MONITORING, REPORTING, AND VERIFICATION SYSTEMS FOR ELECTRIC BUS PROJECTS

A METHODOLOGICAL GUIDE TO THEIR DESIGN, BASED ON A CASE STUDY IN COLOMBIA

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Acronyms and abbreviations

BAU: Business as Usual

BC: Black Carbon

CNG: Compressed Natural Gas

DANE: National Administrative Department of Statistics, by its Spanish acronym

DNP: National Planning Department, by its Spanish acronym

ETUP: Urban Passenger Transportation Survey, by its Spanish acronym

Ex-ante: Latin expression that refers to the estimation of project outcomes before its implementation

GCF: Green Climate Fund

GEF: Global Environment Facility

GHGs: Greenhouse Gases

LAIF: Latin American Investment Facility

MRV: Measurement, Reporting, and Verification

Mintransporte: Ministry of Transportation

NDC: Nationally Determined Contribution

RUNT: National Single Transit Registry, by its Spanish acronym

SETP: Strategic Public Transportation Systems, by its Spanish acronym

SISETU: Information, Monitoring and Evaluation System for Urban Transportation, by its Spanish acronym

SITM: Integrated Mass Transit Systems, by its Spanish acronym

SLCP: Short-lived climate pollutant

UPME: Mining and Energy Planning Unit, by its Spanish acronym

Introduction

In several Latin American and Caribbean countries, the adoption of electric buses in public transport is one dimension of the broader strategic effort to promote sustainable mobility and achieve emission reductions in the transport sector. In this context, several studies and prospective scenarios have identified multiple environmental and economic benefits derived from public transport electrification. These benefits have bolstered support for technology advancement, both politically and financially. In this connection, there is a need to empirically quantify the benefits of bus electrification projects, not only to demonstrate their relevance for investment, but also to facilitate their scaling and replication.

In the interest of guiding the definition of impact monitoring and evaluation systems for electric bus projects, in this document we summarize the findings of the consulting project "Design of a monitoring, reporting and verification (MRV) system for the National Electric Bus Program in Colombia" and we also present the corresponding methodology. The consultancy was part of a series of technical studies financed by the TRANSfer initiative of the German Agency for International Cooperation - GIZ, which has supported the preparation of GHG mitigation actions in different countries of the region.

This methodological guide, which is based on the Colombian case study, considers the most relevant activities when structuring an MRV system. These activities are described in the seven sections of the document as follows:

1. Recognizing the general aspects of an MRV system for electric bus programs.
2. Identifying the program's impacts
3. Standardizing GHG emissions estimation for the electric bus program.
4. Estimating the program's GHG emissions mitigation potential.
5. Defining the indicators for monitoring the electric bus program.
6. Characterizing the information sources and capture instruments for the MRV system
7. Identifying stakeholders and their possible roles in the MRV system

An MRV system designed and implemented based on these seven components, clarifies and facilitates communication between different levels of public decision makers. And so, it helps in a more decisive advancement of bus fleet electrification in different countries of the region. In addition, structuring MRV systems allows for:

- Defining coordination mechanisms between public and private stakeholders, and also connecting local governments with actors at the national level.
- Improving 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).

1. MRV system overview for electric bus investment programs

As shown in Figure 1, there are four general stages for implementing an MRV system:

1. Design and planning
2. Pilot phase
3. Deployment and implementation
4. Evaluation and follow-up

This consultancy project is focused on the design and planning stage, which includes: i) identifying the policy framework ii) clarifying the MRV system technical guidelines iii) identifying stakeholders iv) determining instruments for data collection and processing.

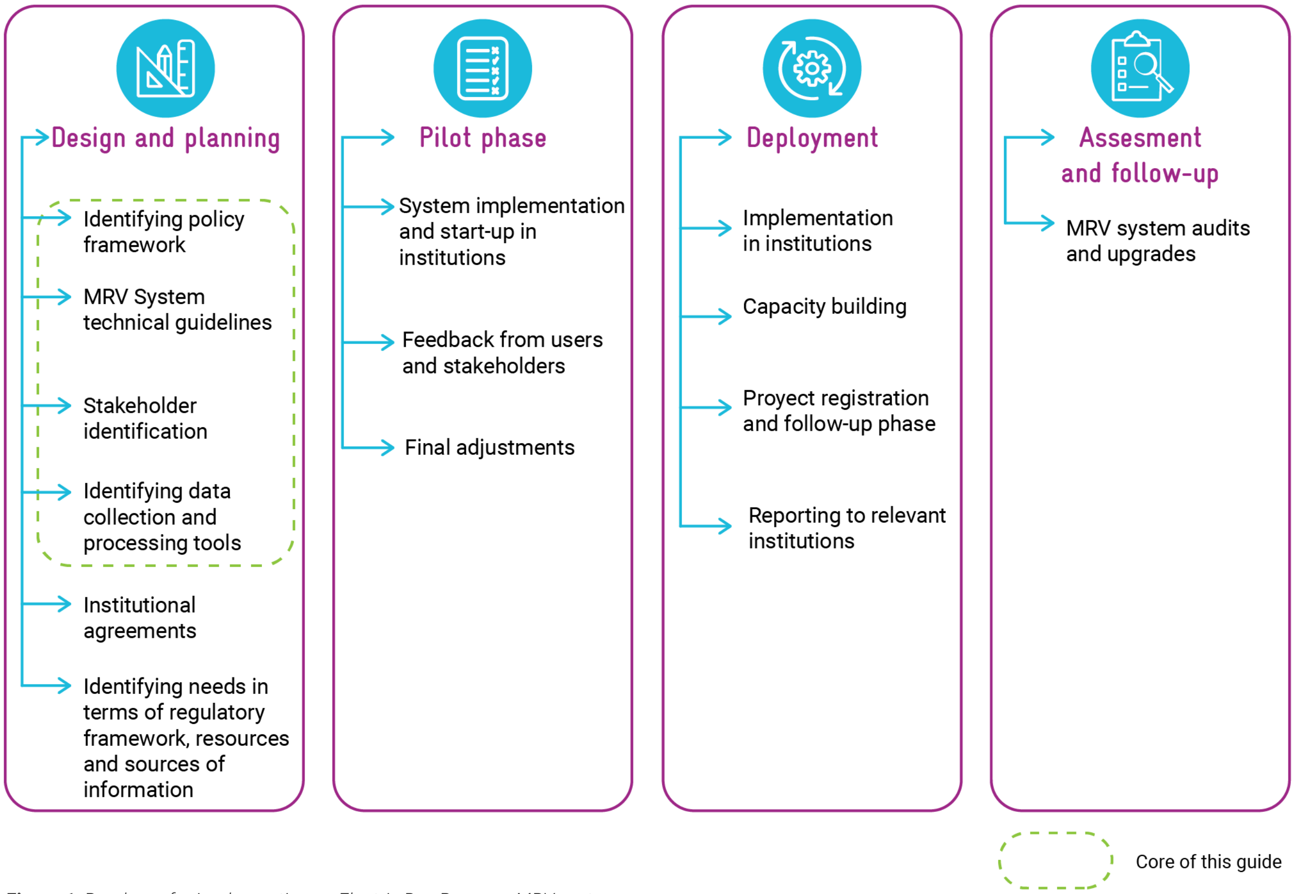

Figure 1. *Roadmap for implementing an Electric Bus Program MRV system.*
Source: *Authors' compilation based on CCAP, 2010; CDKN, 2017; GIZ, 2017b, 2017a; Witi et al., 2018.*

The timeframe for implementing the MRV system should be coordinated with the following processes:

1. The beginning of bus replacements in different transportation systems – namely, the fiscal and budgetary decisions to make a fleet purchase feasible under any contractual or financial scheme, including scrapping or replacement of the fleet in operation.

2. The structuring and procurement of financial resources, including application processes to multilateral climate finance sources such as the Green Climate Fund (GCF), the Global Environment Facility (GEF), and the Latin American Investment Facility (LAIF), or other programs run by multilateral development banks, such as the World Bank (WB), the Inter-American Development Bank (IDB), and the Development Bank of Latin America (CAF).

3. Protocols to update mitigation projects in national registries and emission accounting systems. In Colombia, for example, the electric bus MRV system must be linked to the National Emission Reduction Registry (RENARE).

2. Impact Identification

The net impact of a mitigation action can be estimated by comparing the business-as-usual (BAU) trend to a scenario forecasting the effects of the mitigation measure. In a situation prior to the implementation of an investment project, both scenarios are projections founded on the current conditions of the analysis system (Kooshian et al., 2017). Given this, it is crucial to determine the factors conditioning future trends and the mechanisms through which the mitigation scenario will introduce change in the BAU scenario. To this end, the development of a causal chain analysis and the definition of system limits are two important methodological tools.

The causal chain for fleet electrification in Colombia, as shown in Figure 2, identifies the program's projected differential impacts on GHG emissions. This sets the basis for defining the methodology that will be used to quantify emissions from the public bus fleet in scenarios considering the use of fossil fuel and electricity.

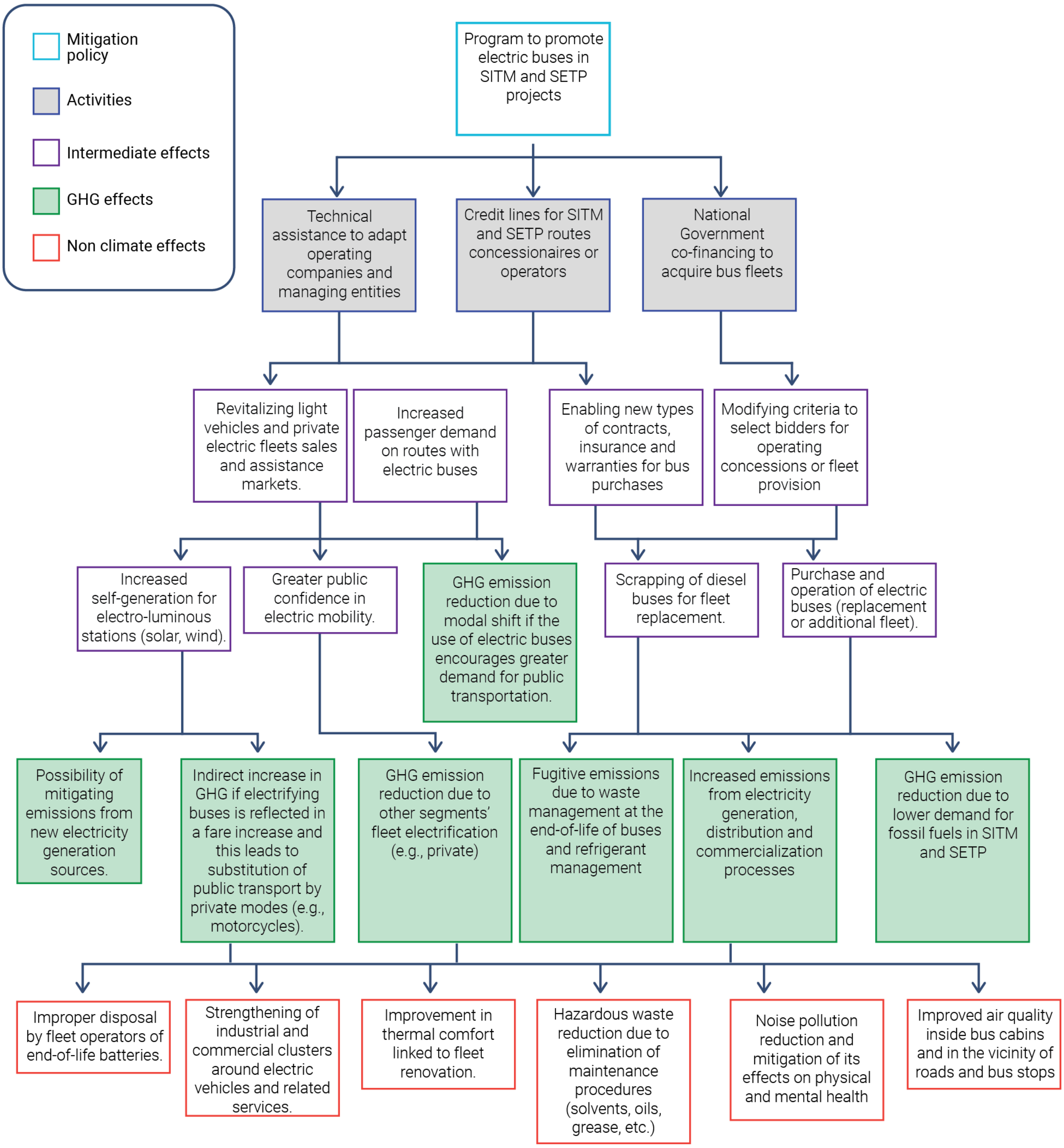

Figure 2. *Electric bus program causal chain map.*
Source: *Authors' compilation.*

In terms of GHG emissions, the causal chain map becomes the main input for identifying system limits when assessing the program. This process requires identifying the most relevant effects, to prioritize resources for measuring the most likely and significant impacts.

Table 1 shows a qualitative evaluation of the climate effects included in the causal chain map associated with the electric bus program in Colombia. An assessment is made of the occurrence probability of the effect in question and its relative impact on GHG emissions, considering the outcomes of similar study cases referred to in the literature. The last column on the right defines whether those specific GHG will be included or excluded in the MRV system. The MRV system includes those effects with a likely and highly likely probability of occurrence, and with moderate and high climate effects.

Table 1. *Assessment of climate effects' probability and magnitude.*

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			
HFCs	Likely	Moderate [1]	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 [2]
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 vehicles			
CO_2	Possible	Low	Excluded
CH_4	Possible	Low	Excluded
N_2O	Possible	Low	Excluded

* **Probability of occurrence:** (from highest to lowest probability) Highly likely, likely, possible, unlikely, and improbable.
** **Relative magnitude:** It describes the effect significance classified as high, moderate, or low.
Source: *Authors' compilation based on the methodology suggested by (Witi et al., 2018).*

In our case study, fine particulate matter is included in the MRV system, mainly due to their relevance for public health in Colombian cities (Ideam, 2018). It should also be kept in mind that black carbon (BC) is a short-lived climate pollutant (SLCP) and that BC content in $PM_{2.5}$ can be close to 90% (Miller & Jin, 2018). BC is also considered within the MRV system.

[1] The electric bus program could establish guidelines on the air conditioning systems to be acquired for the fleet and take advantage of the potential benefits.

[2] It is excluded from the initial stage of the MRV system. The electric bus program could set standards for the carbon footprint associated with electric fleet production and importation; in such case, it would be relevant to include it in the MRV. In general terms, it is recommended to develop a life cycle analysis to better understand the contribution of the different stages and where to focus management to reduce GHG emissions. According to analyses for other countries (T&E, 2020), GHG emissions associated to the production stage of the electric fleet and their batteries may represent about 30% of GHG emissions of the entire life cycle.

3. Standardization of GHG emission estimates for the electric bus program

This section presents the technical guidelines for GHG emission accounting within an electric bus program.

3.1. Analysis of system limits

When designing a monitoring, reporting, and verification system, limits for the analysis system must be set – that is, the scope of the activities that will fall under the MRV system. The proposal we developed for Colombia sought consistency with Colombia's Nationally Determined Contribution (NDC), the guidelines laid out in the national emission inventory, the causal chain map, and the requirements of international funders.

Table 2 shows the limits set for the analysis system, including timeframes, emission sources, and the national GHG inventory categories under IPCC standards. In addition, two different scopes have been defined for the purpose of impact estimation, considering the weight of each source in GHG emissions and the difficulties and uncertainty associated with their estimation at the program's current stage.

Table 2. *Sources considered and associated system limits.*

Limits	Scope 1[3]	Scope 2[4]	
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 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 replacement of compounds with those 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.

Source: *Authors' compilation.*

3.2. Methodology for estimating GHG emissions

This section explains the methodology we used to estimate the emissions of each GHG pollutant identified in the analysis of system limits. Total CO_2 eq emissions are estimated each year according to the following equation:

Equation 1.

$$ECO_2eq_{P,i} = ECO_2eq_{C,i} + ECO_2eq_{A,i} + ECO_2eq_{E,i} + ECO_2eq_{T,i}$$

Table 3. *Equation 1 definitions.*

Term	Meaning	IS units
$ECO_2eq_{P,i}$	$CO_2 eq$ emissions associated with the program fleet in year i.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{C,i}$	$CO_2 eq$ emissions from **fuel combustion during fleet operation**[5] in year i.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{A,i}$	$CO_2 eq$ 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 $CO_2 eq$ emissions associated with **WTT emissions of the electricity consumed.**	$\frac{tCO_2eq}{year}$
$ECO_2eq_{T,i}$	Total $CO_2 eq$ emissions associated with **Fuel WTT emissions (extraction, refining, transport, and distribution)** in year i.	$\frac{tCO_2eq}{year}$

Source: *Authors' compilation.*

[3] 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.

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

[5] According to ICCT (2020) 81%–88% of MAC systems GHG emissions are associated with the energy required to run the AC system. This extra fuel consumption is accounted for in this equation term.

3.2.1. CO_2eq emissions from fuel combustion during fleet operation

CO_2eq emissions are calculated using a bottom-up methodology, as a function of fuel consumption, according to equation 2. Table 4 outlines the terms contained in the equation with their respective units in the international system (IS).

This equation applies to emissions generated by the internal combustion fleet. No CO_2eq emissions are generated by the electric fleet.

Equation 2.

$$ECO_{2_{C,i}} = \sum_t a_{t,i} \sum_c k_i \cdot \frac{1}{r_{t,c,i}} \cdot NCV \cdot FC \cdot fe_c$$

Table 4. *Equation 2 definitions.*

Term	Meaning	IS units
$ECO_{2_{C,i}}$	CO_2 emissions in year i.	$\frac{tCO_2}{year}$
$a_{t,i}$	Average annual activity by type of bus t, in year i.	$\frac{VKT\ s}{year}$
k_i	Proportion of fleet by type and fuel in year i.	Dimensionless (ratio)
$r_{t,c,i}$	Fuel efficiency[6] 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.	$\frac{kg\ CO_2}{TJ}$

Source: *Authors' compilation.*

Under current national GHG emission inventory guidelines, CH_4 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:

Equation 3.

$$ECO_2eq_{C,i} = ECO_{2\,C,i} + [I_{GWP-CH4}] \cdot ECH_{4,i} + [I_{GWP-N_2O}] \cdot EN_2O_i$$

Table 5. *Equation 3 definitions.*

Term	Meaning	IS units
ECO_2eq_i	CO_2eq emissions associated with the program fleet in year i.	$\frac{tCO_2eq}{year}$
$ECO_{2_{C,i}}$	CO_2 emissions from fleet operation phase in year i.	$\frac{tCO_2}{year}$
$ECH_{4,i}$	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.	$\frac{tN_2O}{year}$
$I_{GWP\text{ - }CH4}$	Global Warming Potential (GWP) for methane.	*dimensionless*
$I_{GWP\text{ - }N20}$	Global warming Potential (GWP) for nitrous oxide.	*dimensionless*

Source: *Authors' compilation.*

[6] Units used for fuel efficiency could be liters/100km instead of km/gal

3.2.2. HFC 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. HFC leaks are generated during fleet operation and in the procedures associated with the maintenance of these systems. HFC emissions from buses depend mainly 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 air conditioning system,[7]. The predominant refrigerant gas in the bus fleet is HFC-134a[8]. To estimate baseline emissions, an average emissions factor from an international study was used (see Table 6).

Tabla 6. *Emission factor for HFC-134a.*

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

Source: *EC, (2007).*

The selected value is consistent with the figures reported by different bus studies (Baker, 2010; EC, 2007; New Zealand Ministry of Environment, 2017)[9] and represents a conservative estimate. This is a first 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:

Equation 4.

$$ECO_2eq_{A,i} = \sum_a (FE_{a,t,i} \cdot I_{GWP-HFC} \cdot F_i)$$

Table 7. *Equation 4 definitions.*

Term	Meaning	IS units
$ECO_2eq_{A,i}$	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.	$\frac{kg\ HFC}{year}$
$I_{GWP\text{-}HFC}$	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.	$\frac{buses}{year}$

Source: *Authors' compilation.*

[7] According to the study, 40% of the national fleet in 2015 was equivalent to 82,375 buses. The SITM and SETP systems fleet is 15,272 buses in the base year (2018). Based on this, it was assumed that the entire SITM and SETP fleet has air conditioning systems.

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

[9] The calculation report Excel file shows the values reported in the studies queried.

The recent 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. These improvements are being driven by the stricter regulation of AC systems in various countries, partially as an outcome of the Kigali Amendment to the Montreal Protocol. Electric bus programs could include guidelines on AC systems to increase the benefits of acquiring a new electric fleet.

Additional information on GHG emissions from air conditioning systems, their relevance to the transportation sector, and existing mitigation measures can be found in Blumberg & Aaron (2019), IPCC (2006), and Posada et al. (2017).

3.2.3. CO_2eq emissions from electricity generation

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

Equation 5.

$$ECO_2eq_{\mathrm{E},i} = FE_{\mathrm{E},i} \cdot DE_{\mathrm{E},i}$$

Table 8. *Equation 5 definitions.*

Term	Meaning	IS units
$ECO_2eq_{E,i}$	Total CO_2eq emissions from electricity generation in year i.	$\frac{tCO_2eq}{\mathrm{year}}$
$FE_{E,i}$	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.	$\frac{kWh}{\mathrm{year}}$

Source: *Authors' compilation.*

UPME estimates the electricity emission factor annually based on the electricity generation basket and total electricity generation in Colombia's National Interconnected System.

3.2.4. CO_2eq emissions from fuel WTT emissions

A detailed calculation (bottom-up) of the emission factor during production and transportation of each energetic (ECO_2 $eq_{(T,i)}$ in equation 1) is out of the scope of our study given the complexity of the process. We proposed, as an approximation, estimating it using the relative contribution of this stage, reported in local studies, regarding different fuel life cycle analysis. In our particular case Cuellar & Belalcazar (2016) estimated that upstream emissions contribute 9% to WTW 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_2eq emissions from producing and transporting fossil fuels are calculated using the following equation:

Equation 6.

$$ECO_2eq_{T,i} = \sum_c ECO_2eq_{WTT,c,i}$$

$$ECO_2eq_{WTT,c,i} = (\alpha) \cdot ECO_2eq_{T,c,i}$$

Table 9. *Equation 6 definitions.*

Term	Meaning	IS units
$ECO_2eq_{T,c,i}$	Total CO_2eq emissions from producing and transporting fossil fuels in year i.	$\frac{tCO_2eq}{year}$
$ECO_2eq_{WTT,c,i}$	CO_2eq emissions from producing and transporting fossil fuel c in year i.	$\frac{tCO_2eq}{year}$
α_c	Proportion of CO_2eq emissions generated in the energy production and transportation phase, by fuel type.	*dimensionless*

Source: *Authors' compilation.*

Finally, in the interest of a rigorous MRV system, we recommend Black Carbon (BC) emissions to 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). However, the negative impact of BC on human health and urban microclimates argues for its monitoring and quantification.

4. Electric bus program's GHG mitigation potential

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

For the baseline scenario in Colombia we estimated the most likely GHG emission trends accounting BAU activities of the country's 15 public transport systems – namely, the Integrated Mass Transit Systems (SITMs) in Bogotá/ Soacha, Barranquilla Metropolitan Area, Cali, Valle de Aburrá Metropolitan Area, Centro Occidente Metropolitan Area, Bucaramanga Metropolitan Area, and Cartagena; and the Strategic Public Transportation Systems (SETPs) in Pasto, Sincelejo, Santa Marta, Valledupar, Montería, Armenia, Popayán, and Neiva.

Base year emissions were determined using the bus fleet's size, bus type, characteristics, and activity in 2018. The baseline scenario was projected forward considering future expectations and plans for service coverage, fleet management goals, and operational improvement goals.

4.1. Baseline scenario assumptions for an electric bus program in Colombia

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 2020. Of this number, 2,143 were articulated buses (up to 190 passengers – max 18m length), 2,590 were feeder, or "padrón"[10], buses (up to 120 passengers – max 13.5m length), 7,730 are minibuses (maximum 19 passengers – max 7.5m length), and nearly 21,300 are buses and vans (between 20 and 50 passengers – max 12m length). These figures do not include traditional transport system fleets operating in cities with SITM or SETP systems.

[10] Padrón is a single-deck rigid type of 12 meters bus. It has a dual purpose fitted with doors on both sides so it can operate in bus-only lanes exclusive to the SITM (which demands left-side doors), and mixed-lanes (which demands right-side doors).

Type of bus

Traditional service fleet vehicles are classified according to their type as buses, vans, minibuses, and coach buses; and vehicles in the SITM and SETP fleets are classified as: standard, articulated, or bi-articulated.

Future fleet scenario for public transportation systems

Fleet size is estimated annually based on two factors. First, passenger demand assuming that systems' efficiency remains constant (ratio of passengers to fleet size), and second, the fleet's distribution by bus type, according to the current configuration of the systems. Additionally, distribution of the fleet by fuel type must be taken into account both for the BAU and mitigation scenario. In Colombia's case the participation of electric buses went from 0% in BAU to 30% in the mitigation scenario for minibuses and vans; in the case of padrón and articulated/biarticulated buses, electric participation went up from 60% to 90% for the former and 0% to 30% for the latter. In this case, as electric bus participation goes up, diesel fleet goes down proportionally.

Future demand scenario for public transportation systems

Despite the tendency for lower patronage in public transportation observed in most Latin American cities given rising motorization rates, all SITM systems have plans for future expansion, according to the Ministry of Transportation. While designing the baseline scenario for the electric bus program in Colombia, we assumed that SITM will grow in the years up to 2030 in accordance with the goals set for passenger coverage. These goals imply annual growth of 4.2%.

Fuel consumption factors

Our proposed values are based on information compiled from multiple sources, including the national and international academic literature, SITM and SETP data, and data published by fleet providers, as shown in Table 10. Greater emphasis was given to values that are local and representative of actual operating conditions.

Table 10. *Performance factors used for different vehicle typologies.*

Vehicle category	Value	Fuel efficiency							
		Diesel	*Units*	Nat Gas	*Units*	Electric	*Units*	Hybrid	*Units*
Minibus (6 - 7,5m)	*Average (n=4)*	16.06	l/100 km	5.22	km/m^3	0.50	kwh/m^3	N.A	N.A
	Standard deviation	2.88	dimensionless	0.00	dimensionless	0.04	dimensionless	N.A	N.A
		18%	percentage	0%	percentage	7%	percentage	N.A	N.A
Bus/Van (10,6 - 12m)	*Average (n=5)*	36.26	l/100 km	2.84	km/m^3	0.92	kwh/m^3	N.A	N.A
	Standard deviation	3.05	dimensionless	0.22	dimensionless	0.06	dimensionless	N.A	N.A
		8%	percentage	8%	percentage	6%	percentage	N.A	N.A
Padron (12m)	*Average (n=9)*	43,99	l/100 km	1.70	km/m^3	1.06	kwh/m^3	31.50	l/100 km
	Standard deviation	4.83	dimensionless	0.12	dimensionless	0.26	dimensionless	2.12	dimensionless
		11%	percentage	7%	percentage	25%	percentage	7%	percentage
Articulated (18m)	*Average (n=9)*	71.01	l/100 km	1.22	km/m^3	1.73	kwh/m^3	N.A	N.A
	Standard deviation	15.07	dimensionless	0.02	dimensionless	0.12	dimensionless	N.A	N.A
		21%	percentage	2%	percentage	7%	percentage	N.A	N.A
Bi-articulated (22m)	*Average (n=2)*	61.75	l/100 km	1.50	km/m^3	N.A	N.A	N.A	N.A
	Standard deviation	4.97	dimensionless	0.18	dimensionless	N.A	N.A	N.A	N.A
		8%	percentage	12%	percentage	N.A	N.A	N.A	N.A

*** N.A :** not applicable.

Fleet activity

Values were selected considering the following prioritization:

1. Values reported by cities in surveys conducted as part of this study.
2. Values reported in the study carried out by LatGlobal (2020)[11] for GIZ on this program.
3. Cities' own reference values.
4. An average value of the other cities was used for cities whose information was unavailable in the above-mentioned sources.

Table 11 shows values used for different metropolitan areas and cities with SITM and SETP systems.

Table 11. *Annual activity factors used to estimate program impacts in Colombia.*

City or metropolitan area	Average activity 2018 (km/year-veh)			
	Bus - Van	Minibus	Padron	Articulated - Bi-articulated
Barranquilla Metropolitan Area	72,635	58,035	51,100	82,490
Bogota Metropolitan Area	57,800	57,800	73,365	102,200
Bucaramanga Metropolitan Area	8,220	58,400	58,400	125,925
Cali Metropolitan Area	57,500	57,500	73,365	78,475
Medellín Metropolitan Area	56,739	58,765	58,765	102,200
Pereira Metropolitan Area	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
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.

11 LatGlobal, 2020. Financial and economic assessment from E-Bus Colombia study. Consultancy developed for GIZ Colombia.

4.2. GHG emissions in the program's baseline scenario

The baseline scenario shows the expected trajectory of GHG emissions in the absence of a mitigation initiative (Minambiente, 2018). In this way, the baseline scenario is a reference that helps in showing the positive impact of a bus electrification program. Based on our scenario estimates, aggregate CO_2eq emissions from all Colombian SITM and SETP systems will rise to 2.02 million tons in 2030, up from 1.27 million tons in 2018. Figure 3 shows baseline GHG emissions and the estimated contribution by fleet type.

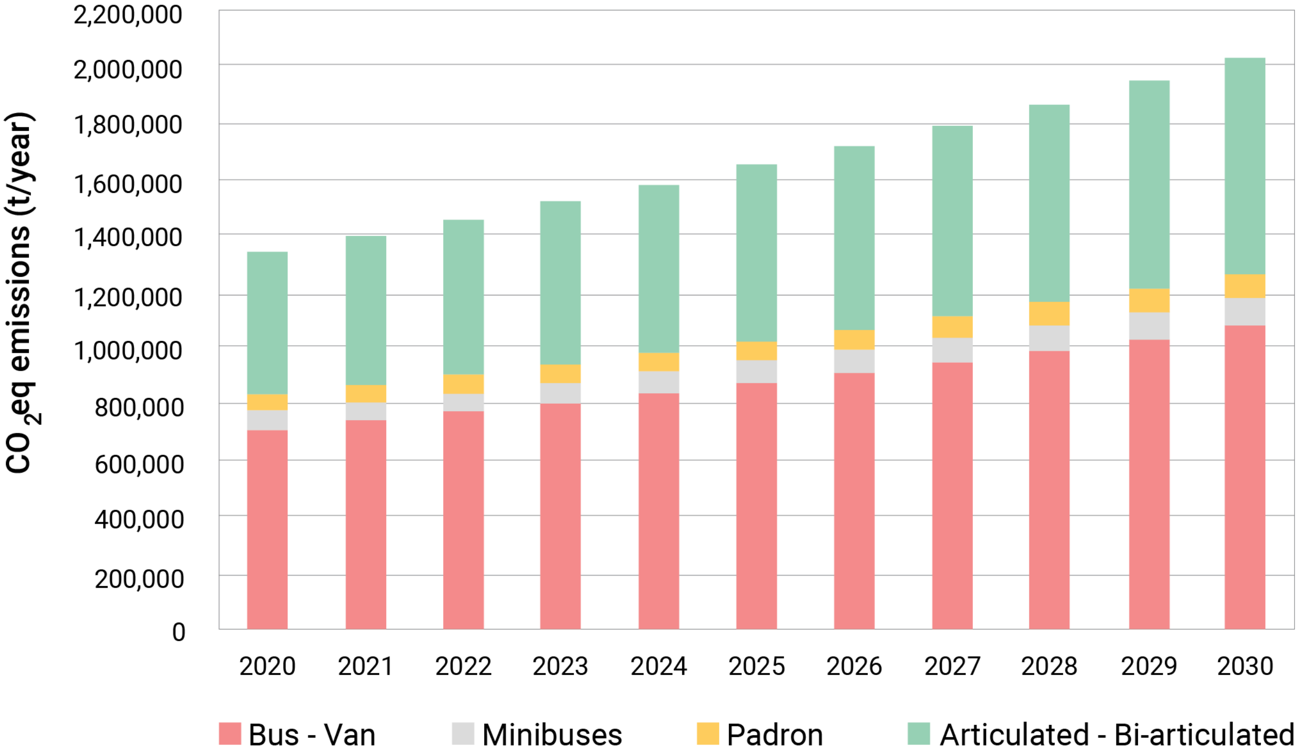

Figure 3. *CO_2eq missions in the baseline scenario by vehicle type.*
Source: *Authors' compilation.*

4.3. GHG emissions mitigation potential of the electric bus program

In order to set a mitigation target, it is necessary to develop an ex-ante projection that, based on the same baseline calculation methodology, incorporates the measures that will reduce vehicle emissions. The proposed mitigation scenario for Colombia involves increasing the share of electric vehicles up to 30 percentage points by 2030 for each bus type. In this scenario, a one-to-one substitution of buses is assumed, i.e. one electric bus replaces one diesel bus. Figure 4 breaks down the energy sources for each vehicle type.

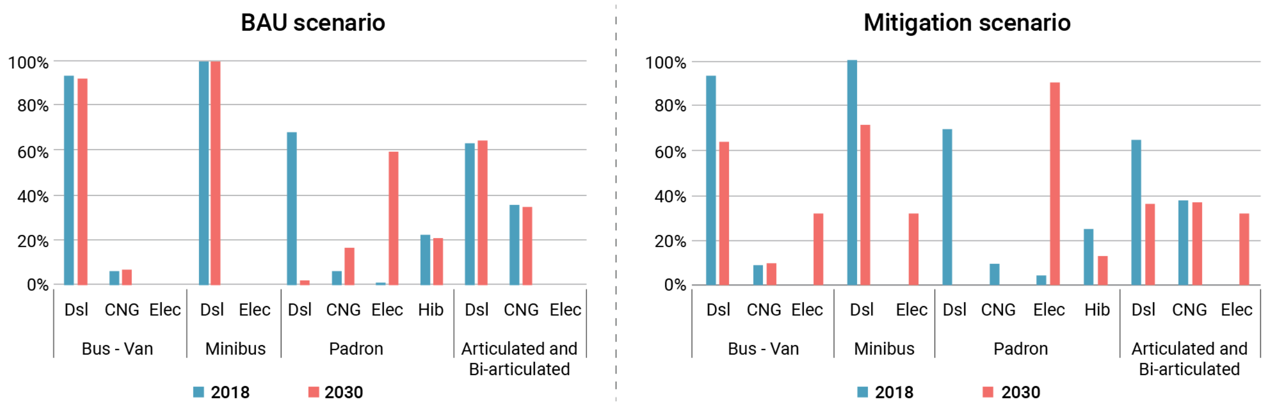

Figure 4. *Vehicle fleet energy sources in BAU and Mitigation scenarios.*

Given the existing fleet of electric buses, a 30 percentage points increase would lead to a 34% share of electric buses in the SITM and SETP systems in 2030. Presuming a 4.2% rise in passenger numbers each year up to 2030, the adoption of electric buses would need to start in 2022. Accordingly, the scenario analyzed in this section is more demanding than the goals defined by Law 1964 of 2019.

Law 1964 of 2019, approved by the Congress of the Republic of Colombia, promotes the use of electric vehicles, and establishes goals for mass transportation systems, including the adoption of a specific percentage of electric buses from 2025 onward. By 2035, 100% of the new vehicles incorporated in SITM systems must be electric. The law foresees various incentives, including discounts on technical-mechanical inspections and vehicle taxes, differentiated parking rates, and other tax exemptions. Such regulatory instruments are very useful for guiding public action and promoting the achievement of legally defined goals.

In comparison to the baseline scenario, the program's implementation would lead to approximately 7,547 additional electric buses during the analysis period. Figure 5 shows the distribution of electric buses that would be adopted given implementation of the program.

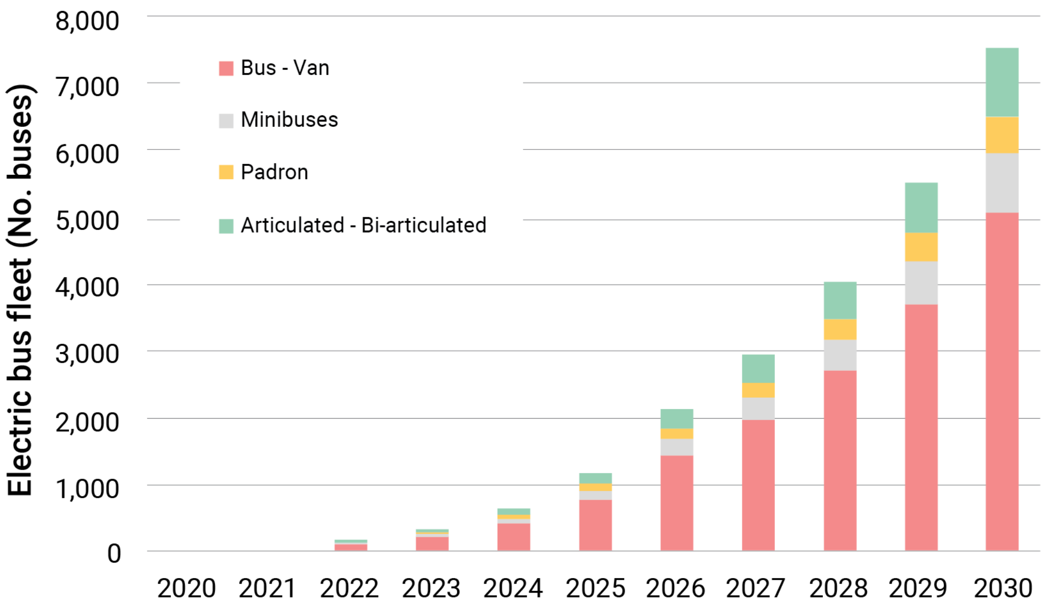

Figure 5. *Projected electric fleet given implementation of the electric bus program.*

This scenario is associated with the avoidance of **1.80 million tons of CO_2 eq** emissions over the analysis period, given the system limits defined at the outset. The mitigation corresponds to 10% of the cumulative emissions during the same period in the baseline scenario. The program's impact by type of emission source is presented in Table 12. Additionally, the program has the potential to reduce the emission of black carbon by **225.3 tons** during the analysis period. In comparison to the baseline scenario, 2030 black carbon emissions are 33% lower.

Table 12. *Change in CO_2eq emissions by source.*

CO_2eq emissions	Cumulative impact 2020-2030 million tons CO_2eq	
Combustion in fleet operation	Reduction	1.83
Combustion in electricity generation	Increase	0.22
Fossil fuel production and transportation	Reduction	0.16
Use of air conditioning systems	Reduction	0.03
Total	Reduction	1.80

Source: *Authors' compilation.*

Definition of monitoring indicators for the electric bus program

In this section we recommend aspects that should be monitored by an MRV system in the interest of developing green finance projects. These recommendations are based on input received from practicing professionals and also take existing local monitoring capacities into account. Specifically, the adopted system for Monitoring, Reporting, and Verification (MRV) 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 13 shows the indicators and their description. They are classified into primary and secondary indicators according to their relevance. The main variables used to monitor them are also presented.

Table 13. *Indicators for monitoring the electric bus program.*

Type of indicator	Indicator	Description	Monitoring variables	To whom it is reported
Follow-up (Primary)	Anual CO_2eq emission reduction (Ton CO_2eq/year)	Reduction of CO_2eq emissions generated annually by SITM and SETP buses linked to the electric bus program, with regard to the baseline scenario.	• Number of buses by fuel type and bus category (see the categories used within this report). • Fleet activity (km) by fuel type and bus category. Fuel consumption by fuel type and bus category (l/m^3/kWh /100km) • Fuel efficiency factors per bus category and fuel.	Climate Financier RENARE
Follow-up (Primary)	Anual $PM_{2.5}$ 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)	Anual 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). • Annual fleet activity (same as above).	Climate Financier
Follow-up (Secondary)	Annual concentration of particulate matter ($PM_{2.5}$ and/or PM_{10}) [12] (ug/µ3)	Annual PM concentration level at air quality monitoring stations in each city.	• Average annual concentrations of particulate matter	Climate Financier
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 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

Source: *Authors' compilation.*

[12] The number of days exceeding a given limit of the pollutant could be also an indicator. It depends on the local air quality norms.

6. Information sources and data collection tools for the MRV system

For an MRV system to work properly, it is of great importance to accurately define the information sources used and 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. As an example of this, we present in this section the information sources identified as part of the case study.

Currently, different monitoring processes are carried out in Colombia by local and national entities to monitor the operation of public transport systems. Although the objective of current monitoring is not directly related to GHG mitigation, we recommend the harnessing of existing capacities and practices when establishing the program's MRV system.

Figure 6 shows various existing options for collecting data, producing reports, and conducting audits while also 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.

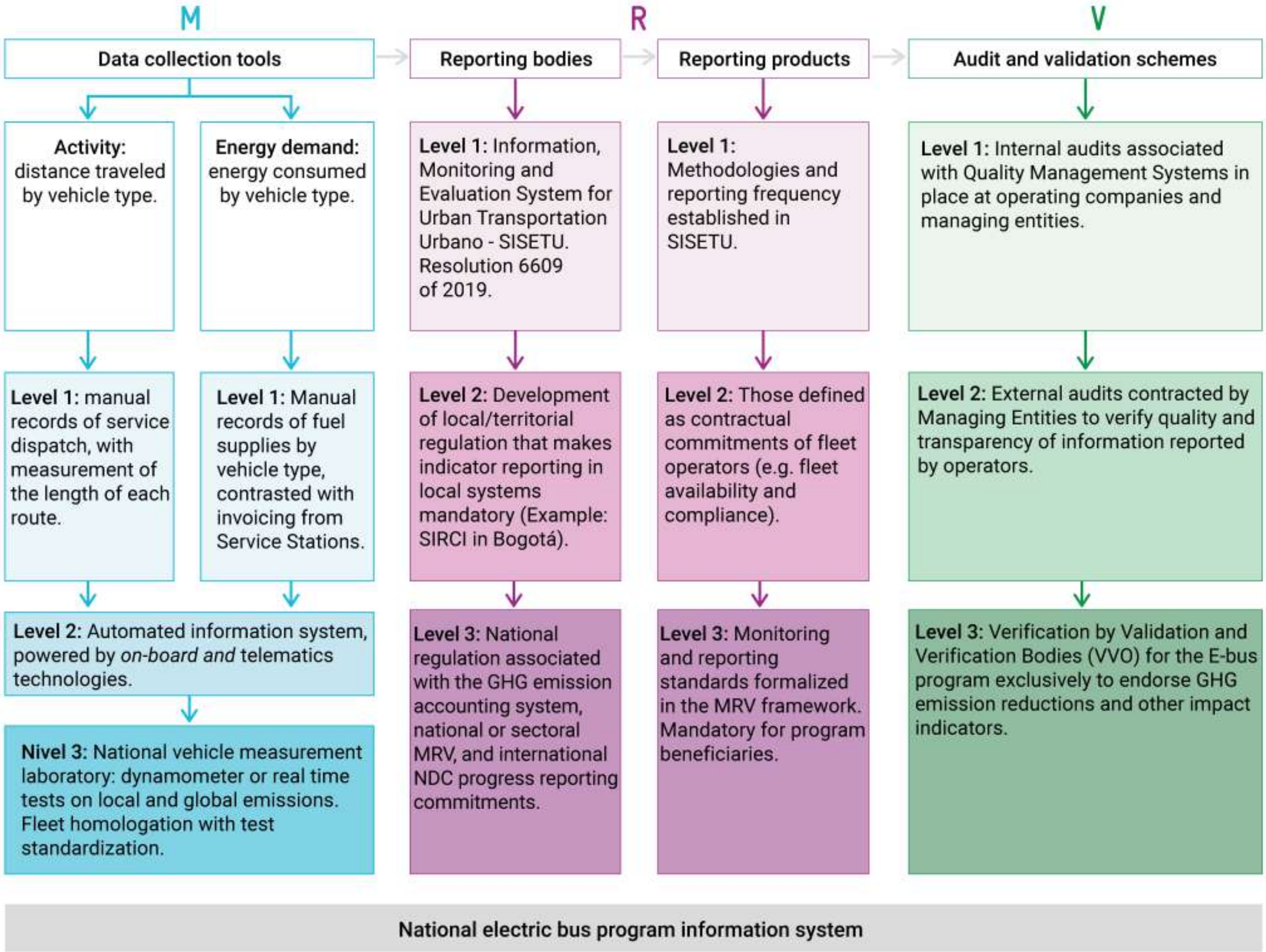

Figure 6. *Existing opportunities for data collection, reporting, and auditing.*
Source: *Authors' compilation.*

The identification of tools for collecting data may reveal technical gaps that can be addressed to augment the relevance of data. For example, by merging data from the Information, Monitoring and Evaluation System for Urban Transportation – SISETU (e.g. size of fleet, type, annual activity factors) with information contained in the National Single Transit Registry – RUNT (e.g. fleet 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, as this study was prepared, it was determined that SISETU data were not up-to-date, and RUNT data were 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 mainly 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 closely 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 information monitoring and reporting at the national level is not an unknown endeavor for public transport authorities or national institutions, but that some improvements are needed.

Developing forms of data collection that allow for homogeneous and verifiable reports is an important practice for reducing uncertainty, improving data representativeness, and guaranteeing the progressive standardization of calculations in an MRV system.

Therefore, three information record forms were developed as part of this study (see Annex). The forms are designed to allow key system stakeholders (namely, the operating companies or concessionaires, and the SITM and SETP project managing entities)[13] to monitor operations and generate the data needed to calculate emission reductions and to implement reporting and verification procedures along the information chain of custody. Accordingly, Figure 7 elaborates an information reporting flow chart within an MRV system.

[13] Managing entities are companies incorporated to implement and operate SITM and SETP systems. The iconic example is Transmilenio S.A. Managing entities are related to fleet operating and supplier companies, and money collection operators through concession contracts under the transport regulatory framework. They also manage co-financing agreements signed between local authorities and the national government, under which information reports may be defined. Investment and management decisions are made within the framework of their boards of directors, which are included as a coordinating stakeholder given their importance.

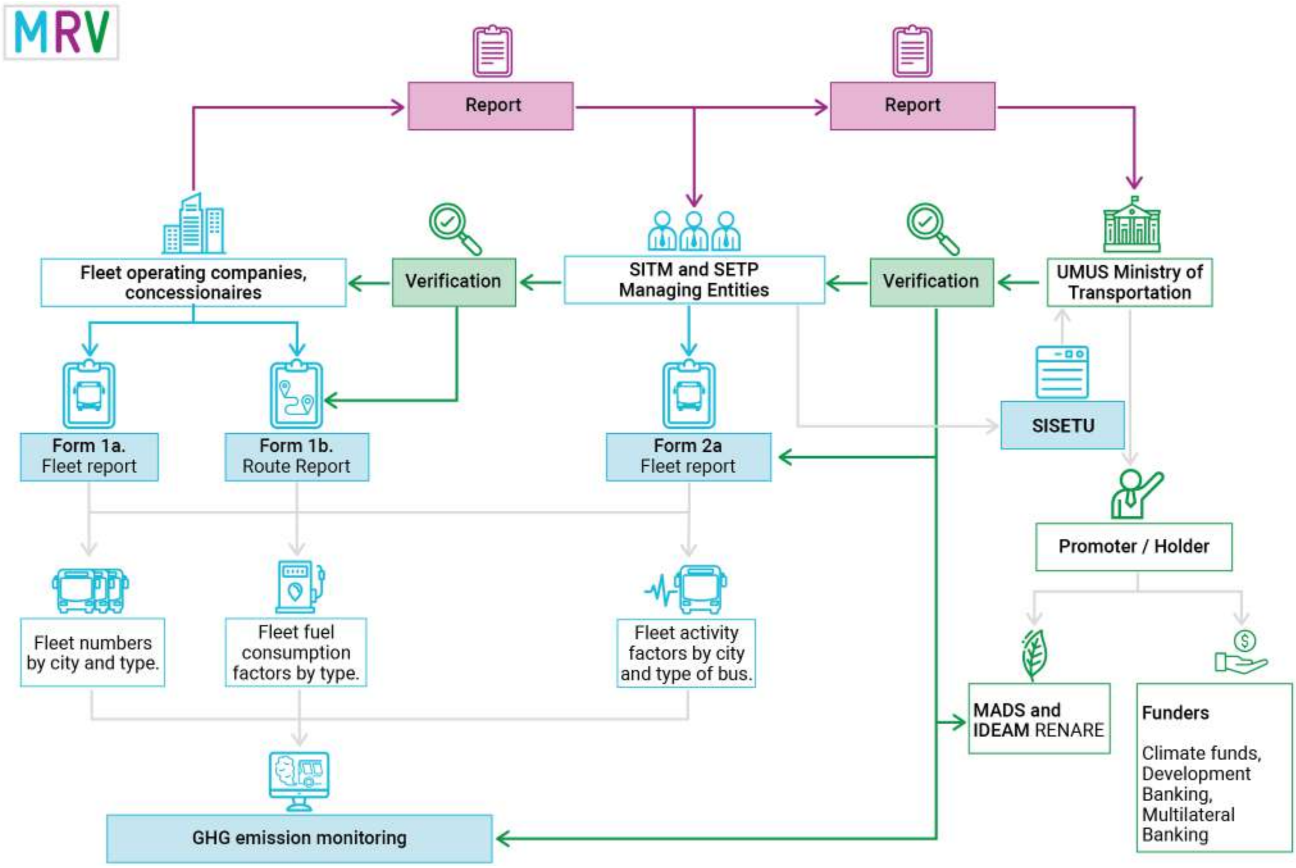

Figure 7. *MRV information reporting flow chart.*
Source: *Authors' compilation.*

7. Identification of MRV system key stakeholders

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

So, aiming at MRV implementation, 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 and transport company level up to the national level, so that data can be reported in an aggregated manner to the corresponding institutions.

Figure 8 shows a map of relations between stakeholders. Local and territorial stakeholders and national and international reporting bodies are identified. The figure highlights the possible information flows and financial resources that will depend on the formalization of the program. Regarding finances, two main alternatives are foreseen for channeling resources from international climate funds or multilateral banks to fleet operators:

1. The first alternative for channeling resources is through 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 SITM and SETP systems will lead the execution of infrastructure works 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 disbursement being coordinated by the Ministry of Finance, the National Planning Department, and the Ministry of Transport. 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. The second alternative for channeling resources is through development banks and local commercial banks that reach out to operating companies directly. Under this option, the operating companies manage the purchase of buses based on mandates by local authorities, local environmental regulations, or financial rationality (in the event of electric buses having lower total operating costs than their conventional counterparts).

In any case, local governments (in particular, mayors' offices and environmental and transport departments) ought to take a leading role in fostering the adoption of zero emission bus fleets. While national governments may offer public policy guidelines or provide economic and financial incentives, it is at the local level where the actual transformation takes place. Indeed, international experience has shown that in places where electric vehicle adoption rates are the highest, the crucial factor has been the local governments defining more ambitious goals and standards than the ones set by national governments.

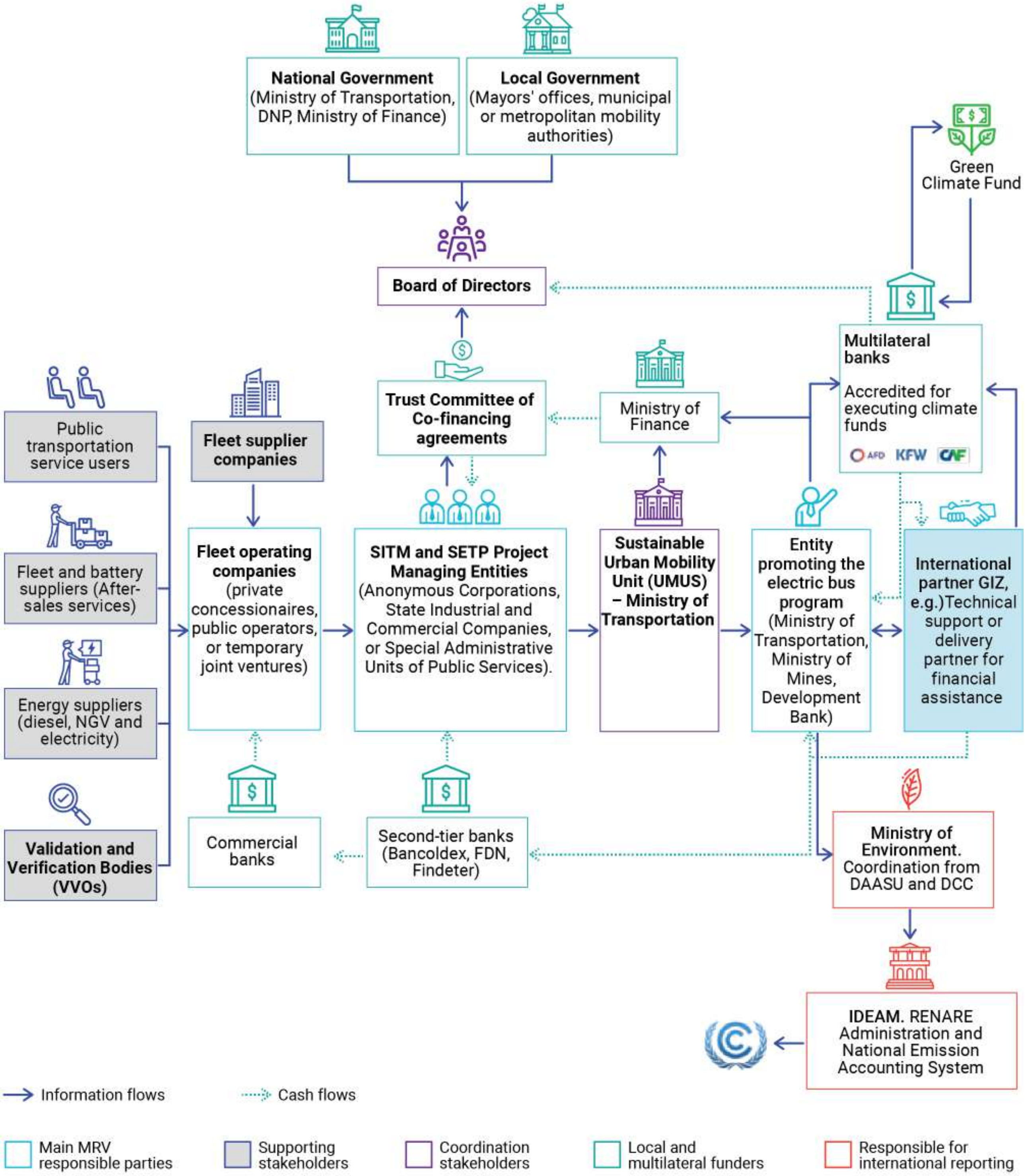

Figure 8. *Map of stakeholders and relations within the electric bus program and the MRV system framework.*
Source: *Authors' compilation.*

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Annex. Public transport data collection forms for the MRV system of the electric bus program.

One technique for reducing uncertainty, improving the representativeness of data, and guaranteeing the progressive standardization of MRV calculations is to establish information collection forms that allow for homogeneous and verifiable reports. The three information-gathering forms presented in this annex were designed for Colombia's electric bus program.

These forms will allow the operating companies or concessionaires and the SITM and SETP managing entities to monitor transport operations data; they will also facilitate the estimation of emission indicators. As the forms were being developed, the project team sought to emphasize information that could be used to compare results from different methodologies and verify the consistency of the primary information reported. Similarly, various options for improving information gathering and analysis were considered. Additionally, the forms serve as a basis for implementing reporting and verification procedures along the information chain of custody.

The forms presented here serve the following purposes:

Form 1a

- Form 1a was designed to record information at the operating company level.
- It is used to record fleet characterization information discriminated at the bus level. It also includes information such as activity factors, passengers transported per year, days in operation per year, and fuel consumption.

Form 1b

- Form 1b was designed to record information at the operating company level.
- It presents information discriminated by route. It includes information such as route length, passengers transported, daily dispatches by route, and predominant type of roadway.

Form 2

- Form 2 was designed to record information at the managing entity level. It enables the consolidation of annual information from fleet operators.
- It includes information discriminated by operator or concessionaire. It includes fleet characterization and operation information.

Form 1a. Operating companies vehicle information report

GHG emission monitoring, reporting, and verification system for the national electric bus program.

Responsible party / Contact details	
Company / concessionaire:	
Contracting Managing entity:	
City of operation:	
Reporting year:	
Name of person in charge:	
Position:	
E-mail:	
Telephone number:	

Summary of indicators

14. Total number of linked vehicles	0
Microbus	
Bus	
Van	
Padron	
Articulated	
Bi-articulated	
15. Average age of fleet	

16. Total energy consumption per year	
Diesel (gallons/year)	
CNG (m^3/year)	
Electricity (MWh/year)	
17. Total kilometers traveled per year	
18. Average fleet performance	
19. Passengers transported annually	
20. Anual refrigerant consumption (MAC)	

Characteristics of linked fleet

Please enter the following information for each and every one of the vehicles linked to your company for passenger collective and mass public transportation according to the information provided by the *on-board* fleet management systems or daily operation manual records . Insert as many rows as necessary to include all your company vehicles.

Should you need further clarification for indicator registration, you can find a description of each of the fields included in this form in the “Definitions” sheet.

1. Type of vehicle	2. Plate	3. Model year	4. Energetic	5. Rendimiento (gal/km, m^3/km, KWh/km)	6. Emission standard	7. Capacity (pax)		8a. Does it have air conditioning (AC)?	8b. What type of AC system does it use?	8c. How often is maintenance performed?	9. What type of refrigerant does it use?	10. Kilometers traveled (km/year)			11. Passengers transported (pax/year)	12. Days in operation per year	13. Fuel consumption (gal, m^3, MWh/year)
						Seated	Standing					Operating	Empty	Total			

Form 1b. Report of service routes provided by operating companies

GHG emission monitoring, reporting, and verification system for the national electric bus program.

Responsible for reporting / Contact details			
Company / concessionaire:		City /Metropolitan area:	
Contracting Managing Entity:		Reporting year:	
Name of person in charge:		E-mail:	
Position:		Contact telephone number:	

Summary of indicators	
21. Total number of routes	
22. Average IPK of routes	
23. Average frequency routes	
24. Average length of routes	
25. Average number of passengers per route and year	

Type of road	Type of route
Mixed lane	Trunk
Segregated trunk	Pre-trunk
Bus lane only	Feeder
	Complementary
	Zonal

Routes characteristics

26. Type of route	27. Name of the route	28. Length (km)	29. Frequency (No. services/day)	30. Passangers transported	31. Number of daily dispatches	32. IPK (passengers kilometer index)	33. Type of roadway

Definitions

1.Vehicle class	Name given to a motor vehicle in accordance with its usage, configuration and technical specifications. In the case of public transport vehicles, it corresponds to the type of vehicle registered in the RUNT and the approval card, according to the size, wheelbase and offer of chairs. The vehicle classes contemplated include: Minibus, van/bus, Padrón, Articulated and Biarticulated.
2. Plate	Public document valid throughout the national territory, which externally and privately identifies a vehicle.
3. Year model	Year assigned by the manufacturer or assembler to the vehicle model, according to the declaration of dispatch for consumption.
4. Energetics	Source of energy for vehicle operation. In this format the following energy are considered: Diesel, Gasoline, Vehicular Natural Gas, Electricity, or others (according to technological developments).
5. Performance	It refers to the relationship between the energy we supply to the vehicle and the useful energy translated into motion (distance travelled). It is expressed in units of volume consumed per kilometer (in the case of fossil fuels) and in electricity demand per kilometer (in the case of electrical energy). It is estimated from the fuel consumption and the kilometers of service of each of the vehicles, which can be compared with the information recorded in the technical data sheet of homologation of the vehicles. Information of actual fleet operating conditions is key to the management of the service.
6. Emission standard	It refers to the emission limits of local air pollutants that motor vehicles comply with, according to environmental regulations and certificates from factory approval procedures, verified at the place where the vehicles are sold. This format includes the euro standards adopted by Colombian regulations: Pre-Euro,EuroII, Euro III, Euro IV, Euro V, Euro VI and others. The identification of the emission standard will allow to update the calculations of emissions that affect air quality, especially fine particulate matter ($PM_{2.5}$).
7. Passengers capacity	It is the number of people authorized to be transported in a vehicle. The format differentiates the availability of space for seated passengers, according to the offer of chairs, and standing passengers.
8a. Does it have air conditioning (AC)?	Since the MRV includes HFCs emissions in its calculations, it is necessary to identify which vehicles have air conditioning systems to calculate the potential emissions of refrigerants.
8b. What type of AC system does it use?	Indicate the brand, series and configuration of the air conditioning system installed on the bus. This determines the type of possible leaks of the cooling compounds.
9. What type of refrigerant does it use?	This information is important for GHG emissions calculations. According to the national inventory of Ozone Depleting Substances (ODS), in the mobility sector there are two products that are used in the country: HFC-134a and R-409. This column should identify what type of refrigerant each bus uses.
10. Kilometers travelled	Measurement of kilometers traveled per year according to average reports of logical units on board vehicles. In case of not having these elements of automatic measurement, the daily direct measurement of operation in the field with odometer will be reported and from this it will be estimated in annual value.
11. Passengers transported anually	Total number of passengers transported per year for each of the vehicles. In the zonal, complementary and pre-trunk services, this figure is obtained from the validations in the collection units with contactless cards that are installed in each of the vehicles. In case of not having this technology, manual readings and records can be reported from mechanical turnstiles installed in each of the buses. For vehicles operating in trunk services, this indicator will be estimated considering the validations in the collection units installed at the stations. This information may be supplemented and compared with that obtained from frequency and visual occupancy exercises in a representative sample of the fleet linked to each operator during working days (Wednesdays) and public holidays.
12. Days in operation	Total number of days in the year the vehicle was in operation. It allows to identify the intensity of use and differentiate the vehicles that were in reserve or out of operation due to repair or maintenance procedures.

Definitions

13. Fuel consumption	Record of annual energy consumption used by each vehicle. It can be obtained from tanking or loading operations. This information can also be obtained with electronic devices (e.g. E-Button chips that are synchronized with fuel dispensers or electrolines), or by other methods validated by the managing bodies.
14. Total number of linked vehicles	Sum of vehicles linked to the dealer/fleet operator, discriminated by vehicle class. The information can be checked annually with the RUNT, which must include the complete lists of vehicles owned by each of the companies.
15. Average age of fleet	For each vehicle, it corresponds to the subtraction between the reporting year and the model year. The average of all vehicles linked to the fleet is then estimated.
16. Total energy consumption per year	Report of energy consumption billed to fleet operators by suppliers. This indicator must coincide with the sum of the consumptions reported for each of the vehicles. This consumption is discriminated in three main types of energy: Diesel (gallons/year), Vehicular Natural Gas (m^3 /year) and Electricity(MWh/year).
17. Total kilometers traveled per year	Sum of the kilometers traveled by the entire vehicle fleet of the dealership, according to the vehicle-to-vehicle records recorded in indicator number 10.
18. Average fleet performance	It corresponds to the division between the energy consumption of the entire fleet over the total activity of all vehicles linked to the operating dealership.
19. Passengers transported annually	Total number of passengers transported per year by the entire fleet of the concessionaire or operating company. It corresponds to the sum of the values recorded for each of the vehicles in indicator 11.
20. Annual refrigerant consumption (MAC)	This value is obtained from the information provided by the companies in charge of the management of refrigerants for air conditioning equipment.
21. Total number of routes	Number of routes operated by the concessionaire.
22. Average IPK of routes	Estimation of the total number of registered passengers transported by the dealership's routes on a working day divided by the kilome-ters travelled in services. The average IPK for each month should be calculated and reported.
23. Average frequency of routes	Annual average of the values recorded in indicator 29 for all routes.
24. Average length	Annual average of the values recorded in indicator 28 for all routes.
25. Average number of passengers per route	Annual average of the values recorded in indicator 30 for all routes.
26. Type of route	It corresponds to the classification of the route according to its operational conditions and with the infrastructure used by the vehicles that operate it. Five path types are recognized in this record: **Trunks:** Trunk routes are services that operate on exclusive lanes and stop at stations and portals located in the center of the road. **Pretrunks:** They correspond to routes that operate on the main and secondary roads, connect different areas of the city and are integrated with the trunk system in some stations (dual buses) and/or mixed with traffic on priority lanes. **Feeders:** These are the routes that help to mobilize the users of the system to and from the areas surrounding the portals, intermediate stations or whereabouts of the Transport System. **Complementary:** Similar to feeder routes, but with payment on board and integrated with trunk service. **Zonal:** They operate by main and secondary roads and connect different areas of the city. Any service provided with buses that is part of the transport system or is integrated into it is included in the group of zonal services except for those specifically highlighted as trunks, pre-trunks or feeders.

Definitions

27. Name of the route	The record of the name of each route, as recognized by users.
28. Length (km)	Route length (km), including distance from the yards to the starting point, and from the end point to the yards. This data, together with the frequency of dispatch, allows to estimate the activity factor of each route and compare it with the measurement of mileage traveled from odometer registration or satellite mapping with units on board.
29. Frequency (No. services/hour)	Lapse in minutes between dispatches of vehicles that fulfill the same route.
30. Passengers transported	Sum of passengers registered in all buses that meet the registered route. In the event that it is not possible to obtain an actual record from collection systems in each of the vehicles, an estimate must be reported from alternative modes of calculation.
31. Number of daily dispatches	Number of dispatches on each route per day, from the start of the daily operation to its completion. Since this may vary throughout the year, the average number of dispatches on Wednesdays should be reported for the annual registration.
32. IPK	This indicator allows to evaluate the way in which the main product of the system, the kilometers traveled in operation, are reflected in its main operating result, the paid passengers. It is calculated by dividing the number of passengers registered daily over the kilometers traveled daily on each of the routes.
33. Type of roadway	Spatial and physical configuration of the roads through which the different routes operated by the concessionairecirculate. They can be segregated trunks, preferential lanes without physical segregation and mixed carriageways.

Form 2. Managing Entity Information Report

GHG emission monitoring, reporting, and verification system for the national electric bus program.

a. Responsible party / Contact details	
Managing entity:	
City or cities of operation:	
Reporting year:	
Name of person in charge:	
Position:	
E-mail:	
Contacto telephone number:	
Total number of concessionaires included:	

b.Summary of indicators	
1. Total number of vehicles by type	0
Microbus	
Bus	
Van	
Padron	
Articulated	
Bi-articulated	
2. Average age of fleet	

c. Operational indicators

3. Total energy consumption per year	
Diesel (gallons/year)	
Nat Gas (m^3/year)	
Electricity (MWh/year)	
4. Total kilometers traveled per year	
5. Anual refrigerant consumption (MAC)	
HFC-134A	
R-437A	

6. Average IPK	
7. Average fleet performance	
Diesel (gal/km)	
Nat Gas (m^3/km)	
Electricity (kWh/km)	
8. Passangers transported	
9. Public transport travel demand served by the Managing entity	

10. Number of vehicles per emission standard	
Pre-Euro	
Euro II	
Euro III	
Euro IV	
Euro V	
Euro VI	
Another	

d. Consolidated operating records of fleet operators

Please enter the following information for each and every one of the concessionaires that operate the routes planned by the Managing Entity according to the information provided in forms 1a and 1b (after verification by those responsible for the Managing Entity operation).
Should you need further clarification for indicator registration, you can find a description of each of the fields included in this form in the "Definitions" sheet.

11. Name of operator/concessionaire	12. Kilometers traveled		
	Operating	Empty	Totals

13. Total energy consumption per year			14. Passangers transported (pax/year)	15. Predominant emission standard	16. IPK
Diesel (gallons)	CNG (m^3)	Electricity (MWh)			

e. Consolidated fleet characterization

Please enter the following information for each and every one of the concessionaires that operate the routes planned by the Managing Entity according to the information provided in forms 1a and 1b, after verification by those responsible for the Managing Entity operation.

Should you need further clarification for indicator registration, you can find a description of each of the fields included in this form in the "Definitions" sheet.

11. Name of operator / concessionaire	Vehicle fleet									
	17.Type of vehicle	18. In operation			19. Out of service / scrapped			20. Programmed acquisitions by contract		
		Diesel	CNG	E-Bus	Diesel	CNG	E-Bus	Diesel	CNG	E-Bus

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