ENVIRONMENTAL BENEFITS FROM A SUSTAINABLE BUS RAPID TRANSIT SYSTEM IN COLOMBIA

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Introduction

- Transportation is the largest source of emissions to the atmosphere in Colombia, both greenhouse gases (GHG) and criteria pollutants.
- Bogota, Colombia´s capital, implemented a Bus Rapid Transit system (Transmilenio) in 2000, and since then the fleet has been growing and expanding throughout the city. Nowadays, 100% of Transmilenio buses operate with diesel (Euro II, IV, V)
- In this work, we estimate emission reductions for 2030 from low or zero emissions buses and conduct air quality modeling to assess environmental benefits.
- PM2.5 emission reductions larger than 95% can be achieved with electric, natural gas and Euro VI diesel buses. However, CO_2 emissions reductions are lower for diesel than natural gas or electric buses.
- Along with environmental concerns, economic and logistic issues are considered when choosing bus technologies.

Materials and Methods

- Emissions were calculated as the product of emission factors and vehicular activity. EFs were collected from different studies and international references.
- A base case was defined for 2030 projecting vehicular growth but no change in bus bus tecnologies.
- Six scenarios were proposed implementing zero or low carbon technologies.

Bus type	Technology	PM10 (g/km)	PM2.5 (g/km)	CO_2 (g/km)	CO (g/km)	NO_x (g/km)	SO_2 (g/km)
 www.scmama.com	Euro II	0.210	0.193	1,254	28.9	21.5	0.027
	Euro IV	0.094	0.087	1,609	15.3	15.0	0.027
	Euro V	0.043	0.039	1,455	10.8	16.0	0.025
	Euro VI	0.002	0.002	1,455	10.7	3.20	0.025
 www.transmilenio.gov.co	Euro IV	0.047	0.043	1,490	17.0	16.4	0.027
	Euro V	0.047	0.043	1,392	7.3	16.4	0.025
	Euro VI	0.002	0.002	1,392	7.3	3.2	0.025
 www.gerente.com	Euro VI Natural gas	0.003	0.003	377.7	32.5	2.0	0

Figure 1. Compilation of emission factors used in the Bogota´s BRT system

Results

Table 1. Emission scenario reduction in the Bogota´s BRT

SCENARIOS	Emissions (tons/year) at 2030					
	PM10	PM2.5	NOx	SO2	CO	CO2
Base Case	6.53	6.01	1329	3.45	1218	194801
1 (100% DIESEL EURO V)	6.22	5.69	1329	3.43	1178	193694
	-4.8%	-5.2%	0.0%	-0.7%	-3.3%	-0.6%
2 (100% DIESEL EURO VI)	0.27	0.25	267	3.43	1178	193694
	-95.8%	-95.8%	-79.9%	-0.4%	-3.3%	-0.6%
3 (80% DIESEL EURO VI, 15% GNV, 5% ELEC)	0.36	0.33	310	2.75	1608	162704
	-94.5%	-94.5%	-76.7%	-20.4%	32.1%	-16.5%
4 (30% DIESEL EURO VI, 40% GNV, 30% ELEC)	0.28	0.25	188	1.73	2057	114130
	-95.8%	-95.8%	-85.8%	-50.0%	68.9%	-41.4%
5 (100% GNV)	0.41	0.38	165	0.00	4440	51659
	-93.7%	-93.7%	-87.6%	-100.0%	264.6%	-73.5%
6 (100% ELEC)	0.00	0.00	0.00	0.00	0.00	0.00
	-100%	-100%	-100%	-100%	-100%	-100%

GNV: NATURAL GAS; ELEC: ELECTRIC FLEET

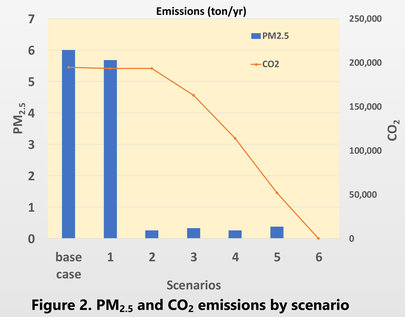

Figure 2. $PM_{2.5}$ and CO_2 emissions by scenario

Main findings

- Having an electric fleet (scenario 6) represents 100% reduction in PM2.5 and CO_2 emissions.
- Scenarios 2 through 5 comprise PM2.5 reductions larger than 93% with respect to base case, but reductions in CO_2 emissios are smaller than scenario 6.
- A full fleet of Euro VI buses can (scenario 2) substantially reduce PM2.5 emissions (~96%), but does not reduce CO_2 with respect to base case.
- A full fleet of natural gas buses (scenario 5) achieves both PM2.5 and CO_2 emission reductions.
- A mix fleet of diesel, natural gas and electric vehicles represents a better opportunity to reduce both PM2.5 and CO_2 emissions.

Table 2. Oportunities and challenges of emission reductions scenarios

Scenario	Opportunities	Challenges
1 & 2	• Infraestructure in place for diesel storage and distribution • Well-known bus maintenance and operation programs results in lower costs •	• Transition towards lower or zero carbon technologies • Unpredictable fossil fuel prices • Health externalities for the use of fossil fuels
3 & 4	• Introduction of low and zero carbon technologies • Transition towards diesel elimination from public transportation	• Development of infraestructura for natural gas storage and distribution • Development of infraestructura for electric battery charging • Health externalities for the use of fossil fuels
5	• Introduction of low carbon technologies • Transition towards diesel elimination from public transportation	• Development of infraestructura for natural gas storage and distribution • Supply of natural gas in the future
6	• Introduction of zero carbon technologies • Stability of electricity prices, mainly hydrogeneration	• Development of infraestructura for electric battery charging

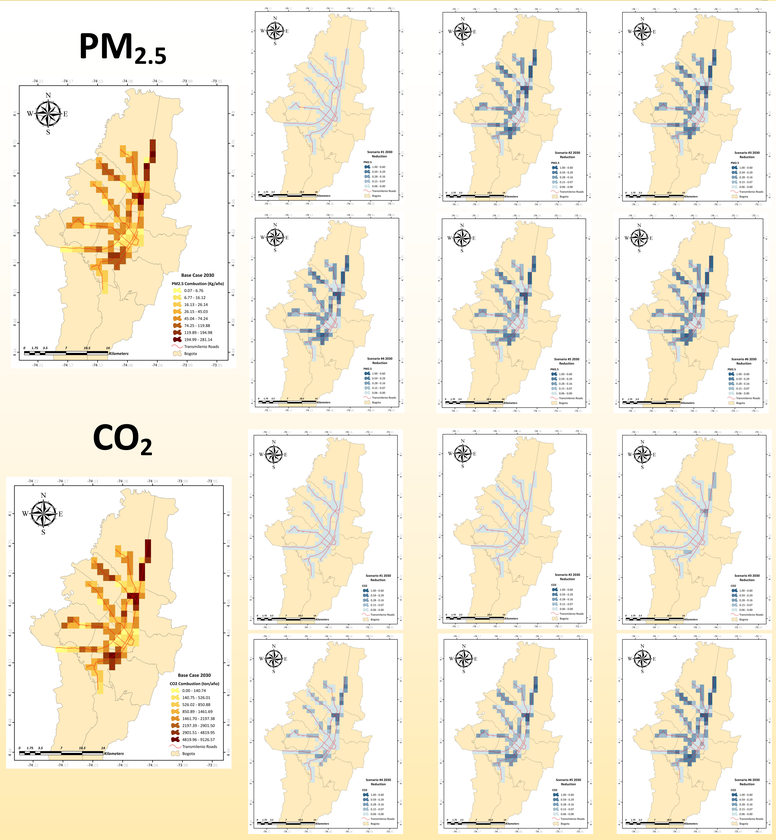

Figure 3. Emission reduction for PM2.5 and CO_2 under different scenarios for BRT in Bogota

Conclusions

- PM2.5 emission reductions larger than 95% can be achieved with electric, natural gas and Euro VI diesel buses. However, CO_2 emissions reductions are lower for diesel than natural gas or electric buses.
- Along with environmental concerns, economic and logistic issues are considered when choosing bus technologies.

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