

GREENHOUSE GAS EMISSIONS

This document has been prepared by a group of experts under the “European Urban Mobility Observatory and Support” contract. It does not reflect or anticipate the position of the Commission. It does not constitute a legal proposal. The purpose of this document is to outline the indicators and the data required to calculate them, which the experts consider to be most appropriate for urban nodes to measure in the respective area. This document is intended to serve as a basis for reflection and further work on relevant indicators required by the TEN-T Regulation.

Data requirements

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
D1	I1 Total population of the city/FUA [<i># inhabitants</i>]	Data on the size of the total population on 1 st January of the year in question (or, in some cases, on 31 st December of the previous year).	Cities, Offices for national or local statistics	n/a	Data collected every year	Survey: 93 city, 4 FUA, 113 both city and FUA 210 total at city and/or FUA level (98% of respondents)
D2	O1 Annual CO ₂ -equivalent emissions from road transport in the city/FUA [<i>t CO₂ e per year</i>]	<u>Preferred dataset</u> Annual CO ₂ equivalent emissions from road transport in the city/FUA, estimated with the approach of the Covenant of Mayors reporting guidelines (using LCA emission factors). The guidelines require as input the final energy consumption of the transport sector by energy carrier. The information can be disaggregated by mode or at aggregate level for the transport sector. CO ₂ emission factors by energy carrier are specified to estimate annual emissions (values could be defined by the city/FUA or using default values).	Cities, Local authorities (province, region)	n/a	Yearly	Survey: <u>any methodology</u> 101 total at city and/or FUA level (47% of respondents) <u>Use of Covenant of Mayors reporting guidelines</u> 59 total at city and/or FUA level (27% of respondents)

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
D3	O2, O3, O6, O7 Public transport bus/coach vehicle stock composition by fuel engine and Euro Emission standard (diesel only) [# vehicles]	<p>Preferred dataset Reports of public transport operator serving the city/FUA, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ CNG ○ LPG ○ Hydrogen ○ Battery electric ○ Plug-in hybrid <p>Euro emission standard (for diesel only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 	Public transport authorities or operators	Vehicle registration	Yearly	<p>Survey:</p> <p><u>By fuel only</u> 22 city, 15 FUA (includes 9 both city and FUA) 28 total at city and/or FUA level (13% of respondents)</p> <p><u>By Euro norm only</u> 12 city, 5 FUA (includes 3 both city and FUA) 14 total at city and/or FUA level (7% of respondents)</p> <p><u>By both fuel and Euro norm</u> 90 city, 44 FUA (includes 26 both city and FUA) 108 total at city and/or FUA level (50% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 112 city, 59 FUA (includes 35 both city and FUA) 136 total at city and/or FUA level (63% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u></p>
		<p>Alternative dataset Database at the more aggregated NUTS level with respect to the city/FUA level, disaggregated by engine fuel and Euro emission standard as above.</p>	ACEA, Offices for national or local statistics	Vehicle registration		

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
						102 city, 49 FUA (includes 29 both city and FUA) 122 total at city and/or FUA level (57% of respondents)
D4	O4, O5, O8, O9 Total bus/coach vehicle stock composition by engine fuel (and Euro Emission standard (diesel only) [# vehicles])	<p>Preferred dataset Database of registered vehicle stock at city/FUA level, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ CNG ○ LPG ○ Hydrogen ○ Battery electric ○ Plug-in hybrid <p>Euro emission standard (for diesel only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 	Vehicle registration entities, Offices for national or local statistics	Vehicle registration	Yearly	<p>Survey:</p> <p><u>By fuel only</u> 28 city, 14 FUA (includes 7 both city and FUA) 35 total at city and/or FUA level (16% of respondents)</p> <p><u>By Euro norm only</u> 10 city, 5 FUA (includes 4 both city and FUA) 11 total at city and/or FUA level (5% of respondents)</p> <p><u>By both fuel and Euro norm</u> 61 city, 32 FUA (includes 22 both city and FUA) 71 total at city and/or FUA level (33% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 89 city, 46 FUA (includes 29 both city and FUA) 106 total at city and/or FUA level (49% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u></p>
		<p>Alternative dataset Database of registered vehicle stock at more aggregated NUTS level with respect to the city level, disaggregated by engine fuel and Euro emission standard as above.</p>				

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
						71 city, 37 FUA (includes 26 both city and FUA) 82 total at city and/or FUA level (38% of respondents)
D5	O10, O11 Public transport water bus stock composition by engine fuel and Euro Emission standard (diesel only) [# vehicles]	Reports of public transport operator serving the city/FUA, disaggregated by: Engine Fuel <ul style="list-style-type: none"> ○ Diesel ○ Hydrogen ○ Battery electric ○ Hybrid Euro emission standard (for diesel only) <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 	Public transport authorities or operators	vehicle registration	Yearly	<i>Inland waterways service is available as a transport mode in a limited number of urban nodes; therefore, data availability should be evaluated considering where the service is effectively in place.</i> Survey: <u>By fuel only</u> 5 city, 5 FUA (includes 3 both city and FUA) (7 total at city and/or FUA level (3% of respondents)) <u>By Euro norm only</u> 1 city, 1 FUA (includes 0 both city and FUA) 2 total at city and/or FUA level (1% of respondents) <u>By both fuel and Euro norm</u> 17 city, 13 FUA (includes 9 both city and FUA) 21 total at city and/or FUA level (10% of respondents) <u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
						<p>22 city, 18 FUA (includes 12 both city and FUA) 28 total at city and/or FUA level (13% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 18 city, 14 FUA (includes 9 both city and FUA) 23 total at city and/or FUA level (11% of respondents)</p>
D6	O12, O13 Private moped vehicle stock composition by engine fuel and Euro Emission standard (diesel, gasoline only) [# vehicles]	<p>Preferred dataset Database of registered vehicle stock at city/FUA level, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid <p>Euro emission standard (for diesel and gasoline only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 	Vehicle registration entities, Offices for national or local statistics	Vehicle registration	Yearly	<p>Data on mopeds Survey:</p> <p><u>By fuel only</u> 22 city, 9 FUA (includes 4 both city and FUA) (27 total at city and/or FUA level (13% of respondents))</p> <p><u>By Euro norm only</u> 3 city, 3 FUA (includes 0 both city and FUA) 6 total at city and/or FUA level (3% of respondents)</p> <p><u>By both fuel and Euro norm</u> 48 city, 18 FUA (includes 12 both city and FUA) 54 total at city and/or FUA level (25% of respondents)</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		<p>Alternative dataset Database of registered vehicle stock at more aggregated NUTS level with respect to the city level, disaggregated by engine fuel and Euro emission standard as above.</p>		Vehicle registration		<p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 70 city, 27 FUA (includes 16 both city and FUA) 81 total at city and/or FUA level (38% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 51 city, 21 FUA (includes 12 both city and FUA) 60 total at city and/or FUA level (28% of respondents)</p>
D7	O14, O15 Private motorcycle vehicle stock composition by engine fuel and Euro Emission standard (diesel, gasoline only) [# vehicles]	<p>Preferred dataset Database of registered vehicle stock at city/FUA level, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid <p>Euro emission standard (for diesel and gasoline only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d 	Vehicle registration entities, Offices for national or local statistics	Vehicle registration	Yearly	<p><u>Data on motorcycles Survey:</u></p> <p><u>By fuel only</u> 24 city, 10 FUA (includes 5 both city and FUA) (29 total at city and/or FUA level (13% of respondents))</p> <p><u>By Euro norm only</u> 8 city, 4 FUA (includes 2 both city and FUA) 10 total at city and/or FUA level (5% of respondents)</p> <p><u>By both fuel and Euro norm</u> 58 city, 23 FUA (includes 15 both city and FUA)</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		<ul style="list-style-type: none"> ○ Euro norm 7 				<p>66 total at city and/or FUA level (31% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 82 city, 33 FUA (includes 20 both city and FUA) 95 total at city and/or FUA level (44% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 66 city, 27 FUA (includes 17 both city and FUA) 76 total at city and/or FUA level (35% of respondents)</p>
		<p>Alternative dataset Database of registered vehicle stock at more aggregated NUTS level with respect to the city level, disaggregated by engine fuel and Euro emission standard as above.</p>				
D8	O16, O17 Private car vehicle stock composition by engine fuel and Euro Emission standard (diesel, gasoline only) [# vehicles]	<p>Preferred dataset Database of registered vehicle stock at city/FUA level, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid <p>Euro emission standard (for diesel and gasoline only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 	Vehicle registration entities, Offices for national or local statistics	Vehicle registration	Yearly	<p><u>Making reference to data on total cars</u></p> <p>Survey: <u>By fuel only</u> 36 city, 13 FUA (includes 7 both city and FUA) (42 total at city and/or FUA level (20% of respondents)</p> <p><u>By Euro norm only</u> 9 city, 5 FUA (includes 2 both city and FUA) 12 total at city and/or FUA level (6% of respondents)</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		<ul style="list-style-type: none"> ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 				<p><u>By both fuel and Euro norm</u> 69 city,31 FUA (includes 20 both city and FUA) 80 total at city and/or FUA level (37% of respondents)</p>
		<p>Alternative dataset Database of registered vehicle stock at more aggregated NUTS level with respect to the city level, disaggregated by engine fuel and Euro emission standard as above.</p>		Vehicle registration		<p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 105 city,44 FUA (includes 27 both city and FUA) 122 total at city and/or FUA level (57% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 78 city, 36 FUA (includes 22 both city and FUA) 92 total at city and/or FUA level (43% of respondents)</p>
D9	O18, O19 Light commercial vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]	<p>Preferred dataset Database of registered vehicle stock at city/FUA level, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid 	Vehicle registration entities, Offices for national or local statistics	Vehicle registration	Yearly	<p>Survey:</p> <p><u>By fuel only</u> 16 city, 9 FUA (includes 4 both city and FUA) (21 total at city and/or FUA level (10% of respondents)</p> <p><u>By Euro norm only</u> 4 city, 2 FUA (includes 1 both city and FUA) 5 total at city and/or FUA level (2% of respondents)</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		<p>Euro emission standard (for diesel and gasoline only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 				<p><u>By both fuel and Euro norm</u> 47 city,21 FUA (includes 13 both city and FUA) 55 total at city and/or FUA level (26% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 69 city,30 FUA (includes 17 both city and FUA) 76 total at city and/or FUA level (35% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 51 city, 23 FUA (includes 14 both city and FUA) 60 total at city and/or FUA level (28% of respondents)</p>
		<p>Alternative dataset Database of registered vehicle stock at more aggregated NUTS level with respect to the city level, disaggregated by engine fuel and Euro emission standard as above.</p>		Vehicle registration		
D10	O20, O21 Heavy goods vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]	<p>Preferred dataset Database of registered vehicle stock at city/FUA level, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid 	Vehicle registration entities, Offices for national or local statistics	Vehicle registration	Yearly	<p>Survey:</p> <p><u>By fuel only</u> 23 city, 10 FUA (includes 4 both city and FUA) (29 total at city and/or FUA level (13% of respondents)</p> <p><u>By Euro norm only</u> 8 city, 3 FUA (includes 2 both city and FUA) 9 total at city and/or FUA level (4% of respondents)</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		<p>Euro emission standard (for diesel and gasoline only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 				<p><u>By both fuel and Euro norm</u> 50 city,23 FUA (includes 16 both city and FUA) 57 total at city and/or FUA level (27% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 73 city,33 FUA (includes 20 both city and FUA) 86 total at city and/or FUA level (40% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 58 city, 26 FUA (includes 18 both city and FUA) 66 total at city and/or FUA level (31% of respondents)</p>
		<p>Alternative dataset Database of registered vehicle stock at more aggregated NUTS level with respect to the city level, disaggregated by engine fuel and Euro emission standard as above.</p>		Vehicle registration		
D11	<p>O22, O23 Taxi and ride-hailing vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles])</p> <p>O24, O25 Shared car vehicle stock composition by engine fuel (and Euro</p>	<p>Taxi, ride-hailing and shared car data on vehicle stock composition, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid 	Cities, taxi, Shared mobility operators	Vehicle stock	Yearly	<p><u>Taxi and shared mobility vehicles (cars) Survey:</u></p> <p><u>By fuel only</u> 13 city, 7 FUA (includes 4 both city and FUA) (16 total at city and/or FUA level (7% of respondents)</p> <p><u>By Euro norm only</u> 3 city, 2 FUA (includes 1 both city and FUA)</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
	Emission standard (diesel, gasoline only) [# vehicles]	Euro emission standard (for diesel and gasoline only) <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 				<p>(4 total at city and/or FUA level (2% of respondents))</p> <p><u>By both fuel and Euro norm</u> 36 city, 18 FUA (includes 10 both city and FUA) 44 total at city and/or FUA level (20% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 49 city, 25 FUA (includes 14 both city and FUA) 60 total at city and/or FUA level (28% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u> 39 city, 20 FUA (includes 11 both city and FUA) 48 total at city and/or FUA level (22% of respondents)</p> <p>Total shared mobility vehicles (cars) Survey: 87 city, 23 FUA (includes 16 both city and FUA) 94 total at city and/or FUA level (44% of respondents)</p> <p>only 56 respondents have access to data for all companies, 28 respondents have data for only some of them</p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
						17 respondents don't have a car sharing system in place
D12	O26, O27 Municipal service car vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles])	<p>Municipal service car data on vehicle stock composition, disaggregated by:</p> <p>Engine Fuel</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Ethanol ○ Hydrogen ○ Battery electric ○ Plug-in hybrid <p>Euro emission standard (for diesel and gasoline only)</p> <ul style="list-style-type: none"> ○ Euro norm 1-4 ○ Euro norm 5 ○ Euro norm 6a-c ○ Euro norm 6d ○ Euro norm 7 	Cities	Vehicle stock	Yearly	<p><u>Cars - municipal vehicles</u></p> <p>Survey:</p> <p><u>By fuel only</u> 22 city, 9 FUA (includes 5 both city and FUA) (26 total at city and/or FUA level (12% of respondents))</p> <p><u>By Euro norm only</u> 8 city, 0 FUA (includes 0 both city and FUA) (8 total at city and/or FUA level (4% of respondents))</p> <p><u>By both fuel and Euro norm</u> 85 city, 26 FUA (includes 15 both city and FUA) 96 total at city and/or FUA level (45% of respondents)</p> <p><u>Total by fuel (= by fuel only + by both fuel and Euro norm)</u> 107 city, 35 FUA (includes 20 both city and FUA) 122 total at city and/or FUA level (57% of respondents)</p> <p><u>Total by Euro norm (= by Euro norm only + by both fuel and Euro norm)</u></p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
						93 city, 26 FUA (includes 15 both city and FUA) 104 total at city and/or FUA level (48% of respondents)
D13	O28 Annual energy purchased for transport by energy carrier from refuelling stations in the city/FUA [l/kg/kWh per year T]	<p>Preferred dataset Annual fuel purchased in the city/FUA, by energy carrier:</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Electricity ○ Ethanol ○ Bio-ethanol ○ Bio-diesel ○ Hydrogen <p>Alternative dataset Fuel purchased in the more aggregated NUTS level zone where the city/FUA is located, to be rescaled based on proxy variable (i.e., total road vehicle fleet of the city/FUA with respect to the NUTS level zone), by energy carrier:</p> <ul style="list-style-type: none"> ○ Diesel ○ Gasoline ○ CNG ○ LPG ○ Electricity ○ Ethanol ○ Bio-ethanol ○ Bio-diesel 	Cities, Local authorities, taxation authorities (province, region)		Yearly	<p>Survey</p> <p><u>Diesel</u> 21 city, 23 FUA (including 12 both city and FUA level) 32 total at city and/or FUA level (15% of respondents)</p> <p><u>Petrol</u> 21 city, 23 FUA (including 12 both city and FUA level) 32 total at city and/or FUA level (15% of respondents)</p> <p><u>Two stroke fuel</u> 8 city, 6 FUA (including 3 both city and FUA level) 11 total at city and/or FUA level (5% of respondents)</p> <p><u>Biofuel/synthetic fuel</u> 11 city, 10 FUA (including 6 both city and FUA level) 15 total at city and/or FUA level (7% of respondents)</p> <p><u>CNG</u></p>

#	Indicator	Dataset	Owner	(Possible) collection methods	Timing & frequency of collection	Comments on data availability
		<ul style="list-style-type: none"> ○ Hydrogen 				<p>12 city, 13 FUA (including 7 both city and FUA level) 18 total at city and/or FUA level (8% of respondents)</p> <p><u>LPG</u> 17 city, 18 FUA (including 9 both city and FUA level) 26 total at city and/or FUA level (12% of respondents)</p> <p><u>Electricity</u> 15 city, 10 FUA (including 4 both city and FUA level) 21 total at city and/or FUA level (10% of respondents)</p> <p><u>Hydrogen</u> 4 city, 3 FUA (including 1 both city and FUA level) 6 total at city and/or FUA level (3% of respondents)</p>

Overview and analysis of data availability

Based on the analysis of responses to the urban mobility data and indicators survey, which was carried out in August-October 2023, and which collected responses from 215 urban nodes out of 430, the following considerations have been drawn for each dataset required for the indicators described above.

Summary and conclusions

The aggregated results of the survey show that almost half of the respondents reported the availability of data on CO2 emissions. On the contrary, fuel sales are reported to be hardly available, with a maximum of 15% of respondents answering positively for diesel and petrol. It is therefore proposed to use the former as an indicator instead of the latter.

Concerning the composition of the vehicle fleet (in terms of registrations), more than half of the respondents reported that they collect data by fuel type for buses, coaches and passenger cars, when considering also reporting availability for both fuel and euro norm. For freight vehicles, mopeds and motorcycles, availability ranges from 35% to 44%. Therefore, the alternative Tier 1 calculation method based on the composition by fuel type is reported for indicators related to average GHG emissions per vehicle kilometre. The proposed calculation methods (Tier 1 and Tier 2) are directly based on the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2023.

For some modes and vehicle types, it is also important to consider that not all modes are universally available or that some modes represent only a marginal share of transport demand in most urban nodes. Therefore, lower absolute values in terms of vehicle stock do not necessarily correspond to lower data availability. Examples include inland waterway transport and car sharing. In the case of car sharing, specific requirements for data sharing could be included in the service contracts.

Overall, an acceptable level of data availability is estimated for the proposed indicators.

Detailed analysis

Please note that the figures provided do not always add up across questions, for example, in some cases respondents have replied only to the first of two related questions, or only to the second of two questions.

D1. (I1) Total population of the city/FUA [# inhabitants]

Survey results

- 210 respondents reported collection of/access to data “total number of inhabitants”:
 - 98% of respondents
 - 93 at city level only, 4 at FUA level only, 113 at both city and FUA level.

D2 (O1) Annual CO₂-equivalent emissions from road transport in the city/FUA [t CO₂ e per year]

Survey results

- 101 respondents reported collection of/access to data on annual CO₂-equivalent emissions from total road transport:
 - 47% of respondents
- 59 respondents reported collection of/access to data on GHG emissions using the Covenant of Mayors reporting guidelines:

- 27% of respondents
- 49 respondents reported collection of/access to data on GHG emissions using other methodology:
 - 23% of respondents
- *Note that the figures provided for the methodology question add up to 108 respondents: 7 respondents reported using both the Covenant of Mayors reporting guidelines and another methodology.*
- To complement the overview, it is worth noting that 155 respondents reported collection of/access to data on “**traffic model used**”:
 - 72% of respondents
 - 91 at city level only, 7 at FUA level only, 57 at both city and FUA level
 - Nevertheless, it is reported in the open-ended answers that the traffic model is only updated every 5 years
 - Data from traffic models could be used for the estimation of energy consumption from transport, as requested by the Covenant of Mayors reporting guidelines

D3. (O2, O3, O6, O7) Public transport bus/coach vehicle stock composition by fuel engine and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 22 at city level only, 15 at FUA level only (including 9 at both city and FUA level)
 - 28 total at city and/or FUA level (13% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 12 at city level only, 5 at FUA level only (including 3 at both city and FUA level)
 - 14 total at city and/or FUA level (7% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 90 at city level only, 44 at FUA level only (including 26 at both city and FUA level)
 - 108 total at city and/or FUA level (50% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 112 city, 59 FUA (including 35 both at city and FUA level)
 - 136 total at city and/or FUA level (63% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 102 city, 49 FUA (including 29 both at city and FUA level)
 - 122 total at city and/or FUA level (57% of respondents), excluding overlap

D4. (O4, O5, O8, O9) Total bus and coach stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 28 at city level only, 14 at FUA level only (including 7 at both city and FUA level)
 - 35 total at city and/or FUA level (16% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 10 at city level only, 5 at FUA level only (4 at both city and FUA level)
 - 11 total at city and/or FUA level (5% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 61 at city level only, 32 at FUA level only (including 22 at both city and FUA level)
 - 71 total at city and/or FUA level (33% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 89 city, 46 FUA (including 29 both at city and FUA level)
 - 106 total at city and/or FUA level (49% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 71 city, 37 FUA (including 26 both at city and FUA level)
 - 82 total at city and/or FUA level (38% of respondents), excluding overlap

D5. (O10, O11) Public transport water bus stock composition by engine fuel (diesel, hydrogen, battery electric, hybrid) and Euro Emission standard (diesel only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 5 at city level only, 5 at FUA level only (including 3 at both city and FUA level)
 - 7 total at city and/or FUA level (3% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 1 at city level only, 1 at FUA level only (0 at both city and FUA level)
 - 2 total at city and/or FUA level (1% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 17 at city level only, 13 at FUA level only (including 9 at both city and FUA level)
 - 21 total at city and/or FUA level (10% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 22 city, 18 FUA (including 12 both at city and FUA level)
 - 28 total at city and/or FUA level (13% of respondents), excluding overlap

- collection of/access to this data **by Euro norm in total**
 - 18 city, 14 FUA (including 9 both at city and FUA level)
 - 23 total at city and/or FUA level (11% of respondents), excluding overlap
- *Note that Inland waterways are a transport mode in only a limited number of urban nodes. Therefore, data availability should be evaluated taking into consideration where the service is effectively in place.*

D6. (O12, O13) Private moped vehicle stock composition by engine fuel and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 22 at city level only, 9 at FUA level only (including 4 at both city and FUA level)
 - 27 total at city and/or FUA level (13% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 3 at city level only, 3 at FUA level only (0 at both city and FUA level)
 - 6 total at city and/or FUA level (3% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 48 at city level only, 18 at FUA level only (including 12 at both city and FUA level)
 - 54 total at city and/or FUA level (25% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 70 city, 27 FUA (including 16 both at city and FUA level)
 - 81 total at city and/or FUA level (38% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 51 city, 21 FUA (including 12 both at city and FUA level)
 - 60 total at city and/or FUA level (28% of respondents), excluding overlap

D7. (O14, O15) Private motorcycle vehicle stock composition by engine fuel and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 24 at city level only, 10 at FUA level only (including 5 at both city and FUA level)
 - 29 total at city and/or FUA level (13% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 8 at city level only, 4 at FUA level only (2 at both city and FUA level)
 - 10 total at city and/or FUA level (5% of respondents), excluding overlap

- collection of/access to this data **by both fuel engine and Euro norm**
 - 58 at city level only, 23 at FUA level only (including 15 at both city and FUA level)
 - 66 total at city and/or FUA level (31% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 82 city, 33 FUA (including 20 both at city and FUA level)
 - 95 total at city and/or FUA level (44% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 66 city, 27 FUA (including 17 both at city and FUA level)
 - 76 total at city and/or FUA level (35% of respondents), excluding overlap

D8. (O16, O17) Private car vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 36 at city level only, 13 at FUA level only (including 7 at both city and FUA level)
 - 42 total at city and/or FUA level (20% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 9 at city level only, 5 at FUA level only (2 at both city and FUA level)
 - 12 total at city and/or FUA level (6% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 69 at city level only, 31 at FUA level only (including 20 at both city and FUA level)
 - 80 total at city and/or FUA level (37% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 105 city, 44 FUA (including 27 both at city and FUA level)
 - 122 total at city and/or FUA level (57% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 78 city, 36 FUA (including 22 both at city and FUA level)
 - 92 total at city and/or FUA level (43% of respondents), excluding overlap
- *Note that the data availability reported is for total cars.*

D9. (O18, O19) Light commercial vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**

- 16 at city level only, 9 at FUA level only (including 4 at both city and FUA level)
- 21 total at city and/or FUA level (10% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 4 at city level only, 2 at FUA level only (1 at both city and FUA level)
 - 5 total at city and/or FUA level (2% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 47 at city level only, 21 at FUA level only (including 13 at both city and FUA level)
 - 55 total at city and/or FUA level (26% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 69 city, 30 FUA (including 17 both at city and FUA level)
 - 76 total at city and/or FUA level (35% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 51 city, 23 FUA (including 14 both at city and FUA level)
 - 60 total at city and/or FUA level (28% of respondents), excluding overlap

D10. (O20, O21) Heavy goods vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 23 at city level only, 10 at FUA level only (including 4 at both city and FUA level)
 - 29 total at city and/or FUA level (13% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 8 at city level only, 3 at FUA level only (2 at both city and FUA level)
 - 9 total at city and/or FUA level (4% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 50 at city level only, 23 at FUA level only (including 16 at both city and FUA level)
 - 57 total at city and/or FUA level (27% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 73 city, 33 FUA (including 20 both at city and FUA level)
 - 86 total at city and/or FUA level (40% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 58 city, 26 FUA (including 18 both at city and FUA level)
 - 66 total at city and/or FUA level (31% of respondents), excluding overlap

D11. (O22, O23) Taxi and ride-hailing vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 13 at city level only, 7 at FUA level only (including 4 at both city and FUA level)
 - 16 total at city and/or FUA level (7% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 3 at city level only, 2 at FUA level only (1 at both city and FUA level)
 - 4 total at city and/or FUA level (2% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 36 at city level only, 18 at FUA level only (including 10 at both city and FUA level)
 - 44 total at city and/or FUA level (20% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 49 city, 25 FUA (including 14 both at city and FUA level)
 - 60 total at city and/or FUA level (28% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 39 city, 20 FUA (including 11 both at city and FUA level)
 - 48 total at city and/or FUA level (22% of respondents), excluding overlap

D12. (O24, O25) Shared car vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 13 at city level only, 7 at FUA level only (including 4 at both city and FUA level)
 - 16 total at city and/or FUA level (7% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 3 at city level only, 2 at FUA level only (1 at both city and FUA level)
 - 4 total at city and/or FUA level (2% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 36 at city level only, 18 at FUA level only (including 10 at both city and FUA level)
 - 44 total at city and/or FUA level (20% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 49 city, 25 FUA (including 14 both at city and FUA level)
 - 60 total at city and/or FUA level (28% of respondents), excluding overlap

- collection of/access to this data **by Euro norm in total**
 - 39 city, 20 FUA (including 11 both at city and FUA level)
 - 48 total at city and/or FUA level (22% of respondents), excluding overlap
- considering also data availability on **total fleet size of free-floating and station-based shared mobility services (cars)**:
 - 87 at city level, 23 at FUA level (including 16 at both city and FUA level)
 - 94 total at city and/or FUA level (44% of respondents), excluding overlap
 - It should be noted that only 56 cities/FUAs (26% of respondents) have access to data for all companies providing the service, while 28 cities/FUAs (13% of respondents) have access to data for only some of them. *Also note that the data on total fleet size may be inconsistent with the number of cities/FUAs that have reported the availability of the data on vehicle stock composition; this discrepancy is due to the impossibility of tracing individual urban node responses back to the survey.*
- 17 cities/FUAs (8% of responders) declare that they **do not have a car sharing system**

D13. (O26, O27) Municipal service car vehicle stock composition by engine fuel (and Euro Emission standard (diesel, gasoline only) [# vehicles]

Survey results

- collection of/access to this data **by fuel engine only**
 - 22 at city level only, 9 at FUA level only (including 5 at both city and FUA level)
 - 26 total at city and/or FUA level (12% of respondents), excluding overlap
- collection of/access to this data **by Euro norm only**
 - 8 at city level only, 0 at FUA level only (0 at both city and FUA level)
 - 8 total at city and/or FUA level (4% of respondents), excluding overlap
- collection of/access to this data **by both fuel engine and Euro norm**
 - 85 at city level only, 26 at FUA level only (including 15 at both city and FUA level)
 - 96 total at city and/or FUA level (45% of respondents), excluding overlap
- collection of/access to this data **by fuel engine in total**
 - 107 city, 35 FUA (including 20 both at city and FUA level)
 - 122 total at city and/or FUA level (57% of respondents), excluding overlap
- collection of/access to this data **by Euro norm in total**
 - 93 city, 26 FUA (including 15 both at city and FUA level)
 - 104 total at city and/or FUA level (48% of respondents), excluding overlap

D14. (O28) Annual energy purchased for transport by energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) from refuelling stations in the city/ FUA [l/ kg/ kWh per year]

Survey results

- collection of/access to this data by **Diesel**
 - 21 city, 23 FUA (including 12 both city and FUA level)
 - 32 total at city and/or FUA level (15% of respondents)
- collection of/access to this data by **Petrol**
 - 21 city, 23 FUA (including 12 both city and FUA level)
 - 32 total at city and/or FUA level (15% of respondents)
- collection of/access to this data by **Two stroke fuel**
 - 8 city, 6 FUA (including 3 both city and FUA level)
 - 11 total at city and/or FUA level (5% of respondents)
- collection of/access to this data by **Biofuel/synthetic fuel**
 - 11 city, 10 FUA (including 6 both city and FUA level)
 - 15 total at city and/or FUA level (7% of respondents)
- collection of/access to this data by **CNG**
 - 12 city, 13 FUA (including 7 both city and FUA level)
 - 18 total at city and/or FUA level (8% of respondents)
- collection of/access to this data by **LPG**
 - 17 city, 18 FUA (including 9 both city and FUA level)
 - 26 total at city and/or FUA level (12% of respondents)
- collection of/access to this data by **Electricity**
 - 15 city, 10 FUA (including 4 both city and FUA level)
 - 21 total at city and/or FUA level (10% of respondents)
- collection of/access to this data by **Hydrogen**
 - 4 city, 3 FUA (including 1 both city and FUA level)
 - 6 total at city and/or FUA level (3% of respondents)

Survey: open-ended feedback

From the interpretation of the open-ended answers, it is reported that in 9 urban nodes the estimation of GHG emissions is performed using transport models, while 13 respondents said they base it on fuel data. Furthermore, 6 respondents mentioned that the estimation is carried out at regional/state level and 5 at national level.

Regarding fuel sales data, 4 respondents mention that it is collected at regional/state level and 6 at national level. For vehicle fleet data, it is reported that in 7 urban nodes the authority responsible for collection is at national level, and 7 at regional/state level.

Concerning data relevant for monitoring GHG, 4 urban nodes mention the importance of distance travelled by vehicle type for the estimation.

In this context it is worth mentioning that 155 respondents reported using a traffic model (72% of respondents). However, some of the open-ended responses indicate that the model is updated every 5 years. 10 respondents indicated that the model is developed/used in the context of the SUMP.

In terms of methodology for CO₂ estimation and emission factors, 6 respondents said they use COPERT, while 2 said they use the HBEFA factors.

Comment: Energy purchased and CO₂ equivalent emissions

The survey question on data on annual sales of fuel for mobility purposes showed that this information is hardly available at city or FUA level, with 32 positive responses for diesel/petrol being the maximum. The survey also included a question on data on annual CO₂ and CO₂ equivalent emissions from transport: in this case, an acceptable number of positive responses was reported in relation to total emissions from road transport (101 respondents). It has therefore proposed to replace the output indicator on fuel sales with data on CO₂ emissions.

Furthermore, in terms of methodology, the majority of respondents who report collecting data on annual CO₂ and CO₂ equivalent emissions from transport indicated that they follow the Covenant of Mayors reporting guidelines (59 out of 101 respondents). It is therefore suggested to use the same approach for comparability reasons.

Finally, it is worth noting that 155 respondents reported collecting or having access to data on the "transport model used", i.e. 72% of respondents, although some of them reported in the open responses that it is only updated every 5 years. This information suggests traffic models could be used for the estimation of energy consumption from transport, as requested by the Covenant of Mayors reporting guidelines.

Comment: Vehicle stock composition by vehicle type, fuel and Euro norm

The survey showed that data on fuel engine for buses, coaches and cars is available for more than half of respondents when taking the reporting availability for both 'by fuel engine' and 'by both fuel and Euro norm' into account. For freight vehicles, mopeds, and motorcycles, data availability ranges from 35% to 44%. On the other hand, data by euro standard generally show lower proportions of positive responses in terms of availability. The shares of total availability by Euro standard (including both fuel and Euro standard) are only above 50% for bus and coach data, while for cars it is around 43% and for freight vehicles, mopeds, and motorcycles it is between 28% and 35%. Therefore, for the estimation of the average emission factor per vehicle-km, it is proposed to use data on vehicle stock by fuel engine as an alternative methodology (Tier 1), if more detailed data by both fuel engine and euro norm are not available to apply the Tier 2 estimation.

With reference to taxi and car shared vehicles, it should be considered that the lower availability of data on stock composition may be due to less stringent contracts with cities, where urban nodes are not informed about details of service characteristics. In the future, upon contract renewal, it is possible that a requirement could be introduced for operators to provide the requested data.

Concerning inland waterways ferries and waterbuses, the feedback may not look promising at first sight. However, it should be noted that inland waterway services are only available in a limited number of urban nodes. Therefore, data availability should be assessed taking into account where the service is actually provided.

Indicators

Number	Indicator	To be calculated by:
<i>Input indicators</i>		
I1	Total population of the city/FUA [<i># inhabitants</i>]	Urban node
<i>Output indicators</i>		
O1	Annual CO ₂ -equivalent emissions from road transport in the city/FUA [<i>t CO₂ e per year</i>]	Urban node
O2	Public transport bus vehicle stock composition by diesel engine fuel and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O3	Public transport bus vehicle stock composition by engine fuel (CNG, LPG, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O4	Total bus vehicle stock composition by diesel engine fuel and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O5	Total bus vehicle stock composition by engine fuel (CNG, LPG, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O6	Public transport coach vehicle stock composition by diesel engine fuel and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O7	Public transport coach vehicle stock composition by engine fuel (CNG, LPG, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O8	Total coach vehicle stock composition by diesel engine fuel and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O9	Total coach vehicle stock composition by engine fuel (CNG, LPG, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O10	Public transport water bus stock composition by diesel engine fuel and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node

O11	Public transport water bus stock composition by engine fuel (diesel, hydrogen, battery electric, hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O12	Private moped vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O13	Private moped vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O14	Private motorcycle vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O15	Private motorcycle vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O16	Private car vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O17	Private car vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O18	Light commercial vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O19	Light commercial vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O20	Heavy goods vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O21	Heavy goods vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O22	Taxi and ride-hailing vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O23	Taxi and ride-hailing vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node
O24	Shared car vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [<i># vehicles</i>]	Urban node
O25	Shared car vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [<i># vehicles</i>]	Urban node

O26	Municipal service car vehicle stock composition by engine fuel (diesel, gasoline) and Euro emission standard in the city/FUA [# vehicles]	Urban node
O27	Municipal service car vehicle stock composition by engine fuel (CNG, LPG, ethanol, hydrogen, battery electric, plug-in hybrid) in the city/FUA [# vehicles]	Urban node
O28	Annual energy purchased for transport by energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) from refuelling stations in the city/FUA [l/kg/kWh per year]	Urban node
<i>Result indicators</i>		
R1	Annual well-to-wheel GHG emissions from road transport in the city/FUA per inhabitant [t CO ₂ e/inh. per year]	EC
R2	Average well-to-wheel GHG emission per vehicle-km of public transport bus vehicle stock [g CO ₂ e/km]	EC
R3	Average well-to-wheel GHG emission per vehicle-km of total bus vehicle stock [g CO ₂ e/km]	EC
R4	Average well-to-wheel GHG emission per vehicle-km of public transport coach vehicle stock [g CO ₂ e/km]	EC
R5	Average well-to-wheel GHG emission per vehicle-km of total coach vehicle stock [g CO ₂ e/km]	EC
R6	Average well-to-wheel GHG emission per vehicle-km of public transport water bus stock [g CO ₂ e/km]	EC
R7	Average well-to-wheel GHG emission per vehicle-km of private moped vehicle stock [g CO ₂ e/km]	EC
R8	Average well-to-wheel GHG emission per vehicle-km of private motorcycle vehicle stock [g CO ₂ e/km]	EC
R9	Average well-to-wheel GHG emission per vehicle-km of private car vehicle stock [g CO ₂ e/km]	EC
R10	Average well-to-wheel GHG emission per vehicle-km of light commercial vehicle stock [g CO ₂ e/km]	EC
R11	Average well-to-wheel GHG emission per vehicle-km of heavy goods vehicle stock [g CO ₂ e/km]	EC
R12	Average well-to-wheel GHG emission per vehicle-km of taxi and ride-hailing vehicle stock [g CO ₂ e/km]	EC
R13	Average well-to-wheel GHG emission per vehicle-km of shared car vehicle stock [g CO ₂ e/km]	EC
R14	Average well-to-wheel GHG emission per vehicle-km of municipal service car vehicle stock [g CO ₂ e/km]	EC
R15	Annual well-to-wheel GHG emissions from road transport energy purchased (from refuelling stations in the city/FUA) per inhabitant [t CO ₂ e/inh. per year]	EC
R16	Annual transport energy purchased (from refuelling stations in the city/FUA) per inhabitant by energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) [l/kg/kWh/inh. per year]	EC

Method of calculation of result indicators

Please note that the equations below could be applied centrally at European level to calculate the values of the result indicators based on input and output data provided by the urban nodes under the input and output indicators.

#	Method name (component of indicator)	Indicator(s)	Equation	Variables
M1	Annual well-to-wheel GHG emissions from road transport in the city/FUA per inhabitant <i>[t CO₂e/inh. per year]</i>	R1	$G = \frac{C}{P}$	<ul style="list-style-type: none"> - G = Annual GHG emissions Well-to-Wheel from road transport in the city/FUA per inhabitant <i>[t CO₂e/inh. per year]</i> - C = Annual CO₂-equivalent emissions from road transport in the city/FUA <i>[t CO₂e per year]</i>, indicator O1 - P = Total population <i>[# inhabitants]</i>
M2	Average well-to-wheel GHG emission per vehicle-km of each vehicle type (PT bus/total bus/PT coach/total coach/PT water bus/private moped/private motorcycle/private car/light commercial vehicle/heavy goods vehicle/taxi and ride-hailing vehicle/shared car/municipal service car) considered <i>[g CO₂e /km]</i>	R2 – R14	<p>Based on Tier 2 method for Energy specific consumption factor per vehicle-km (vehicles by engine fuel f and Emission standard e)</p> $AG^m = \left(\sum_k \left(\sum_{fe} EF_{kfe}^m * \frac{V_{fe}^m}{\sum_{fe} V_{fe}^m} \right) * (T_k + W_k) \right) * 1000$ <p>The formula estimates GHG emissions per vehicle-km making reference to the equations (1) to (5) for vehicle operation (Tank to wheel) and vehicle energy provision (Well to tank) GHG emissions of the TOC of the ISO standard (chapter 8.3)[6]. In more detail:</p> <ul style="list-style-type: none"> - EF_{kfe}^m corresponds to the quantity of GHG activity related to combustion of fuel during vehicle operation - T_k corresponds to the vehicle operation GHG emission factor 	<ul style="list-style-type: none"> - AG^m = Average well-to-wheel GHG emission per vehicle-km of each vehicle type m considered <i>[g CO₂e/km]</i> - EF_{kfe}^m = Energy specific consumption factor per vehicle-km by energy carrier k by engine fuel f and Emission standard e <i>[ℓ or kg or kWh/km]</i> - V_{fe}^m = Vehicles of engine fuel f and Emission standard e per vehicle type m <i>[# vehicles]</i> (see Annex for an example to structure this variable from the required output indicators) - m = Vehicle type (PT buses/ PT coaches/ PT water buses/ total buses / total coaches / taxi and ride-hailing / shared cars/ municipal service cars/ private mopeds / private motorcycles/ private cars/ light commercial vehicles/ heavy goods vehicles) - f = engine fuel (diesel, gasoline, CNG, LPG, hydrogen, battery electric, plug-in hybrid)

			<ul style="list-style-type: none"> - W_k corresponds to the vehicle energy provision GHG emission factor <p>Data on vehicle by engine fuel and Emission standard (V_{f^e^m}) is used to estimate the average value representing the vehicle stock composition.</p>	<ul style="list-style-type: none"> - e = Emission standard of diesel / gasoline engine ((1) Euro norm 1-4, (2) Euro norm 5, (3) Euro norm 6a-c, (4) Euro norm 6d, Euro norm 7) - T_k = Tank to wheel CO₂ emission per unit of energy carrier k considered [kg CO_{2e}/ℓ or kg CO_{2e}/kg or kg CO_{2e}/kWh] - W_k = Well to tank CO₂ emission per unit of energy carrier k considered [kg CO_{2e}/ℓ or kg CO_{2e}/kg or kg CO_{2e}/kWh] – <u>Please note that the CO₂ emission factor for electricity generation depends on the energy mix of each Country</u> - k = Energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) - multiplied by 1000 to transform kg to grams
			<p>Alternative calculation</p> <p>Based on Tier 1 method for Energy specific consumption factor per vehicle-km (vehicles by engine fuel f only)</p> $AG^m = \left(\sum_k (\sum_f EF_{kf}^m * \frac{V_f^m}{\sum_f V_f^m}) * (T_k + W_k) \right) * 1000$ <p>The formula estimates GHG emissions per vehicle-km making reference to the equations (1) to (5) for vehicle operation (Tank to wheel) and vehicle energy provision (Well to tank) GHG emissions of the TOC of the ISO standard (chapter 8.3)[6]. More in details:</p> <ul style="list-style-type: none"> - EF_{kf^e^m} corresponds to the quantity of GHG activity related to combustion of fuel during vehicle operation - T_k corresponds to the vehicle operation GHG emission factor - W_k corresponds to the vehicle energy provision GHG emission factor 	<ul style="list-style-type: none"> - AG^m = Average well-to-wheel GHG emission per vehicle-km of each vehicle type m considered [g CO_{2e}/km] - EF_{kf^e^m} = Energy specific consumption factor per vehicle-km by energy carrier k by engine fuel f [ℓ or kg or kWh/km] - V_{f^m} = Vehicles of engine fuel f per vehicle type m [# vehicles], (output indicators O3, O5, O7, O9, O11, O13, O15, O17, O19, O21) - m = Vehicle type (PT buses/ PT coaches/ PT water buses/ total buses / total coaches / taxi and ride-hailing / shared cars/ municipal service cars/ private mopeds / private motorcycles/ private cars/ light commercial vehicles/ heavy goods vehicles) - f = engine fuel (diesel, gasoline, CNG, LPG, hydrogen, battery electric, plug-in hybrid) - T_k = Tank to wheel CO₂ emission per unit of energy carrier k considered [kg CO_{2e}/ℓ or kg CO_{2e}/kg or kg CO_{2e}/kWh]

			Data on vehicle by engine fuel and Emission standard (V_{fe}^m) is used to estimate the average value representing the vehicle stock composition)	<ul style="list-style-type: none"> - W_k = Well to tank CO_2 emission per unit of energy carrier k considered [$kg\ CO_{2e}/\ell$ or $kg\ CO_{2e}/kg$ or $kg\ CO_{2e}/kWh$] – <u>Please note that the CO_2 emission factor for electricity generation depends on the energy mix of each Country</u> - k = Energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) - multiplied by 1000 to transform kg to grams
M3	Annual GHG emissions Well-to-Wheel from transport energy purchased (from refuelling stations in the city/FUA) per inhabitant [$t\ CO_{2e}/inh.$ per year]	R15	$sales_G = \frac{(\sum_k I_k * (T_k + W_k))}{P} / 1000$ <p>The formula estimates GHG emissions making reference to the equations (1) to (5) for vehicle operation (Tank to wheel) and vehicle energy provision (Well to tank) GHG emissions of the TOC of the ISO standard (chapter 8.3)[6]. In more detail:</p> <ul style="list-style-type: none"> - I_k corresponds to the quantity of GHG activity related to combustion of fuel during vehicle operation - T_k corresponds to the vehicle operation GHG emission factor - W_k corresponds to the vehicle energy provision GHG emission factor 	<ul style="list-style-type: none"> - $sales_G$ = annual GHG emissions from transport energy purchased (from refuelling stations in the city/FUA) per inhabitant [$t\ CO_{2e}/inh.$ per year] - I_k = Energy purchased for transport from refuelling stations in the city/FUA by energy carrier k [ℓ or kg or kWh] - T_k = Tank to wheel CO_2 emission per unit of energy carrier k considered [$kg\ CO_{2e}/\ell$ or $kg\ CO_{2e}/kg$ or $kg\ CO_{2e}/kWh$] - W_k = Well to tank CO_2 emission per unit of energy carrier k considered [$kg\ CO_{2e}/\ell$ or $kg\ CO_{2e}/kg$ or $kg\ CO_{2e}/kWh$] – <u>Please note that the CO_2 emission factor for electricity generation depends on the energy mix of each Country</u> - k = Energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) - P = Total population [$\#$ inhabitants] - divided by 1000 to transform from kg to tonnes
M4	Annual transport energy purchased (from refuelling stations in the city/FUA) by energy carrier (diesel,	R16	$E_k = \frac{I_k}{P}$	<ul style="list-style-type: none"> - E_k = Annual transport energy purchased (from refuelling stations in the city/FUA) by energy carrier k per inhabitant [$\ell/ kg/ kWh/inh.$] - I_k = Energy purchased for transport from refuelling stations in the city/FUA by energy carrier k [ℓ or kg or kWh]

gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) per inhabitant [ℓ/kg/kWh/inh. per year]			<ul style="list-style-type: none"> - k = Energy carrier (diesel, gasoline, CNG, LPG, electricity, ethanol, bio-ethanol, bio-diesel, hydrogen) - P = Total population [# inhabitants]
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Definitions of terms and acronyms used

Term	Definition	Source(s)
Bus	A passenger road motor vehicle designed to carry more than 24 persons (including the driver), and with provision to carry seated as well as standing passengers. Refers to class I and class II of categories M2 and M3 of the UN Consolidated Resolution on the Construction of Vehicles (R.E.3).	<ul style="list-style-type: none"> - Eurostat Glossary for transport statistics, page 40, C9 (5th edition, 2019): https://ec.europa.eu/eurostat/documents/3859598/10013293/KS-GQ-19-004-EN-N.pdf/b89e58d3-72ca-49e0-a353-b4ea0dc8988f
Car	A vehicle used for carriage of passengers, comprising not more than eight seats in addition to the driver's (UNECE category M1).	<ul style="list-style-type: none"> - UNECE Consolidated Resolution on the Construction of Vehicles (R.E.3), Rev. 6, page 6: https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP.29-78r6e.pdf
Carbon dioxide equivalent (CO ₂ e)	A unit for comparing the radiative forcing of a greenhouse gas (GHG) to that of carbon dioxide. The carbon dioxide equivalent is calculated using the mass of a given GHG multiplied by its global warming potential.	<ul style="list-style-type: none"> - ISO 14083:2023. Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations, Chapter 3.2.1 https://www.iso.org/obp/ui/#iso:std:78864:en
City	A city is a local administrative unit where at least 50 % of the population lives in one or more urban centres (i.e., a cluster of contiguous grid cells of 1 km ² - excluding diagonals - with a population density of at least 1,500 inhabitants per km ² and	<ul style="list-style-type: none"> - Eurostat glossary (webpage): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Category:Regions_and_cities_glossary

	collectively a minimum population of 50,000 inhabitants after gap-filling).	
Coach	Passenger road motor vehicle designed to seat 24 or more persons (including the driver) and constructed exclusively for the carriage of seated passengers. Refers to class III of categories M2 and M3 of the UN Consolidated Resolution on the Construction of Vehicles (R.E.3).	- Eurostat Glossary for transport statistics, page 40 (5th edition, 2019): https://ec.europa.eu/eurostat/documents/3859598/10013293/KS-GQ-19-004-EN-N.pdf/b89e58d3-72ca-49e0-a353-b4ea0dc8988f
Emission standard of vehicles	The maximum amount of discharge legally allowed from a single source, mobile or stationary. Since 1992, the EU has introduced increasingly stricter exhaust emission limits for each new vehicle sold in the EU. The legal framework for road vehicles consists of a series of EU directives, providing the definition of the standard, defining when they come into force, and what they apply to.	
Energy carrier (fuel type)	Substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes. For the purpose of this document, it includes: diesel, gasoline, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), electricity, ethanol, bio-ethanol, bio-diesel, hydrogen	- ISO 14083:2023. Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations, Chapter 3.2.2: https://www.iso.org/obp/ui/#iso:std:78864:en
Energy-specific consumption factor per vehicle-km by energy carrier and vehicle category (Tier 1 and Tier 2) [<i>ℓ or kg or kWh/km</i>]	A measure of the energy efficiency of a vehicle category, i.e., the energy consumed to travel one km, by energy carrier. Taken from literature. See table in the Annex. When using Tier 2 method, vehicles are segmented by fuel engine and Euro emission standard, when using Tier 1 by fuel engine only.	- EMEP/EEA air pollutant emission inventory guidebook 2019 (update Oct. 2020) - Fuel consumption factors: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view <ul style="list-style-type: none"> ○ Tier 2 method, page 33 ○ Tier 1 method, page 23
Fuel type	<i>See definition of energy carrier.</i>	-

Functional urban area (FUA)	A functional urban area consists of a densely inhabited city and a less densely populated commuting zone whose labour market is highly integrated with the city (OECD, 2012).	<ul style="list-style-type: none"> - Eurostat glossary (webpage): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Category:Regions_and_cities_glossary
Greenhouse Gas (GHG)	Gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. For a list of GHGs, see the latest Intergovernmental Panel on Climate Change (IPCC) Assessment Report.	<ul style="list-style-type: none"> - ISO 14083:2023. Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations, Chapter 3.2.5 https://www.iso.org/obp/ui/#iso:std:78864:en - IPCC reports: https://www.ipcc.ch/reportshttps://www.ipcc.ch/reports/
Heavy goods vehicle	A vehicle used for the carriage of goods and having a maximum mass exceeding 3.5 tonnes (UNECE categories N2 and N3).	<ul style="list-style-type: none"> - UNECE Consolidated Resolution on the Construction of Vehicles (R.E.3), Point 2.3.2. and 2.3.3, page 8: https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP.29-78r6e.pdf
LCA (Life Cycle Assessment) emission factors	Emission factors for the overall life cycle of each energy carrier, i.e. including not only the GHG emissions due to fuel combustion but also emissions of the entire energy supply chain – exploitation, transport and processing.	<ul style="list-style-type: none"> - Covenant of Mayors for Climate & Energy Europe - Reporting guidelines (2020), page 18: https://eu-mayors.ec.europa.eu/sites/default/files/2022-10/Covenant-reporting-guidelines-EN-final.pdf
Light commercial vehicle	A vehicle used for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes (UNECE category N1).	<ul style="list-style-type: none"> - UNECE Consolidated Resolution on the Construction of Vehicles (R.E.3), Rev. 6, page 8: https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP.29-78r6e.pdf
Moped	A two-, three- or four-wheeled road motor vehicle which is fitted with an engine having a cylinder capacity of less than 50cc and a maximum authorized design speed in accordance with national regulations. Where limitations concerning the engine displacement are not applicable, a restriction in terms of motor power may be in force. Refers to categories L1 and L2 of the UN	<ul style="list-style-type: none"> - Eurostat Glossary for transport statistics, page 37 (5th edition, 2019): https://ec.europa.eu/eurostat/documents/3859598/10013293/KS-GQ-19-004-EN-N.pdf/b89e58d3-72ca-49e0-a353-b4ea0dc8988f?t=1568383761000

	<p>Consolidated Resolution on the Construction of Vehicles (R.E.3). For the purposes of this document, speed-pedelegs are also considered mopeds.</p>	
Motorcycle	<p>A two-, three- or four-wheeled road motor vehicle not exceeding 400 kg of unladen weight. All such vehicles with a cylinder capacity of 50 cc or over are included, as are those under 50 cc which do not meet the definition of moped. Refers to categories L3, L4, L5, L6 and L7 of the UN Consolidated Resolution on the Construction of Vehicles (R.E.3).</p>	<p>- Eurostat Glossary for transport statistics, page 38 (5th edition, 2019): https://ec.europa.eu/eurostat/documents/3859598/10013293/KS-GQ-19-004-EN-N.pdf/b89e58d3-72ca-49e0-a353-b4ea0dc8988f?t=1568383761000</p>
Municipal service car	<p>A car owned by the city and used by city personnel who are authorized to operate such vehicles.</p>	
Public transport (PT)	<p>Service to a transport service user provided or planned/organized by public authorities for the transport of passengers from an origin to a destination. Here it includes the following modes: buses, trolleybuses, coaches, trams, light rail, metros, trains, water buses.</p>	<p>- ISO 14083:2023. Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations, Chapter 3.1.31: https://www.iso.org/obp/ui/#iso:std:78864:en</p>
Shared (mobility service)	<p>A transport system where users share a vehicle over time as personal rental, allowing them to access the service on an as-needed basis. For the scope of this document, it is generally intended for short-distance travels (within the city/FUA) and limited rental periods.</p>	
Speed-pedelec	<p>A type of pedal-assisted bicycle where the electric assistance cuts off when the vehicle reaches approximately 45 km/h (exact limit depends on local regulations). A speed-pedelec only provides assistance when the user is pedalling.</p>	<p>- International Transport Forum (ITF) - Measuring New Mobility Definitions, Indicators, Data Collection, p.20: https://www.itf-oecd.org/sites/default/files/docs/measuring-new-mobility-definitions-indicators-data.pdf</p>

Tank to wheel CO ₂ emission per unit of energy carrier	<p>CO₂ emission factor per unit of energy carrier (kg CO₂/ kg unit) related to the burning/usage of a fuel in a vehicle. Taken from literature.</p> <ul style="list-style-type: none"> • Gasoline 3.19 • Diesel 3.17 • CNG 2.79 • LPG 3.05 • LNG 2.84 • Ethanol 0.01 • Bio-Diesel 0.15 • Hydrogen 0 • Electricity 0 	<ul style="list-style-type: none"> - ISO 14083:2023. Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations, Table K.1 — European GHG emission factors for liquid fuels and electricity, page 88: https://www.iso.org/obp/ui/#iso:std:78864:en - EMEP/EEA air pollutant emission inventory guidebook 2019 – Update Oct. 2020: https://www.eea.europa.eu/themes/air/air-pollution-sources-1/emep-eea-air-pollutant-emission-inventory-guidebook - Alternative source: Greenhouse gases emission factors for local emission inventories, Covenant of Mayors databases - Version 2022, page 5-6: https://publications.jrc.ec.europa.eu/repository/handle/JRC129433
Taxi or ride-hailing (service)	<p>A licensed passenger car for hire with a driver, without predetermined routes. Includes ride-hailing which refers to ordering a customised ride online, usually via a smartphone application, usually for immediate start of the service. Ride-hailing companies, via websites and mobile apps, match passengers with drivers.</p>	<p><i>Taxi:</i></p> <ul style="list-style-type: none"> - Eurostat Glossary for transport statistics, page 39 (5th edition, 2019): https://ec.europa.eu/eurostat/documents/3859598/10013293/KS-GQ-19-004-EN-N.pdf/b89e58d3-72ca-49e0-a353-b4ea0dc8988f?t=1568383761000 <p><i>Ride-hailing:</i></p> <ul style="list-style-type: none"> - European Commission Notice on well-functioning and sustainable local passenger transport-on-demand (taxis and PHV) 2022/C 62/01, I. Introduction: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022XC0204%2803%29#ntr1-C_2022062EN.01000101-E0001
Total population	<p>Total number of inhabitants (usual resident population) of a given area (Functional Urban Area or city): the number of inhabitants on 1st January of the year in question (or, in some cases, on 31st December of the previous year).</p>	<ul style="list-style-type: none"> - Eurostat glossary (webpage): https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Population_figure
Water bus	<p>An inland waterways passenger vessel (ferry) designed to transport passengers, and sometimes also vehicles and cargo, across or along waterways.</p>	<ul style="list-style-type: none"> - Eurostat Glossary for transport statistics, page 65 (5th edition, 2019): https://ec.europa.eu/eurostat/documents/3859598/10013293/KS-GQ-19-004-EN-N.pdf/b89e58d3-72ca-49e0-a353-b4ea0dc8988f

	<p>A waterbus transports passengers only on a public scheduled service.</p>	
<p>Well to tank CO₂ emission per unit of energy carrier</p>	<p>CO₂ emission factor per unit of energy carrier (kg CO₂/kg) related to the cascade of steps required to produce and distribute the energy carrier (starting from the primary energy resource), including vehicle refuelling.</p> <p>Except for electricity, the following values are taken from ISO STANDARD 14083e as the difference between GHG emissions (total) and GHG emissions (operational) (based on equation (5) (chapter 8.3):</p> <ul style="list-style-type: none"> • Gasoline 0.64 • Diesel 0.57 • CNG 0.79 • LPG 0.66 • LNG 0.87 • Ethanol 1.29 • Bio-Diesel 1.27 • Hydrogen 13,73 • Electricity 0.275 (Kg CO₂ / KWh average at EU level) <p>Concerning electricity generation, the CO₂ emission factor depends on the energy mix of each Country; for this reason, <u>it is required to specify the Country in which the city/FUA lies.</u></p>	<ul style="list-style-type: none"> - ISO 14083:2023. Greenhouse gases — Quantification and reporting of greenhouse gas emissions arising from transport chain operations, Table K.1 — European GHG emission factors for liquid fuels and electricity, page 88: https://www.iso.org/obp/ui/#iso:std:78864:en - For GHG emission factor of electricity by country: https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-12/#tab-chart_2 - Alternative source: Greenhouse gases emission factors for local emission inventories, Covenant of Mayors databases - Version 2022, pages 5-6, 13: https://publications.jrc.ec.europa.eu/repository/handle/JRC129433

ANNEX: Method of calculation M2

Method of calculation M2: variable V_{fe}^m = Vehicles of engine fuel f and Emission standard e per vehicle type m [# vehicles]

Example of variable V_{fe}^m for mode m= public transport vehicles

Fuel engine f	Euro Emission standard e	Output indicator
Diesel	Euro norm 1-4	O2 - Public transport bus vehicle stock composition by diesel engine fuel and Euro emission standard ((1) Euro norm 1-4, (2) Euro norm 5, (3) Euro norm 6a-c, (4) Euro norm 6d and Euro norm 7) in the city/FUA [# vehicles]
	Euro norm 5	
	Euro norm 6a-c	
	Euro norm 6d	
	Euro norm 7	
CNG	n.a.	O3 - Public transport bus vehicle stock composition by engine fuel (CNG, LPG, hydrogen, battery electric, plug-in hybrid) in the city/FUA [# vehicles]
LPG	n.a.	
Hydrogen	n.a.	
Battery electric	n.a.	
Plug-in hybrid	n.a.	

Energy consumption factor per vehicle-km by engine fuel and euro emission standard

Tier 2 method EMEP/EEA air pollutant emission inventory guidebook 2023. Fuel consumption factors, page 33

<https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view>

Energy consumption factor per vehicle-km by engine fuel

Tier 1 method EMEP/EEA air pollutant emission inventory guidebook 2023. Fuel consumption factors, page 23

<https://www.eea.europa.eu/publications/emep-eea-guidebook-2023/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view>