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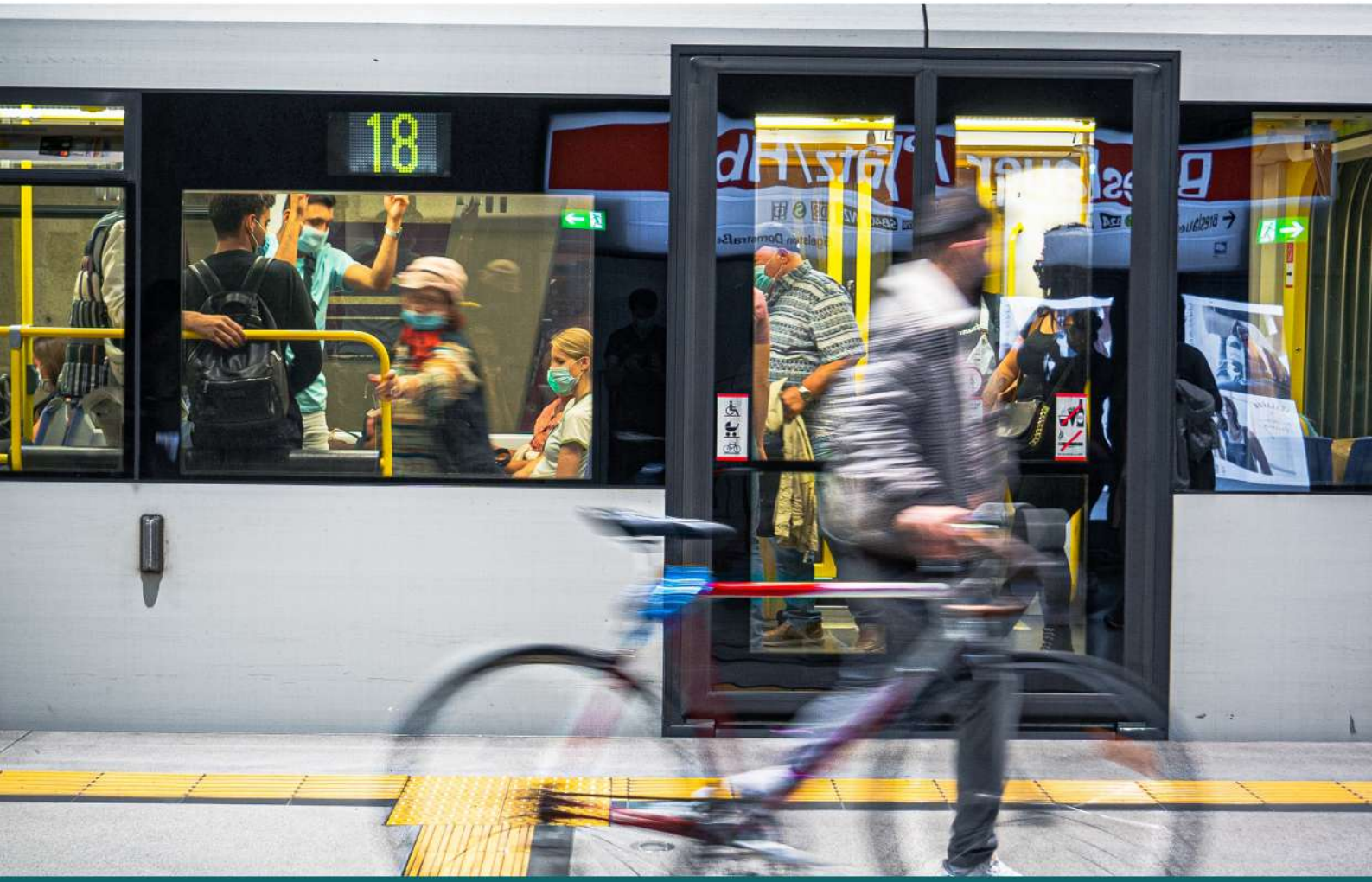

Assessing Transportation Data from Google Environmental Insights Explorer

December 2021

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About the report: In collaboration with Google, ICLEI Europe has undertaken a comprehensive analysis of the Google Environmental Insights Explorer (EIE) tool to better understand the extent to which it can assist European cities in advancing local climate action and achieving their carbon emissions reduction goals. As part of the analysis, ICLEI Europe conducted a technical assessment of EIE's transport data to investigate how it may be able to support cities in their efforts to reduce local-level transport emissions and promote sustainable urban mobility.

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Foreword

The following technical assessment outlines the results of ICLEI Europe's analysis of the Google Environmental Insights Explorer (EIE) tool. It investigates how EIE data is able to support cities in their efforts to reduce local-level transport emissions and promote sustainable urban mobility.

This assessment builds on ICLEI Europe's experience in exploring the functionality of the Google EIE tool and in using its data alongside nine European cities: Athens (GR), Florence (IT), Greater Manchester (UK), Izmir (TR), Lisbon (PT), Madrid (ES), Malmö (SE), Mannheim (DE) and Warsaw (PL).

The results show that cities are willing to invest a substantial amount of effort to harness the potential of innovative tools, such as Google's EIE, that provide new mechanisms to improve or refine their GHG emissions accounting processes, establish ambitious climate targets and identify future pathways to reduce transport emissions and improve the efficiency of local transport systems.

ICLEI Europe recommends that cities and regions experiencing challenges in developing their GHG inventory and/or a lack of mobility data explore the EIE tool. City officials and practitioners are also invited to read the Overview for Policymakers Report, which provides a summary of the assessment's key findings and offers insights on how EIE data could bring value to EU cities' transport emissions accounting processes in the future.

ICLEI Europe will continue to facilitate additional exchanges with cities and further research with community interest groups to ensure local contexts are reflected in EIE's evolving datasets.

"In order to be effective in accelerating sustainable mobility and related climate action at the local level, we need access to current, reliable data that provide us with an evidence base. In our digital world, this also means exploring new sources of information to support related decision-making processes. We encourage local governments in Europe to examine the Google Environmental Insights Explorer (EIE) tool which, in combination with existing local knowledge and data sources, holds great potential for enhanced climate action."

Wolfgang Teubner. Regional Director, ICLEI Europe

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1 Introduction

The use of different sources of data to support decision-making processes for accelerated environmental and climate action at the local level has gained traction in Europe, and worldwide, in recent years. The new EU Green Deal places accessible and interoperable data at the heart of data-driven innovation. Combined with digital infrastructure and artificial intelligence solutions, this data could facilitate evidence-based decision-making and expand the capacity to understand and tackle environmental challenges. (European Commission, 2019)

Transport is recognised as one of the main drivers of direct greenhouse gas (GHG) emissions in urban areas. In 2019, GHG emissions from road transportation accounted for 27% of the total in Europe, followed by public electricity and heat production (25%), manufacturing and industries (15%), and residential sector emissions (11%). (EEA, 2021) Cities have been investing substantial efforts into establishing ambitious climate targets and defining clear roadmaps to reduce emissions in the transport sector. During this journey, policymakers and practitioners face great challenges in developing strategies, plans, and actions against the backdrop of limited data availability.

EIE was launched by the Global Covenant of Mayors (GCoM) and Google in 2018 and is designed to make Google's significant data resources available to cities. The purpose is to accelerate measurement and planning stages for cities regarding climate action. (GCoM, 2020) Google EIE estimates and calculates transport emissions in cities worldwide by harnessing proprietary data and different modelling techniques. (Google Earth and Earth Engine, 2020).

In 2019, ICLEI USA conducted a technical review of city-level GHG emissions inventory data provided by Google EIE, comparing it to other data sources commonly used in North American cities. The results of the report highlighted that EIE could provide interesting insights for cities, particularly by making on-road transportation activity and multimodal transport data available, including pedestrian and bicycle data. (ICLEI USA, 2019)

In Europe, Google EIE data is available for more than 3,500 cities. Local authorities can access EIE data via a city signup process and are able to use, revise, and validate their emissions data for publication on the EIE website. The city of Dublin, Ireland is taking advantage of the Google EIE tool to help tackle the climate crisis with the development of an on-site data analysis process. Results of the study prove Google EIE to be fairly accurate when estimating traffic intensity and obtaining data on walking and cycling modes, which are usually difficult for cities to evaluate. (GCoM, 2021)

Europe's decarbonisation efforts in the last decade have highlighted the importance of tackling emissions from different sectors, especially at the local level. National and sub-national governments have been investing in establishing ambitious climate targets and defining clear roadmaps to reduce emissions in several sectors, including transport, which is recognised as one of the main drivers of direct emissions in urban areas.

This introductory chapter includes:

- An overview of the direction of sustainability transformations in the mobility domain that are being planned and enacted in Europe
- A broader ICLEI analysis, including a summary of the GHG emissions accounting methodologies used by European cities

- Results of an initial city profiling exercise based on the cities selected for the deep-dive analysis, with emphasis on GHG emissions methodologies, climate and sustainable mobility policies, and geographical boundaries.

1.1 Sustainable Mobility in European Cities

Understanding the European climate and sustainable mobility landscape is key to framing the assessment findings. The new EU Green Deal calls for a 90% reduction in GHG emissions produced by transport in order to reach EU climate-neutrality by 2050. This will be achieved mainly by making all transport modes more sustainable, by providing mobility alternatives, and by providing the right incentives for transition to a zero-emissions mobility model. (European Commission, 2020)

All these transformations are mainly being implemented at the local level, which means cities will need to be prepared to achieve success. Cities in Europe have ample experience in developing and implementing different strategies to improve the efficiency of local transport systems (e.g., through Sustainable Urban Mobility Plans). Some cities are also developing Sustainable Energy and Climate Action Plans (SECAP) to identify mitigation actions that could reduce transport emissions. To do this, cities require a clear understanding of the different types of transport used, related emissions, and the impact of the measures on the city's overall emissions.

Many cities in Europe are characterised by dense historic centres that were not designed to accommodate automotive transport, and by rapidly growing suburbs. Over the past decade, there has been strong momentum across Member States to decarbonise transport, with active modes of public transport (train, rail, bus, tram) being strongly promoted. At the same time, national, regional, and local governments are introducing policies and implementing measures to discourage private car ownership and use.

Sustainable Urban Mobility Plans (SUMP) are increasingly being used as a standard for European cities to strategically plan for the mobility needs of citizens and businesses. (ELTIS, 2013) Compared to traditional transport planning processes, which focused on cars and roads, SUMPs place people at the centre of the planning process, ensuring accessibility, safer environments and cleaner air.

Cities can generally be placed on a spectrum from "car-oriented city," to "sustainable mobility city," to, most successfully, a "city of places" where citizens can enjoy the public space. (CREATE Project, 2018) Many cities are being supported by the European SUMP Guidelines, whose update was led by ICLEI, and continue to base daily planning decisions on the ICLEI-endorsed Shared Mobility Principles (SMP). These guiding tools help lead decisions toward sustainability. (SMP Coalition, 2017)

There are other characteristics of sustainable mobility planning at play in Europe that look at air quality improvements, noise reduction, and safety. These approaches highlight the importance of understanding transport and mobility patterns to improve the cities' overall sustainability. European cities have a strong interest in decarbonising transport by offering alternatives such as walking and improved cycling conditions, alongside introducing car-free support services such as Mobility-as-a-Service (or MaaS, which uses technology to bring together tools for the public to plan and use transport alternatives). (ICLEI, 2017)

Cities all have some sort of official transport function, but the organisation styles vary. The size of teams focussed on mobility, as well as the level of support from agencies and local companies, will differ from city to city. Several cities have models to assess mobility patterns.

However, these have historically been focussed more around measuring the movement of cars. Modal split towards better mobility planning relies on tools that can measure, monitor, and compare all modes of transport, which is a capability offered by Google EIE.

1.2 Report Scope and Methodological Approach

This assessment analyses how Google EIE data on transport and mobility can support cities in their transport emissions accounting processes and provide insights on sustainable urban mobility goals. This report constitutes the first deliverable resulting from a broader analysis of the potential of Google EIE data to support European cities with their climate action and sustainability journeys.

The assessment starts with the identification of commonly used GHG emissions accounting methodologies in European cities. The assessment then offers analysis of climate action strategies and data in nine selected cities, with an emphasis in the transport sector, and also includes the identification of methodological differences and data gaps when comparing emissions accounting approaches with the Google EIE data.

The deep-dive analysis does not include in-depth statistical analyses of cities' data, nor does it include a specialised validation process of Google EIE emissions or modal split data.

For the deep-dive analysis, ICLEI developed a city engagement process, which included questionnaires and stakeholder interviews aimed at identifying methodological differences among accounting approaches, and understanding the data gaps between EIE and local calculations. Cities participating in the deep-dive analysis were provided access to a dedicated Google EIE workspace, which allowed city-level experts to visualise and evaluate emissions for their city and to explore the tool in detail.

1.2.1 GHG Emissions Accounting in European Cities

An initial evaluation of methodologies used and reported by European cities in the ICLEI-CDP Unified Reporting System was conducted, primarily by screening entries as well as by consulting relevant reports. This system provides a global platform for cities to measure, manage and disclose their environmental data. (CDP-ICLEI, 2018).

A review of city-level methodologies reported during 2018, 2019, and 2020 showed that a diverse range of methods and standards were, and still are, in use. In this initial overview, three main methodologies were identified among the cross-section of cities:

- The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC); (GHG Protocol, 2014)
- The Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines; (IPCC, 2006)
- The Baseline / Monitoring Emissions Inventory Approach (BEI/MEI) of the EU Covenant of Mayors (Bertoldi, P. et al., 2018), and;
- Hybrid or custom approaches from national guidelines, often based in part on the methodologies mentioned above)

The screening of methodologies revealed that the number of European cities reporting via the CDP-ICLEI System has increased significantly between 2018 and 2020, with 165 cities reporting emissions in 2020. See Figure 1 below.

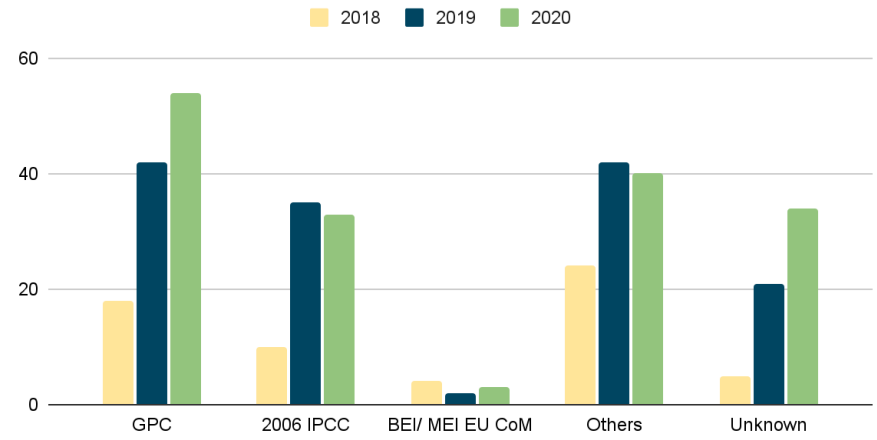

Figure 1. *GHG emissions accounting methodologies used by European cities. Source: CDP/ICLE Unified Reporting System.*

As visualised above, GPC is the most used methodology for emissions accounting in European cities, followed by the 2006 IPCC and the BEI/MEI EU CoM methodologies. The change in methodologies used over time suggests that the utilisation of GPC, as well as unknown approaches, is increasing significantly.

As the second-largest category captured by the assessment, the "other" methodologies refer to inventories that were compiled by or for cities in countries with robust national and pre-established reporting guidelines (e.g., France, Germany, Denmark, and Norway). For the "unknown" category, several cities could not be evaluated due to the lack of reports on the methodology used.

The number of reporting cities, and the diversity of methodologies encountered, seem to confirm the significant levels of experience many European cities have in GHG emissions accounting, in addition to underscoring the maturity of climate action in Europe.

1.2.2 City Selection Process

Over 50 European cities that are part of the ICLEI network were included in an initial scoping exercise, leading up to the assessment of emissions calculation methodologies. Of these, 24 were identified as potential cities to be explored further, with the availability of data in the ICLEI-CDP Unified Reporting System and in Google EIE being the core selection criteria.[1]

Further indicators underpinning the city selection included demonstrated climate action efforts, ability to share updated GHG emissions inventory data, and level of engagement within the ICLEI city network.

From these 24 cities, ICLEI created an engagement process to identify eight to 10 cities interested in further exploring Google EIE data and sharing their methodological insights. The final selection for the deep-dive analysis included nine cities to serve as a control group: Athens (GR), Florence (IT), Greater Manchester (UK), Izmir (TK), Lisbon (PT), Madrid (ES), Malmö (SE), Mannheim (DE), and Warsaw (PL).

[1] The CDP-ICLEI System provides access to standardised and publicly available emissions data directly reported by cities, facilitating data comparisons.

ICLEI ensured that the city sample was both representative in terms of geographical distribution as by city size, with populations ranging from 193,000 to 4.36 million inhabitants. This population data corresponds to the geographical boundaries of the cities as reported in the CDP-ICLEI Unified Reporting System. It's important to note that many cities have different methods of counting population – such as whether only the urban core or the wider metropolitan area is considered.

Open access to EIE allowed city-level practitioners to benchmark their cities against their European peers to explore the tool's functionalities and data, and to provide feedback on strengths, concerns and usability issues. Figure 2 shows the cities that were selected for the deep-dive analysis.

Figure 2. *Selected cities for the deep dive. Source: ICLEI Europe.*

1.3 Deep-Dive Analysis, Cities Profiling

The deep-dive analysis included a city profiling exercise for the selected cities:

1. Assessment of the GHG emissions inventory used
2. Analysis of the city's overall emissions calculation processes, data sources, and data governance structures
3. Analysis of strategies and planning processes for climate action and sustainable urban mobility
4. Evaluation of the cities' geographical boundaries to set the basis for comparative analysis between cities' data and Google EIE.

1.3.1 GHG Emissions Accounting Inventories

The cities engaged in the deep dive have transparently reported their emissions inventories in the last few years and have demonstrated their experience in calculating GHG emissions, using standardised methodologies. Of these, six use the GPC methodology: Madrid, Warsaw, Lisbon, Greater Manchester, Malmö, and Athens. Izmir and Florence use the EUCoM BEI/MEI

Approach, and Mannheim uses the Bisko Standard. **Annex 1** describes the different emissions accounting methodologies explored in the deep-dive city analysis, and approaches to transport emissions.

The compilation of emissions inventories is carried out under the leadership of the climate, environmental, and sustainability units or departments of the municipalities, harnessing in-house skills and knowledge. In some cities, such as Malmö, Athens, and Warsaw, the inventory compilation process is carried out internally. Other cities, like Madrid, Lisbon, Greater Manchester, Florence, and Izmir, combine local authority capacities with external organisations, such as universities, consulting firms, and research organisations – especially when modelling work is necessary.

Cities also count on such organisations to validate inventory results and to prepare any information needed for external reporting to different platforms such as CDP-ICLEI, My Covenant, and others.

The process of developing an inventory typically takes six to 12 months, due to the need to involve different departments within the municipality, as well as external bodies like utilities, energy agencies, statistics offices, and national ministries. For this reason, not all cities are able to develop an inventory on an annual basis. Instead, some cities opt to carry them out every two years, which is also a common practice in cities aligned with internationally agreed reporting approaches such as the Global Common Reporting Framework (GCoM, 2019). In addition, to support the development of their inventories, based on the various accounting methods, cities make use of a range of tools and calculation spreadsheets.

Most city-level GHG emissions inventories in the deep-dive analysis date back to 2018, with only two inventories updated in 2019. Overall, very few cities are able to calculate their GHG emissions inventory for the current evaluation year annually. Malmö, Athens, and Lisbon are able to calculate and report their emissions on an annual basis

The selection of the GHG emissions inventory methodology is key to defining a base for comparing cities' calculation methods in relation to Google EIE data, especially for transport emissions. **Annex 2** describes the different governance structures to develop the GHG emissions inventories in the selected cities, as well as the time and frequency of the development. It also includes the tools used by the cities to support their efforts.

1.3.2 Cities' Planning Strategies and Processes

All selected cities also demonstrate leadership in climate action and sustainable urban mobility planning processes. As summarised in Table 1, the cities have mid- and long-term targets to reduce GHG emissions, which indicate the important role of emissions data in their climate planning processes.

Table 1. *Summary of Cities' Climate and Sustainability Policies, Plans, and Goals*

City	Sustainable Energy and Climate Action Planning Instruments	Sustainable Urban Mobility Planning (SUMP) Instruments
Athens	The city is currently updating its Climate Action Plan (CAP) and has developed a Scenario Development Report (2020) to evaluate pathways to become carbon neutral by 2050.	Athens is currently being supported in the development of a SUMP, and data has been collected to inform this process.
Florence	The city has formulated a Sustainable Energy Action Plan (SEAP), which will be	Florence has a detailed Sustainable Urban Mobility Plan, known locally as

	upgraded to a Sustainable Energy and Climate Action Plan (SECAP). Source: City of Florence, 2015	PUMS (Piano Urbano di Mobilitá Sostenible), and a first monitoring report exists. Source: City of Florence, 2019
Greater Manchester Combined Authority	In 2019, Greater Manchester set out its first five-year Environment Plan to be carbon neutral by 2038. Greater Manchester aims to be a clean, carbon-neutral, climate-resilient city region with a thriving natural environment and a circular, zero-waste economy – focussed on smart infrastructure, green spaces, and a sustainable economy. Source: Greater Manchester, 2019	Greater Manchester's Sustainable Urban Mobility Plan (2017, updated 2021) won the Sustainable Urban Mobility Plan Awards in 2019. The plan is supported by a range of documents, including a delivery plan, an indicator matrix, and a household survey summary. Source: Greater Manchester, 2021
Izmir Metropolitan City	Izmir has a SECAP (2020) in which the city has committed to CO2 emission reductions of at least 40% (per capita) against a 2018 baseline year by 2030. In addition, the city aims to increase its climate resilience and provide secure access to sustainable and affordable energy in a manner that is integrated with the mitigation and adaptation plans. The city's SECAP is aligned with the development of the Green City Action Plan (GCAP, 2020). Source: Izmir Metropolitan City, 2020	Izmir has a detailed Transportation Master Plan (2017/2018) which includes modal split and transport data supported by analyses for different parts of the metropolitan city. The city is working with the National Government and the Ministry of Transport to commission the development of Izmir's Sustainable Urban Mobility Plan. Source: Izmir Metropolitan City, 2017
Lisbon	Lisbon has a SECAP (2018) in place, and its Climate Action Plan 2030 (CAP Lisbon 2030) was recently approved in a Public Meeting of the Municipal Executive inJune 2021 with the following goals: reduce GHG emissions by 70% between 2002 and 2030; achieve climate neutrality by 2050; adapt the city to extreme weather events, increase its resilience to climate risks and its capacity to respond to crises and shocks; fight inequalities, focused on eradicating energy poverty. Source: City of Lisbon, 2021	Lisbon has developed a future vision for mobility (MOVE Lisboa - Strategic Vision for Mobility 2030, 2021). The city will develop a Sustainable Urban Mobility Plan, including guidelines for the use of operational instruments to improve mobility and urban accessibility. Source: City of Lisbon, 2021
Madrid	In 2021, Madrid launched its new 2050 Carbon Neutrality Roadmap. By 2030 the city intends to reduce emissions by 65% (10 percentage points higher than the European goal) and to achieve climate neutrality by 2050. In the city's Climate and Air Plan (2017), the target was to achieve 40%+ reduction in total GHG emissions in the municipality of Madrid by 2030 as compared to 1990 emissions levels. With the more recent CN roadmap, the city has increased its target. Source: City of Madrid, 2017	Madrid's sustainable mobility plan (Movilidad Sostenible, 2018) includes modal split data for each zone of the metropolitan area (central, periphery, metropolitan, and regional), as well as for the whole region. The city's Climate and Air Plan aims to meet its commitment to reduce GHG emissions caused by urban mobility by 50% by 2030 compared to 2012 levels. In 2021, it approved updates to the plan. Source: City of Madrid, 201
Malmö	The Environmental Programme for the City of Malmö 2021-2030 includes the following objectives: GHG emissions in	Malmö's Traffic and Mobility Plan (2016) includes historic modal split data and places a particular focus on

	Malmö to be reduced by 70% compared to 1990 values; net-zero emissions for city operations; by 2030, Malmö's consumption-based GHG emissions will be well on their way to reaching a sustainable level; Malmö will be supplied with 100% renewable and recycled energy. Source: City of Malmö, 2021	people-friendly transport. A new Traffic and Mobility Plan for the upcoming decade is being developed. Source: City of Malmö, 2016
Mannheim	The city already has a SECAP, which is made up of the Climate Protection Concept 2020 (2009) and the Climate Adaptation Concept (2019). The city is aiming to achieve climate neutrality well before 2050 and is therefore working on a new SECAP Climate Action Plan 2030 to achieve this ambitious goal. In addition, the city of Mannheim is presenting itself as a pilot city for the Local Green Deal.	Mannheim's current approach to mobility is embodied in its Green City Plan (Nachhaltige Mobilität für die Stadt, 2018, namely Sustainable Mobility for the City, 2018). This includes an analysis of its modal split. In addition to the analysis of the mobility sector within the framework of the Climate Action Plan 2030, a Sustainable Urban Mobility Plan 2035 (SUMP) is also being developed. Source: Mannheim City Council, 2018
Warsaw	Warsaw is currently updating its SEAP into a SECAP, including long-term emissions scenario development for 2030 and 2050. In addition, the city has launched the development of its Green City and Climate Action Plan (GCCAP). The GCCAP is the first of its kind due to the partnership between EBRD and C40, outlining low-carbon and climate resilience development pathways for Warsaw. In the next and final step, reduction targets and pathways will be considered when deciding to update the SEAP into a SECAP.	Warsaw has a detailed sustainable mobility plan for the Warsaw Functional Area (2016) with small-scale levels of analysis and planning as well as procedures for transport system monitoring. Currently the new SUMP is being developed. Source: City of Warsaw, 2016

Sources: Official planning documents, complemented by city interviews

1.3.3 Cities' Boundaries

In order to complete the deep-dive analysis correctly, cities' geographical boundaries defined in their GHG emissions inventories[2] were analysed in relation to the geographical boundaries set in EIE, which uses the administrative city boundaries as represented in Google Maps and develops a quality validation process for larger boundaries corresponding to provincial and metropolitan areas.

Table 2 shows that most of the cities have approximately the same boundaries. But in two cities – Madrid and Izmir Metropolitan City – divergences in surface area coverage were identified.

[2] An inventory boundary identifies the gases, emissions sources, geographic area, and time span covered by a GHG inventory.

Table 2. *Deep-Dive Cities' Geographical Boundaries*

City	City GHG Inventory Boundary CDP-ICLEI (km²)	City Boundary Google EIE (km²)
Athens	39	38,04
Florence	102,4	102.1
Greater Manchester	1277	1272
Izmir Metropolitan City	12019	236
Lisbon	85,9	85
Madrid	604,45	384
Malmö	157	173
Mannheim	145	145
Warsaw	517	515

Source: ICLEI Europe.

The table above underscores that a very broad sample of city sizes has been selected to add breadth to the deep-dive analysis findings. The differences in boundaries can be attributed to several causes, including Google EIE's identification of city boundaries based on Google Maps, the existence of different functional urban areas (FUA) (OECD, 2013)[3], or the delimitation of the core city urban area versus metropolitan areas. These boundaries are relevant when understanding mobility patterns on a local level. Table 3 summarizes some of the key mobility patterns of the selected cities.

Table 3. *Deep-Dive Cities' Mobility Patterns*

City	City Mobility Patterns
Athens	Athens forms the central part of a connected metropolitan area with many transboundary movements and radial routes from the surrounding areas into Athens itself.
Florence	One of the city's main characteristics is tourism, which affects the transport system. The Metropolitan City of Florence has the highest rate of private motorisation in Italy.
Greater Manchester	Greater Manchester represents a combination of a number of local authorities, each with their own urban centres and less densely built up surrounding areas. The city of Manchester, located centrally, forms the largest urban area by far within this combined area.
Izmir Metropolitan City	With more than four million inhabitants, Izmir is one of the most populous urban areas studied in this report, and its growing population represents a challenge to transport planning.
Lisbon	Lisbon forms one part of a sprawling and historic urban area in a peninsula bounded by the sea and separated by a river from further urban areas to the east, with few bridge connections.
Madrid	Mobility in the city of Madrid can not be understood without considering relations with the rest of municipalities in the metropolitan area. Within the city, there are

[3] Functional urban areas (FUA) are composed of a city or core, and its commuting zone. FUAs encompass the economic and functional extent of cities based on people's daily movements. (OECD, 2013)

	notable differences in the mobility of the central area, which has a successful model of modal share, and the periphery, which relies more on private cars.
Malmö	One of the peculiarities of transportation in Malmö is its connection with the city of Copenhagen, Denmark, and other surrounding towns, where a considerable amount of workers commute every day.
Mannheim	Mannheim is highly connected to its surrounding urban areas such as Heidelberg, which means transport interrelationships need to be considered across this area.
Warsaw	The vast majority of trips performed by Warsaw residents are those of an internal nature, beginning and ending in Warsaw). Most of the trips are taken on the west left side of the Vistula river or are associated with crossing the river.

Source: Cities' SUMPs and Household Surveys.

The identification of these differences has been considered in the deep-dive analysis, due to impact on the analysis of transport emissions data, and also, how these differences can affect modal split calculations. From a sustainable urban mobility planning perspective, it is important to understand and analyse mobility data together with commuter flows – that is, how many people are working from within the urban core, the immediate peripheries of the urban core, or the entire metropolitan area. Some cities may have a good overview of this flow – such as FUA to core and vice-versa – as many jobs are located outside the city. It's also very important to understand the length of commutes, whether they're done entirely by car or by car and public transport.

2 Transport Emissions and Mobility Deep Dive

This deep dive includes a methodological analysis of the Google EIE transport emissions accounting method in comparison to cities' related practices. In addition, it provides insights into the evaluation of the differences between EIE data and cities' emissions data. Finally, it explores, in more detail, modal split calculations and how they could contribute to sustainable urban mobility planning processes.

2.1 Methodological Analysis

2.1.1 Understanding the Google EIE Calculation Method for Transport Emissions

The Google EIE tool is able to characterise both trips taken within a city's boundaries and those crossing the city's boundaries within its functional urban area, which is based on Google's proprietary data. The main input data is anonymized user location data, which is predominantly derived from historical Google Maps and mobile phone information.

Several privacy filters, aggregation/anonymisation techniques and inference models were applied to this data. Similar to the population and occupancy factor scaling techniques used by transportation models based on Household Travel Surveys, Google is able to estimate annual trips by mode and distance travelled (km) for all trips within a city's boundaries. Vehicle Kilometres Travelled (VKT) is an important indicator for GHG emissions accounting purposes. (Google, 2018)

These trips and the distance travelled (kilometres) are then combined with regional-specific assumptions from CURB, The Climate Action for Urban Sustainability Tool,[4] to identify vehicle fleet mix and fuel combinations as well as average fuel efficiency factors. This provides fuel consumption values that can then be translated into GHG emissions (CO2e) based on predefined emissions factors as seen in the CURB tool. (The World Bank, 2016)

The Google EIE calculation method for on-road transport emissions has been recognized as a bottom-up approach, a city-induced activity method. (Snapshot, 2020) Estimating emissions requires different information on transport modes, trips, and distance travelled as input data, combined with fuel efficiency and emissions factors from different data sources.

Figure 3 describes Google's approach to transport emissions accounting.

[4] This tool was developed by the World Bank Group, C40 Cities Climate Leadership Group, Bloomberg Philanthropies, the Global Covenant of Mayors for Climate and Energy, and AECOM Consulting.

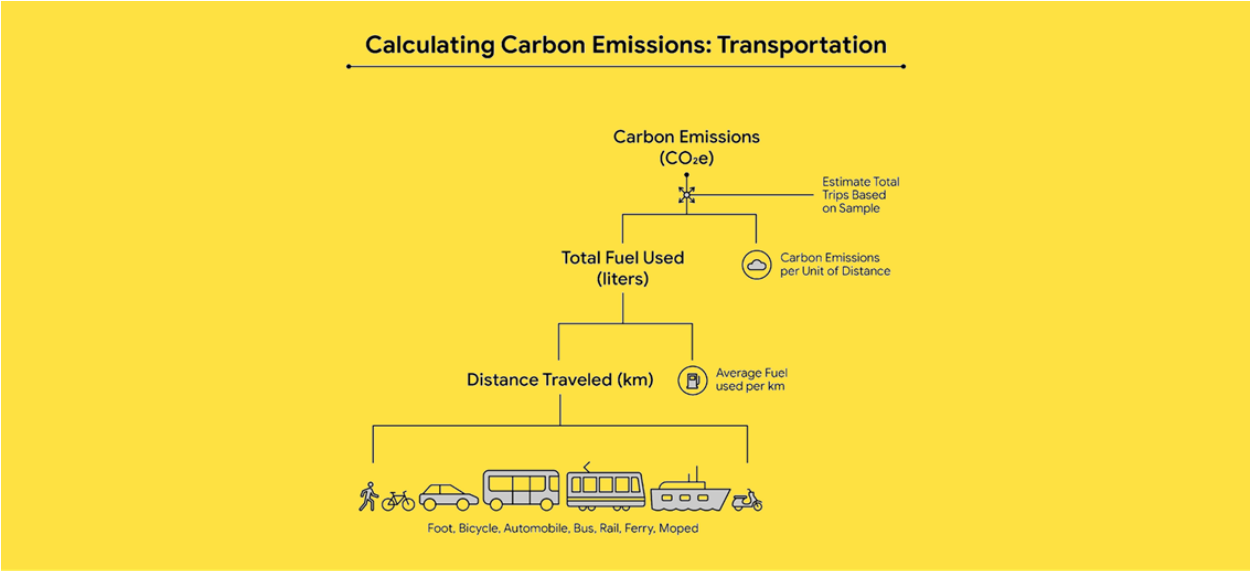

Figure 3. *Google EIE transport emissions calculation methodology. Source: insights.sustainability.google/methodology.*

In order to better understand the fuel efficiency factors from the CURB Tool, ICLEI examined version 2.1 of the tool, finding that most of the factors are average values from 2016. With regard to the fleet mix, it appears that the default distribution of vehicle types quoted in the CURB tool is being applied across all of Europe by Google EIE. The default distribution set by the CURB tool is 91% passenger automobiles, 8% light-duty trucks, and 1% medium-duty trucks.

These defaults might not be representative of current European mobility patterns, where types of fleets are diverse across countries. Values pertaining to the distribution of fuel type per vehicle class are sourced from the International Council on Clean Transportation and are very similar for all European countries. Emissions factors per type of fuel are likely to be taken from a general source, which was not clearly identified. (The World Bank, 2016)

In addition, as a result of the most recent update to the tool, Google EIE is able to show total on-road transport emissions for cities (including in-boundary and transboundary emissions) and is also able to provide emissions data adjusted to the GPC methodology using the induced activity method. (GHG Protocol, 2014). This method requires that emissions from 50% of transboundary trips be accounted for in the inventory. This update is particularly relevant because it will allow for a meaningful comparison with cities' local emissions data following the same methodological approach of GPC, which is increasingly being used by cities in Europe and the world.

The Google EIE tool provides the following input data to calculate the emissions for the years 2018, 2019, and 2020.

- **Mode:** Transport mode (automobile, cycling, ferryboat, motorcycle, rail, standard bus, subway, tram, and walking)
- **Travel_bounds:** Extent and direction of the trip (in-boundary, inbound, and outbound)
- **Trips:** Total number of trips
- **Full_distance_km:** Full travel activity. Total distance travelled (in kilometres)
- **GPC_distance_km:** Total distance travelled according to GPC Methodology l (in kilometres)
- **Full_co2e_tons:** Total emissions measured in tCO2e

- **GPC_co2e_tons:** Total emissions for the year measured in tCO2e (GPC Protocol compliant)
- **Year:** Data collection year

Google EIE is able to provide detailed data on trips and kilometres, but when calculating emissions, it focuses on on-road transport emissions only, excluding electricity-sourced vehicles and rail systems. In this sense, the comparative analysis of emissions data from transport and Google EIE data should be focussed only on road-transport emissions produced by fossil fuels, meaning Scope 1 (Direct Emissions) or Scope 3 (Other Indirect Emissions) for cities interested in accounting these emissions.

2.1.2 Understanding Cities' Calculation Methods for Transport Emissions

As mentioned above, cities participating in the deep-dive analysis mainly use the GPC Methodology, the CoM BEI/MEI Methodology and, for the case of Mannheim, the Bisko Standard. During the evaluation of the calculation methods in the deep-dive cities, specifically for on-road transport emissions, the report found that cities' accounting methods tend to be chosen on the grounds of data availability at the local level, and are based on guidelines from the different methodologies used.

To estimate emissions, city-level approaches can generally be categorised as either bottom-up or top-down methods.[5] The analysis suggests that both are used equally and/or combined depending on the mode of transport evaluated. Of the nine cities participating in the deep dive, six use a top-down approach and three use a bottom-up approach. This is considered in the comparative analysis conducted later in this report. Tables 4a and 4b provide an overview of the emissions calculation methods used by cities, clustered between cities using top-down and bottom-up methods. In addition, it includes a mention of the quality of the activity data used for the emissions calculation processes, as reported in their GHG emissions inventory.

Table 4a. *On-Road Transport Emissions Methods In Use By Cities Using Top-Down Approach*

Cities	Core Accounting Method	Input Data and Modelling	Data Quality
Athens	Top-down: Fuel sales approach. Extrapolation from regional to municipal data.	Public transport emissions are calculated based on real fuel consumption data. For private vehicles, estimations take the TREMOVE model as reference, which provides input of fleet distribution and fuel consumption per type of vehicle. Fleet distribution and fuel consumption data are obtained from regional government data derived from national statistics. TREMOVE is a policy assessment model designed to study the effects of different transport and environment policies on the transport sector. (Transport and Mobility Leuven, n.d.)	High for municipal/public fleet, Medium for private fleet
Florence	Top-down: fuel sales approach. Extrapolation from national to regional data.	Public transport emissions are calculated based on real fuel consumption data. For private and commercial transport, energy consumption is calculated from top-down data and from provincial data on fuel sales, which	Not specified

[5] Top-down approaches start with fuel consumption as a proxy for travel behaviour and emissions are calculated because of total fuel sold/consumed multiplied by a GHG emissions factor for each fuel. Bottom-up approaches include detailed activity data (transport activity, mode share, fuel efficiency, etc). (GHG Protocol, 2014)

		is extrapolated locally taking into account the consistency of the city's private fleet data.	
Greater Manchester	Top-down: fuel consumption approach.	On-road transport emissions are obtained from SCATTER, which takes input data on fuel consumption from the Department for Business, Energy & Industrial Strategy (BEIS). Data is obtained combining traffic activity data with fleet composition data and fuel consumption/emission factors. The vehicle fleet composition data is based on licensing statistics and evidence from automatic plate recognition data. These provide an indication of the vehicle mix by engine size, vehicle size, age, engine and exhaust treatment technology, EU emissions standards, and fuel type as observed on different road types. Other data is obtained from the COPERT V[6] model.	Not specified
Izmir Metropolitan City	Top-down: fuel sales approach. Extrapolation from national to regional data.	Public transport emissions are calculated based on real fuel consumption data. Private vehicle estimates are based on percentage share, number and types of vehicles registered in the city. Vehicle categories are updated yearly.	Not specified
Lisbon	Top-down: fuel sales approach. Extrapolation from national to regional data.	Public transport emissions are calculated based on real fuel consumption data. Other transport emissions are estimated from data inputs from total fuel sales within city boundaries. No additional downscaling per mode of transport is done.	Medium for scope 1, low for scope 2
Malmö	Top-down: fuel sales approach. Extrapolation from national to regional data.	Emissions are calculated based on real fuel consumption data from regional and national levels. The city also uses modelling of flows to complement accounting processes. As of 2021, Malmö will be using a bottom-up approach to calculate emissions from the transport sector through modeling of flows in the ENVIMAN-modelling program.	Medium

Source: Cities GHG Emissions Inventory and Cities' Interviews.

Table 4b. *On-Road Transport Emissions Methods in Use by Cities Using Bottom-up Approach*

Cities	Core Accounting Method	Input Data and Modelling	Data Quality
Madrid	Bottom-up: Geographic / territorial method	Public transport emissions are calculated based on real fuel consumption data. Other transport emissions are estimated by combining data from the city traffic model (intra-city mileage rates, average speeds, etc.) and vehicle types, with size mix from local studies on fleet characterisation. Additional data and modelling options are evaluated with the COPERT V Model.	High
Mannheim	Bottom-up: Geographic / territorial method	Emissions are calculated under a methodological combination of fuel sales approach and a geographical territorial VKT method. For fuels such as petrol, CNG, diesel, and LPG, data is obtained from regional data extrapolated at the national level. This method is defined in the German Methodology Bisko Standard.	Medium
Warsaw	Bottom-up: Resident activity Method	Public transport emissions are calculated based on real fuel consumption data. Private transport emissions are calculated using data from average daily traffic volumes, number of vehicles registered, and average distance.	High for municipal /public fleet, low for

[6] COPERT V (Computer Programme to Calculate Emissions from Road Transport) is a model and database of vehicle emission factors developed on behalf of the European Environment Agency (IEA) and is used widely by other Member States to calculate emissions for road transport.

			private fleet

Source: Cities' GHG Emissions Inventory and Cities' Interviews.

Cities that use a top-down fuel sales approach to estimate their emissions employ local and regional data as input to refine their calculations, making their GHG emissions calculations as close to their local reality as possible. From a methodological point of view, all of the cities are compliant with the guidelines established in the GPC or the BEI/MEI EU CoM approach.

All cities are able to calculate emissions from public transport in a precise manner, as they are able to gather data from fuel consumption from their fleets and publicly controlled transport systems every year. Evidence shows that further challenges in terms of data collection result from the accounting of private and commercial vehicle emissions, and emissions produced by those travelling from other jurisdictions across city boundaries.

Several cities with advanced experience in estimating emissions based on a geographic territorial model or with advanced statistical data inputs (Madrid, Malmö, Athens, and Greater Manchester) use supporting modelling tools such as COPERT V or, as in the case of Athens, the TREMOVE tool to refine their on-road emissions modelling.

It is important to note that cities use standardised emissions accounting methodologies to develop their GHG inventories, but the calculation methods used to estimate transport emissions differ from city to city. Although these methods have methodological consistency, there is a certain level of uncertainty when compared to Google EIE emissions data, as cities select the accounting method based on their local context and data availability, which sometimes is not high-quality enough. This is particularly relevant for cities calculating emissions under top-down approaches. From a methodological perspective, it is recognized that the fuel sales approach does not capture all on-road travel as the different vehicles circulating in the city may be fuelled at locations outside the city boundary. (GHG Protocol, 2014).

2.2 Transport Emissions Data Analysis

Several assumptions and methodological steps were defined to carry out a comparative analysis between the transport emissions calculated in Google EIE and the emissions calculated by cities, including the following:

Emissions sources being compared: Analysis will focus only on comparing on-road transport emissions from modes sourced by fossil fuels (automobile, bus, and motorcycle). EIE does not calculate emissions for rail-based transport systems (tram, metro, subway, ferry). Therefore, emissions from direct combustion from fossil fuels related to rail (Scope 1 emissions) and from the grid-supplied electricity used to power transportation systems (Scope 2 emissions) will not be considered for this analysis. Emissions from the portion of transboundary journeys occurring outside cities boundaries (Scope 3 emissions) are not considered either, as the cities in the deep dive currently do not account or report them.

Emissions data being compared: A high level comparative analysis will be done using cities' on-road transport emissions data and both Google EIE calculation approaches with:

- EIE full on-road transport activity data and
- EIE data that is compliant with the GPC methodology, considering 100% of in-boundary trips and 50% of transboundary trips and emissions.

Calculations for the GPC methodological specifications will follow the induced activity method, which seeks to quantify transport emissions induced by the city, including trips that begin and end in or are fully contained within the city (excluding pass-through trips). (GHG Protocol, 2014)

For cities using a bottom-up approach: The comparison of total on-road transport emissions per mode on a city level can be done mainly against Google EIE GPC compliant emissions data due to methodological consistency. Nevertheless, the comparison will be also made against EIE full transport activity data to identify potential tendencies in the analysis.

For the cities using the top-down (fuel sales) approach method: The comparison of cities emissions data for on-road transport, has also been made against EIE emissions data from full travel activity data and from Google EIE GPC compliant emissions data. This will allow the identification of data gaps, considering that the fuel sales approach method used by cities, has limitations in capturing all on-road travel data, as vehicles may be fuelled at locations outside the city boundary but driven within the city (GHG Protocol, 2014).

GHG emissions: All emissions (CO2, CH4 and N2O) were included in the analysis without disaggregation, as cities and Google EIE report aggregated GHG emissions.

Emission factors: Cities in the deep-dive analysis use different emissions factors to carry out their GHG emissions inventories. Regarding emissions from fossil fuel combustion for stationary energy, cities obtain emissions factors from different sources, mainly national or local sources, but also from the IPCC Guidelines. The emissions factors for transport emissions accounting methods were not explored in the deep dive due to the CURB Tool's lack of data sourced from Google EIE, and because in Europe, these fuel emissions factors do not change drastically over time.

The comparative analysis between the on-road transportation emissions data from Google EIE and the emissions values reported by cities in their inventories is presented below in Tables 5a and 5b. The results are divided into two groups: Table 5a shows the cities' on-road transport emissions data in comparison to Google EIE emissions data (considering full travel activity data) and Table 5b shows the cities' data in comparison to Google EIE emissions calculated using the GPC Methodology.

Table 5a. *High-level Comparative Data Analysis: Google EIE on-road transport emissions from Full Travel Activity Data in relation to City Reported Data in the CDP-ICLEI Unified Reporting System*

City and Year (*)	Emissions from City Inventory (tCO2e)	Google EIE Emissions (tCO2e) Full Travel Activity	Difference Between Emissions (tCO2e)	Difference Between Emissions (percentage)
Cities Calculating Emissions Under Top-Down Approach (2018, 2019)				
Athens (2018)	844.669	832.445	-12.224	⇩ 1.5%
Athens (2019)	981.985	894.402	- 87.582	⇩ 8.9 %
Florence (2018)	462.742	730.333	267.591	⇧ 57.8%
Greater Manchester (2018)	3.719.583	3.957.636	238.053	⇧ 6%
Lisbon (2018)	756.181	1.655.924	899.743	⇧ 118%
Malmö (2018)	315.186	628.776	313.591	⇧ 99.5%
Malmö (2019)	330.377	683.784	353.407	⇧ 107%
Izmir Metropolitan City (2018)	5.278.046	2.959.912	-2.318.134	⇩ 44%
Cities Calculating Emissions Under Bottom-up Approach (2018)				
Madrid	2.653.340	5.960.000	3.306.660	⇧ 124%
Mannheim (2018)	656.953	533.000	-123.953	⇩ 18.9%
Warsaw (2018)	1.790.517	4.320.000	2.529.483	⇧ 141%

1. *Athens and Malmö have available emissions data for 2018 and 2019, while other cities only have 2018 data.*
2. *Izmir Metropolitan City and Madrid's geographical boundaries differ from those used by Google EIE.*

As the table 5a demonstrates, the emissions gap between Google EIE and cities calculating emissions using a top-down approach differs from city to city. This gap is understandable, since cities employ different data sources and estimation models to calculate their emissions, such national and regional data on fuel sales, which is extrapolated and adapted to local fleet types and fuel efficiency patterns.

For cities that calculate their emissions using bottom-up approaches, data differences could also be caused by the accounting methods used differ from each other in the three cities using this approach.

Table 5.b, on the other hand, shows the comparison between cities emissions data in relation to EIE data considering the 50% emissions from transboundary trips, approach compliant with the GPC Method. Emissions differences from cities calculating emissions under top-down approaches show a reduced gap in comparison to full activity data comparison, but further analysis should be done.

Table 5b. *High-level Comparative Data Analysis: Google EIE on-road transport emissions from Travel Activity Data Compliant with GPC in Relation to City Reported Data in the CDP-ICLEI Unified Reporting System*

City and Year (*)	Emissions from City Inventory (tCO2e)	Google EIE Emissions (tCO2e) GPC-Compliant Emissions Data	Difference Between Emissions (tCO2e)	Difference Between Emissions (percentage)
Cities Calculating Emissions Under Top-down Approach (2018, 2019)				
Athens (2018)	844.669	472.000	-372.669	⇩ 44%
Athens (2019)	981.985	501.000	-480.985	⇩ 49%
Florence (2018)	462.742	429.000	-33.742	⇩ 7.3%
Greater Manchester (2018)	3.719.583	2.860.000	-859.583	⇩ 23%
Lisbon (2018)	756.181	982.000	225.819	⇧ 29.8%
Malmö (2018)	315.186	389.000	73.814	⇧ 23.4%
Malmö (2019)	330.377	423.000	92.623	⇧ 28%
Izmir Metropolitan City (2018)	5.278.046	2.100.000	-3.178.046	⇩ 60.2%
Cities Calculating Emissions Under Bottom-up Approach (2018)				
Madrid (2018)	2.653.340	3.730.000	-1.076.660	⇧ 40.5%
Mannheim (2018)	656.953	306.000	350.953	⇩ 53.4%
Warsaw (2018)	1.790.517	2.910.000	-1.119.483	⇧ 62.5%

1. *(*) Athens and Malmö have available emissions data for 2018 and 2019, while other cities only have 2018 data. Source: ICLEI Europe.*
2. *Izmir Metropolitan City and Madrid's geographical boundaries differ from those used by Google EIE.*

For the cities where Google EIE geographical boundaries differ from city inventory boundaries (Madrid and Izmir), data differences shown, make more relevant the importance of analysing how boundary differences impact emissions values.

In summary, for all cities examined in the deep-dive analysis, the differences between city emissions and Google EIE emissions data (GPC emissions and full activity data) can be attributed to several factors, such as the different calculation methods used, the emissions factors selected, the fuel efficiency of vehicles, etc. Taking data availability into consideration when evaluating these parameters, further analysis of emissions differences should be explored with the cities. The next subsection includes a general analysis identifying the key factors that might influence these differences.

2.2.1 Exploring Potential Reasons for Observed Divergences in Emissions

To better understand the possible reasons for the diverging emissions values attributed to transport emissions, two key aspects that underpin the EIE approach were analysed: the modes of transport identified and measured by Google EIE and by cities; and the differences between the top-down and bottom-up calculation methods used by the cities and Google EIE.

2.2.1.1 City Geographical Boundaries Differences

Google EIE cities' geographical boundaries differed more than others when compared to the cities official boundaries, which meant there were also discrepancies in population counts and the scope of estimated emissions. This is especially relevant for the cities of Madrid and Izmir Metropolitan City, which calculate their emissions using bottom-up and top-down approaches respectively.

To better understand these data differences, similar local, metropolitan and regional boundaries must be defined properly, especially considering the nature of transport emissions from transboundary trips.

2.2.1.2 Quality of Local Data from modes of Transport Included and Emissions Calculated

Google EIE captures, in great detail, the majority of modes of transport used from 2018 to 2020. For the 2018 data, very specific data of modes of transport, and their related emissions, were not available as well as all boundary and transboundary (in-bound and outbound) trips values. For example, no ferry boat data is included for Izmir, which is an observed mode of transport in the city. This could be due to the relevance and magnitude of this particular mode of transport in the city. Nevertheless, Google EIE includes a relatively high selection of modes of transport.

It is also important to mention that there are gaps in emissions data availability for some modes of transport on the cities' side, especially for cities that calculate emissions using top-down fuel-sales approaches. It is not always possible to obtain fuel transport data under disaggregated categories, limiting the potential for comparison with Google EIE data. On the other hand, cities accounting their emissions on a bottom-up approach also have several gaps in data collected from different sources and due to the use of different modelling techniques.

The cities participating in the deep dive analysis have previously defined processes and methods with which they collect data and calculate emissions for on-road transport activities.

High quality data is particularly significant when assessing public transport data (bus, rail, tram, etc.). Meanwhile, data sources used to estimate emissions from private vehicles might differ in quality from city to city. In addition, cities' use of different accounting methods and modelling techniques, makes the comparison to Google EIE data difficult and does not allow conclusions to be drawn in this regard.

2.2.1.3 Bottom-up and Top-down Methodology Data Divergences

ICLEI further explored the differences between Google EIE emissions and the data from cities' inventories to better understand if the accounting method (bottom-up or top-down) used by each city could explain existing data gaps. The percentages of variation identified in each city, namely the variation between data from cities' inventories and Google EIE emissions, were grouped according to the emissions accounting method they use. Thus, Athens (2018 and 2019), Florence (2018), Greater Manchester (2018), Lisbon (2018) and Malmö (2018 and 2019) belong to the top-down approach (TD) group. Meanwhile, Mannheim (2018) and Warsaw (2018) were placed in the bottom-up approach group (BU).

Data from Izmir and Madrid was not taken into account due to differences in measured city boundaries as explained above.

The aggregated data from emissions differences for both groups of cities in relation to EIE emissions considering full travel activity data is presented in a box-plot in Figure 4 below.

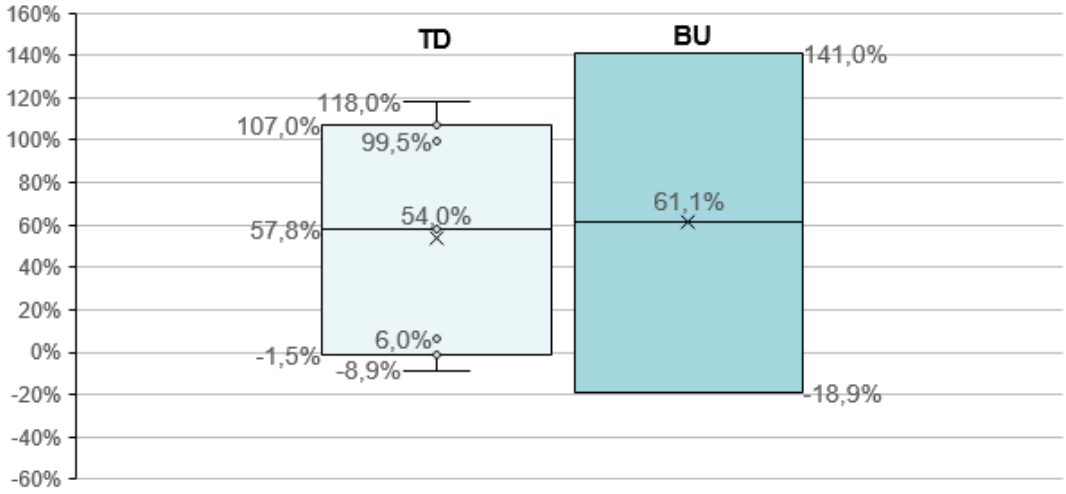

Figure 4. *Data Variation Analysis per Methodological Approach considering the Google EIE emissions from full travel activity data. Source: ICLEI Europe.*

It is possible to observe a large variation in the interval of the upper and lower limits for both the TD group (between -8.9% and 118%) and the BU group (between -18.9% and 141%).

In terms of cities that are part of the TD group, Athens had the most similar results when comparing the EIE data to the city's data (-1.5% in 2018 and -8.9% in 2019), followed by Greater Manchester (6% higher when comparing 2018 data). At the same time, the city of Lisbon data comparison resulted in a representative variation (118%) and in Florence (57.8%). The same happened when analysing the data from Malmö for both years. This could be explained due to commuters' cross boundary trips that might not be represented by the fuel sales method approach.

The fact that the results of Mannheim, as part of the BU group, are a bit more similar to the current values in Google EIE (-18.9% difference) does not mean that considering the full travel activity data for cities that use the bottom-up approach is the best alternative. In Warsaw for example, part of the BU group, the variation of emissions values between what the city reports, and the Google EIE data was large (141% more). This difference can be explained due to the nature of the bottom-up methodological approach, which is more comparable to EIE emissions data compliant to the GPC methodology.

The aggregated data of percentage differences for both groups of cities considering the EIE GPC compliant emissions data is presented in a box-plot in Figure 5 below.

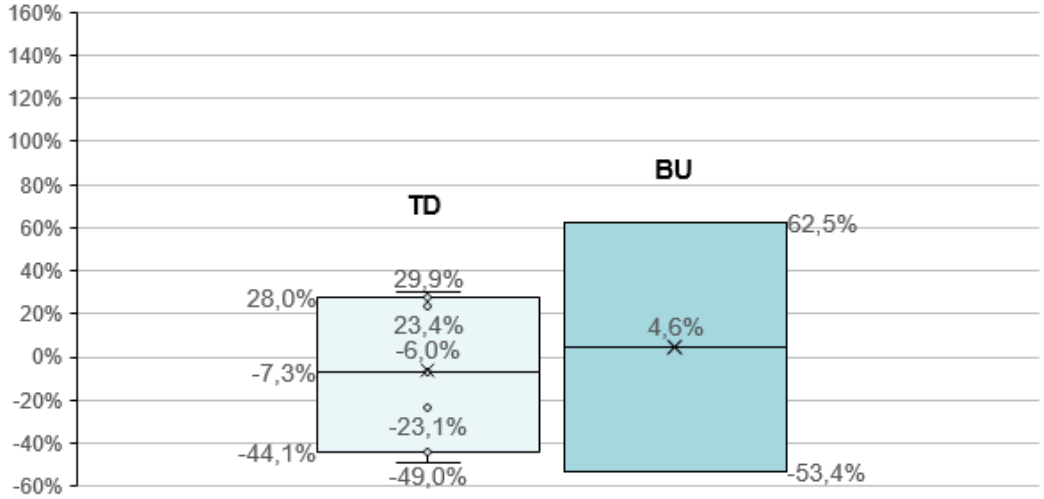

Figure 5. *Data Variation Analysis per Methodological Approach considering the EIE GPC compliant emissions values. Source: ICLEI Europe.*

As observed through the upper and lower limits above, the variation in values related to the TD group is smaller in comparison to the variation found in the BU group. In addition, when comparing the variation of the upper and lower limits of the TD group in figures 4 and 5, it can be observed that there is a significant difference in favour of the graph that encompasses only the data from EIE emissions data compliant with the GPC Methodology.

In summary, in figure 4 the variation is 127% (between -8.9% and 118%) and in figure 5 is 78.9% (from -49% to 29.9%). This could mean that the option of using GPC compliant emissions data in Google EIE would be more appropriate when exploring the relation to cities using the Top-Down approach.

The city of Florence had the most similar results when comparing the data from Google EIE and the data from the city's GHG inventories (7.3% lower in comparison to 2018 data). A variation between 20% and 30%, both positively and negatively, was observed when comparing data involving Greater Manchester (2018), Lisbon and (2018) Malmö (for both years). The highest variation between the Google EIE data and the values in city inventory was observed in Athens (-44% in 2018; and -49% in 2019). Despite this, it is noted that the differences were not extremely large when compared to Google EIE's emissions values from full travel activity data which exceeded 100% in some cities.

As it can be observed in both cases (Figures 4 and 5), the results do not indicate that one accounting method for calculating transportation emissions is better than the other, nor does it suggest that the accounting method influences the variation between Google EIE data and city emissions data. It is very difficult to draw conclusions in this sense. The use of a larger

sample of cities (especially regarding the BU group) and further time series evaluation is recommended to achieve more in-depth conclusions.

Since Google EIE calculates emissions based on trips and kilometres from different modes of transport, ICLEI has conducted a high-level analysis to evaluate modal split data from the deep-dive cities in relation to Google EIE data.

2.3 Mobility Data Analysis: Taking a Closer Look at Modal Split in Cities

Google EIE, alongside its emissions calculations, provides an important opportunity for cities to have raw and comparable data across all their modes of transport. In some cases this has never been available – for example, for modes of transport such as walking and cycling. In other cases, it has been difficult to keep the data up to date. In transport planning, data is often used to support a policy and political approach to transport.

EIE holds the potential to become part of the data sources to inform and create SUMPs and determine priorities for investment. EIE can also provide information about other, similar cities so that benchmarking activities can drive changes.

The users of the data within local authorities differ between teams. However, transport planners are an audience with real potential for using EIE. Therefore, an analysis with their uses and concerns has been undertaken in parallel to the focussed comparisons on emissions. Transport and mobility departments lead the development of modal split calculations and analysis; however, GHG emissions calculations processes are not in the core of their day-to-day work.

2.3.1 City Data Collection and Reporting Practices

In the cases where local modal split is used in bottom-up approaches to emissions, cities tend to use detailed but infrequent surveys to collect local data to inform their SUMP and carbon reporting. Most of them refresh these surveys when they update the SUMPs, which, at the earliest, is once every 5-6 years. Some examples of the practices followed are covered below.

Table 6. *Surveys Carried Out by Cities*

City Example	Survey Coverage/Sample
Greater Manchester Combined Authority	2,000 households per year; all trips made by each resident over four years of age in a 24-hour period; each district is represented proportionately, based upon the demographics of the resident population; covers the duration of a full year, with surveys in-field every day; over 10,000 trips, made by 4,500 residents. (2017-2019) (TFGM, 2019)
Izmir Metropolitan City	40,000 households for all trips in 24 hours (2014). (Izmir Metropolitan City, 2017)
Malmö	5,800 residents aged 16-84 years, trips and daily travelling habits, every five years. (2018) (City of Malmö, 2018)
Warsaw	17,000 residents across 9,000 households interviewed. The modal split obtained from surveys was calibrated and validated by the Automatic Movement Measurement, consisting of over 100 points within the city and on its borders. (2014) (City of Warsaw, 2016)
Madrid	Covering the entire Region of Madrid, 34,653 residents across 13,009 households were interviewed face to face and another 50,412 residents were interviewed by phone. Interviews were made on Monday to Thursday mobility between February and May 2018. (2018) (City of Madrid, 2018)

Source: Cities SUMPs and Household Surveys.

Household surveys have some benefits, including the engagement of key stakeholders in the transport planning process, creating awareness of transport decision making, and obtaining greater detail about users, their transport choices, and the destinations of their trip. In Europe, the role of movement data and the effect of individual transport choices on society, such as walking, public transport, and car use, are gaining an increasingly high profile.

Cities participating in the deep dive also acknowledge potential limitations in their local modal split data, including reliance on old datasets (e.g., five years old or more), lack of disaggregated reporting or lack of precise definition between modes (e.g., rail/tram/metro/subway, car/motorcycle, or walk/cycle), or even data constraints where there is a need for extrapolation of regional/national datasets, or mixed sources across modes.

In addition, other shortcomings include the lack of attention to non-car modes (cycling or walking) or limits to data collected for those who are not residents in the city, and may not be surveyed but travel within the city's boundaries.

Many cities use different methodologies and a very mixed approach to data sources and collection (where the ideal of one single source such as a household survey is not available), where results support the calculation of the modal split indicator. Sometimes, the approaches to data sources are shared with emissions calculation and reporting processes.

A typical example of combining mixed methods can be found in Izmir Metropolitan City, which has included data from cordon studies – external and screenline, where people or vehicles are counted past a particular point, speed studies and public transport survey data in their field survey. (Boğaziçi Proje A.Ş., 2017)

Other cities rely on significant levels of modelling, such as Florence and Madrid, which also provides insights for bottom-up emissions accounting methods, but tends to focus on, or be refined around, private vehicular trips. This shows the potential complexity of building a comprehensive picture of modal split without one transparent and complete set of data for all modes of transport being available.

Cities also work to present the results of their household surveys to the public, using several tools and communication displays. Malmö, for example, is particularly targeted at the public at large and shows the importance that cities place on communicating data as well as using it for their own planning purposes (City of Malmö, 2018).

Greater Manchester also produced an advanced analysis worthy of comparison to the EIE output interface (TFGM, 2019). Metrics from local data on issues such as social and geographical breakdown of transport choices are more disaggregated than those currently available publicly in EIE. Details of the communication material used by the cities can be found in **Annex 3**.

2.3.2 Comparison of EIE Data with City Data on Modal Split

To inform an exploration of how Google EIE could contribute to improving cities' modal split calculations, a high-level comparative analysis was done considering figures quoted for modal split provided by the cities, and those provided through Google EIE. This analysis focuses on modal split based on the number of trips, which is the prevalent method in transport planning.

Table 8 below provides a summary of the modal split in all cities. This shows the diverse historic nature of some of the data collection exercises undertaken, and the variability in

modal split year and percentages of trips measured per mode within the city sample. Such a spread of modal splits and approaches to data are beneficial for the analysis.

Table 7. *Deep-Dive Cities' Modal Split*

City	Survey Year	Private Motorized Transport (car)	Rail / Metro / Tram	Buses (incl. BRT)	Walking	Cycling	Taxis or For-Hire Vehicles	Other	Total
Athens	2019	39.2	17.0	11.1	28.1	4.6			100
Florence (*)	2019	40.0	19.0		16.0	7.0		18.0	100
Greater Manchester (**)	2018	57.0	2.7	7.0	29.0	2.2	1.9		100
Izmir Metropolitan City	2015	25.7	24.9	13.9	35.0				100
Lisbon	2017	46.1	8.9	12.2	29.8	0.6		2.4	100
Madrid (***)	2018	20.3	34.8		40.0			4.9	100
Mannheim	2018	33.0	13.0		34.0	20.0			100
Malmö	2018	33.7	8.4	17.1	13.7	26.0		1.0	100
Warsaw	2015	31.7	46.8		17.9	3.1		0.5	100

Source: Cities information.

(*) Florence's "other" category corresponds to motorcycles.
(**) Greater Manchester's share corresponds to car/van driver plus passenger trips.
(***) Madrid modal share values correspond to data for Madrid Central Boundary (Madrid Almendra).

In order to carry out this analysis, several assumptions were made. First, the year of the analysis corresponded to the available data for the cities and Google EIE. For cities with data before 2018, the comparison was made with the Google EIE data from 2018. Secondly, as some cities have different modes of transport aggregation approaches, values were clustered as close as possible to the Google EIE modes of transport.

Google EIE data on total trips per mode was taken as input information to calculate a modal share value applicable to all cities. Finally, these modal share values were also distinguished for EIE data, considering only in-boundary trips and another value taking inbound and outbound trips as its only reference.

During this high-level analysis it was identified that differences are quite varied depending on the city and the mode of transport. Due to the data uncertainty and the limitations of cities' updated modal split data, no specific conclusions can be extracted. But general findings were identified for all cities, including:

- The proportion of bus trips is higher in city data than EIE data in all cities.
- The proportion of walking trips is higher in EIE data than data in all cities.
- The proportion of car trips varies inconsistently across cities, with EIE data noticeably higher than city data in Izmir, Madrid, Mannheim, Malmö, and Warsaw, and lower than city data in the other cities (see Figure 5 below) – aside from Greater Manchester, where modal split for car use is similar.

This difference in the proportion of car trips among cities indicates the relevance of exploring this type of mode of transport further. It is also the biggest source of transport emissions at the local level.

A headline transport indicator or metric is often the proportion of car trips to non-car trips, with many cities agreeing that 50:50 is a reasonable target. Many cities currently have 60-80% car use for certain purposes, such as travel to work. Hence, the level of car use has been analysed as a proxy for overall success in reducing levels of car use, which is commonly the target for both transport and climate policies. Reducing levels of car use offers a more consistent comparison than targets for individual alternative modes, which vary between cities.

Figure 5 below illustrates the percentage of car trips using two data sources, namely city-provided sources and Google EIE full travel activity data. It shows how the ranking of cities according to the percentage of car-use varies according to the data source used.

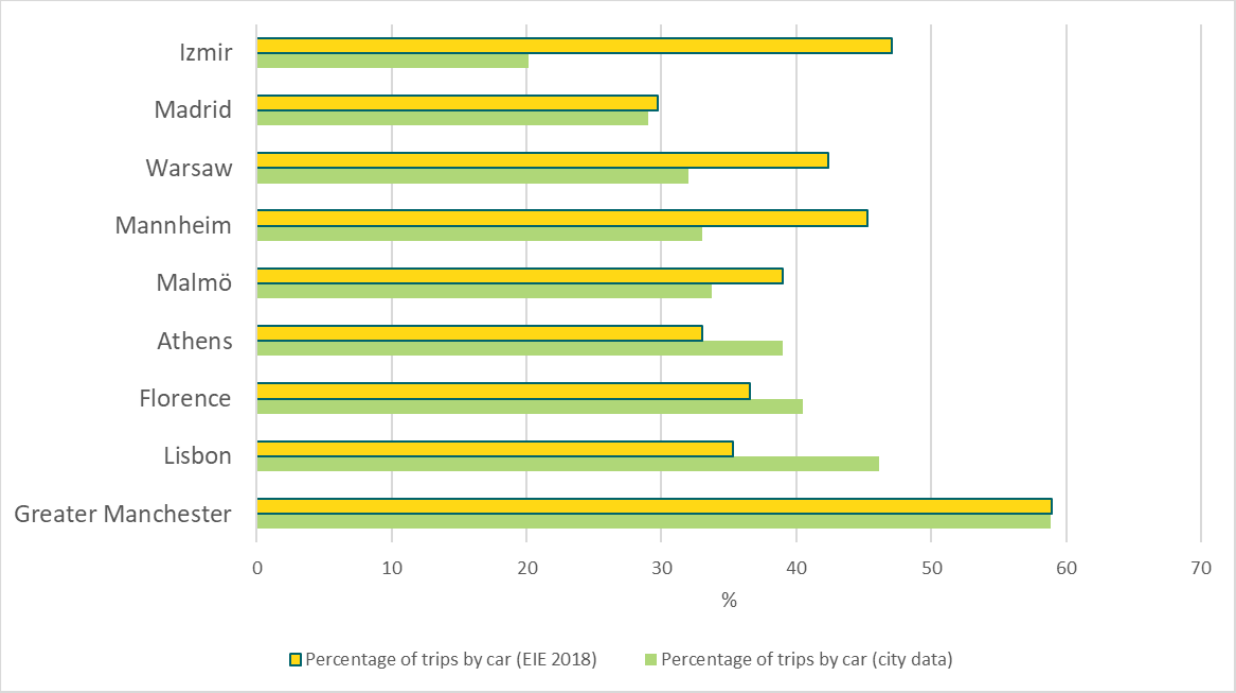

Figure 6. *Comparison percentage of trips by car, Cities Data and Google EIE Data. Source: ICLEI Europe.*

From the city sample, it can be seen that Greater Manchester has the largest percentage of trips by car, and this is the case for both city and EIE data. However, for some cities, there is a higher proportion of car journeys in EIE than in city data, such as Mannheim and Warsaw. For other cities, there is a lower proportion of car journeys in EIE than in city data, such as

Lisbon. In the case of Izmir and Madrid, the difference cannot be evaluated due to the geographical boundary differences in EIE.

The positive match of Greater Manchester data with Google EIE data could be due to several reasons. The city has a rigorous household survey method, comparable to the comprehensiveness of the EIE. In addition, the city has a high level of trips within its borders, and most trips can be counted by a resident's survey carried out within its own boundaries. Finally, its inhabitants are those of a large, modern city with many modes of transport to choose from, which may encourage use of tools such as Google Maps. However, to confirm these reflections, further analysis and validation is needed.

There is no immediate common pattern or relationship between the city data and EIE data for trip percentages across the sample. It could be that cities use different survey methods to obtain their modal split data, bringing uncertainty when compared to Google EIE data.

It is also important to note that city data for modal split by trips does not have a consistent relationship with city data for modal split based on distance. Whilst modal split based on trips can suggest that the comparison between modes looks a certain way when observing distances travelled, the differences between modes can appear more extreme.

Future research on these patterns should be conducted, including identifying which dataset is used and quoted, and for which purpose. The first steps for cities will be to undertake a comparison of their own data with the Google EIE data. Some potential areas for investigation are covered in the following section.

2.3.3 Potential Patterns for Observed Divergences in Modal Split Data

Further study is needed to understand observed data divergences. Potential reasons could include different scopes of data (e.g., geographically or demographically), age of data, or miscalculation/misreporting/underreporting of modes. Possible reasons are suggested in the table below. Using this as an initial checklist may help cities review the quality of their own data, whilst at the same time Google will continue to refine the inferences it uses to track different modes of transport accurately.

Table 8. *EIE Modal Split Observations*

Mode of Transport	Nature of Consistency	Possible Causes	Example Cities
Walking	⇧ Higher proportion of journeys in EIE data	EIE counts walking journeys that are part of other trips (e.g., public transport), which may be unreported or underreported by users in city surveys of "main modes." EIE may recognise "trips" that users may not consider as trips (e.g., walking around a shopping centre or park). Lack of good walking data available to the city locally for comparison.	Athens Florence Madrid Greater Manchester
Cars	⇧ Higher proportion of journeys in EIE data	Cross-boundary trips may be included in EIE where they may not be in household surveys (i.e., inbound trips may be excluded from surveys where only residents inside the boundary are canvassed); this may also apply to rail. Car sharing is not included as a separate category in EIE (i.e., a passenger and a driver) and may affect modal split and emissions calculations if all those travelling by car are assumed to be in single-occupancy vehicles. Car occupancies may also be unknown	Madrid Mannheim Greater Manchester Warsaw

		or not locally correct in both methods. Google EIE assumes more than one person per car on average.	
Cycling 	⇩ Lower proportion of journeys in EIE data	Cycling can be seasonal and could be affected by the timing of local surveys (whereas EIE collates journeys throughout the year including periods of lower use). Cycling could be mistaken in EIE for other modes (e.g., motorcycling). Leisure trips may be underreported or not registered in local surveys where cycling can be more highly represented than other more widely reported trip purposes, such as commuting. Lack of good cycling data available to the city locally for comparison.	Athens Florence Greater Manchester (e.g, by distance)
Bus use 	⇩ Lower proportion of journeys in EIE data	Bus use could be mistaken in EIE for other modes (e.g., car use), particularly when in traffic or congestion. Public transport users could have a lower proportion of smartphone users than other modes (e.g., older people), affecting data quality. Very good local knowledge of public transport patronage in some cities, therefore good local data available to cities.	Izmir Lisbon Madrid Greater Manchester Warsaw Athens
Other	Differing proportion of motorcycles in EIE	Where this is the case, data should be checked against reliable local data or data from other cities with similar local mobility cultures (e.g. where motorcycling is significantly higher than normal).	Athens Florence Izmir

Source: ICLEI Europe.

2.3.3.1 Impact of Boundary Location in Relation to Functional Urban Area

In order to understand these relationships better, a supporting analysis has been made to provide insights on where EIE and cities' methods differ, for example in the inclusion of transboundary data. This approach explored how the locations of the boundaries in relation to the functional urban area can affect the proportion of in-boundary and transboundary trips (i.e. the apparent level of containment of trips within city boundaries), with some cities' EIE data showing a far greater proportion of trips coming from outside their own area than others.

Transboundary data issues can have an impact when comparing EIE with city-based data, as city data may have a lesser proportion of transboundary movements included, and cross-boundary journeys (included as standard in EIE) can have a different modal split.

Within boundaries, the modal split of walking and cycling is often greater, and across boundaries, modal split of car and rail trips is often greater. In particular, in distance-based modal split calculations EIE includes the whole journey distance for transboundary journeys. (Google Earth and Earth Engine, 2021) Further work is required with cities to better understand how Google EIE can become a new source of data for modal split calculations on a local level.

2.4 Key Findings from the Transport Emissions and Mobility Deep Dive

The transport emissions analysis in the selected cities reveals that both top-down and bottom-up transport emissions calculation methods are used, depending on data availability and quality. All deep-dive cities demonstrated expertise in calculating emissions, which improved their ability to compare their data with data from EIE and try to understand methodological and data gaps. The analysis focussed on on-road transport emissions (bus, car, and motorcycle) only, as Scope 2 emissions from rail, tram, or metro modes are not considered in EIE.

The comparative analysis identified emissions differences, with no clear pattern of justification for this divergence. The accounting methods used by the cities (e.g., fuel sales, geographic/territorial, etc.) did not explain the emissions difference, but might need further evaluation, depending on the input data quality and calculation limits in the cities.

It was also observed that the comparison of cities' emissions data to Google EIE emissions - based on both full travel activity data or the GPC compliant approach - differed from city to city. This shows the importance of understanding the methods used by the cities (bottom-up or top-down) in order to define the causes of the differences in emissions calculations and to develop further assessments.

During the analysis and after sharing the results of emissions differences with cities, local government contacts expressed interest in exploring EIE data further and in understanding the EIE accounting method – particularly in relation to mobility data (trips and distance) as well as fuel efficiency considerations. In the case of deep-dive cities already using a bottom-up approach, Google EIE was generally perceived as a potentially promising secondary input data source to validate assumptions.

Regarding the analysis of modal split and mobility data from EIE, there were some differences between EIE data and city data, particularly around bus use, walking, and car use. This might be the result of the uncertainty and limitations in modal split data including on the cities' side. Cities recognised the added value that EIE might bring once the calculation differences are fully explained. Further analysis of the relationship between the share of modes in terms of number of trips and distance travelled (km) is recommended. This will help foster an integrated management approach for both transport and climate work based on the same set of data. Moreover, an evaluation on boundary and cross-boundary trips and their impact on modal share could be an important area for future research in reconciling city and EIE data. Findings would allow cities to better understand how EIE data could contribute to modal split calculations or to emissions accounting processes.

3 Summary of Findings and Learnings from Deep-Dive Cities

The summary chapter brings together key observations from ICLEI's work with the cities as well as the analytical results of the transport emissions and mobility deep dive. The focus is on the potential of Google EIE to support GHG emissions accounting processes, the scope and boundaries of analysis of Google EIE, and EIE as a data source for transport emissions estimations, modal split measurement, and mobility planning.

3.1 Reflections on Google EIE Supporting Transport Emissions Accounting

Cities voiced strong interest in EIE, aiming to understand and evaluate the tool's data sources and how it can support or complement their emissions accounting processes. Areas that are relevant for cities interested in using EIE include:

- **Supporting climate ambitions implementation:** Cities reshaping climate planning processes to meet new ambitious goals by 2030 or 2050 confirm that the continuous access to Google EIE data is an attractive opportunity to tap into new data-driven processes. The data will allow cities to collaborate with other departments such as transport to improve climate actions planning and evaluate alternatives for emissions reduction.

> *"Information is the guiding light of climate action. It is necessary to incorporate all the technological resources that allow us to expand and improve its reliability, following principles of transparency and accessibility".*
>
> Luis Tejero, Coordinator of Climate Change Programs, Madrid City Council

- **Easy use, contributing to local sectoral analysis:** The EIE interface and features are perceived as easy to use and navigate. The data download functionality is appreciated by cities, as data can be fed into their own internal tools to perform more specific cross-checking analysis.

> *"Google EIE takes an exciting approach to balancing municipal emissions. The user interface is very straightforward and user-friendly. However, the data calculated by Google EIE still differs from the data of the City of Mannheim. Nevertheless, we see potential especially in the transport sector, as well as the possibility to compare ourselves with international cities. I'm curious to see how the tool will develop in the future".*
>
> Dominik Stroh, Climate Protection Monitoring Specialist, City of Mannheim

- **Complementing monitoring:** Cities see value in using EIE to conduct a comparative analysis with their concurrent methods and tools for emissions accounting. Differences between Google EIE and their own calculations could be taken as an "alert" to confirm the integrity and consistency of monitoring results. Applicability of EIE could be enhanced by feeding city data into Google EIE.

> *"Monitoring city data and rapid data collection is very important, hence, the Google EIE tool is very promising because it can provide cities additional insights to assess the current status of the city and develop a correlated analysis with the cities' own data. We believe that the tool will provide comprehensive and rapid information to cities working to tackle climate change."*
>
> Dr. Çağlar Tükel, Engineer, Izmir Metropolitan Municipality, Directorate of Climate Change and Clean Energy

> *"I think that the EIE tool challenges the way we currently approach climate data and calculations. It provides an easy-to-use, complementary monitoring and hopefully in the near future it will contribute to in-depth sectoral analysis as well as optimised emissions accounting on a city level. Once the method is further developed, I think that there is huge potential in an open data model like EIE to standardise climate change work across cities."*
>
> Jonas Persson, Climate Strategist at the Strategic Environmental Department, City of Malmö

- **Optimising GHG emissions accounting:** If openly and freely available and accessible on an annual basis, EIE data could potentially reduce the time and effort required for developing inventories and facilitating reporting. Cities express interest in understanding how EIE can optimise their emissions accounting, monitoring, and reporting processes. To best exploit Google EIE data, the following is recommended:
    - **A better understanding at a technical level** can help cities gauge the potential for using Google EIE data, merging it with or replacing existing emissions modelling approaches. Cities are interested in learning more about the methodological approaches of Google EIE, especially how transport emissions and mobility data is obtained and extrapolated at a city level. Existing information could be complemented with examples and case studies from other municipalities in the region.
    - **Adding another level of analysis**, including the evaluation of annual changes in emissions by densifying the available data beyond the analysis made with the cities' 2018 emissions, can be beneficial to understanding differences.

> *"CO2 emissions data offers information about our way of life and the choices we make as governments, companies, and citizens. Google EIE can definitely help cities achieve higher standards regarding emissions data quality, and could serve as an alternative data source offering further confirmation of existing data with high spatial resolution."*
>
> Rui Dinis, Climate Advisor, Lisboa E-Nova (Lisbon Environment and Energy Agency)

3.2 Reflections on Google EIE Scope and Boundaries of Analysis

The deep dive showed that the development of a meaningful analysis of local accounting methods, paired with the Google EIE approach, requires a clear understanding of the tool's scope and boundaries of analysis. The key areas identified with direct impact on the assessment results include:

- **Spatial coverage and geographical boundaries:** Within Google EIE, this information differed from some of the official city administrative boundaries. Similar local, metropolitan and regional boundaries are important in order to understand any differences. This boundary setting can allow cities to develop additional analysis towards understanding emissions trends and differences, especially in the transport emissions accounting processes, where trip distribution can directly influence the amount of emissions generated within the functional city area.
- **Data for specific emissions sources:** Types of emissions have to be clearly identified and differentiated to avoid misinterpretation when analysing both local and EIE data. On transport, Google EIE covers only on-road transport emissions (Scope - 1 emissions), excluding emissions mainly coming from rail, metro/tram, and also from electric mobility (Scope - 2 emissions). For cities, a comprehensive analysis of transport emissions should include the latter types of emissions. These are especially relevant in Europe, where these modes of transport play an important role in urban mobility and will grow in relevance in years to come.
- **Currency of emissions factors:** The deep-dive analysis demonstrated that emissions factors used by cities were more up to date in all cases than those used by Google EIE. Acknowledging that emission factors can be changed manually, and that cities are able to include their own emission and energy intensity factors in EIE, an update of default values is recommended to show methodological consistency and technical coherence to cities exploring EIE. More recent values could be easily obtained from European and global sources.
- **City coaching and benchmarking:** The practice of comparing emissions across cities via the EIE platform and peer-to-peer experience sharing facilitated by an external advisor, as performed by ICLEI, is praised as a highly valuable tool to understand differences and identify opportunities for development and improvement. In light of this, further engagement of cities to explore such additional applications, functions, and benefits of Google EIE is recommended.

> *"Google EIE represents a powerful tool for cities to test and complement existing data sources and analysis tools. Offering a different approach to emissions estimation based on big data, it can provide a unique opportunity for cities to explore trend analysis and comparison with other cities. The transition to a greener future is boosted by widely available data."*
>
> Alessandra Barbieri, Fundraising Office and EU Projects Manager, City of Florence

3.3 Reflections from the Transport Emissions and Mobility Data Analysis

Cities perceive Google EIE as a new source of data that could bring additional insights to support transport emissions calculations, and support data collection for the development and implementation of mobility strategies. Once methodological assumptions are clarified, EIE can be used by cities, especially for the following processes:

- **Refining existing estimation techniques:** The assessment of the transport emissions accounting methods of cities and EIE was exclusive to on-road transport emissions, and limited to cities' bottom-up or top-down approaches. Those using bottom-up methods can use EIE data to complement, improve, or validate their vehicle kilometres travelled (VKT) estimations, after having completely understood the tool's calculation approach and data inputs. Similarly, cities using national data sources to estimate transport emissions can benefit from access to the Google EIE data to develop more accurate bottom-up approaches or to validate top-down assumptions.

- **Providing a new source of data:** Mobility data from Google EIE is perceived as a new and detailed data source that could provide novel insights about mobility patterns at the local level. The deep dive generated significant interest in the use of the data for modal split calculations amongst participating cities, particularly regarding how data is collected.

- **Further understanding of modal split:** The deep dive showed some patterns in relation to how the current values in EIE differ compared to city data, often giving a greater modal split for car use and always a lower modal split for buses. This is an area that requires further investigation, as the sample size of the examined cities and ability to re-engineer or adjust inferences in EIE data was limited.

> *"For cities to have accurate data on modal share, it is important to base the data on on-site annual observations, not only for the estimation and mitigation of greenhouse gases, but also for the improvement of commuting, which is also vital for the quality of life within cities".*
>
> Dr. Eleftheria Alexandri, Civil Engineer, City of Athens

4 Recommendations to Enhance the Potential of Google EIE for Reducing Transport Emissions and Driving Sustainable Urban Mobility

The transport sector is one of the main sources of GHG emissions in cities. Therefore, offering access to new sources of data on energy and emissions from this sector is key to informing and accelerating integrated climate action at the local level and promoting sustainable mobility. The potential of Google EIE can be seen from different angles, especially focusing on the cities' need to accelerate climate action in the transport sector and to foster sustainable urban mobility.

4.1 Google EIE Supporting the Reduction of Transport Emissions in Cities

The Google EIE transport emissions data can bring important insights to cities, especially in the following climate mitigation areas:

- **Significant potential:** The Google EIE data is a potentially valuable resource to support cities in estimating and validating city-level GHG emissions calculations in the transport sector. More work with cities is needed, though, to refine calculation methods on both sides. It is expected that the user base of the tool will grow progressively, as more European cities analyse and compare their transport emissions data with EIE and share these findings with stakeholders. Currently commentary within the community is rather low, but this can suddenly and rapidly increase as knowledge of the tool becomes more widespread.
- **Single accounting method:** Google EIE is able to provide emissions data for several modes of transport based on a single type of accounting method for all cities. This makes city level data comparable and data analysis more straightforward as assumptions are similar in all cases.
- **Frequent data returns:** The ability of the Google EIE to provide transport emissions data once per year, or perhaps more often, could help cities swiftly identify key deviations that could prompt further analysis, follow-up, and action.
- **Encouraging new users:** Greater potential for the use of Google EIE can be achieved in cities that are not able to develop their inventories on an annual basis or are starting the development of their baseline emissions inventory, including accounting processes for transport emissions.

Further developments in EIE could help raise interest in the use of the tool, including:

- **Increasing district and neighbourhood planning relevance:** Google EIE provides aggregated emissions data at a city level, but the potential of the tool to provide more granular information (on the district level, for example) is expected to raise further interest and options for the tool to be applied in various contexts in European cities. Making the EIE data available at a greater resolution than the city

boundaries is crucial, as it would allow for the examination of urban systems and urban-rural interlinkages beyond political jurisdiction.

- **Developing a community of interest:** Google EIE is an interesting tool to provide new data and insights for cities' climate transport emissions modelling processes. Work with universities, cities and specialised entities that support cities in the emissions calculation processes could pave the way to identify data gaps and to analyse calculation methods and climate models in more detail.

4.2 Google EIE Enhancing Sustainable Urban Mobility Planning

The Google EIE modal split data can bring important insights to cities' sustainable urban mobility planning processes, especially in the following areas:

- **Coverage of all modes in one tool:** Google EIE is able to provide mobility data on passenger trips and kilometres, which can help some cities understand measures to foster modal shift to bike, walking, or public transport. Transport planners are interested in individual trips and journeys rather than the overall quantum of emissions arising from trips at a system level; hence the different users of the tool from climate and transport teams remains important to recognise.

- **International benchmarking:** Google EIE's ability to gauge sectoral city-level emissions or modal split data internationally and communicate these via a centralised platform shows great promise. EIE can support benchmarking processes among cities, especially if clear information about the accounting methods, data sources and models used is provided. The tool could allow cities to benchmark themselves against other similar cities to evaluate patterns, such as the degree of cross-boundary travel, city size, or specific modal share characteristics.

- **Support cities with the embryonic data collection process for mobility:** The importance of data in transport, technically and politically, is unquestioned. Google EIE is already providing better insights on travel activity and transport emissions than many local authorities in Europe, who have fewer technical capacities and resources.

- **Lend support to SUMP development:** Cities working on the development of their SUMP could find further avenues to test and explore Google EIE data in this process. EIE could provide information on trips relating to the entire functional urban area. This could support more consistent comparisons between trips in cities and their performances in achieving sustainable mobility.

Further developments in EIE could help raise interest in the use of the tool, including:

- **Transparency:** To enable transparency between local government departments, politicians, and citizens, there needs to be greater explanation and detail on how trips are counted in Google EIE. City officials must be able to confidently explain EIE and its data to their politicians, the public, and potentially to those who seek to challenge their decisions. Data privacy and data governance issues are a key concern in the European context and Google EIE data and insights. In order to reach more cities, Google EIE data needs to be easily comprehensible, reliable, and verifiable.

Transparent information and open communication to cities and stakeholder groups about sources of data will be essential to unlocking the potential of Google EIE in Europe.

- **Disaggregation of data:** Sustainable urban mobility planning requires information beyond number or trips, distance travelled, or GHG emissions produced. Other indicators such as the purpose of journeys, or social data such as gender and age, are vital parameters for mobility planning. Existing EIE data, or new data that could be combined[7] with these indicators, could support cities in advancing sustainable mobility planning processes. Such a combined approach further underscores the need to understand why datasets may differ, in addition to providing cities with explanations.

[7]The combination of big data and socio-demographic data from other sources is also supported by other work in this area. (International Transport Forum, 2021)

5 Further Areas of Research

EIE's ability to provide detailed and timely access to transportation emissions data, for all modes of transport, could bring valuable insights to European cities, in addition to helping them advance climate action and local sustainable mobility planning. However, more cities need to access and review EIE data in order for its true potential to be realised.

Greater understanding of the tool among a larger community of users in the climate action and sustainable mobility planning ecosystems is needed. Work with universities, consulting firms and research organisations that work directly with cities is also needed to encourage the use of EIE and promote collective action.

The following areas of research have been identified to enhance the understanding of Google EIE emissions data at the local level in Europe:

- **Impact analysis of geographical boundaries in emissions calculations:** Understanding how city boundary differences in Google EIE impact emissions data will bring clarity to data gaps. Work could be done with cities to explore and identify existing gaps (geographical/administrative/functional) and to identify opportunities for improvement towards standardised comparative analysis. It is important to identify uncertainties in cities' calculation methods, especially in relation to transboundary trips.

- **Injection of cities' own data into Google EIE modelling schemes to better assess emissions deviations and correlations**: Local governments have different sources of data that could be taken as input to refine Google EIE calculations. As mentioned before, although the tool gives flexibility to include certain values, there might be an earlier stage where a test with some cities could be done to better understand data gaps and differences in the calculations methods. Some of the data that could be evaluated include VKT data and emissions factors.

- **Analysis of emissions data gaps per mode of transport:** Further comparative analysis on emissions per mode of transport could be done with cities that are able to provide this information, allowing for a better understanding of data differences and identification of new EIE data validation processes. An evaluation of the value EIE could bring to cities regarding scope 3 emissions could also be an interesting avenue to explore as part of this effort.

- **Testing of the EIE tool within the transport community and fostering the development of deep-dive reviews:** Transport planners play an essential role in local sustainable mobility. Further work to analyse EIE data from a transport planning perspective, including possible new features, will be key to advancing the adoption of the tool throughout Europe. Providing advice on the use of EIE and its related methods to transport planners would raise the profile and utility of EIE data[8]. In addition, deep dive reviews are recommended to further exploit the potential of Google EIE data to enhance low-carbon and sustainable mobility planning process, including the following topics:

[8] Adjustments to the presentation and data organisation on the EIE portal could be tested with user groups to make it more persuasive to transport planners, and to build interest for further use. In the medium term, providing advice on EIE and related methods to transport planners through their own channels, such as supporting a SUMP Topic Guide (ELTIS, 2021) could raise the profile and utility of EIE data and channels such as CIVITAS, of which ICLEI is a partner. Such developments could potentially be facilitated through ICLEI.

- **Analysis of public transport measurements at the local level:** Some patterns were found in relation to how the current values provided by Google EIE differ compared to city data, giving a greater modal split to car use, and often a lower modal split for buses. This is an area that requires further investigation with cities able to provide modal split data.

- **Refining the accurate splitting of modes:** Public transport modes (tram, bus, metro, subway, trolleybus), active travel modes (walking, cycling, scooter) and fuel type (internal combustion engine vs. electric car) are not always adequately separated in local data, and this is a useful function that Google can refine and offer. Google could investigate working with cities which have good datasets on particular modes of transport (such as cycling) to compare measurements of overall numbers of trips/total distances, or those who are embarking on new widespread census exercises. It is worth noting that Google has conducted ground truth validation of EIE car journey data at street segment level in select U.S. cities involving more than 120,000 vehicles; total modelled vehicle counts from EIE were within 6% to 17% of the actual counts. (Google Earth and Earth Engine, 2019)

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7 Annexes

Annex 1: GHG Emissions Accounting Methodologies Approach to On-Road Transport Emissions Calculations

Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)

Depending on the available data and objectives of the inventory, different methods can be used to quantify and allocate transportation emissions. The methods most commonly used for transportation modelling and planning vary in terms of their "system boundaries," or how the resulting data can be attributable to a city's geographic boundary and thus the GPC scopes framework. The GPC does not require a specific calculation method for each transport mode, and therefore the emissions reported in each scope will likely vary by method. The GPC categorizes emission sources in the transportation sector by transit mode, including on-road, railway, water-borne, aviation, and off-road transportation.

Scope 1 should reflect emissions from transportation occurring in the city. Scope 2 refers to emissions from grid-supplied electricity used in the city for transportation. Scope 3 reflects emissions from the portion of transboundary journeys occurring outside the city, and transmission and distribution losses from grid-supplied energy from electric vehicle use.

The GPC does not define a specific method for calculating on-road emissions due to the variation in data availability at local level. However, cities should calculate, and report emissions based on one of four common methods described below, and that can be broadly categorized as top-down (mainly fuel-sales approach) and bottom-up approaches. Bottom-up approaches generally rely on an ASIF framework.

- Fuel sales method: the volume of fuel purchased within the city boundary
- Induced activity method: in-boundary trips and 50% of transboundary trips that originate or terminate within the city boundary
- Geographic method: all on-road travel occurring within the geographic boundary
- Resident activity method: a measurement of the transport activities of city residents

Source: (GHG Protocol, 2014)

IPCC Guidelines for National Greenhouse Gas Inventories

Chapter 3 of the guidelines on mobile combustion provides a detailed overview of how emissions can be estimated for a number of modes of transport. The category of on-road transport differs slightly from the GPC method in that it excludes vehicles and mobile machinery used in industry, agroforestry, and on the premises of ports or airports. IPCC does, however, use the same methodology, extrapolating emissions either from fuel consumption and vehicle kilometres travelled (VKT). Both methods require some degree of bottom-up data collection to identify prevalent vehicle and technology types and activity data. Emission modelling tools can be used to develop activity data that considers road types and environmental factors.

With regard to railways, national inventory compilers will generally differentiate between the types of train engines (electric vs. diesel) and calculate CO2 emissions for trains not using electricity by examining fuel consumption and carbon content. To estimate CH4 and N2O emissions, activity data and emission factors (disaggregated by locomotive technology type) should be considered. At city level the national inventory approach has its limitations, and more detailed activity data will be needed to extrapolate Scope 1 and 3 emissions. The boundaries for calculating emissions at city level limit the applicability of the IPCC methodology, necessitating significant data collection efforts to capture activity data and extrapolate emissions.

For off-road transport it is unlikely that disaggregated fuel consumption and activity data is available. If this sector is considered a key source category, it will in all likelihood be necessary to conduct surveys on the basis of which city-level emissions are modelled, using national or default emission factors. Whilst mobile machinery and vehicles used in forestry, agriculture and industry (as well as airports) are considered in the "off-road" IPCC category, the GPC does not.

Source: (IPCC, 2006)

BEI/MEI EU Covenant of Mayors

After selecting the emission inventory approach, the local government can either use local emission factors or default (national/European/global) emissions factors, such as the IPCC (2006) and the CoM default emission factors provided in this Guidebook. GHG emissions (direct emission from fuel combustion and indirect emission due to consumption of grid-supplied energy) occurring for transportation purposes within the city boundary are to be reported. In addition, local authorities are recommended to further disaggregate by mode (on-road, rail, waterborne navigation and off-road) and by fleet type (municipal, public and private and commercial transport).

Local authorities are recommended to use the "geographic (territorial)" methodology to estimate activity data in the transport sector. In specific circumstances, other methodologies such as "fuel sales," "resident activity," and "city-induced" can be used. BEI/MEI acknowledges that a key challenge of calculating the energy consumption/GHG emissions in urban transport is related to the potential high share of sources moving across the border of the urban territory, which makes it difficult to allocate the energy consumption to a certain territory.

Source: (Bertoldi, P. et all., 2018)

BISKO Standard

The BISKO calculation method is integrated into tools such as the "Klimaschutz-Planer" (Climate Protection Planner), which many German cities use for inventory compilation. With regard to accounting transport emissions, guidelines for the use of the BISKO standard, published in German, recommend a final energy-based territorial approach that encompasses all motorized vehicles (passenger and freight transport). Guidelines further recommend that the origin of and reasons for travel are analysed. Furthermore, it is advised that inventory compilers differentiate between transport activity that can be easily influenced by local authorities (e.g., public transport travel, municipal fleets, etc.) and activities that are difficult to control (e.g., long-distance travel).

For on-road traffic, vehicle kilometres travelled are to be surveyed or modelled and differentiated according to road categories (urban, rural, motorway). Differentiations according to road types, traffic situations, and vehicle fleet compositions are not deemed to be necessary, as national averages are seen to be sufficiently accurate. Emission factors for traffic are differentiated according to means of transport and energy sources and (in road traffic) according to road categories. In Germany, these emission factors are regularly updated and included in the TREMOD model. Whilst default values for transport activity (all motorised transport, but not public transport) are available, it is recommended that inventory compilers base their estimates on locally gathered or modelled data, to ensure greater accuracy. Recommendations for obtaining data for various transport modes are included in the BISKO guidelines.

Source: (H. Hertle, et all., 2019)

Annex 2: Summary of Cities' GHG Emissions Accounting Processes

City	Responsable Unit	Inventory Frequency	Inventory Time Dev. (months)	Support Organisation	Tools Used by Cities
Athens	Resilience and Sustainability Department	Yearly	6-12	C40	City Inventory Reporting and Information System (CIRIS)[9]
Florence	Collaboration system between municipality and external consultancy	2 years	3-6	Spes Consulting	SECAP EU Covenant of Mayors Template, mainly used by European Covenant signatories
Greater Manchester	Environment Directorate	Yearly	Unknown	SCATTER (developed by Anthesis Group on behalf of BEIS)	SCATTER is a local authority-focussed emissions tool, built to help create local low-carbon strategies, mainly used by cities and regions in UK (Scatter, 2018)
Izmir Metropolitan City	Climate Change and Clean Energy Directorate	2 years	6-12	Consulting firm	SECAP EU Covenant of Mayors Template, mainly used by European Covenant signatories
Lisbon	Lisbon Environment and Energy Agency (Lisboa E-Nova)	Yearly	1-3	Lisboa E-Nova can be considered a third party; Lisbon City Council is its biggest member	City Inventory Reporting and Information System (CIRIS)
Madrid	Energy and Climate Change Department	Yearly	6-12	Chemistry Environmental Dept. at the Polytechnical University of Madrid	City Inventory Reporting and Information System (CIRIS)
Malmö	Climate and Energy Unit. Environmental Department	Yearly	1-3	N/A	City Inventory Reporting and Information System (CIRIS)
Mannheim	Climate Protection Control Center	3 years	6-12	Institute for Energy and Environmental Research (ifeu)	Klimaschutz-Planner software tool is mainly used by cities in Germany (H. Hertle, et all., 2019)
Warsaw	Air Protection and Climate Policy Department	2 years	3-6	C40	City Inventory Reporting and Information System (CIRIS)

Source: Cities questionnaire and interviews.

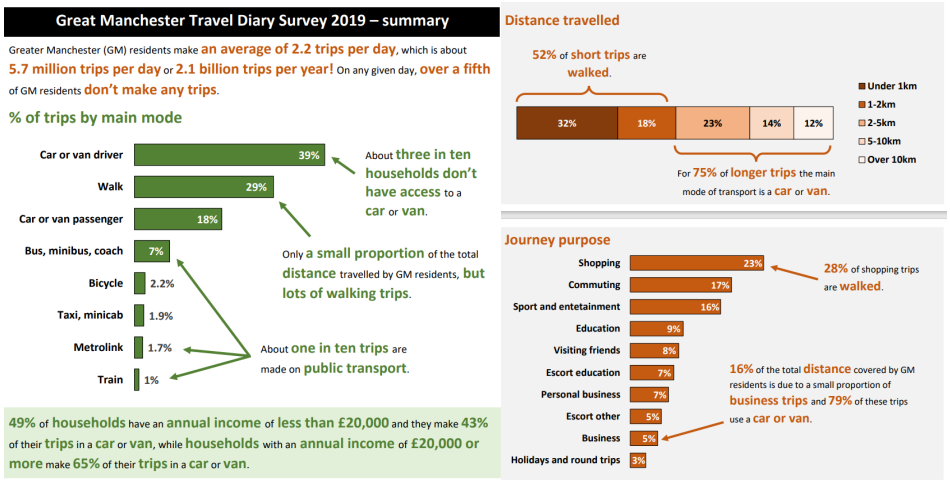
[9] C40 CIRIS Tool, a flexible Excel-based tool for managing and reporting city GHG inventory data. This tool is mainly used in cities that are part of the C40 group, but also by those implementing advanced GHG emissions accounting methods. Source: https://resourcecentre.c40.org/resources/reporting-ghg-emissions-inventories.

Annex 3: Deep-dive Cities Examples: Field Surveys Development and Reporting

Field Survey - Izmir Metropolitan City. Source: Izmir Transportation Master Plan. 2015 (Boğaziçi Proje A.Ş., 2017).

Modal Split Public Report - Mälmo. Source: City of Malmo factsheet. (City of Malmö, 2016)

Modal Split Public Report - Greater Manchester - Source. GM Travel Diary Survey. (TFGM, 2019)



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