Methodology to design and select the best emission reduction strategies for urban passenger transport

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CASAP IX
CONGRESO COLOMBIANO Y CONFERENCIA INTERNACIONAL DE CALIDAD DE AIRE, CAMBIO CLIMÁTICO Y SALUD PÚBLICA

Outline IAM to design and select the best emission reduction strategies for urban passenger transport

Step 1

Total emissions (direct and indirect)

Well-to-Wheel emission inventory estimation

Original Paper | Open Access | Published: 13 February 2023

Well-to-Wheels emission inventory for the passenger vehicles of Bogotá, Colombia

Y. Cuéllar-Álvarez, M. A. Guevara-Luna, L. C. Belalcázar-Cerón & A. Clappier

International Journal of Environmental Science and Technology (2023) | Cite this article

379 Accesses | 9 Altmetric | Metrics

Step 2

Classification of technologies using total emissions

Comparison of Well-to-Wheel emissions and ranking of the abatement strategies

Research Article | Published: 24 May 2022

Well-to-wheel emissions and abatement strategies for passenger vehicles in two Latin American cities

Yohén Cuéllar-Álvarez, Alain Clappier, Mauricio Osses, Philippe Thunis & Luis Carlos Belalcázar-Cerón

Environmental Science and Pollution Research 29, 72074–72085 (2022) | Cite this article

231 Accesses | 3 Altmetric | Metrics

Step 3

Classification of technologies using total emissions and cost (TOC)

Well-to-wheel emissions and total ownership cost from current and future road passenger transport vehicles

Step 4

Comparison between the different modes

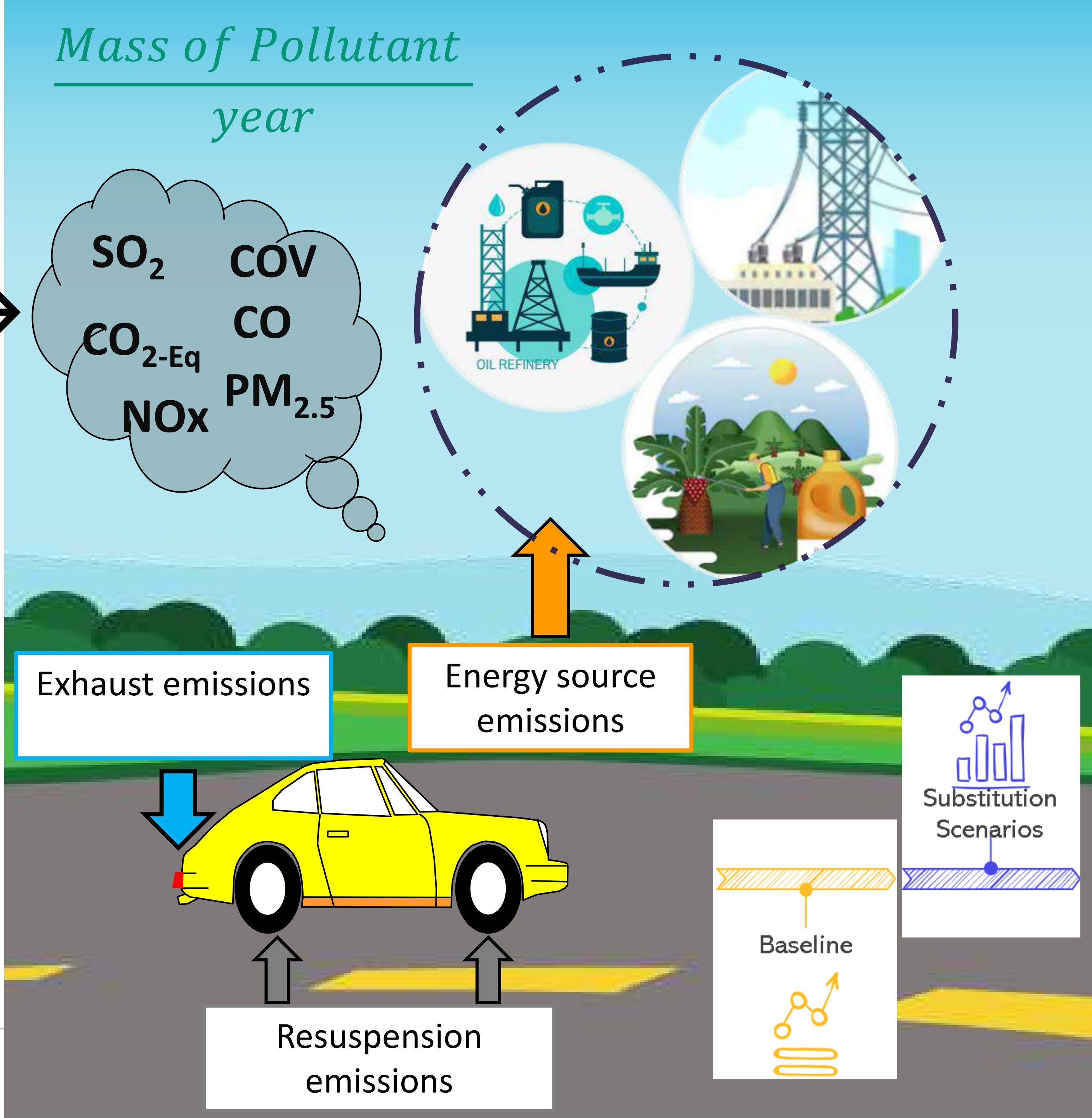
Environment, safety-related risk, and social welfare trends assessment of transport modal share

Step 1.

Well-to-Wheel emission inventory estimation

Base year: **2015**

Pollutants →



Direct emissions

- Exhaust (Copert 2018)
- Wear and dust resuspended in the roads (US EPA 2001, EMEP/EEA 2016)

Indirect emissions

- Software: **OpenLCA®**
- Database: **Ecoinvent 3.4**

Manufacture of vehicles and their parts is* ***not included*.

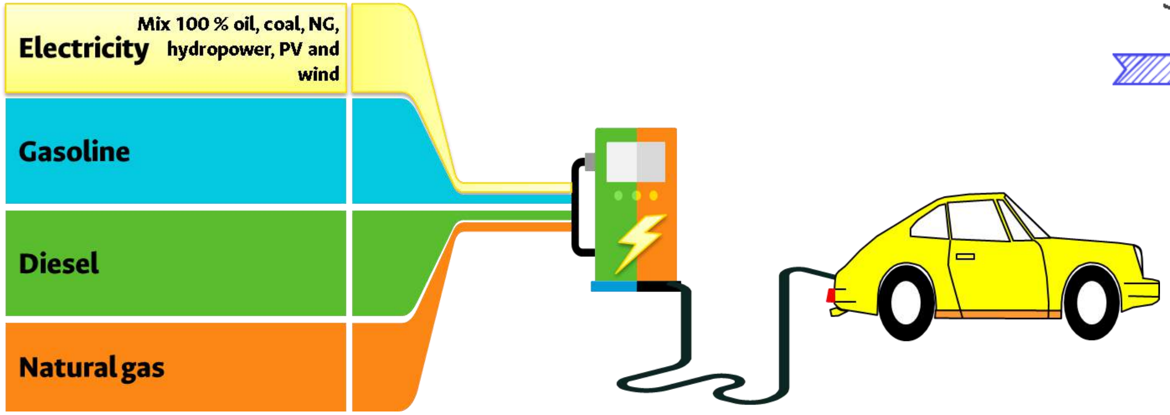
Step 2.

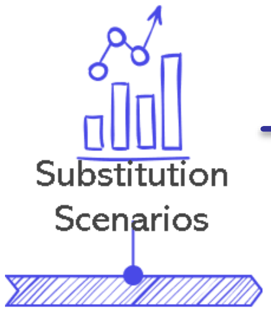
Comparison of Well-to-Wheel emissions and ranking of the abatement strategies

Base year: 2015

- Activity kept at baseline VKT values.

Scenarios

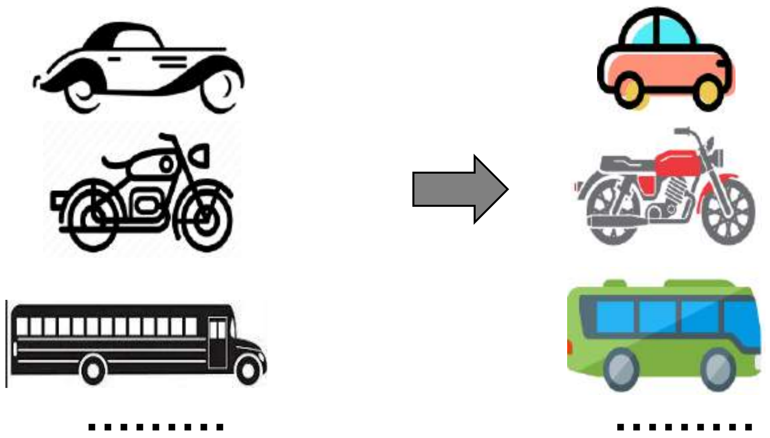




Manufacture of vehicles and their parts is **not included.*

1. Replacing **all current fleet** vehicles with **newer combustion** technologies.

Pre - Euro, Euro 1, 2, … → **Euro 5, 6**

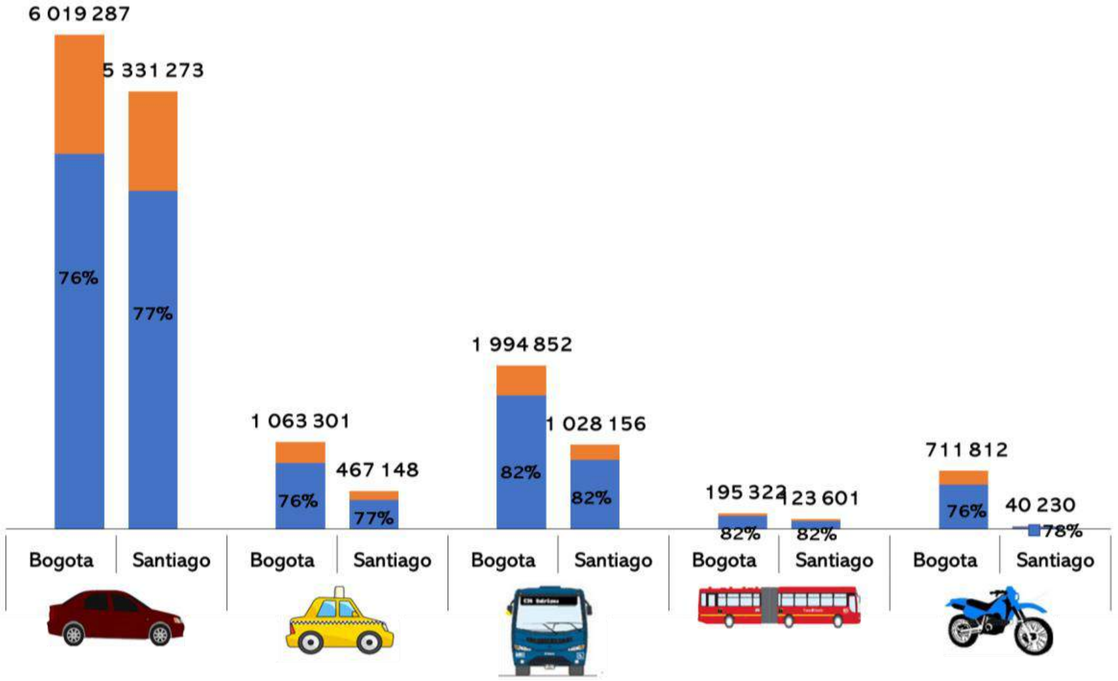


2. Changing **the electricity** production for **battery electric** vehicles.

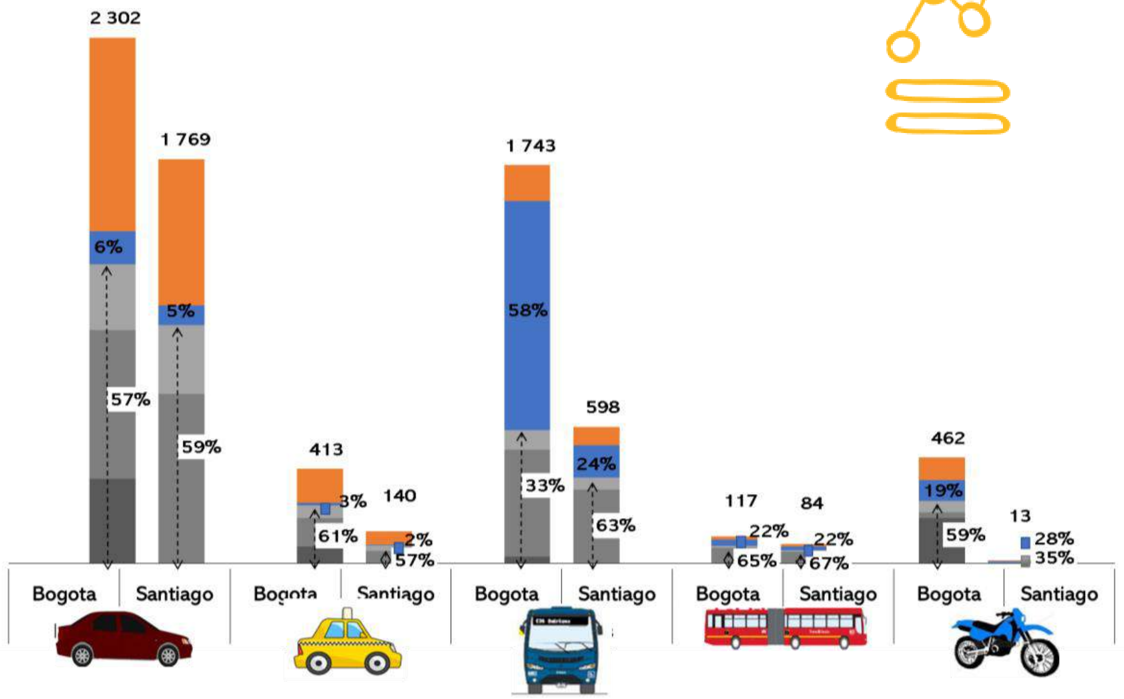
Mix (%)	Bogotá	Santiago
Hydropower	87	27
Thermopower	12	56
Wind and solar	< 1	15

Baseline WTW Emissions [t. year^{-1}] – Comparison Emissions Inventories

CO_2-Eq



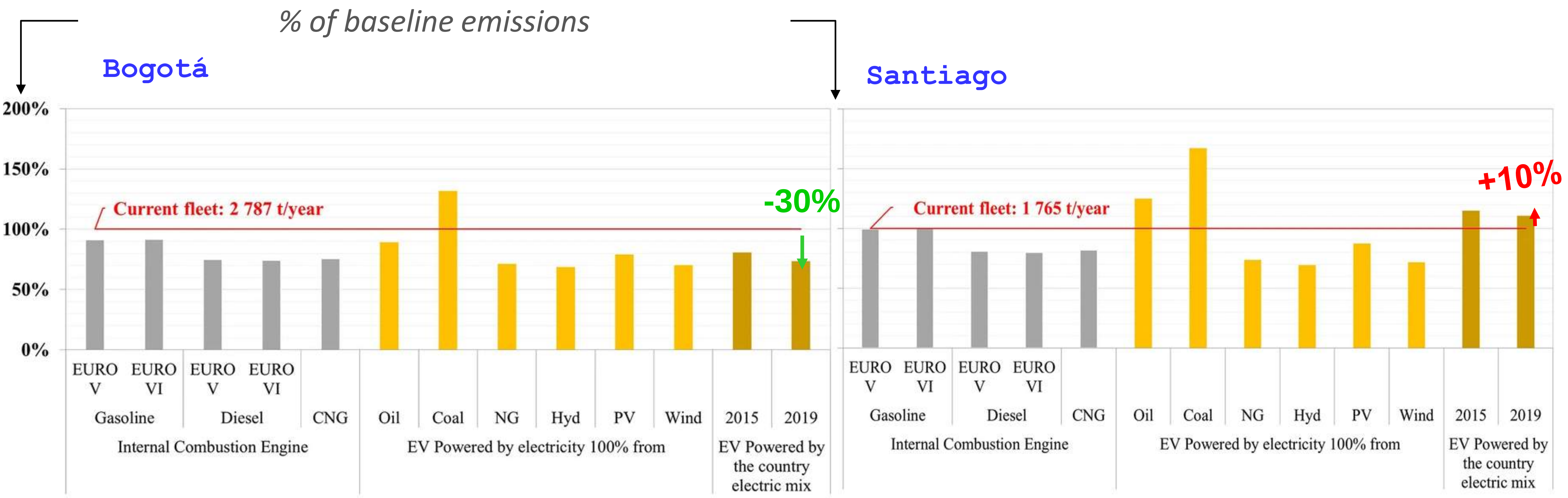
$PM_{2.5}$



■ Indirect emissions
■ Direct emissions - Wear
■ Direct emissions - Unpaved resuspension
■ Direct emissions - Exhaust
■ Direct emissions - Paved resuspension

Manufacture of vehicles and their parts is* ***not included**.*

Total *passenger car* emissions (direct + indirect) relative to the emissions of the current fleet - $PM_{2.5}$



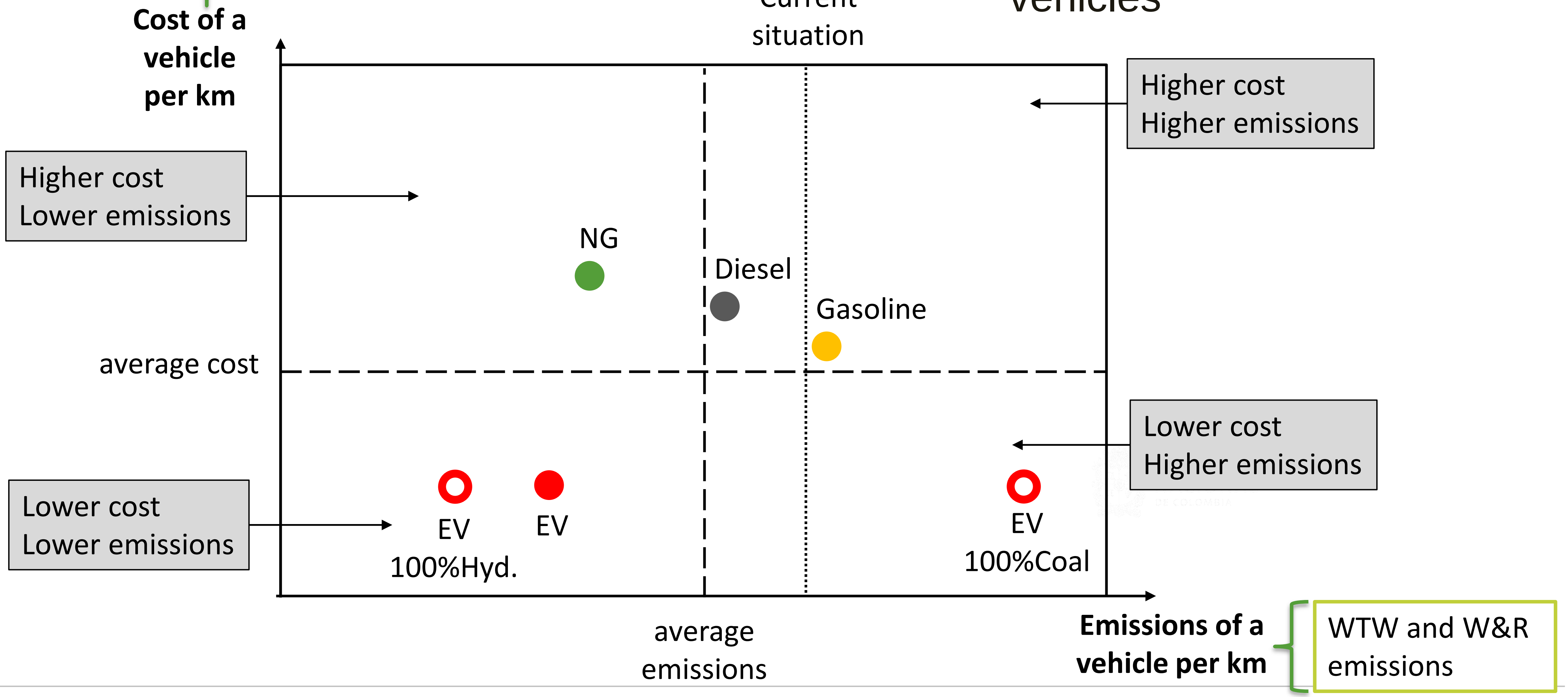
- **Electric vehicles reduce** direct emissions, **except $PM_{2.5}$** emissions.
- **W&R** is a **crucial** source of **$PM_{2.5}$** in both cities and must be better controlled.

Manufacture of vehicles and their parts is **not included.*

Step 3.

Well-to-wheel emissions and total ownership cost from current and future road passenger transport vehicles

$$TOC = C_y^{Cap*} + C_y^{Oper} + C_y^{Rep}$$

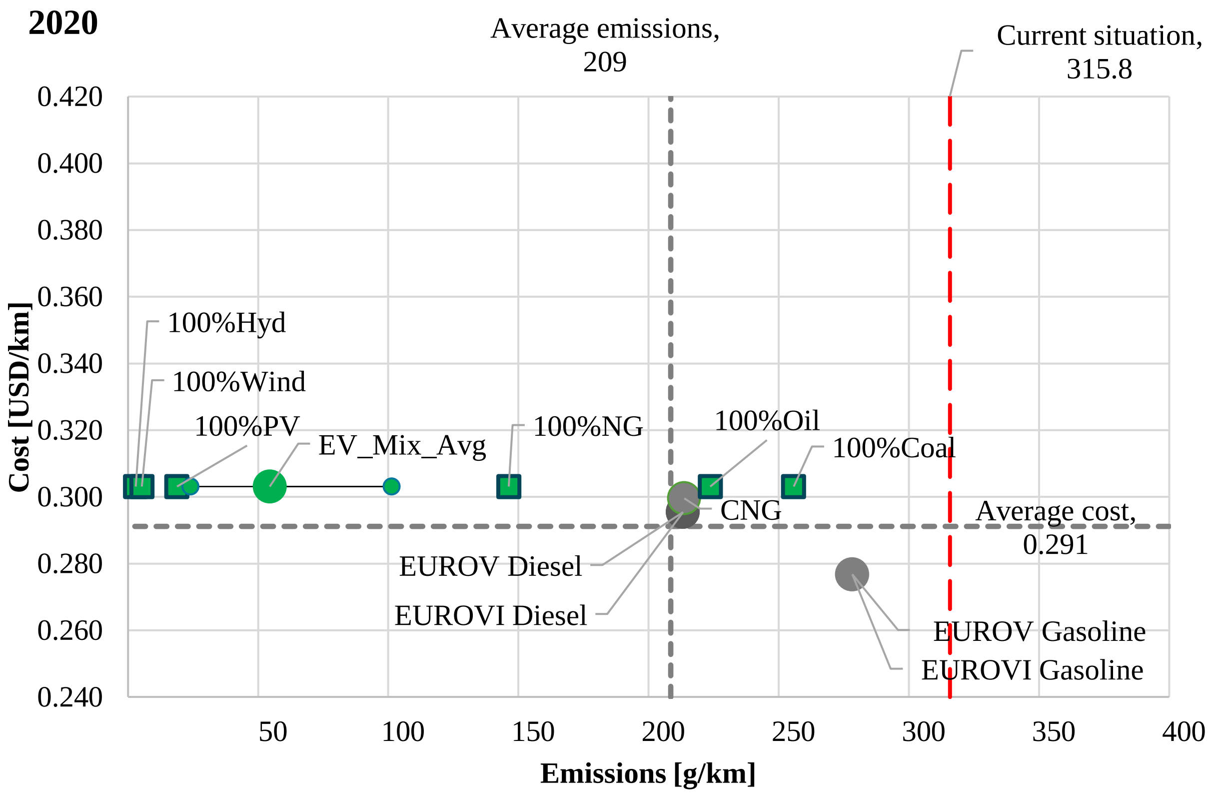


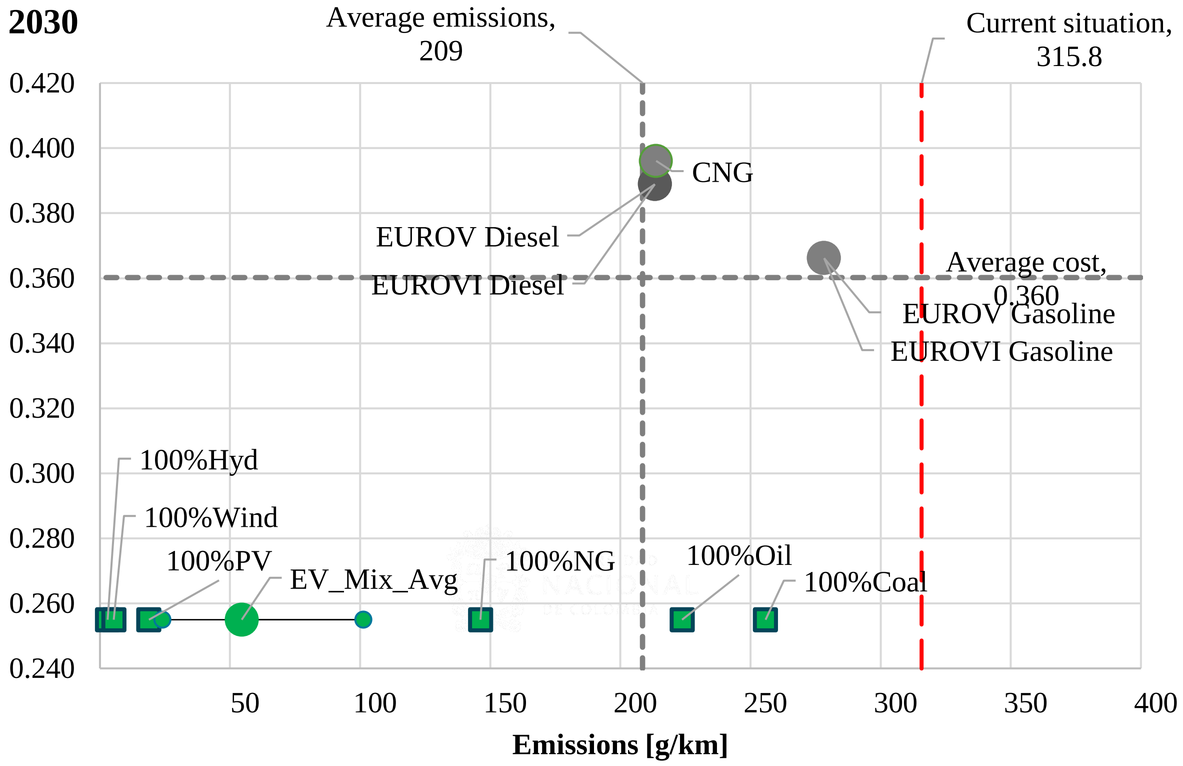
The average are computed using all technologies except the different scenarios for electricity mix.

Total emissions [$g.km^{-1}.veh^{-1}$] of *passenger car* regarding to baseline and TOC [$USD.\ km^{-1}.veh^{-1}$] in years 2020, and 2030

CO_2-Eq

Bogotá





***Manufacture of vehicles and their parts is *not included*.**

Step 4. Environment, safety-related risk, and social welfare trends assessment of transport modal share

The benefits and drawbacks of urban passenger transport modes were evaluated using a set of criteria

Environmental

WTW emission inventory

- Emissions [g/trip] → CO_2-Eq
  $PM_{2.5}$
- Energy consumption [kWh/trip]

Risk

Road safety

- Mortality [total deaths/trip]
- Injuries [total injuries/trip]

From statistics.

Social welfare

- Vehicle congestion [10^{-6} of passengers]
- Travel time [min]
- Discomfort [fraction]

From literature and surveys.

Calculating a dimensionless value for the indicators allows them to be compared. This value is computed as a centered reduced value.

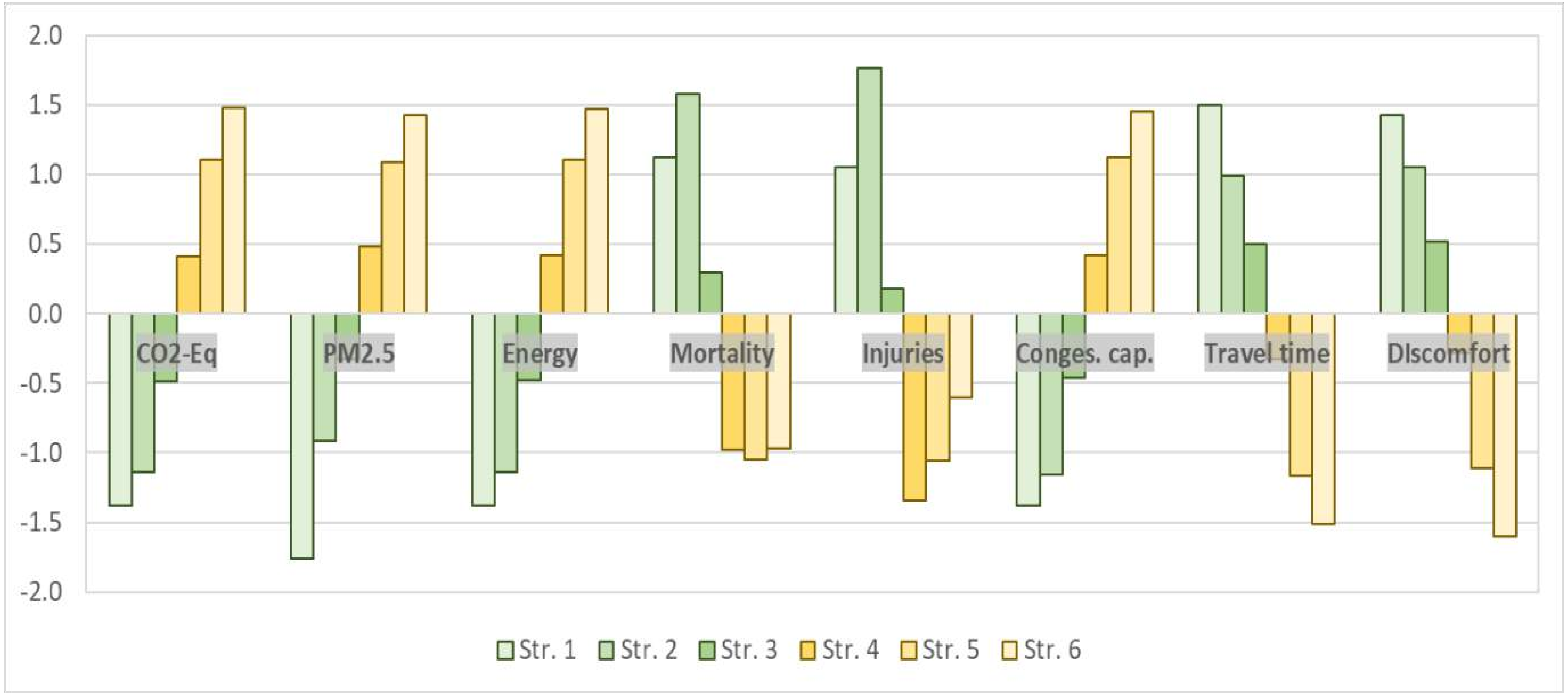
It compared travel mode share patterns across households in various socioeconomic tiers.

Higher values → disadvantages

Lower values → advantages.

Indicators and socioeconomic strata - Bogotá

Indicator deviations for the different transport modes by strata



An average trip in strata 1, 2, and 3:

- Emits less CO_2-Eq and $PM_{2.5}$, uses less energy, and uses less space on the road.
- Has higher mortality and injuries, taking more travel time for more dissatisfaction.

It is the exact opposite for an average trip in strata 4, 5, and 6.

Conclusions

This is the first application of an integrated assessment methodology (IAM) to design and select emission reduction strategies for urban passenger transport, incorporating the wear and resuspension emissions (**W&R**), the well-to-wheel (**WTW**) analysis, the total ownership cost (**TOC**), **and** reduction strategies related to **a set of criteria from environment, risk, and social welfare**.

It was observed how **the proposed methodology allows evaluating** the impact of the implementation **of technical and non-technical measures** in terms of **emissions, costs, and social welfare**. It allows the comparison of technical measures by mode of transport and technology of WTW and TOC emissions; and non-technical measures related to the city's social context.

Future research

- Making IAM available online.
- Effects of increased demand for electric power from electric vehicles and the cost of utilities
- Additional LCA Impact categories: land use, resource consumption, water footprint.
- Consider the effects of vehicle manufacture, end-of-life, and the relative prices of vehicular technologies.
- Other countries and vehicular categories
- Including uncertainty in the IAM.

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Thank you for your attention

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