NET ZERO CITIES

Requirements for a data & visual data interface systems

Deliverable D2.10

Version N°1.0

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Abbreviations and acronyms

Acronym	Description
WP	Work Package
NZC	NetZeroCities
GHG	GreenHouse Gas
EU	European Union
MEL	Monitoring, Evaluation and Learning

Summary

The main objective of this deliverable, D2.10, is the presentation of the result of gathering different types of requirements from mission guidance documents and scientific literature, existing reporting tools and cities and their related stakeholders on the monitoring data-/and visual interface systems that will guide the development of NetZeroCities (NZC) shared data infrastructure concept and related visuals. These requirements will be taken into account in the deployment activities of WP3.

This deliverable presents results that stem from previous documentation produced in the context of this project as well as in EC-mission documents, several inputs from other NZC workpackages, ideas taken from existing reporting tools, mostly focused on GHG emissions (e.g., MyCovenant, CDP), and a co-creation activity run in Madrid during July 2022, in the context of the Open Summer of Code 2022 edition.

As a result of this work, several low-fidelity prototypes have been created on the potential websites that could be shown by cities in the EU Mission, which will need to be refined further once indicators for the Monitoring, Evaluation and Learning (MEL) framework are established in the context of the project.

Keywords

Mission, data, visualization, requirements for data-/and visual data interface systems

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1. Introduction

NetZeroCities is a four-year project designed to help cities overcome the current structural, institutional, and cultural barriers they face to achieve climate neutrality by 2030. It will enable European cities and citizens to show the way forward towards an inclusive, thriving, climate resilient and sustainable future. NetZeroCities is part of the Horizon 2020 Research and Innovation Programme in support of the European Union's Green Deal and supports the work of the EU's Mission 100 Climate-Neutral and Smart Cities by 2030.

This deliverable, D2.10, is developed as part of the NetZeroCities WP2, dedicated to the "Impact Metrics & Monitoring, Evaluation and Learning activities", which operates in close interaction with other key strategic WP of NZC. This deliverable reports the results from project T2.3, which was designed **to identify requirements (technical and non-technical) for MEL data-/and visual data interface systems** that will be deployed by the NetZeroCities platform to describe the activities that they are performing and the results of the collection and calculation of indicators.

It is important to note that the aim in NetZeroCities is to go beyond current practice on data presentation from existing GHG reporting frameworks, providing data visualisations in one single platform (which can be replicated in each of the cities according to their characteristics and activities), and moving from GHG data visualisation to the presentation of many other aspects that are relevant in the context of their work towards the EU Mission, namely those aspects related to co-benefits, portfolios of projects in their activities, and training and dissemination material. Therefore, this deliverable goes beyond proposing actual data visualisations into proposing a design that takes into consideration the different types of stakeholders and the different ingredients that are relevant for the EU Mission activities in each city.

UPM, VTT, ICLEI and AIT have contributed to this deliverable, and some cities from the EU Mission have contributed to the collection of requirements and the discussion of potential solutions.

2. Approach towards the collection of requirements

Our approach for the collection of requirements has followed a method where multiple sources of requirements have been considered, as well as multiple techniques for such requirement collection. The following activities have been done (including literature reviews and a workshop), which are presented in this deliverable:

- A review of the requirements that are identified in some of the existing documents associated to the EU Mission, such as the EU Mission documents, the JRC Information kit for EU Mission cities, etc.
- A review of the results already obtained, as well as ongoing work, in the NZC Work package 2, such as D2.4 (Comprehensive indicator framework) and the work on cities needs after some workshops as presented in deliverable D2.3 (Monitoring, evaluation and learning for the transition to climate neutrality. Understanding cities' needs).
- A literature review of requirements for the visualisation of indicators.
- A comparative analysis on GHG inventory practices.
- A three-week co-creation workshop run in the city of Madrid under the context of the Open Summer of Code 2022 edition, focused on the creation of several low-fidelity prototypes for the websites to be created, and partially validated with the participation of some cities from Spain.

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3. Analysis towards the requirements

3.1 Requirements based on the EC mission documents and WP2 deliverables

Dynamic and real-time monitoring of the progress towards climate-neutrality is essential for cities the cities and stakeholders involved. At the same time, real-time monitoring allows for informed and flexible adjustments to the Mission if and when necessary.

To this end and according to the requirements of the European Mission "100 Climate-Neutral and Smart Cities by 2030" predefined in the Implementation Plan and InfoKit for cities (European Commission, 2021), NZC will need to establish a simple yet robust monitoring system using established methodologies based on short (progress in implementation), medium (delivery of tangible results) and longer term (impact) indicators. These general sets of indicators (presented in D2.4 and overviewed below) set the **requirements to monitoring data, reporting mechanisms and respective data visuals**.

- **Implementation indicators** will measure the level of city interest for climate neutrality, their preparedness and diversity;
- **Results indicators** will measure the level of city commitment to climate neutrality, their diversity and mobilisation of EU/regional/national financing;
- **Impact indicators** will measure the actual progress towards the climate neutrality of Mission cities as well as their overall contribution towards the 55% target of the European Green Deal, and ultimately the number of climate-neutral cities.

The decreased level of GHG emissions in Europe delivered by cities will be measured in line with the three main indicators identified in the Global Covenant of Mayors. The calculation of climate neutrality should be based on the following scope indicators.

- Scope 1: GHG emissions for the city within the geographic boundary (mandatory from the beginning of the Mission). This indicator will be calculated based on the emissions from buildings, industry, transport, waste treatment (solid waste and wastewater), agriculture and forestry and from other activities within city boundaries
- Scope 2: GHG emissions for the city within the geographic boundary (mandatory from the beginning of the Mission). This indicator will be calculated based on indirect emissions due to consumption of grid-supplied electricity and indirect emissions due to consumption of grid-supplied heating and/or cooling
- Scope 3: GHG emissions for the city (to be considered further but not to be adopted before 2030). Scope 3 emissions would be calculated based on the emissions from "out-of-boundary" emissions from treatment of waste produced within the geographic boundary, out-of-boundary emissions from transmission and distribution of energy consumed within the geographic boundary, out-of-boundary emissions from transportation of citizens living within the geographic boundary, out-of-boundary emissions from consumption made within the geographic boundary (food, clothes, furniture, materials, etc.) and other indirect emissions.

When it comes to pollution, relevant indicators on air quality could be the levels of air pollution within city boundaries as reported under the EU legislation ($PM_{2.5}$ concentration levels [highest annual mean observed at (sub)urban background stations; NO_2 concentration levels (highest annual mean observed at traffic stations).

To address the above requirements the **specific sets of indicators are defined by NZC partners in scope of WP2 work**. These specific indicators will support cities to monitor and evaluate various impacts (direct and indirect) and progress towards the targets and goals that are defined in their Climate Neutrality Action Plans. And as mentioned earlier, some of these indicators (Implementation-, Results- and some of Impact-indicators) will assist the Mission to make adjustments when needed, based on the monitoring data provided by cities.

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The detailed specification of all defined indicators (and the required datasets and sources of data) can be found in the WP2 deliverables D2.5 to D2.8.

The domains of the current set of defined indicators (which are still being developed at the time of writing this document and may suffer some changes) are summarised below. We provide first a list of the domains and their subdomains, and then a table-based view of them.

- Direct impacts
  - GHG Emission / CC Mitigation
    - Energy generation on grid-distributed electricity, steam, heat, cooling
    - Mobility & Transport
    - Circular Economy & Waste
    - Nature-based Solutions, Agriculture, Forestry and other Landuse
    - Industrial Processes and Product use
    - Stationary Environment
- Indirect impacts
  - Co-Benefits: Climate Change Adaptation, Health, Social, Resource Efficiency, Economy, Biodiversity
  - Governance Innovation: Governance Structures, Principles, Governance Processes
  - Social Innovation: Skills & Capacity Building , Empowerment & Inclusion, Regulation & Support, System solutions – Top-Down systematic Approaches
  - Finance & Funding: Capital Investment, Private-to-Public Capital, Carbon x Capital Invested
  - Learnings & Capabilities: Strategic Learning for impact and learning by doing processes (sensemaking), Learning Platform engagement, organisational learning and knowledge dissemination, Capacity and capabilties building, knowledge-sharing and peer-to-peer or mutual learning

	Impacts (including co-benefits) and impact categories
Direct impacts	**<u>Climate Mitigation</u>** • Reduced GHG emissions • Increased energy efficiency or rate of retrofit (including district heating) • Reduced energy demand, needs, or consumption • Increased access to clean, stable, affordable energy • Reduced energy poverty • Increased modal shift to public transit, walking, cycling • Decreased modal share of private vehicles • Increased uptake of low-carbon technology vehicles for private, freight, public transport (EVs, e-bikes, hydrogen-fuelled etc.)
Indirect impacts	**<u>Climate Adaptation</u>** • Increased carbon sequestration (for e.g., through NBS) • Enhanced stability of urban infrastructure • Reduced risk to natural/climate disasters or hazards • Increased preparedness to uncertainty of climate impacts
	<u>Public Health & Environmental Impacts</u> • Improved air quality • Reduced noise pollution • Increased road safety • Reduced heat island effect • Enhanced physical & mental well-being • Enhanced liveability attractiveness/ aesthetics (align with New EU Bauhaus Goals) • Increased physical activity and active lifestyles • Equitable & affordable access to housing

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	Social Inclusion, Democracy & Cultural Impacts • Enhanced citizen & communities' participation & social capacities for participation/engagement • Increased social justice • Improved social cohesion, gender equality, equity • improved functioning of democratic institutions • Increased awareness of social issues • Increased access to job/employment and skill development opportunities • Improved access to information, awareness & behaviour change
	Economic Development Impacts • Increased investments in R&I • Decreased future maintenance & capital costs • Increased number of skilled jobs & rate of employment • Increased economic thriving (quality of jobs, sustainable supply chains etc.) • Increased economic returns of natural capital • Increased technological readiness & rate of adoption • Local economic activity & global connectivity • Increased local entrepreneurship & local businesses/ventures • Increased visibility & knowledge/tech transfer for local businesses/ventures • Mainstreaming of new economic models like proximity & sharing economy
	Resource Efficiency Impacts • Improved waste management and efficiency • Increased deployment of material cycles & circular economy • Increased water quality • Enhanced water management process/implementation • Sustainable & resilient food production & supply systems • Decreased food waste • Increased production & consumption locally grown food • Improved land-use management practices (linked to biodiversity)
	Biodiversity Impacts • Increased urban forestry, plantation & improved plant heath • Reduced harmful ecological footprint • Increased non-invasive species & pollinators • Improved soil-health • Reduced risk of disease outbreak/pandemic • Increased ecological awareness • Enhanced ecological habitat connectivity • Improved nature restoration

The cities are encouraged to use the **existing in-use GHG emission inventory mechanism**s to report their baseline and monitoring data (European Commission, 2021a, 2021b). The NZC Mission Platform will support cities with reporting activities, therefore the two widely used reporting tools (MyCovenant and CDP-ICLEI) that are envisioned to be part of NZC Mission Platform, are analysed in detail to assess their suitability for the Mission to report the required data to monitor and evaluate the progress towards climate neutrality (see chapter 4). The reporting mechanisms are assessed from various perspectives related to inventory methodology (GHG emissions collection), interoperability (sharing mechanism, open data) and user-friendless (usability aspects).

In addition to the GHG inventory, other direct and indirect impacts (co-benefits) need to be monitored and evaluated (see D2.4 Chapter 3.2). This sets the r**equirements for the additional reporting tools**

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to support 9 defined steps that are included in the monitoring process. We can summarize these steps as follows.

- **Step 1: Define Scope**: Cities declare which sectors and stretches of territory will be subject to the Climate Neutral City Action Plan.
- **Step 2: Identify Objectives**: Cities will determine their objectives in each monitoring dimension, including Greenhouse Gas Emissions / Climate Change Mitigation, Co-Benefits, Governance Innovation, Social Innovation, Finance and Funding, Learnings and Capabilities.
- **Step 3: Select Indicators:** Indicators need to be selected that allow cities to monitor their progress in each monitoring dimension and for all objectives. For each objective, at least one indicator needs to be chosen.
- **Step 4: Select Impact Pathways:** The city would be supported to self-assess and identify a sequenced hierarchy of changes and outcomes, culminating into long-term impacts and co-benefits for the city's climate mission. Online tools and guidelines would be made available for cities to conduct this exercise with their internal teams.
- **Step 5: Identify Data Sources**: The city needs to identify the data sets that are necessary to calculate the indicators and to check if local data for calculating the indicators is available, accessible, and up to date.
- **Step 6: Assess & Report the Baseline:** A base year needs to be chosen and each indicator needs to be calculated for this base year. This will allow to assess progress by benchmarking the monitoring values reported for year two and year four against the baseline values.
- **Step 7: Evaluate & Report Progress after 2 Years:** Calculating values for each indicator based on data sets from year 2 and benchmarking them against the base year and against the smart objectives.
- **Step 8: Evaluate & Report Progress after 4 Years:** Calculating values for each indicator based on data sets from year 4 and benchmarking them against the base year and against the smart objectives.
- **Step 9: Evaluate & Report Long-Term Impact**: Cities are asked to give an outlook on their expected impact after ten years. This outlook should be given at the end of year 4 based on data from that year.

3.2 Usability requirements and cities' needs

City dashboards, which visualize urban performance indicators in an appealing manner, are increasingly studied in literature towards addressing the need of cities to evaluate urban energy efficiency and to plan and assess the sustainability and progress of urban developments. It is pointed out that effectiveness of urban dashboards requires not only dealing with data issues, but also ensuring that presentation of analysed data is user-friendly and reflects users' views and needs (Mori et al, 2015; Jing et al, 2019; Salgado et al, 2022).

Visualization is well recognised as an effective method for conveying data exploitation results to non-professional audiences. Visualization can also provide interactive features and hereby facilitate a participatory approach among various stakeholders.

The presentation of urban performance indicators needs to be, on the one hand, designed using established User Experience (UX) design principles, and on the other, designed to meet the specific needs of its prospective users specifically targeting urban planning and policy-making context, as discussed in the following.

The UX principles and guidance to effective data visualization have been widely elaborated in scope of Human-computer interaction (HCI) research. The aspects of urban monitoring and data visualization have been addressed in scope of domain specific studies that were dedicated in particular to the assessment of city dashboards (Gareth et al, 2020). These principles are to be taken into the consideration to the visuals designs of indicators (i.e. data presentation) as well as criteria to assess the existing reporting mechanisms (MyCovenant and CDP) that are envisioned to be leveraged by NetZeroCities MEL framework and hereby are shortly highlighted in the following.

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From a **general set of principles of usability for human-computer interaction**, the design should ensure that interaction with MEL dashboard and its indicators is **easy to learn**, **effective**, and **enjoyable** from the perspective of the user (Shneiderman et al, 2016; Nielsen, 1994). Therefore, to incorporate usability into the creation of MEL dashboard, it is important to have purposefully constructed, well-designed, and robustly validated interface guidelines. Furthermore, with respect to data visualization, a fundamental aspect of dashboard design, graphics need to present complex ideas with **clarity**, **precision**, and **efficiency** (Tufte, 2001). In addition, the importance of other **human elements** in user interaction design such as behaviours, **empathy and emotions** is widely acknowledged in UX-related studies.

From an **urban management and policy-making point of vie**w, the MEL dashboard and its indicators should be able to serve various city stakeholders with means to monitor the progress of city developments and to perform the assessment and decision-making tasks. Ideally, the MEL dashboard should be able to provide various views, such as **analytical** as well as **strategical** view for different stakeholders i.e. city decision makers and other relevant users (citizens, business) (Kitchin et al, 2015). Analytical views may provide diagnostic or assess(ive) status of city developments defined in the climate action plan and it's in particular useful for city decision makers. Strategical views can be used by cities to predict the future status of the city developments and impact targets, based on existing patterns of developments and progress achieved, where data are input into well-defined models to predict future outcomes.

The **NetZeroCities MEL framework** will be composed from **two types of indicators**: direct benefit indicators and indirect benefit indicators.

Direct benefit indicators are defined to assess whether a city meets the necessary GHG emissions targets described in the city climate action plan. Indirect impact indicators measure the co-benefits that cities generate in social, economic and other aspects. As city creates more co-benefits, prosperity, wellbeing and satisfaction of various stakeholders (citizens, business) increase. Concerning indirect impact indicators, city performance can be evaluated and presented in a concise way, - the higher the co-benefits are, the better the performance of the city is and consequently the higher impact is. Indeed, a comparative visualization of indirect indicators among the cities (e.g. using spider chat-based technique) may require the application of some standardised normalization techniques before the data is visualised.

Direct benefit indicators might not require scaling or normalization because the necessary minimum conditions for city GHG emissions (i.e., target values) are derived from the target values that are defined in the city climate action plans. Various types of visualizations such as progress bars, gauge graphs or color-coded alerts can be used to present the progress of the city towards the target.

Indirect benefit indicators are assessed after the conditions of the direct benefit indicators are met. An ability of visual analytics to identify and indicate any **cause-effect relationships** between the levers of change, on the one hand, and those two types of benefits, on the other hand, would be a desirable feature for cities. This feature would allow policymakers to adjust their climate action plans, prioritise and to specify the actions and policies that should be implemented to achieve the best possible outcome for sustainable development. Visually interactive features that would allow manipulation of weightings among indirect impact indicators can support alternative graphical representations of different development scenarios. Furthermore, inclusion of unique aspects of city characteristics (demographics, climate zone, cultural aspects) into the visualization models, would add more dimensions in the exploration of the cause-effect relationships among defined indicators [3].

3.3 Results of the co-creation workshop run in July 2022

Once that we have shown the results of the initial literature survey on human-computer interaction and indicators, we considered relevant to have a hands-on experience towards working on a very initial prototype on how all the relevant information for all stakeholders may be shown. It is important to notice that the results presented in this section are by no means the ones that will be finally proposed for the EU Mission platform, since the ongoing activity on the definition of indicators and many other elements

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related to the mission activities will help configuring further what needs to be shown and how it can be navigated.

This co-creation workshop for the development of visualisations that may be used by the NetZeroCities platform and the cities participating in the EU MIssion was organised during the first three weeks of July 2022, under the context of Madrid's Open Summer of Code 2022 edition (https://www.lanavemadrid.com/actividad/open-summer-of-code-2022/, https://2022.summerofcode.es/). This annual event, which has been running in Madrid since 2013 and further in Belgium, is focused on providing the opportunity to university students to try their first work and training experience on a real project, commonly sponsored by public organisations, NGOs and foundations, under the supervision of mentors from public universities (mostly from Universidad Politécnica de Madrid). The only restriction is that all the work that is produced by all students in all projects needs to be openly licensed, and available in the corresponding GitHub repository (in the case of our project, this was made available at https://github.com/osoc-es/NetZeroCities/).

In this project, three students participated, with the supervision of Prof. Oscar Corcho, and the participation of some external stakeholders from the cities of Madrid, Valencia and Sevilla, which helped in producing requirements and validated partially some of the designs that were made, what was useful to produce the final results that are presented in Annex I. The three students had complementary profiles: one of them with a Computer Science background and two of them with a background on Design (more specifically, game design). This ensured a non-technical bias in the solutions that were proposed.

Figure 1 shows a picture taken during one of the initial brainstorming sessions where stakeholders and their needs were identified (as tweeted by Oscar Corcho on July 6th 2022).

Figure 1. Twitter image

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The following phases were run for this three-week workshop:

- Phase 1 (week 1) was focused on understanding the general context of the EU Mission, literature on city indicators and their presentation, and existing reporting systems. The team also checked the plans published by several of the EU Mission cities, and run some ideation sessions using the toolkit developed in the context of the AI4Gov Master (https://ai4gov-master.eu/). During this week several short interviews were run with citizens not aware of the EU Mission activities (found in the neighbourhood), so as to understand what may be relevant for them when talking about the EU Mission and climate change in general.
- Phase 2 (week 2) was focused on the generation of an initial set of low-fidelity prototypes, done mostly in paper. The results of phase 1 suggested that it was not only a question of visualising the data about reported or calculated indicators, as it is done in most existing websites, but also a presentation of the other elements in the ecosystem, the co-benefits and training material and accessible material for non-experts. This is in line with the conclusions obtained in D2.3. We also run interviews with representatives of the cities of Madrid (via some of the people involved in helping with this activity) and Seville. The interviews were recorded (but not transcribed as it was not considered necessary) so as to allow identifying later all the requirements derived from the discussion. They already saw parts of the prototypes.
- Phase 3 (week 3) was focused on the generation of the final low-fidelity prototypes in the fig.ma tool, as available in https://github.com/osoc-es/NetZeroCities/blob/main/src/ClimMate.fig. There was also a final discussion with a representative from the city of Valencia, which helped in the final steps of the prototype generation.

Some of the main conclusions from this work can be summarised as follows:

- There are at least four main groups of stakeholders to be considered on the website: Citizens, scientists interested in climate change, activists (individuals, NGOs, companies, etc.), and politicians. Each of them will have different information displayed for them.
- Each city should have its own place on the NZC website (or adapted in their own websites) with the main elements that are considered relevant (objectives in the EU Mission, including their climate city contracts, ongoing values in their indicators, portfolio of projects run by the city and by companies in the city, events, etc.)
- The climate city contracts should be further developed on the website with clear indications of the main characteristics of the contracts. They should also provide details on the amount of money that has been mobilised, number of projects and links to them, etc.
- Data visualisation can be based on the indicators identified in the MEL framework, with different types of visualisations (as presented in Annex I), and with the possibility of downloading all the data as open data.
- It should be possible to navigate to other similar cities in terms of their climate city contracts, their characteristics in terms of emissions or portfolios of projects, etc. It should be also possible to compare their contracts with those of other cities.
- There should be a guide for citizens with simple actions that they can do to contribute to the mission of their city.

As discussed above, the results of the low-fidelity prototype, in Spanish, are presented in Annex I. All the material generated during the workshop can also be found at https://github.com/osoc-es/NetZeroCities/, as aforementioned:

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4. Comparative analysis on Greenhouse Gas inventory practices

The **aim** of this section is **to analyze and compare** existing Greenhouse Gas (GHG) inventory practices available to guide a city´s accounting of GHG emissions and demonstrate climate neutrality with an idea of discovering how they meet requirements of the European Mission "100 Climate-Neutral and Smart Cities by 2030" predefined in the Info Kit for Cities. The object of the comparative analysis are two reporting frameworks that are widely used by cities, namely

- Covenant of Mayors Europe or Sustainable Energy and Climate Action Plan (SECAP) approach https://www.covenantofmayors.eu/support/reporting.html
- CDP-ICLEI Track approach https://www.cdp.net/en/guidance

The results of the comparative analysis highlights the main comparative characteristics of existing GHG inventory practices available to guide a city´s accounting of GHG emissions and demonstrate climate neutrality. The comparative analysis is based on the set of criteria, as presented below i.e. Group 1 – Inventory methodology, Group 2 – Inventory interoperability and Group 3 – Inventory user-friendliness. This comparison technique allows us to distinguish similarities and differences between the current GHG inventory practices, and to evaluate their alignment with the requirements of the European Mission "100 Climate-Neutral and Smart Cities by 2030" predefined in the Info Kit for Cities.

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Comparative Analysis Criteria

Group 1 – Inventory methodology	Group 2 – Inventory interoperability	Group 3 – Inventory user-friendliness
1-1 Greenhouse gases (GHG)	**2-1** Availability of manual means to insert reporting data	**3-1** Simplicity and easiness to follow the User Interface
1-2 Sources and sectors of GHG emissions	**2-2** Availability of the Application Programming Interface (API)	**3-2** Easiness to control/ correct actions/ errors
1-3 Scope of GHG emissions	**2-3** Support for importing data from other reporting systems	**3-3** Attractiveness and aesthetics (design)
1-4 Emission factors used to calculate CO2 emissions	**2-4** Level of openness in sharing reported data with other systems	**3-4** Flexibility in data management and data analytics
1-5 Activity data	**2-5** Supported visual features	**3-5** Control, security and privacy aspects

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
	EUROPEAN UNION EU MISSIONS 100 CLIMATE-NEUTRAL AND SMART CITIES	Covenant of Mayors for Climate & Energy EUROPE	CDP DISCLOSURE INSIGHT ACTION ICLEI Local Governments for Sustainability
Group I – Inventory methodology			
1-1 Greenhouse gases (GHG)	Six GHGs **should be included** in terms of carbon dioxide equivalent (CO_2e).	Three main long-lived GHGs **might be considered** in the Covenant: CO_2, CH_4 and N_2O. Inclusion of CH_4 and N_2O depends on whether to reduce also these GHGs are planned in the SECAP, and also on the approach chosen (activity-based or life cycle assessment).	(Question 2.1b) Select the GHGs included in your inventory **(select all that apply).** The list consists of the main gases as defined by the United Nations Framework Convention on Climate Change.

	Carbon Dioxide (CO_2)	✓	Carbon Dioxide (CO_2)	✓	Carbon Dioxide (CO_2)	✓ *Select option
	Methane (CH_4)	✓	Methane (CH_4)	✓	Methane (CH_4)	✓ *Select option
	Nitrous Oxide (N_2O)	✓	Nitrous Oxide (N_2O)	✓	Nitrous Oxide (N_2O)	✓ *Select option
	F-gases (hydrofluorocarbons and perfluorocarbons)	✓	F-gases (hydrofluorocarbons and perfluorocarbons)	Not requested	F-gases (hydrofluorocarbons and perfluorocarbons)	✓ *Select option
	Sulphur hexafluoride (SF_6)	✓	Sulphur hexafluoride (SF_6)	Not requested	Sulphur hexafluoride (SF_6)	✓ *Select option
	Nitrogen trifluoride (NF_3)	✓	Nitrogen trifluoride (NF_3)	Not requested	Nitrogen trifluoride (NF_3)	✓ *Select option

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements		Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
			Covenant of Mayors for Climate & Energy EUROPE		CDP DISCLOSURE INSIGHT ACTION ICLEI Local Governments for Sustainability	
Group I – Inventory methodology						
1-2 Sources and sectors of GHG emissions	Five sources and sectors of GHG emissions **should be included** in a city´s GHG inventory:		In the context of the Covenant of Mayors initiative, four Covenant **key sectors have been defined.** They are considered the main sectors where local authorities can influence energy consumption and consequently reduce related CO_2 emissions.		**Cities are asked** to provide a breakdown of their emissions by sector **depending on the reporting format,** e.g. Global Protocol for Community Greenhouse Gas Emissions Inventories, GCoM Common Reporting Framework, etc.	
	Buildings	✓	Municipal buildings, equipment / facilities	✓	Stationary Energy	✓ *Select option
	–	–	Tertiary (non-municipal) buildings, equipment / facilities	✓	–	–
	–	–	Residential buildings	✓	–	–
	Transport	✓	Transport	✓	Transportation	✓ *Select option
	Waste	✓	–	–	Waste	✓ *Select option
	Industrial processes and Product Use (IPPU)	✓	–	–	Industrial processes and Product Use (IPPU)	✓ *Select option
	Agriculture, Forestry, and Other Land Use (AFOLU)	✓	–	–	Agriculture, Forestry, and Other Land Use (AFOLU)	✓ *Select option

Analysis criteria	**European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements**	**Covenant of Mayors Europe approach**	**CDP-ICLEI Track approach**
	EUROPEAN UNION EU MISSIONS 100 CLIMATE-NEUTRAL AND SMART CITIES	Covenant of Mayors for Climate & Energy EUROPE	CDP DISCLOSURE INSIGHT ACTION ICLEI Local Governments for Sustainability
Group I – Inventory methodology			

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements			Covenant of Mayors Europe approach			CDP-ICLEI Track approach		
									
Group I – Inventory methodology									
1-3 Scope of GHG emissions	The scope of the GHG emissions which **should be included** in a city´s GHG inventory.			Local authorities **focus on reducing the energy demand in their territory** as well as on matching energy demand with supply by promoting the use of local energy resources.			**Cities are asked** to provide a breakdown of their emissions by scope **depending on the reporting format,** e.g. Global Protocol for Community Greenhouse Gas Emissions Inventories, GCoM Common Reporting Framework, etc.		
	Direct emissions (Scope 1)	Indirect emissions (Scope 2)	Out-of-boundary emissions (Scope 3)	Direct emissions (Scope 1)	Indirect emissions (Scope 2)	Out-of-boundary emissions (Scope 3)	Direct emissions (Scope 1)	Indirect emissions (Scope 2)	Out-of-boundary emissions (Scope 3)
	Buildings			**Municipal buildings, equipment / facilities**			**Stationary Energy**		
	✓	✓	Not applicable	✓	✓	–	✓	✓	✓
	–			**Tertiary (non-municipal) buildings, equipment / facilities**			–		
	–			✓	✓	–	–		
	–			**Residential buildings**			–		
	–			✓	✓	–	–		
	Transport			**Transport**			**Transport**		
	✓	✓	Recommended by 2030	✓	✓	–	✓	✓	✓
	Waste			–			**Waste**		

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
			
Group I – Inventory methodology			
	✓ Not applicable ✓	–	✓ ✓ ✓
	Industrial processes and Product Use (IPPU)	–	**Industrial processes and Product Use (IPPU)**
	✓ Not applicable Not applicable	–	✓ ✓ ✓
	Agriculture, Forestry, and Other Land Use (AFOLU)	–	**Agriculture, Forestry, and Other Land Use (AFOLU)**
	✓ Not applicable Not applicable	–	✓ ✓ ✓

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements		Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
						
Group I – Inventory methodology						
1-4 **Emission factors used to calculate CO_2 emissions**	Emissions from electricity consumption within the city boundary are calculated using so-called emission factors.		Three approaches can be adopted.		Cities are requested **to evaluate and report the quality of the emission factors** used for each applicable sector and scope, i.e. (High, Medium, Low). * if the inventory has been developed using the Global Protocol for Community Greenhouse Gas Emissions Inventories (GPC)	
	Local, regional, national or European emission factor	✓	**National/ sub-national**	✓	**Local, regional, or country specific sources**	✓
	Intergovernmental Panel on Climate Change (IPCC) default factors	✓	**Intergovernmental Panel on Climate Change (IPCC)**	✓	**Intergovernmental Panel on Climate Change (IPCC) default factors**	✓
	–		**Life Cycle Assessment (LCA)** – emission factors for the overall life cycle of each energy carrier	✓	–	
	–		–		**Data from the Emission Factor Database (EFDB)17**	✓
	–		–		**Other standard values from international bodies that reflect national circumstances**	✓

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements		Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
						
Group I – Inventory methodology						
1-5 Activity data	Buildings	• Combustion of fossil fuels associated with heating/cooling buildings. • Consumption of grid-supplied electricity and/or district heating/cooling.	Municipal buildings, equipment / facilities	**Final energy consumption:** • Electricity. • District heating and cooling. • Fossil fuels (natural gas, liquid gas, heating oil, diesel, gasoline, lignite, coal, other fossil fuels). • Renewable energies (biogas, plant oil, biofuel, other biomass, solar thermal, geothermal).	Stationary Energy	• Energy use. • The use of grid-supplied electricity, heat, steam and/or cooling.
	–	–	Tertiary (non-municipal) buildings, equipment / facilities		–	–
	–	–	Residential buildings		–	–
	Transport	• Combustion of traditional fossil fuels in transport activities. • Consumption of electricity delivered via the grid (e.g.,	Transport	**Final energy consumption:** • Electricity. • District heating and cooling, i.e., (*) the	Transportation	Mode share: • Passenger mode share.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements		Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
						
Group I – Inventory methodology						
		electricity generation to charge electric vehicles). • Production process of alternative clean fuels (e.g., hydrogen).		use of grid supply electricity) • Fossil fuels (natural gas, liquid gas, heating oil, diesel, gasoline, lignite, coal, other fossil fuels). • Renewable energies (biogas, plant oil, biofuel, other biomass, solar thermal, geothermal).		• Freight mode share. Passenger and Freight mode share: • Annual emissions from transport mode (metric tonnes CO2e). • Total fleet size per mode. • Electric fleet size per mode. • Hybrid electric vehicle fleet size per mode. • Plug in hybrid electric vehicle fleet size per mode. • Hydrogen fleet size per mode.
	Waste	**(I) Generation of waste** **(II) Collection, recovery, disposal and treatment of waste and wastewater:**	–	–	Waste	Waste-related data area • Amount of solid waste generated (tonnes/year).

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
Group I – Inventory methodology					
		• On-site energy use within the waste and wastewater facilities (e.g., electricity used for pumping, natural gas for heating, etc.). • Energy used for transporting waste to and from the facilities (e.g., diesel used in waste collection vehicles) as well as off-road vehicles operating within the facilities. • The decay of solid waste and anaerobic degradation of wastewater in the facilities. Other sub-sectors of waste management: • Biological treatment of waste, including composting and anaerobic digestion of organic waste. • Waste burning in controlled, industrial process (incineration) as well as open burning.				• Percentage of the solid waste generated that is diverted away from landfill and incineration (%). • Percentage of the diverted solid waste generated that is recycled (%). • Percentage of the diverted solid waste generated that is utilized for waste to energy (%). • Percentage of the diverted solid waste generated that is reused (%). • Percentage of waste collected where separation at source is taking place (%). • Total annual amount of food

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements		Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
						
Group I – Inventory methodology						
		• Wastewater discharge into an open body of water or its treatment (either aerobic or anaerobic).				waste produced in the jurisdiction (tonnes/year). • Volume of wastewater produced within the jurisdiction boundary (megalitres/year) . • Percentage of wastewater safely treated to at least secondary level (%).
	Industrial processes and Product Use (IPPU)	• Industrial activities and processes that chemically or physically transform materials, including mineral industry, chemical industry, and metal industry. • Greenhouse gas emissions used or contained in products such as refrigerators, foams or aerosol cans.	–	–	Industrial processes and Product Use (IPPU)	• Industrial processes (metric tonnes CO2e). • Product use (metric tonnes CO2e).

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements		Covenant of Mayors Europe approach		CDP-ICLEI Track approach	
Group I – Inventory methodology						
	Agriculture, Forestry, and Other Land Use (AFOLU)	• Urban land use efficiency. • Spatial planning and urban land use change. • Urban green and blue infrastructure. • Enlargement or enhancement of natural sinks.	–	–	Agriculture, Forestry, and Other Land Use (AFOLU)	• Livestock (metric tonnes CO2e). • Land use (metric tonnes CO2e). • Other AFOLU (metric tonnes CO2e).

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Group II – Inventory interoperability			

2-1 **Availability of manual means to insert reporting data**	The Mission doesn´t impose strict procedural and other requirements on the GHG inventory guiding principles. It highlights, that with the relatively short-term nature of the Mission and the associated need for immediate and urgent climate action, cities should not delay their action planning processes on account of overly-detailed GHG inventory processes. That said, direct and indirect benefits will need to be reported at least every two years until the end of the Mission (see D2.4.1). Several guiding documents are also currently being prepared.	The following Covenant of Mayors for Climate and Energy Reporting Platform supporting guidance documentation is available for the cities: • Reporting Guidelines. The following additional resources are available for the city support: • Sustainable Energy and Climate Action Plan (SECAP) template – a simplified Excel version of the reporting and monitoring framework. • The short Video tutorials: (1) My Strategy, (2) Emission inventory, (3) Risk and vulnerability assessment, (4) Actions. Below is a list of guidance materials developed by the Covenant of mayor Office and the Joint Research Centre to assist signatories in designing and implementing their strategies and action plans. • Guidebook “How to develop a Sustainable Energy and Climate Action Plan (SECAP)”, Part 1, Part 2 and Part 3. • Quick reference guides: “Joint Sustainable Energy & Climate Action Plan”, “Monitoring SECAP implementation” and “Grouped SECAP analysis”. • E-learning platform (available in My Covenant). • Urban Adaptation Support Tool (Urban-AST). • Webinars.	The following CDP-ICLEI Track supporting guidance documentation is available for the cities: • Guide to the Reporting Platform. • Cities Reporting Guidance. • Cities Scoring Methodology. The following additional resources are available for the city support: • Cities Questionnaire. • Cities Questionnaire Changes Map. • Cities Framework Alignment Map. • Guidance Note on the Task Force on Climate-related Financial Disclosures Recommendations for City, State, and Regional Governments. • Questionnaire Pathway Map. • Questionnaire Pathways Guidance Note. • Webinars.
Analysis criteria	European Mission´s “100 Climate-Neutral and Smart Cities by 2030” requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
			

Group II – Inventory interoperability			
2-2 **Availability of the Application Programming Interface** **(*) to support automated importing and sharing of reporting data**	The Mission highlights that measures to enable and foster digitalisation span three dimensions: technological, policy-driven and funding/ finance. It highlights, that as cities may have different needs, a technology governance framework is required that they can consult and adapt to local circumstances.	Currently there is no evidence about the API available from My Covenant platform. You can extract the data in the comma-separated values (CSV) files but there is no way if you want to build a bridge between the My Covenant platform and the Mission´s platform. Then we will need an API for that. So, it will not be the same that CDP-ICLEI is using with My Covenant or the open API that CDP-ICLEI has at the moment. If we need to integrate data from My Covenant to the Mission platform we will need to build an API.	In terms of API, what we have available right now is an API in CDP-ICLEI platform and it is the same API that is also communicated with My Covenant. It means that when you are reporting to the CDP-ICLEI platform you are also integrating these data in My Covenant platform. This API is open and everyone can use it. You can integrate it with any kind of system.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Group II – Inventory interoperability			
2-3 **Support for importing data from other reporting systems** (*) which mechanisms (e.g. file/format, other), which systems	The Mission doesn´t impose strict requirements on the support for importing data from other reporting systems. It highlights that digitalisation can also improve organisational and administrative capacity, enhance operational performance, and help overcome challenges such as excessive bureaucratisation and silo approaches to policy development, which are detrimental to the adoption of integrated and cross-sectoral solutions critical to achieving climate neutrality.	Covenant of Mayors reporting platform has **climate action planning document uploading function.** Please see Step 3 "Upload action plan document(s)". To upload documents in My Covenant, it is necessary to implement the following tasks: • Go to My Strategy in the Reporting corner. • Click the My Action plan documents tab. • Scroll down to "Documents upload". All documents should be uploaded in a *PDF format, in the national language, unless an English translation is available. The uploading of at least one action plan document (e.g. mitigation action plan/ adaptation action plan/ integrated mitigation and adaptation action plan) is mandatory. The upload of additional documents is optional.	The following questions of the CDP-ICLEI Track Cities Questionnaire have response **data import/ attachment function:** **Section** • Emissions Inventory • Community-wide Emissions Inventory Methodology **<u>Question (2.1a)</u>** Provide an attachment (in spreadsheet format) or a direct link to your community-wide emissions inventory. Community-wide inventory attachment (spread-sheet) and/or link (with unrestricted access): • If available it is preferred that the jurisdiction attaches a spreadsheet (i.e., excel) format of city´s emissions inventory. Macro-enabled spreadsheets that use spreadsheets that use the ".xlsm" format (e.g., CIRIS, earlier versions of the GPC reporting tool) should be saved as Excel workbooks ".xlsx" to be attached to the questionnaire. • Clearpath Users: if the jurisdiction is using the ClearPath tool, then the jurisdiction is asked to attach both extracts.

			• Clearpath, CIRIS, Snapshot, SCATTER and/or ClimateView Users: if the jurisdiction imports data from CIRIS, Clearpath, Snapshot, SCATTER and ClimateView to the jurisdiction response the jurisdiction is still required to attach the inventory itself to this question. **Question (2.1b)** Provide the following information regarding your latest community-wide GHG emissions inventory. Table column 8 “Has the methodology and/ or boundary used for this inventory changed when compared to the previously reported inventory?” • If the jurisdiction most recent emissions inventory that is being reported is based upon a different methodology and/ or boundary than previously reported inventory, the jurisdiction is asked to indicate it. • If the changes are significant enough then it is recommended that the emissions for previous years are retroactively recalculated to reflect the changes. • If this is the case, then the jurisdiction is asked to attach the updated historical emissions where available. The jurisdiction is asked to ensure the historical emissions inventory document(s) is attached in Excel format. **Section** • Community-wide Emissions Inventory Data **Question (2.1c)** Provide a breakdown of your community-wide emissions by scope. If the inventory has been developed using the Global Protocol for Community Greenhouse Gas Emissions

			Inventories (GPC) you will also be requested to provide a breakdown by sector. Requested content General • If the jurisdiction uses the City Inventory Reporting and Information System (CIRIS) or ClimateOS (ClimateView) tools for managing and reporting emissions inventory data, the jurisdiction can import their response data for selected questions for selected questions for this question. Further guidance on how to import can be accessed in the Guidance for Importing Emissions Data into Questions 2.1c and 2.1d. **Question (2.1d)** Provide a breakdown of your community-wide emissions in the format of the Common Reporting Framework. Requested content General • If the jurisdiction uses the City Inventory Reporting and Information System (CIRIS) or ClimateOS (ClimateView) tools for managing and reporting emissions inventory data, the jurisdiction can import their response data for selected questions for selected questions for this question. Further guidance on how to import can be accessed in the Guidance for Importing Emissions Data into Questions 2.1c and 2.1d. **Section** • Consumption-Based Emissions Inventory **Question (2.2)** Does your jurisdiction have a consumption-based emissions inventory to measure

			emissions from consumption of goods and services? The jurisdiction is asked to provide an overview and attach jurisdiction´s consumption-based inventory, along with any supporting methods/ calculations. **Section** • Government Operations Emissions **Question (2.3a)** Attach your government operations emissions inventory and report the following information regarding this inventory. Requested content Government operations emissions inventory attachment and/ or link (column 1) • The jurisdiction is asked to use this field to attach their government operations emissions inventory. • If available it is preferred that the jurisdiction attach a spreadsheet (i.e., excel) format of their emissions inventory. Macro-enabled spreadsheets that use the ".xlsm" format should be saved as Excel workbooks ".xlsx" to be attached to the questionnaire. Finally, it is important to mention that in addition to the data import/ attachment function some questions of the CDP-ICLEI Track Cities Questionnaire have file (i.e., climate action planning document) attachment function.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
			
Group II – Inventory interoperability			
2-4 **Level of openness in sharing reported data with other systems**	The Mission doesn´t impose strict requirements on the level of openness in sharing reported data with other systems. It highlights that data platforms and the use of open standards and technical specifications to share data across sectors, will also be of importance for the (scaling-up of) digital transformation.	Over the course of 2019, the Covenant for Climate and Energy. Europe framework was aligned with the recommendations of the Global Covenant of Mayors for Climate and Energy (GCoM) Common Reporting Framework and GCoM DATA4CITIES initiative.	The CDP-ICLEI Cities Questionnaire is aligned with the reporting requirements of several frameworks and initiatives including: • Global Covenant of Mayors Common Reporting Framework (CRF). • Race to Resilience. • Race to Zero. • Task Force on Climate-related Financial Disclosures (TCFD). • European Climate Pact. • Sustainable Development Goals. • ICLEI initiatives (Green Climate Cities Program, Eco Mobility/ Eco Logistics). • C40 Cities.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Group II – Inventory interoperability			
2-5 Supported visual features	The Mission doesn´t impose strict requirements on climate action data visualisation. It highlights the following aspects/ benefits of data visualisation: • That digital tools are a powerful instrument for citizen engagement, by presenting data and evidence in a compelling way, and for simulations and visualisations, which can help engage citizens in shaping their city. • Digital twins of a city are considered the next phase in smart city management, as they enable policy-makers to visualise and simulate the impact of their decisions in a test environment, while facilitating the participation of citizens in decisions around urban planning that impact their lives. • Digital technologies can assist with citizen engagement, for example by visualising data in a way which clearly communicates the impact of actions, or for participative planning and decision-making.	Covenant of Mayors reporting platform offers users option to indicate the emission factors that they have used for their CO2 emissions calculation. Users can visualise default fuel emission factors in the table. The emission factors are displayed based on the emission factor approach and reporting unit previously selected. If users have used these default values, they can simply select them. Default emission factors for local emission inventories are regularly published by the Joint Research Centre.	CDP Open Data Portal homepage has eight tiles each containing a key statistic based on the latest cities, states and regions data: 1. **Governance** – datasets containing full responses to the annual questionnaire, lists of governmental organizations reporting through CDP-ICLEI Track, and datasets on the impact of COVID-19 on climate action and climate change. 2. **Emissions** – all datasets on emissions. 3. **Opportunities** – datasets on opportunities from addressing climate change, collaboration with businesses on sustainability, and projects seeking financing. 4. **Water** – datasets on water security risks and water resources management. 5. **Climate Hazards** – datasets on environmental and climate-related risks, climate risk and vulnerability assessments, and social and health-related impacts of climate risks. 6. **Adaptation** – datasets on adaptation plans and actions. 7. **Mitigation** – datasets on emissions reductions targets, plans, and actions. 8. **Energy** – datasets on energy mix and renewable energy targets.

			Each tile represents a different category covering the main areas of CDP´s work with local governments. CDP Open Data Portal homepage has the data filtering and visualizations creating functions. Using the Filter function in the menu, users can filter data in any of the columns in the dataset by selecting the column users wish to filter and the blue tick box. Users can also create visualizations of the data by selecting Launch New Visualization under the Visualize function in the menu. If users are interested in creating visualizations, Socrata, the website provider for the CDP Open Data Portal, has many useful resources to support users.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Group III – Inventory user-friendliness			
3-1 **Simplicity and easiness to follow the User Interface**	The Mission doesn´t impose strict requirements on the quality attributes of the GHG inventory User Interface. It highlights that due to the distributed and heterogeneous nature of the information, creating a digital twin of a city is both technically and organisationally challenging, yet could be a powerful means to break administrative silos and address complex urban challenges. From the perspective of this comparative analysis criteria, climate action data reporting through My Covenant and CDP-ICLEI Track platform can support European cities in systematization of the climate information.	Cities are asked to respond to information requests using the Covenant of Mayors reporting platform – My Covenant. The platform consists of the Sustainable Energy and Climate Action Plan (SECAP) template. There are available Reporting Guidelines for the cities. This document provides step-by-step guidelines to signatories on how to report information in the various sections of the Covenant of Mayors reporting platform. It has been developed by the Covenant of Mayors Europe Office in collaboration with the Joint Research Centre of the European Commission to assist signatories in understanding the Covenant of Mayors reporting framework and successfully completing the reporting process. The guidelines are complemented with practical recommendations and useful resources. The reporting and monitoring process consist of five steps: 1. **Log in My Covenant** – My Covenant is accessible from the European Covenant of Mayors website or via the private space of the European Covenant of Mayors Community https://mycovenant.eumayors.eu/site/landing. To log in, signatories need to use the email and password which they received during registration stage.	Cities are asked to respond to information requests using CDP-ICLEI Track. The platform consists of the Cities dashboard and the Online Response System: 1. **The dashboard** – the dashboard is a portal containing information regarding the Cities questionnaire, the authorities are being requested to respond to, city´s user account page, the Guidance tool and other resources. 2. **The Online Response System** – the Online Response System is where the city inputs information into its questionnaire(s) and submit its response. There is available guide to using CDP-ICLEI Track for the cities. It provides a comprehensive guide on how to use the reporting platform and explains all of its features. The guide contains sequential and detailed textual and visual information on the following elements and associated functions of the User Interface: • **The basics** – (1) Register, confirm and sign in; (2) Join additional

		2. **Complete My Strategy, My Inventories, My Actions** – the section My Strategy, My Inventories, My Actions are the core of the Covenant reporting and monitoring framework. Reporting Guidelines provides an overview of these sections in My Covenant. They also indicate the respective chapters in these guidelines which explain in detail how to complete the sections. • **My Strategy** – (1) Specify your targets and commitments, administrative structure, involved stakeholders, budget information, etc. • **My Inventories** – (1) Emission Inventory: specify all mitigation-related data (energy consumption, electricity production, etc.); (2) Risks and Vulnerabilities: specify all adaptation-related data (climate hazards, vulnerable sectors, adaptive capacity, etc.). • **My Action** – (1) My Actions Overview: specify aggregated data for your mitigation and adaptation actions; (2) My Actions Details: specify details for each mitigation and/or adaptation action, and/or energy poverty, including key actions. 3. **Upload action plan document(s)** – to upload documents in My Covenant, (1) go to My Strategy in the Reporting corner; (2) click the My Action plan documents tab; and (3) scroll down to "Documents upload". All documents should be uploaded in a *PDF format, in the national language, unless an English translation is available. The uploading of at least one action plan document is mandatory. 4. **Submit template** – only once you have completed the respective reporting sections of My Covenant (Step 2) and uploaded the action plan document(s) (Step 3), it is possible to submit your action plan to the Covenant of Mayors.	projects and initiatives; (3) Choose your questionnaire pathway; (4) Note the deadline; (5) Your CDP-ICLEI Track Dashboard. • **Activating your questionnaire** – (1) Your dashboard after activating your questionnaire; (2) Joining and reporting to additional projects and initiatives after activation; (3) Projects & initiatives; (4) Guidance tool; (5) My Account; (6) Organization details (Main users only); (7) Changing languages; (8) User types; (9) Adding new users. • **The Online Response System** – (1) The Online Response System Homepage; (2) Navigating the Online Response System; (3) Accessing guidance; (4) Saving your response; (5) Copy Forward; (6) Audit Log; (7) Cultural settings; (8) Question types and additional question features; (9) Sharing your response; (10) Signing out; (11) To return to the Online Response System; (12) Export your response from the Online Reporting System: Export to Word / Export to Excel; (13) Import your response to the Online Reporting System: Excel import best practice; (14) Guidance for Importing GHG Data to Questions 2.1c and 2.1d / Steps to Import. • **Submitting your response** – (1) Making your submission choices; (2) How to submit your response (Main User only); (3) Submission trouble shooting; (4) Submission confirmation; (5) Your dashboard after submitting your response. • **Amending your response** (Main User only) – (1) Change your questionnaire pathway and join

		5. **Monitor progress** – progress is monitored via submission of a monitoring report every two years after the action plan´s submission date. The aim of monitoring is to assess the progress made towards the targets set in the action plan´s strategy. Monitoring is an integral part of every planning cycle that allows corrective measures to be planed. As such, the monitoring report in My Covenant is not a separate section; instead, the monitoring report is a set of additional fields in the various template sections under Step 2: • **My Strategy** – (1) Indicate progress towards the target, staff capacity allocated for plan implementation, budget spent so far, describe the monitoring process. • **My Inventories** – (1) Emission Inventory: update energy consumption, production and emissions factors submitting a Monitoring Emission Inventory (MEI); (2) Risks and Vulnerabilities: update, as needed, all the previously reported data; note there are no additional fields for monitoring. • **My Action** – (1) My Actions Overview: update progress of implementation; (2) My Actions Details: update progress of implementation.	additional projects and initiatives during an amendment. • **Viewing your response** – (1) In the Online Response System as a snapshotted response; (2) As a formatted response from Scores and Responses. • **Further help.**

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
			
Group III – Inventory user-friendliness			
3-2 **Easiness to control/ correct actions/ errors**	The Mission doesn´t impose strict requirements on the easiness to control and correct the GHG inventory actions and errors. It highlights that careful and transparent consideration is needed when addressing issues of public control and ownership of data collected through (new) technologies, particularly in cases where services are outsourced to third parties. Technologies in themselves are neutral – it is how they are managed that will determine the real impact on city life. The Mission indicates that collaboration between cities and communities will be key, even if they have data and digital technologies at their disposal, to increase impact and have more control over the smart solutions they ultimately choose. In order to remain flexible in their choice of technology providers and to create added value from their data for the common good, recent studies suggest that cities should implement interoperable, urban data platforms using a common set of open standards.	My Covenant has an automatic integrated verification system that identifies any errors (matching against value ranges or predefined values), validates the data format (text, number, date, hyperlink, single or multiple choice), and detects missing mandatory information. It has integrated algorithms which reduce the margin for human error, e.g. when calculating the emission inventory. If errors are detected, the system displays notification error messages at the bottom of each respective table in My Covenant. The section "My Overview" indicates whether all required sections in My Covenant have been properly completed, using the following legend: • Complete. • Incomplete. • Not applicable. The city will only be able to submit its data after correcting all errors throughout the reporting and monitoring template.	If the Online Response System detects errors or warnings in the city response the "Errors and Warning" box will be flagged for the city to rectify the issue. If the city tries to submit with errors in its response the city will see a red **"submit failed"** notification in the corner. This will occur if the city tries to submit: • Without having completed all mandatory fields. • With fields that have a value that is out of range. • With fields that exceed the character limit. If the city clicks on the errors and warning button, a pop-out box will show the list of **errors** (red) and **warning** (yellow). If the city clicks an error or warning it will take the city to that field in the Online Response System for the city to amend. Once the error or warning is resolved it will disappear from the errors and warning list. The city will be able to submit once all errors are resolved. Warning do not prevent the city from submitting.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Group III – Inventory user-friendliness			
3-3 **Attractiveness and aesthetics (design)**	The Mission doesn´t impose strict requirements on the attractiveness and aesthetics (design) of the GHG inventory framework. It highlights that the Digital Europe Programme will support the creation and validation of a governance scheme and reference architecture for a data space for smart communities, for the secure exchange of public and privately held data at European Union level. The identification of common priority datasets linked to the environment and climate-related challenges will increase the potential for sharing data solutions between communities across borders and sectors and help them meet the objectives of the European Green Deal. The action will contribute to the definition of the technical infrastructure for data sharing across relevant domains (in particular, traffic, electricity, pollution, extreme weather events, water, sewage, waste management, urban infrastructure, etc.), in order to create cross-domain innovation and move towards the Green transition in each local context.	My Covenant reporting and monitoring framework has been developed in consultation with practitioners from local and regional authorities, climate and energy experts and with the methodological support of the European Commission´s Joint Research Centre. In 2018 the new My Covenant section has been developed using inputs from Covenant users and accommodating them in the best possible way in the design, logic and security of the system: • **The start page** – the start page has been changed to accommodate a quick overview of what is considered useful information for the city when logging in. • **The reporting corner** – the reporting corner has been made more flexible to insert information in cities´ SEAPs / SECAPs and corresponding monitoring reports. • **The eye icon** – for Covenant coordinators, one of the most useful features is the eye icon. By clicking on the eye icon, the Covenant coordinator will be able to "impersonate" the signatory and see	In 2022 CDP and ICLEI have updated the questionnaire and made it more attractive and user-friendly. The new, streamlined questionnaire replaced the existing one, raising the bar on tracking progress on cities climate action and simplifying the process for reporting cities. For the convenience of the users, the CDP-ICLEI Track Online Reporting System has eight main features: • **Exit Online Reporting System** – signs the user out of the Online Reporting System. The user can then close that tab or window. The user may still be signed into the dashboard. • **Dashboard links** – link back to the relevant parts of the user´s dashboard, where the user can perform the action required. • **Save, Share and Submit** – depending on the user type the user may see all, some or none of these permissions. Using "Save" displays a warning for parts of questionnaire not yet completed, or that have an error. • **Import/Export** – these buttons allow users to export and import the questionnaire, including all responses entered, as a *Word or *Excel document.

		its profile as if the Covenant coordinator was the signatory itself. • **The overall layout and design** – the overall layout and design of My Covenant has been modernised and simplified, in line with the "feel" of the public Covenant website.	• **Audit Log** – this button takes the user to the audit log. It allows the user to track all changes made in the Online Reporting System by any user. • **Floating blue progress bar** – this indicates the number of questions the user has saved an answer for so that the user can track his/her progress. Depending on the user answers, the total number of questions may fluctuate. • **Navigation menu** – the user can click the arrow and use the menu to jump between modules and pages. It will also show the user which sections have unanswered questions. • **Previous, Next, and skip buttons** – for moving between neighbouring pages or skipping to the start or end of the questionnaire.

	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Analysis criteria			
Group III – Inventory user-friendliness			
3-4 **Flexibility in data management and data analytics**	The Mission doesn´t impose strict requirements on the flexibility in GHG inventory data management and data analytics. It highlights that data can illustrate the sometimes initially intangible value that cities have generated and can be used to attract private investment and finance smart city solutions. Data is also a fundamental opportunity that smart cities can exploit in the future. For example, data-driven innovations can improve the circular economy, by more accurately managing consumption and production processes.	Over the course of 2019, the Covenant framework was aligned with the recommendations of the Global Covenant of Mayors for Climate and Energy Common Reporting Framework. https://eumayors.eu/FAQs_2021.pdf	In 2022 the new, streamlined Cities Questionnaire replaced the existing one, raising the bar on tracking progress on cities climate action and simplifying the process for reporting cities. Three questionnaire pathways have been introduced to reflect the different contexts of cities and to streamline reporting. This enables reporting to a core set of questions for all cities and additional questions only where relevant and valuable. The pathways vary in the number and type of questions presented to local governments based on their impact and capacity to act: • **Pathway 1** – contains 17-27 questions. • **Pathway 2** – contains 24-34 questions. • **Pathway 3** – contains 30-40 questions. The 2022 Cities Questionnaire was developed alongside partners to ensure the integration and alignment of initiatives and framework reporting requirements including the Common Reporting Framework (CRF), Task Force on Climate-related Financial Disclosures (TCFD), Science-Based Climate Targets (SBT), Race to Zero (RtZ) and Race to Resilience (RtR). It tracks the performance and impact of key actions, defines critical climate actions and assesses the increasing links between environmental action and social impacts.

Analysis criteria	European Mission´s "100 Climate-Neutral and Smart Cities by 2030" requirements	Covenant of Mayors Europe approach	CDP-ICLEI Track approach
Group III – Inventory user-friendliness			
3-5 **Control, security and privacy aspects**	The Mission doesn´t impose strict requirements on the control, security and privacy aspects of the GHG inventory framework. It highlights that one of the challenges for cities to consider is the data protection policies and protected Information and Communication Technology platforms concerning data use, sharing, management, and exploitation by public and private sectors. Including data ownership, appropriate and consistent legislation, data sharing and standards, and cybersecurity.	My Covenant is in line with all current European Union cybersecurity guidelines and compliant with the European Union General Data Protection Regulation (GDPR). My Covenant has the Data Policy that sets the rules that the European Commission applies for collecting, processing, sharing and publishing data of local and regional authorities and other organisations in the context of the My Covenant. By default, all Covenant Data are considered "open data". It means that Covenant Data should be open (published and made available for re-use for both commercial and non-commercial purposes), timely, comprehensive, accessible and usable, comparable and interoperable. It should contribute to improving governance, citizen engagement, inclusive development and innovation. Signatories reporting through My Covenant make data publicly available free of charge through the Covenant of Mayors for Climate and Energy. Europe website, as well as on the European Union Open Data Portal or the website of the European Commission (https://ec.europa.eu/jrc/en).	When responding to the Cities Questionnaire, the city will be given a choice as to whether its response can be made public or whether its response is non-public, unless the city decides to participate in the GCoM initiative and/or European Climate Pact and/or Cities Race to Zero (RtZ) and/or Race to Resilience (RtR) in which case the city can only respond publicly. If the city agree that its response can be made public, CDP may use it in furtherance of its charitable mission, including by: • Making it available as soon as it is received by CDP to its partners (including C40, GCoM, ICLEI, and the European Climate Pact), appointed report writers and any other parties CDP deems appropriate. • Making it publicly available, for example through the CDP Open Data Portal (and stored and preserved on CDP servers indefinitely thereafter.

		Key data from signatories under the Global Covenant of Mayors for Climate and Energy (GCoM) website and shared with the online Global Climate Action portal (GCAP) hosted by the United Nations Framework Convention on Climate Change (UNFCCC).	• Compiling it in CDP databases and making it available in original, modified or adapted form for use by commercial (for a fee or otherwise) and non-commercial organizations. • Amalgamating it with information about the Responding City from other public sources. • Using in any other way that accords with the CDP charitable mission.

Both of the analytical Greenhouse Gas inventory practices, i.e. Covenant of Mayors Europe or Sustainable Energy and Climate Action Plan (SECAP) approach and CDP-ICLEI Track approach have conceptual correspondence to the Greenhouse Gas emissions requirements of the European Mission "100 Climate-Neutral and Smart Cities by 2030". Cities currently using one or both of the above-mentioned European Mission "100 Climate-Neutral and Smart Cities by 2030" demonstrate the level of the Greenhouse Gas emissions accounting and target setting practice experience. Thus, the use of these two current Greenhouse Gas emissions accounting practices for the purpose of baselining would be recommended. However, individual city-based methodological adaptation actions at the local level will be necessary. It would ensure that all Greenhouse Gases in terms of carbon dioxide equivalent (CO_2e) are included in a city´s Greenhouse Gas inventory for the purpose of the Mission, and all sources and sectors of Greenhouse Gas emissions are accounted for (please see comparative analysis results of using criteria 1-1, 1-2, 1-3, 1-4 and 1-5). As the Mission doesn´t impose strict requirements on the Greenhouse Gas inventory practice´s interoperability (please see comparative analysis results of using criteria 2-1, 2-2, 2-3, 2-4 and 2-5) and user-friendliness (please see comparative analysis results of using criteria 3-1, 3-2, 3-3, 3-4 and 3-5), these characteristics should be considered and adopted in line with the design, functionality and operability of the upcoming NZC platform. Finally, it is important to mention that the CDP/ICLEI platform covers emissions in a way that is similar to the approach that NZC is following, as well as questions for qualitative monitoring, which will be also considered in NZC.

5. Conclusion

This deliverable has focused on the identification of requirements (technical and non-technical) for the monitoring data-/and visual interface systems that will guide the development of NZC shared data infrastructure concept and related visuals, that will be taken into the deployment activities of WP3.

The collection of requirements has been based on the analysis of multiple sources of information such as a Mission documents, previous WP2 deliverables, literature review, analysis of existing platforms and a three-week co-creation with cities workshop run in the city of Madrid.

It is highlighted in the document that

- The Mission cities will need the support from NZC to set-up their monitoring and evaluation activities (MEL framework) in the form of 9 steps, as presented in the chapter (Chapter 3.1).
- Both of the analytical Greenhouse Gas inventory practices, i.e. Covenant of Mayors Europe or Sustainable Energy and Climate Action Plan (SECAP) approach and CDP-ICLEI Track approach have conceptual correspondences to the Greenhouse Gas emissions requirements of the European Mission "100 Climate-Neutral and Smart Cities by 2030". Thus, the use of these two current Greenhouse Gas emissions accounting practices for the purpose of baselining would be recommended (Chapter 4).
- From the usability point of view, the presentation of performance indicators needs to be, on the one hand, designed using established User Experience (UX) design principles, and on the other, designed to meet the specific needs of its prospective users specifically targeting urban planning and policy-making context (Chapter 3.2).
- At least four main groups of stakeholders should be considered as users of the platform: Citizens, scientists interested in climate change, activists (individuals, NGOs, companies, etc.), and politicians. Each of them will need to have different information displayed for them.
- The climate city contracts should be further developed on the website with clear indications of the main characteristics of the contracts.
- Data visualisation can be based on the indicators identified in the MEL framework, with different types of visualisations (as presented in Annex I), and with the possibility of downloading all the data as open data.
- It should be possible to navigate to other similar cities in terms of their climate city contracts, their characteristics in terms of emissions or portfolios of projects, etc. It should be also possible to compare their contracts with those of other cities.
- There should be a guide for citizens with simple actions that they can do to contribute to the mission of their city.

While a lot of attention has been put in the visualisation of indicators that are related to existing GHG reporting frameworks, it has been clear from the analysis of documents and from the interactions in workshops that any visualisation system should move from GHG data visualisation only to the presentation of many other aspects that are relevant in the context of their work towards the EU Mission, namely those aspects related to co-benefits, portfolios of projects in their activities, and training and dissemination material.

As a future action, once that the list of indicators are stable and a complete indicator framework is available in the context of WP2, activities will resume again to discuss on the best way to visualise all of these elements. In course of this work it's planned to have a series of workshops with technical partners and designers (which will take place in October-November time), that will be dedicated to the alignment and finalising of MEL indicators at one hand and scoping of requirements and needs of cities at the other hand.

The final shared data infrastructure concept, including visualization of KPIs and respective usability evaluation will be presented in the deliverable D2.9 (M24).

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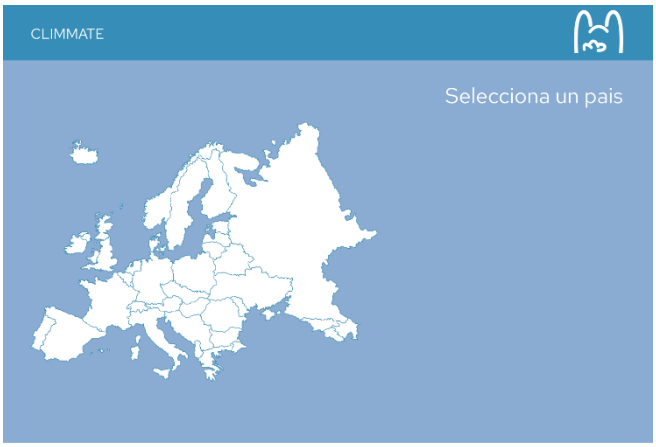
Annex I. Results from the co-creation workshop

The results that are presented in this annex are those referring to the low-fidelity prototypes generated for different types of stakeholders during the co-creation workshop. It is important to note that given the bias in the interactions held during the workshop (Spanish-speaking counterparts), all the results are presented in Spanish, with their corresponding translation provided here in text for the convenience of non-Spanish-speaking readers.

This project has received funding from the H2020 Research and Innovation Programme under the grant agreement n°101036519.

I.1 Main site for the EU Mission



¿Qué es el proyecto NetZeroCities?

NetZeroCities (NZC) es un proyecto financiado por el programa Horizon Europe, cuyo objetivo es apoyar a varias ciudades europeas en su ambición por conseguir la neutralidad climática antes de 2050 (Misión UE «100 Cimate-Neutral and Smart Cities by 2030», parte del programa Horizonte Europa). Para conseguir este objetivo cada una de las ciudades en esta misión requerirá cambios sistémicos y profundos.

NetZeroCities reconoce la necesidad de las ciudades de desarrollar estrategias específicas que se adapten a los contextos locales y regionales, y las ayudará con servicios y temáticas agregadas y co-diseñadas por expertos a través de una plataforma one-stop-shop accesible para todas las ciudades a través de un portal online (Mission Platform).

Información básica

Objetivo de reducción de las emisiones

Reducción y utilización de Residuos

Reducción del Consumo de electricidad

Calidad del agua

¿A quienes nos dirigimos?

Científicos

Ciudadanía

Activistas

Políticos

Preguntas frecuentes

¿Para quien es esto?

¿Qué hace que esto sea diferente y mejor de lo que las ciudades informan directamente?

¿Las ciudades tienen que pagar una suscripción?

¿Con qué frecuencia se actualizarán los datos? ¿Puedo ver y descargar datos históricos? ¿Se pueden usar los datos presentados en esta herramienta para el monitoreo regular de los inventarios de emisiones?

CLIMMATE

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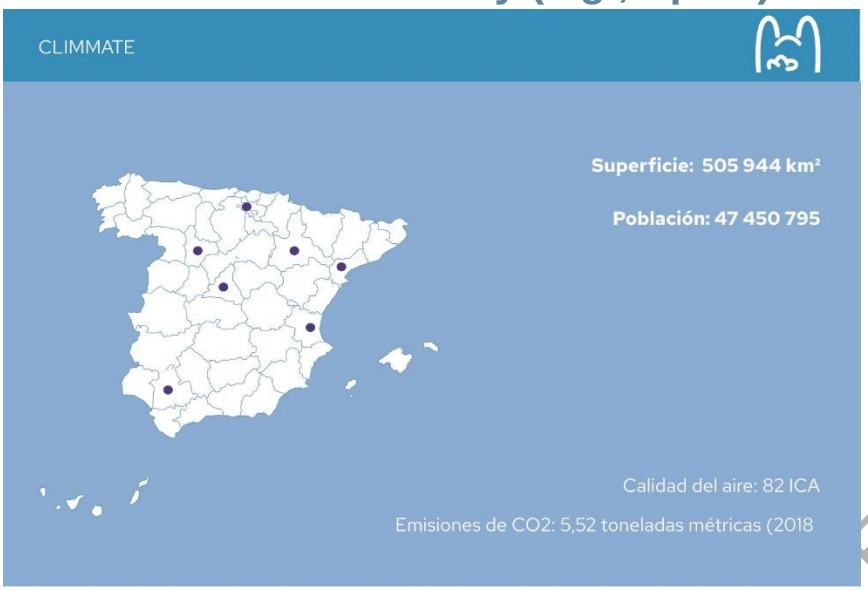
I.2 Main site for a country (e.g., Spain)



This project has received funding from the H2020 Research and Innovation Programme under the grant agreement n°101036519.

I.3 Main site for a city (e.g., Madrid)

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This project has received funding from the H2020 Research and Innovation Programme under the grant agreement n°101036519.

I.4 Climate City Contract page

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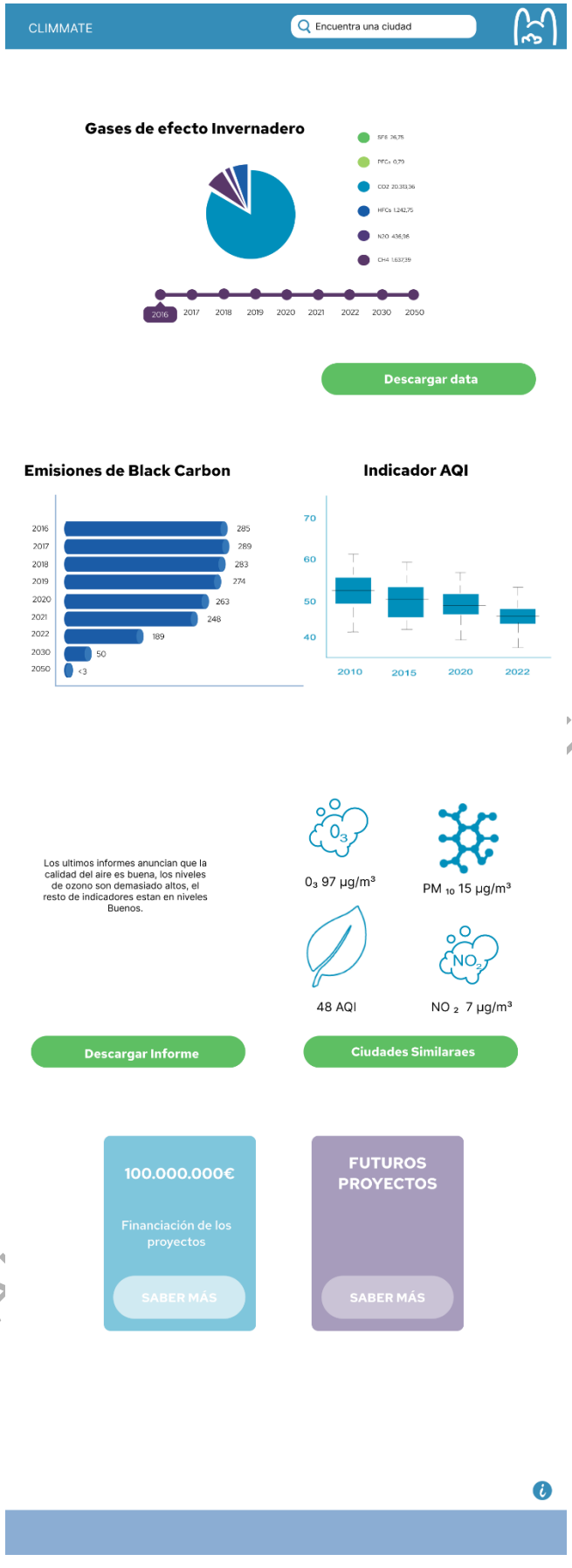
I.5 Visualisation of quantitative indicators



This project has received funding from the H2020 Research and Innovation Programme under the grant agreement n°101036519.

I.6 Site for organisations

I.7 Project portfolio

This project has received funding from the H2020 Research and Innovation Programme under the grant agreement n°101036519.