EVALUATION FRAMEWORK

WP3, TASK 3.1

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AUTHORS:

Eduardo Mariño Fernández, Cristina Juárez Batlle (CARNET)

CONTRIBUTORS:

Ana Quijano, Julia Vicente (CARTIF), Laura del Río (UPM), Daniel Rubio, J. Víctor del Barrio (ALSA), Thomas Otto (Fraunhofer), Esti Sanvicente (RC)

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List of abbreviations

ACRONYM	DESCRIPTION
2Zero	Towards Zero Emission Road Transport
AV	Autonomous Vehicle
CCAM	Cooperative, Connected, and Automated Mobility
CCC	Climate City Contract
CDP	Carbon Disclosure Project
CIRIS	City Inventory Reporting and Information System
CORINAIR	COoRdination of INformation on AIR
EF	Emission Factor
EFDB	Emission Factor Database
EMEP	European Monitoring and Evaluation Programme
EU	European Union
EU-CEM	European Common Evaluation Methodology
EV	Electric Vehicle
FAME	Framework for coordination of Automated Mobility in Europe
GPC	Global Protocol for Community-Scale Greenhouse Gas Inventories
IA	Innovation Actions
ICLEI	Local Governments for Sustainability
ICR	Impact Category Responsible
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LC	Leading City
LCA	Life Cycle Assessment

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LCC	Life Cycle Cost
LEG	Local Evaluation Group
LEM	Local Evaluation Manager
LL	Living Lab
ML	Measure Leader
PEM	Project Evaluation Manager
PET	Project Evaluation Team
PFCs	Perfluorocarbons
PM	Particulate Matter
PU	Public
RC	Research Coordinator
RES	Renewable Energy Sources
RIA	Research and Innovation Actions
SC	Site Coordinator
SMART	Specific, Measurable, Attainable, Relevant, Timed
SRL	Societal Readiness Level
SUMI	Sustainable Urban Mobility Indicators
TERM	Transport and Environment Reporting Mechanism
TRL	Technological Readiness Level
UNPD	United Nations Population Division
UT- Labs	Urban Transport Labs
VRU	Vulnerable Road User
WRI	World Resources Institute

List of symbols

SYMBOL	DESCRIPTION
CO	Carbon Monoxide
CO_2	Carbon Dioxide
dB	Decibel
€	Euro (Used in Economic KPIs)
Hours/units	Hours per Unit (Charging Time)
Km	Kilometres
KWh	Kilowatt-hours
KWp	kilowatt 'peak
Microg/m^3	Micrograms per Cubic Meter (Air Quality Metric)
NO_x	Nitrogen Oxides
Ppb	Parts per Billion
SF_6	Sulfur Hexafluoride
$TnCO_2eq$	Tonnes of CO_2 Equivalent
%	Percentage

Publishable summary

The MOBILITIES for EU project aims to support the European Climate-Neutral and Smart Cities Mission by advancing sustainable urban mobility solutions. The project addresses key challenges such as reducing greenhouse gas emissions, improving energy efficiency, enhancing public health, and improving social equity in urban mobility systems. Central questions include how innovative measures can be effectively implemented, monitored, and scaled across cities while ensuring stakeholder collaboration and public acceptance.

The project brings together a diverse consortium, including public authorities, private sector leaders, academic experts, and civic organizations. Madrid and Dresden lead the implementation of pilot initiatives, with Ioannina, Trenčín, Espoo, Gdańsk, and Sarajevo serving as replication cities to adapt and scale successful measures.

Eleven pilot initiatives are featured in Madrid and Dresden, supported by 27 innovative measures, including electric and hydrogen infrastructure, smart mobility systems, and participatory Urban Transport Labs (UT-Labs). These labs engage citizens and stakeholders in co-designing solutions tailored to local needs. The project addresses pressing urban challenges, including carbon reduction, energy optimisation, public health improvements, and social equity in mobility, empowering local authorities, technology developers, industry stakeholders, and researchers in understanding the efficacy of sustainable transport interventions.

MOBILITIES for EU applies an evaluation framework derived from the CIVITAS model and including crucial ideas from the Cities Mission Platform, SUMI, 2Zero and CCAM. The framework leverages Key Performance Indicators (KPIs) to monitor environmental, energy, transportation, economic, and social impacts, aligning with goals to advance public health, resource efficiency, and social acceptance.

The present deliverable outlines significant progress, including:

- Robust Monitoring Framework: A centralised KPI system to track reductions in CO_2 and NOx emissions, energy efficiency improvements, stakeholder collaboration, and public satisfaction. A before-and-after scenario analysis is included to consider the impacts and benefits of pilot implementations.
- Stakeholder Engagement: UT-Labs foster public participation, increasing awareness, acceptance, and support for sustainable mobility measures.
- Innovative Monitoring Tools: Real-time data integration and monitoring frameworks by SAP and T-Systems ensure consistent reporting and scalability across pilot and replication cities.

The application of this framework supports data-driven and collaborative approaches to effectively address urban mobility challenges, supporting cities in transitioning toward climate neutrality, enabling cross-city collaboration, and informing effective decision-making. The report highlights anticipated benefits, including insights into measure implementation, process performance, and the environmental, social, and economic impacts of the pilot measures.

This deliverable is essential for policymakers, urban planners, transportation professionals, and European Union evaluators. It offers actionable insights for implementing, monitoring, and scaling sustainable urban mobility solutions across diverse urban contexts, providing a roadmap for other cities aspiring to achieve sustainable mobility goals.

The report underscores the effectiveness of structured evaluation frameworks in driving climate-neutral urban mobility and offers valuable insights for broader EU adoption. By establishing an adaptable evaluation framework and fostering innovation measures, MOBILITIES for EU sets a strong foundation for advancing sustainable urban mobility across Europe, aligning with the EU's vision for climate-neutral cities by 2030.

1. Introduction

1.1 MOBILITIES for EU concept

MOBILITIES for EU is a Horizon Europe innovation project and part of the European Commission's Climate-Neutral and Smart Cities Mission, which is dedicated to pioneering sustainable solutions for urban mobility across Europe.

The aim of the project is to demonstrate that innovative concepts for passenger mobility and freight transport, developed and implemented using approaches focused on the participation of the users, are both cost-effective and viable solutions. These innovations play a key role in advancing cities toward climate neutrality, accelerating efforts to achieve emissions reductions by 2030.

The cities of Madrid (Spain) and Dresden (Germany) will serve as Lead Cities (LC), implementing 11 pilot projects encompassing 27 highly innovative solutions for passenger and freight mobility. Both cities aspire to pioneer these transformative efforts by building upon existing social engagement initiatives, which will be integrated into the concept of Urban Transport Labs (UT-Labs).

Moreover, five Replication Cities—Ioannina (Greece), Trenčín (Slovakia), Espoo (Finland), Gdańsk (Poland), and Sarajevo (Bosnia & Herzegovina)—will participate directly through their own UT-Labs, enabling them to actively engage in the process and eventually take the lead in designing their own mobility solutions.

1.2 Contribution from Partners

The following depicts the main contributions from participating partners in the development of this deliverable. The contributions are based on the responsibility of the partners for the different ethical concerns.

Table 1. Partners Contribution

PARTNER SHORT NAME	CONTRIBUTIONS
CARNET	Overall content. Main author.
CARTIF	Deliverable Review Section 2.4.4 – Energy, and final deliverable review
UPM	Deliverable Review Section 2.4.4 - Economy
ALSA	Deliverable Review Section 2.4.4 – Transport System
Fraunhofer	Deliverable Review Section 2.4.4 – Environment, and deliverable Peer Review
RC	Deliverable Review Section 2.4.4 - Society

In the following table (Table 2) we can observe the whole list of partners participating in the MOBILITIES for EU project. From this table, partners will have different roles in the Work Package 3 (WP3) and in this deliverable. While a set of the partners play a direct role in the contribution of the deliverable D3.1 (Table 1), others contribute by providing information on their corresponding actions and pilots. The roles and responsibilities of the partners in WP3 is provided as a chapter in the Evaluation Framework section.

Table 2. List of partners participating in the MOBILITIES for EU project

Number	Short name	Legal name	Country
1	CARTIF	FUNDACION CARTIF	ES
2	MADRID	AYUNTAMIENTO DE MADRID	ES
3	MERCAMADRID	MERCADOS CENTRALES DE ABASTECIMIENTO DE MADRID SA	ES
4	EMT	EMPRESA MUNICIPAL DE TRANSPORTES DE MADRID SA	ES
5	ORANGE	ORANGE ESPAGNE SA	ES
6	FERROVIAL	FERROVIAL CONSTRUCCION SA	ES
7	TSY	T-SYSTEMS ITC IBERIA SA	ES
8	PLEXIGRID	PLEXIGRID SOCIEDAD LIMITADA	ES
9	UPM	UNIVERSIDAD POLITECNICA DE MADRID	ES
10	PZGR	PREZERO GESTION DE RESIDUOS SA	ES
11	ALSA	PROYECTOS UNIFICADOS SA	ES
12	DRESDEN	LANDESHAUPTSTADT DRESDEN	DE
13	VWGI	VOLKSWAGEN AKTIENGESELLSCHAFT	DE
14	Fraunhofer	FRAUNHOFER GESELLSCHAFT ZUR	DE
15	SAP	SAP SE	DE
16	TUD	TECHNISCHE UNIVERSITAET DRESDEN	DE
17	CARNET	FUNDACIO CENTRE D'INNOVACIO I TECNOLOGIA DE LA UPC	ES
18	SAENA	SACHSISCHE ENERGIEAGENTUR - SAENA GMBH	DE
19	ESPOO	ESPOON KAUPUNKI	FI
20	TRENCIN	MESTO TRENCIN	SK

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21	STUBA	SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE	SK
22	SARAJEVO	CABINET OF THE PRIME MINISTER SARAJEVO CANTON	BA
23	GDANSK	GMINA MIASTA GDANSKA	PL
24	IOANNINA	MUNICIPALITY OF IOANNINA	EL
25	STEINBEIS	STEINBEIS INNOVATION GGMBH	DE
26	AEDIVE	ASOCIACION DE EMPRESAS PARA EL DESARROLLO E IMPULSO DEL VEHICULO ELECTRICO	ES
27	RC	RIGHT-CLICK	FR
28	IRF	INTERNATIONAL ROAD FEDERATION	CH

1.3 Purpose of the deliverable

This deliverable is linked to the WP3 and outlines the evaluation framework for the MOBILITIES for EU project, with a focus on performance assessment and the reduction of CO_2 emissions. It can be observed in the Figure 1 how this WP3 is established in the MOBILITIES for EU Work Plan. The primary goal is to define a comprehensive set of Key Performance Indicators (KPIs) and an evaluation methodology that will assess the environmental, social, and economic impacts of the mobility and logistics solutions developed in the lead cities, which will serve as an example for the potential measures in the following cities.

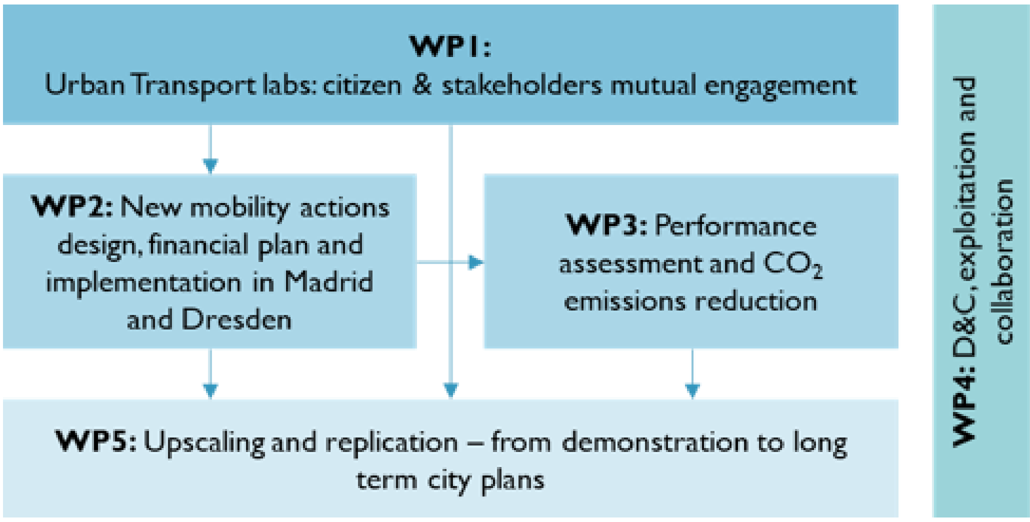

Figure 1. MOBILITIES for EU Work Plan – WP3

This document corresponds to the deliverable of the first of four tasks that have been considered for the WP3:

- T3.1 Evaluation framework, KPI identification and definition
- T3.2 Monitoring programmes
- T3.3 Data collection and KPI calculation
- T3.4 Evaluation and contribution to City-wide Climate Neutrality objectives, 2Zero and CCAM partnerships

The evaluation framework is based on the identification and analysis of key sources and methodologies, including:

1. Cities Mission Platform (NetZeroCities) indicators, which focus on measuring climate neutrality, considering all three emissions-reduction scopes.
2. CIVITAS Process and Impact Evaluation Framework, which evaluates the impact of mobility interventions across six key categories—society (people and governance), the transport system, the economy, energy, the environment.
3. Sustainable Urban Mobility Indicators (SUMI), which provide a standardized approach to measuring the sustainability of urban mobility systems.
4. 2Zero and CCAM project-related evaluation frameworks, which research on societal readiness of net zero technology and connected and automated mobility measures.

The deliverable will define and select relevant KPIs, focusing particularly on emissions through a detailed analysis of urban metabolism, including the movement of resources, particularly those linked to mobility. The key subtasks include:

- ST3.1.1: Defining KPIs for CO_2 emissions.
- ST3.1.2: Establishing KPIs for energy demand reduction and cost analysis.
- ST3.1.3: Developing KPIs for social acceptance of mobility solutions.
- ST3.1.4: Identifying KPIs for co-benefits such as safety, traffic congestion, public health (noise and disease reduction), and environmental factors like air quality.

By establishing this evaluation framework, MOBILITIES for EU will provide a robust method for measuring and assessing the impact of urban mobility innovations on CO_2 emissions, contributing to the broader goals of climate neutrality and sustainable urban development.

1.4 Intended audience

The dissemination level of D3.1 is public (PU) and is meant primarily for all members of the MOBILITIES for EU project consortium.

This document aims to serve not just as an internal guideline and reference for all MOBILITIES for EU beneficiaries, but also for the larger communities of city administrators, urban planners, policy makers, environmental mobility development and testing, and the general public to understand the benefits, progress, and societal impacts of the project.

2. Evaluation framework

In this chapter, we aim to present the MOBILITIES for EU impact assessment framework which will be used to assess the activities carried out during the demonstrations and evaluate the success of the actions.

It includes the process to determine the framework that will be considered in the evaluation of the actions, the detailed explanation of the frameworks considered, and the inventory of indicators to be measured and monitored during the lifetime of the project. Moreover, it also presents the potential barriers related to these indicators that might appear during the implementation of the actions, while also providing guidelines to the cities on how to collect and share their data and information.

2.1 Evaluation Framework Review

To develop the MOBILITIES for EU impact assessment framework, the indicators from Cities Mission Platform, CIVITAS Process and Impact Evaluation Framework, and Sustainable Urban Mobility (SUMI) were considered. Moreover, 2Zero and CCAM project-related evaluation frameworks that research on societal readiness, were also analysed as part of this Work Package.

2.1.1 CITIES MISSION PLATFORM

The Cities Mission Platform (NetZeroCities) is an initiative designed to support cities in achieving climate neutrality by 2030. A fundamental aspect of this platform is its framework for measuring climate impact, which revolves around three emissions-reduction scopes: direct emissions (scope 1), indirect emissions (scope 2), and induced emissions (scope 3). This structured approach offers a comprehensive way to account for the various sources of greenhouse gas (GHG) emissions within cities and provides valuable insights for both policymakers and urban planners aiming to meet ambitious climate goals.

Moreover, as part of the climate neutrality 2030, the Cities Mission Platform works towards a roadmap to guide cities' actions to explore innovative solutions to reach climate objectives with the use of Climate City Contracts (CCC). They represent a collaborative and iterative learning process led by cities and involving multiple stakeholders at various governance levels. The CCC holds great value in gathering all actors to explore the most effective pathways to climate neutrality by 2030, and in joining forces on a common agenda to get there.

The Cities Mission Platform's focus on all three emission scopes ensures that cities take a holistic approach to achieving climate neutrality. Rather than focusing solely on direct emissions, the framework pushes cities to consider their broader environmental footprint, including energy sources and the lifecycle of goods and services consumed by urban residents.

1. Scope 1: Direct Emissions

Scope 1 covers direct emissions that are produced within a city's geographical boundaries. These emissions come primarily from activities such as:

- On-road transportation, including private vehicles, public buses, and freight services.
- Building operations, particularly heating, cooling, and electricity generation on-site, especially if these rely on fossil fuels.
- Industrial processes that release GHGs directly into the atmosphere.

Cities aiming for climate neutrality must focus on reducing Scope 1 emissions by transitioning to clean energy sources for heating and electricity production, adopting electric vehicles, and improving energy efficiency in buildings. The NetZeroCities platform encourages cities to adopt technologies like district heating, renewable energy production, and zero-emission public transportation. Tracking Scope 1 emissions offers cities a clear view of the emissions they can directly control and influence. Reducing them include infrastructure transitions (e.g., electrification of transport) and ensuring that renewable energy sources are available and affordable.

2. Scope 2: Indirect Emissions from Purchased Energy

Scope 2 refers to indirect emissions resulting from the consumption of purchased electricity, heat, or steam, which are produced outside the city's boundaries but used within the city. In urban areas, this is often the largest source of emissions, given the widespread reliance on electricity for lighting, appliances, transportation, and industrial operations.

The transition to renewable energy sources like wind, solar, and hydropower for electricity production is critical to reducing Scope 2 emissions. Cities that are part of the NetZeroCities initiative are encouraged to pursue green power procurement strategies, such as entering into long-term renewable energy purchase agreements or developing local renewable energy projects (solar, wind) to meet their electricity needs.

By reducing Scope 2 emissions, cities can achieve significant gains in their climate neutrality targets without necessarily affecting in excess local infrastructure, since the shift primarily relies on the external energy grid becoming cleaner. However, cities also need to focus on energy efficiency initiatives that reduce overall demand for electricity, such as installing energy-efficient appliances, and promoting energy conservation behaviours.

3. Scope 3: Induced Emissions

Scope 3 encompasses induced emissions, which are indirect emissions generated by activities associated with a city but occurring outside its boundaries. These include:

- Emissions from the production and transport of goods consumed by the city's residents, businesses, and institutions.
- Upstream and downstream emissions related to transportation systems, including vehicle manufacturing and fuel production.
- Waste management, where emissions result from the disposal and treatment of waste products generated within the city.

This integrated approach aligns well with the objectives of the MOBILITIES for EU project, particularly in reducing emissions. By evaluating mobility-related measures in cities and emphasizing energy efficiency, renewable energy adoption, and sustainable logistics solutions, the project contributes directly to the goals set by the NetZeroCities platform.

Scope 3 emissions are the most challenging to measure and mitigate, as they are spread across various sectors and often occur outside the direct control of the city. The key challenges usually include complexity in tracking emissions across extended supply chains and the need for multi-level coordination. The NetZeroCities platform encourages cities to adopt a broader view of their supply chains, promoting circular economy strategies, such as reducing consumption, reusing materials, and improving waste management systems. Cities can also focus on decarbonizing supply chains by encouraging the procurement of low-emission goods and services and fostering local production to reduce transportation emissions.

A more detailed description of the emission scopes and the methodologies proposed to be considered in the actions for each pilot and Madrid and Dresden, which can be used as an example for the following cities, is developed in the chapter 2.2 Emission Scopes. There we include general and alternative methodologies, as well as specific examples for the actions presented in this project.

In addition, the use of urban metabolism models, which track the flows of resources, energy, and emissions into and out of a city, offers cities a detailed understanding of how mobility and urban logistics contribute. This approach facilitates targeted actions to reduce emissions, such as encouraging more localized production, shifting to electric freight vehicles, or optimizing urban waste management systems. Urban Metabolism will be further analysed in the impact evaluation of the project, in chapter 2.3.6.

The Cities Mission Platform indicators provide a robust framework for cities to assess their progress towards climate neutrality. By focusing on Scope 1 (direct), Scope 2 (indirect), and Scope 3 (induced) emissions, cities can adopt a comprehensive strategy to reduce their environmental impact. The MOBILITIES for EU project is well-positioned to align with the ideas in this framework, particularly through its focus on energy-efficient mobility solutions and reducing urban logistics-related emissions.

2.1.2 CIVITAS EVALUATION FRAMEWORK

The CIVITAS Evaluation Framework emphasizes the importance of systematic and evidence-based evaluation across all projects. It ensures that the findings from mobility innovations contribute to the broader European knowledge base of sustainable urban mobility solutions. As an integral part of the CIVITAS Initiative, this framework presents key ideas that can support the MOBILITIES for EU project's performance assessment, guiding the analysis of the impact and processes related to urban mobility measures.

Evaluation is recognized as a critical component of all CIVITAS projects. It serves to quantify the nature and extent of the impacts introduced by urban mobility measures, as well as to analyse the processes underlying their implementation. The objective is to capture both the outcomes and the operational steps involved, offering a comprehensive understanding of how different interventions perform in diverse urban environments.

Given the wide range of mobility projects undertaken within the CIVITAS Initiative, a "one-size-fits-all" approach is neither appropriate nor feasible. However, maintaining consistency across evaluations is essential to ensure that results can be interpreted and utilized by various stakeholders. To achieve this, the CIVITAS framework recommends the use of:

- Unified terminology: Projects should adopt a common vocabulary to describe mobility measures, their impacts, and their implementation processes.
- Standardized impact categories: This enables consistent evaluation of the effects of mobility measures on various urban systems, including environment, energy, transport, society-people, society - governance and economy.
- Consistent reporting structure: Findings should be presented in a manner that is transparent, comparable, and accessible to interested parties across different sectors and regions.

By adhering to these principles, the CIVITAS framework ensures that findings are robust, scientifically sound and understandable to a wide range of stakeholders, from policymakers to urban planners and researchers.

The CIVITAS Evaluation Framework is designed to accommodate the complexity and diversity of mobility projects, whether they involve multiple integrated measures or focus on specific innovations. It distinguishes between two key types of projects:

1. Innovation Actions (IA): These projects typically involve the implementation of integrated packages of mobility measures. For IA projects, the CIVITAS framework provides a detailed guideline to ensure that evaluation is conducted consistently across different cities and project sites. This consistency is critical to generating results that are transparent, comparable, and usable by various stakeholders.
2. Research and Innovation Actions (RIA): RIA projects often focus on developing and validating specific measures or solutions. While these projects may not implement integrated packages, the CIVITAS framework offers inspiration for developing a focused and consistent evaluation approach. RIAs should align with the CIVITAS principles in terms of terminology, impact categories, and evaluation methods, ensuring that their results contribute to the broader CIVITAS knowledge base.

In the case of the MOBILITES for EU project, the CIVITAS framework can be used to evaluate actions and pilots which could be considered as Innovation actions, as they implement actions part of mobility measures. One of the key concepts of the CIVITAS Evaluation Framework is to ensure that the lessons learned from individual projects are captured and shared across Europe. By using consistent terminology, categories, and reporting formats, the framework enables different cities and stakeholders to compare their experiences and understand the broader impacts of urban mobility innovations. This cross-city learning process contributes significantly to the European knowledge base on evidence-based solutions for sustainable urban mobility.

In conclusion, the CIVITAS Evaluation Framework provides a structured, flexible, and robust approach to evaluating the impact and processes of mobility measures in urban environments. For the MOBILITIES for EU project, it offers essential guidance for performance assessment, ensuring that the project’s findings on CO_2 emissions reduction, social acceptance, and energy efficiency are comprehensible and valuable to stakeholders across Europe.

2.1.3 SUSTAINABLE URBAN MOBILITY INDICATORS (SUMI)

The Sustainable Urban Mobility Indicators (SUMI) provides a comprehensive set of indicators designed to assess the sustainability of urban mobility systems across European cities and urban areas. Aligned with the European Commission's Urban Mobility Package, which creates a consistent standard for driver safety and care, increased sustainability, and fairer competition between member states in Europe, SUMI is intended to support cities in measuring progress toward sustainable urban mobility and to guide decision-making for further improvements. This section analyses the role of SUMI indicators within the broader framework of the project's evaluation, particularly in terms of their relevance to KPI assessment and CO_2 emissions reduction.

SUMI proposes 19 indicators that address a wide array of aspects within urban mobility, focusing on environmental sustainability, economic efficiency, social inclusiveness, and quality of service. These indicators allow cities to measure the performance of their mobility systems in a standardised way, facilitating comparability between cities and enabling policymakers to identify areas of improvement. From that list of 19, some indicators relevant to this project include:

1. **Greenhouse Gas Emissions (GHG):** This indicator measures CO_2-equivalent emissions generated by urban transport activities, making it directly relevant to the project's goal of reducing CO_2 emissions. The indicator helps cities quantify their contribution to climate change and track progress toward carbon neutrality.
2. **Air Quality:** By measuring pollutants such as nitrogen oxides (NOx) and particulate matter (PM), this indicator is critical in understanding the broader environmental impacts of transportation beyond CO_2 emissions. Reduced air pollution is a co-benefit of decarbonising urban mobility.
3. **Energy Efficiency of Transport:** This indicator evaluates the amount of energy consumed per kilometre, providing insight into the operational efficiency of urban transport systems. It is closely linked to CO_2 emissions reduction, as improved energy efficiency directly impacts emissions levels.

Within the MOBILITIES for EU project, SUMI indicators provide essential tools for evaluating both the impact and effectiveness of the mobility measures implemented across participating cities. Some of the benefits of including SUMI's framework in this project include:

- Holistic evaluation approach, which enables a more comprehensive assessment, considering not only CO_2 emissions but also other sustainability factors.
- Comparability between the project's pilots and actions.
- Data-driven insights that support policymakers in making informed decisions about urban mobility.
- Key metrics for tracking the project's primary objective of reducing emissions.

While SUMI provides a robust framework for evaluating sustainable urban mobility, some challenges may arise: not all cities have access to the necessary data to calculate all the proposed SUMI indicators accurately. Additionally, urban mobility systems vary significantly between cities in terms of scale, infrastructure, and socio-economic conditions, which may require adapting or contextualising indicators to specific scenarios. Moreover, while SUMI framework also includes indicators related to enhancing modal shifts, improving public transport services, and addressing social inclusivity, some of which can complement the project's pilots, these may not align fully with the focus of the actions.

In conclusion, the SUMI indicators play an important role in assessing the effectiveness of mobility measures and the sustainability of urban mobility systems. By monitoring energy efficiency, transportation measures, and GHG emissions, SUMI allows cities to quantify their progress toward achieving climate goals.

2.1.4 2ZERO AND CCAM PROJECT-RELATED EVALUATION FRAMEWORKS

The 2Zero (Towards Zero Emission Road Transport) and CCAM (Connected, Cooperative, and Automated Mobility) frameworks are key European initiatives focused on sustainable and automated transport solutions. While they target different technological and environmental goals, both aim to assess the technical success of the implemented measures and the societal readiness and acceptance of new mobility solutions.

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This section will examine the evaluation frameworks used in these projects, with a particular focus on how they integrate the concept of societal readiness into their assessment methodologies.

The 2Zero (Towards Zero Emission Road Transport) framework

The 2Zero is a co-programmed Partnership funded under the Horizon Europe programme. It aims towards a climate-neutral European road transport system and contributes to the acceleration of the necessary transition by supporting innovation on road transport mobility within the European Research Area, including the MOBILITIES for EU project.

As a Horizon Europe project, LeMesurier is building a framework to track 2Zero's impact and effectiveness on sustainable road transport research and innovation, and is also being considered and analysed as part of MOBILITIES for EU project. It measures KPI achievement and quantifies the impact of the partnership's project while recommending improved evaluation methods.

Within the 2Zero partnership and the LeMesurier framework, proposed indicators have been considered and analysed including:

- GO.KPI.3: Reduction of CO_2 emission from road transport for all types of vehicles.
- SO.KPI.1: Ability to determine, realistically and reliably, the energy intensity (tank-to-wheel).
- SO.KPI.2: Reduce GHG of mobility of people and goods.
- SO.KPI.3: Reduction of development time and effort.

The focus of 2Zero is the decarbonisation of road transport, primarily through the promotion of electric and hydrogen-powered vehicles and the contribution to the European Union's climate neutrality targets by advancing zero-emission technologies and solutions for passenger cars, vans, trucks, and buses. In the context of evaluation, the 2Zero project framework places considerable emphasis on assessing the technological readiness level (TRL) of new mobility solutions, but it also recognizes the importance of societal readiness level (SRL), which measure how ready society is to adopt new technologies and the potential barriers to their large-scale deployment.

Some of the key aspects of societal readiness level evaluation in the 2Zero framework include:

- **Public Acceptance** to assess the willingness of individuals and communities to adopt zero-emission technologies such as electric vehicles (EVs) and hydrogen-powered transport.
- **User Experience** to evaluate how new technologies impact users' day-to-day mobility behaviour, and how those can affect individuals' travel routines and trip planning.
- **Stakeholder Engagement** to evaluate how well city authorities, transport operators, and energy providers can collaborate to support zero-emission technologies.

By integrating these societal aspects into the evaluation, the 2Zero framework ensures that the transition to zero-emission transport is not only technologically feasible but also socially acceptable and supported by the general public. The framework emphasizes the importance of understanding public perceptions and ensuring that innovations are designed and implemented aligned with societal values and needs.

The CCAM (Connected, Cooperative, and Automated Mobility) framework

The CCAM initiative focuses on advancing connected, cooperative, and automated mobility solutions that enhance traffic safety, efficiency, and sustainability. As mobility advances towards autonomous systems, the CCAM framework includes a strong emphasis on societal readiness alongside technical development.

Within the CCAM initiative, societal readiness evaluation ensures the deployment of autonomous vehicles (AVs) and connected mobility systems is safe, secure, and widely accepted by society. This framework addresses four evaluation levels, depending on the characteristics and potential impact of the measure: 1) single vehicles, 2) humans, 3) traffic and transport, and 3) the society overall.

As part of this framework, the MOVE2CCAM project was reviewed to consider specific aspects on the social acceptability and behavioural change that can be associated to CCAM and new mobility solutions present in the MOBILITIES for EU project. MOVE2CCAM developed a multi-systems impact assessment modelling tool to estimate the impacts of autonomous vehicles to transport passengers and freight using system dynamic modelling approaches. This model is composed of a set of variables (indicators) and chains of cause-and-effects relations for each of the dimensions affected by the CCAM solutions presented in such project. As such, the framework and the factors that can influence societal acceptance developed as part of MOVE2CCAM were analysed and considerations regarding the indicators for the societal readiness and acceptance of CCAM innovations in the MOBILITIES for EU were included.

To support the testing of CCAM systems, the Horizon Europe programme has funded the Framework for coordination of Automated Mobility in Europe (FAME), and a part of the CCAM framework is the EU-CEM, which provides guidance in the form of a handbook. It establishes a robust evaluation foundation during the preparation phase, and designing a feasible evaluation plan for CCAM projects, as well as specific guidelines for evaluation areas across the four evaluation levels mentioned, ensuring comprehensive assessment. The CCAM framework incorporates the following key aspects:

- **Trust in Automation:** A key factors in societal readiness is the trust that users place in automated systems (i.e., CVs and AVs). The CCAM framework evaluates user comfort with fully or partially AVs.
- **Ethical and Legal Considerations:** The shift to autonomous mobility raises ethical concerns, particularly related to safety decision-making by machines, privacy, and data security. The CCAM framework examines societal views on these issues and assesses the adequacy of existing legal frameworks.
- **Inclusivity and Accessibility:** Ensuring automated mobility systems are inclusive and accessible to all members of society, including those with disabilities, the elderly, and individuals in underserved areas, is critical. This framework assesses whether AVs and connected mobility solutions contribute to a more equitable mobility system.
- **Public Involvement in Decision-Making:** The CCAM framework assess public participation in shaping automated mobility policies. Through participatory planning processes, it measures citizen participation in the decision-making process of measures, ensuring societal concerns and priorities are reflected in the design and implementation of new technologies.

CCAM framework addresses the societal challenges posed by innovative transport technologies like electric vehicles and autonomous systems, which are integral to the measures considered in this project. Evaluations typically involve pilots, simulations and surveys. Key principles from this framework will be included and applied in this project's evaluation process to assess the societal readiness of pilots and actions.

2.2 Project's Evaluation Framework

The main parameters considered by CARNET as evaluation manager, and shared with the consortium, when stablishing our project evaluation framework were mainly two:

- The capacity of the chosen evaluation framework, and this its results, to be understood and easily shared with all sorts of stakeholders.
- The capacity to define efficient key performance indicators and monitoring systems appropriate for the project pilots.

This first approach was firstly shared with all the Mobilities for EU partners during the project Kick off meeting in Madrid in January 2024. After consensus with all the parties, we proceed to review all the evaluation frameworks available and presented in section 2.1.

After reviewing all evaluations frameworks available, the CIVITAS evaluation framework appeared as the most common framework used in similar projects as Mobilities for EU, and also in the other Cluster Projects funded under the same call (or similar). This first approach to use the CIVITAS framework as the backbone of Mobilities for EU framework (after agreeing it with the project partners during our monthly meetings) was presented to CINEA in a Clustering meeting for projects funded under HORIZON-MISS-2023-CIT-01 call organized in Brussels in the 22nd of February 2024. During this clustering meeting we were aligned with both the Commission and with the other funded projects in the use of the CIVITAS evaluation framework.

Taking into account our 2 parameters for stablishing Mobilities for EU framework, being able to share a similar evaluation framework with our clustering projects, was key to assure the effective knowledge share of the impacts of the project with all the involved stakeholders.

During the monthly meeting for WP3 held on Wednesday March 20, we presented to the consortium the final Evaluation Framework of Mobilities for EU, build from CIVITAS framework (Figure 2Figure 1).

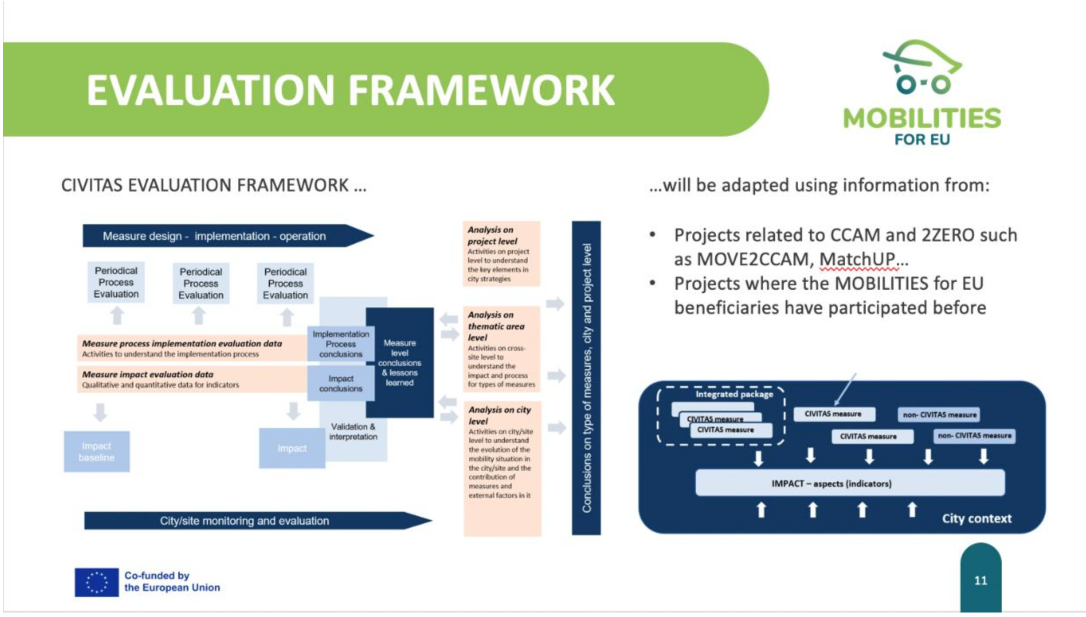


Figure 2. Evaluation Framework of Mobilities for EU, build from CIVITAS framework

As stated above, in the context of urban mobility and sustainability, several frameworks and indicators have been developed to evaluate and measure the effectiveness of actions aimed at achieving climate neutrality, reducing emissions, and improving sustainable transportation systems. As previously mentioned, the Cities Mission Platform, the CIVITAS Evaluation Framework, and the Sustainable Urban Mobility Indicators (SUMI) framework each provide a designed approach to monitor and improve urban mobility. They propose a similar goal of enhancing urban sustainability and reducing emissions; however, they present a different approach, methodology, and scope.

The Cities Mission Platform, developed as part of the NetZeroCities initiative, primarily focuses on supporting cities in achieving climate neutrality by 2030 and emphasizes the three scopes of emissions. The emphasis on emissions across all scopes is crucial but does not provide a detailed guidance for the process and impact evaluation of other transport, energy or societal measures, which are also a central aspect of our project. MOBILITIES FOR EU will work in the CCC that cities are defining and refining with the Mission Platform NetZeroCities to reach climate neutrality in 2030. It will help to integrate lessons learnt in a continuous updating of those contracts, particularly providing projects results and best practices on 2ZERO and CCAM solutions for sustainable mobility.

Moreover, as part of the framework of this project and similarly to the NetZeroCities methodology, a funnel of experience sharing will be a primary tool help structure and reflect on key experiences (see Figure 3). This tool provides a guided template to organize discussions and document insights by offering specific categories for input collection. With the help of this tool, it's possible to enable more effective knowledge sharing and recording. The funnel organizes these reflections along two key dimensions: project phases (planning, execution, and closing) and activity types (actions, outcomes, and learnings). By populating the template with actions and outcomes at the top, it enables a process where insights and lessons learned naturally emerge at the bottom. This structured approach ensures that valuable experiences are captured, refined, and accessible for future projects, fostering continuous improvement and effective knowledge transfer across teams.

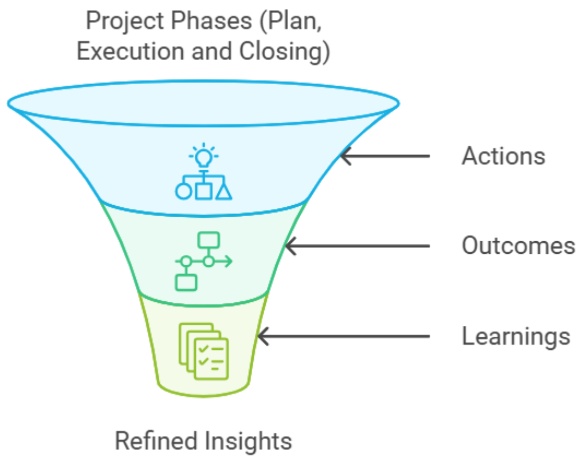


Figure 3. Funnel of Experience Sharing tool

The SUMI framework offers a well-defined set of indicators to measure the sustainability of urban mobility systems. For our project, SUMI can be particularly valuable for cities to improve specific aspects of their mobility systems, however, it does not provide some other category indicators needed for our project and does not offer the same level of evaluation process analysis than other frameworks, making it less effective for understanding the why behind the success or failure of individual measures.

The CIVITAS Process and Impact Evaluation Framework stands out by offering a dual approach that combines both impact evaluation and process evaluation. This framework is particularly well-suited for projects like ours, which not only aim to reduce GHG emissions but also want to understand the underlying factors that contribute to the success or failure of specific mobility measures. The CIVITAS framework provides a structured approach to assess the effectiveness of individual mobility measures and their implementation processes in real-world urban settings.

Both the 2Zero and CCAM frameworks place a significant emphasis on societal readiness, which represents a huge element in the evaluation and result of the project. This aspect differs from the presented frameworks, giving a greater importance to the human factors of technological adoption. While CIVITAS includes some aspects of public acceptance engagement, the emphasis on societal readiness ensures that new mobility technologies are not only technologically advanced but also socially acceptable and supported. By including these considerations in the framework, societal actions can be easily analysed through questionnaires and surveys, and qualitative indicators. This global approach will contribute to the long-term success and replicability of the mobility solutions being developed.

Given these considerations, the evaluation framework considered in this project will include the concepts presented, where the CIVITAS Impact Evaluation Framework will have a stronger impact as the basis of evaluation tool. Its focus on measuring the direct impacts of mobility measures and evaluating the processes of implementation aligns closely with the needs of the project. Elements from both SUMI and the Cities Mission Platform will still be integrated into our evaluation strategy, especially in the KPI selection process, and in the Impact and Process Evaluation. From SUMI, we will consider several of the quantitative indicators related to mobility and air quality; and from the Cities Mission Platform, we will consider the three scopes of emissions (Scope 1, 2, and 3) as an additional layer to CIVITAS's impact evaluation. This broader perspective on emissions will allow us to better account for indirect and induced emissions associated with urban mobility measures, ensuring a more comprehensive analysis of their climate impact.

2.3 Emission Scopes

Cities are the cornerstone of the climate change scenario, as the account for 75% of global CO_2 emissions related to energy use, either directly or indirectly (WRI, C40, ICLEI, 2014). At the same time, urban environments are particularly vulnerable to climate change impacts, especially because they comprise 75% of the EU population (UNPD, 2018). In response, European programs have developed robust frameworks to help cities tackle climate change across all its phases. The present section focuses on one of the most important phases: identifying and estimating CO_2 emission sources.

Cities' ability to manage emissions should begin with creating a detailed map of carbon sources and removals, referred to as GHG inventory. This tool allows cities to draw strategic mitigation efforts and monitor their performance. As climate change is a global issue, GHG inventories must adhere to standardised frameworks to ensure data quality, enable intercity comparisons, treat transboundary emissions, and aggregate data at different levels (local, subnational, and national).

In response to this challenge, the *Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC)* was developed by the GHG Protocol at the World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and Local Governments for Sustainability (ICLEI). The GPC provides a comprehensive framework for calculating and reporting GHG emissions at the city level.

Base principles

The GPC method is based on five key principles: *relevance, completeness, consistency, transparency, and accuracy*.

- ***Relevance:*** Ensures that selected data appropriately reflects the city's emission patterns.
- ***Completeness:*** Requires inclusion of all emission sources within the chosen boundaries.
- ***Consistency:*** Establishes a consistent approach to boundaries, methodology, and calculations, following GPC guidelines.
- ***Transparency:*** Demands adequate documentation and disclosure of activity data, emission sources, emission factors, and methodologies to enable verification.
- ***Accuracy:*** Guarantees data quality sufficient to assure the integrity of the reported information, therefore supporting effective decision-making.

Spatial, temporal, and elemental boundaries

Cities must establish a *geographic boundary* for their GHG inventory that defines the spatial area for emissions reporting, typically aligning with administrative areas like local governments, wards, or metropolitan regions. This boundary must remain consistent over time to allow for comparisons. The chosen boundary should be independent of the municipal facilities located outside the city, such as power plants or landfills.

Regarding *time periods*, the inventory should cover a continuous 12-month period, ideally aligned with the city's calendar or financial year. While GHG emissions are generally quantified for the reporting year, certain sectors, like waste management, may also estimate future emissions resulting from current activities.

Cities must report *emissions* from carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). This selection accounts for the seven gases currently required for most national GHG inventories under the Kyoto Protocol[1].

Framework for categorising emissions

The GPC method categorises emissions based on two dimensions: their location (geographical boundaries) and their source.

[1] https://unfccc.int/kyoto_protocol

As mentioned in the Cities Mission Platform section (Section 2.1.1), emissions are categorised based on their location, as activities taking place within the defined boundary can also generate emissions outside of it. To clarify this relationship, the scope structure was created, with the following definitions:

1. **Geographic location:**

   Emissions are divided into three scopes:

   - **Scope 1:** Direct GHG emissions from sources located within the city boundary.
   - **Scope 2:** Indirect GHG emissions from grid-supplied electricity, heat, steam, or cooling consumed within the city boundary.
   - **Scope 3:** All other indirect GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

2. **Emission sources:**

GPC methodology divides them in six sectors responding to their emission location (refer to Table 3): 1) *stationary energy, 2) transportation, 3) waste, 4) industrial processes and product use (IPPU), 5) agriculture, forestry, and other land use (AFOLU),* and 6) any *other emissions* occurring outside the geographic boundary as a result of city activities. Each sector is further divided into subsectors and, if needed, in sub-categories.

Table 3 relates emissions categorization by location and source, thus, providing an understanding of how these two frameworks relate.

Table 3. Emission divided by source and scope (WRI, C40, and ICLEI, 2014)

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
STATIONARY ENERGY			
Residential buildings	✓	✓	✓
Commercial and institutional buildings and facilities	✓	✓	✓
Manufacturing industries and construction	✓	✓	✓
Energy industries	✓	✓	✓
Energy generation supplied to the grid	✓		
Agriculture, forestry, and fishing activities	✓	✓	✓
Non-specified sources	✓	✓	✓
Fugitive emissions from mining, processing, storage, and transportation of coal	✓		
Fugitive emissions from oil and natural gas systems	✓		
TRANSPORTATION			
On-road	✓	✓	✓
Railways	✓	✓	✓
Waterborne navigation	✓	✓	✓
Aviation	✓	✓	✓
Off-road	✓	✓	
WASTE			
Disposal of solid waste generated in the city	✓		✓
Disposal of solid waste generated outside the city	✓		
Biological treatment of waste generated in the city	✓		✓
Biological treatment of waste generated outside the city	✓		
Incineration and open burning of waste generated in the city	✓		✓
Incineration and open burning of waste generated outside the city	✓		
Wastewater generated in the city	✓		✓
Wastewater generated outside the city	✓		
INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)			
Industrial processes	✓		
Product use	✓		
AGRICULTURE, FORESTRY AND OTHER LAND USE (AFOLU)			
Livestock	✓		
Land	✓		
Aggregate sources and non-CO_2 emission sources on land	✓		
OTHER SCOPE 3			
Other Scope 3			

✓ Sources covered by the GPC
Sources required for BASIC reporting
\+ Sources required for BASIC+ reporting
Sources required for territorial total but not for BASIC/BASIC+ reporting (*italics*)
Sources included in Other Scope 3
Non-applicable emissions

The GPC method coverage for scope 3 emissions is limited. To address this, the "Other scope 3" category was created to encourage cities to report broader emissions, like those from fuels, water, and construction materials.

The framework uses two complementary reporting approaches (the colours in the table correspond to these distinct yet interrelated approaches):

- ***Scopes Framework***: Categorises emissions based on their source: within the city boundary (scope 1 or "territorial"), grid-supplied energy (scope 2), and outside the boundary (scope 3).
- ***City-Induced Framework***: Measures GHG emissions from activities within the city boundary, covering selected scope 1, 2, and 3 sources, offering two reporting levels: the 'BASIC' level which includes the most common emissions with easily accessible data; the "BASIC+" level provides a more comprehensive overview, requiring more detailed data collection and calculation.

Figure 4 provides illustrates how these two frameworks interact:

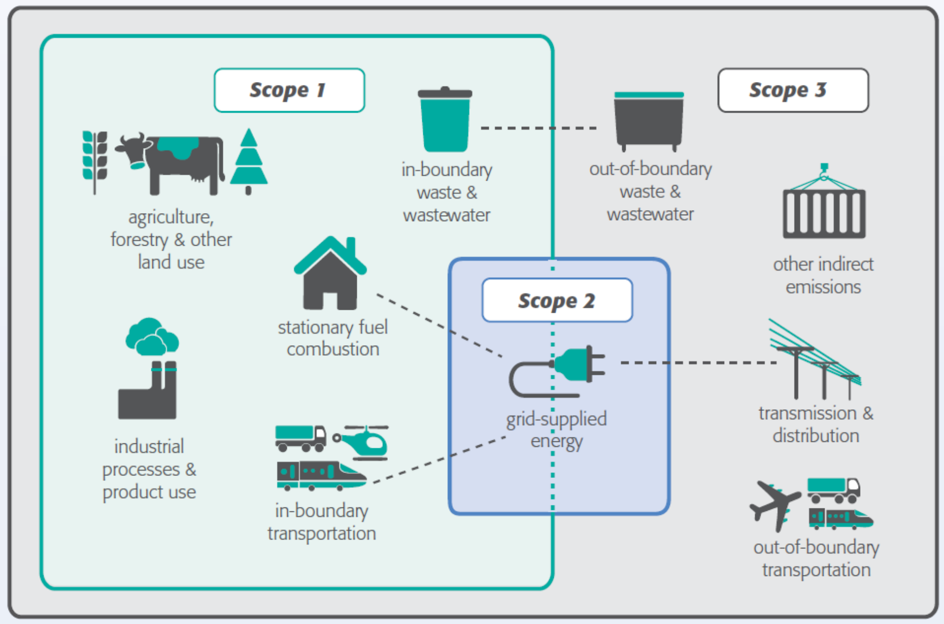


Figure 4. Illustrated interaction of emissions categorization (WRI, C40, and ICLEI, 2014)

Estimating emissions

For data collection and calculation of GHG emissions, cities should choose methodologies based on their specific context, such as the inventory's purpose, available data, and alignment with national inventories or reporting programs. While the GPC does not prescribe exact methods, it provides guidelines for creating a city-wide GHG emissions inventory, recommending alignment with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

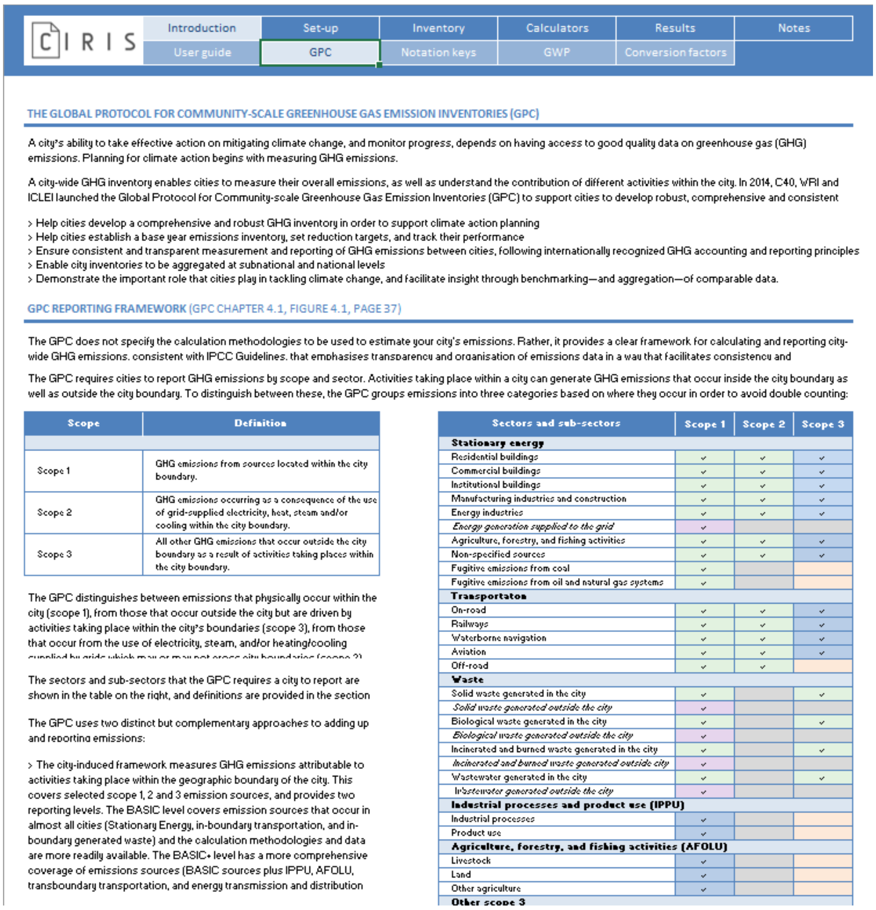
For some activities, cities can directly measure GHG emissions, such as using continuous emissions monitoring systems at power stations. However, most emissions need to be estimated. This is typically done by multiplying activity data (e.g., gas consumed, distance travelled, waste produced) by an emission factor, which indicates the amount of GHG emissions per unit of activity. GHG data should be reported in metric tonnes for each gas, along with CO_2 equivalents (CO_2e).

Data sources must be reliable, robust, temporally and geographically specific to the inventory boundary, as well as the technology used in the activities being measured. Sources may include government agencies, national GHG inventories, research institutions, or peer-reviewed publications. Local and national data should be prioritised over international sources. If the data does not perfectly align with the city's geographical or time boundaries, adjustments using scaling factors may be applied. Alternatively, cities can generate new data through physical measurement, sampling activities, or surveys.

Emission factors convert activity data into GHG emissions, such as tonnes of CO_2 per kilometre travelled or CH_4 emissions per amount of landfilled waste. These factors should be relevant to the inventory boundary, be specific to the measured activity, and be derived from credible sources, such as government, industry, or academic publications. Emission factors may be activity-based (estimated at the final activity point) or life-cycle-based (covering all life-cycle emissions). If local-specific sources are unavailable, cities should rely on IPCC default factors, the Emission Factor Database (EFDB), or other standardised values provided by international organisations that account for national conditions.

To help with the creation of this inventory, C40 created *The City Inventory Reporting and Information* System (CIRIS). This Excel-based tool is accessible and easy-to-use and designed to assist with managing, calculating, and reporting emissions. Based on the GPC framework, CIRIS provides a structured template that guides users through building an inventory and producing outputs compatible with the Reporting Framework format. These outputs can be directly uploaded to the CDP-ICLEI Track reporting platform (C40 Cities Climate Leadership Group, 2022).

The CIRIS template provides step-by-step guidance, including explanations of the GPC framework (Figure 5), instructions for inputting data (Figure 6), official conversion factors (Figure 7), and sections for entering data sources and emission factors (Figure 8 and Figure 9). The final inventory is compiled in a structured format (Figure 10), facilitating accurate and standardised reporting.



CIRIS

Introduction | Set-up | Inventory | Calculators | Results | Notes

User guide | GPC | Notation keys | GWP | Conversion factors

THE GLOBAL PROTOCOL FOR COMMUNITY-SCALE GREENHOUSE GAS EMISSION INVENTORIES (GPC)

A city's ability to take effective action on mitigating climate change, and monitor progress, depends on having access to good quality data on greenhouse gas (GHG) emissions. Planning for climate action begins with measuring GHG emissions.

A city-wide GHG inventory enables cities to measure their overall emissions, as well as understand the contribution of different activities within the city. In 2014, C40, WRI and ICLEI launched the Global Protocol for Community-scale Greenhouse Gas Emission Inventories (GPC) to support cities to develop robust, comprehensive and consistent

> Help cities develop a comprehensive and robust GHG inventory in order to support climate action planning
> Help cities establish a base year emissions inventory, set reduction targets, and track their performance
> Ensure consistent and transparent measurement and reporting of GHG emissions between cities, following internationally recognized GHG accounting and reporting principles
> Enable city inventories to be aggregated at subnational and national levels
> Demonstrate the important role that cities play in tackling climate change, and facilitate insight through benchmarking—and aggregation—of comparable data.

GPC REPORTING FRAMEWORK (GPC CHAPTER 4.1, FIGURE 4.1, PAGE 37)

The GPC does not specify the calculation methodologies to be used to estimate your city's emissions. Rather, it provides a clear framework for calculating and reporting city-wide GHG emissions. consistent with IPCC Guidelines. that emphasises transparency and organisation of emissions data in a way that facilitates consistency and

The GPC requires cities to report GHG emissions by scope and sector. Activities taking place within a city can generate GHG emissions that occur inside the city boundary as well as outside the city boundary. To distinguish between these, the GPC groups emissions into three categories based on where they occur in order to avoid double counting:

Scope	Definition
Scope 1	GHG emissions from sources located within the city boundary.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking places within the city boundary.

The GPC distinguishes between emissions that physically occur within the city (scope 1), from those that occur outside the city but are driven by activities taking place within the city's boundaries (scope 3), from those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (scope 2)

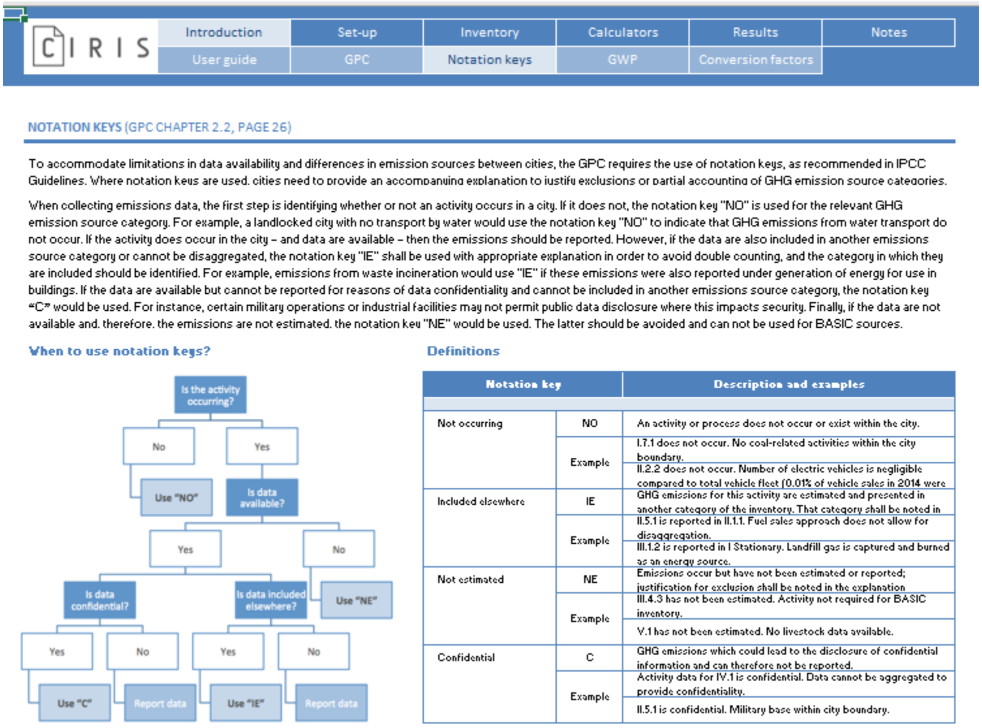
The sectors and sub-sectors that the GPC requires a city to report are shown in the table on the right, and definitions are provided in the section

The GPC uses two distinct but complementary approaches to adding up and reporting emissions:

> The city-induced framework measures GHG emissions attributable to activities taking place within the geographic boundary of the city. This covers selected scope 1, 2 and 3 emission sources, and provides two reporting levels. The BASIC level covers emission sources that occur in almost all cities (Stationary Energy, in-boundary transportation, and in-boundary generated waste) and the calculation methodologies and data are more readily available. The BASIC+ level has a more comprehensive coverage of emissions sources (BASIC sources plus IPPU, AFOLU, transboundary transportation, and energy transmission and distribution

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
Stationary energy			
Residential buildings	✓	✓	✓
Commercial buildings	✓	✓	✓
Institutional buildings	✓	✓	✓
Manufacturing industries and construction	✓	✓	✓
Energy industries	✓	✓	✓
Energy generation supplied to the grid	✓		
Agriculture, forestry, and fishing activities	✓	✓	✓
Non-specified sources	✓	✓	✓
Fugitive emissions from coal	✓		
Fugitive emissions from oil and natural gas systems	✓		
Transportaton			
On-road	✓	✓	✓
Railways	✓	✓	✓
Waterborne navigation	✓	✓	✓
Aviation	✓	✓	✓
Off-road	✓	✓	
Waste			
Solid waste generated in the city	✓		✓
Solid waste generated outside the city	✓		
Biological waste generated in the city	✓		✓
Biological waste generated outside the city	✓		
Incinerated and burned waste generated in the city	✓		✓
Incinerated and burned waste generated outside city	✓		
Wastewater generated in the city	✓		✓
Wastewater generated outside the city	✓		
Industrial processes and product use (IPPU)			
Industrial processes	✓		
Product use	✓		
Agriculture, forestry, and fishing activities (AFOLU)			
Livestock	✓		
Land	✓		
Other agriculture	✓		
Other scope 3			

Figure 5. CIRIS tool page for explaining GPC method (C40, 2022)



NOTATION KEYS (GPC CHAPTER 2.2, PAGE 26)

To accommodate limitations in data availability and differences in emission sources between cities, the GPC requires the use of notation keys, as recommended in IPCC Guidelines. Where notation keys are used, cities need to provide an accompanying explanation to justify exclusions or partial accounting of GHG emission source categories.

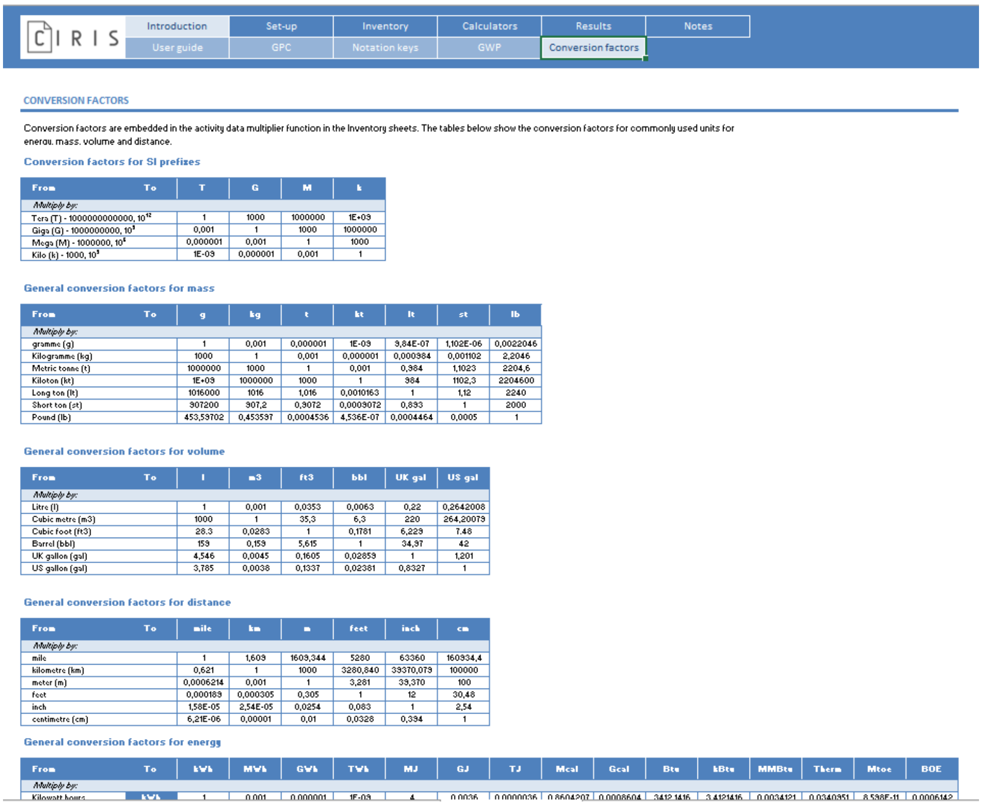
When collecting emissions data, the first step is identifying whether or not an activity occurs in a city. If it does not, the notation key "NO" is used for the relevant GHG emission source category. For example, a landlocked city with no transport by water would use the notation key "NO" to indicate that GHG emissions from water transport do not occur. If the activity does occur in the city – and data are available – then the emissions should be reported. However, if the data are also included in another emissions source category or cannot be disaggregated, the notation key "IE" shall be used with appropriate explanation in order to avoid double counting, and the category in which they are included should be identified. For example, emissions from waste incineration would use "IE" if these emissions were also reported under generation of energy for use in buildings. If the data are available but cannot be reported for reasons of data confidentiality and cannot be included in another emissions source category, the notation key "C" would be used. For instance, certain military operations or industrial facilities may not permit public data disclosure where this impacts security. Finally, if the data are not available and, therefore, the emissions are not estimated, the notation key "NE" would be used. The latter should be avoided and can not be used for BASIC sources.

When to use notation keys?

Definitions

Notation key		Description and examples
Not occurring	NO	An activity or process does not occur or exist within the city.
	Example	I.7.1 does not occur. No coal-related activities within the city boundary.
		II.2.2 does not occur. Number of electric vehicles is negligible compared to total vehicle fleet (0.01% of vehicle sales in 2014 were
Included elsewhere	IE	GHG emissions for this activity are estimated and presented in another category of the inventory. That category shall be noted in
	Example	II.5.1 is reported in II.1.1. Fuel sales approach does not allow for disaggregation.
		III.1.2 is reported in I Stationary. Landfill gas is captured and burned as an energy source.
Not estimated	NE	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation
	Example	III.4.3 has not been estimated. Activity not required for BASIC inventory.
		V.1 has not been estimated. No livestock data available.
Confidential	C	GHG emissions which could lead to the disclosure of confidential information and can therefore not be reported.
	Example	Activity data for IV.1 is confidential. Data cannot be aggregated to provide confidentiality.
		II.5.1 is confidential. Military base within city boundary.

Figure 6. CIRIS tool directions on how to input data (C40, 2022)



CONVERSION FACTORS

Conversion factors are embedded in the activity data multiplier function in the Inventory sheets. The tables below show the conversion factors for commonly used units for energy, mass, volume and distance.

Conversion factors for SI prefixes

From To	T	G	M	k
Multiply by:				
Tera (T) - 1000000000000, 10^{12}	1	1000	1000000	1E+09
Giga (G) - 1000000000, 10^{9}	0,001	1	1000	1000000
Mega (M) - 1000000, 10^{6}	0,000001	0,001	1	1000
Kilo (k) - 1000, 10^{3}	1E-09	0,000001	0,001	1

General conversion factors for mass

From To	g	kg	t	kt	lt	st	lb
Multiply by:							
gramme (g)	1	0,001	0,000001	1E-09	9,84E-07	1,102E-06	0,0022046
Kilogramme (kg)	1000	1	0,001	0,000001	0,000984	0,001102	2,2046
Metric tonne (t)	1000000	1000	1	0,001	0,984	1,1023	2204,6
Kiloton (kt)	1E+09	1000000	1000	1	984	1102,3	2204600
Long ton (lt)	1016000	1016	1,016	0,0010163	1	1,12	2240
Short ton (st)	907200	907,2	0,9072	0,0009072	0,893	1	2000
Pound (lb)	453,59702	0,453597	0,0004536	4,536E-07	0,0004464	0,0005	1

General conversion factors for volume

From To	l	m3	ft3	bbl	UK gal	US gal
Multiply by:						
Litre (l)	1	0,001	0,0353	0,0063	0,22	0,2642008
Cubic metre (m3)	1000	1	35,3	6,3	220	264,20079
Cubic foot (ft3)	28.3	0,0283	1	0,1781	6,229	7.48
Barrel (bbl)	159	0,159	5,615	1	34,97	42
UK gallon (gal)	4,546	0,0045	0,1605	0,02859	1	1,201
US gallon (gal)	3,785	0,0038	0,1337	0,02381	0,8327	1

General conversion factors for distance

From To	mile	km	m	feet	inch	cm
Multiply by:						
mile	1	1,609	1609,344	5280	63360	160934,4
kilometre (km)	0,621	1	1000	3280,840	39370,079	100000
meter (m)	0,0006214	0,001	1	3,281	39,370	100
feet	0,000189	0,000305	0,305	1	12	30,48
inch	1,58E-05	2,54E-05	0,0254	0,083	1	2,54
centimetre (cm)	6,21E-06	0,00001	0,01	0,0328	0,394	1

General conversion factors for energy

From	To	kWh	MWh	GWh	TWh	MJ	GJ	TJ	Mcal	Gcal	Btu	kBtu	MMBtu	Therm	Mtoe	BOE
Multiply by:																
Kilowatt hours	kWh	1	0,001	0,000001	1E-09	[illegible]	0,0036	0,0000036	0,8604207	0,0008604	3412,1416	3,4121416	0,0034121	0,0340951	8,598E-11	0,0006142

Figure 7. Official conversion factors provided in the CIRIS tool (C40, 2022)

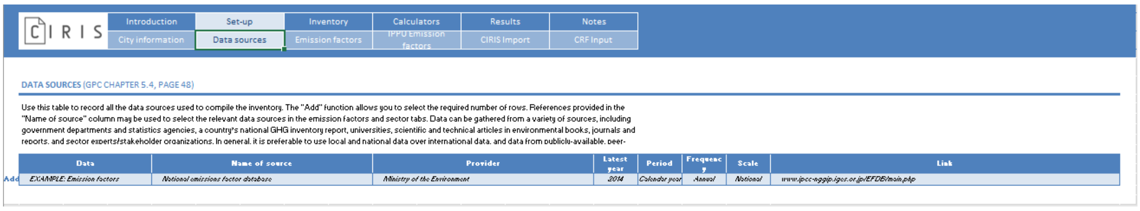


Figure 8. CIRIS tool session for emission factors input (C40, 2022)

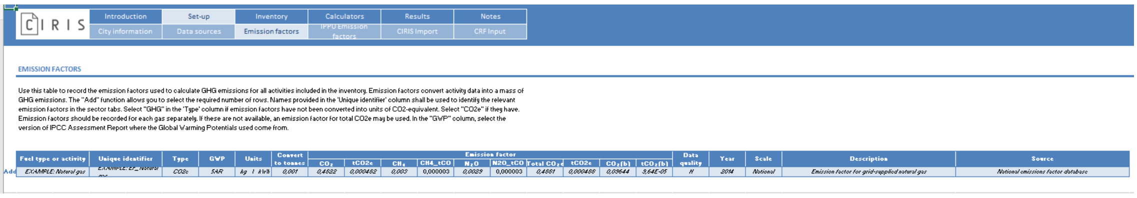


Figure 9. CIRIS tool session for data source input (C40, 2022)

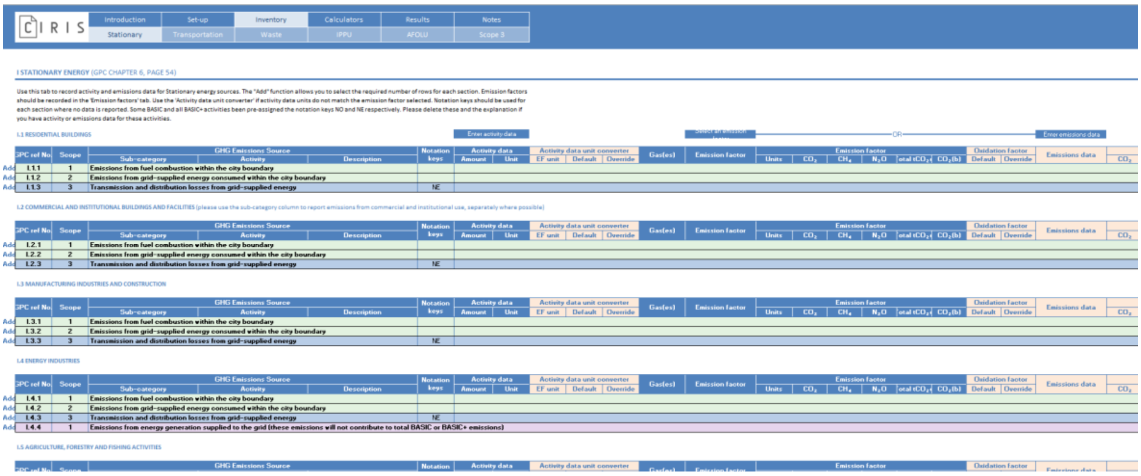


Figure 10. CIRIS tool inventory page (C40, 2022)

The Madrid GHG inventory case

Madrid municipality has been reporting its emissions since 1999 under the EMEP/CORINAIR methodology (EEA, 2023), which is similar to the GPC method and is also compatible with the IPCC guidelines. To ensure comparability and reliance, CORINAIR establishes 11 concepts:

- **Accuracy:** Emission estimates should closely reflect true emissions, avoiding both overestimation or underestimation. This requires minimising uncertainties by employing the most appropriate methodologies.
- **Comparability:** Emission estimates must be comparable across different inventories. This is achieved by following accepted methodologies and standardised reporting formats.
- **Completeness:** An inventory is considered complete when it includes all emission sources and pollutants within the full geographical area. Missing data should be documented the with notation keys to ensure transparency.

- **Consistency:** Inventories must be consistent across all reported years, sectors, and pollutants by using the same methodologies and datasets. This internal consistency is crucial for tracking emission trends over time and ensuring reliable projections.
- **Decision Trees:** Decision trees assist inventory compilers in selecting the most appropriate methodologies based on the emission category and available resources. They prioritise the use of higher-tier methods for key categories to enhance accuracy.
- **Tiers:** The tier system provides levels of methodological complexity. Tier 1 is the simplest approach, Tier 2 offers intermediate complexity, and Tier 3 offers greater accuracy but requires more detailed data requirements. Higher tiers are preferred for key categories to ensure precise estimates.
- **Good Practice:** Good practice ensures the development of high-quality inventories by following established principles and methodologies. This reduces uncertainties and avoids significant errors, adhering to the latest IPCC guidelines.
- **Inventory Year and Time Series**: National inventories report emissions for the calendar year in which they occur. When specific-year data is missing, estimates may be made based on other years' reports, using extrapolation methods. Consistency in time series data is essential for tracking emissions trends and informing policy decisions.
- **Inventory Reporting:** This involves submitting standardised tables for specific substances and sources for a given reporting year. While requirements vary depending on a country's obligations, standardised formats maintain uniformity.
- **Key Categories:** A key category is an emission source that significantly impacts a country's total emissions, emission trends, or uncertainties. Identifying key categories helps prioritise resources and focus efforts on the most impactful areas of the inventory.
- **Pollutants:** The guidebook covers a wide range of pollutants that must be reported under various protocols. It includes mandatory and optional substances for voluntary reporting, offering comprehensive emissions data coverage.
- **Sectors, categories, and sources:** Reporting sectors include energy industrial processes and product use, agriculture, waste, and others. Each sector is divided in categories (e.g., transport) and subcategories (e.g., passenger vehicles). Emissions are calculated at the subcategory level and aggregated into national totals, except for 'memo-items', which are reported separately following political agreement (EEA, 2023).
- **Transparency:** Transparency requires that data sources, assumptions, and methodologies are clearly explained, enabling users to replicate and assess the inventory. This facilitates effective communication and evaluation.

Similar to GPC method, the CORINAIR methodology calculates emissions by multiplying human activity data by an emission factor (EF), which quantifies emissions or removals per unit of activity. The basic equation is:

$$Emissions = AD \; x \; EF \tag{1}$$

Where:

AD: activity data

EF: emission factor

This basic equation adapts depending on the tier used:

- **Tier 1:** Assumes a linear relation between AD and EF. AD is obtained from readily available sources and EF are generalised, representing a typical condition. These emission factors are provided by the methodology (EEA, 2023).
- **Tier 2:** Uses similar activity data as Tier 1 but it incorporates local EFs specific to process conditions, fuel characteristics, and other factors, improving result quality.
- **Tier 3:** Employs highly specific AD and EF data, often based on facility-level data and accurate models.

For the present study, the structure follows the Madrid emission inventory (2022), which presents a detailed structure for category-defining and aggregation, and the list of emission factors used. The city divides emissions into two categories: direct emissions (Scope 1) and Indirect emissions (Scope 2 and 3).

The structure and references used in the estimation of direct emissions are summarised in Table 4.

Table 4. Framework used in the Madrid municipality inventory

Grupo SNAP	Principales variables de actividad	Fuentes de información consultadas para la variable de actividad	Fuentes de información empleadas para los factores de emisión
02. Combustión no industrial	Consumo de combustible en calderas: - carbón - gas natural - gases licuados del petróleo (GLP) - gasóleo - biomasa	- Censo de Calderas de Carbón de la Ciudad de Madrid – años 2014-2020 - Nedgia S.A. y Madrileña Red de Gas S.A.U. (gas natural) - Repsol y Cepsa (GLP) - Calordom S.A. (biomasa)	- Libro Guía EMEP/EEA[1] - Balance de masa
03. Combustión industrial	- Consumo de combustibles en la industria	- Nedgia S.A. y Madrileña Red de Gas S.A.U. - Repsol - Cuestionarios remitidos a las instalaciones consumidoras	- Libro Guía EMEP/EEA[1] - Balance de masa - CITEPA[2] - API Compendium[3]
04. Procesos industriales sin combustión	- Producción de acero en horno eléctrico - Uso de carbonato sódico	- Cuestionarios remitidos a las instalaciones consumidoras/productoras - MITECO, 2022[4]	- Libro Guía EMEP/EEA[1] - Balance de carbono - Manual Referencia IPCC[5]
05. Extracción y distribución de combustibles	- Consumo de gas natural en el municipio	- Nedgia S.A. y Madrileña Red de Gas S.A.U. - CLH[6] - Comunidad de Madrid (CM)	- MITECO, 2022[4]
06. Uso de disolventes	- Consumo de pinturas y disolventes en distintas industrias y aplicaciones industriales - Población - Nº empleados en el municipio por código CNAE[7]	- Cuestionarios remitidos a las instalaciones industriales - MITECO, 2022[4] - Instituto Nacional de Estadística (INE) - Comunidad de Madrid (CM) - RIECOV[8]	- Libro Guía EMEP/EEA[1] - MITECO, 2022[4] - Manual CORINAIR (1994)
07. Transporte por carretera	- Recorridos por tipo de vehículo y por categoría de vehículo - Velocidades medias - Características propias de los combustibles - Temperaturas medias mínimas y máximas mensuales	- Modelo de tráfico del Ayuntamiento de Madrid - Estudios de caracterización del parque circulante en la ciudad de Madrid (AM, 2014; AM, 2019) - COPERT - AEMET[9]	- Libro Guía EMEP/EEA[1] - COPERT
08. Otros modos de transporte	Consumo de combustible en: - ferrocarril - aviones - maquinaria agrícola	- MITECO, 2022[4] - RENFE[10] - AENA[11]	- Libro Guía EMEP/EEA[1] - Balance de masa - Organización de Aviación Civil Internacional (OACI, 2016)
		- Organización de Aviación Civil Internacional (OACI, 2016)	
08. Otros modos de transporte	- maquinaria de construcción y obras públicas, y plantas de compostaje - maquinaria de jardinería - otros	- Cuestionarios enviados a las plantas compostaje - Ayuntamiento de Madrid - CLH[6]	- Libro Guía EMEP/EEA[1] - Balance de masa - MITECO, 2022[4]
09. Tratamiento de residuos	- Residuos incinerados y combustible auxiliar en incineración - Residuos a vertedero y biogás de vertedero recuperado - Número de incineraciones de cadáveres - Agua residual tratada en EDAR - Consumo gas natural en cogeneraciones de secado de lodos - Entradas de residuos a compostaje - Entrada de residuos a biometanización	- PTV[12] - Cuestionarios enviados a E.M.S.F[13] - Ayuntamiento de Madrid - INE	- Cuestionarios PTV[12] - Libro Guía EMEP/EEA[1] - Guías IPCC[14] - MITECO, 2022[4]
10. Agricultura	- Superficie cultivada - Superficie de cultivos fertilizada - Número de cabezas por tipo de ganado	- CM, 2022[15] - MITECO, 2022[4]	- Libro Guía EMEP/EEA[1] - Guías IPCC[14] - MITECO, 2022[4]
11. Naturaleza	- Superficie forestal - Temperatura ambiente - Superficie quemada - Superficie espacios acuáticos - Población	- I.F.N. (III)[16] - MITECO, 2022[4] - Comunidad de Madrid - Ayuntamiento de Madrid - AEMET[8] - INE - AM, 2022[17]	- Libro Guía EMEP/EEA[1] - Guías IPCC[14] - MITECO, 2022[4]

When estimating indirect emissions, the municipality considers only those resulting from electricity consumption. To estimate them, the municipality used data on its final energy consumption, multiplied by a nation-specific emission factor of 0,170 (tCO_2/MWh).

Alternative methodologies

The presented tools primarily focus on Scope 1 and 2 emissions. For Scope 3, the GPC offers additional guidance to support robust and consistent reporting. One approach is the *consumption-based accounting* (CBA) method, which focuses on the GHG emissions linked to the goods and services consumed by city residents, regardless of where they are produced.

Wiedmann (2020) et al. highlight a research gap in supporting the reliable and comprehensive r Scope 3 emissions reporting. They propose enhancing CBA methods, which are holistic, transparent, and provide a broader horizon for emission reduction. Specifically, their study introduces a new method based on the *consumption-based carbon footprint* (CBCF) method. The CBCF method covers global upstream emissions in a city-bound supply chain, including missions from raw material production, manufacturing, distribution, retail, and disposal.

The carbon footprint (CF) used in CBCF is called *areal* CF, which includes household consumption and other final demands such as government consumption and gross fixed capital formation. Its calculation balances emissions embodied in trade, as shown in Equation 2 and is illustrated in Figure 11. Wiedmann's illustrated method logic (Wiedmann et al. (2020)).

$$CBFC = TE + EEI - EEE \qquad (2)$$

Where:

CBFC: consumption-based carbon footprint

TE: territorial emissions

EEI: emissions embodied in imports

EEE: emissions embodied in exports

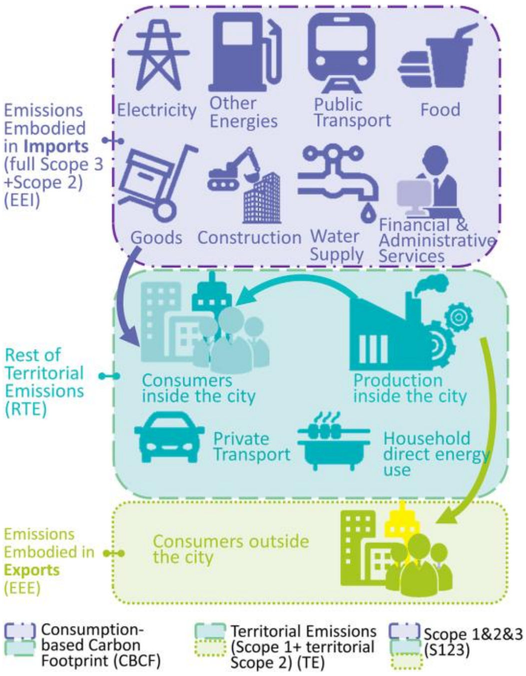


Figure 11. Wiedmann's illustrated method logic (Wiedmann et al. (2020))

The method proposes an adaptation of the *global multi-region input-output* (GMRIO) model, separating city-specific structures from nationally aggregated information. This results in a city-specific input-output table (IOT), which details city's pattern of final demand. The table enables the evaluation of GHG contributions from local, regional, and global supply chains in satisfying urban demands.

While this method's complexity and data requirements may limit its application in the present study, the logic of the CBA method presented in Equation 2 may be suitable for estimating some specific emissions that occur in this work case.

The concepts of the three emission scopes are a key aspect already initiated in the Cities Mission Platform (NetZeroCities) to support cities in achieving climate neutrality by 2030. These scopes are integral to this project and are key in defining indicators for pilot measures. Given the difficulties to obtain emission values for certain measures, especially for Scopes 2 and 3, Annex 1 proposes scenarios where these three scopes could be measured or estimated to facilitate partner monitoring.

2.4 Impact evaluation

The impact evaluation process in MOBILITIES for EU includes the definition of the indicators to be measured and monitored for each city to evaluate the impact of proposed actions across different domains (subsection 2.4.4). The assessment relies on **'before-and-after' comparisons** and should be consistently conducted across all cities, facilitating experience sharing and mutual learning.

The impact evaluation process followed by MOBILITIES for EU will generally follow these steps:

1. **Define indicators:** Identify a set of indicators that align with the city's characteristics and goals.
2. **Collect baseline data:** Gather initial baseline values for these indicators (before the implementation of the proposed actions) and set target values.
3. **Implement actions:** Execute the proposed actions in the cities;
4. **Estimate final values:** Determine the final values of the indicators (after the implementation of the proposed actions).

Finally, the baseline and final values of the indicators will be compared to draw conclusions about the results for each lead city and action. These conclusions will provide insights into the benefits and limitations of the proposed pilots, guiding subsequent proposals and future measures in the following cities.

In the following subchapter we will present the description of the approach used for the evaluation of the framework, the roles and responsibilities for the partners from the MOBILITIES for EU project, a short description of the actions included in the pilots, the methodology proposed and presented for the data gathering and collection, and special considerations on the implications of the measures in the urban metabolism of the cities, and the Life Cycle Costing (LCC) and Life Cycle Assessment (LCA) of the project.

2.4.1 DESCRIPTION OF THE APPROACH AND KEY CONCEPTS

The MOBILITIES for EU project is based in the CIVITAS Evaluation Framework to guide its assessment processes, building on its well-established methodology for evaluating urban mobility measures. This framework enables a comprehensive understanding of both project performance and the impact of mobility-related measures implemented within cities. In this subchapter, key concepts adapted from the CIVITAS framework are introduced including the basis of the performance evaluation, the implementation of the process of evaluation, and core evaluation activities. Those key concepts would be further developed and applied in the selection of indicators in subchapter 2.4.4 and the process evaluation of the MOBILITIES for EU presented in chapter 2.5.

Project Performance Evaluation

One of the key aspects of the evaluation process is the Project Performance Evaluation, which monitors whether the MOBILITIES for EU project meets its objectives. This involves assessing whether the project and its individual Work Packages deliver the outputs promised in the proposal. Additionally, it evaluates the efficiency and effectiveness of various project activities, such as dissemination efforts, take-up strategies, and stakeholder engagement.

By ensuring that the operational side of the project runs smoothly, the performance evaluation helps to confirm that tasks such as research, innovation, and demonstration activities are completed successfully and on time. This process provides a clear picture of whether the project's intended outcomes are being realised.

Impact and Implementation Process Evaluation

The second core activity considered in the evaluation process and adapted from the CIVITAS evaluation approach focuses on assessing the impact and implementation process of mobility-related actions introduced in cities. These actions, implemented in real urban environments, aim to improve mobility, reduce emissions, and enhance urban sustainability. In this context, the evaluation framework aims to provide evidence-based insights into which mobility measures succeed, which do not, and the reasons behind their outcomes. This knowledge is essential not only for improving the current actions but also for informing future projects across Europe.

A measure refers to any mobility-related action implemented by a city or its stakeholders, such as:

- **New infrastructure:** e.g., constructing a new electric vehicle charging system.
- **New services:** e.g., implementing electric vehicle-sharing systems.
- **Organizational changes:** e.g., reorganising travel-to-work patterns.
- **Awareness campaigns:** e.g., promoting sustainable transport modes through public engagement.

Each measure is evaluated to determine its effectiveness, scalability, and transferability to other cities. This ensures that successful interventions can be optimised and shared widely across European cities.

Core evaluation activities

Impact evaluation aims to quantify the effects of a measure, or a package of measures, on various aspects of urban mobility. In MOBILITIES for EU we have considered five Impact Categories for the actions proposed:

- Environment
- Energy
- Transport
- Society (People and Governance)
- Economy

Complementing impact evaluation, process evaluation examines the planning, execution, and operation phases of mobility actions. It identifies the barriers and enablers that affected the process. Using before-and-after measurements and a set of predefined indicators, this evaluation determines *the direct contribution of the mobility measure* while accounting for *external factors* that might influence *observed changes*. The Impact Evaluation will be further analysed in section 2.5.

Understanding this implementation process is crucial for explaining both the successes and the challenges of actions, paving the way for improvements in future initiatives. Together, these evaluation activities provide an integrated and detailed picture of how mobility measures perform in real-world urban settings. This integrated evaluation approach allows for deeper insights into the cause-and-effect relationships within urban mobility systems, ensuring that the findings are scientifically robust and relevant to policymakers.

To achieve efficient and accurate evaluations, it is important to structure the measures and supporting activities clearly. A well-structured evaluation approach will clarify the following:

- Objectives of the measure, including both qualitative goals and quantifiable targets.
- Outputs, including the specific changes achieved (e.g., replacement of diesel buses with electric buses).
- Expected and unforeseen impacts, whether positive or negative.
- Target groups affected (e.g., commuters, residents).
- Geographical area impacted.
- Other influencing factors, including city context and interactions with other measures. When measures are interconnected, working towards the same goals and affecting the same target groups, it is useful to evaluate them together, particularly when they overlap impact categories. This can offer a holistic understanding of their impact on the urban environment.

A critical aspect of the evaluation approach is its contribution to the scalability and transferability of mobility measures. By identifying which measures succeed, under what conditions, and why, cities across Europe can adapt and replicate these interventions. The use of consistent terminology, impact categories, and evaluation methods ensures that knowledge can be easily shared and applied elsewhere.

By adapting the CIVITAS evaluation framework, MOBILITIES for EU ensures that its project performance and mobility measures are assessed rigorously and consistently. This approach guarantees that the findings are transparent, comparable, and relevant, providing quantitative and qualitative insights into the project's effectiveness. This approach not only supports innovations in urban mobility but also contributes to reducing CO_2 emissions, fostering the development of more sustainable and efficient urban mobility systems across Europe.

2.4.2 ROLES AND RESPONSIBILITIES

For a consistent and effective evaluation in a project involving multiple sites and various measures, a clear assignment of roles and responsibilities is essential. Ensuring uniform evaluation activities across different locations while accounting for local particularities requires a well-defined structure. The next subsections detail the roles (Sections 2.4.2.1 to 2.4.1.3) and cooperation platforms (Section 2.4.2.4 to 2.4.1.5) that are key for achieving successful and systematic evaluation results in the MOBILITIES for EU project.

2.4.2.1. Project Evaluation Manager (PEM)

The PEM plays a central role in overseeing the evaluation process across all participating cities and sites. The PEM's primary responsibilities include:

- **Supporting cities in evaluation activities:** Assisting local teams in conducting evaluations effectively, ensuring alignment with the project's goals and consistency in activities.
- **Synthesising evaluations:** Consolidating the findings from individual city or site evaluations into a comprehensive project-level report.
- **Drawing project-level conclusions:** Collaborating with key stakeholders to interpret the evaluation results to extract conclusions focusing on areas such as CO_2 emissions reduction and the impact of mobility measures on urban sustainability.

CARNET serves as the PEM in T3.1 of the WP3, acting as the bridge between the project's local-level evaluation activities and overarching project objectives. While CARTIF acts as the global PEM of the project, CARNET ensures harmonised data collection, analysis, and result interpretation across the Evaluation Framework definition (T3.1).

2.4.2.2. Local Evaluation Manager (LEM)

The Local Evaluation Manager (LEM) leads evaluation process in a specific city or site. The LEM's key tasks include:

- **Coordinating evaluation activities:** Overseeing all evaluations implemented within their respective city or site, working closely with the Site Coordinator (SC) and Measure Leaders (MLs), and ensuring seamless execution of data collection and process evaluation activities.
- **Data collection:** Directly collecting or coordinating data collection for impact indicators.
- **Process evaluation:** Documenting qualitative aspects of the evaluation, including implementation processes, barriers, and driving factors.

To maintain objectivity and provide a comprehensive view, the LEM operates independently from the measures being implemented. This allows the LEM to impartially analyse and interpret data, ensuring a well-rounded and accurate evaluation. Each leading city, Madrid and Dresden, has assigned ALSA and SAP as their respective LEMs to coordinate local actions.

2.4.2.3. Site Coordinator (SC) and Measure Leaders (MLs)

At the local level, the Site Coordinator (SC) and Measure Leaders (MLs) play key supporting roles:

- **Site Coordinator (SC):** Manages overall project activities within a specific city or site. This includes working with the LEM to ensure that evaluation activities are aligned with measure implementation.
- **Measure Leaders (MLs):** Responsible for individual measures, assisting in timely and accurate data collection while the LEM leads the analysis and interpretation of the data.

The partners involved in pilots and actions serves as SCs and/or ML in each case, ensuring consistent collaboration among the PEM, LEM, SC, and MLs for quantitative and qualitative data collection and evaluated. While the roles of the PEM, LEMs and MLs are clear, depending on the situation, certain partners will act as SCs in their actions and pilots, and in others, the LEMs might act as SCs as well. For this reason, in the Table 5 we have specified the PEM

Moreover, based on the KPIs considered in the CIVITAS framework, five project partners have been assigned as Impact Category Responsible (ICR)**,** who will lead the indicators revision corresponding to their category. These partners' responsible are assigned as:

- FHG - Environment KPIs
- CARTIF – Energy KPIs
- ALSA – Transport KPIs
- RC – Society KPIs (including both people and governance)
- UPM – Economy KPIs

2.4.2.4. Project Evaluation Team (PET)

The Project Evaluation Team (PET) operates at the project level, coordinating evaluation activities across all demonstration cities. The PET's primary roles include:

- **Coordination of evaluation activities:** Ensuring that all evaluation tasks are carried out uniformly across the different cities, aligning them with the overall project objectives.
- **Discussion and resolution of challenges** Addressing potential difficulties or barriers in the evaluation process collaboratively.

Participants in the PET include the Project Evaluation Manager (PEM) and the Local Evaluation Managers (LEMs). Regular meetings have been organized with corresponding LEMs and partners of Madrid and Dresden to facilitate continuous communication between the central and local teams, ensuring consistency in the evaluation process.

2.4.2.5. Local Evaluation Group (LEG)

The Local Evaluation Group (LEG) operates at the city or site level and is responsible for organising evaluation activities locally. The LEG's roles include:

- **Coordination of local evaluation:** Conducting evaluation activities in line with the project's evaluation framework, from data collection to interpretation.
- **Information exchange:** Facilitating insights on measure implementation, addressing specific local conditions.

Participants in the LEG include the LEM, SC, and MLs. This platform ensures that local insights and conditions are fully considered in the evaluation process, while also maintaining alignment with the project's overall evaluation objectives. Each partner designates individuals to act as SCs and MLs based on pilot characteristics and KPI methodologies.

Table 5 presents a modified version of the partner list presented in the introduction (Table 2). It summarises the roles of each partner regarding the project and WP3. The table specifies shows each partner's short name, their corresponding Leading City (if applicable), and their assigned roles.

Table 5. List and distribution of partners per role and responsibility

Short name	Leading City	Role
CARTIF	-	Global Project Coordinator / ICR
CARNET	-	PEM
MADRID	Madrid	LEM
MERCAMADRID	Madrid	ML
EMT	Madrid	ML
ORANGE	Madrid	ML
FERROVIAL	Madrid	ML
TSY	Madrid	ML
PLEXIGRID	Madrid	ML
UPM	Madrid	ML / ICR
PZGR	Madrid	ML
ALSA	Madrid	ML / ICR
DRESDEN	Dresden	LEM / ML
VWGI	Dresden	ML

Fraunhofer	Dresden	ML / ICR
SAP	Dresden	ML
TUD	Dresden	ML
SAENA	Dresden	ML
RC	-	ML / ICR

One critical responsibility shared by the PEM and LEMs is the selection of indicators for both impact and process evaluation. These indicators must align with the project's goals, particularly CO_2 emissions reduction and improved urban mobility. Subsequent chapters detail the selection process and of the indicators most relevant for this project.

2.4.3 TECHNICAL DESCRIPTION OF THE PILOTS AND ACTIONS

MOBILITIES for EU is an innovation project a dedicated to pioneering sustainable solutions for urban mobility across Europe. Madrid (Spain) and Dresden (Germany) serve as Lead Cities (LC), implementing 11 pilot projects encompassing 27 highly innovative solutions for passenger and freight mobility. Detailed descriptions of these pilots and solutions are available in Deliverable 2.1.

Below, two summary tables are presented, one for each lead city (Madrid in Table 6 and Dresden in Table 7), including the corresponding pilot, the action, a short description and the type of solution. These tables serve as a reference for the indicators presented in subsequent chapters.

Table 6. List of actions per pilot in Madrid

Pilot	Name of the action	Summary	Type of solution
Pilot 1	A1.1 Autonomous e-buses in Mercamadrid area for people	Demonstrates a mid-size autonomous electric bus service in Mercamadrid, featuring full automation and electrification, aiming for no direct emissions and reducing emissions from upstream and downstream activities like production and recycling.	CCAM
Pilot 1	A1.2 Automated Guided Vehicle for waste collection at Mercamadrid	Demonstrates a fully automated electric tow tractor for waste collection in Mercamadrid, using 5G and sensors, enhancing efficiency and lowering emissions, focusing on upstream and end-of-life emissions from vehicles and technology.	CCAM
Pilot 1	A1.3 Last mile autonomous electric transport for food markets	Deploys an autonomous electric tow tractor for last-mile delivery in Mercamadrid, using AI, 5G, and IoT for smarter space management, with no direct emissions and an emphasis on reducing conventional vehicle use.	CCAM
Pilot 1	A1.4 Development of 5G Private Mobile Network (PMN) services in SA (Stand Alone) for CCAM connectivity	Designs and operates a 5G Private Mobile Network to support autonomous mobility in Mercamadrid, with emissions primarily from the electricity needed for the 5G network and hardware lifecycle management.	CCAM connectivity

Pilot 2	A2.1 Distributed Smart Grid for Eco Transportation.	Installs a 700 kWp photovoltaic plant at Mercamadrid to power V2G chargers, supporting green last-mile transport, with emissions linked to PV and battery production, installation, and IT infrastructure.	RES/Power Grid
Pilot 2	A2.2 Digital Twin and power grid management for flexibility	Uses digital twins to optimize Mercamadrid's power grid, integrating more devices, reducing emissions through enhanced flexibility, and focusing on the lifecycle of digital and IT hardware.	RES/Power Grid
Pilot 3	A3.1 Electrification of 329 e-buses and full electrification of Carabanchel Bus Depot.	Electrifies 329 buses and the Carabanchel bus depot, with a focus on analysing the city's emissions reduction, and considering lifecycle emissions of buses and infrastructure.	2Zero
Pilot 3	A3.2 Intelligent sharing of charging infrastructure and energy between vehicles for the transport of people and freight EMT	Tests shared charging infrastructure for people and freight vehicles, using AI to optimize charging capacity, with emissions from electricity used by shared points and infrastructure lifecycle.	2Zero
Pilot 4	A4.1 Implementation of H2 Refuelling Station and 10 H2 fuel cell buses	Deploys a hydrogen refuelling station and 10 fuel cell buses, focusing on reducing emissions from hydrogen production and the lifecycle of buses and the refuelling station.	2Zero
Pilot 5	A5.1 Green Energy Data Space in Mobility for the Decarbonization of Madrid and other Cities	Creates a digital twin and data space for green energy in mobility, aiming to optimize energy use, with emissions from IT infrastructure and data management systems.	High value/ Innovative services

Table 7. List of actions per pilot in Dresden

Pilot and action	Name of the action	Solutions	Type of Solution
Pilot 1 ***(DoA: A1.2-A1.4)***	Charging robots	Autonomous Robots for Charging e-vehicles. 2 autonomous electric Volkswagen charging robot systems will be designed, deployed and tested.	CCAM
Pilot 2: A2.1 ***(DoA: A2.1)***	Infrastructure assistance Automated Connected Driving (Control Center)	Infrastructure assistance (communication issues for automation tasks and safe operation as well as efficient autonomous driving for people and freight) and control center for Automated Connected Driving development.	CCAM connectivity
Pilot 2: A2.2 ***(DoA: A2.2)***	Mobility Data Space for Automated Connected Driving	Open data space for driving and operation of automated mobility solutions for both people and freight to enable a secure exchange of sensitive data.	High value / Innovative services
Pilot 3: A4 ***(DoA: Pilot 3. A3.1)***	Autonomous e-vehicles for freight	Mobility solutions for mobility of people. Development and commissioning of CCAM	CCAM

		solutions for people mobility: 2 vehicles (lending/leasing) to release the pilot routing.	
Pilot 3: A5 ***(DoA: Pilot 3. A3.2)***	Feasibility study for 2 routes for autonomous e-vehicle for passengers	Analysis of routes and feasibility study to tender autonomous mobility (i.e., 2 vehicles) as part of a plan to integrate different sports facilities and improve the access into the district.	CCAM
Pilot 3: A6 ***(DoA: Pilot 3. A3.3)***	Mobility concept for the district with focus on intermodal mobility / bike usage	Establish Ostra District as a gateway to the city center and offer intermodal transport services. A specific focus lies on active mobility like walking and cycling. The crossing Elbe cycle path will contribute to this effort. Check on app- and gamification-based concepts that might support the endeavour.	Intermodal mobility
Pilot 4: A7 ***(DoA: Pilot 4. A4.1)***	Electrification of the public bus fleet	Implementation of 20 e-buses with 20 pantographs in the bus fleet of the city.	2Zero
Pilot 4: A8 **(DoA: Pilot 4. A4.2)**	Bidirectional charging for cars	One tuneable/configurable e-car for mobility of people with bi-directional charging and network integration capabilities.	2ZeroRES/Power Grid
Pilot 5: A9 ***(DoA: Pilot 5. A5.1)***	Platform for servicing events: Estimate traffic flows (predictive) to improve event management via data pooling on a platform	Expandable, cloud-based and modular platform for flexible integration of a wide variety of data (event based, e-vehicle information), supported by AI.	High value / Innovative services
Pilot 5: A10.1 ***(DoA: Pilot 5. A5.2)***	City App for services including reservations and payment	App to enable reservation and payment functions and offer of mobility information when feasible.	High value / Innovative services
Pilot 5: A10.2 ***(DoA: Pilot 5. A5.1)***	Enable City App to allow tracking of mobility capacity data and giving wayfinding guidance	Link of diverse data sources in a secure way to enable mobility capacity tracking and to manage traffic flows; Wayfinding guidance will be supported by 15 displays and road guidance systems for disabled people and solar lighting systems incl. parking cameras.	High value / Innovative services
Pilot 5: A11 ***(DoA: Pilot 5. A5.3)***	Mobility monitoring via image processing and provision via platform for traffic management in Demosite district	Development and platform integration of visitor numbers and traffic flows, generating anonymized data on traffic situation and occupancy of sports and event venues. Focus is OSTRA Park. GDPR conformity will be taken care of.	High value / Innovative services
Pilot 6: A12 ***(DoA: Pilot 6. A6.1)***	5G private communication network in Ostra district	Development of 5G communication interfaces and data transmission solutions the whole Ostra district ensuring connectivity and compatibility with the higher-level platform.	CCAM connectivity
Pilot 6: A13 ***(DoA: Pilot 6. A6.1)***	Slicing for use case e.g. events	To ensure reliable connectivity, 5G network slicing is envisaged, prioritizing critical data streams related to the power grid, machine control and traffic safety.	CCAM connectivity
Pilot 6: A14 ***(DoA: Pilot 6. A6.2)***	Power grid-based optimization and control	Power grid-based optimization and control: demand-oriented transport and e-charging solutions to optimize the power grid, especially charging stations with optimization logic for charging.	RES/Power Grid

2.4.4 SELECTION OF INDICATORS

The selection of indicators is a crucial step in defining the evaluation framework for a project such as this. Key Performance Indicators (KPIs) should reflect how effectively the project is achieving specific objectives and serve as essential tools for assessing progress toward strategic goals. Furthermore, they guide process evaluation, monitor performance, and enable organisations and following cities to make data-driven decisions.

To define specific indicators (KPIs) it is important to recognize that in real-world scenarios, a multitude of factors can influence the assessment of the actions' impact and the trajectory of specific KPs. For instance, while the implementation of an action may impact one facet of a KPI, other city-related factors may simultaneously influence the same KPI. The identified KPIs aim to adhere to the SMART criteria: be Specific, Measurable, Attainable, Relevant, Timed and Simple to understand:

- **Specific:** Target a specific domain or field.
- **Measurable:** Allow for quantifiable evaluation.
- **Attainable:** Achievable with the resources, technology, and the time available.
- **Relevant:** Connected to meaningful evaluation and success.
- **Timed:** Collectible within time-frames aligned with the project timeline (e.g., facility readiness).

Before selecting the KPIs, we first prepared a database in excel in which each technology partner and each city could add their data collection capacity, taking into account their pilots. Once those data collection capabilities were clear, we could better align the KPI selection considering the capacity of calculation of each indicator.

Based on the capabilities and the impact that was necessary to evaluate within the project, we prepared a basket of indicators that could be assigned to each pilot. From this initial basket of indicators per pilot and the data collection capabilities database, we could separate which partner could participate in the calculation of each KPI per pilot. This separation was presented in a form of a list to each partner. This list was called "Dedicated list of KPIs" and was shared individually with each partner. A series of bilateral meetings with each individual partner were held in order to review and adjust the final list. The main criterion to agree on the final list per partner was to make sure that all the selected KPIs were targeting the main project impacts and that the partners were capable to calculate them before, during and after the implementation of each pilot.

The criteria for including an indicator in the impact evaluation process of a measure included: the importance and value that the KPI had for the project and the partner in charge of the action; and the availability to gather the information, considering the data needed to obtain each KPI.

Throughout the task 3.1, bilateral meetings were organized between PEMs and assigned SCs and MLs from partners. These meetings aimed to confirm the KPIs best suited for each pilot, considering the availability of data and the importance of the indicator's performance and follow-up evaluation.

This process consisted on various meetings among the PEM, cities' representatives, and project partners to clarify:

- Which of the identified KPIs are currently measured by the cities and/or the partners? What types of data are used?
- Which of the identified KPIs are affected by the MOBILITIES for EU actions in each city?
- Do the partners have access to the data needed for KPI calculation?
- The full list of 23 indicators (refer to Figure 12) was created, including the following information:
- CIVITAS impact category.
- KPI name and definition (including a short description)
- KPI measuring unit
- Supporting data and methods for measurement and monitoring

Environment	Energy	Transport	Society	Economy
Reduction of CO2 emissions (TnCO2eq)	**Energy consumption** (kWh/unit)	**Mileage** (km/unit)	**Acceptance** (% or Qualitative score)	**Capital investment** (€)
Reduction of NOX emissions (ppb)	**Energy savings** (kWh/unit)	**Quantity of waste collected** (weight/unit)	**Awareness** (% or Qualitative score)	**Average operating costs** (€)
Reduction of small particle emissions (microg/m3)	**Energy delivered** (kWh/unit)	**Number of trips per day** (nº trips/day)	**Customer satisfaction index** (%)	**Pollution cost avoided** (€)
Reduction of noise level (dB)	**Use of clean energy sources** (%)	**Charging times** (hours/unit)	**Quality of cooperation structures with stakeholders** (Qualitative score)	**Economical impact** (€)
	RES production (kWh)	**Commercial speed** (km/h)		
		Perception of security (Qualitative score)		

Figure 12. List of 23 indicators to evaluate the measures of MOBILITIES for EU Measures

After analysing this list collaboratively with cities, a subset of eight core KPIs (Figure 13) was selected and included in the Inception Report, a document delivered to the European Commission to monitor the indicators evaluating the project. It consisted on an initial review half way the first year of the project, of the relevant documentation. This report set out the conceptual ideas to be used in an evaluation, the key evaluation questions and methodology, including information on data sources and collection, and as mentioned, the sampling of core key indicators This set will be measured and monitored across cities, encompassing applicable measures.

Environment	Energy	Transport	Society	Economy
Reduction of CO2 emissions (TnCO2eq)	**Energy consumption** (kWh/unit)	**Mileage** (km/unit)	**Acceptance** (% or Qualitative score)	**Capital investment** (€)
Reduction of NOX emissions (ppb)	**Energy savings** (kWh/unit)	**Quantity of waste collected** (weight/unit)	**Awareness** (% or Qualitative score)	**Average operating costs** (€)
Reduction of small particle emissions (microg/m3)	**Energy delivered** (kWh/unit)	**Number of trips per day** (nº trips/day)	**Customer satisfaction index** (%)	**Pollution cost avoided** (€)
Reduction of noise level (dB)	**Use of clean energy sources** (%)	**Charging times** (hours/unit)	**Quality of cooperation structures with stakeholders** (Qualitative score)	**Economical impact** (€)
	RES production (kWh)	**Commercial speed** (km/h)		
		Perception of security (Qualitative score)		

Figure 13. 8 core KPIs from the full list of indicators

Subsequently, the selected KPIs were tailored to each pilot and action, ensuring that the indicators capture relevant impacts for each city. While the intent is to maintain uniformity in KPI definitions and units across all cities, partners and, actions, challenges such as data limitations and varying measurement practices among partners necessitate slight adjustments. These adjustments ensure the KPIs remain coherent and comparable between baseline and target years. When possible, the original KPI list will be retained, preserving uniformity, provided that data availability and format permits such continuity.

In the following sections, the five main categories foreseen for the MOBILITIES for EU Evaluation framework are presented. These categories draw on concepts from the CIVITAS framework, Cities Mission Platform, SUMI, and evaluation frameworks from 2Zero and CCAM projects. Each section has been developed with input from the respective Impact Category Responsible:

1. Environment

The Environment impact category is designed to assess the environmental consequences of urban mobility measures. This category emphasizes the importance of evaluating how well transport systems contribute to reducing the negative impacts of transportation on the urban environment, particularly in terms of air pollution. The primary objective of evaluating the environmental impact of MOBILITIES for EU actions is to understand and mitigate their ecological footprint while promoting healthier and more sustainable cities.

The CIVITAS framework recognises the significant role urban transportation plays a major role in greenhouse gas (GHG) emissions, air pollution, and noise levels. It focuses on strategies to reduce emissions and improve urban air quality. This category highlights the importance of aligning environmental goals with mobility improvements to create efficient and environmentally friendly transport systems. Several KPIs within the Environment impact category, have been selected to reflect these priorities.

The selected KPIs aim to measure the project's contribution to reducing harmful emissions and improving urban liveability. By focusing on these indicators, the project can align with environmental objectives, such as contributing to climate action and improving public health. These KPIs will provide insights into the long-term environmental benefits of the mobility solutions implemented.

Incorporating the Cities Mission Platform framework concepts into the Environment impact category ensures alignment with broader climate neutrality goals. This framework provides a structured approach to reducing emissions from direct, indirect, and induced sources; complementing the KPIs selected in the CIVITAS framework. This alignment ensures the project contributes not only to local environmental improvements but also to global climate action initiatives.

To assess the environmental performance and impact of the implemented actions, the following KPIs were selected. These indicators are crucial for understanding how the project is contributing to reducing pollution and promoting a more sustainable urban environment. FHG is reviewing the Environmental category as the ICR. A detailed summary of the KPIs can be found in Annex 2.

1. **Reduction of CO_2 Emissions**: Carbon dioxide (CO_2) is the primary greenhouse gas contributing to global climate change, making its reduction a key focus of sustainable transport projects. This KPI measures the reduction in CO_2 emissions achieved through implementing sustainable transport measures, optimized traffic management systems, and more efficient electrification networks. Monitoring CO_2 reduction helps assess the project’s contribution to mitigating climate change locally and globally. Emissions from scopes 1, 2 and 3 are considered as part of this KPI to align with global initiatives.
2. **Reduction of NOx Emissions:** Nitrogen oxides (NOx) are harmful pollutants that contribute to air quality degradation and cause respiratory health issues in urban areas. Reducing NOx emissions is a priority for improving air quality and public health. This KPI assesses the reduction in NOx emissions resulting from the adoption of cleaner and more efficient technologies. By tracking NOx emissions, the project can determine its impact on reducing harmful air pollutants in cities.
3. **Reduction of Small Particle Emissions:** Small particles are among the most harmful air pollutants, penetrating deep into the lungs and bloodstream, posing significant health risks. This KPI measures the reduction of small particle emissions, often associated with road transport. Measures such as cleaner vehicle technologies and optimised traffic patterns aim to reduce these emissions.
4. **Reduction of Noise Levels:** Noise pollution significantly impacts quality of life and public health in urban areas. This KPI assesses how transport measures, such as the introduction of electric vehicles and improved infrastructure, contribute to quieter cities. Reducing noise pollution is critical for creating more liveable urban spaces and improving residents' well-being.

The selected KPIs for the Environment impact category are vital for assessing the project’s contribution to reducing pollution and improving the overall environmental quality. These KPIs will help measure progress towards reducing greenhouse gas emissions, air pollutants, and noise levels, all essential for promoting healthier, more sustainable cities. By careful analysing and monitoring these indicators, the project will provide valuable insights into the effectiveness of mobility measures in reducing the environmental footprint of urban transportation systems. Moreover, the outcomes of these evaluations will support the European Union's goals to reduce urban pollution and transition to more sustainable, climate-friendly mobility solutions.

Evaluation

Environmental KPIs in the MOBILITIES for EU project present unique challenges, particularly in data collection. Measuring certain impacts like emissions and air quality often requires complex methodologies that may go beyond direct measurement. Some actions may necessitate reliance on estimation models and simulations, incorporating emission factors to approximate reductions and impacts, as described in the emission scopes chapter (Section 2.3). Furthermore, the variability of pilot scales complicates, in some scenarios, the translation of local results into broader environmental impacts, requiring simulation techniques and scalability models to extrapolate findings.

Given the significance of these KPIs, data collection is mandatory for all measures, with particular emphasis on the CO_2 emissions KPI. Efforts will focus on obtaining data across all the three emission scopes. However, the small scale of most pilots presents challenges, especially for indicators such as noise reduction, where isolating specific noise sources from background elements is complex.

Particular attention is placed in the mobility measures aimed at reducing the environmental impact of passenger and freight transport. These measures are expected to yield the most significant emissions reductions and insights. For instance:

- In Madrid, autonomous e-buses (Pilot 1), replacing conventional buses with electric ones (Pilot 3), and implementing hydrogen fuel buses (Pilot 4) are anticipated to demonstrate significant impacts. Initial estimates indicate that electric buses consume approximately 70kWh/100 Km, compared to diesel busses averaging 25 litres/100 Km; with a target of zero direct emissions for these implementations.
- In Dresden, autonomous vehicles for passenger and freight transport (Pilot 3) and electrification of the public bus fleet (Action 7) are key focus areas.

Other measures include the implementation of new electric infrastructure and system optimisation. For example, in Madrid, the implementation of a 5G network in Mercamadrid (Action 1-4) aims to maintain a zero-emission scenario, while optimising the power grid and illumination system (Pilot 2). Partners will provide data on vehicle and systems emissions, or estimations based on specifications, as well as baseline reports for 2023 and relevant emission scope.

2. Energy

The Energy Impact Category plays a crucial role in this project as cities move toward more sustainable and energy-efficient mobility solutions. This category is designed to evaluate the impact of transport-related and other energy efficiency measures on energy use, energy savings, and the transition to cleaner energy sources. The main goals include reducing dependency on fossil fuels, minimising energy consumption, and promoting the adoption of renewable energy sources (RES). In alignment with the broader European Union decarbonisation goals, this category ensures that urban transport systems contribute to long-term sustainability by reducing energy demand and increasing efficiency.

The selected KPIs aim to measure progress in reducing energy use, promoting energy efficiency, and transitioning to clean energy. These metrics are particularly important for projects that incorporate innovative technologies, such as electric vehicles (EVs) and renewable energy infrastructure. By focusing on energy-related KPIs, the project can monitor the environmental and economic benefits of these actions, supporting the development of a resilient, sustainable urban transport system, and efficient energy infrastructure. CARTIF is reviewing the Energy category as the ICR.

For this project, the following KPIs have been selected to assess the energy performance of the mobility measures implemented and their contribution to the overall energy transition. A detailed summary is detailed in Annex 2.

1. **Energy Consumption:** This KPI measures the energy used by the proposed pilots, including vehicles, infrastructure, and supporting services. Monitoring energy consumption helps assess system efficiency and the total energy demand. Reductions in energy consumption indicate the successful implementation of energy-efficient technologies and practices. This KPI applies to measures involving EV fleets, power grids, and energy-efficient infrastructure, including metrics such as energy consumption per vehicle, per distance, per trip or per passenger transported.
2. **Energy Savings**: Energy savings represents the amount of energy is conserved through more efficient systems or cleaner technologies. This KPI quantifies the benefits of energy-efficient measures by comparing reductions against traditional transport methods or energy grids. For example, transitioning from conventional fuel-based vehicles to electric or hybrid options yields substantial energy savings, making this a critical metric for assessing the success of implemented measures.
3. **Energy Delivered:** This KPI measures the total energy delivered to vehicles, particularly EVs, through charging infrastructure and electric bus replacement. Measuring energy delivered is crucial for evaluating the system's capacity to meet current and future demand. It also provides insights into the operational efficiency and scalability of the infrastructure. This KPI applies to the energy delivered across various systems including from grids to vehicles, from RES facilities to smart grids, and from vehicles back to grids in bidirectional charging scenarios.
4. **Use of Clean Energy Sources:** This KPI tracks the extent to which clean, renewable energy sources such as solar, wind, or hydrogen power transport systems and electric infrastructures such as smart grid systems. A higher percentage of clean energy use indicates a successful shift away from fossil fuels, directly contributing to greenhouse gas emissions reductions. This KPI is particularly relevant for measures integrating renewable energy into urban mobility and other energy systems.
5. **RES Production:** Renewable energy production (RES) refers to the generation of energy from sources like solar panels for powering transport systems, grids, and other infrastructures. This KPI assesses the system's self-sufficiency and its ability to generate clean energy for its own use. Measures focusing on solar energy for powering the infrastructure, for instance, align with project goals to reduce emissions and energy dependency.

Evaluation

This category of KPIs predominantly focuses on implementing and optimising grids and energy infrastructure. Many project actions intend to substitute conventional modes of transport with electric alternatives, enabling more efficient systems and significantly reducing emissions. Consequently, most actions are considered within the Energy category, especially those mentioned in the Environmental category.

Beyond energy consumption in mobility measures, the project prioritises transitioning from conventional energy sources to 100% clean sources Additionally, it focuses on optimising power grids and developing infrastructure for efficient and intelligent vehicle charging.

- In Madrid, energy KPIs are crucial in Pilot 2, which involves installing a700 kWp photovoltaic plant at Mercamadrid to power V2G chargers and optimising the grid with digital twins. Pilot 3 focuses on electric buses and their charging infrastructure. Key metrics include reducing energy consumption and increasing the share of clean energy, with an initial estimate of 3.5% clean energy use at Mercamadrid and a target of at least 35%. Energy produced and consumed will directly depend on vehicle specifications and infrastructure use. Partners will gather information about energy needed from bus depot pantographs and Mercamadrid operations.

- Similarly, Dresden will provide energy KPIs data for autonomous vehicles in Pilots 1 and 3, bus electrification (Action 7), and developing bidirectional charging infrastructure (Action 8). Data collection will rely on vehicle specifications and energy measurements from bus depots and charging infrastructure.

3. Transport system

The Transport System impact category is a key component of this project and the CIVITAS guidelines, incorporating SUMI concepts into the framework. It evaluates the performance, functionality, and efficiency of urban transportation networks. This category emphasises the technical aspects of mobility, assessing how well transportation systems meet the needs of citizens and cities while advancing sustainability and reducing negative impacts such as congestion and inefficiency.

The primary objective of evaluating urban transport systems is to improve the effectiveness and sustainability of mobility solutions. This includes understanding the effects of actions on traffic flow, public transportation efficiency, and accessibility for all citizens. The CIVITAS Framework addresses multiple aspects of transportation systems that contribute to their overall performance. For this project, KPIs are selected within this category to measure progress towards these goals.

The chosen KPIs align with the project's objectives of reducing emissions, improving mobility, and enhancing urban quality of life. The SUMI further expand on the CIVITAS framework by providing additional insights into sustainability and user satisfaction. By incorporating SUMI's focus, the project adopts a more holistic perspective on the transport system's impact on cities and residents.

The following KPIs have been selected to assess the performance and impact of the implemented measures, offering a comprehensive picture of the transport system's functionality in real-time and throughout the project's implementation. ALSA is reviewing the Transport System category as the ICR and a summary of these KPIs is available in Annex 2.

1. **Mileage**: Mileage measures the distance travelled by vehicles within the transport system. It is particularly relevant for understanding vehicle utilisation, fuel consumption, and emission. Tracking mileage is essential for determining the environmental impact of transportation, particularly in relation to carbon emissions. A reduction in mileage, through more efficient routes or improved transport modes, can significantly contribute to the reduction of Scope 1 emissions. This KPI will be considered in measures related to vehicle mobility and efficiency.
2. **Quantity of waste collected:** This indicator is specific to waste collection vehicles. Efficient waste collection is vital for the cleanliness and health of a city. By evaluating the quantity of waste collected, the efficiency of the waste collection system can be evaluated. This PKI applies to measures targeting waste collection as part of mobility initiatives.
3. **Number of trips per day:** This KPI tracks the daily number of trips made by vehicles, reflecting transport system usage and demand. Analysing trips numbers offer insights into user behaviour, transport efficiency, and congestion levels. This indicator is used in measures where mobility innovations impact the frequency or nature of vehicle trips.
4. **Charging times:** With electric vehicles (EVs) becoming integral to sustainable transport systems, monitoring charging times is essential. Charging time refers to the duration required for electric vehicles to replenish their battery power. This KPI evaluates the practicality and efficiency of EV charging solutions within cities, supporting the transition to clean energy.
5. **Commercial speed:** Commercial speed, including stops, measures the average operational speed of vehicles. It is a critical performance indicator that affects service reliability, user satisfaction, and the appeal of transport modes. This KPI is used in mobility measures involving vehicle use, especially where speed data is available.

6. **Perception of security:** This qualitative indicator measures users' sense of safety while using transport services. Perceptions of security can influence travel behaviour and the adoption of public or shared transport modes. A positive perception encourages use, while negative perceptions may deter users. This KPI is particularly relevant for mobility innovations altering travel patterns, such as the incorporation of vehicles operating autonomously, where the perception of security and safety of users and bystanders is crucial to achieve high levels of acceptance.

The KPIs selected for the Transport System Impact Category are essential for evaluating both the performance and user experience within the urban mobility ecosystem. By tracking these KPIs, the project gains valuable insights into the effectiveness of the implemented mobility measures. This evaluation ensures the project contributes to enhanced sustainability, efficiency, and reliability of urban transport systems. Additionally, the findings provide valuable evidence to future transport initiatives and support the European Union's sustainable urban mobility and emissions reduction goals.

Evaluation

The Transport System Category evaluates the performance of urban transportation networks, focusing on mobility pilots where data on vehicle usage and trips can be gathered.

In Madrid, transport KPIs are particularly relevant for Actions 1, 2 and 3, from Pilot 1, which test innovations using autonomous vehicles for people and freight. For instance:

- The use of an electric bus within Mercamadrid will provide data on mileage, charging times, trips, and speed. These metrics depend on the specified route and vehicle frequency.
- Autonomous vehicles for waste collection and food market logistics in Mercamadrid will also supply KPI data. Efficiency improvements, such as route optimisation, aim to halve daily average mileage from 30 km tod to 15 km in the waste collection action.

In Dresden, transport KPIs focus on mobility measures. Including:

- Autonomous robots for charging e-vehicles (Action 1).
- Mobility solutions incorporating AVs for people and freight (Pilot 3).
- Electrification of the public bus fleet (Action 7).

In both cities, data on the mileage, charging times, commercial speed, and trips per day will be gathered based on vehicle specifications, route planning, and usage frequency. Baselines and targets will be defined to measure the impact and progress of these initiatives.

4. Society – People & Government

The Society – People & Government Impact Category examines the societal readiness, public engagement, and governance dynamics essential for the success of sustainable urban mobility measures. It emphasizes the importance of public acceptance, awareness, and cooperation between stakeholders, including governments, local authorities, private sector partners, and the citizens who use and benefit from transport systems. This category assesses the integration of mobility measures within communities and their alignment with societal needs, expectations, and values.

The 2Zero and CCAM projects provide useful insights into societal readiness, stressing the need for proactive public involvement in adopting new mobility technologies and solutions. These projects underline the importance of aligning public policies, fostering stakeholder collaboration, and facilitating knowledge sharing. By integrating these concepts with the CIVITAS framework, the role of public participation, cooperation, and governance emerges as essential elements for the success of urban mobility initiatives.

The selected KPIs within this category aim to measure public engagement, awareness levels, and user satisfaction, and the quality of governance structures and stakeholder cooperation. RC is coordinating the Society category as the ICR and a summary of the KPIs can be found in Annex 2.

1. **Acceptance:** Acceptance understands how well the project's new mobility measures are embraced by the public and stakeholders. This KPI measures the support from citizens, local governments, and other stakeholders for the adoption of new transport technologies or innovations. High acceptance levels are crucial for the long-term success of these measures, as resistance or scepticism can undermine the project's objectives. This KPI will specifically monitor stakeholder interactions with newly introduced technologies or operational changes.
2. **Awareness:** Awareness evaluates stakeholders' understanding of the mobility measures, highlighting their benefits and alignment with broader sustainability and climate objectives. It reflects the success of communication strategies, educational efforts, and public consultations in fostering understanding and support for mobility innovations. Clear and effective communication enhances public acceptance and strengthens engagement. Knowledge dissemination efforts, including campaigns, workshops, and outreach activities, will be monitored through the UT Labs to assess the project's effectiveness in raising awareness about sustainable transport solutions.
3. **Customer Satisfaction Index:** The Customer Satisfaction Index evaluates user satisfaction with the mobility services and innovation introduced by the project. It evaluates perceptions of convenience, reliability, safety, and service quality. Positive feedback indicates the project's success in meeting user needs and improving urban quality of life. The KPI will be particularly important in initiatives involving new public transport services or shared mobility platforms.
4. **Quality of Cooperation Structures with Stakeholders:** This KPI evaluates the effectiveness of collaboration among public authorities, private entities, and other stakeholders. Governance and strong cooperation structures, especially between partners, are essential for implementing mobility measures and ensuring long-term project sustainability. This KPI focuses on the quality of stakeholder partnerships and the inclusivity of governance mechanisms. Collaboration efforts will be assessed by analysing meeting outcomes, partnership agreements, and coordination activities across pilots and actions.

The 2Zero and CCAM projects, as mentioned previously, reinforce the importance of early public involvement, clear communication, and aligning policies with societal values. Incorporating these principles into the MOBILITIES FOR EU framework ensures that mobility measures are not only technically robust but also socially inclusive and sustainable. Transparent governance structures and responsive public engagement foster trust, allowing mobility innovations to achieve their full potential and contribute to a more sustainable urban future. This approach ensures that the societal implications of mobility measures are thoroughly addressed, supporting their successful integration and long-term acceptance.

Evaluation - Urban Transport Labs (UT Labs)

Urban Transport Labs (UT Labs) are integral to the MOBILITIES for EU project, serving as innovation spaces to co-design urban mobility solutions through a collaborative and participatory approach. Operated as Living Labs (LLs), these real-life environments enable iterative feedback, rapid prototyping, and comprehensive assessments across various aspects of urban mobility and sustainability. In the context of this evaluation framework, UT Labs are essential for collecting both qualitative and quantitative data related to the *Society* impact category, focusing on KPIs such as Acceptance, Awareness, Customer Satisfaction Index, and Quality of Cooperation Structures with Stakeholders.

UT Labs are designed as collaborative platforms where stakeholders can actively contribute to the design, testing, and scaling of mobility solutions. They define management structure and roadmaps of action, supporting the development of innovative governance models and the aligning with broader objectives such as climate neutrality, Sustainable Urban Mobility Planning (SUMP), and Sustainable Urban Logistics Planning (SULP). This multi-dimensional approach ensures that the UT Labs function as effective environments for collecting qualitative data through direct engagement and surveys with participants and citizens.

A core role of UT Labs is the collection of qualitative and quantitative data to evaluate societal KPIs:

- **Acceptance and Awareness** are assessed through surveys, participatory workshops, and focus groups. These methods provide insights into public attitudes, knowledge levels, and perceptions of urban mobility solutions. Informational sessions and workshops further promote understanding and acceptance, creating a feedback loop to refine solutions based on user input.
- **Customer Satisfaction Index** measures the perceived quality, reliability, and safety of mobility innovations.
- **Quality of Cooperation Structures** evaluates the effectiveness and inclusivity of stakeholder partnerships. UT Labs facilitate collaboration through workshops and feedback mechanisms, helping stakeholders align efforts and identify areas for improvement.

Figure 14 illustrates the UT Labs' approach, which spans initial assessments, ongoing monitoring, and the evaluation of implementation sustainability. These steps include interactions with stakeholders and users at various stages of the strategy. This process ensures that solutions are continually refined to meet societal needs and expectations.

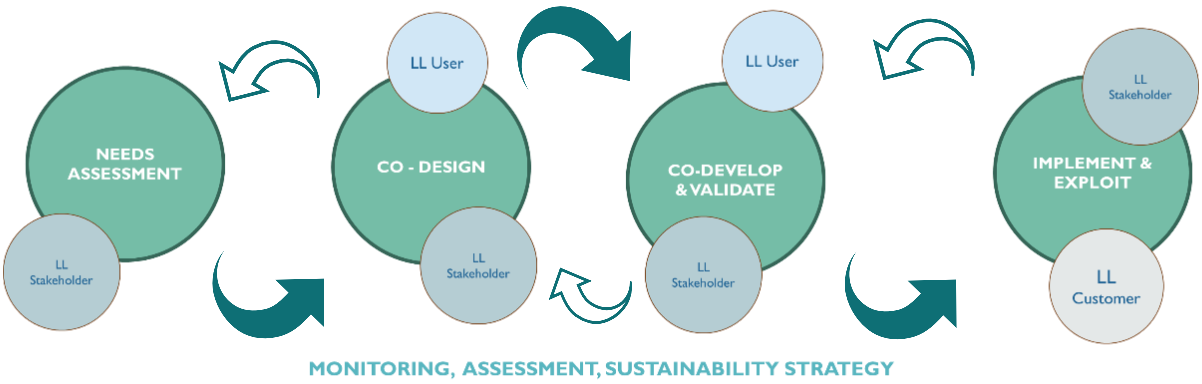


Figure 14. Monitoring, Assessment and Sustainability strategy of UT Labs (MOBILITIES for EU Kick-off Meeting, Madrid (Spain), 2024)

UT Labs play a pivotal role in assessing governance-related KPIs, particularly the Quality of Cooperation Structures with Stakeholders. Activities such as workshops, feedback sessions, and stakeholder surveys provide valuable data on the effectiveness of partnerships and governance mechanisms. These efforts enhance stakeholders' capacity to manage and implement mobility measures while fostering collaboration.

The UT Labs methodology is informed by insights from projects like 2Zero and CCAM, which highlight the importance of measuring social acceptability and societal readiness for advanced mobility solutions. Structured surveys and participatory sessions within UT Labs create a robust foundation for assessing societal needs, enabling the project to stay responsive to community priorities.

The UT Labs approach is applied across pilots with the most impactful and innovative actions expected to yield significant societal effects. Social assessments will be conducted for the following actions:

- Electric autonomous bus for passengers in Mercamadrid, Madrid (Action 1).
- Autonomous vehicle for waste collection (Action 1.3)
- RES Grid and V2G chargers (Action 2)
- Electrification and charging infrastructure for public transport (Action 3 and 4)

- Autonomous vehicles for people and freight in Dresden (Pilot 3).
- Electrification of Dresden's public bus system (Action 7).

Each action is designed to test and evaluate the societal readiness of mobility innovations, ensuring they align with user needs, stakeholder collaboration, and governance frameworks.

Initial targets for Acceptance and Awareness are set at 70–80% satisfaction, reflecting high public engagement and alignment with project objectives. Similarly, the Quality of Cooperation KPI will monitor stakeholder relationships, with satisfaction levels also targeted at 70–80%.

Our partners from Right-Click will lead the survey processes to gather societal data required for KPI evaluation. Their expertise will ensure robust data collection and analysis, providing actionable insights to improve mobility solutions across pilots.

By embracing the Living Lab methodology, UT Labs ensure urban mobility innovations are responsive to societal needs and expectations. This participatory approach not only enhances the societal impact of mobility measures but also strengthens collaboration among stakeholders, fostering a shared commitment to sustainable urban mobility. The integration of societal KPIs into all pilots reinforces the importance of societal readiness and provides critical insights for the continuous improvement of mobility initiatives.

5. Economy

The *Economy* Impact Category addresses the financial sustainability and economic outcomes of urban mobility measures. This category encompasses the costs of implementing new systems, the financial benefits realised, the reduced costs of pollution, and the overall contribution of economic growth. A successful urban mobility solution not only enhances transportation efficiency and sustainability but also delivers economic benefits to cities, businesses, and citizens.

CIVITAS recognizes pivotal role of economic impacts in ensuring the long-term viability of mobility measures. By assessing key economic indicators from this framework, the project can evaluate the financial performance of its transport initiatives and their broader economic effects. For MOBILITIES for EU, specific KPIs have been selected to ensure that the implemented measures are not only environmentally and socially effective but also economically sound. A summary of these KPIs is provided in Annex 2 and UPM is reviewing the Economy category as the ICR.

1. **Capital Investment:** Capital investment is a fundamental KPI for assessing the upfront costs associated with implementing new mobility measures. This indicator tracks the financial resources allocated for infrastructure, vehicles, technology, and other initial investments required to launch the project. Understanding capital investment levels is essential for evaluating the project's economic feasibility and ensuring efficient use of funding.
   This KPI is particularly relevant for measures involving significant infrastructure upgrades or vehicle procurement. It also aligns with broader economic goals, such as job creation and stimulating local industries. By monitoring Capital investment, the project can assess their contribution to economic development in the cities involved.
2. **Average Operating Costs:** Average operating costs measure the day-to-day expenses associated with maintaining and running the systems introduced by the project. This KPI includes costs related to fuel or energy consumption, vehicle maintenance, personnel, and other operational aspects. Monitoring operating costs over time is essential for understanding the financial sustainability of the project and ensuring that the implemented measures remain cost-effective.
   This KPI will be assessed in measures that involve the daily operation of new transport services, where operational efficiency is crucial for sustaining the services beyond the project's timeline. By tracking average operating costs, the project ensures that the mobility measures are financially manageable for both cities and citizens.

3. **Pollution Cost Avoided:** The Pollution Cost Avoided KPI captures the financial savings achieved by reducing air pollution, which has significant economic impacts on public health and the environment. While closely linked to environmental KPIs, this indicator specifically calculates cost savings associated with reduced emissions of CO_2, NOx, and other pollutants. These savings translate into fewer health-related expenses, less environmental damage, and improved quality of life.
   This KPI is particularly relevant for measures aimed at reducing emissions, such as the introduction of electric and clean energy vehicles. By calculating the pollution costs avoided, the project can demonstrate the economic benefits of improving air quality and reducing the city's environmental footprint.
4. **Economic Impact**
   The Economic Impact KPI evaluates the broader financial effects of mobility measures on the local economy, including job creation, economic growth, and changes in property values. It goes beyond direct costs and savings to evaluate how the project contributes to economic development and enhances the city's overall economic well-being.
   This KPI will be monitored in measures that have the potential to generate significant economic benefits for the local community, such as increasing economic activity by improving access to jobs, services, and markets. It also considers the project's role in making cities more attractive to businesses and tourists, contributing to long-term economic resilience.

Evaluation

This Economy Impact Category's KPIs provide a comprehensive framework for evaluating the financial sustainability and economic benefits of the project's mobility measures. By tracking Capital Investment, Average Operating Costs, Pollution Cost Avoided, and Economic Impact, the project ensures that its solutions deliver financial gains alongside environmental and mobility improvements.

The evaluation of these KPIs focuses on optimising resource allocation to maximise both financial and environmental returns. Partners are required to provide data economic KPIs, with reporting often linked to their internal financing systems. Particular attention is given to actions that reduce dependency on conventional transportation modes in favour of electric alternatives, which can yield long-term economic benefits by reducing emissions and enhancing efficiency.

For example, data from the project proposal shows that the automated vehicle for waste collection in Mercamadrid (Action 1.2) has an average operating cost of 63.749,75€, with a target to reduce this cost by half. Similarly, in Madrid, increased energy efficiency from Action 2 is expected to reduce the pollution costs by 25% and economic impact costs by 20%. In Dresden, the implementation of e-buses (Action 7) could yield annual savings of 15,200€ per bus in healthcare and environmental costs due to pollution reduction.

2.4.5 METHODOLOGY

In evaluating the KPIs across the impact categories in the presented framework, a robust methodology is essential to ensure data accuracy, relevance, and scalability. The methodology considered in this project leverages the diverse technological capabilities of the partners, and it allows for a comprehensive, multi-modal approach to data collection and analysis. The pilots aim to gather real-time data from sensors and detectors, whenever possible, as well as to obtain information from simulation models and surveys. This approach seeks to deliver well-rounded and scalable insights into emissions, energy, and mobility systems, considering the scope of urban sustainability and improved mobility of the MOBILITIES for EU project.

Each project partner is responsible for implementing and monitoring the KPIs within their respective pilots, as detailed in Deliverable 2.1. These partners bring advanced technological capabilities, including specialised sensors, detectors, and monitoring equipment, to capture emissions, energy consumption, and mobility system data. For example, emissions monitoring can include detectors specifically designed to capture CO_2, NOx, and particulate matter (PM) emissions, which can be deployed within pilot zones to provide accurate, real-time data on environmental impacts. These detectors are strategically placed to cover key intervention areas where significant changes are anticipated. Similarly, energy and mobility monitoring tools, such as energy meters and mobility detectors, track critical indicators like energy consumption, energy sources, and vehicle mileage. This data enables a direct evaluation of KPIs related to energy efficiency, renewable energy use, and transport system functionality.

Given the potential limitations of pilot projects, including scope size, sensor availability, and data collection challenges, estimation and simulation tools are essential for scaling results and drawing broader conclusions. Simulation models help extend findings from small-scale pilot projects to city-wide scenarios, offering valuable insights into the potential impact of interventions. For example:

- **Emission Reductions:** Simulation software estimates the impact of mobility and energy actions on emissions at a city-wide scale, predicting reductions in CO_2, NOx, and PM. These models incorporate emission factors derived from vehicle specifications and technologies to address data gaps.
- **Transport efficiency:** Mobility simulations project improvements such as reduced mileage and increased commercial speeds when certain interventions are adopted across a larger scale.
- **Energy Usage:** Energy simulation tools estimate cumulative impacts on energy savings and environmental performance, offering projections of benefits at broader levels.

For qualitative data, especially for society-related KPIs, surveys and the UT Labs play a crucial role. Surveys administered to citizens and stakeholders within pilot areas provide essential insights into KPIs like Acceptance, Awareness, and Customer Satisfaction Index. Additionally, UT Labs serve as open innovation spaces, fostering co-design processes where participants offer feedback and evaluations that inform societal readiness and satisfaction indicators.

The combination of real-time data collection, simulation modelling, and qualitative surveying conform a robust methodology for assessing the KPIs within the presented framework. Detailed proposals for gathering information on most KPIs are presented in Annex 3, obtained from concepts proposed in the CIVITAS Framework and methodologies proposed by the Madrid City Council. By leveraging the technological strengths of project partners, employing estimation techniques, and incorporating qualitative perspectives through surveys and UT Labs, the methodology ensures that KPI data is accurate, representative, and supportive of evaluating the project's impact on urban sustainability and mobility.

2.4.6 URBAN METABOLISM

The MOBILITIES for EU project addresses urban transformation through the concept of urban metabolism, treating cities as complex living organisms where resources flow, are consumed, and then repurposed. This approach provides insights into how energy, transportation, water, waste, and goods circulate within cities, and how these flows impact overall sustainability. By examining these flows, city planners and stakeholders can better understand and manage urban resource consumption, supporting resilience and environmental health on both local and global scales.

In a metabolic framework, urban activities, such as transportation, energy consumption, waste production, and infrastructure development, are interconnected and form key aspects of the actions proposed in this project. Analysing these flows allows city planners to visualize the impact of human activity on urban health, identifying opportunities to optimise energy and resource use. This approach not only reduces environmental impacts but also improves residents' quality of life by fostering sustainable urban ecosystems.

Madrid integrates sustainable mobility and renewable energy solutions aligned with urban metabolism principles through several targeted actions in the MOBILITIES for EU project. Initiatives such as the installation of a 700 kWp photovoltaic plant at Mercamadrid, EV alternatives, and vehicle-to-grid (V2G) charging infrastructure aim to minimise reliance on fossil fuels and reduce carbon emissions. The measures promote sustainable energy practices and reduce external energy dependency. By generating electricity locally, Madrid decreases energy waste and its metabolic load of non-renewable resources, enhancing the city's energy self-sufficiency.

Additionally, Digital twins in Mercamadrid's power grid allow enable real-time monitoring of energy flows, identifying bottlenecks and suggesting optimisation opportunities. This advanced monitoring aligns with urban metabolic principles by ensuring resources are efficiently allocated and retained within the urban ecosystem. By incorporating tools to assess and adjust these flows, Madrid demonstrates how urban metabolism can be a fundamental strategy for reducing waste, improving sustainability, and building a more circular urban ecosystem prepared for future challenges.

Similarly, Dresden includes urban metabolism into its pilots, focusing on electrification and advanced energy management systems for public transportation and autonomous vehicles. By integrating electric buses and bidirectional EV charging infrastructure, Dresden aims to significantly lower emissions and create a sustainable energy flow within the city. These actions also reduce dependence on external non-renewable energy sources, creating a more circular energy system. This approach aligns with metabolic principles by ensuring is efficiently used, retained and reused rather than wasted.

The deployment of these EV infrastructures reduces Dresden's carbon footprint. Energy-measuring devices within transportation hubs, such as bus depots, provide valuable data on energy consumption patterns. This data enables Dresden to track, adjust, and maintain a low-waste, efficient ecosystem. Prioritizing renewable energy in public transport reinforces a circular approach to energy use. Dresden exemplifies the urban metabolism framework, using local resources to minimise environmental impacts and maximise resource efficiency.

The MOBILITIES for EU project also considers participatory urban metabolism by involving citizens in mapping and designing sustainable initiatives. Through the UT Labs, surveys and *Society* KPI analysis, this approach provides a platform for residents to engage in the transition to more balanced communities. Citizen involvement ensures that city-level planning aligns with neighbourhood-specific needs while encouraging sustainable behaviours among stakeholders.

Through these integrated urban metabolism strategies in both Madrid and Dresden, the MOBILITIES for EU project sets a model for resource conservation, resilience, and sustainability. The actions, including photovoltaic plants, electric transport systems, and energy-monitoring initiatives, provide transferable concepts to other cities within and beyond the project. These initiatives reflect a commitment to aligning urban infrastructures with ecological cycles, fostering healthier, self-sustaining urban ecosystems across Europe. Madrid and Dresden provide an exemplary blueprint for cities globally to advance towards a balanced and regenerative future.

2.4.7 LIFE CYCLE COSTING (LCC) AND LIFE CYCLE ASSESSMENT (LCA)

Life Cycle Costing (LCC) and Life Cycle Assessment (LCA) are essential methodologies for evaluating the long-term economic and environmental impacts of urban mobility and sustainability measures. While LCC focuses on the total costs associated with an intervention throughout its lifespan, LCA assesses environmental impacts, including emissions, resource use, and waste generated, from production to disposal. Together, these methodologies provide a comprehensive view of the sustainability and cost-effectiveness, supporting informed decision-making and long-term planning.

In this project, LCC and LCA measure the cost and environmental implications of each action within the evaluation framework. The diverse nature and scale of the pilot projects present challenges in applying these methodologies. To address these complexities, the project has developed guidelines and scenarios consistent and scalable assessments.

Life Cycle Costing (LCC)

LCC calculates the total cost of a project over its entire lifespan, accounting for initial capital costs, operational expenses, maintenance, and disposal. Many LCC-related concepts are integrated into the *Economic* KPIs, such as capital investment and operational costs. This financial analysis is applied to each pilot measure to ensure economic viability and resource optimisation.

LCC is particularly useful for evaluating urban mobility solutions requiring significant initial investments, such as electric vehicles or charging infrastructure. It balances upfront costs with long-term savings from lower fuel costs, reduced maintenance, and sustainable mobility incentives.

Challenges in applying LCC in this project include the small scale and experimental nature of several pilots, which may not fully capture long-term operational costs and savings. Site-specific requirements and local pricing structures also complicates standardisation of the LCC approach across all actions. To mitigate these challenges, the project suggests:

- **Scenario Analysis:** Evaluating alternatives for maintenance and frequency to estimate cost variability.
- **Upscaling Methodologies:** Extrapolating cost data from small-scale pilots to estimate city-wide implementation costs, offering insights into long-term economic impacts.

Life Cycle Assessment (LCA)

LCA examines the environmental impacts of a measure across its lifecycle, from production and usage to disposal. Factors such as energy consumption, emissions, material usage, and waste generation are assessed to determine environmental performance. These aspects align with the project's environmental KPI monitoring system.

LCA provides insights into how each measure contributes to environmental goals, considering impacts like CO_2 emissions, infrastructure optimisation, and energy consumption. For example, while EVs reduce local CO_2 emissions, LCA also examines the environmental impact of battery production, energy sources, and finally the recyclability and disposal.

Similar to LCC, applying LCA poses challenges given the small scale and varying nature of the pilot projects. Limited project durations and geographical restrictions can hinder the comprehensive evaluation of environmental impacts. Local variables such as energy sources and material availability, further complicate standardised assessments.

To overcome some of these challenges, partners employ:

- **Reference scenarios:** Using standardised emission factors across pilot sites (e.g., for electric vehicle emissions) to enable consistent comparison.
- **Extrapolation techniques:** Estimating the environmental impact of scaling up small-scale pilot results.

Example: Potential LCC/LCA analysis - EMT

Based on the project's LCC and LCA guidelines, the following example illustrates how these methodologies can be applied to two key actions in Madrid's pilots 3 and 4: an electric bus charging infrastructure and a green hydrogen fuelling station. A comprehensive evaluation of these systems is provided, focusing on the stages of the LCA from resource extraction to end-of-life disposal, allowing decision-makers to understand their ecological footprint and sustainability within Madrid's urban metabolism.

This section highlights the key stages and considerations involved in these two installations.

1. Electric bus charging infrastructure: The lifecycle of this infrastructure encompasses multiple stages, each addressing distinct environmental aspects associated with producing, operating, and dismantling the infrastructure:

- **Production and Construction:** Evaluates the environmental impact of manufacturing charging points and infrastructure installation, including raw material extraction (e.g., copper, steel, aluminium), production energy use, and material transportation to the site.
- **Operation:** Assesses electricity consumption for bus charging, focusing on energy sources (renewable vs. fossil-based), system efficiency, periodic maintenance, and replacement parts. It also considers emission reductions from replacing traditional buses s.
- **End-of-Life:** Examines infrastructure decommissioning, including waste disposal, recyclability of materials (e.g., copper), and hazardous waste management. Recycling metal components in chargers is for reducing environmental burdens.

- **Energy Distribution:** Analyses energy losses during distribution in the grid and the environmental impact of supporting infrastructure, such as substations and power lines.

2. Green Hydrogen Fuelling Station: The lifecycle includes unique phases related to hydrogen production and use:

- **Production and Construction**: Covers the production of electrolysis equipment, storage tanks, compressors, and renewable energy installations (e.g., solar panels). Key materials include steel, membranes, and catalysts (e.g., platinum).
- **Operation:** Focuses on energy consumption for hydrogen production via electrolysis, potential direct emissions (e.g., hydrogen leaks), storage impacts, and equipment maintenance, such as membrane replacements.
- **End-of-Life**: Considers equipment decommissioning, material disposal, and recycling potential (e.g., platinum from electrolyser membranes).
- **Hydrogen Distribution:** While typically included, this step is not relevant to this action due to its localised nature.

Commonly in both actions and LCC/LCA processes, the renewable energy sources powering installations will be evaluated, particularly their integration with new solar or wind plants. Moreover, the life cycle of electric and hydrogen buses may be evaluated to capture their environmental implications. Social and economic impacts, such as the benefits from emission reductions, job creation in renewable energy sectors, and public health improvements from reduced pollution, will also be considered. These insights will help align the actions with Madrid's sustainable urban metabolism and long-term environmental goals.

By employing scenario analysis, upscaling methodologies, and reference standards, the findings from each pilot will inform scalable strategies for long-term urban mobility plans and policy decisions. LCC and LCA thus serve not only as project evaluation tools but as essential components of sustainable urban planning that align with the environmental and economic goals of the MOBILITIES for EU project.

2.5 Process evaluation

During the bilateral meetings with the cities, it was made clear that KPIs' measurements should be done both before and after the MOBILITES for EU actions' implementation. Moreover, over the course of WP3, the process to define and obtain each KPIs target values and baseline was developed, including both the current values and the expected outcome of each action.

In this subsection, the deliverable will delve into the process considered to apply the impact evaluation framework to the actions. Special focus is placed into the approach considered to process to gather the values for the KPIs presented in the subsection 2.4.4, and to compare them, considering the initial information that can be obtained, and how it will be compared with the final results obtained. Moreover, as part of the WP3, monitoring considerations are being introduced as well as the frameworks that are being developed. Finally, we will comment the performance evaluation system that will be followed once the pilots are finalized, as part of the evaluation framework.

The first step in the process evaluation consisted in determining the baselines and targets of the KPIs.

Setting the baseline and target values is an important step, as the aim is to provide a clear and accurate snapshot of the systems before the actions, allowing us to assess the true impact of our interventions. To determine the most appropriate value information, the following considerations were considered:

- **Data Availability:** One of the primary factors considered was data availability. We agreed to KPIs for which the partners have or could obtain comprehensive and reliable data. The suggestion was to use data recent enough to reflect the current conditions in each scenario and when possible, and the

context in which the interventions will take place. In the situations where the measures were very innovative.
- **Frequency:** The interval at which information can be obtained is crucial for the correct monitoring of this project. As such, during the process of determining baselines and targets, partners are asked to provide information of the frequency at which they will be able to obtain information for each KPI.
- **Qualitative KPIs:** We contacted partners to give us information about their current situation in terms of this type of KPIs, however, as actions implemented are based on new pilots, most initial values were kept as non-existent. For this KPIs, the target proposed would have a more important role, and would be the value at which partners aspire to get with those KPIs.

Overall, the discussions with the cities and partner's representatives were crucial, as the latter provided useful insights into the most appropriate baselines and targets based on the specific mobility context and recent developments in the city. Notably, for most of the actions recent data have been used. However, given the nature of the novelty of some pilots and actions, no baseline was available to use as a comparison with the target in some of these cases.

It is worth mentioning that, in the cases where it was possible to obtain, partners were asked to provide the baseline data before the application of the action, or information to compare future values. Moreover, it was also required to provide the expected target after the actions, to give an idea of the outcome of the actions after the implementation for each KPI.

Afterwards, during the initial phases and the operation of the pilots, partners will obtain information for the KPIs, subject to their availability and their limitations in terms of the frequency at which data can be obtained or estimated. Finally, partners are asked to provide with the final value of those KPIs at the end of the actions, which will give us a value to compare with the initial target that was proposed.

These are determined in collaboration with the pilot's representatives to ensure that target values align with the cities' goals and priorities, as well as with the actions to be implemented.

As introduced in the methodology section of the impact evaluation, the final values of the quantitative KPIs will be generated from two main data sources:

- **Outcomes of the MOBILITIES for EU cities' implementations:** This source involves collecting data directly from the partners where the pilots and interventions have been implemented. It encompasses real-world observations and measurements of the mobility interventions and their effects. Data may be collected through various methods, including sensors, questionnaire surveys, data collection from existing databases of the city (e.g., municipalities, transport operators) and monitoring systems.
- **Transport modelling and simulation outcomes:** This involves the use of transport models and simulations to predict how mobility interventions will affect the transportation system. Such tools will be developed as part of the actions in some pilots depending on the complexity of the data collection.

These same requisites would be applied in the different stages of the pilots. After the initial values of baselines and targets, frequency would have more importance, as well as the final result. As such, the information of said values would be further explored in future deliverables. In the Figure 15 we can observe a description of the stages of the project and the pilots from the point of view of the actions to be implemented. In each step, we will be considering the baselines and targets needed at the beginning, the monitoring during the implementation and the frequency of the data to be obtained, and final result at the end of the operation.

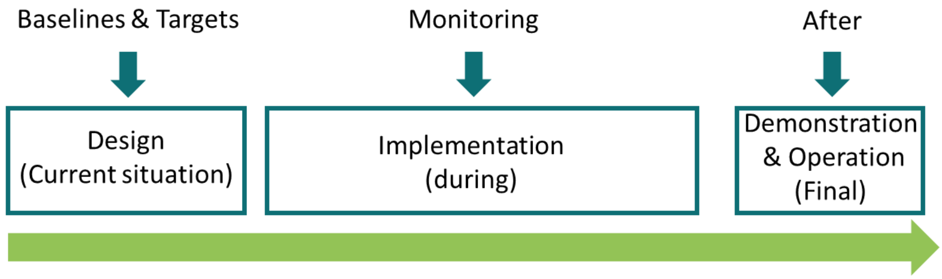


Figure 15. Description of the stages of the project from the point of view of the actions.

2.5.1 APPLICATION AND OPERATION OF THE EVALUATION FRAMEWORK

In this project, process evaluation helps to understand how each measure is implemented and operates, providing insights that are vital for determining success factors and identifying potential barriers. The evaluation framework for this project places special emphasis on the KPI selection, the monitoring and the analysis across multiple levels, from individual measures to integrated packages in pilots, and across the entire cities. This approach ensures a robust and systematic evaluation of both implementation processes and outcomes, allowing us to draw meaningful conclusions that inform long-term urban mobility strategies.

The approach in the process evaluation examines the whole cycle of a measure, from initial design and planning to implementation and operation, even considering known information previous to the measures. By focusing on this progression, the evaluation provides a clearer picture of the steps and decisions that contribute to a measure's success or, conversely, reveal obstacles that hinder its effectiveness. This approach helps answer fundamental questions, such as:

- Why did certain measures succeed or fail? And How?
- What role did supporting activities, such as stakeholder engagement play in shaping the impact of a measure?
- How did the specific characteristics of each measure's urban context affect its implementation?

In addition to assessing the individual phases of each measure, the process evaluation considers the influence of supporting activities that may enhance the measure's acceptance and effectiveness. These activities, such as participatory planning, information campaigns, or collaborative decision-making, are key to creating a sustainable impact and would be further analysed and implemented in following stages of the project. For instance, engaging stakeholders early in the design phase can address potential barriers, and provide greater support and acceptance of the measures.

To ensure consistency, the evaluation framework provides structured guidelines applicable to all actions and pilots covering:

1. **Evaluation Approach:** A common evaluation approach ensures that each measure's outcomes are equivalently analysed through a similar lens, fostering transparency and facilitating cross-site comparisons.
2. **Indicators:** Standard indicators measure the direct impacts of the measures while allowing cities to introduce additional indicators that may be relevant to their unique urban contexts.
3. **Measurement Methods:** Clear and consistent measurement methods help ensure that the data collected across sites is comparable, accounting for context-specific variations.
4. **Monitoring:** By monitoring the measures and the external factors that could influence mobility outcomes, such as demographic changes, economic factors, or infrastructure improvements, the project gains a comprehensive understanding of each measure's real-world impact.

In the MOBILITIES for EU evaluation framework, each partner responsible for individual pilots and actions is tasked with providing comprehensive data for each relevant KPI from the described category list. This established data gathering process enables clear, measurable insights which can be directly connected to the impact of each action. For each partner a data structure has been provided where the first elements for each data entry are provided, and as already described in the indicators section, include the name, description, units, category and applicable actions for each agreed KPI. Then, for each one of those KPIs, the following key data points are required to each partner to ensure a robust and consistent evaluation:

1. **Before:** This captures the baseline value of each KPI before the implementation of the action. This initial data serves as the reference point, providing critical context for assessing the actual impact and effectiveness of each action over time.
2. **BAU (Business-as-Usual):** Each partner is required to estimate the KPI's projected value at the end of the implementation period, assuming no intervention was made. This business-as-usual projection offers a hypothetical scenario that helps isolate the specific impacts of the implemented actions by contrasting expected natural progress against actual results.
3. **After:** This value will be recorded following the completion of the action implementation. It reflects the KPI's actual outcome post-intervention, allowing for direct comparison with both the baseline and business-as-usual projections.
4. **Monitoring System:** To ensure data quality and comparability, each partner documents the methods used for data collection, aspects already described in section 2.3.5 of this deliverable, along with the monitoring frequency. This includes specifying the monitoring tools or systems, data sources, and periodicity of data recording. This transparency in methodology ensures that data collected across different pilots and actions are consistent and can be confidently interpreted within the whole project evaluation.
5. **Target:** Each partner defines an expected target value for the KPI post-implementation, indicating the desired outcome or improvement anticipated from the intervention. This target provides a measurable goal against which actual outcomes can be assessed. It supports the evaluation of each action's effectiveness.

This structured approach for KPI data reporting, which can be observed in Table 8, allows for a detailed standardized assessment across the MOBILITIES for EU project, provides a clear before and after comparison and promotes a consistent tracking and reporting of action impacts. By comparing those values, along with detailed monitoring methodologies, MOBILITIES for EU partners can accurately evaluate each action's effectiveness, adapt processes as needed, and generate insights for future mobility improvements.

Table 8. KPI data structure evaluation

KPI	Before	BAU (Business-as-usual)	After	Monitoring System	Target
Information provided about the indicator, units, category and applicable action	Value before the implementation of the action	Projected value achieved without any actions by the end of the implementation	Value recorded after the implementation of the actions	Method of data collection and frequency	Expected value after the implementation of the actions

The evaluation framework and the KPIs presented for this project and which represent the basis of the success of the actions, include key concepts in a similar way to the CIVITAS thematic areas, such as:

- Organisational and infrastructural mobility measures: Car-Independent Lifestyles, Collective Passenger Transport, Clean Fuel, Zero Emissions, Energy Efficient systems, Urban Freight Logistics.
- General aspects of the mobility system: Safety and Security, infrastructure design and efficiency, shared space and secured paths.
- Technological support of the mobility systems: Transport Telematics, Intelligent Transport Systems and communication.
- Measures directly working on the users' acceptance and attitude and their travel demand: Integrated Planning, Sustainable Urban Mobility Plans, Mobility Management and Public Involvement – multi-stakeholder consultations, information campaigns, participatory processes

2.5.2 PLANNING AND MONITORING OF THE EVALUATION FRAMEWORK

Effective monitoring is essential for understanding how and why various actions occurred. By keeping track of the actions and KPIs, we can create a reference point especially valuable for more complex projects. This framework helps to identify crucial factors that will shape the project implementation and final results.

To plan and organise the process evaluation work, a pre-analysis of the measure should be done in order to have a clear view on the elements important for the implementation of the measure. Several guiding process evaluation questions can be used to examine the process and can be considered before and during the monitoring.

1. Which obstacles may arise during the reporting period, and what actions can be taken by project partners to overcome these barriers?
2. What elements may help advance the project goals and the measure's objectives?
3. How can project risks impact the implementation, and what risks remain in the path to meeting project objectives?

During the different stages of the measure, it is essential to monitor all relevant events and reflect regularly and critically to understand what has happened and why. There are different techniques that can be employed to monitor the implementation process, ensuring comprehensive tracking and evaluation of activities. Some of them include:

1. **Event Logbook:** a document that remarks significant events during the implementation, with comments on their relevance and impact, and that can reveal how specific actions impacted the project's progress.
2. **Milestone Tracking:** Monitoring relevant milestones established during the project setup helps in evaluating whether the project is advancing as expected and identifying points of delay or acceleration.
3. **Project Management Data:** Additional project management information, such as timelines, resources, and schedules, offers a broader understanding of operational contexts impacting the project's flow.

Periodic evaluations at key points in the project allow partners to reflect on the implementation process, assess current progress, and adjust strategies to benefit the outcomes of the project. This evaluation is essential to ensure a good alignment with objectives and improving project trajectory. These periodic evaluations can occur at different stages and follow two main approaches:

1. **Stage-Based Evaluation:** Evaluation can occur at the end of each project stage, such as after planning, execution, or closing. This allows for a focused review of the process within a specific phase.
2. **Fixed-Time Evaluation:** To gain a broader perspective on the project, evaluations may also take place at pre-determined times throughout the project's lifespan. For example, the CIVITAS proposes projects to conduct formal evaluations at 20, 38, and 44 months, aligned with their administrative reporting schedule. These times will depend on the characteristics of the projects, and in our case, in the lifespan of the pilots and the actions.

Evaluations at both city and project levels can further support adaptive project management, highlighting opportunities for improvement clear understanding of factors influencing implementation. Depending on the characteristic of the KPI, one, the other, or a combination of both approaches can be used to determine the best periodic evaluation. However, as a general approach, most of the KPIs will be subject to fixed-time evaluations, giving some room for strictly staged actions, and qualitative KPIs (Society Category), which might require external elements to be evaluated, such as the use of surveys. Nevertheless, partners are asked to provide a frequency timing for the monitoring to adjust to the best approach in each KPI and action.

The monitoring methods presented can be adjusted for each partner and their management practices. However, it's important to keep a good balance between the depth of the monitoring and its practical value. Collecting extensive data can be time consuming, so the process should remain efficient and directly beneficial to understanding and improving the implementation. For that reason, following the initial data structure provided to gather initial information about the KPIs per action, MOBILITIES for EU is considering and developing a data framework to support an efficient data gathering during the monitoring of the actions. T-systems in Madrid, and SAP in Dresden, are closely working on providing a data structure where partners can include and share their data collected for each pilot. Partners are encouraged to keep track of their actions using the presented activities, and provide the monitoring frameworks with the required KPI values. In the following section, we provide with the key concepts of those frameworks.

2.5.3 MONITORING FRAMEWORK

A robust monitoring framework is essential to systematically monitor and evaluate the progress of KPIs in the MOBILITIES for EU project. This framework ensures consistency, transparency, and accuracy in data collection and interpretation across project actions, creating a unified approach for the diverse data inputs from various partners. By establishing standardized data spaces and structured formats for sharing, storing, and referencing information, the monitoring framework optimizes data use between partners, particularly in relation to shared or similar actions in Madrid and Dresden (LCs). It will have a significant impact specially during the implementation of pilots and in the monitoring stage of the project, with the task and deliverable 3.2.

The framework outlines the necessary data quality standards, frequency of reporting, and procedures for data verification to ensure all partners have a similar and cohesive approach. Through this standardized approach, partners can easily capture changes in KPI values at the same time that they can accurately align the progress with project targets. The framework also allows to keep in mind information about “Before,” “BAU (Business-as-usual),” and “After” stages of each action, including baselines and targets for each KPI.

Considering centralized data spaces is a key aspect for the monitoring framework. They function as repositories where all project data is stored, organized, and made accessible to relevant stakeholders. These data spaces can be designed with structured formats to categorize information by city, action, KPI, and reporting period, thus enabling partners to locate and reference data with ease. In addition, the data spaces facilitate real time data sharing between all partners in both cities, Madrid and Dresden, allowing them to access information on similar measures being implemented independently of the city.

This is particularly beneficial for actions with transversal applications, such as the deployment of electric vehicle (EV) infrastructure or the optimization of public transport systems, as partners can directly refer to data on related KPIs. As a result, the project benefits from a continuous cycle of learning and innovation, contributing to the shared sustainability goals of both Madrid and Dresden.

As part of the actions in the project, T-Systems (pilot 5 in Madrid) and SAP (pilot 5 in Dresden) are collaboratively working towards the creation of monitoring platforms that can be used to track KPI data in their respective cities. Both platforms face similar requirements in terms of data management, data types and platform user's, however, those will depend on the specifics of each city's partners and actions. By collaboratively working, we can ensure a more efficient development of tasks, the mutual benefit in facing similar challenges, and providing a resulting framework which can be similar in both cities.

T-Systems is developing a comprehensive monitoring framework centred on the use of data spaces through a Data Intelligent Hub (DIH), designed to drive data accessibility, control, and analysis for the MOBILITIES for EU project. The DIH serves as a centralized marketplace for secure and reliable data exchange, enabling partners to share and utilize project data while ensuring data sovereignty and control for each participant (Figure 16). This structure emphasizes the importance of data harmonization and accessibility across diverse datasets, supporting the use of analytics and AI to generate new insights. By allowing access to a rich pool of data in a collaborative workspace, T-Systems' DIH facilitates the creation of innovative business applications that leverage shared knowledge. The solution is cloud-agnostic, enabling portability and interoperability, and is compliant with EU standards such as GAIA-X, EIDAS, JWT, ISO, and ETSI. These attributes together establish a robust data infrastructure that not only supports the project's monitoring needs but also lays a solid foundation for future smart city initiatives.

Figure 16. Data Intelligent Hub as a data space for the Monitoring Framework of T-Systems (T-Systems – Smart Cities World Congress 2024)

With the DIH, T-Systems also introduces a valuable opportunity for Madrid to implement a city-wide data space that enhances the exchange of energy and mobility information, enabling the development of impactful services for citizens and businesses. Among the services identified in the DIH marketplace are:

- Energy Marketplace, which can help users consider the supply and demand of electricity in real time, and identify more efficient vehicle charging patterns
- KM 0 Carbon Footprint and Proximity Products, which helps localize and minimize emissions
- Dynamic Allocation of Recharging Points, allowing for optimized and responsive electric vehicle charging infrastructure.

Through a series of collaboration and data-sharing workshops, T-Systems can identify strategic dimensions and ecosystem players, promoting a structured, cooperative approach to data sharing. This hub-based approach, can emphasize the use urban data-sharing frameworks, promote sustainability, and drive the creation of new services aligned with the city's energy and mobility goals.

The proposal by SAP for the monitoring framework leverages SAP Business Technology Platform (BTP) to provide an integrated and accessible dashboard for monitoring project performance. SAC enables customized, dynamic views of each KPI, with the capacity for trend analyses and projections, helping project partners from Madrid and Dresden, for instance, to assess progress on shared initiatives like electric vehicle infrastructure and clean energy measures. This unified visualization platform enhances the decision-making process using real data, and facilitates cross-city comparison of similar project actions.

Moreover, SAP Datasphere serves as the data integration and management foundation within BTP, which can consolidate diverse data sources into a structured environment that ensures consistency and quality across the project's KPI datasets. SAP Datasphere facilitates transparency in data storage and accuracy, particularly important in managing complex environmental and economic KPIs that may require estimation models or simulation adjustments. These two services from BTP will be considered to be the foundation of the framework that enables partners to monitor, manage, and analyse data.

To determine the data architecture and elaborate the platforms, some information will be obtained from the partners regarding their own data structure and data gathering aspects within the implementation and evaluation of their actions. Some of which is being discussed in this deliverable and will be extended and clarified with the collaboration of partners and stakeholders:

- Data Sources, availability of technical integrations and manual input
- Data Types involved and data privacy or security requirements
- Calculation Requirements within the input values and the logic behind the data model
- Frequency of KPI data updates
- User Roles and List of groups who will access the dashboard

The monitoring framework will have a crucial impact in the implementation and evaluation of actions. Data spaces and structured data management tools form a comprehensive system for managing and evaluating the KPIs within the MOBILITIES for EU project. This system not only ensures accuracy in KPI reporting but also helps to promote sharing of knowledge and collaboration between cities, reinforcing the project's goal of progressing towards sustainable urban mobility across European cities.

2.5.4 PERFORMANCE EVALUATION

The process evaluation activity is a critical procedure of the general evaluation and is related to the assessment of how mobility measures and initiatives are planned, implemented, and managed within the project's demonstrations

This evaluation activity focuses on understanding the process followed by each city and aims to answer questions related to how well the activities were executed, what challenges were encountered, and what lessons can be learned from the implementation process itself. For many projects it is important to assess the achievements and performance of the project itself, also in relation to the resources and funds used for it.

Specific objectives could be:

- To monitor and check whether a project or a work package fulfils its objectives.
- To identify the effect(s) of specific activities in the project.
- To identify the effect(s) of the project on the take-up of the actions.

The use of a common framework and terminology across all sites facilitates the interpretation and comparison of data, strengthening the reliability of conclusions. The process evaluation in this project is structured around several levels:

1. **Action Level:** At this foundational level, data is gathered on specific indicators affected by each individual action. For instance, an action designed to reduce car dependency through cycling infrastructure would focus on tracking metrics such as cyclist count, reduced car usage, and public satisfaction. This level forms the basis for all other evaluations, focusing on the direct area and target group influenced by the measure.

2. **Pilot Level:** This level involves evaluating groups of measures implemented with common objectives or target groups. For instance, a mobility measure to reduce emissions may be evaluated alongside measures aimed at improving the energetic efficiency of the infrastructure or a platform to improve connectivity and accessibility. The goal is to understand which measures complement each other and assess the combined impact of these pilots.

3. **City Level:** At the city level, evaluation monitors broader indicators which can reflect mobility changes across the entire city or large areas. This includes city-wide data collection campaigns and surveys that provide baseline and trend data on the urban mobility landscape. This level captures trends beyond the immediate impact of individual measures, accounting for influences from other external factors or general changes in the mobility context.

This multi-layered approach allows the project team to draw conclusions that reflect not only the effectiveness of individual measures but also the cumulative impact on the broader urban environment.

As mentioned in the Process Evaluation - Approach section, each action of the project undergoes process evaluation across three phases, which have specific emphasis on key ideas. These stages are not rigid; some projects, particularly those with overlapping design and implementation elements, require flexibility in defining the phase boundaries:

1. **Design Stage:** This phase includes idea generation, planning, and design development. Potential barriers are identified early on, and stakeholder engagement activities are conducted to improve acceptance and mitigate obstacles. By the end of this stage, all necessary planning details are finalized.
2. **Implementation Stage:** In this phase, measures are brought into real world settings. Information campaigns may be conducted to prepare users for the change, and progress is carefully monitored to ensure that milestones are met.
3. **Operational Stage:** Once operational, measures are opened to the public. Continuous monitoring and, where applicable, supplementary campaigns, help maintain user engagement. At this stage, the measure's impact becomes evident, allowing for final adjustments if necessary.

These concepts are considered in the specifics of the framework presented. Given the data structure for the KPIs and actions, the first step consists on obtaining the baselines and targets, during the design stage, and compare them to get insights on the expected benefits that can be obtained or expected by the development of the actions. Moreover, given the requirements and limitations of the data collection of partners, once the information is obtained, partners would also provide the methodology used and the frequency at which the information would be obtained during the implementation. In the second stage, we should ensure that partners are providing regular data using the platforms developed for such purpose, to draw reliable insights of the implementation Finally, in the third stage of each action, the performance evaluation concludes with the comparison between the final values of each indicator and the initial baseline, to assess the impact of the interventions.

The conclusions drawn from process evaluation are based on findings at multiple levels, providing insights into a range of policy and strategic questions. Those can come from the individual action level, to the integrated pilots, city level and finally, given the similarities between actions in both leading cities, conclusions can also come from a cross site level, maximizing the project's relevance and impact. However, the process evaluation can also present major challenges, such as accounting for the complex, dynamic nature of urban environments; and acknowledging the implications of the small scale of some pilots, where short timeframes and limited geographical reach can limit the applicability of findings. However, by setting up reference scenarios and standardizing indicators across cities, the project overcomes these limitations, enabling reliable upscaling and more accurate interpretation of results.

Process evaluation is the final step of the evaluation framework of this project with the approach to assess the effectiveness and replicability of urban mobility measures. It shows a consistent structure that is set to consider not only the measures' immediate impacts, but also to provide with deep insights into the conditions and activities that support the successful implementation of innovative actions. By combining these findings with the impact evaluation, the project generates valuable recommendations that contribute to sustainable urban mobility practices across diverse European contexts, presenting solutions that are scalable, adaptable, and beneficial for cities aiming to improve their mobility systems.

3. Conclusions

The MOBILITIES for EU project represents a concerted effort to transform urban mobility across Europe, with a focus on sustainable, accessible, and efficient transportation. Through the deployment of eleven pilot projects in Madrid and Dresden and the engagement of five replication cities, the initiative contributes significantly to the European Climate-Neutral and Smart Cities Mission. Addressing urban congestion, environmental impact, and accessibility, the project adopts a structured approach centred on measurable objectives, systematic evaluation, and cooperative improvements. The project prioritises environmental, transport, energy, social, and economic Key Performance Indicators (KPIs) that measure progress across mobility, public engagement, energy efficiency, and environmental impact, supporting the European Commission's goal of achieving carbon neutrality by 2030. By leveraging both quantitative and qualitative metrics, MOBILITIES for EU creates an adaptable framework that supports local governments, stakeholders, and citizens in achieving these goals.

The project's evaluation framework, adapted from the CIVITAS Evaluation Framework and incorporating principles from the Cities Mission Platform, SUMI, 2Zero, and CCAM projects, provides robust structures for assessing both project processes and impacts. Key steps within the evaluation process involve determining KPIs for each action, gathering baseline data, establishing KPI targets, and measuring post-implementation changes to quantify the effects of each action. The defined KPIs cover diverse areas, including reductions in CO_2, NOx, and PM emissions, energy usage, stakeholder cooperation, and public satisfaction, creating a foundation for assessing both immediate and long-term outcomes.

This KPI-driven methodology ensures consistent definitions and data measurement standards across cities, facilitating comparability of actions. Projections of business-as-usual (BAU) scenarios are included to capture both anticipated and actual impacts. Pilot project partners contribute specific data, enabling the evaluation framework to map how each action contributes to MOBILITIES for EU's overarching goals.

The careful selection of indicators has been crucial in accurately tracking and evaluating progress. Indicators are directly tied to project objectives, such as reducing environmental impacts, increasing public transit use, and enhancing urban accessibility. Designed for flexibility, these indicators accommodate different urban contexts, allowing cities of varying sizes and infrastructure capabilities to monitor and adjust their specific implementation measures effectively.

The evaluation approach combines quantitative data, gathered through environmental sensors, usage statistics, and other digital tracking tools, with qualitative insights from stakeholders, users, and implementation leaders. This dual approach provides a comprehensive understanding of each action's impact and interactions within the urban ecosystem that may not be immediately evident through quantitative data alone.

To enhance learning and knowledge-sharing, the framework includes the collection, synthesis, and analysis of information across the project's planning, execution, and closing phases. This continuous improvement process captures actions and outcomes, translating them into learnings that could guide future urban mobility initiatives.

Process evaluation centres on understanding implementation barriers, drivers, and the quality of supporting activities, including public communication and stakeholder engagement. By monitoring these activities, each city can identify significant influences on the project's progress, from policy support to logistical challenges in data collection. Feedback mechanisms, including surveys and regular milestone evaluations, enable the team to make informed adjustments, reinforcing adaptability as a core project strength.

The MOBILITIES for EU initiative demonstrates substantial progress toward achieving climate-neutral urban mobility by:

- **Reducing Pollution and Enhancing Public Health:** KPIs focus on emission reductions (CO_2, NOx, and PM) and noise levels, addressing public health and environmental sustainability.
- **Improving Energy Efficiency and Adoption of Renewable Sources:** The project measures energy consumption and sources, aimed to increase renewable energy usage to minimise carbon footprints.
- **Innovating in Transportation Mobility:** Actions include advanced technologies such as autonomous vehicles (AVs), bidirectional charging infrastructure, and e-buses, with transport KPIs assessing their impact.

- **Societal Engagement and Stakeholder Collaboration:** Public surveys and stakeholder feedback loops ensure alignment with public acceptance, awareness, and satisfaction.
- **Economic Impact:** Monitoring economic KPIs (e.g., capital investment, operational costs, and pollution cost savings) reflects the financial sustainability and economic benefits derived from improved environmental outcomes.

While the evaluation framework has provided a clear path for monitoring, several challenges have emerged, particularly in collecting data for environmental indicators requiring complex estimation models for emission scopes and scaling localised pilot results to broader urban contexts. Advanced modelling and simulation techniques are necessary to predict larger impacts effectively.

MOBILITIES for EU is well-positioned to offer valuable insights for future urban mobility initiatives across Europe. By developing an integrated evaluation framework and fostering collaboration between cities and industry partners, the project sets a new standard for data-driven, citizen-centred urban mobility planning. Its insights and methodologies serve as a valuable resource, guiding efforts to create sustainable, inclusive, and efficient urban mobility solutions.

Future recommendations include:

- **Enhanced Data Sharing Infrastructure:** Developing a centralised data hub to store, process, and share insights across all cities and partners to facilitate comparative evaluations.
- **Focus on Replication and Scalability:** Building tools based on the successes and challenges in Madrid and Dresden could support replication cities in customising their own climate-neutral mobility plans.

In conclusion, MOBILITIES for EU demonstrates that a strategic, data-driven approach to urban mobility can support positive and sustainable changes. The project delivers actionable and replicable strategies that meet immediate mobility and environmental goals while laying a strong foundation for the continuous transition toward climate-neutral urban ecosystems. By leveraging a flexible, multi-level evaluation framework and robust monitoring process, the project offers invaluable insights for other cities aiming to implement similar actions. With continued attention to monitoring, evaluation, and stakeholder engagement, the findings from MOBILITIES for EU lay the basis for sustainable urban transportation practices across Europe.

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5. Annexes

Annex 1: Proposal of emission scopes for the actions in Madrid and Dresden:

Madrid

PILOT 1: Autonomous e-vehicles within Mercamadrid for goods and people

A1.1: Autonomous E-buses in Mercamadrid Area for People

Summary: This activity involves demonstrating a mid-size autonomous electric bus service for passenger transport in the Mercamadrid area, focusing on full automation and electrification of routes and mobility systems.

- Scope 1: No final direct emissions, compare with baseline, if possible, as the bus is electric.
- Scope 2: Applicable for emissions from the electricity used to charge the e-bus.
- Scope 3:
    - Upstream emissions from production and maintenance of the e-buses, batteries, and infrastructure.
    - Potential downstream emissions from changes in transport patterns.
    - End-of-life emissions related to disposal or recycling of buses and batteries.

A1.2: Automated Guided Vehicle for Waste Collection at Mercamadrid

Summary: This involves demonstrating a fully automated electric tow tractor for waste collection at Mercamadrid, including automated operation of trolleys, sensors, and a 5G-connected management system to improve efficiency and reduce emissions.

- Scope 1: No final direct emissions, compare with baseline if possible (vehicles are electric).
- Scope 2: Applicable for emissions from the electricity used by the vehicles and IT infrastructure.
- Scope 3:
    - Upstream emissions from the production of vehicles, sensors, batteries, and 5G infrastructure.
    - Emissions from production and maintenance of IT and connectivity equipment.
    - End-of-life emissions from disposal of vehicles, batteries, and electronic components.

A1.3: Last Mile Autonomous Electric Transport for Food Markets

Summary: This activity involves deploying an autonomous electric tow tractor to enhance last-mile delivery in Mercamadrid, using advanced technologies like AI, 5G, and IoT for intelligent urban space management and improved transport security.

- Scope 1: No final direct emissions, compare with baseline if possible (electric vehicles with no direct emissions).
- Scope 2: Applicable for emissions from electricity used by the tow tractor, intelligent signalling, lighting, and other supportive infrastructure.
- Scope 3:
    - Upstream emissions from manufacturing the tow tractors, urban infrastructure, and supporting technology.
    - Changes in logistics, potentially reducing conventional vehicle use.
    - End-of-life emissions for disposal or recycling of vehicles and tech components.

A1.4: Development of 5G Private Mobile Network Services in SA for CCAM Connectivity

Summary: This activity focuses on designing and operating a 5G Private Mobile Network to support connectivity for autonomous and connected mobility solutions in Mercamadrid, leveraging advanced network technologies for reliability and scalability.

- Scope 1: No final direct emissions, compare with baseline if possible, unless involving on-site generators or similar sources.
- Scope 2: Applicable for emissions from the electricity needed to power 5G network components, such as servers and network nodes.
- Scope 3:
    - Upstream emissions from the production of 5G hardware, servers, and network components.
    - Emissions from installation, operation, and maintenance of the network.
    - End-of-life emissions from disposal or recycling of 5G equipment and related components.

PILOT A2: RES-BASED POWER GRID AND V2G CHARGERS IN MERCAMADRID

A2.1: Distributed Smart Grid for Eco Transportation

Summary: This activity involves installing a 700 kWp photovoltaic (PV) plant on Mercamadrid rooftops to supply green energy to a battery system and 7 vehicle-to-grid (V2G) bi-directional chargers, supporting last-mile transportation decarbonization.

- Scope 1: No final direct emissions, compare with baseline if possible (no direct emissions since the system uses renewable energy).
- Scope 2: Applicable for the emissions from the production and installation of the PV plant and batteries if sourced from the grid.
- Scope 3:
  - Upstream emissions from the manufacturing and installation of the PV panels, batteries, and V2G chargers.
  - Emissions from the software development and IT infrastructure used for real-time energy management.
  - Downstream emissions related to the lifecycle of the batteries and PV panels, including recycling or disposal.

A2.2: Digital Twin and Power Grid Management for Flexibility

Summary: This activity focuses on using digital twins and IT solutions to manage Mercamadrid's power grid, enhancing grid capacity and integrating more devices by optimizing electrical flexibility.

- Scope 1: No final direct emissions as there are no direct emissions from these digital and IT-based activities.
- Scope 2: Applicable for emissions from the electricity used by servers, data centers, and other IT infrastructure required to run the digital twins and grid management system.
- Scope 3:
  - Upstream emissions from producing digital infrastructure, software, and IT equipment.
  - Emissions from the lifecycle management of IT hardware, including disposal and recycling.
  - Potential downstream emissions reductions from increased grid efficiency and optimization of renewable energy use.

PILOT A3: EFFICIENT CHARGING AND ELECTRIFICATION OF PEOPLE AND FREIGHT FLEETS

A3.1: Electrification of 329 E-buses and Full Electrification of Carabanchel Bus Depot

Summary: This activity involves the electrification of the Carabanchel bus depot and switching 329 buses to electric, analysing the impact on emissions reduction at the city level.

- Scope 1: No final direct emissions, compare with baseline if possible, as electric buses do not emit GHGs directly during operation.
- Scope 2: Applicable for emissions from the electricity used to charge the e-buses and to operate the depot infrastructure.
- Scope 3:
  - Upstream emissions from the production of the e-buses, batteries, and charging infrastructure.
  - Emissions related to the construction and electrification of the bus depot.
  - End-of-life emissions from the disposal or recycling of buses, batteries, and infrastructure.

A3.2: Intelligent Sharing of Charging Infrastructure and Energy Between Vehicles

Summary: This action tests sharing charging infrastructure between people and freight vehicles in Mercamadrid, leveraging AI to identify available charging points and maximize capacity utilization.

- Scope 1: Not applicable, as this involves electric vehicles and shared infrastructure.
- Scope 2: Applicable for emissions from electricity used in shared charging points.
- Scope 3:
  - Upstream emissions from producing the shared charging infrastructure, software, and AI systems.
  - Emissions related to the increased efficiency in energy use and potential changes in fleet operations.
  - End-of-life emissions from the disposal of charging stations and associated tech components.

PILOT A4: IMPLEMENTATION OF H2 REFUELING STATION AND 10 H2 FUEL CELL BUSES

A4.1: Implementation of H2 Refuelling Station and 10 H2 Fuel Cell Buses

Summary: This activity involves deploying a hydrogen refuelling station (HRS) and 10 hydrogen fuel cell buses, analysing their impact on emission reductions and environmental impact at the city level.

- Scope 1: Applicable for direct emissions from hydrogen production if using methods that involve fossil fuels.
- Scope 2: Applicable for emissions from the electricity used to operate the HRS and related infrastructure if not fully supplied by renewables.
- Scope 3:
  - Upstream emissions from the production of hydrogen fuel cell buses and the HRS.
  - Emissions associated with the hydrogen production process (especially if not green hydrogen).
  - End-of-life emissions from disposal or recycling of the buses and HRS infrastructure.

PILOT A5: IMPLEMENTATION OF HIGH VALUE SERVICES

A5.1: Green Energy Data Space in Mobility for the Decarbonization of Madrid and Other Cities

Summary: This activity involves creating a digital twin and data space for green energy use in mobility, aiming to optimize energy usage and improve air quality across Madrid using open standards and modular building blocks.

- Scope 1: Not applicable, as it focuses on digital and data services with no direct emissions.
- Scope 2: Applicable for emissions from the electricity used by data centres and IT infrastructure supporting the digital twin and data space operations.
- Scope 3:
  - Upstream emissions from the production of IT equipment, data storage, and network components.
  - Emissions related to the development and maintenance of digital infrastructure.
  - End-of-life emissions from IT hardware and data infrastructure components.

Dresden

PILOT 1: Innovative and Space Saving e-Charging via Charging Robots

A1.2-A1.4: Charging robots

Summary: Two autonomous Volkswagen charging robot systems, each equipped with a 25 kWh battery, will be developed and tested to charge vehicles at their parking spots. This reduces the need for fixed charging stations and minimizes land use.

- Scope 1: No final direct emissions, compare with baseline if possible (no direct emissions from robot operation).
- Scope 2: Applicable for emissions from electricity used to charge the robots and batteries.
- Scope 3:
  - Upstream emissions from manufacturing the robots, batteries, and associated infrastructure.
  - Emissions related to the software and communication systems used to manage and navigate the robots.
  - Downstream emissions from the disposal or recycling of robots and batteries.

PILOT 2: Infrastructure Assisted Automated Connected Driving via Control Center and Mobility Data Space

A2.1: Infrastructure assistance Automated Connected Driving (Control Center)

Summary: Installation of smart sensor systems and communication devices at an intersection, with a control center for safe and efficient autonomous driving of vehicles and protection of vulnerable road users (VRUs).

- Scope 1: No final direct emissions.
- Scope 2: Applicable for electricity used by the control center, sensors, and communication devices.
- Scope 3:
  - Emissions from the production and installation of sensors, communication devices, and IT infrastructure.
  - Emissions related to data processing and operation of the control center.

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A2.2: Mobility Data Space for Automated Connected Driving
Summary: Development of a decentralized data ecosystem for automated driving, integrating data assets like vehicle states, traffic flow, weather, and infrastructure information to support safe autonomous fleet operations.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by data servers and communication systems.
- Scope 3:
  - Emissions from the production of IT infrastructure and data management systems.
  - Emissions from data processing, storage, and secure exchange mechanisms.

PILOT 3: Development of Traffic, Transport, and Operator Concepts and Establishment of Business Models

A4: Autonomous e-vehicles for freight
Summary: Development of autonomous small-scale freight transport e-vehicles and Smart Energy Tower/Charging stations for logistics of food and beverage delivery in sports facilities.

- Scope 1: Not applicable (electric vehicles).
- Scope 2: Applicable for emissions from electricity used by the e-vehicles and charging stations.
- Scope 3:
  - Upstream emissions from manufacturing e-vehicles, charging stations, and other infrastructure.
  - Emissions from the operation and maintenance of the autonomous transport system.

A5: Feasibility study for 2 routes for autonomous e-vehicle for passengers
Summary: Analysis of routes and feasibility study to tender autonomous mobility (i.e., 2 vehicles) as part of a plan to integrate different sports facilities and improve the access into the district.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from the electricity used by the e-vehicles and charging stations infrastructure.
- Scope 3:
  - Emissions from manufacturing e-vehicles, charging stations, and other infrastructure.
  - Emissions from the operation and maintenance of the autonomous transport system.

A6: Mobility concept for the district with focus on intermodal mobility / bike usage
Summary: Establish Ostra District as a gateway to the city center and offer intermodal transport services. App- and gamification-based initiatives to promote cycling and intermodal transport services.

- Scope 1: No final direct emissions.
- Scope 2: Not significantly applicable (focus on digital services).
- Scope 3:
  - Emissions from the development and maintenance of the app and digital infrastructure.
  - Potential emissions reductions through increased use of bicycles.

PILOT 4: Mobility of People: Electrification of the Public Bus Fleet and Configurable e-Car

A7: Electrification of the Public Bus Fleet
Summary: Continuous electrification of Dresden's public bus fleet, with MOBILITIES FOR EU evaluating performance, environmental impact, and social acceptance.

- Scope 1: No final direct emissions, compare with baseline, if possible, electric buses.
- Scope 2: Applicable for emissions from electricity used to charge the buses.
- Scope 3:
  - Upstream emissions from manufacturing buses, batteries, and charging infrastructure.
  - Emissions related to the maintenance and lifecycle of the e-buses.

A8: Bidirectional charging for cars
Summary: Development of a configurable electric car with bi-directional charging, integrated into the network to offer mobility solutions for people.

- Scope 1: No final direct emissions, compare with baseline if possible.
- Scope 2: Applicable for emissions from the electricity used by the e-car and charging systems.
- Scope 3:
  - Upstream emissions from the production of the e-car and charging infrastructure.
  - Emissions from software development and integration into the mobility network.

Co-funded by the European Union

PILOT A5: Platform for Services, Data, and Components with Open Interfaces

A9: Platform for servicing events: Estimate traffic flows (predictive) to improve event management via data pooling on a platform

Summary: Development of an expandable, cloud-based platform integrating data for various mobility services, supported by AI for traffic and charging management.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from the electricity used by cloud servers and AI processing systems.
- Scope 3:
    - Emissions from the development and maintenance of the platform.
    - Emissions from data integration and ongoing operations.

A10.1: City App for services including reservations and payment

Summary: App to enable reservation and payment functions and offer of mobility information when feasible.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by IT and communication systems.
- Scope 3:
    - Emissions from software development, platform integration, and maintenance.
    - Emissions from data processing and communication.

A10.2: Enable City App to allow tracking of mobility capacity data and giving wayfinding guidance

Summary: Link of diverse data sources in a secure way to enable mobility capacity tracking and to manage traffic flows, including displays, road guidance for disabled people and parking cameras.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by cameras and data processing systems.
- Scope 3:
    - Emissions from manufacturing camera systems and IT infrastructure.
    - Emissions from processing and managing image data.

A11: Mobility monitoring via image processing and provision via platform for traffic management in Demosite district

Summary: Use of camera systems and image processing algorithms to monitor traffic flows, predict parking space utilization, and enhance the platform's functionality.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by cameras and data processing systems.
- Scope 3:
    - Emissions from manufacturing camera systems and IT infrastructure.
    - Emissions from processing and managing image data.

PILOT A6: 5G Private Communication Network and Power Grid-Based Optimization and Control

A12: 5G private communication network in Ostra district

Summary: Deployment of a 5G private network with capabilities for coordinating transport, energy provision, and safety, including slicing for dedicated bandwidth for critical services.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by 5G base stations, antennas, and mobile edge cloud infrastructure.
- Scope 3:
    - Emissions from producing 5G network components and IT infrastructure.
    - Emissions from ongoing network maintenance and operation.

A13: Slicing for use case e.g. events

Summary: To ensure reliable connectivity, 5G network slicing is envisaged, prioritizing critical data streams related to the power grid, machine control and traffic safety.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by 5G base stations, antennas, and mobile edge cloud infrastructure.
- Scope 3:
    - Emissions from producing 5G network components and IT infrastructure.
    - Emissions from ongoing network maintenance and operation.

Co-funded by the European Union

A14: Power grid-based optimization and control

Summary: Optimization of the power grid with an emphasis on charging stations, integrating a large number of technical components to enhance charging efficiency and management.

- Scope 1: No final direct emissions.
- Scope 2: Applicable for emissions from electricity used by charging stations and grid management systems.
- Scope 3:
  - Emissions from the production of grid components, charging points, and data acquisition systems.
  - Emissions from the operation, maintenance, and optimization of the power grid infrastructure.

Annex 2

Environmental KPIs:

Name	Definition	Unit
Name of the indicator used to monitor the progress of the action	*Definition of the indicator*	*Unit measure-ment*
Reduction of CO_2 emissions	The average CO_2 emissions per unit reduced as a result of the actions package implementation. This value takes into account SCOPE 1, 2 and 3 emissions.	$TnCO_2eq$
Reduction of NOX emissions	Average NOX emissions per unit reduced as a result of the implementation of the package of actions.	ppb
Reduction of small particle emissions	Average small particle emissions per unit reduced as a result of the implementation of the package of actions.	microg/m3
Reduction of noise level	Noise level (dB(A)) measured on-site in the area or corridor under study.	dB(A)

Energy KPIs:

Name	Definition	Unit
Energy consumption	The energy consumption per unit of activity.	kWh/unit
Energy savings	Reduction in energy consumption (per distance, per trip, per passenger transported)	kWh/unit
Energy delivered	Energy delivered from charging infrastructure to vehicle Energy delivered from the grid to the vehicle Energy delivered from the vehicle to the grid Energy delivered from RES facilities to the smart grid Energy delivered from RES facilities to the battery Energy delivered from RES facilities to the vehicle	kWh/unit
Use of clean energy sources	The total volume of non-conventional energy resources. It can also be measured as a percentage of the total energy used.	%
RES production	RES production per activity.	kWh

Transportation KPIs:

Name	Definition	Unit
Mileage	Total distances driven in an area during a day.	km/unit
Quantity of waste collected	Waste collected by vehicle, trip, etc.	weight/unit
Number of trips per day	Vehicle frequency	nº trips/day
Charging times	Time needed to charge a vehicle	hours/unit
Commercial speed	The average journey speed of public transport services between two points, including any delay at stops	km/h
Perception of security	Qualitative perception of security	Qualitative score

Society KPIs:

Name	Definition	Unit
Acceptance	The percentage of the population who favourably receive or approve the measures.	% or Qualitative score
Awareness	The percentage of the target population with knowledge of the measures implemented in the testing area on account of provided Information.	(% or Qualitative score
Customer satisfaction index	The reported satisfaction of the quality of the specific services deployed.	%
Quality of cooperation structures with stakeholders	Level of quality of cooperation structures between all public and private stakeholders to develop and implement innovative mobility solutions.	Qualitative score

Economy KPIs:

Name	Definition	Unit
Capital investment	The total capital costs for purchase of infrastructure, equipment and vehicles. It can also include the total costs expended in setting up the action and cover a period from the initiative of the measure preparation until the start of the measure implementation.	€
Average operating costs	Operating costs including for example, the personnel costs, fuel, electricity and maintenance costs for the vehicle(s) involved.	€
Pollution cost avoided	The estimated financial savings resulting from the reduction of pollution due to implemented actions.	€
Economic impact	Financial benefits to end users and to entities from the transition from petrol to clean energy vehicles, the adoption of bidirectional charging, etc.	€

Annex 3:

Category	Name	Unit	Method	Method
From CIVITAS	*Name of the indicator*	*Unit measurement*	*Method CIVITAS ANNEX 1*	*Method Proposal Madrid City Council**
ENVIRONMENT	Reduction of CO_2 emissions	$TnCO_2eq$	Emissions can be measured through many methods including field trials or modelling. The COPERT software (see http://vergina.eng.auth.gr/mech/lat/copert/copert.htm) can be used to estimate emissions of all regulated air pollutants (CO, NOx, VOC, PM) produced by different vehicle categories (passenger cars, light duty vehicles, heavy duty vehicles, mopeds and motorcycles) as well as CO_2 emissions on the basis of fuel consumption. This data can be also derived from operational data, or surveys for private transportation. It is required data on trip distances but also the details of vehicles used for motorized trips, including the bus fleet in the city, electric vehicles and the fuel mix, including source and equivalent emissions of electric power.	Comparison using The COPERT software of vehicles in demonstration area
	Reduction of NOX emissions	ppb		
	Reduction of small particle emissions	microg/m3		
	Reduction of noise level *	dB(A)	The indicator is evaluated based on field measurement at locations along the corridor. The measurements should be executed during the daytime period (traffic noise is more important during the daytime, higher risk of other noise sources in night time). The measurements are weighted depending on the density of the measurement points.	
ENERGY	Energy consumption	kWh/unit	For commercial vehicles (PT and freight fleet), fuel consumption by each type of vehicle and the corresponding vehicle-km and passenger-km can be collected from service operators, by recording fuel used and passenger-km or vehicle-km completed during the given periods. For passenger cars, the data may be obtained from local or national sources such as	The service operators are required to record all information

			transport statistics report or others. Information from other relevant sources is also useful for the measurement	
	Energy savings	kWh/unit		The service operators are required to record all information
	Energy delivered	kWh/unit		The service operators are required to record all information
	Use of clean energy sources	%	The total volume of non-conventional energy resources. It can also be measured as a percentage of the total energy used.	The service operators are required to record all information about the renewable energy consumed and also a study of impact on electric vehicle fleet at Mercamadrid at scale is planned.
	RES production	kWh		The service operators are required to record all information
TRANSPORT SYSTEM	Mileage*	km/unit		Surveys, field analysis, data analysis of the autonomous vehicle.
	Quantity of waste collected	weight/unit	Sites or areas where CIVITAS measures have significant impacts on freight movements need to be identified. The counting of freight movement should include mass freight transport and small items: - For small item delivery, data may be collected by a survey of goods delivery services (web shopping), counts or modelling. - For mass freight transport, a survey of arrival or starting points - Other specialised freight (e.g. waste) should be identified and described in a good quantitative way	Surveys, field analysis, data analysis of the autonomous vehicle.
	Number of trips per day	nº trips/day		Surveys, field analysis, data analysis of the autonomous vehicle.

	Charging times	hours/unit		Surveys, field analysis, data analysis of the autonomous vehicle.
	Commercial speed*	km/h	The introduction of GPS technology can overcome the difficulties in the past in terms of information availability, although it presents the challenge of processing huge amounts of data in a systematic way.	Surveys, field analysis, data analysis of the autonomous vehicle.
	Perception of security*	Qualitative score	CIVITAS measures having significant impacts on security will need to be identified. In the sites/areas, perceived PT security can be assessed though a survey which take the form of mailed questionnaires, face-to-face interviews, telephone interviews etc.	Surveys
SOCIETY-PEO-PLE	Ac-ceptance*	% or Qualitative score	Sites or areas where CIVITAS measures have significant impacts should be identified first. User acceptance can be assessed through surveys (e.g., questionnaires by mail or by face-to-face interviews). In the questionnaire, user acceptance could also ad-dress: - Understanding level (% of users with good understanding of the measures) - Usefulness level (% of users feeling measure is useful) - Willingness to change (% of users likely to change mobility behaviour)	Surveys (baseline and during imple-mentation phase)
	Awareness*	(% or Qualitative score	Sites or areas where CIVITAS measures would have significant impacts should be identified first. Data could be collected by means of surveys (e.g., questionnaires by mail or by face-to-face interviews). Awareness can be at a variety of levels e.g., hav-ing heard of project/actions, recognise a logo, and understand the aim of the pro-ject and the potential benefits and drawbacks of the measures.	Surveys (baseline and during imple-mentation phase)
	Customer satisfaction index	%	User satisfaction can be assessed through surveys (e.g., questionnaires by mail or by face-to-face interviews). It can be part of a household survey. An alternative will be to piggy back onto any general survey about quality of public services. A question in either survey should be “How satisfied are you with the quality of your regular walk/cycle/bus/train/metro/car journeys in the city?” and the answer can be given on a five-point scale of “very satisfied” to “very dissatisfied”.	Surveys at different stages of the project
	Quality of coopera-tion struc-tures with	Qualitative score	Surveys and interviews with decision makers and stakeholders	Surveys and interviews with deci-sion makers and stakeholders

	stakeholders			
ECONOMY	Capital investment	€	The data needed should be provided by service providers or derived from other data available.	Data from service providers and manufacturers.
	Average operating costs	€	The data needed should be provided by service providers or derived from other data available.	Data from service providers or derived from other data available.
	Pollution cost avoided	€		Data from service providers or derived from other data available.
	Economic impact	€	The data needed should be provided by service providers or derived from other data available.	Data from service providers or derived from other data available.