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Tools for implementing the European Green Deal in cities: defining a sustainable urban mobility indicator

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Abstract: This paper is aimed at determining GHG emissions related to urban mobility per passenger and kilometer in Spain's sixteen most populous cities using a straightforward yet comprehensive methodology, to assess their performance in relation to the European Green Deal (which seeks to reach carbon neutrality within the EU by 2050). For that purpose, the proposed methodology blends the three main aspects that shape urban mobility emissions: modal share, occupancy rate and propelling technology. The document concludes by emphasizing the need for an open and updated national database that allows for more convenient estimations.

Keywords: urban mobility; sustainable mobility; GHG emissions; modal share; occupancy.

1. Introduction

In 2019, the European Commission introduced the European Green Deal, a set of strategic proposals aimed at achieving carbon neutrality within the European Union by 2050 [1]. In order to measure its applicability in towns and neighborhoods (due to their critical role in tackling climate action), Fundación Renovables, alongside Universidad de Málaga, launched an assessment tool called *The European Green Deal Goes Local* [2], encompassing a series of indicators to monitor the cities' record within the different areas included in the European Green Deal (climate action, clean energy, sustainable industry, building and renovation, sustainable mobility, farm to fork, biodiversity and eliminating pollution), as well as suggesting specific actions to improve their performance regarding the ongoing climate crisis.

Within the field 'sustainable mobility' it was developed a global indicator to estimate GHG emissions related to mobility, whose accuracy was proven by testing it on Spain's sixteen most populated capital cities. The present document seeks to define the methodology employed for GHG emissions estimation, which incorporates three main parameters: propelling technology (electricity-powered, fuel-powered, alternative fuel-powered, etc.), occupancy (the average number of passengers traveling onboard a given vehicle), and modal split (a basic parameter for a city's mobility assessment).

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2. Methodology

The characterization of urban mobility emissions was conducted in three different phases: a first stage, where emissions by vehicle and km were estimated (for motorized modes only); a second stage, which comprised occupancy data collection (again, only for motorized modes); and a third and final stage, in which the modal share was obtained for every studied city. At that point, the final parameter (GHG emissions per passenger and km) could be calculated straight away.

The estimation of GHG emissions per km and vehicle was performed differently for every motorized mode. In the case of private car, average emissions were determined for all the existing environmental labels [3] (CERO, which includes BEV and PHEV; ECO, made up by HEV and vehicles propelled with LPG and CNG; C, which encompasses Euro 6 diesel cars Euro 4, 5 and 6 gasoline cars; B, comprising Euro 4 and 5 diesel cars and Euro 3 gasoline cars; and finally, no label, namely Euro 2 and 3 diesel cars and Euro 2 gasoline cars). The final emissions for private car were calculated as a weighted average (considering the label share of every Spanish province's car pool and assuming that there is no significant difference between province and capital city car pools) [4].

Regarding public transit, GHG emissions per km were calculated separately for commuter rail (*Cercanías*), rapid transit (*metros*), light rail transit (i.e., trams) and urban buses. In the case of commuter rail, emissions were obtained weighting train energy consumption (in kWh/km for EMU, Electric Multiple Units) or fuel consumption (in liters/km for DMU, Diesel Multiple Units) by the rolling stock composition for every commuter rail network (considering the corresponding electric mix or emission factor [5], respectively). The procedure is slightly different for rapid transit and LRT, as both modes are fully electrified: in this case, only energy consumption is required (in kWh/km), bearing in mind that while EMU models are different for all metro systems in Spain, LRT systems tend to employ the same rolling stock. Finally, emissions were also obtained for urban buses (considering 12 meters standard buses only) according to the propulsion type (be it diesel fuel, CNG, LPG, diesel fuel hybrid or electric battery) and the number of buses per technology type in every bus fleet.

Upon emissions calculation (per vehicle and km), occupancy rate was estimated for all public transit modes, dividing the number of passengers-km by the number of vehicles-km (both data collected from various Metropolitan Mobility Observatory annual reports) [6-12]. Occupancy in private cars was however obtained consulting the corresponding SUMP (Sustainable Urban Mobility Plan).

Finally, modal split was obtained for every single of the sixteen Spanish cities studied. Data for Madrid, Barcelona, Valencia, A Coruña and Granada were collected through the OMM annual reports; data for Basque cities (Bilbao and Vitoria) were extracted from the 2016 Basque Country Mobility Survey [13], considering internal travel only; data for Las Palmas de Gran Canaria were accessed through a monographic document [14]; for the remaining cities, modal share was retrieved from the corresponding SUMP. In all cases, only the most updated data were considered. Note that for the scope of the present document modal split comprises active mobility (be it walking or cycling), public transit and private car (in cities where taxi services are contemplated separately, they have been added to private car).

The final GHG emissions (per km and passenger) for each mode were estimated as the product of two of the previous parameters: emissions per vehicle and kilometer, and occupancy rate (passengers/vehicle). In the case of public transit, since it comprises several modes, the final emission data was obtained as a weighted average (considering ridership). Active mobility, meanwhile, has zero emissions (as common sense suggests). After that, final GHG emissions for every city studied were calculated as the product of every mode's emission and its weight within modal split (expressed in percentage), divided by one hundred.

3. Results

The results for the sixteen cities surveyed are listed in the table below (including GHG emissions for all the considered motorized modes, modal share and final emissions). Bilbao showed lower emissions than any other city studied (mainly due to the high share of active mobility and public transit combined). On the opposite, Las Palmas was found to be the most emitting city, given its high private car share within modal split.

Table 1. GHG emissions per motorized mode, modal share and overall emissions (by city)

City	GHG emissions (gCO_2e/km·pas)					Modal split (%)			Overall emissions (gCO_2e/km·pas)
	Commuter rail	*Rapid Transit*	*Light Rail Transit*	*Urban Bus*	*Private Car*	*Active Mobility*	*Public Transit*	*Private Car*	
Madrid	6.45	10.39	52.48	128.69	96.52	38.80	34.40	25.40	40.85
Barcelona	5.48	11.26	9.60	95.95	79.41	55.30	30.00	14.70	24.37
Valencia	22.22	11.83	14.92	94.28	111.88	55.30	21.80	21.50	36.24
Sevilla	27.44		13.88	113.09	96.31	32.00	23.00	40.50	58.94
Zaragoza	19.27		15.88	66.19	105.65	48.80	23.70	26.90	41.51
Málaga	5.90		17.83	55.18	87.04	41.70	12.80	45.40	45.15
Murcia	51.25		25.00	106.96	106.74	38.80	8.80	52.40	62.53
Palma		103.79		58.30	116.35	41.00	13.00	42.00	56.54
Las Palmas				110.56	121.10	15.50	13.00	71.50	100.96
Bilbao	28.67	14.81	47.09	81.73	102.67	66.10	21.30	12.00	18.67
Alicante	30.06		8.03	168.15	113.95	51.40	11.20	37.20	53.04
Córdoba				81.29	111.87	43.80	8.70	44.20	56.43
Valladolid				45.50	112.65	52.90	13.10	30.00	39.76
Vitoria			38.47	58.24	112.48	65.40	8.80	25.70	33.44
A Coruña				93.85	111.04	52.80	15.40	31.60	49.54
Granada			4.14	54.68	120.08	45.20	15.60	36.50	49.93

4. Conclusion

Results suggest a strong relationship between modal split and overall emissions, as seen in the table above, emphasizing the need to look for strategies to reshape modal share (through public policy, urban planning, etc.) towards urban models that encourage active mobility followed up by public transit, while discouraging the use of private cars. Electrified transit modes were found to be substantially cleaner (if occupancy was sufficient) than urban buses (which can be sometimes even less sustainable than private cars due to low occupancy rates). After conducting a T Student statistical test (unpaired data), it was also found that cities where all the four major transit modes co-exist (Madrid, Barcelona, Valencia and Bilbao) have a much higher public transit share than cities where such scenario is not met ($t(14) = 4.21$, $p = 0.0009$, which indicates strong statistical significance at a 95 % confidence level), supporting the statement that multimodality empowers the use of public transit.

Nevertheless, it should be noted that many public institutions fail to report updated data. In that sense, they should be urged to improve the quality, timeliness and openness of the figures they report, as a way to guarantee open access to data for everyone, as well as ensuring that all the reported data is centralized within the same database (at least nationwide).

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