.

- The TRANSfer III project in Colombia took a comprehensive approach that started with a technical and financial assessment of the market potential for electric buses in order to then identify suitable policies and programs. While such an approach requires greater effort and time expenditure, and may be rendered difficult by the time limitations imposed on the cooperative initiative, it results in a solution that is much better tailored to the country in question, while also encouraging greater ownership on the part of local decision-makers.

  It is also important to consider that transformational measures, such as a law that creates a public investment fund that is endowed with significant resources, may necessitate lengthy political negotiations that surpass the time horizon of the project. Therefore, strengthening institutional capacities in the transport sector is particularly important for guaranteeing continuity and ensuring the continued dedication that is required to fulfill the project's aims. In addition, institutional capacity building can pave the way for further action in the domain of sustainability and climate policy, beyond the parameters of the original project.

- The most challenging aspect of electrifying fleets in public transport systems is the price gap between e-buses and their conventional counterparts. For this reason, the effective structuring and implementation of the Public Investment Fund for e-buses, which has yet to take place, will be crucial for closing the cost gap and meeting the country's climate goals.

- While it may be easy to overlook during policy planning activities, the establishment of a robust and competitive market requires the training of the professionals and technicians who will operate and maintain the vehicle fleets. Given the high maturity level of electric vehicles, the capacity building process means that there is a fantastic opportunity to reform deep-seated cultural assumptions and practices, such as the myth that transport is an exclusively male sector, thus opening the door to new employment opportunities for women, as well as to gender equity in the transport domain.

- At the same time, to develop a competitive market for electric vehicles, it is necessary to consider the objectives and needs of actors in the private sector, such as equipment manufacturers, utilities, and investors. Therefore, the policies that are developed must accommodate business models that are attractive to firms. For example, the guidelines proposed for the development of charging infrastructure sufficient to service new fleets and kick-start a broader transition must consider adequate incentives to mobilize the energies of the private sector. Subsidies and other forms of support should of course be considered while weighing the costs of such support in relation to anticipated benefits, e.g. for the climate and human health.

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Registered offices:
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Friedrich-Ebert-Allee 36+40
53113 Bonn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15
E info@giz.de
I www.giz.de

Authors

Alejandro Ceballos / Technical Adviser – GIZ

Andres Felipe Martinez / Senior Technical and Financial Adviser – GIZ

María Fernanda Ortiz / Consultant

Sergio Eduardo Martínez / Consultant

MRV section: Dr. Juan Felipe Franco, Dr Mónica Espinoza, Juan Camilo Florentino Marquez / Hill Consulting

Proofreading and backstopping: Nadja Teager /Adviser – GIZ

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Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ)
GmbH

Registered Offices
Bonn and Eschborn

Friedrich-Ebert-Allee 36+40
53113 Bonn, Germany

T +49 228 44 60-0
F +49 228 44 60-17 66