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Deliverable 2.7: Benchmarking of selected solutions WP2, Task 2.4

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Abbreviations and Acronyms

Acronym	Description
BEMS	Building automation and control system
ВМ	Business Model
CCC	Climate City Contract
CHP	Combined Heat and Power
CoM	Covenant of Mayors
DoA	Description of Action
DH	District Heating
DHW	Domestic Hot Water
EC	European Commission
EE	Energy Efficiency
ENCI	Energy Citizenship
ETS	Emission Trade System
EU	European Union
EV	Electric Vehicle
FW	Fellow
FWC	Fellow City
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIS	Geographic Information Systems
GWP	Global Warming Potential
ICT	Information and Communication Technologies
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LH	Lighthouse
LHC	Lighthouse City
LULUCF	Land use, Land-use change, and forestry
Mission	EU Mission for 100 Climate-Neutral and Smart Cities by 2030
NZEB	Near Zero Energy Building
NGO	Non-Governmental Organisation



PEB	Positive Energy Building
PED	Positive Energy District
PPP	Public Private Partnership
RES	Renewable Energy Sources
SCC	Smart Cities and Communities
SCPG	Smart City Planning Group
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
SUMP	Sustainable Urban Mobility Plan
SWOT	Strengths, Weaknesses, Opportunities and Threats (analysis)
UNFCCC	United Nations Framework Convention on Climate Change
WP	Work Package



0. Executive Summary

The present deliverable provides a comprehensive approach to analyse the goals and actions that shape the carbon neutral city vision of the eight ATELIER cities.

WP2 aims at the development of a City Vision for every city in the project. The objective of the whole WP is structure under the Cities4ZERO methodology (Urrutia et al, 2020¹) to guide the cities to develop the urban transformation strategy for decarbonisation. D2.7 is the last of the eight deliverables expected in WP2, meaning that seven deliverables have been submitted previously. Considering that they present the city vision and master scenarios and the action plans of the cities, crucial information to support D2.7, the latest two deliverables must be highlighted: D2.6 City Vision 2050 for LHs and FCs (submitted in December 2023) and D2.8 Updated SEAP/SECAP for LHs and FCs (submitted in May 2024).

Starting from the City Vision and the Action Plan, D2.7 focuses on evaluating the proposed pathway to achieve the city's decarbonization objectives. It outlines the method for benchmarking of selected solutions, including the impact assessment of the master scenario; provides a practical application example for the lighthouse city of Bilbao; and includes the material needed to perform the analysis in the eight ATELIER cities. Moreover, this deliverable address "Design Thinking" as a method useful to deal with city's systemic problems that may rise from the benchmarking process. The latter was addressed through a common workshop aimed at capacitating the cities on how to implement Design Thinking within the municipalities.

Furthermore, D2.7 intends to go in deep into the benchmarking of the social considerations and proposes an innovative method to address energy citizenship at city level. Beyond the social acceptance, energy citizenship pretends to convert citizens in active agents of the energy transition. The method proposes starting from understanding current situation by collecting the point of view of the citizens through a survey. Recommendations can be given to foster the energy transition by facilitating citizens implementations.

In addition, Copenhagen, Riga and Amsterdam share selected lessons learnt from the experience, for a successful planning and climate city contract preparation. Finally, D2.7 presents in annexes an updated version of the ATELIER cities City Vision. In the case of Bratislava, the energy model is described as well, and Riga presents an updated version of the master scenario in accordance with the Climate City Contract.

This work has been developed by Tecnalia together with ATELIER cities. Cartif leaded design thinking activities and collaborated in preparing the material needed for benchmarking processes. TNO supported Amsterdam in the process of reporting.

With this work, the WP2 "City Vision" of ATELIER project comes to an end after five years dedicated to defining the energy city vision. Looking back to the beginning of the project in 2019, WP2 activities started with encompassing a deep analysis of cities' status, engaging key stakeholders to be part of the process and establishing methodological recommendations to guide the city vision development. In terms of reports, in August 2020, the planning framework report for each city was presented (D2.1). Five months later, in January 2021, cities presented their so-called Smart City Planning Group, or in other words, the governance model that would drive the city vision creation (D2.2). Moreover, just one month later, in February 2021, the common methodological framework for city vision development was presented, based on the

¹ https://doi.org/10.3390/su12093590





Cities4ZERO methodology. Each city adapted the common methodology to their own needs and presented the process for developing the city vision through the so-called vision co-development roadmaps (D2.4, June 2021). In December of the same year, the energy diagnosis and the business-as-usual scenario were presented, along with the method for prioritizing the energy transition narratives that would shape the master scenario (D2.5, December 2021).

Once the process was methodologically clearly defined, activities shifted to focus on implementing the recommendations for effective planning. Cities did a remarkable effort in defining their city vision and master scenario, demonstrating flexibility and adaptability to evolving circumstances, such as being selected to be part of EU cities mission initiative "100 Climate neutral cities in 2030". The city vision and master scenario were presented in December 2023 (D2.6), followed by the action plan in May 2024 (D2.8).

The approach presented in this deliverable concludes WP2 activities by providing the method and material necessary to evaluate the goals and actions that shape the carbon neutral city vision developed over these years. Applying this approach may help cities identify strengths and weakness, enabling precise adjustments and refinements.

It is important to note that City Vision creation is a living process in constant evolution. Therefore, even though the WP ends, City vision activities will continue within the municipalities by including the latest innovations, implementing learnings from the experience, adopting new perspectives, and more, in an ongoing and enriching process.



1. Introduction

WP2 intends to develop a 2050 City Vision for the cities of the project. With that purpose, the flow of the work package is structured according to *Cities4ZERO: The Urban Transformation Strategy for Cities' Decarbonisation* (Urrutia et al, 2020²), a step-by-step methodology that guides the cities through the process of developing the most appropriate strategies, plans and projects as well as looking for commitment of key local stakeholders for an effective transition; all from an integrated planning approach.

Within Cities4ZERO methodology, WP2 is focused on the Strategic Stage (Figure 1), providing a strategic planning framework which enables the cities to:

- Engage key city stakeholders (institutional analysis and Smart City Planning Groups).
- Review the planning framework of the city.
- Analyse and diagnose the city' strengths and opportunities.
- Formulate the co-visioning process for urban transformation towards energy transition, including potential future scenarios.
- Develop the strategic plans (SECAP in ATELIER case) to deploy that city vision, identifying the key projects for the city.

In the case of D2.7 – Benchmarking of selected solutions, the work developed in this deliverable aims to analyse the goals and actions that shape the carbon neutral city vision of the eight ATELIER cities. It does not correspond to a specific step of Cities4ZERO methodology, but to evaluate the results obtained thanks to the application of the whole methodology.

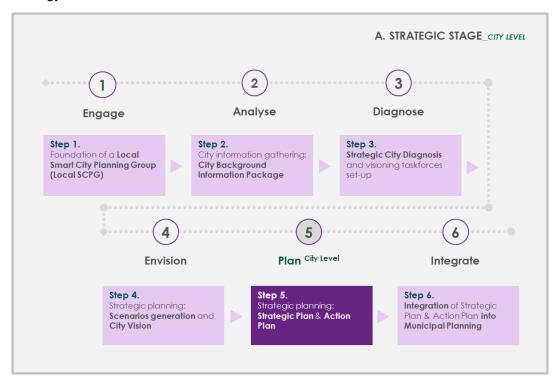


Figure 1. Strategic Stage in Cities4ZERO approach by Tecnalia (Urrutia et al, 2020)



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² https://doi.org/10.3390/su12093590



1.1. Purpose and Target Group

The main purpose of this deliverable "D2.7 Benchmarking of selected solutions" is reporting the method proposed to evaluate the proposed pathway to decarbonize the energy systems of the eight ATELIER cities. Beyond the method, the material needed to do the analysis in each city is provided, together with the latest updates in the city vision process.

Being the last of the 8 deliverables of the WP2, D2.7 presents in annexes the results obtained from the latest steps of T2.4, related to the city vision. Therefore, even though this deliverable is public, the target audience are the 8 ATELIER cities.

The public nature of this deliverable offers an opportunity to share methodological insights, along with a practical example, that can assist municipal technicians in their efforts to create and evaluate city vision. Moreover, Amsterdam, Riga and Copenhagen wanted to share selected lessons learnt from their experiences, which may also be valuable for other municipalities.

The present deliverable is structured as follows:

The section 1 gives an introduction to the entire WP2, to the methodology carried out in it, as well as to the deliverable and its distribution (by chapters and by partners).

The section 2 provides the description of the overall approach proposed to do the benchmarking of selected solutions.

The section 3 presents the results obtained from applying the benchmarking of selected solutions to the case of Bilbao, as front runner in the application of WP2 activities.

The section 4 presents selected lessons learnt from Amsterdam, Riga and Copenhagen in the City Vision creation process.

The section 5 provides the conclusions.

The deliverable includes additional information as annexes. Annex 1: related to the Climate Neutral Energy survey conducted in cities; and Annex 2: Impact assessment assumptions, related to the assumptions considered for the impact assessment of the master scenario.

It is important to note that Annexes 3 to 10 collect, for each city, the latest updates on city vision creation, the impact assessment of the master scenario and the materials used for the benchmarking of selected solutions. In particular, the content in D2.7 for each city is summarized in Table 1.

Table 1. ATELIER city's content in D2.7



Content	Amsterdam	Bilbao	Bratislava	Budapest	Copenhagen	Krakow	Matosinhos	Riga
City vision	✓		√	✓	✓	✓		√
Selection of the final scenario regarding the City Vision 2050			✓					✓
Analysis of expected impacts in the environmental field (energy supply and demand sides) but also in the economic and social field		✓	✓	√		✓	√	√
Assessment of the goals and actions by the different solutions (Benchmarking)	√	√	√	√	√	√	✓	√
Analysis of how better citizenship engagement can promote the achievement of the city's decarbonization objectives.		√						
Lessons learnt in City Vision creation process	√				✓			✓

1.2. Contributions of Partners

Table 2 depicts the main contributions from project partners in the development of this deliverable.

Table 2. Contributions of Partners

Partner short name	Contributions	
Tecnalia	Deliverable and Work Package leader.	
CARTIF	Design thinking method and Workshop. Benchmarking boards of Amsterdam, Bratislava, Budapest, Krakow, Matosinhos and Riga.	
PSI	Deliverable reviewer.	
EVE	Deliverable reviewer.	
AMST-TNO	Section 4.3, Annex 3.1, 3.2, 3.3 and	
City of Bilbao	Front runner in methodology implementation.	
MunBud	Annex 5.1 and 5.2.	
COP	Section 4.1, Annex 6.1, 6.2	
RIGA EnAg	Section 4.2, Annex 10.1,10.4	
BRATISLAVA City	Annex 4.1 and 4.2.	
City of Krakow	Annex 7.1 and 7.3.	
Matosinhos	Contributions to develop Annex 8	



2. Benchmarking of selected solutions: Overall Approach

There are different meanings of benchmarking. The Cambridge Dictionary defines it as the act of measuring the quality of something by comparing it with something else of an accepted standard³. Benchmarking practices are commonly used in the business context. Finding best practices and competitive advantages, increasing efficiency, and implementing improvement, among others, are usual objectives of applying benchmarking.

For the purpose of ATELIER WP2, benchmarking is understood as the evaluation of the suitability of proposed pathway. Benchmarking in ATELIER will align the vision and the action plan trying to answer the question "How suitable is proposed pathway?". Benchmarking must allow identifying both strengths and weaknesses in defined pathway to propose recommendations that will foster the conversion into neutrality.

Figure 2 summarizes benchmarking approach followed. At this stage of the project, there is key information available and ready to support benchmarking activities. This information is highlighted in purple in Figure 2: the city vision and the master scenario (presented in D2.6) and the action plan (presented in D2.8), are remarkable results that have been considered in benchmarking activities. Existing information has been completed with the activities highlighted in blue to facilitate the benchmarking.

Firstly, to support the discussion about the suitability of selected pathway, it was considered interesting to describe more deeply the city vision and, more specifically, how the cities visualize their climate neutral energy system. An extensive form was created to make the cities reflect about important issues regarding the energy system. Those issues have to be considered when planning the transition into climate neutral (see section 2.1 and Annex 1).

Additionally, to provide more information about the convenience of the pathway defined, it was considered interesting to calculate the impact of the master scenario in energy, environment and socioeconomic terms. The indicators and method applied are explained in section 2.2. and provide relevant information to drive the discussion.

Presenting all the existing information in a coherent and manageable way was one of the main challenges of the benchmarking task. Special focus has been put in organizing the information and getting it manageable to be presented and discussed during a participatory Workshop, helping in driving the discussion to the main topics as it was extracted from the information treatment and presenting it in a visual way. As a result, the so called "Benchmarking boards" have been obtained (see section 2.3).



³ BENCHMARKING | English meaning - Cambridge Dictionary



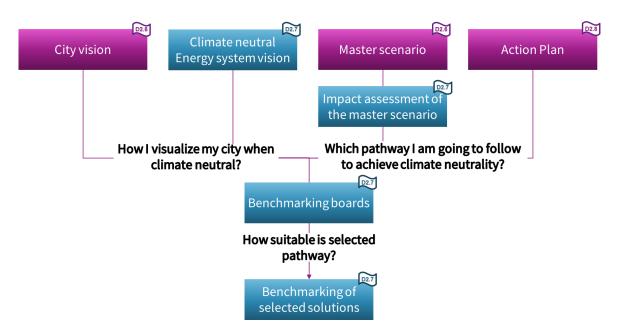


Figure 2. Benchmarking approach (source: own elaboration).

The benchmarking of selected solutions by itself is performed in ATELIER through a participatory Workshop (WS) that aims to identify the suitability of proposed pathway. As lighthouse city, Bilbao has conducted this WS, which is explained in section 3.2.

Trying to go in deep into systemic problems that cities deal, system thinking methodology is proposed. The method was explained to the cities in a participatory workshop (see section 2.4.).

Furthermore, section 2.5 intends to go in deep into the benchmarking of the social considerations and proposes an innovative method to address energy citizenship at city level. The aim of the method is understanding the willingness of citizens to implement energy transition actions and to draw municipal recommendations to foster the energy transition by facilitating citizens implementations.

2.1. Climate neutral energy system

At this stage of the project, there is key information available and ready to support benchmarking activities: the city vision, the master scenario and the action plan of each city. While defining the benchmarking approach, it was identified the need of making a deeper reflection about how the cities would like their carbon neutral energy system to be in terms of energy use, energy generation and energy distribution.

The decarbonization of the energy system plays a crucial role in the climate neutrality pathway, but it is not an easy task. Cities are implementing different strategies to decarbonize their energy systems and, considering their current situation, they have characterized how they would like their carbon neutral energy system to be in the future. In this context, 85 questions were defined to help the cities in doing this crucial reflection, which, together with the city vision, allows to answer the question: "How I visualize my energy system when climate neutral?".



Energy system refers to the interdependent network of infrastructure, technologies, actors, regulations, market structures and consumers involved in generation, distribution and use of energy. This system can be broken down into three primary urban systems: energy supply, buildings, and transportation. With the intention of characterizing the climate neutral city energy system proposed by ATELIER cities with respect to 1) Energy Use, 2) Energy Generation and 3) Energy Distribution, an extensive questionnaire was conducted. Collected information has been useful to describe the climate neutral energy system city vision.

The survey invited the municipalities to reflect carefully about how it should include a carbon neutral energy system. In ATELIER, this information has been used to complete the central part of the benchmarking boards (see section 2.3).

Before completing the questionnaire, Cities were called to read, reflect and discuss the questions among Smart City Planning Group and/or the local governance model that supports city vision creation. The questionnaire is included in Annex 1, and the conclusions of the responses given by cities are included in section 5 Conclusions.

2.2. Impact assessment of the Master scenarios

Master scenarios of each city will be evaluated under energy, environmental, and socioeconomic criteria. Indeed, besides the quantification of final energy and GHG savings displayed in D2.6 for cities Master scenarios (D2.7 for Riga and Bratislava), a set of additional indicators have been defined to support a holistic impact assessment. This addition intends to widen the approach of the scenario evaluation aiming to provide further insights of their performance concerning final energy, primary energy, and emissions abatements, investment costs, and socioeconomic impact.

Table 3. Defined indicators for the impact assessment of Master scenarios.

Dimension	Indicator	Definition
Energy	Cumulative final energy savings	Sum of yearly final energy consumption savings (compared to the BaU scenario) achieved all along the scenario period
	Cumulative total primary energy savings	Sum of yearly total primary energy consumption savings (compared to the BaU scenario) achieved all along the scenario period
	Cumulative non- renewable primary energy savings	Sum of yearly non-renewable primary energy consumption savings (compared to the BaU scenario) achieved all along the scenario period
Environmental	Cumulative GHG emissions savings	Sum of yearly GHG savings (compared to the BaU scenario) achieved all along the scenario period
Socioeconomic	CAPEX	Additional total capital expenditures (compared to the BaU scenario) required for the deployment of the decarbonisation measures considered all along the scenario period
	GDP impact	Additional GDP generated (compared to the BaU scenario) as a result of the deployment of the decarbonisation measures considered all along the scenario period
	Employment	Additional number of job positions created (compared to the BaU scenario) as a result of the deployment of the decarbonisation measures considered all along the scenario period



As described in Table 3, indicators have been defined with regard to the BaU scenario. Indeed, the former represents the inertial trend of the city (including already committed measures), serving both as a reference from which to generate the alternative scenario and as a benchmark to compare the former with a baseline situation (in which the city may find itself at any given year)⁴. In the case of the defined indicators, they refer to the area between both BaU and Master scenario projections (see Figure 3), representing the cumulative value of energy/GHG savings, investment costs, and socioeconomic impacts achieved through the whole scenario period.

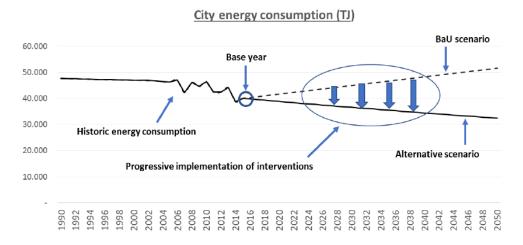


Figure 3. Conceptual scheme of scenario modelling and impact assessment approach in ATELIER project.

2.3. Benchmarking of selected solutions process

The benchmarking of selected solutions in ATELIER was designed to be conducted through a participatory Workshop, using the so-called benchmarking boards as supporting material. Cities are invited to reflect on the suitability of the proposed pathway by adapting the workshop model explained below.

- Objective: Benchmarking of selected solutions.
- Dynamic: discussion about the suitability of the proposed pathway
- Participants: Members of the local governance model or SCPG (Smart City Planning Group) and other key stakeholders.
- Starting point: City vision, climate neutral energy system vision, master scenario, master scenario impact assessment, action plan
- Material: benchmarking boards summarizing the key points mentioned in the starting point information and with proposal for reflection.

During the city vision creation, a considerable amount of data, information and material has been processed and developed for each city. To reflect on the convenience of the proposed pathway to achieve carbon neutrality, it became necessary to summarize this information,



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⁴ Muñoz, I., 2023. Integrated Long-term City Planning. Methodology for the Modelling and Prospective Assessment of Urban Energy Systems. Ph.D. Thesis, University of the Basque Country. https://addi.ehu.es/handle/10810/60197



making it more manageable and facilitating the analysis by stakeholders not necessarily familiar with all the process. The goal was to ensure the information remained complete, maintaining relevant considerations, while also being brief enough to show potential strengths and weaknesses and focus the discussion on the key points or highlights.

Benchmarking boards address this need by providing a visual summary of the main results of the city vision creation process, making the information more accessible for a participatory discussion or workshop. The boards synthetize the city vision and the action plan, linking the actions to their corresponding target.

The benchmarking boards are 6 boards divided as follows:

- 1. City Vision. It includes the city commitment with carbon neutrality and the city vision by itself.
- 2. Master scenario. It includes the assumptions taken and the results of the energy, environmental, and socioeconomic impact assessment of the master scenario.
- 3. Energy use: How is the climate neutral building system? It includes the energy use of the city when climate neutral and the actions proposed in different action plans to achieve those targets.
- 4. Energy generation. It includes how the energy is generated when climate neutral and the actions proposed in different action plans to achieve those targets. It is divided in two:
 - a. How is the energy generation? Electricity.
 - b. How is the energy generation? Thermal.
- 5. Energy distribution: How is the energy distribution in a carbon neutral city? It includes how the city visualizes their energy distribution when climate neutral and the actions proposed to accomplish these objectives.

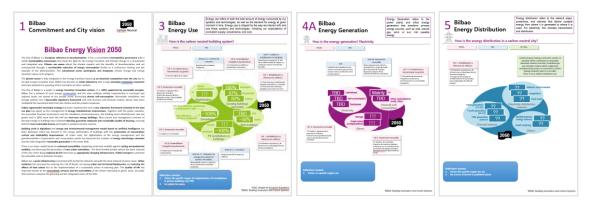


Figure 4. Benchmarking boards examples (source: own elaboration).

Energy use, energy generation and energy distributions boards establish the link between actions and their corresponding target, highlighting the extent to which the targets are addressed by the actions included in the different Action Plans towards decarbonization.



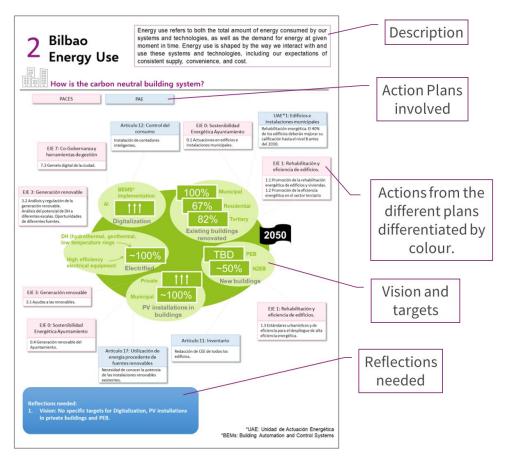


Figure 5. Benchmarking board structure.

The central part of the boards, related to the vision and targets, has been developed according to the information provided by the cities to the climate neutral energy system survey explained in section 2.1. Considering that every ATELIER city has completed the survey, the central part of the boards has been developed and is presented in each city section. Mainly because of the language used, difficulties arise to the technical partners when it comes to complete the actions connected to the targets. Therefore, except for the city of Bilbao, this part has been let to be completed by the cities.

2.4. Systems thinking: addressing city's challenges

To complete the benchmarking of selected solutions, **systems thinking** was identified as a valuable method to address systemic challenges affecting the cities. The benchmarking process may reveal the strengths and weaknesses of the proposed pathway, highlighting issues with systemic origins that are particularly challenging to address.

In this sense, CARTIF conducted a systems thinking workshop with Atelier cities to evaluate and benchmark selected topics from their climate neutrality goals and actions. **Systems thinking** was proposed as a methodology to help cities identify externalities, gaps and enablers that could support their journey towards climate neutrality. This approach facilitates the organisation, analysis and planning of complex systems, allowing participants to manage interdependencies more effectively.

The workshop focused on a specific objective: the decarbonisation of the mobility and transport sector. Through this objective, participants analysed how this sector interacts with other urban



systems, such as energy, buildings, the environment and citizens. By identifying interdependencies and potential ripple effects, cities can minimise negative impacts or leverage positive synergies across sectors, empowering them to make more informed decisions. A key tool used in the systems thinking method as well as showcased in the workshop is the **casual loop diagrams**, which helps visualise the feedback loops within systems and encourages holistic problem-solving. Participants practiced this method, providing them with a foundation they could later apply in their municipal teams.

The workshop began with an icebreaker and a presentation of the agenda (Figure 6), followed by an introduction of the workshop's objectives, participation guidelines (Figure 7) and an overview of systems thinking principles, supported by practical examples (Figure 8 and Figure 9).



Figure 6. Workshop opening: agenda and icebreaker.



Introduction to Workshop

In WP2 you have been creating a city model, and master scenarios, as well as mapping your Action plans and interventions you have planned. Today we would like to assess for the "mobility and transport" sector from the system perspective.

The aim is to explore together a **complex problem** (e.g. decarbonisation of mobility and transport sector), **analyse its relations and interdependencies between other systems** (energy, buildings, environment, citizens) **across the city.**

This will be done through the **Iceberg model** and if we have time we will finalise with a Casual Loop Diagrams

The output of the workshop contributes to the "benchmarking" task within T2.4 D2.7 in WP2

Rules for the workshop

- This is not a lecture or webinar: You will not just listen; we expect from you to engage actively.
- Your input is essential. To make the most of our time together and to contribute meaningfully to the discussions and the final deliverable, everyone needs to participate.
- The more you engage, the more you will learn about using the systems thinking tools.
 Together, we will explore complex problems and potential solutions, but remember that this is a guided exploration—we don't have all the answers.
- This exercise is a starting point. You will be able to repeat this process with your smart city planning teams or innovation ATELIERS to address more specific issues in your city.
- Today, we will be working with general issues, as we have eight cities and cannot address all city-specific problems in this session.
- This workshop is a tangible example of how systems thinking can be applied to a complex city problem. It is meant to prepare you for defining proper actions in urban planning.
- You can replicate this process with relevant stakeholders or municipal agents to tackle specific problems in your city.

Figure 7. Workshop context and participation guidelines.



Introduction to systems thinking

A system is a set of interconnected elements that work together to achieve a purpose



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It's not just a collection of parts but a structured whole where the interactions between those parts define its behavior.

The systems approach can be defined as a method for organizing, analyzing, and planning complex systems in an effective and organized manner (Abbas & Bell, 1994).

Systems thinking is a framework/method for seeing and understanding interrelationships. It helps organize complex information and see how different parts of a system influence each other

A systems thinker might approach a problem by asking:

- What could be under the surface that we don't see?
- What are the conditions (budgets, resources) that influence the problem?
- What issues, people or systems are working together to create what is seen above the water?
- What ripple effects might be created by our ideas/solutions?

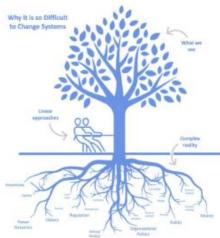
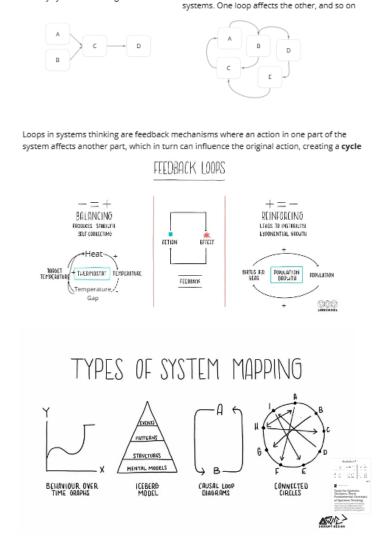


Figure 8. Introduction to systems thinking methodology.

Event oriented thinking:

My system is a "straight" line





Systems thinking:

My system is a loop, interconnected to other

Figure 9. Practical examples of systems thinking applications.

2.4.1. First part of the workshop: framing and exploring the system

Once participants were introduced to the workshop's context, the main exercise commenced, focusing on framing and exploring the system (Figure 10). This activity was divided into three parts:

- Context and problem statement, where participants began by collaboratively defining
 the primary question "How to decarbonise the transport and mobility sector to
 ensure liveability, safety, inclusivity and resilience in cities?". Although mobility
 was predetermined as the central topic, this question was fine-tuned to reflect the
 shared goals.
- System of systems, in which participants discussed critical factors affecting mobility, identifying barriers and enablers related to behaviour, infrastructure, regulations, social



dynamics and technological change. Key themes, such as safety, affordability, urban planning, behavioural change and reliability of public transportation, were colour-coded and organised after initial brainstorming (Figure 11).

- **3. Roots of the problem**, in which, using the iceberg model, participants explored deeper layers of the mobility issue, by categorising observations into:
 - Situation: what's currently happening.
 - Trends: changes over time and emerging patterns.
 - **Underlying structures**: influences, systems, norms and rules that contribute to the observed situation.
 - Mental models: the beliefs, values and assumptions driving behaviours in the system.

Participants used colour-coded post-its to provide insights across the iceberg layers (Figure 12).

Framing and exploring the system We need to formulate a complex question/problem to analyse the system, and be as concrete as possible, so we can explore deeper CONTEXT & PROBLEM STATEMENT SYSTEMS OF SYSTEMS How to <u>decarbonise</u> the transport and mobility sector so that we ensur liveability, safety, inclusivity a resilience in cities? The roots of the problem SITUATION What is happening TRENDS What is been happening What is changing UNDERLYING Influences, connections norms, cultures, policies MENTAL MODELS values, believes, assumptions

Figure 10. Framing and exploring the system.



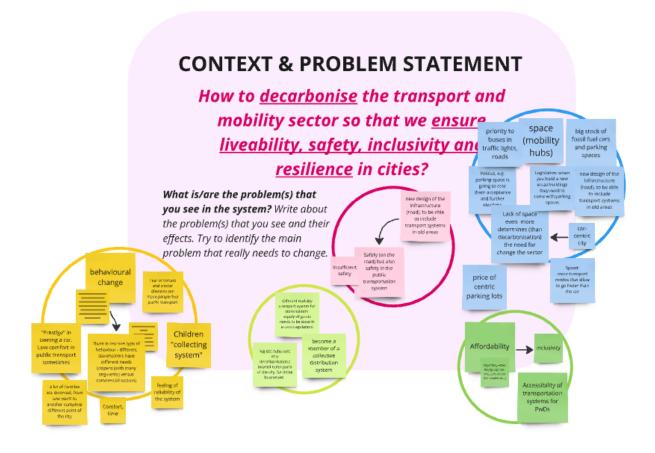


Figure 11. Context and problem statement activity.



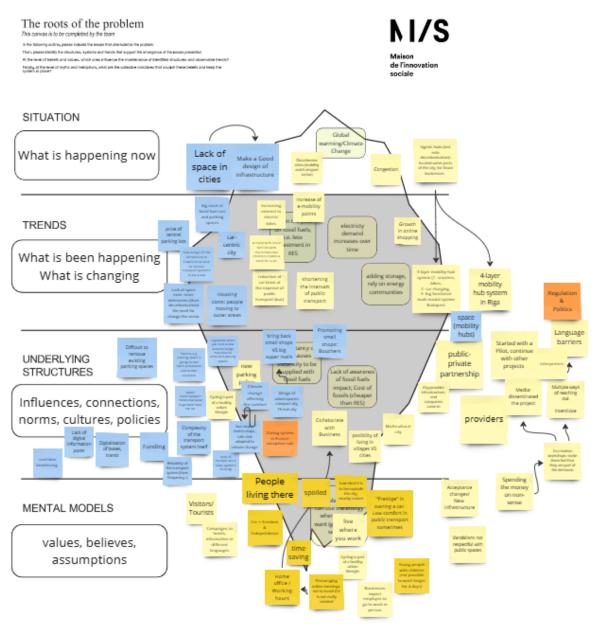


Figure 12. Roots of the problem: iceberg model analysis.

The activity identified several key trends and challenges impacting urban mobility. Rising private car use has led to increased demand for parking and road space, which, combined with urban population growth, is putting significant pressure on existing infrastructure. High housing costs are pushing more people to the outskirts of cities, increasing their mobility needs and reinforcing reliance on private vehicles.

Efforts to promote sustainability transport options, such as bike lanes and pedestrian-friendly areas, are underway but often create conflicts over space with car users. While the shift toward electrified transport is positive for emissions reduction, it introduces the need for extensive charging infrastructure, and the rise of e-mobility options, like e-scooters, adds new safety and policy challenges for urban planners trying to manage shared spaces.



Another trend is the compact city approach, which aims to reduce travel needs and improve urban walkability. However, this model limits available space for large-scale projects like multimodal mobility hubs, complicating efforts to create integrated transport systems. Families with children, who often find cars necessary, and the growing demand for logistics to support online shopping and additional factors placing new demands on the transportation system.

Historical land-use policies that favoured cars have contributed to car-centric urban environments. Today, competing priorities (such as real estate development versus the preservation of public spaces) and complex regulatory frameworks continue to slow the reallocation of space towards sustainable mobility. Funding priorities often favour road expansion and maintenance over public transportation improvements, and political hesitations around pedestrianisation and transit-focused policies reflect concerns about public resistance to change.

Public transport systems face funding and technological challenges, lacking investment in critical upgrades like decarbonisation efforts and real-time monitoring, which limits their reliability and public appeal. Cultural attitudes also play a role: cars are still strongly associated with freedom, convenience and status, specially in suburban and less densely populated areas, reinforcing car-oriented urban planning.

Several potential solutions were discussed to address these issues. Public-Private Partnerships (PPP) could support the development of multi-functional mobility hubs that integrate different transport options, and mixed-use zoning regulations could reduce travel needs by bringing amenities closer to residential areas. Additional strategies include supporting local businesses, promoting remote work and encouraging smaller-scale urban projects. Shifting the deep-rooted cultural association of cars with personal freedom and convenience, however, remains a key challenge.

2.4.2. Second part of the workshop: casual loop diagrams

The second part of the workshop (Figure 13) introduced casual loop diagrams, guiding participants through common steps for creating these systems maps (Figure 14). Facilitators provided an example centred on designing an efficient and accessible bus stop, incorporating insights from prior discussions on mobility (Figure 15).



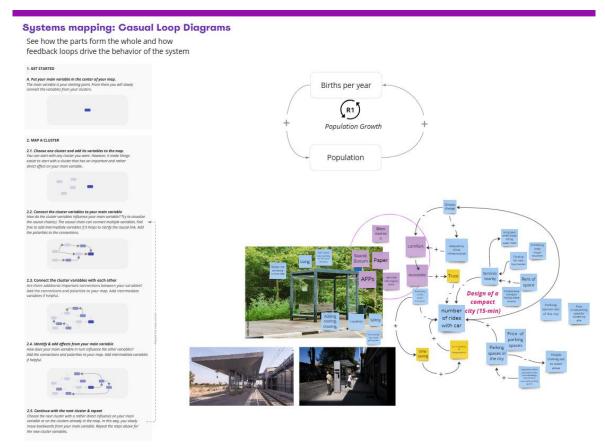


Figure 13. Overview of casual loop diagram activity.



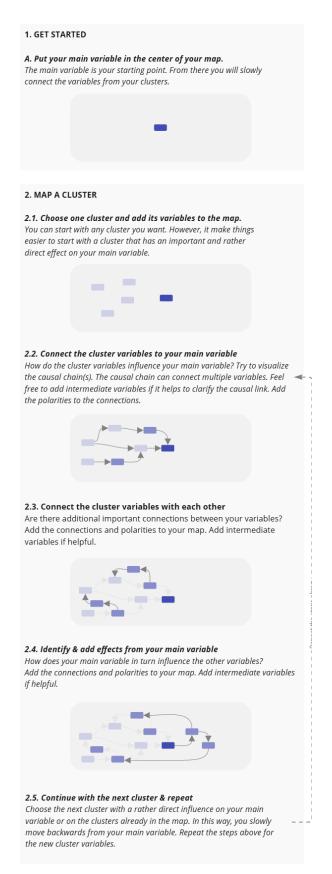


Figure 14. Steps for developing casual loop diagrams.



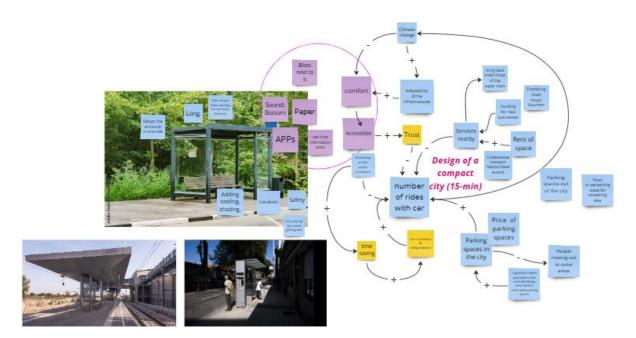


Figure 15. Collaborative casual loop diagram: designing and effective bus stop.

Participants analysed the complexities of urban mobility, where increased car use and population growth heighten demands on road space and parking, while compact city trends constrain large-scale infrastructure projects. Casual loops helped visualise feedback effects, such as how prioritising road maintenance could perpetuate car dependency or how public transport reliability could reduce private vehicle use.

The collaborative design for an effective bus stop emphasised adaptability and comfort to encourage public transit over private cars. Climate resilience was a priority, with ideas for shaded, cooled and enclosed waiting areas to improve comfort. Reliability also stood out, with calls for real-time information displays and apps to increase accessibility and trust.

To reduce car dependency, proposals included relocating parking outside city centres, alongside shared transport options like e-vans. Nearby amenities, like small shops supported by voucher programmes, would add convenience and encourage foot traffic, reducing the need for trips to large shopping centres. Together, these elements create a bus stop that's functional, community-friendly, and promotes sustainable urban transit.

2.4.3. Workshop key insights

The workshop underscored both the challenges and opportunities for achieving sustainable urban mobility. Key insights revealed that urban growth, rising car usage and suburban expansion continue to heighten demand for road space and parking, complicating efforts to promote public transport and active mobility. Historical land-use policies and cultural mindsets, which equate cars with freedom and convenience, add further resistance to transitioning toward sustainable transport. Despite these barriers, several potential solutions were identified, such as Public-Private-Partnerships to create multi-modal hubs and zoning changes that support mixed-use developments and local businesses.

A primary takeaway was the critical role of adaptive design and reliable infrastructure in shifting behaviour toward public transport. Strategies like accessible, well-equipped bus stops, increased parking outside city centres and e-mobility sharing hubs were suggested as



impactful measures to reduce car dependency. Additionally, fostering local business networks near transit stops and supporting compact urban design could help make sustainable choices more accessible and attractive.

To support continued exploration of these systems-based solutions, workshop materials on systems thinking were shared with participants, with the hope that cities can apply and expand upon these approaches in their own efforts toward climate-neutral urban mobility.

2.5. Energy citizenship: promote active engagement in the energy transition.

The ongoing energy transition calls not only for technological innovations, as often discussed in accounts of sustainable energy pathways, but also for various social-institutional transformations⁵. The development of energy citizenship is an important part of the latter. It is widely believed to hold potentials for transforming towards more sustainable and just societies.

There are different definitions of energy citizenship and energy citizen. For the purpose of ATELIER, the definition of GRETA project has been considered.

- Energy citizen is understood as an individual who participates individually or collectively in the transition of energy systems in a particular geographical area. Energy citizens use, consume, produce and/or store energy in an improved or reduced manner. Energy citizens' activities and behaviours affect the decarbonisation of current energy systems in the long run. Their energy-related knowledge, when shared, allow energy citizens to have also an advocacy role. The effects can be positive (e.g. supporting the clean energy transition, investing in energy-efficient appliances or participating in a local energy initiative), or negative (e.g., public resistance to new forms of renewable energy) or neutral. For the purpose of the energy citizenship study considered in ATELIER, only the positive effect has been considered.
- **Energy citizenship** is about the active participation of citizens in energy systems in a particular geographical area. Active participation can be both social and political, either as individuals (e.g., through energy efficiency measures in households) or in larger groups (e.g., through engagement with energy policy in climate activist groups or energy communities). The effects of energy citizenship can be positive (e.g. supporting the clean energy transition, investing in energy-efficient appliances or participating in a local energy initiative), or negative (e.g., public resistance to new forms of renewable energy) or neutral.



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⁵ EnergyPROSPECTS D2.1 310821 final.pdf



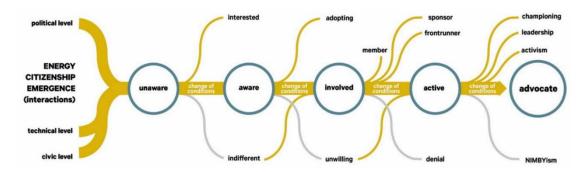


Figure 16. Concept of energy citizenship emergence in terms of engagement. Source: GRETA D1.1

The complexity of understanding energy citizenship in ATELIER has been simplified in order to provide an overview and set a starting point providing a preliminary answer to the following questions:

- Which is the energy citizenship engagement status in specific geographical area? / Which is the willingness of the citizens to implement energy transition actions?
- How can be promoted the emergence of energy citizenship?
- What benefits can be obtained from a better energy citizenship emergence?

In order to provide an answer to these questions, the method summarized in Figure 17 is proposed:



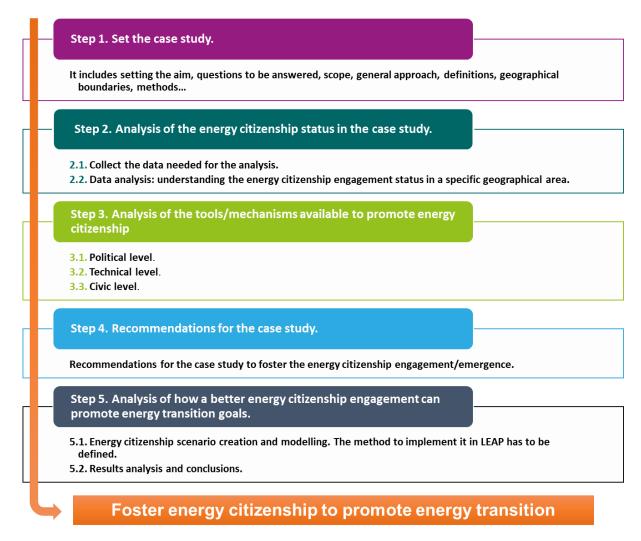


Figure 17. Energy citizenship emergence in terms of engagement. Source: Own creation.

Going in depth in each step:

Step 1. Set the case study.

The first step aims to set the **general approach** to be applied considering the case study selected.

Aim: In general, studies related to energy citizenship will have a similar aim: fostering energy citizenship to promote energy transition.

Questions to be answered: taking into account selected aim, potential questions to be answered by the study are the following:

- Which is the energy citizenship engagement status in specific geographical area? / Which is the willingness of the citizens to implement energy transition actions?
- How can be promoted the emergence of energy citizenship?
- What benefits can be obtained from a better energy citizenship emergence?



Scope: it includes the selection of the steps that are going to be considered in the analysis to properly answer defined questions.

Definitions: clearly define important concepts for the purpose of the analysis. Energy citizen and energy citizenship concepts have been defined previously. Other important concepts to be defined are the following:

- Different forms of energy citizenship (ENCI):
 - Unaware
 - o Aware
 - o Involved
 - Active
 - Advocate
- Energy citizenship actions: The project GRETA proposed a catalogue of energy citizenship actions. From this catalogue, 14 actions have been selected to be considered in ATELIER due to its potential relation with LEAP model. One action has been added with respect to GRETA catalogue.

Table 4. Energy citizenship actions, description and impact (M: Mobility, E: energy)

Impact	Energy citizenship action and description
Very high	M1. Regularly use environmentally friendly alternatives to private cars. Citizens that avoid the use of private cars and decide to use more environmentally friendly alternatives, have a very high positive impact over the energy transition.
Very high	M3. Buy an electric car. Citizens that have to buy a car and decide buying an electric car instead a fuel-based car, have a very high positive impact over the energy transition.
High	M4. Buy a new car and consider its low fuel consumption as an important factor in their choice. Citizens that buy a new car and consider the low fuel consumption of it, have a high positive impact. It must be note, that this action and action M3 applied only for those cases where the citizens are obligated to buy a car. Action M3, related to buy an electric car, it is considered to have a higher positive impact than M4, as avoids the use of fossil based fuels.
High	M5. Participate in carpooling. Citizens that use carpooling services instead private cars when public transport or other transport modes are not suitable for them, have a high positive impact over the energy transition
Very high	E1. Considering a lower energy consumption as an important factor in the choice when buying a new household appliance. Household appliances consumption can represent between 14% and 30% of the total household energy consumption ⁶ . Choosing a lower energy consumption appliance when buying a new one will have a very high positive impact in energy consumption reduction.
Very high	E2. Better insulate their homes to reduce their energy consumption. Improve the isolation at homes can reduce the heat and air conditioner energy consumption in a 40% as an average. Therefore, citizens living in old building stock that implement this action will have a very high positive impact over the energy transition.
Medium	E3. Have switched to an energy supplier which offers a greater share of energy from renewable resources. The share of renewables in the European countries electricity mix is being increased. Moreover, there are companies offering a greater share of energy from renewable resources. Citizens demanding this type of services contribute to the incrementation of them.
High	E4. Be member of an energy cooperative.

^{6 20%} in Spanish households for the year 2010 https://www.idae.es/uploads/documentos/documentos Informe SPAHOUSEC ACC f68291a3.pdf



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	This action refers to citizens that join renewable energy cooperatives and contribute to the deployment of renewable based energy.			
Very high	E5. Participate in energy community. Being part of an energy community could imply putting in place one or several energy citizenship actions in a collective way. Because of that, the impact of this action could be very high.			
High	E6. Have installed equipment in their home to control and reduce their energy consumption. Citizens that have installed equipment in their home to control and reduce their energy consumption (e.g., smart meter) and/or citizens that use of apps to track their energy consumption, contribute to the energy transition.			
Very high	E7. Install solar panels in their homes. Citizens deciding to install solar panels to produce and consume renewable energy will contribute in a very high way to energy transition.			
High	E8. Buy a low-consumption energy home. Citizens taking into account the energy consumption of their homes as a criteria to buy them, have a high positive impact over the energy transition.			
Medium	E9. Battery storage. By storing the excess electricity produced for example, by solar panels, battery storage increases renewable energy self-consumption. As the battery has necessarily accompany renewable energy generation installation, this action by itself it is considered to have a medium positive impact over the energy transition.			
High	E10. Save energy in everyday life. There are different ways to reduce the energy use and save energy in everyday life. For example, actions like heat one's home less in winter and use air conditioning less in summer or turn off electrical appliances rather than put them on standby mode, have a high positive impact over the energy transition.			
High	New TBD: E11. Change the electricity consumption based on the share of renewables (or based on the hourly price of electricity). This action can be in close relationship with E6. Have installed equipment in their home to control and reduce their energy consumption, as far as apps can support swifting the consumption and or programming the appliances to function in specific time slots. Doing it manually is a suitable option as well (covered by this action).			

Geographical boundaries: for the purpose of ATELIER the geographical scope is "city level". Whitin this geographical scope, differences per district and/or other kind of zones of the city will try to be considered depending on the data availability.

Methods: it includes the selection of the methods and tools that will support conducting each step.

Target audience: other interesting element to clarify in early stages of the study, is the target audience of the results that are going to be obtained. Depending on it, how the results are presented and/or communicated can be different. In general, this information will be created for policy makers.

Step 2. Analysis of the energy citizenship engagement status

2.1. Collect the data needed for the assessment.

Energy citizenship is a term relatively new (selected definition was set in 2021). Therefore, it will be difficult to find existing data that can support the case study analysis set in Step 1. In order to collect the data needed to understand the energy citizenship engagement status in a specific geographical area, adapt and conduct the following survey is proposed.

Aim of the survey:





- Understand the energy citizenship engagement status of a specific area and/or the willingness of citizens to implement energy transition actions.
- Identifying potential barriers that the citizens have to implement energy transition actions.
- Identifying the main elements that will foster the implementation of energy transition actions by citizens (from the point of view of citizens).

Target audience of the survey: citizens of the defined geographical area.

Description of the survey: the survey is implemented in google forms. As it was thought for Bilbao citizens, it is in Spanish. It includes 7 general questions to know a bit about the citizen that is fulfilling the survey, a short introduction and then 25 questions related to the 14 actions described in Table 4. The main difference with other surveys is that for each action, the respondent can select among the following alternatives:

- 1) I wasn't aware about its relevancy.
- 2) I am aware.
- 3) I am aware, but it is not possible.
- 4) I have implemented the action.
- 5) I have implemented the action and I invite my family and friends to implement it.

These alternatives are in close relation with the forms on ENCI described before: unaware, aware, involved, active and advocate respectively. After selecting the level of involvement, respondents are called to give more information about the reasons of their choice. Respondents can provide their own answer, but a complete list of potential reason for and against is given to facilitate the post processing of the information.

2.2. Data analysis and results visualization.

As the study information to make georeferenced distinctions have been implemented, the results can be represented in a Map, a Geographical information System (GIS) or similar. According to the geographical boundaries set in Step 1. **understanding the energy citizenship engagement status in a specific geographical area.**

Step 3. Analysis of the tools/mechanism available to promote energy citizenship.

For the analysis of the tools mechanism available to promote energy citizenship, the GRETA project approach has been adopted and adapted to ATELIER needs.

The feasibility of citizens to put in place energy transition actions depends on the combination of dynamic features or energy citizenship analytical components, which are classified in the following levels:

- 3.1. Political level
- 3.2. Technical level
- 3.3. Civic level

Step 4. Recommendations to foster the energy citizenship engagement/emergence. From unaware to advocate.

This analysis can be done thanks to the conclusions of the survey and the results obtained from Step 3.





Step 5. Analysis of how a better energy citizenship engagement can promote energy transition goals achievement at city level.

5.1. Creating an energy citizenship scenario and modelling it in LEAP software.

A preliminary information considered by LEAP model that may have an impact depending on the citizens engagement is given in Table 5.

Table 5. Relationship between LEAP parameters and Energy citizenship actions.

Sector	Parameter LEAP	Related ENCI actions
	Refurbishment rate (%)	Better insulate their homes to reduce their energy consumption, Buy a low-energy home.
	Energy demand reduction for refurbished buildings	Have installed equipment in their home to control and reduce
	(compared to current standard building)	their energy consumption (for example, smart meter), Buy a low-energy home.
	Energy demand reduction in new buildings (compared to	Have installed equipment in their home to control and reduce
	current standard building)	their energy consumption (for example, smart meter), Buy a low-energy home
	PV self consumption rate (%)	Install solar panels in their homes, Battery storage
Share of %: Electrification, Natural gas, Fossil fuels, DH, Other renewable. DHW consumption reduction (litres) Heating or cooling set point temperature adjustment Households fuel emission factor reduction Have switched to an energy supplier whice share of energy from renewable resources	Considering a lower energy consumption as an important factor in the choice when buying a new household appliance, Participate in energy community.	
	DHW consumption reduction (litres)	Save energy in everyday life (DHW)
	Heating or cooling set point temperature adjustment	Save energy in everyday life (heating or cooling)
	Households fuel emission factor reduction	Have switched to an energy supplier which offers a greater share of energy from renewable resources, Change the electricity consumption based on the share of renewables (or based on thehourly price of electricity), Be member of an energy cooperative.
Appliances consumption reduction	Appliances consumption reduction	Considering a lower energy consumption as an important factor in the choice when buying a new household appliance.
Public	Increase in the use of public transport (%)	Regularly use environmentally friendly alternatives to private
transport	Deployment of active mobility measures (biking, walking)	Regularly use environmentally friendly alternatives to private
	Share of electric cars (%)	Buy an electric car.
	Other electric vehicles (%)	Regularly use environmentally friendly alternatives to private
	Increase in the use of public transport (%)	Regularly use environmentally friendly alternatives to private
Private fleet	Decrease in the use of private vehicles (%)	Participate in carpooling, Regularly use environmentally friendly alternatives to private cars.
	Deployment of active mobility measures (biking, walking)	Regularly use environmentally friendly alternatives to private
	Increase/reduction in the vehicle fleet	Regularly use environmentally friendly alternatives to private
	Reducción en el consumo del parque de vehículos (kWh/km)	Buy a new car and consider its low fuel consumption as an important factor in their choice.

Results from the ENCI survey contribute to understand current situation. Strategies to improve citizens engagement according to the recommendations given in Step 4 may promote the implementation of ENCI actions and foster the energy transition. The ENCI scenario obtained as a result, can be modelled in LEAP to estimate quantitatively the impact of promoting ENCI actions, supporting decision making processes.

5.2. Results analysis and conclusions.

According to the results of the study, final recommendations to foster energy citizenship to promote energy transition.



3. Benchmarking of selected solutions: The case of Bilbao

3.1. Impact assessment of the Master scenario

Based on the results of the BaU and Master scenarios agreed with the city, the latter achieves an additional cumulative saving of 23,667 GWh of final energy consumption regarding the former through the whole scenario period (2018-2050), in order to fulfil the City Vision set for 2050 by the municipality. The Master scenario also reaches additional cumulative savings of 27,518 GWh and 32,968 GWh of total and non-renewable primary energy respectively compared to the BaU scenario. In the environmental dimension, the quantity of cumulative emissions additionally abated by the Master scenario regarding the BaU amounts to 7,203 ktonnes CO_2 through the whole scenario period.

Table 6. Bilbao Master scenario energy and environmental indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Savings
Energy	Cumulative final energy (GWh)	108,788	85,111	23,677
	Cumulative total primary energy (GWh)	141,614	114,097	27,518
	Cumulative non-renewable primary energy (GWh)	114,434	81,466	32,968
Environmental	Cumulative GHG emissions (kton CO ₂ eq)	20,176	12,972	7,203

The implementation and deployment of the additional measures considered in the Master scenario, compared to the BaU, require an additional investment of €1329 million. In turn, it generates €795 M in GDP and 9539 more jobs than the BaU.

Table 7. Bilbao Master scenario socioeconomic indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Additional investment/ Increase in GDP/employment
Socioeconomic	CAPEX (M€)	3,293	4,622	1,329
	GDP impact (M€)	2,152	2,947	795
	Employment (jobs created)	26,550	36,089	9,539

3.2. Benchmarking of selected solutions

In the case of Bilbao, the WS was performed the 19th of November 2024 during 3 hours of inperson meeting and had the following characteristics:

Participants:

- Bilbao municipality: Jon Fernandez and Mikel González Vara.
- Bilbao Energy Agency (BilboEner): Jaione Ortiz.
- Basque Energy Agency (EVE): Gloria Etxebarria and Jesús Casado.





- Technical experts (Tecnalia): Lara Mabe, Patxi Hernández and Pablo de Agustín.

Agenda:

- Welcome and presentation of the WS objectives.
- 2050 city vision prepared in 2021 reading.
- Scenario and 2030 objectives revision.
- Discussion on the alignment of the pathway defined until 2030 and the vision 2050

Dynamic:

Most of the discussion was focused on the city vision. Considering that city vision is continuously being updated and the last available version was from 3 years ago, many comments and new ideas arise.

The last point of the agenda was not such intensely discussed, showing the need of dedicating more time to it in another workshop. In any case, a couple of strengths and weaknesses of proposed pathway were identified, helping the municipality in putting the focus on promoting the achievement of proposed objectives.

Below, the boards that were used in the benchmarking of selected solutions workshop conducted in Bilbao, can be find. As it was explained in section 2.3, the boards summarize the results obtained in the city vision creation process and were used to drive the discussion on the suitability of the pathway proposed to achieve carbon neutrality (last point of the agenda).



1 Bilbao Commitment and City vision



Bilbao Energy Vision 2050

The City of Bilbao is a **European reference in decarbonization**. It has a consolidated **metropolitan governance** with a stable **Sustainability Commission** that leads the fight for the Energy Transition and Climate Change in a coordinated and integrated way. **Citizens are aware** about the climate impacts and the benefits of decarbonization and act consequently through a **considerable reduction of energy consumption** thanks to a continuous training and the example of the administration. The **educational sector participates and integrates** climate change and energy transition values in its program.

The **private sector** is fully integrated in the energy transition favouring **an attractive competitive over the city** due to its high energy innovative level. Bilbao has become an **urban laboratory** with a huge **emerging companies ecosystem** that have allowed the upscaling of the innovation to other markets.

The City of Bilbao is a leader in energy transition innovative actions, it is 100% supported by renewable energies. Bilbao has a network of local energy communities and the solar rooftops initially implemented in municipal and regional assets are spread to the private sector promoting shared self-consumption. Renewable installation and storage systems has a favourable regulatory framework and new business and financial models, whose have been multiplied the investment both from the citizens and the private companies.

Urban regeneration municipal strategy has been implemented and a **new urbanistic instrument included in the land use plan** has speed up the management of **energy refurbishment interventions**. Together with the public subsidies, the accessible financial mechanisms and the inhabitant conscientiousness, the building stock refurbishment rate has grown and in 2050 more than the half are **near-zero energy buildings**. New control and management schemes of thermal energy in buildings have achieved **allowing guarantee adequate and sustainable quality of housing**, ensuring that the **most vulnerable homes** participate in adopted climatic solution.

Building stock is digitalized and energy and environmental management model based on artificial intelligence has been deployed, which has derived in the energy optimisation of buildings with the automation of consumption control and habitability improvement. At urban scale, the digitalization of the energy management and the georeferentiation of generation and consumption points has favoured the creation of energy interchange networks and the fully integration renewable generation in the urban field.

There is an urban model based on universal accessibility, displacing motorised mobility against cycling and pedestrian mobility, and favouring the generation of new urban centralities. The fossil-fuelled private vehicle has been reduced of the city centre being replaced by EVs that have an appropriate charging infrastructure. Public transport is powered by renewable and no pollutant energies.

Bilbao has a green infrastructure connected with territorial networks and with the local network of green areas. Urban resilience has increased by reducing the risk of floods, increasing urban and territorial biodiversity and reducing the effects of heat island due to the implementation of a sustainable urban re-naturing plan. The quality of life has improved thanks to the ecosystemic services and the accessibility of the whole citizenship to green areas. All public interventions comprise the greening and the integrated vision of the SDG.

Figure 18. Bilbao City Vision Benchmarking board.





Bilbao Master scenario Master scenario characterization Increase of accessible local green High awareness of housing The pace of rehabilitation reaches 3% of renovation and improvement of built-up land per year by 2030. 15% of the private residential building stock had been rehabilitated, and 20% of private tertiary building, considered a priority due to the MOBILITY AND PUBLIC SPACE areas 35% reduction in car traffic thermal installations modes of micro-mobility, **BUILDING STOCK** <u>Innovative business models</u> for building renovation, installation and operation of thermal installations. shared mobility 20% increase in the demand for public greater ease of management. After pedestrian mobility, promotion of cycling and public transport as priority modes of transport in the city. High rate of retrofitting and electrification of equipment is achieved, supported by public funds. Technological change: gas installations are progressively replaced by high efficiency (and medium-high cost) electrical equipment. Progressive penetration of aerothermal heat Drogressive penetration of aerothermore The refurbishment of 35% of the municipal 100% of the municipal fleet electrified, 67% of the bilbobus fleet electrified (the rest Combination of active mobility. strategies with the promotion of the strategies with the promotion of the motorbikes (50%), vans (30%), buses (30%) capacity to manage retrofitting through the deployment of neighbourhood offices and a public-private management model. pumps and pilot projects of other more efficient solutions (e.g. hydrothermal, geothermal, low temperature rings). Demand for both public electric charging points and car-free zones · An energy office has been set up to raise public By 2030, a deployment of 50% of the maximum PV potential on municipal and private rooftops is achieved. Strong commitment to renewable energies due to their economic profitability. Business models mainly run by <u>large companies</u> <u>Hydrogen</u> is starting to become a relevant energy vector, mainly in the <u>mobility sector</u> New projects are being developed for the deployment of <u>heat networks</u> based on renewable energies or waste heat recovery. New <u>renewable energy communities</u> (RECs) are being created in the city, in which the city council participates and which are developing multiple public-private generation projects and even micro-grids. Master scenario impact assessment **GDP Employment** Nonrenewable PE* **GWP* CAPEX** generation generation jobs created MWh saved tonCO2 eq saved K€ invested K€ generated /inhabitant /inhabitant /inhabitant /inhabitant /inhabitant *PE: Primary Energy *GWP: Global Warming Potential

Figure 19. Bilbao Master Scenario Benchmarking board.





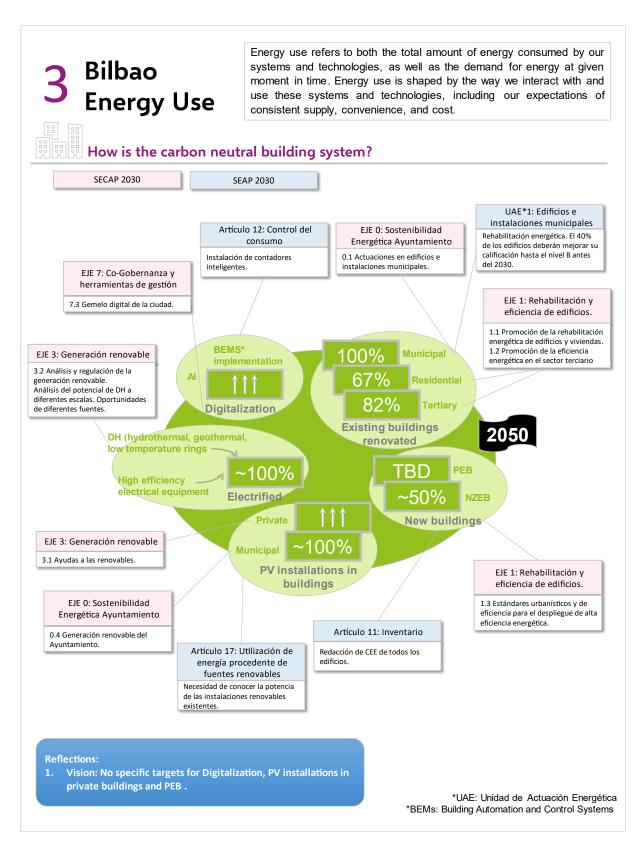


Figure 20. Bilbao Energy Use Benchmarking board.



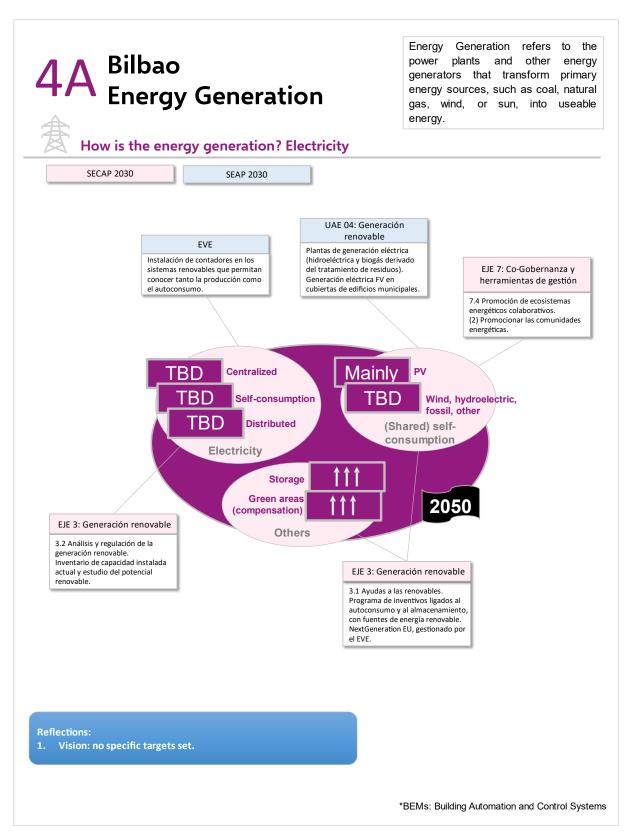


Figure 21. Bilbao Energy Generation "Electricity" Benchmarking board.



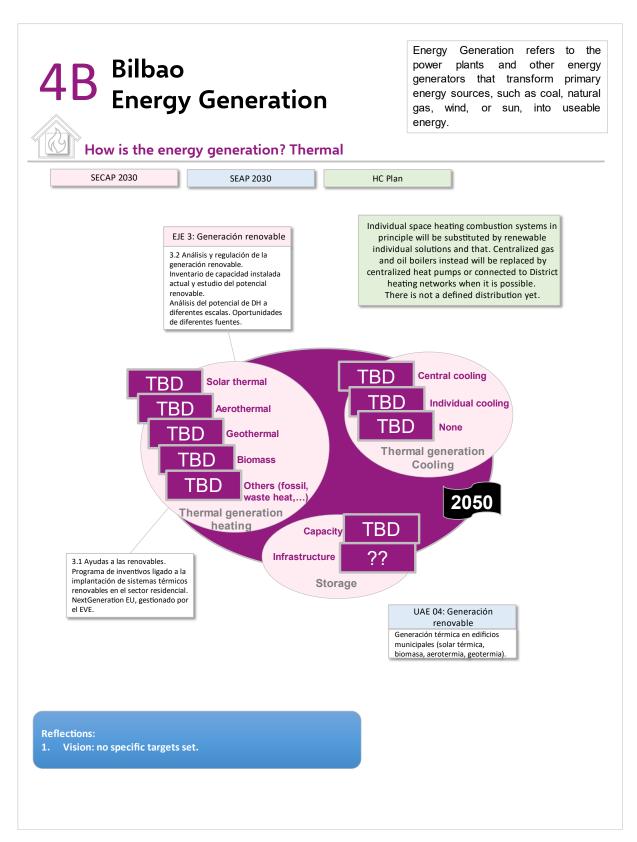


Figure 22. Bilbao Energy Generation "Thermal" Benchmarking board.



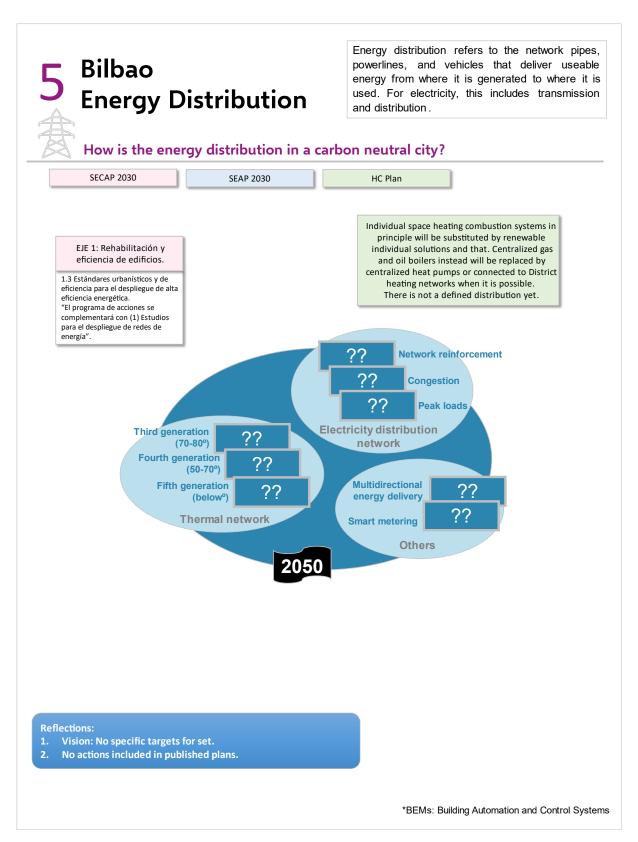


Figure 23. Bilbao Energy Distribution Benchmarking board.



3.3. Energy citizenship in Bilbao

This section presents the results obtained through the Energy Citizenship (ENCI) survey conducted in Bilbao. ENCI survey aimed to understand current willingness of Bilbao citizens to implement energy citizenship actions. This information may help Bilbao municipality to understand how they can improve citizens engagement in energy transition, by helping them to become active agents of the transition process.

120 citizens completed the survey, from which 96 live in Bilbao. Figure 24 shows the geographical representation of the citizens from Bilbao that completed the survey.

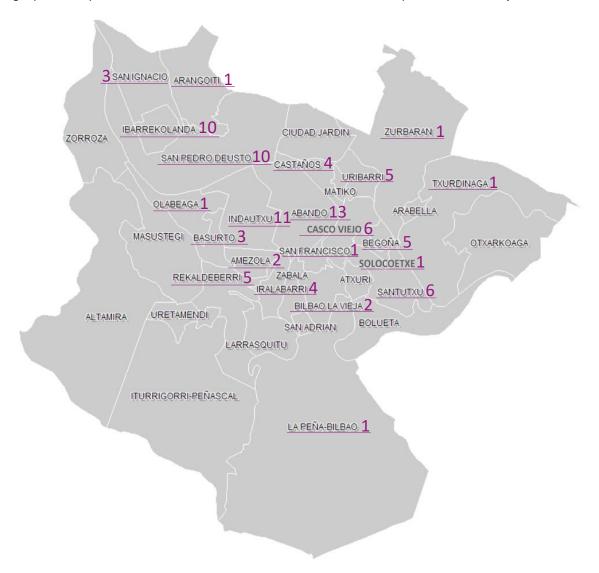


Figure 24. Geographical representation of the Energy Citizenship survey conducted in Bilbao.

It is important to note that this is a preliminary study for which a sample of 96 answers helps to provide an overview of the situation in the whole city. To conduct the study properly, it is needed to increase the number of respondent and to have representativeness from all the neighbourhoods.



Results are presented per energy citizenship action for the whole city. Firstly, the willingness of the respondent to put in place the action is presented. The classification of the willingness mentioned in the methodological section is connected with the respondents answers as follows:

- I wasn't aware about its relevancy: **Unaware.**
- I am aware: Aware.
- I am aware but is not possible: Involved.
- I have already implemented: Active.
- I have already implemented, and I invite family and friends to implement it: Advocate.

Secondly, the reasons of the respondents for implementing or being interested in implementing the action are summarized. Finally, explanations are provided regarding why the respondents choose not to implement the action or find it difficult to do so.

Do you/Would you save energy in your daily domestic activities?

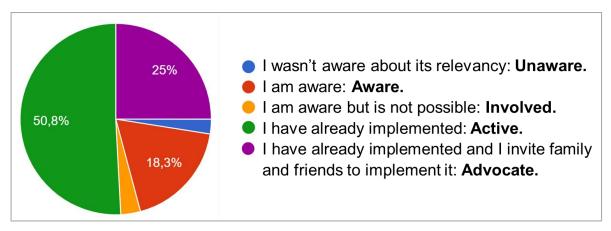


Figure 25. Saving energy in daily domestic activities.

Most of respondents are active or advocate to save energy in their daily domestic activities. Most mentioned responses that motivate the commitment in saving energy are:

- It involves saving energy and, therefore, reducing expenses (90%).
- Environmental awareness (72,5%).

Less respondents but still a good representation (21,7%), selected the option "I want to have less energy dependency".

On the other hand, some of the reasons given by the respondents that have doubts about saving energy are:

- I don't have control over the devices that consume energy (34,2%).
- It is difficult to save energy (31,7%).

The 24,2% of the respondents also mentioned that they would need more information to implement this action.

Would you buy a dwelling considering its energy certificate?



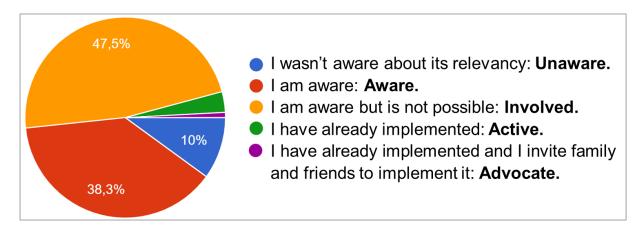


Figure 26. Buying a low energy consumption dwelling.

Most of respondents are aware or even involved in considering the energy certificate when buying a dwelling. However, only few of them are active in implementing this action.

Reasons motivating the implementation are:

- It involves saving energy and, therefore, reducing expenses (95,8%).
- I have been told positively about it, and I would like to be part of it (23,3%).

Reasons against the implementation are:

- I am not thinking in changing dwellings (63,3%).
- I am not aware about this type of dwellings in Bilbao (21,7%).
- Low energy consumption dwellings are much more expensive (21,7%).

Would you improved or did you improve the dwelling's isolation to reduce energy consumption?

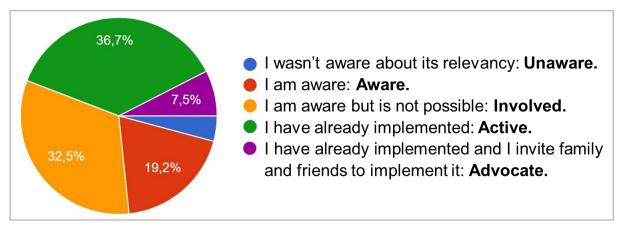


Figure 27. Improve dwelling's isolation.

Most of respondents are at least aware, involved and even active about the importance of this action. Some of the respondents even invite their family and friends to implement it.

Reasons motivating the implementation are:

- It involves saving energy and, therefore, reducing expenses (84,2%).
- It improves dwelling's comfort (64,2%)



It is also interesting to highlight that the 18,3% of the respondents answered that there are subsidies to implement this action.

Reasons against the implementation are:

- I am not thinking in doing construction works (38,3%).
- It's inconvenient to do construction works (32,5%).

Another regularly selected answer against the implementation (22,5%) is that the costs of the construction works do no compensate the savings.

Do you consider low energy consumption as an important factor when buying an appliance?

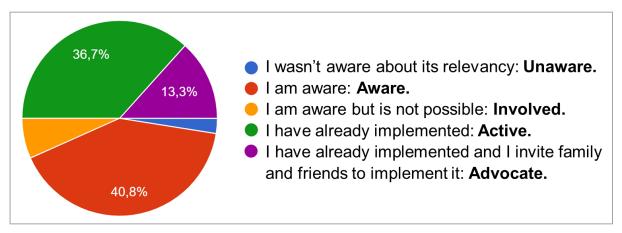


Figure 28. Considering low energy consumption when buying an appliance.

Even though most of respondents are aware about the importance of this action, only half of them have implemented it.

Reasons motivating the implementation are:

- Acquisition cost is similar and they will be profitable in the long run due to their lower consumption (55%).
- To me considering the energy consumption is essential when selecting an appliance (50,8%).
- It is easy and understandable identifying low energy consumption appliances (48,3%).

Reasons against the implementation are:

- Are more expensive (45%).
- The information is not clear (24,2%).

It seems that for most of the respondents the information to identify low energy consumption appliances is clear, while almost a quarter answered just the opposite. It is also interesting to highlight that 12,5% of the respondents are suspicious about the low-energy labels.

Are you part or would you be part of an energy cooperative?





Figure 29. Being part of an energy cooperative.

Only few respondents are part of an energy cooperative. Even though most of the respondents are aware or involved, a considerable percentage (37,5%) are not aware about its relevancy.

Reasons motivating the implementation are:

- I want to have more autonomy, knowledge and participate in decisions (45,8%).
- Someone told me in positive and I wanted to be part (22,5%).

Reasons against the implementation are:

- I would need more information (63,3%).
- It requires extra effort from me (28,3%).

A considerable number of respondents (17,5%) also mentioned that it doesn't give them confidence.

Would you, or have you, switched to an energy provider with a green energy contract?



Figure 30. Energy provider with a green energy contract.

In comparison with the action of being part of an energy cooperative, more respondents are active (17,5% merging active and advocate respondents) in having a green energy provider. In any case, a considerable number of respondents are still unaware about the action relevance.

Reasons motivating the implementation are:



- I support renewable energy (57,5%)
- Someone told me in positive and I wanted to be part (28,3%).

It has to be highlighted that 19,2% of the respondents mentioned that there are incentives for using renewable energy.

Reasons against the implementation are:

- This type of providers are more expensive (31,7%)
- I distrust the providers of this type of service (23,3%)
- There is no capacity to provide so much renewable energy (23,3%)

Are you part or would you be part of an energy community?

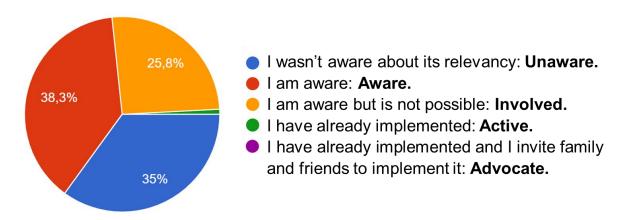


Figure 31. Being part of an energy community.

Even though the partnership to an energy community was asked, there are no energy communities by itself in Bilbao. Therefore, this question aims to understand the knowledge and interest of the respondents on this topic.

Reasons motivating the implementation are:

- I believe it is the best way to contribute to the energy transition (51,7%)
- Someone told me in positive and I wanted to be part (17,5%).
- I would like to live surrounded by neighbourhoods that share my concerns (15,8%)

Reasons against the implementation are:

- I would need more information (55,8%).
- It requires extra effort from me (31,7%).

The 25% of the respondents commented that there are no energy communities available.

Would you, or have you, installed solar panels at home?



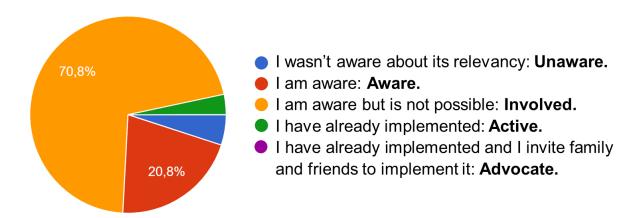


Figure 32. Install solar panels at home.

Most of the respondents (70,8%) answered that they are aware of the relevance of installing solar panels. However, it is not possible for them implementing this action. Understanding the key factors that would shift citizens from being involved to being active may promote the implementation of this relevant action.

Reasons motivating the implementation are:

- It involves saving energy and, therefore, reducing expenses (67,5%).
- I want to promote the use of renewable energy (55,8%).
- I want to reduce my energy dependence (increase my autonomy) (49,2%).

Reasons against the implementation are:

- I don't have an adequate place to make the installation (lack of space/unsuitable orientation) (60,8%).
- I would need more information (28,3%)

Even though the above reasons against the implementation were the most selected, several respondents mentioned the costs associated: The installation is costly (25,8%), the implementation implies a cost that I am not willing to pay (19,2%), It will take long before the savings compensate the investment (14,2%). Moreover, it has to be highlighted that the 16,7% of the respondents mentioned that the regulations do not favour it.

Would you, or have you, installed energy storage at home?

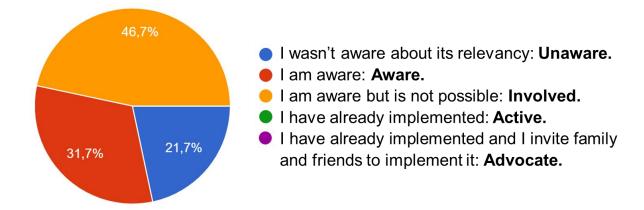




Figure 33. Install energy storage at home.

Not being any respondent active in installing energy storage at home, it is remarkable the number of respondents answering that they are aware (31,7%) or even involved (46,7%) in this action.

Reasons motivating the implementation are:

- It involves saving energy and, therefore, reducing expenses (55%).
- I want to reduce my energy dependence (increase my autonomy) (40%).
- I want to promote the use of renewable energy (38,3%).

Reasons against the implementation are:

- I don't have an adequate place to make the installation (lack of space) (59,2%).
- The installation is costly (38,3%)
- I would need more information (35%)

Reasons in favour and against are similar to the reasons given to the action "Installing solar panels at home".

Would you, or have you, implemented at home improvements in the heating and domestic hot water system, like heat pumps and/or thermal energy storage?

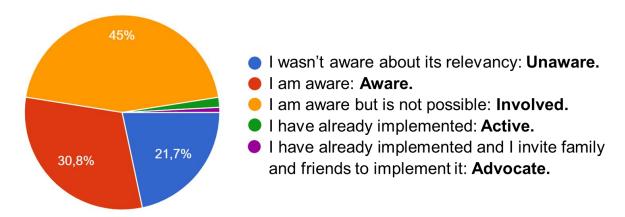


Figure 34. Improve home's heating and domestic hot water system.

Only few respondents (less than 5%) have implemented this action. However, most of them are aware (30,8%)) of its relevance and even involved (45%) on it. The latter means that they have considered the convenience of implementing it.

Reasons motivating the implementation are:

- It involves saving energy and, therefore, reducing expenses (62,5%).
- I want to promote the use of renewable energy (46,7%).
- I want to reduce my energy dependence (increase my autonomy) (35%).

Reasons against the implementation are:

- I don't have an adequate place to make the installation (lack of space) (54,2%).
- I would need more information (36,7%)
- The installation is costly (35%)



Do you regularly use environmentally friendly alternatives to a private car to get around Bilbao?

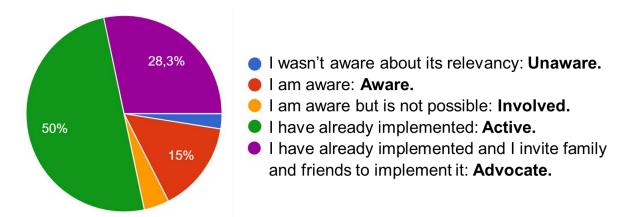


Figure 35. Use environmental friendly alternatives to the a private car to get around Bilbao.

It is remarkable the number of respondents that are active on the use of alternatives to a private car to get around the city (78,3% in total). It has to be highlighted as well that, beyond being active, the 28,3% of them also invite family and friends to implement this action.

However, the most selected reasons motivating the implementation are not directly related to the energy transition:

- It helps me avoid traffic jams (72,5%).
- It helps me to reduce expenses (60%).

Reasons to use the private car are:

- It provides me with comfort and convenience (35%).
- The alternative to the use a private car requires me to spend much more time on the journey (27,5%).

It has to be noted that 20% of the respondents mentioned that the public transport is not adapted to their needs and the 10% that the bike lanes are not suitable for them. Moreover, the 7,5% allege that there are zones in the journey difficult to cross on foot.

How do you see buying an electric car or a pluggable hybrid in Bilbao?

Bilbao municipality it is implementing progressively a low emissions zone.



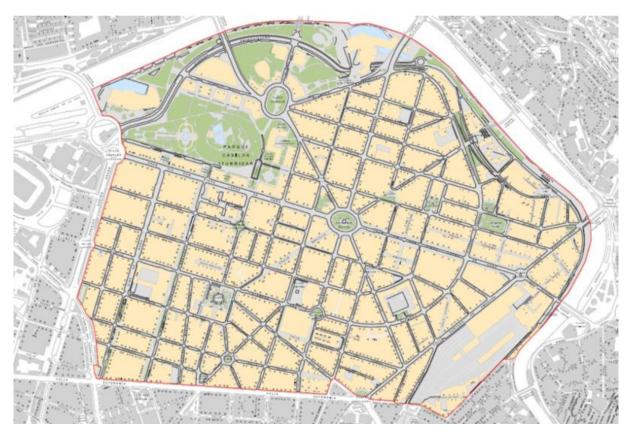


Figure 36. Bilbao low emissions zone in 2024. Source: <u>Bilbao.eus, Zona de Bajas Emisiones de</u> Bilbao, Área y horarios de aplicación.



Figure 37. Buying an electric car or a pluggable hybrid in Bilbao.

Even though few respondents have implemented this action (less than 5%), most of them are aware or involved on it (77,5%). It is also important to note that 11,7% of the respondents do not have a car and do not think about buying one.

Some comments from the implementors are:

- It allows to get around the low emissions zone (25,8%).
- Finding charging points is complex (22,5%).
- Acquisition costs and installing a charging point is expensive (15,8% and 12,5% respectively).



Comments from the respondents that find difficult buying an electric car are:

- Electric cars are expensive (74,2%).
- There are no enough charging points in Bilbao (54,2%).
- I cannot afford charging point installation investment costs (43,3%).

A considerable number of respondents (31,7%) answered that it is no reliable, that the electricity is expensive (13,3%) and even that they feel pressure to implement this action and that makes them feel aversion.

Even though the sample of responses to the survey is limited, valuable information is obtained. Thanks to the survey, Bilbao's municipality technicians have an idea about the feeling of the citizens with the energy transition, and decisions can be taken to promote the involvement. Depending on the willingness of citizens to implement each action, recommendations to foster citizens involvement include ensuring the access to clear and transparent information, gaining trust, facilitating the action implementation by creating funding mechanism and suggesting reliable providers, among others.

The survey results provide an overview of the energy citizenship situation in Bilbao, but still more work is needed to complete the method proposed in section 2.5.



4. Lessons learnt in City Vision creation process.

There are multiple methods to approach the City Vision creation. In ATELIER, the Cities4ZERO methodology has been proposed and implemented by Bilbao as front runner and by Bratislava, Budapest, Krakow, Matosinhos and Riga as followers. On the other hand, Amsterdam and Copenhagen followed different approaches, as their own processes were in progress when ATELIER project was approved, and they prefer to maintain them.

In previous WP2 deliverables, Amsterdam and Copenhagen approaches have been explained as follows:

- Amsterdam and Copenhagen innovation ecosystem: D2.2 Report on Smart City Planning groups (SCPGs), 2021.
- Amsterdam methodology City Vision / Roadmap 2050: D2.3 Common methodological framework for Vision development, 2021.
- Overview on how Amsterdam developed The Amsterdam Climate Neutral Roadmap 2050 (approved in spring 2020) and how the so-called Climate Budget supported the creation of it: D2.5 Prioritization matrix, 2021.
- Copenhagen Climate Plan 2035: Expected work process for the new climate plan: D2.5 Prioritization matrix, 2021.
- Lessons learnt in City Vision Creation process: D2.6 City Vision, 2023:
 - o The case of Amsterdam: 3 years of monitoring.
 - o The case of Copenhagen: working on post-neutrality plan.

Beyond this information, this section explains the methodological approaches implemented by Copenhagen for a successful planning and how Amsterdam has approached the Climate City Contract (CCC). Moreover, Riga presents the process that they are following/have followed to create the CCC, that was supported by some of the tools provided by the Cities4ZERO method, like the governance model or Smart City Planning Group (SCPG) and energy modelling.

It has to be noted that Copenhagen expects to present their CCC by the end of the year 2024. However, roughly speaking, they do not have had any special process associated with the CCC development. The driving force and focus has been and still is the development of their climate plan (including energy strategy) and the CCC just reports what has been going on in the climate plan process.

4.1. Methodological approaches for a successful planning. The case of Copenhagen.

The overall work process for preparation of Copenhagen's energy strategy 2035-2050 was as follows:

- Relatively narrow group of key stakeholders ("the usual suspects")
 - Vision of the future what future do we look into and what challenges awaits us? – "taking the pulse"
 - Political ambition level Climate positivity
- Wide range of stakeholders and multiple work groups:
 - o Dilemmas i.e. conflicting ambitions that require "political" decisions.





- E.g. no use of wood fired biomass for energy production contra REbased production within/near Copenhagen.
- Guiding principles for the energy strategy decisions.
- Innovation sprints.
 - Problem trees.
- Gross list of possible actions looking to 2035 and 2050.
 - Potential carbon reduction, costs, organisation, etc.
- Emission sub-targets and selection of net-list of actions for the first action plan (2026-2029).

For more detail, please consult the previous deliverables under WP2.

Four of the key tools applied in the City Vision creation process in Copenhagen are:

- Full scale cooperation.
- Double diamond design process.
- Problem tree analysis.
- Problem theory (and program theory).

These four tools are described below:

Full scale cooperation (excerpt from D2.6) – Wicked problems require cooperation across value chains. The "remaining" climate mitigation challenges facing Copenhagen are not easily overcome. In our thoroughly regulated society with well-established institutions that are used to optimizing their businesses, we have to innovate and integrate the different sectors of society in new and more radical ways. Furthermore, we are globally facing a fast-approaching climate crisis. What is facing us is so-called "wicked problems" or even "super-wicked problems" (see for example 'Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future', Richard J. Lazarus, 2009). These problems are characterised by the following: 1) Time available for solving them is running out, 2) Those who try to solve the problems are also part in creating the problems, 3) The government cannot control the societal choices that must be made in order to find a solution, and 4) Decision-makers are more worried about the short-term costs than the long-term consequences. What is needed is not to tame the problems or solve them but rather to develop a common understanding of the problems and a common understanding of possible solutions - the target being not find the one and only solution but to create a focused and cohesive effort since it is impossible to solve the problems in a way that is simple and final. What is required is a holistic approach to future focused solutions. And this is best done through collaborative reasoning in involving all parties so that a multitude of resources are mobilised, and a joint ownership of the solutions is formed.

<u>Double diamond design process</u> - The double diamond diagram was developed through inhouse research at the Design Council in 2005 as a simple graphical way of describing the design process. It is divided into four distinct phases, namely Discover, Define, Develop and Deliver, and illustrates the divergent and convergent stages of a design process. The double diamond design process is applied for the entire climate plan process. For more information see https://www.designcouncil.org.uk/our-resources/archive/reports-resources/11-lessons-managing-design-global-brands/.



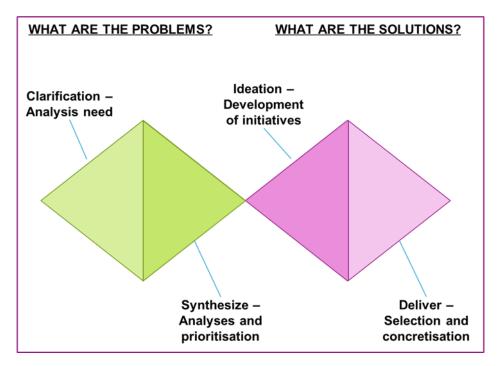


Figure 38. Double diamond approach as applied in Copenhagen.

Below you may find a description of the lessons learned so far from the applied double diamond process.

Table 8. Lessons learned from the application of Double Diamond method in Copenhagen.

Title: Double diamond

Brief description:

Copenhagen has used the so-called "double diamond" approach (discover, define, develop, deliver) in the development of the Energy Strategy 2035/2050 and the Climate Plan 2035. The double diamond approach guides a development process through four steps, where the first and third step are explorative (divergent) and the second and fourth selective (convergent):

- Step 1 Clarification (Discover) Here the aim for Copenhagen has been to get to understand the required changes and their challenges and dilemmas and how the different stakeholders see these. Do we jointly have the right and sufficient data to be able to form a substantiated and clear picture of the situation and the possibilities? Is there a need for launching analyses to furbish the teams with the necessary information and data?
- Step 2 Synthesize (Define) Analyses are defined and carried out. The guiding principles for decisions regarding formulating initiatives and prioritisation among initiatives and competing options are the outcome of this step. Differences in the interests and point of view of the different stakeholders may result in compromises.
- Step 3 Ideation (Develop) Development of a gross list of possible initiatives is developed by each team based on a succession of focused sprint sessions using among other problem theory as a tool.
- Step 4 Deliver Selection of initiatives and concretisation of targets The gross list of options is
 elaborated with assessment of impact and costs and ranked in order to arrive at a selection of
 initiatives to be included in the first road map.



Stakeholders involved:

In the energy track alone approximately 100 persons have been actively involved. (To this is to be added the much larger group involved in the work relating to reduction of citizens' consumption.)

Application process: Active engagement of numerous stakeholders in developing and understanding the paradigm for our energy system and the challenges (wicked problems) we face jointly – leading to development of initiatives for the energy strategy (and the climate plan) that already has a high commitment from the stakeholders. An important output is thus also the work relation and trust built among the stakeholders during the process.

Learnings					
To be repeated	To be improved	Conclusions/recommendati ons			
Using the double diamond approach has provided room for "free thinking" and time to collect the necessary information and data before making political decisions on what should become part of the Energy Strategy. The focussed sprint sessions have required a lot of time of the participants but also enabled deeper professional discussions on strategic dilemmas which benefits the overall result.	The process is very labour intensive and should therefore not be used without serious consideration and allocation of time.	We recommend using the double diamond approach and the very intensive and active involvement of a large number of stakeholders when a new carbon paradigm is being introduced.			

<u>Problem tree analysis</u> – Problem tree analysis is a structured approach to mapping out the caused and effects of a problem. In order to design successful interventions, the problems must be clear. Mapping the aspects and their relationship in a transparent manner can be useful in finding key factors. The problem tree analysis approach is applied by each thematic work group. One thematic work group is responsible for the energy strategy development and for the energy strategy alone there are six subgroups (Role of buildings in the energy system, Heat production including waste incineration, Centralised wind and PV, Decentralised/local energy production, Electricity grid and electrically driven transport means, and finally, Green certificates and calculations). For more information on the problem tree approach see for example https://odi.org/en/publications/planning-tools-problem-tree-analysis/.

After identifying key problems to be addressed by the energy strategy, the work group was divided into smaller work teams (2-3 persons) responsible for each their set of problems to be described using the problem tree framework. Then each tree was presented to the entire work group after which each person in the work group had to indicate which factor was most important to address. This then leads to formulating first sketches of climate initiatives. The next step will then be to assess the potential impact and costs of these initiatives after which the Energy Strategic Forum will determine which initiatives should be part of the energy strategy and the first action plan. First then will the actual design of the chosen initiatives take place.

As illustration of the process results, the list of identified problems to be addressed by the energy strategy 2035 for example related to the role of buildings in the energy system are:



- Energy waste in the operation of buildings.
- Excessive use of heat energy due to poor building envelope.
- An increasing electricity demand for ventilation and air-conditioning of buildings.
- Many buildings are not ready for low-temperature district heat supply.
- Many buildings are not able to act flexible and thus help reduce the need for fossil fuel fired peak district heat load.
- · Lacking readiness for electric flexibility.
- Slow uptake of building integrated PV-based electricity production.
- The buildings and the home are in general not perceived as an attractive way to contribute to the green transition.

An example in Danish of the many problem trees developed, is for example the problem tree for avoiding and limiting the cooling demand of buildings which was developed by the work group for buildings.

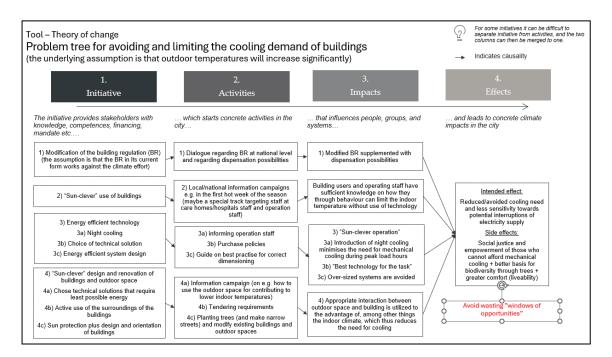


Figure 39. The first take on a problem tree for avoiding and limiting the cooling demand of buildings in Copenhagen.

<u>Problem theory (and program theory)</u> – To design successful interventions it is insufficient to understand the intervention logic alone. What is required is to also understand the problem logic. In the design process, the stakeholders mapped problems, their root causes and their effects. This tool is to be applied in the coming months when the initiatives that will form part of the first action plan are being developed. Suggested further reading – 'Realistic evaluation', R. Pawson and N. Tilley, 1997, London. Sage Publication.



4.2. Approaches for a successful climate city contract. The case of Riga.

Riga CCC was elaborated in highly participatory process, demonstrating an understanding of the role of stakeholder engagement as a driving force of the city's transition towards climate-neutrality.

The following sequential co-creation process was applied:

- 1) June 2023. Launch and introduction: Climate goals of Riga and CCC process Thematic focus: assumptions for each sector and scenario analysis. Assessment on the emissions' reduction expected at EU, National and Riga city level. CCC development process and ecosystem of CCC stakeholders.
- 2) July September 2023. Round of internal consultations Thematic focus: internal consultations among Riga municipal departments, municipal services providers on the CCC development. Review of the city' strengths and opportunities, assessment of challenges and barriers. Identification of municipal needs, potential measures and next steps to reach "net zero".
- 3) September 2023 February 2024. Building and refining pathways and scenarios Thematic focus: co-creation process addressing all CCC sectors in various consecutive sectorial co-creation sessions (transport, buildings, industry, energy and consumption, waste, urban greening, etc). Understanding the measures and how the measures contribute to reach net zero. Local experts from each sector presented top-down needs for the sector, during each sectorial session, top down and bottom-up approaches were reconciliated.
- 4) March July 2024. Validation. Thematic focus: climate goals, adopted pathways and preferred policy scenario validated by stakeholders and policymakers.
- 5) September October 2024. Public Hearings. Thematic focus: Public presentation of CCC: adopted transition pathways and preferred policy scenario already assumed by decision-makers and over 130 stakeholders.
- 6) Political validation.
- 7) Submission.

Citizens were involved in development of Riga CCC and citizens will continue to be empowered and included in the decision-making processes on climate actions through mechanisms institutionalised in the governance model of climate actions.

The strategic, participatory and multi-sectorial energy planning approach highlighted as part of the Riga CCC development process, will be also an integral part of the Riga CCC implementation and social innovation interventions. Different aspects of Riga CCC are planned to be further elaborated as specific topics for public discourses and integrated in related projects and activities. For example, as part of the "Greening Plan of Riga" elaboration, in September - October 2024 Riga co-organized the first citizen climate assembly (a series of planning workshops) that contributed to the development of new urban greening measures. A



total of 41 highly valued proposals were submitted by the active part of society that will be further integrated in the "Greening Plan of Riga".

Conclusion:

Participatory approach was a key to success:

- Chosen communication strategy during the elaboration of Riga CCC had a decisive role.
- Facilitation of co-creation and co-development, paired with multi-sectorial energy planning approach helped us to balance interests, achieve compromises, reach mutual agreements and airmark funding for the implementation of Riga CCC measures.
- Riga CCC already was signed by over 50 key stakeholders, both internal (municipal institutions and enterprises) and external (regional and state institutions, academia, research, NGO's, associations, businesses, etc.) The number of signatories is growing day by day.
- Riga team believes that in such way we managed to promote a sense of ownership and commitment among the involved stakeholders towards the achievement of the common climate goals.

4.3. Approaches for a successful climate city contract. The case of Amsterdam.

Reflection on the steps taken

The Strength

The net-zero missions, and thus the development of the CCC, requires *an agile and adaptive process*, and monitoring that process with the appropriate milestones is crucial. This agile process depends on the support across the organization and a solid overview of the ongoing and planned policy measures towards climate neutrality. A process is needed that keeps up with the dynamics of the sustainability transitions, a process that must accelerate and not get in the way of ongoing initiatives. The dynamics of the process require clear markers that keep an overview of the beaten path and reflect the relationship to parallel paths/initiatives.

Network and knowledge management are the foundation of a well-functioning process. The networks of actors and knowledge play an important role for the CCC. The roles of network manager and knowledge manager have been fulfilled (implicitly) in the CCC team. In addition to the definition of these roles, a corresponding process is required for the fulfilment of these roles. It is also recommended to include a role of process manager into the process.

Another strength of the CCC is that it **encourages a holistic approach** to sustainability and forces the process to make an overview of what is happening within a city as precondition. The holistic approach is considered a strength, looking broader than the energy transition, but also at the circular transition and the transition to a green and healthy city. This is to be in line with the holistic approach included in "Our City of Tomorrow".



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⁷ Rīgas iedzīvotāju klimata asambleja Rīgas domei iesniedz 41 - Zaļā brīvība



In Amsterdam, climate and sustainability policy is distributed and interdependencies are sometimes unclear/implicit. The CCC process is enabling the improvement to the overview across the organisation, in the case of Amsterdam, by collecting information in the form of interviews with civil servants and studying policy documents.

The Challenges

The lack of **overview in Amsterdam's sustainability policy and actions** was a challenge in the discussions with the policymakers and did not help to get them on board with the process of identifying new opportunities and solutions.

"Why do something new, if we are not sure whether it is actually not being done yet".

Other relevant questions in establishing improved overview are: how up-to-date and complete are certain policy documents? What is the status of the execution? Which internal developments are not recorded in this document, but are important? Due to the lack of overview in what is already happening it requires continuous explanation to policymakers, of whom the support is critical, what the added value of the mission is. While the support of the mission to achieve a sustainable city is stable and high within the organization, a challenge was that **sub-optimal or underdeveloped support for the development of the CCC as a product throughout the organization**. The playing field around sustainability is constantly evolving and the CCC process must be adaptive to this.

Moreover, potential *inconsistencies in Sustainability Policy* form a challenge towards acceleration of sustainability action. These inconsistencies, for example between national energy standards for new buildings and local standards, may form an obstacle to making the organisation and the city more sustainable. Improved coherence can channel towards complementary and enforcing actions which can accelerate the transition. In order to get a better picture of the Amsterdam organisation and its sustainability policy, including the possible inconsistencies and its consequences, the CCC team took over 30 interviews throughout the organisation. However, the time in these internal conversations has come at the expense of the time for the conversations with city actors.

The municipality was **cautious to engage actors** in the city for the mission, as the added value of the ccc was unclear. As a result, the CCC team could not connect well to the existing processes and contacts. The difficult connection to the other parts of the municipal organization hindered a coordinated approach and cooperation with city actors.

Getting **capacity and support of civil servants** available and committed the mission and the CCC is a challenge. In particular, freeing up implementation capacity for writing the CCC and connecting with actors. This can be related to the observation that organisation-wide support for a CCC seems to be low.

The team also experienced an **Innovation VS failure paradox**. Innovation is important for this mission. Although policymakers acknowledge the need to look for acceleration opportunities, there often is a lack in confidence to try new things.

Reflection on the mission, the CCC as a tool and national cooperation

The strength

A much-valued strength of the CCC is that it encourages a more holistic approach to the climate transition and sustainability. We are convinced that this holistic approach is also of



added value for the other municipalities in the Netherlands, and Europe, where there is still a lot of fragmentation of sustainability policy.

The NetZeroCities program developed and made available **a broad set of resources and expertise for the mission cities**. For instance, the Economic Case Model⁸ was used for an initial estimate of the costs associated with the 2030 objectives of Amsterdam.

The **National Cooperation Structure (NSS)** has been set up for strategic and tactical challenges between city (Dutch Mission cities) and national (relevant ministries) governments. Cities can exchange experiences and learn from each other, and work together on lobbying activities towards other governments, such as the national government and the EU. In addition, a city alone is not enough of a 'market' to create change among market parties. However, when several Dutch or even European cities join forces and ask the same sustainability question to the market, mass is created that can make the transition financially more attractive for the private sector.

The Challenges

As mentioned earlier under the lessons associated with the chosen approach, one challenge is that the **support for the CCC** within the **organization** seems to be low. This is partly since Amsterdam already has a wide variety of sustainability policy, which made a CCC feel like things were being done twice. This makes it difficult to draw up a CCC in the form of how it is presented by the Mission. The position and role of the 100 Climate Neutral and Smart Cities mission had to be redefined again and again because it is not a focal point of municipal climate policy. In its design, the mission seems to assume a role and position with ample mandate, which is currently lacking in Amsterdam. Key moments that can contribute to the position of the mission in Amsterdam were: a new college and the policy under "Our City of Tomorrow", the urgent letter from the civil servants and climate events of the Sustainable Civil Servants Network in Amsterdam, the Board assignment "Sustainable future city and organization", introduction of the municipal transition team and the development of an Integral Monitor & Climate Budget.

The **communication of the mission** has also been experienced as a challenge. The team has experienced that the mission is difficult to communicate because it is so large. That doesn't help to make it manageable for colleagues. The CCC often focuses on the mission and its discourse/thoughts, while this does not easily connect to local implementation. If it is already complicated to get this message to land internally within the municipality – where people work on these kinds of themes daily – this is likely to present an even greater difficulty when other actors in the city are involved, from residents to companies and non-profits. This makes the CCC **difficult to communicate**. The use of "Contract" in the CCC scares off cooperation (internal and external). The term 'contract' triggers the legal alarm bells in the Dutch context.

In addition, the team experienced **the long-term mission vs short-term product paradox** as a challenge. It is a long-term mission towards climate neutrality with needs that are often still conditional in nature, such as research to identify the impact (CO_2 and co-benefits) of actions or setting up new sustainability coalitions for a sound and responsible participatory process. On the other hand, there is pressure to deliver a CCC with actions in the short term, while many of the preconditions are still unclear or not yet implemented.

⁸ NetZeroCities





The team also experienced significant **challenges in writing the CCC** based on the template and guidelines. With the Roadmap Climate Neutral Amsterdam 2050, Amsterdam had already delivered an action plan and commitment document that is in line with the expression of interest. Because this was not considered sufficient because it did not match the NZC templates, it had to be redone. That takes time, money and provokes resistance from the officials. A more efficient writing process would save a lot of time, which could be invested in increasing support in the municipality for the mission and developing or renewing sustainability coalitions in the city.

Finally, **the scalability of the CCC** is a challenge. The current version of the Amsterdam CCC is already a lengthy document. The more we progress in the sustainability transition, the less useful a CCC becomes. The document then becomes too long and there is a need for a different/more workable way of recording the agreements and progress. The aim of the Mission for Amsterdam is to accelerate sustainability. This will not be achieved by drafting lengthy documents.



5. Conclusions

D2.7 Benchmarking of selected solutions presents the method for evaluating the pathways developed by the eight ATELIER cities to decarbonize their energy systems. In addition to outlining the method, a practical example focused on the lighthouse ATELIER city of Bilbao, along with the necessary materials for conducting the analysis in each ATELIER city is provided. Latest updates in the city vision creation process are also given in annexes.

Benchmarking in ATELIER supports municipal decision making by aligning the vision and the action plan to address the question "How suitable is the proposed pathway?". Benchmarking identifies both the strengths and weaknesses of the defined pathway, providing decision-makers with valuable insights to foster the transition into neutrality. ATELIER's benchmarking approach focuses on the energy and the technical aspects, complements the analysis with socioeconomic information, and introduces a self-developed method to involve citizens in the energy transition. Additionally, a practical example of "design thinking" as a method to address the systemic problems identified through benchmarking is provided. Specifically, benchmarking in ATELIER includes:

- Climate neutral energy system form: An extensive survey designed to guide the municipalities in reflecting about on what a climate neutral energy system should entail and what factors must be considered for an effective transition.
- Impact assessment of the master scenario: Provides cities with insights into the potential energy, environmental and socioeconomic impacts of the proposed master scenario.
- Benchmarking boards: Visually organizes all the information generated throughout the process, facilitating the discussion among key stakeholders to identify strengths and weaknesses of the proposed pathway.
- Benchmarking process: establishes a participatory framework that encourages open discussion among selected stakeholders within the municipality.
- Design thinking: Addresses systemic problems identified during the benchmarking process. Municipalities can implement this method as many times as needed.
- Energy citizenship: Deepens citizens involvement in the energy transition by promoting actions that individuals can independently undertake.

Conclusions and comments from the responses from cities to climate neutral energy system form and from the impact assessment of master scenario are given below.

Climate neutral energy system

The eight ATELIER cities completed the climate neutral energy form. In the following paragraphs an overview of the responses given from all of them is provided. Due to confidentiality concerns, specific answers per city are not given.

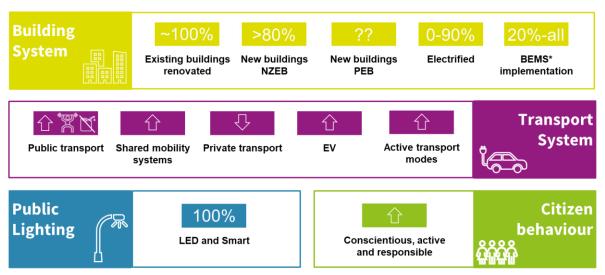
Six out of eight ATELIER cities joined the "100 climate neutral cities by 2030" Missions initiative and submitted their climate city contracts in September 2024. While exploring pathways for this transition, cities faced numerous challenges, leading some to opt for extending the timeline for conversion (Figure 40).





Figure 40. ATELIER cities commitment to reach carbon neutrality.

A carbon neutral city inherently requires a carbon neutral energy system, which was the primarily focus of the conducted form. Energy system refers to interdependent network of infrastructure, technologies, actors, regulations, market structures and consumers that generate, distribute and use energy. An overview on how ATELIER cities visualize their energy system when climate neutral in terms of Energy Use, Energy generation and Energy Distribution is given in Figure 41, Figure 42 and Figure 43 respectively.



*BEMS: Building automation and control system

Figure 41. ATELIER cities visualization of Energy Use when carbon neutral.

Several commonalities can be identified in how the cities envision energy use when climate neutral. Nearly 100% of the existing buildings need to be renovated, while new buildings must accomplish strict energy efficiency rules. Regarding electrification, responses vary widely, ranging from it being considered non-essential to envisioning 90% of the building system as electrified. Building automation and control system are seen as playing an important role, with some cities even envisioning their implementation in all buildings across the city.

There are more similarities in the public lighting, which is uniformly envisioned as 100% LED and smart, and in the energy use in the transport system. In the latter, the share of non-fossil-fuel-based vehicles must increase, alongside widespread alternatives to private transport, such as public transport, shared mobility systems and active transport modes.



The relevance of citizen involvement is also highlighted, with citizens envisioned as becoming more conscientious, active and responsible in their roles within the energy transition.

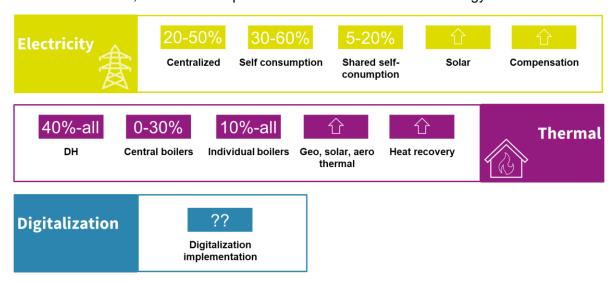


Figure 42. ATELIER cities visualization of Energy Generation when carbon neutral.

Regarding how cities envision the energy generation when climate neutral, the approach to electricity generation seems to be quite similar. On-site solar generation is expected to increase, and compensation mechanisms will continue to play a significant role.

While renewable sources for thermal energy generation and the heat recovery are envisioned to increase in all the cities, discrepancies emerge regarding how the envisioned contribution of district heating systems, as well as central or individual boilers. Additionally, there are uncertainties about the role digitalization will play in energy generation.



Figure 43. ATELIER cities visualization of Energy Distribution when carbon neutral.

How cities envision the energy distribution in a climate-neutral future is still un-clear. Several cities have identified the potential for congestion problems due to an increasing electricity demand, indicating that the network will need to be reinforced and strategies to mitigate potential peak loads must be defined. Responses to this part of the questionnaire highlight the need to address energy distribution concerns with special attention to avoid potential issues in the future.

Master scenario impact assessment

Table 9 summarises the impact assessment results for each city and refer them to their population, aiming to provide a basis for comparing the indicators across cities.

Table 9. Summary of impact assessment indicators referred to population.

	BILBAO	BRATISLAVA	BUDAPEST	KRAKOW	MATOSINHOS	RIGA
SCENARIO HORIZON	2050	2050	2050	2050	2030	2030





BASE YEAR POPULATION	346,332	475,577	1,759,000	790,279	172,000	634,000
CUMULATIVE FINAL ENERGY (GWh saved/inhabitant)	0.068	0.110	0.187	0.068	0.073	0.043
CUMULATIVE TOTAL PRIMARY ENERGY (GWh saved/inhabitant)	0.079	0.160	0.309	0.285	0.126	0.049
CUMULATIVE NON RENEWABLE PRIMARY ENERGY (GWh saved/inhabitant)	0.095	0.196	0.394	0.441	0.220	0.055
CUMULATIVE GWP (kton CO₂eq saved/inhabitant)	0.021	0.051	0.064	0.128	0.051	0.011
CAPEX (M€ invested/inhabitant)	0.004	0.031	0.009	0.008	0.020	0.009
GDP generation (M€ generated/inhabitant)	0.002	0.022	0.009	0.007	0.016	0.007
Employment generation (jobs created/inhabitant)	0.028	0.275	0.119	0.092	0.212	0.099

In final energy terms Budapest and Bratislava are the cities that must achieve the highest savings in their master scenarios to achieve carbon neutrality. Regarding primary energy and GHG emissions, Krakow, followed by Budapest, has to perform the greatest effort amongst the cities to become carbon neutral. This deeply lies in the current fuel mix and supply of the city, which is heavily based on fossil fuels. Henceforth requiring an additional effort, regarding the other cities, to reduce its environmental footprint (non-renewable primary energy and GHG impact). Conversely Riga and Bilbao have to abate less emissions and reach less energy reductions per inhabitant to achieve their carbon neutrality objectives. Concerning the socioeconomic dimension, Bratislava and Matosinhos are the cities with the higher investment costs per inhabitant required to carry out their master scenarios. In turn, their master scenarios are the ones were larger levels of additional GDP and job positions are generated.

Table 10 provides additional information regarding the economic effort required to cities to achieve the energy and GHG reductions proposed in their Master scenarios to achieve carbon neutrality. Bratislava and Matosinhos are the cities with the highest cost by GWh saved, while Bilbao and Budapest have to spend less to reduce a GWh of final energy. Although Krakow has to drastically reduce its emissions, the cost of abating a ktonnes CO₂ is the cheapest across cities (in this case the city benefits form the decarbonisation of the national grid, which is an investment that does not depend on the municipality). Conversely, Riga, has the highest GHG abatement cost. This is partly explained by the fact that the cost of the Master scenario is relatively high, compared to the other cities, for the small emissions savings needed in the Master scenario to achieve carbon neutrality.

Table 10. Energy reduction and GHG abatement effort by city.

	BILBAO	BRATISLAVA	BUDAPEST	KRAKOW	MATOSINHOS	RIGA
€/GWh saved (final energy)	0.0561	0.2813	0.0490	0.1184	0.2801	0.2187
€/kton CO ₂ saved	0.1844	0.6056	0.1422	0.0631	0.4022	0.8342

Finally, it should be noted that these results depend on several considerations that should be highlighted:





- Results depend on the BaU defined by the city. That is, savings are calculated regarding this scenario, hence the more conservative this scenario is assumed to be (i.e. the lesser decarbonisation measures are considered within it), the more reductions are required to achieve carbon neutrality.
- Results depend on a certain extent on the city base year. That is, if the current fuel mix
 of the city is predominantly based on fossil fuels (or their power and heat networks are
 very carbon intensive like Krakow or Budapest), cities require more effort to achieve
 their energy and climate targets (especially in primary energy and GHG terms).
- Considered sectors vary across cities. Indeed, while Bilbao and Bratislava didn't include the industry in their assessment, the other cities did. This affects the differences between cities results.
- Results are affected by the impact of the national grid decarbonisation. That is, cities
 in countries with carbon-based power networks must achieve higher emissions
 reductions and non-renewable primary energy savings (e.g. Krakow in Poland).
 Nevertheless, this effort is not up to them but to national governments to decarbonise
 their power systems.

Ensuring a successful transition of the energy system into climate neutral is no an easy task. Cities are making a remarkable effort to establish a plausible pathway towards achieving their carbon neutrality goals. Their strong commitment to the energy transition is evident through the allocation of necessary resources, the execution of numerous studies to support decision-making, the setting of ambitious objectives and the actions to accomplish them, the inclusion of diverse perspectives, and the involvement of all stakeholders in the participatory processes among other initiatives.

City vision creation is a living process that requires continuous updates to adapt to changing circumstances, incorporate the latest innovations, and apply the lesson learned from experience. This enriching process is key to fostering the transition. In this context, benchmarking activities help to analyse the feasibility of proposed pathway, providing methodology that evaluates the alignment of the action plan with the vision. These activities also facilitate the identification of potential strengths and weaknesses, complementing the city vision creation efforts undertaken.

ATELIER cities value the adaptability of benchmarking and the methods proposed in WP2. They have embraced the materials provided, utilizing the opportunity to adapt the tools and methods to suit their specific needs and timelines.

The public nature of this deliverable offers an opportunity to share methodological insights, along with a practical example, that can assist municipal technicians within and outside ATELIER in their efforts to create and evaluate city vision.



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Annex 1: Climate Neutral City - Energy System Form



AmsTErdam BiLbao cltizen drivEn smaRt cities

WP2 City Vision Survey:

Climate Neutral City - Energy System Form

Date of document 11th of August 2023



his project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864374





Introduction

The decarbonization of the energy system plays a crucial role in the climate neutrality pathway, but it is not an easy task. Cities are implementing different strategies to decarbonize their energy systems and, considering their current situation, they have characterized how they would like their carbon neutral energy system to be in the future.

Energy system refers to the interdependent network of infrastructure, technologies, actors, regulations, market structures and consumers that generate, distribute and use energy. This system can be broken down into three primary urban systems: energy supply, buildings, and transportation.

Six out of eight ATELIER cities are committed to be climate neutral in 2030 under the 100 Climate Neutral Cities Initiative. Moreover, <u>Matosinhos</u> municipality established this ambitious objective as well.

The intention of this questionnaire is characterizing the climate neutral city energy system proposed by ATELIER cities with respect to 1) Energy Use, 2) Energy Generation and 3) Energy Distribution. Collected information will be useful to describe the climate neutral energy system city vision. The survey invites the municipalities to reflect carefully about how it should include a carbon neutral energy system and act accordingly to make it real. In ATELIER, information will be helpful to complete the chapter dedicated to <u>describe</u> the City Vision in Deliverable 2.6. It has to be noted that the master scenario must be aligned with the city vision.

Before completing the <u>questionnaire</u> Cities are called to read, reflect and discuss the following questions among Smart City Planning Group and/or the local governance model that supports city vision creation. Please, once the answers are agreed complete the online form:

https://docs.google.com/forms/d/e/1FAlpQLSfrvQMUz_BGb1ETLbeQE7BBPJZfHByA00EKz_KXMRly7D0iSRq/viewform?usp=sf_link

Sources: Cities that presented to EU Missions initiative have completed similar information in the application form.

Survey

PART A - General Questions

- 1. City name:
- 2. Please introduce your name:
- 3. Please detail your position within the municipality:
- Contact details (e-mail):
- Briefly describe who and how participated in the discussions regarding the answers provided in the form:
- City council commitment to reach carbon neutrality (year):
- Is your city part of the Missions initiative 100 Climate Neutral Cities <u>20302</u>:



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If yes to the previous question: When was presented/it is expected to be presented the Climate City Contract (CCC)?

Before going ahead, please, answer all the questions from the survey thinking that your city has reached carbon neutrality.

PART B - Climate Neutral City - Energy Use

Energy use refers to both the total amount of energy consumed by our systems and technologies, as well as the demand for energy at given moment in time. Energy use is shaped by the way we interact with and use these systems and technologies, including our expectations of consistent supply, convenience, and cost.

Reminder: answer the following questions thinking that your city has reached carbon neutrality.

B1. How is the carbon neutral building system?

- Give an overview of how is the carbon neutral building energy system of your city (general highlights).
- Give a description on what the city understands as Nearly Zero Energy Buildings (NZEBs) (any related standard?)
- Percentage of the NEW buildings that are NZEBs (new buildings: built after 2020) in the climate neutral scenario.
- Percentage of buildings that have been renovated/retrofit to fulfil with NZEBs requirements in the climate neutral scenario.
- In summary, total percentage of NZEBs in the city when climate neutral (considering both new and existing buildings)
- 14. Give a description on what the city understands as Positive Energy Buildings (any related standard?)
- Percentage of the NEW buildings that are Positive Energy Buildings (new buildings: built after 2020) in the climate neutral scenario.
- Percentage of buildings that have been renovated/retrofit to fulfil with Positive Energy Buildings requirements in the climate neutral scenario.
- In summary, total percentage of Positive Energy Buildings in the city when climate neutral (considering both new and existing buildings)

Building electrification is the process of switching from fossil fuels to clean and renewable electricity (e.g., for heating, for cooking).

- Percentage of the NEW buildings that are 100% electrical in the climate neutral scenario.
- Percentage of the existing buildings that have been electrified (e.g., for heating, for cooking) in the climate neutral scenario.
- In summary, total percentage of 100% electrified Buildings in the city when climate neutral (considering both new and existing buildings)
- Briefly explain the city strategy regarding the change to Energy efficient electrical appliances.



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- 22. Briefly explain how <u>has been the integration of Renewable Energy Sources (RES)</u> <u>systems into the buildings</u> (refers to any active/passive envelope system that uses RES from the natural environment to produce power or thermal energy. Examples: building-integrated photovoltaics (BIPV), building-integrated solar thermal (BIST), thermoelectric embedded envelopes).
- Percentage of the buildings that have a Building Automation and Control Systems (BEMS) in the climate neutral scenario.
- 24. Any other information that you want to give regarding new buildings energy requirements (for example, regarding digitalisation)?
- 25. Any other information that you want to give regarding building refurbishment/retrofit requirements in the climate neutral scenario?
- 26. Any other information that you want to give regarding energy system renovation?
- 27. Thinking at city level, indicate the percentage of the city surface that in the climate neutral scenario it is expected to be:
 - a. Energy community:
 - b. Positive (Clean) Energy District:
 - c. Other strategy, which one?
- 28. Due to your experience, which is the main challenge that the city is facing nowadays to achieve the above-mentioned building energy system of the future and how is dealing with it?
- 29. Other challenges that you want to share regarding energy in the building system.

B2. How is the carbon neutral transportation system?

- Give an overview of how is the carbon neutral transportation system of your city (general highlights) in the climate neutral scenario.
- 31. What are the mobility patterns in your city when climate neutral (percentage)?

a) Walking	<u>B)Bike</u> / scooter	c)Electric bike / scooter	d)Public transport	<u>e)Private</u> transport (vehicle)	<u>f)Other</u> (which one?)

- 32. Which are the public transport characteristics and infrastructure in your city when climate neutral? Please briefly describe:
 - a. Metro
 - b. Tram
 - c. Bus
 - d. Public transport bike /scooter system
 - e. Public transport electric bike /scooter system
 - f. Other (which one?):
- 33. If exist, explain shared mobility systems, like car sharing. Are public, private or both?
- 34. Share of vehicles when climate neutral (the sum per row must be 100%):

Electric cars Electric Other Hybrid vehicles Hydrogen Fossil

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	buses	electric vehicles	vehicles	vehicles
1.Municipal fleet				
2.Public transport				
3.Private fleet				

- 35. Briefly explain the city strategy when climate neutral regarding:
 - a. The implementation of electric vehicles charging stations.
 - b. The implementation of hydrogen vehicles charging stations.
 - c. The deployment of active mobility measures (biking, walking
 - d. Other strategy:
- 36. Percentage of the total surface of the city as "zero-low emissions zone" when climate neutral:
- 37. Describe the characteristics of the "zero-low emissions zone" when climate neutral
- 38. In case a "proximity city model" has been implemented when climate neutral, give a percentage of the city that follows this model and briefly describe it.
- Briefly explain the digitalisation of the transportation system.
- 40. Due to your experience, which is the main challenge that the city is facing nowadays to achieve the above-mentioned transport system of the future and how is dealing with it?
- Other challenges that you want to share regarding mobility.

B3. Public Lighting.

- 42. Briefly explain the Public Lighting strategy in the climate neutral scenario.
- 43. Which of the following public lighting strategies have been implemented in your climate neutral city?
 - a. Energy efficiency
 - Integrated renewable energy
 - c. Information and Communication Technologies
 - d. Other, which ones?

B4. Citizen behaviour

44. Briefly describe which is the citizens behaviour in a climate neutral city.

PART C - Climate Neutral City - Energy Generation

Imagine that your city it is already Climate Neutral. How it is the energy generation?

Energy Generation refers to the power plants and other energy generators that transform primary energy sources, such as coal, natural gas, wind, or sun, into useable energy.

- 45. Briefly explain city strategy for a climate neutral energy generation.
- 46. Expected percentage of energy generation: ELECTRICITY (the sum must be 100%):
 - a. Centralized (imported):



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- b. Distributed (generated in the city):
 - i. Energy generation for Self-consumption:
 - Energy generation for shared self-consumption (for example, for energy communities):
- 47. Expected percentage of ELECTRICITY generation within the city in the climate neutral scenario per source:

	Solar PV	Wind	Hydroelectric	Fossil	Other
Self- consumption					
Shared self- consumption					

- 48. There is any initiative to compensate CO2 emissions? And if yes, which ones?
- 49. In case in the climate neutral scenario there is still fossil fuel-based electricity, in which sector(s) is consumed?
- Explain the city strategy regarding electricity storage in the climate neutral energy system and expected infrastructure implemented.
- 51. Electricity storage capacity (kWh) when climate neutral
- 52. If the electricity demand it is expected to grow due to the incrementation of electric cars and electric heating/cooling systems, how it is expected to be supplied this growing electricity demand?
- 53. Expected percentage of energy generation when climate neutral: THERMAL:
 - a. District heating:
 - b. Central boilers:
 - c. Individual boilers:
- Expected percentage of THERMAL generation for heating per source when climate neutral (the sum per row must be 100%):

	a)Geothermal	<u>b)Solar</u> thermal	c)Aerothermal	d)Hydrothermal	e <u>)Biomass</u>	f <u>jNatural</u> gas	g)Eossil	<u>h)Others</u> (waste heat)
District heating								
Central boilers								
3.Individual boilers								

- 55. In case in the previous question the percentage of natural gas and/or fossil it is not cero, it is expected to be compensated? And if yes, how?
- 56. In case in the expected climate neutral system there is still fossil fuel-based electricity, in which sector(s) is consumed?
- 57. Expected percentage of buildings with THERMAL generation for cooling when climate neutral:
 - a. Central cooling
 - b. Individual cooling
 - c. None:
- Briefly explain the carbon neutral strategy for Heat recovery from industrial processed and/or other sources. Give numbers when possible.
- 59. Any other energy source for thermal generation? Which one?



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- Explain the city strategy regarding thermal storage in the climate neutral energy system and expected infrastructure implemented.
- 61. Thermal energy storage capacity (kWh):
- 62. Any reflection regarding the digitalisation of the energy generation?
- 63. Due to your experience, which is the main challenge that the city is facing nowadays to achieve the mentioned energy generation of the future and how is dealing with it?
- Other challenges that you want to share regarding energy generation.

Part D - Climate Neutral City - Energy Distribution

Energy distribution refers to the network pipes, powerlines, and vehicles that deliver useable energy from where it is generated to where it is used. For electricity, this includes transmission and distribution.

An expected growing electricity demand in a climate neutral city scenario, needs to ensure the supply and an appropriate distribution network.

- 65. Which kind of actions have been implemented in the Climate Neutral City to ensure the capacity of the electricity distribution network to absorb increasing energy demand (power lines for electricity transmission and distribution)?
- 66. Which kind of actions have been implemented in the Climate Neutral City to modernized and/or reinforce electricity transmission and distribution system to increase distributed energy generation?
- 67. An increasing demand can cause peak loads, which has been the strategy to avoid them? Explain how your city has reinforced the distribution network in the Climate Neutral scenario.
- 68. Does a multidirectional energy delivery exist? How does it work?
- 69. Does a multidirectional "prosumer" model exist? How does it work?
- Explain the Smart metering strategy and Real-time metering strategies to drive energy management in the climate neutral system.
- 71. Explain the thermal network characteristics. Percentage of the city that is supplied by the following networks:
 - a. Third generation (70-80 degrees):
 - b. Fourth generation (50-70 degrees):
 - c. Fifth generation (Below 40 degrees):
- 72. Explain the role that the digitalisation plays in the energy distribution.
- 73. Due to your experience, which is the main challenge that the city is facing nowadays to achieve the mentioned energy distribution of the future and how is dealing with it?
- Other challenges that you want to share regarding energy distribution.

PART E – Other Climate Neutral City information – elements to foster the conversion

75. Briefly explain the city strategy to avoid energy poverty.



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- Briefly explain the city strategy to regarding energy justice.
- 77. Briefly explain how the regulations support the climate neutral scenario.
- Briefly explain the action plans expected to support the energy strategy (SECAP, CCC, adaptation plan etc.)
- 79. Financial resources that facilitated the conversion:
 - a. EU funding
 - b. National and/or regional funding
 - c. Public-private partnership (PPP)
 - d. Private investment
 - Blended finance: financial mechanisms that use public (or philanthropic) funds to attract additional private finance for projects
 - f. City budget
 - g. Other, which one?
- 80. Briefly explain the Business models that facilitate the conversion
- 81. Briefly explain the Digitalisation strategy (if anything to add)
- 82. Briefly explain the Informative campaigns/ education
- 83. Briefly explain the role of the Innovation hubs and/or other mechanism to dynamize the local ecosystem that promotes the climate neutral energy system.
- 84. Questions or comments.
- 85. Other information that you want to provide.

Thank you!

ATELIER WP2 team.





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Annex 2: Impact assessment assumptions

- Primary energy conversion factors for the different used fuels have been issued from Ecoinvent database.
- Emission factors from JRC⁹ and cities inventories have been used for the quantification of cities GHG emissions. On this mater, biomass, biogas, biofuels, and green hydrogen have been considered carbon neutral.
- To estimate future GHG and primary energy impacts derived from the used of electricity from the national grid, NECP and national long-term strategies have been considered.
- Only CAPEX (see Table 11) has been considered to quantify scenario investment costs. On this matter, current prices have been assumed (i.e. no price evolution nor discount rates have been considered).
- Assumed costs in Table 11 represent the relative cost of replacing the current technology by an alternative one. Thus, symbolizing that at the end of life of the different devices and technologies these are not replaced by equivalent but by alternative ones (e.g. envelope renovation vs. not renovation, replace boiler by boiler vs. replace boiler by heat pump, replace diesel car by diesel vs. replace diesel car by e-Vehicles...).
- Regarding vehicles renovation costs, only the price of the vehicle has been considered (i.e. auxiliary infrastructure like charging points is not considered).

Table 11. Estimated CAPEX for each of the considered energy conservation measures (ECM) in cities scenarios.

Measure	Estimated CAPEX	Unit	Sour ce
BILBAO Household renovation (depending on the		€/m2	[1]
building typology and construction period)	143-287		
BRATISLAVA Household renovation (60% saving)	148	€/m2	[1]
BRATISLAVA Household renovation (13% saving)	50	€/m2	[1]
BRATISLAVA Household renovation (30% saving)	82	€/m2	[1]
BUDAPEST Household renovation (BAU: 40% saving)	6,387	€/household	[1]
BUDAPEST Household renovation (MASTER: 60%		€/household	[1]
saving)	10,096		
KRAKOW Household renovation pre 2030 (40% saving)	94	€/m2	[1]
KRAKOW Household renovation post 2030 (60%		€/m2	[1]
saving)	148		
MATOSINHOS Household renovation (BAU: 45%		€/household	[1]
saving)	8,797		
MATOSINHOS Household renovation (MASTER: 50%		€/household	[1]
saving)	10,368		
RIGA Household renovation (BAU: 45% saving)	99	€/m2	[1]
RIGA Household renovation (MASTER: 50% saving)	105	€/m2	[1]
Systems renovation (heat pump vs fossil boiler)	59	€/m2 supplied	[2]
Systems renovation (DH connection vs fossil boiler)	30	€/m2 supplied	[2]

⁹ https://publications.jrc.ec.europa.eu/repository/handle/JRC107518





Systems renovation (biomass boiler vs fossil boiler)	36	€/m2 supplied	[2]
Systems renovation (solar thermal support)	52	€/m2 supplied	[2]
Systems renovation (heat pump vs electric heater)	30	€/m2 supplied	[2]
Systems renovation (heat pump vs DH)	29	€/m2 supplied	[2]
Private tertiary buildings ECMs	125,000	€/saved GWh	[3]
Municipal buildings ECMs	125,000	€/saved GWh	[3]
Industry ECMs	75,000	€/saved GWh	[4]
Agriculture ECMs	75,000	€/saved GWh	[4]
LED lamp post	2,000	€/device	[5]
Car electrification (EV vs fossil-fuelled)	9,014	€/vehicle	[1]
Motorcycle electrification (EV vs fossil-fuelled)	3,426	€/vehicle	[1]
Van electrification (EV vs fossil-fuelled)	9,298	€/vehicle	[1]
Truck electrification (EV vs fossil-fuelled)	120,671	€/vehicle	[1]
Bus electrification (EV vs fossil-fuelled)	150,196	€/vehicle	[1]
Car H ₂ (H ₂ vs fossil-fuelled)	15,338	€/vehicle	[1]
Motorcycle H ₂ (H ₂ vs fossil-fuelled)	0	€/vehicle	[1]
Van H2 (H2 vs fossil-fuelled)	14,366	€/vehicle	[1]
Truck H ₂ (H ₂ vs fossil-fuelled)	114,869	€/vehicle	[1]
Bus H ₂ (H ₂ vs fossil-fuelled)	114,326	€/vehicle	[1]
Rooftop Solar PV	1,240,000	€/MW_elec	[2]
Biomass HOB	470,000	€/MW_heat	[2]
Biomass CHP	1,250,000	€/MW_heat	[2]
Waste HOB	1,850,000	€/MW_heat	[2]
Waste CHP	3,040,000	€/MW_heat	[2]
Geothermal DH	1,340,000	€/MW_heat	[2]

- [1] Eu reference scenario (https://energy.ec.europa.eu/data-and-analysis/energy-modelling/eu-reference-scenario-2020_en)
- [2] Danish Energy Agency Technology Database (https://ens.dk/en/our-services/technology-catalogues)
- [3] EU Energy Efficiency in buildings report (https://op.europa.eu/webpub/eca/special-reports/energy-efficiency-11-2020/en/) (https://op.europa.eu/webpub/eca/special-reports/energy-efficiency-11-2020/en/) (https://op.europa.eu/webpub/eca/special-reports/energy-efficiency-11-2020/en/) (https://op.europa.eu/en/resources-and-tools/publications/data-service-energy-saving-cost-effective-heating-solutions)
- [4] European Commission (https://energy.ec.europa.eu/data-and-analysis/energy-prices-and-costs-europe_en)



Annex 3: Amsterdam

The Amsterdam Climate City Contract

In recent years, Amsterdam has intensified its commitment to combating climate change. For example, in 2019, the city drafted the *Amsterdam Climate Agreement* with input from over 1,000 conversations with people and actors from the city. The *2020 Roadmap for Climate Neutrality 2050* (as reported in D2.6) implements this. Through various channels, such as the platform New Amsterdam Climate, we continuously map and monitor what is happening in the city in terms of sustainability, and what opportunities remain unattended.

Despite many efforts, Amsterdam has a long way to go. The goal of Amsterdam is to reduce emissions to 60% of the 1990 levels by 2030. According to the latest study on the effect of the current national and municipal climate policy in place on Amsterdam by CE Delft (2024), the 2030 emissions will be reduced to 45% relative to the 1990 emissions. In addition, the 2050 climate neutrality goal remain out of reach, with the study estimating 72% emission reduction in 2050. Change and transformation is needed. That means looking for new ways of working but also phasing out unsustainable practices. In September 2023, the council published letter 'Our City of Tomorrow', in which the entire city council of Amsterdam commits to Amsterdam's climate policy. Sustainability is no longer a treated as a separate task, but is the responsibility of the entire municipal organization. We work according to the principle of 'Sustainable, unless'. "Our City of Tomorrow" encompasses the Energy Transition, the transition to a Circular Economy and the transition to a Green and Healthy City.

To support and endorse the city's efforts, the City of Amsterdam has committed itself to the EU Mission (Mission) for 100 Climate-Neutral and Smart Cities by 2030, to accelerate the climate transition. This is done by promoting cooperation between cities, actors within cities and between layers of government. We want to remove barriers to this acceleration, scale up and innovate. As part of the mission, each city must draw up a "Climate City Contract (CCC)" that sets out the commitment, including an action and investment plan, for the mission. The Amsterdam CCC builds upon the 2050 Climate Neutrality Roadmap and the "Our City of Tomorrow" initiative as the relevant local policy context.

The municipality of Amsterdam has an estimated direct influence on 42% of the total emissions (in scope 1 and 2) in Amsterdam. The remaining percentage requires policy from other levels of government and city actors. Cooperation between governments and other actors is therefore a precondition, and is shaped, among other things, by the national cooperation structure (NSS) which includes the Dutch Mission cities along with the ministries of Climate and Green Growth, Housing and Spatial Planning and Infrastructure and Water Management. Through this improved collaboration and bundled innovation and scale-up power, the city aims to accelerate the implementation of our current strategies. In addition, we can also share the lessons we have learned with others, which can help to scale up in other municipalities later. Some of these lessons are reported in this deliverable, see section 4.3.

Climate neutral energy system

Combining measures and actions from the Roadmap Climate Neutral 2050 and the "Our City of Tomorrow" policy package, the action plan in the CCC presents fifteen impact pathways, over four sectors, for the transition to a sustainable energy system. These impact pathways



are summarized below, the specific actions under these impact pathways can be found in Amsterdam's CCC Action Plan.

Built environment

Amsterdam has around 420,000 dwellings and 25,000 buildings. The built environment's share of Amsterdam's total CO₂ emissions is large: 25% or 1,250 ktonnes. Dwellings account for more than 50 percent of CO₂ emissions in the built environment, mainly due to the use of natural gas for heating, cooking and hot water. The rest of the CO₂ emissions come from buildings with a business function (20%), buildings with a social function and other buildings. Of the 442,000 homes in Amsterdam, 30% are owned by residents, 42% by corporations and 28% by private landlords. Home Owner Associations (HOA's) encompass over 56% of dwellings, and Amsterdam has over 21,000 HOAs.

About 3,000 buildings have a social function. The municipality has a role as owner, tenant or subsidy provider of these buildings used in primary education, sports, arts and culture. At hospitals, colleges and universities, the municipality has no formal role. The Built Environment as sector will remain the sector with the largest residual emissions in 2030 and it is difficult to accelerate sustainability in this sector. This intervention is required 'behind the front door', which involves intruding on personal privacy. Every neighbourhood and even every house/household is different, making it difficult to make a big impact here all at once, on top of what is already included in the estimate. The Amsterdam action plan for the built environment encompasses the following action pathways:

1. Accelerating energy-efficient homes and utility buildings

Consumption of electricity and heat must be reduced, to achieve a CO2-neutral built environment by 2050 and ensure that buildings are ready for a natural gas-free city. Energy is a scarce commodity, especially renewable electricity and renewable heat as an alternative to natural gas, while the other advantage is that energy-efficient buildings are often more comfortable and have lower costs for occupants and users. Companies with an eye for energy can reduce their costs as well as contribute to a climate-neutral Amsterdam. Therefore, we are going to ensure that owners of all buildings in the city take measures to reduce energy use.

2. Accelerating expansion and sustainability of heating and cooling networks

For Amsterdam, district heating is not a novelty. The construction of a heat network already started in the 1990s, the council approved the strategy "Towards a city without natural gas" in December 2016 and the Heat Transition Vision in September 2020. However, increasing the share and the sustainability of the city's district heat supply is comprehensive and difficult, as the Court of Auditors concluded back in 2019¹⁰.

According to figures from Liander and Amsterdam Research & Statistics (R&S) (2023), 19% of home in Amsterdam, constructed in 2020 or earlier, are natural gas-free. This totals 109,000 home equivalents. The Amsterdam Climate Neutral 2050 Roadmap sets the goal of a total of 260,000 home equivalents being natural gas-free by 2030, which could substantially reduce the city's CO₂ emissions. For homes, the natural gas-free share is currently at 14%, and for non-residential buildings (such as office buildings), it is at 34%. This means the heat transition is well underway, although much work remains to be done.



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https://publicaties.rekenkamer.amsterdam.nl/verduurzaming-warmtevoorziening-met-warmtenettenonderzoeksrapport/index.html



Electricity

Electricity plays a key role in the transition from fossil to renewable energy. The transition to a natural gas-free city means more electricity is needed to heat our buildings and cooking. Further digitisation and the growth of electric vehicles is leading to a sharp increase in electricity demand. Replacing fossil fuels by using electricity is desirable because we can generate electricity sustainably. Amsterdam is part of a larger electricity system in which every municipality, region and province contributes to maximum sustainable electricity production. We see many opportunities for rooftop PV in Amsterdam. Expanding provincial regulations have made new locations in Amsterdam suitable for generating energy with wind turbines. However, there are also regional decisions which hamper new wind projects in Amsterdam. This has to be balanced to maximize the potential for wind energy in the region. Currently, the generation of electricity used in Amsterdam emits 1,960 ktonnes of CO₂ every year, equal to 39% of total CO₂ emissions of the city. To reduce these emissions, one of our efforts is to incentivize energy efficiency, while the main focus in this sector pertains to maximising renewable energy generation in Amsterdam territory with mature technologies such as solar panels and wind turbines. The Amsterdam action plan for the sector electricity encompasses the following action pathways:

3. Increasing the sustainability of Amsterdam's energy

We believe that, in the future, we will be able to locally produce up to 30 percent of our electricity needs sustainably. Support for solar and wind energy is high among Amsterdam residents. Research by Amsterdam R&S from 2022 shows that 9 in 10 residents are in favour of the switch to renewable energy, with 90% and 86% respectively identifying solar and wind energy as sustainable. In Amsterdam, a lot of roof space is suitable for solar power generation and we aim to ensure that no roof is left unused. In total, there is room for about 1,100 MW of PV panels. We aim for half of Amsterdam's rooftop potential to be utilised by 2030, and by 2040 all suitable roofs should be used for renewable energy generation.

For onshore wind energy, we aim for 52 MW of additional installed capacity on Amsterdam territory by 2030. That results in a total of 127 MW of installed capacity by 2030.

While additional renewable energy generation in Amsterdam helps to reduce the national emission, the overall effect is limited. Emissions in this sector can largely be reduced by focusing on increased efficiency (e.g. LED lighting, heat pumps), energy conservation and barring large consumers.

4. Innovating and expanding towards a smart and flexible power grid

In 2050, the demand for electricity in Amsterdam will be three to four times higher than today, according to scenario studies by TenneT, Liander and the City of Amsterdam (Thematic Study Electricity Amsterdam (TSA) - TSA 1.0 and TSA 2.0). Sustainability plays a role in this, e.g. via: EVs, heat pumps and the production of electricity with solar and wind. In addition, other factors will have greater impact on grid capacity in 2050, namely: the development of data centres, economic development and new construction. This increases the overall demand for electricity and the load on the grid. At the same time, we see that the power grid is reaching its limits in the city. Liander, the DSO, has already announced congestion in several areas within the City of Amsterdam. Sufficient capacity on the grid is a precondition for electrification of current energy demand and thus for a climate-neutral city. The consequences of congestion are profound. It is getting more difficult to connect new building clusters or businesses in



congested zones. The municipality is working with Liander and other stakeholders to create a future-proof power grid that aligns with the energy transition and other municipal ambitions.

Port and Industry

The Amsterdam port area is part of the North Sea Canal Area (NZKG) and is part of the industrial area of provincial importance. This area has two dominant functions: the nautical-logistical function of the seaport and providing space for industrial activity. Activities at the port range from industrial production, goods and fuel storage and transit, urban waste distribution and treatment, to power generation. Energy plays a central role here. For industry in the port area, it is about both consumption and generation of energy, and for the port, its position in global energy trade is of great importance. The opportunity and challenge for the port and the companies located there, is to transform from an energy-intensive to a sustainable industry, and from fossil energy cluster to a leader in renewable energy, heat and alternative fuels for shipping and aviation. How the municipality is shaping this is reflected in the municipal port vision. Industries in Amsterdam emit 920 kilotonnes of CO₂ annually (18% of the total), more than half of which comes from AEB Amsterdam (waste incineration). The Amsterdam action plan for the Port and Industry encompasses the following action pathways:

5. Accelerating industry sustainability: energy efficiency and electrification

Emissions in port and industry can be divided into three categories: 1) industry covered by the European Emissions Trading Scheme (ETS), 2) smaller industry and 3) shipping. The ETS companies get incentives to become more sustainable, especially at European and national level, through the ETS price and the carbon tax. These companies can achieve (limited) emission reductions through energy-saving measures, but to become truly sustainable, energy-intensive production processes ultimately need to be redesigned. Several options exist for this, however the impact on businesses is significant. Some new technologies are still in their infancy, but a lot is also possible with current technologies. High energy prices, in addition to CO₂ prices, are an increasingly strong incentive for industry to become more sustainable.

Grid congestion is an important barrier for electrification of industry and hence emission reduction. Resolving grid congestion is therefore a priority. In addition, the development of other infrastructure is needed, e.g. heat (and steam) infrastructure, hydrogen infrastructure and CO_2 infrastructure.

For smaller industry, there should be a focus on energy saving and sustainable heating for SMEs and industry without energy-intensive processes. This can be done, for example, through the use of heat pumps, which can deliver up to 90% emission reductions through the combined effect of the 3-6 times higher efficiency and the much lower emission factor of electricity compared to that of gas in 2030.

Port and inland navigation are also part of this sector. This requires increasing use of shore power, for which grid congestion can also form a barrier. Ships themselves should also become more sustainable. The availability of refuelling infrastructure and the higher price of, for example, hydrogen compared to marine diesel are currently barriers to making inland navigation more sustainable.

6. Working on the H₂ economy

This includes projects to establish the necessary H₂ (distribution and production) infrastructure in the port of Amsterdam, in addition to the development of local and global consortia to further shape the H₂ supply chains.



7. Working on CCS

This includes working on projects such as CCS for the AEB waste incineration plant. AEB's total emissions (including the biogenic part, but excluding heat generation from the biomass plant) were around 1.5 Mtonnes in 2018. Of this, approximately 520 ktonnes were fossil. Current plans for CCS at the AEB plant amount to 480 ktonnes. Since a maximum of 90% of CO₂ emissions can be captured via CCS in practice, we assume a potential for additional CCS of 650 ktonnes. This would concern mostly biogenic carbon and capture thus leads to negative emissions.

If CCS is realised at AEB, and the distribution infrastructure is in place, it is relatively easy to connect other point sources of CO₂ near AEB to this infrastructure. With a significant effort from Amsterdam, it is possible to realise additional projects before 2030. This is partly about capturing biogenic CO₂, creating negative emissions. Southpole (2022) has identified potential sources of biogenic emissions, where negative emissions can be realised with CCS:

- Cargill: 40 ktonnes of CO₂/year
- Advanced Methanol Amsterdam: 116 ktonnes of CO₂/year
- Bio energy NL
- Waternet: 85 ktonnes of CO₂/year

8. Working on the sustainable energy port

This impact pathways encompasses a variety of actions to transform the Port of Amsterdam towards a hub in the European Energy Transition. Among others Amsterdam will work on: Increasing the flow of alternative fuels and building materials; Growing of renewable energy production capacity; Driving the sustainability of trade chains; Creating development space for new projects, Realising a sustainable nautical and land infrastructure, Working towards clean shipping via e.g. the infrastructure for sustainable ship energy carriers, and Reducing CO₂ emissions in the port area via e.g. Port Emission Reduction Technologies.

9. Working towards a sustainable digital sector

Recalibration of data centre policy will be considered, among others including not honouring new data centre applications for a 75-ktonnes emission reduction. The blocking of ongoing plans and projects are considered as undesirable, however, new establishment conditions can prevent the power of data centres to exceed 670 MW in 2030, which is currently set as the maximum in the establishment decision.

After adoption of the Data Centres zoning plan, Amsterdam will apply a 'no, unless...' policy: new data centres can only be built in Amsterdam if they directly serve an Amsterdam interest and meet new sustainability requirements. The policy applies to new establishments or expansions of more than 5 MW.

Mobility and Logistics

Mobility includes all traffic, including mobile machinery and goods transport by road and rail, but excluding inland shipping. The number of residents and visitors in Amsterdam will grow substantially in the coming years and so will mobility. The main goal is to minimise polluting kilometres and thus reduce CO₂ emissions from mobility in Amsterdam. In doing so, we aim for all traffic within Amsterdam's built-environment to be zero-emission by 2030. Motorised traffic in Amsterdam is responsible for 18% of total CO₂ emissions. Reducing this is a hefty task. Half of emissions from mobility come from traffic on municipal roads. The rest consists of



emissions from recreational boating, ferries and traffic on the highway and provincial roads. On these regional roads we have no influence as a municipality, however, the Amsterdam measures will have a 'radiating effect' on these roads.

A plethora of policy and actions are put into action in the city. With various (mobility) programmes, we are working on the city of tomorrow, this includes among others the programmes Air Quality, Smart Mobility, Urban Logistics and the Bridges and Quay Walls Action Plan. Together with the Transport Region, we are working on the Mobility Investment Agenda, the Urban Public Transport Development Strategy 2020-2030, the Regional Public Transport Future Vision and the regional cycling network, among others. All these developments affect mobility and public space in the city and region. We therefore consider the various measures in conjunction and coordinate their implementation.

10. Optimising public space for pedestrians, cyclists and public transport

Besides this mobility challenge, there are major spatial challenges in the areas of climate (adaptation) and urban conservation, i.e. there are limits to the possibilities of using scarce public space. Choices in mobility and public spaces can and should contribute to equal access for everyone in the city. As a city, we want to make space for pedestrians, cyclists and children playing, and set ourselves the goal of raising the quality of public space and making it greener. The focus is on cars because of their high spatial impact.

11. Facilitating, encouraging and regulating supply and use of shared mobility

Mobility utilized a large proportion of space in the city, while often much of the means of transport stand idle, essentially taking up unnecessary space. We want to free up more space and make smarter use of it. A flexible, robust and universally accessible mobility system is needed to respond to rapid developments. This calls for a mobility transition, shifting to use rather than ownership. Fewer privately owned passenger cars offer opportunities for a cleaner mobility system and more efficient use of space. Shared mobility plays an important role in this, as it is sustainable, flexible and it encourages chain travel. We are committed to facilitating, encouraging and regulating the supply and use of shared mobility.

12. Facilitating and regulating full-fledged charging network

As a city we aim to be a zero-emission city, 100% zero-emission mobility is part of this. Electric transport is needed to achieve this goal. The presence of all electric vehicles and vessels requires a charging network and as a city we are committed to develop a safe, reliable, accessible and affordable charging infrastructure.

13. Making private (passenger) transport more sustainable

The switch to clean passenger transport is a tall order. For example, of the 200,000 passenger vehicles driving daily within the Ring, 3% are now electric. Of the 800 coaches, 1% are electric and of the 50,000 scooters, 5% are electric. Leasing companies, car-sharing companies, the moving sector and the taxi industry are further along in the transition. We support this ambition by focusing, among other things, on geographical restrictions for combustion engine vehicles, and compensation schemes for the transition towards zero-emission mobility.

14. Making public transport more sustainable

We support this ambition by, among other things, replacing current combustion-engine vehicles and vessels. Currently, 7 of the 14 ferries are already hybrids. During 2024, the first



electric ferry will sail from Central Station to IJplein. Between 2024 and 2026, a total of four new zero-emission electric ferries will be commissioned.

15. Making logistics more sustainable

We support this ambition by focusing, among other things, on geographical restrictions on combustion-engine vehicles and vessels, and regulations to support stakeholders in this transition.

New opportunities to accelerate the solutions towards climate neutrality

After conducting interviews with over 30 officials from various parts of the organization, many (new) ideas have come up to accelerate the transition to a climate-neutral Amsterdam. These opportunities are presented in this section. While the opportunities contribute to CO₂ emissions reduction, the benchmarking is not focussed on emissions. The opportunities presented in this section have been selected using the following three criteria:

- The opportunity brings progress in at least two transitions of the three:Energy Transition, Circular Economy, and Green and Healthy City.
- The opportunity supports governance innovation as enabler for transitions.
- Energy and enthusiasm within the organization to seize the opportunity.

Due to these three criteria, these innovative actions can contribute to Amsterdam's journey towards climate neutrality, while also improving living standards in the city, reducing inequalities and fostering a more resilient, future-proof city. This is also the ambition of the "Our City of Tomorrow" policy package, on which the CCC builds upon. Due to the cross-transition nature, the impact on coherence between transitions can be significant, the governance innovation increases the odds that the change is sustainable/permanent, and the energy/enthusiasm of the civil servants makes the buy-in within the organization promising. While the complete process focussed on cross-cutting opportunities, in this paragraph we will focus on the opportunities which mainly target a climate neutral energy system.

Governance innovation

Reflective and visible monitoring

First, sustainability and the climate objectives are increasingly given a prominent place in the municipal budget and accountability, and these need to be subject to reflexive and integral monitoring. By making climate indicators more visible, and linking them to actions and the budget, resources can be allocated more effectively to where they can have the most impact. Research shows that, although indicators are not always direct inputs to policymaking, they provide different kinds of conceptual and political use and influence. Indicators can help to advocate a vision and/or strategy for sustainable development, and indicators can generate indirect influence. In addition to the necessary data for the indicators, time should be spend on aligning them with the policy context and the characteristics of the actors to whom this monitor applies.

Transformative governance

In conclusion, there is a gap between ambition, policy and implementation. For example, we hear from the interviews:





"EVERYTHING has to be overhauled to achieve the objectives" but also "We don't want to do anything new, it's too scary."

There is no shortage of commitment and enthusiasm at the municipality. The civil servants are working very hard to make good policy that does justice to the social challenges and the uncertainty that characterises them. It is crucial to nurture and stimulate the enthusiasm of the officials in all cases. Largely by removing barriers, making it easier to act (beyond policymaking) and creating opportunities for civil servants who are not yet working on sustainability. A transformative municipal government, where decisiveness is paramount and so-called "change agents" are given sufficient space and resources to shape plans, would benefit through out-of-the-box governance arrangements.

Study incoherent policy objectives and measures.

During the CCC process, it has been found that there are policies that seem to contradict. Examples are mainly pertaining to incoherence between national and local policy, and this may hamper the realization of the local ambitions, due to the risk for resistance from actors in the city towards the higher (often more stringent) targets and measures. For instance, the national energy standards for newly build dwellings ("Almost Energy Neutral Buildings" BENG standards with a criteria equivalent to the previous Energy Performance Coefficient (EPC) < 0,4) are lower that the Amsterdam requirements ("Amsterdamse BENG" with EPC < 0,2). Follow-up research can be conducted on the effects of this on policy objectives. Questions that can be investigated include: How do these policies contradict? what are the effects of contradictory policies? What does this mean for whether policy and climate targets are met and the pace at which this is happening? What does this mean for politics and society?

Policy for innovation and innovation for policy

Amsterdam is successful in initiating and researching innovations relevant to the sustainability transitions, however, scaling up and scaling in (adopting) in the organization lags behind the potential. During the discussions, the following was mentioned:

"Amsterdam innovations are more successful outside the city of Amsterdam."

A pilot such as the positive energy district in Amsterdam-Noord, part of the ATELIER project serves as an example. We also see the development of experiments with battery swap stations for electric vehicles and the setting up of sharing platforms for electric cargo bikes that can contribute to making the mobility sector more sustainable, which lack the step towards scaling up. By focusing on short-cyclical interaction between innovation and policy, action can be taken faster and better. It is also important that users and private actors with the ability to invest in these innovations are included in these policy-innovation cycles.

Integrated programming of critical infrastructure

Accelerating the transitions in coherence through hubs

Integrated programming in the electricity grid should make it easier to deal with scarce space. To this end, knowledge and ways of working on this integrated programming are necessary on the local level. What can also contribute in this integrated programming are energy hubs. Energy hubs and decentralised energy grids are already being set up in the city. These hubs stimulate the sharing of energy, a smart way to relieve the congested grid. Smartening the grid is an important pillar that serves as a precondition for sustainability policy in the Netherlands, of which electrification is an important part. For example, the Province of Noord-Holland is



focusing on Smart Energy Hubs and organizations such as Resourcefully are looking for opportunities in Amsterdam East.

Following on from the energy hubs that are high on the political agenda, a need is identified to study the hub function for the width of the sustainability transitions in Amsterdam. All transitions face the challenge of scarce space and need to coordinate and manage supply and demand more effectively. We are introducing this as Amsterhubs: hubs to accelerate sustainability transitions that are designed based on the specific requirements of a particular area. For example, it can be an energy and logistics hub in area X, because the area is characterized by a major role for logistics processes and facilities that are subject to the energy transition and are therefore a source of flexibility. While in area Y it can be a heat and food hub, because the area is characterized by a desire to establish more urban food forests integrated in the buildings and infrastructure locally. It can therefore also function as a source of sustainable heat to a low-temperature heat network and as a buffer for the electricity grid via the flexibly controllable heat pump for heating the urban food forest.

Civil, digital and network infrastructure

Making the other infrastructure in the city, e.g. civil infrastructure, digital infrastructure and network infrastructure, more sustainable also requires an integrated approach. This is necessary because of the interconnectedness of this infrastructure with each other and with the metabolism of the city. A traditional siloed approach results in high costs, challenging plannability and feasibility challenges. These influence not only the sustainability of these infrastructure, but also the reliability and safety.

Analysis of laws and regulations

Existing laws and regulations will have to be reviewed and weighed against the strategic goals of the city. An example is that it is currently not allowed to place charging gutters in the pavement. However, this relatively simple intervention could form a flywheel in the electrification of passenger transport. It is valuable to review these types of laws and regulations and to assess when the means justifies the end.

Circular Energy Systems

There are strong interdependencies between the energy transition and circular transition, and improved coherence yields great potential. If the energy transition is not realized in a circular manner, the transition to a circular economy becomes even more challenging. Amsterdam is successful in rooftop PV and other energy assets such as wind turbines, batteries and charging stations will continue to increase in the coming years. The time is now for proactive policies to responsibly control the material flows associated with these energy assets. This contributes to a circular economy in Amsterdam, where we identify three opportunities that require further research. Firstly, it is about providing lifecycle subsidies on the decentralised energy assets (such as circular PV panels) that proactively stimulate the upcycling/reuse/recycling of sustainable energy assets. Second, it is recommended to stimulate a local/regional refurbished market for the energy assets. This allows energy assets to be circulated locally and regionally for maximum efficiency. Thirdly, it is considered an opportunity to stimulate recycling infrastructure from a regional perspective. The regional perspective increases the market and thus the financial attractiveness of this recycling infrastructure. For each of these opportunities, perspective is seen in the Amsterdam labour market where there is room for new entrepreneurship, within the city but also regionally.



Sport facilities and forest for the sustainability transition

The Sports & Forests department sees great opportunities to function as a flywheel in social innovation. This encompasses informing certain target groups through sports clubs and including them in the sustainability ambitions, or by making canteens and accommodations more sustainable and thereby making Amsterdam residents become more familiar with the sustainability transitions. Additionally, in the development of an energy cluster or hub with sports parks.

Innovative forms of collaboration in the city

Accelerating the set-up of Strategic Sustainability Coalitions and Sustainability Action Coalitions

In Amsterdam Strategic Sustainability Coalitions are being set up to accelerate together with the city, based on cooperation in the city. It is recommended that these coalitions be initiated quickly, but that they be put together carefully, utilizing both the structure of formal and informal collaborations that are already present in the city. In the context of sustainability coalitions, climate tables can also be organised with the city to ensure participation and to collect creative ideas for additional climate actions. Such initiatives can also be used to allow cross-pollination to take place and to further boost ownership by the city.

In addition to the strategic sustainability coalitions, we are convinced that more action-driven coalitions can accelerate Amsterdam's sustainability transitions. We propose to use the CCC action plan as a framework to identify and initiate these action coalitions. Existing sector-specific and cross-sectoral networks and mechanisms such as the city deals can be used for the initiation. Furthermore, we recommend that three elements be included in the action coalitions: a problem owner (property owner, consumer, company), an investor, and an orchestrator.

Two-way communication with the market

By daring to give direction, by being transparent about barriers, difficulties and preconditions and by being willing to help organize more outside one's own organization, by the municipality of Amsterdam, stakeholders can be motivated to think along. Rather than reactively, but proactively welcoming solutions from the market, private parties can contribute to the sustainability transitions faster and more efficiently. It is about working outside-in and inside-out. By further elaborating the ambitions of the private actors in the city and investigating what they need, acceleration can be achieved. In this way, the private sector can be better included and supported in sustainability policy, resulting in a empowered private sector which can increase its role in the energy transition and realize the necessary breakthroughs.

It also applies to the International Innovation Policy in Amsterdam, which can be aligned with the needs of the sustainability policy, for example by actively focusing on attracting entrepreneurs who develop services or products for flexibility on the grid or electrification of heavy transport for construction and logistics. This is an example of working outside-in. But working inside-out is also relevant here, for example exporting innovations and knowledge developed in Amsterdam to the rest of the world.

Climate innovation hub with public-private partnerships

Establish a climate innovation hub where startups, businesses, government, and academia work together on green innovations (technological and social). This hub can provide a home



for the sustainability action coalitions and should focus on developing and scaling breakthrough innovations, such as energy-efficient building materials, next-generation renewable energy solutions, and sustainable urban infrastructure designs. It creates the necessary safe space for trial-and-error and acts as a testing ground to identify and evaluate the innovations on a small scale before rolling them out.

Financing transitions and transitions of financing

Finally, paying more attention to the financing of the sustainability transitions yields great opportunities to accelerate the transitions. This entails the way in which the municipality finances its role in the transition, but also how financial resources that flow through the city can be mobilized towards making the city more sustainable. Part of the latter is to invest more in sustainable financial services and products. With the financial sector in the Zuidas the opportunities for this are enormous.

Sustainable Finance Capital

We identified opportunities to turn Amsterdam into the Sustainable Finance Capital of the world. By acting as a partner for the financial sector in the development of these sustainable financial products and services, concrete steps can be taken. This is a new and innovative way of working with the financial sector. The impact is increased by acting as a launching customer in addition to development.

To accelerate the impact, it is recommended to initiate this collaboration with the mortgage lenders. Based on the Climate Agreement and CSRD, these financial institutions are motivated to reduce the CO₂ emissions of their portfolios, including mortgages and investments in commercial real estate. This means that they are also motivated (to varying degrees) in making the built environment more sustainable. The impact can be increased by setting up cooperation with health insurers, which contributes to the Green and Healthy City. It is also good to mention that many insurers also invest in real estate and therefore have an interest in making the built environment more sustainable.

Scaling up local initiatives

Two initiatives that are identified as promising for helping to mobilize local capital towards local sustainability are the *district investment platform* linked to the integrated design method for public space (WIOOR) and the *ESG hub*. The ESG Hub provides a platform for matching ESG agendas, such that parties can work together towards corresponding ESG objectives. The WIOOR is a concept for a platform to co-create the district of the future and then enter into discussions about financing. A collaboration with the financial institutions offers opportunities to bring these initiatives towards implementation.

Benchmarking of selected solutions

Even though Amsterdam follows their own approach to develop the City Vision, the municipality completed the climate neutral energy system survey. Therefore, it was allowed to develop the benchmarking of selected solutions boards that are presented below.



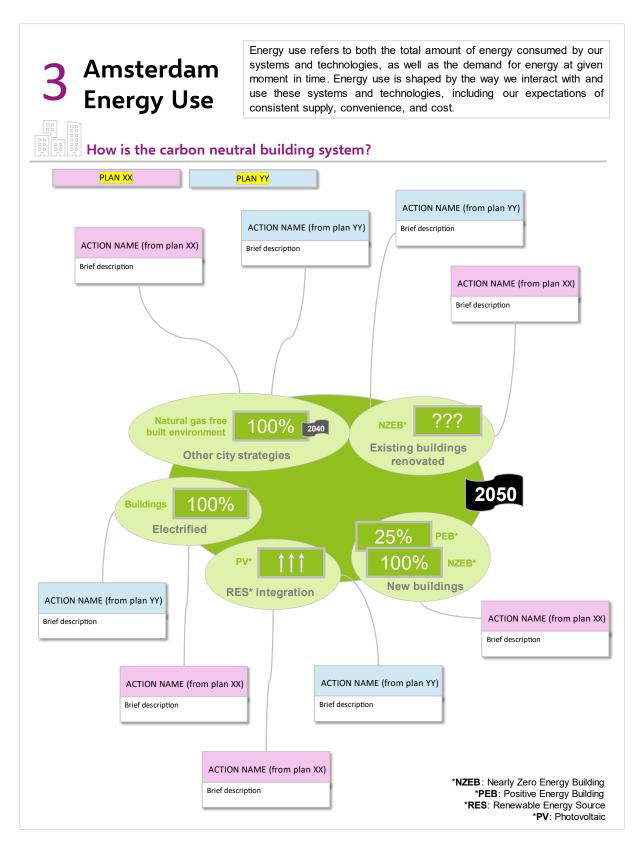


Figure 44. Amsterdam Energy Use Benchmarking board.



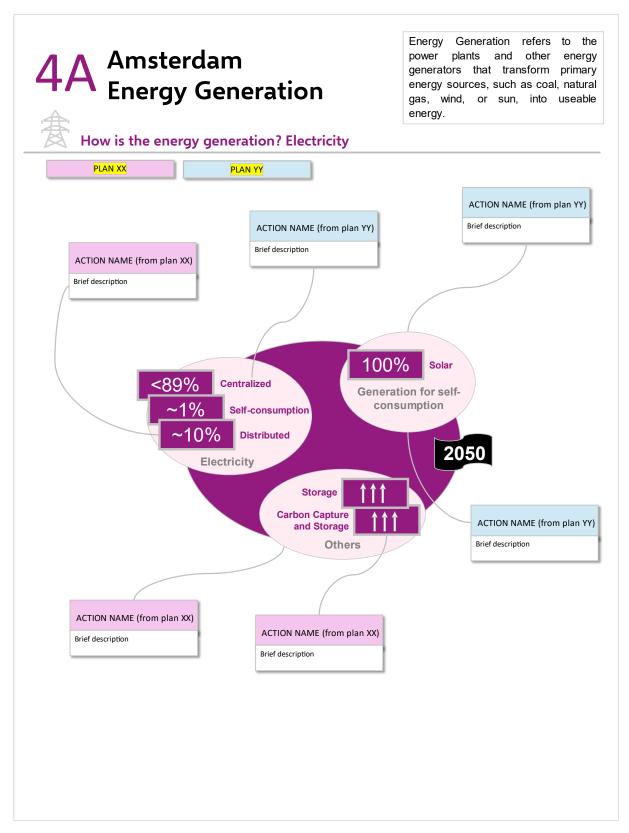


Figure 45. Amsterdam Energy Generation "Electricity" Benchmarking board.



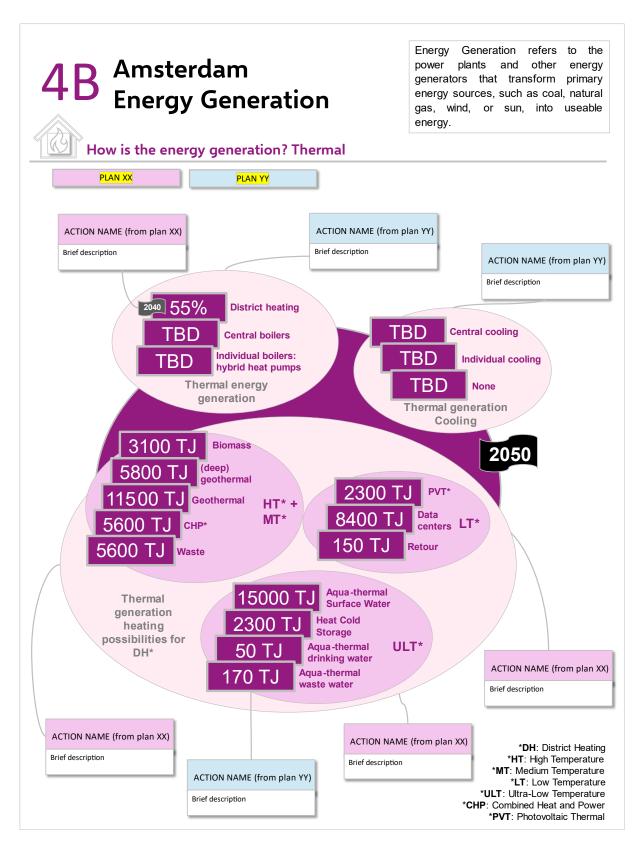


Figure 46. Amsterdam Energy Generation "Thermal" Benchmarking board.



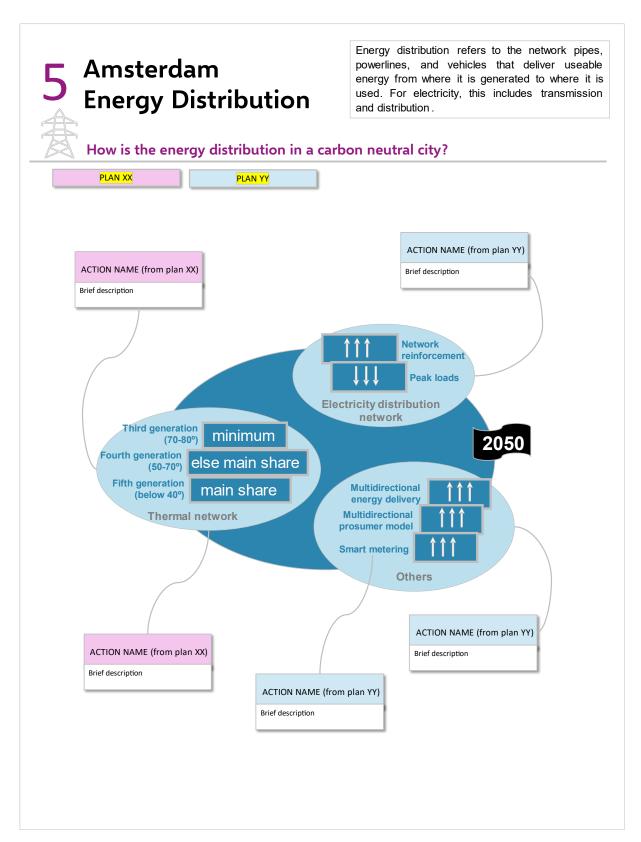


Figure 47. Amsterdam Energy Distribution Benchmarking board.



Annex 4: Bratislava

City vision

The City of Bratislava is guided by a number of policies, strategies, initiatives and regulations at different levels to achieve its climate goals. The following is the main document Bratislava 2030, where the main strategic objectives are described.

Local level policies

Bratislava 2030 (2022)

The strategic development of the city is guided by the Bratislava 2030 – City Development Strategy 2022 – 2030. The document outlines the city's development vision across three key areas: a caring, accessible, and resilient Bratislava. Below is a list of strategic objectives for each area, with climate change-related goals primarily included in the last category.

- Bratislava is a city made for people
- C.1.1 A caring city for a dignified life for all. A city that ensures conditions for a dignified life for all its inhabitants, regardless of their living situation, background, or disadvantage.
- C.1.2 Cooperation as a principle. Bratislava as an open and inclusive city for all, which actively cooperates and involves the public in the planning and running of the city.
 - Bratislava is a healthy, vibrant 15-minute city
- C.2.1 An accessible city. A 15-minute city that offers services, amenities, and access to sustainable transport within walking distance of residences.
- C.2.2 A city that offers quality culture and cohesive neighbourhoods. A city that develops and promotes the unique character of each neighbourhood and a diverse local culture.
- C.2.3 A green and healthy city. The city provides conditions for healthy living and opportunities for recreation, sports and healthy lifestyles through the protection and development of its green and blue infrastructure.
 - Bratislava is a city prepared to face future challenges. It is resilient and self-assured, successfully positioning itself within Central Europe. The city is strategically, professionally, and efficiently managed, with modern institutions and a digital, datadriven, and technical infrastructure that meets future needs. Bratislava is also making significant progress in reducing the impacts of the climate crisis.
- C.3.1 Bratislava, a recognised European metropolis, is a strong metropolis in terms of its economic development and jurisdiction/competences, which benefits from its position as the capital of the Slovak Republic and an internationally renowned metropolis of the Central European region.
- C.3.2 A modern and efficient city. The management and operation of the city is efficient, transparent and fully digitised. It emphasises strategic prioritisation of projects, collaboration, and increasing the satisfaction of city employees. Environmental and social sustainability are important factors in the city's decision-making.



C.3.3 A city ready to face climate change. The city is proactively preparing for climate change through sustainable management of natural resources and waste, reducing its carbon footprint and building its resilience to environmental threats.

The Bratislava 2030 document was transformed into a targeted strategy and project portfolio for the Sustainable Urban Development financial envelope, specifically allocated to Bratislava from the national ESI funds (Integrated Territorial Strategy for the Sustainable Urban Development of Bratislava for 2021 – 2027). This includes an ERDF allocation of 26.99 million EUR for areas such as smart city initiatives, energy efficiency, renewable energy sources, waste management and the circular economy, and blue and green infrastructure. Additionally, there is a 221.891 million EUR allocation from the Cohesion Fund for sustainable transport investments. Actions and projects funded by this envelope are clearly marked in the CCC Action and Investment Plans.

Bratislava Sustainable Energy and Climate Action Plan 2030 (2024)

Adopted in 2024, the Bratislava Sustainable Energy and Climate Action Plan (SECAP) establishes the first comprehensive, science-based framework for the city to reduce greenhouse gas emissions by 55% by 2030, compared to 2005 levels. Serving as the current cornerstone of Bratislava's climate strategy, the SECAP integrates various City initiatives and supports cross-sectoral cooperation to achieve significant emissions reductions and progress toward climate neutrality. It includes 16 strategic priorities and 65 measures, organised according to the GCOM methodology into six sectors: city property, waste management, transport, tertiary sector, residential sector (including energy poverty), and climate change adaptation. Most of these measures have been incorporated into the CCC Action and Investment Plans, focusing on key pathways and levers to facilitate the journey toward climate neutrality.

Bratislava Thermal Energy Development Strategy (in development until 2025)

Decarbonising district heating in Bratislava is crucial for achieving significant GHG emissions reductions, as it accounts for up to 40% of the city's total emissions. The heating sector in Bratislava is fragmented, with several private companies operating in different parts of the city. Therefore, the local heating plan remains a critical tool for the city to regulate this market and support heat decarbonisation.

The current heating plan from 2020 will soon expire and will therefore need to be revised. We will use this opportunity to engage with local suppliers to identify pathways and solutions for long-term greenhouse gas reductions in the heating sector.

The current strategy envisions developing a fourth-generation district heating system and establishing conditions for using renewable energy sources. These options will be further developed in line with the long-term goal of achieving carbon neutrality in the heating sector by 2050, as defined in the European Energy Efficiency Directive 2023/95549, Article 26. By 2030, the intermediate goal is to reduce the emission factor of supplied heat from the current 0.257 tCO₂e/MWh to 0.122 tCO₂e/MWh in 2030 and locally generated electricity from the current 0.477 tCO₂ev/MWh to 0.286 tCO₂ev/MWh in 2030.

Municipal Waste Management Strategy for Bratislava: Transitioning to a Circular Economy (2021 – 2026, update in development)

This strategy aims to transition from a linear to a circular economy by focusing on waste reduction, recycling, and resource recovery. It outlines interim milestones and projects for the



City and its waste management company, OLO, to achieve a minimum 65% sorting and recycling rate/material recovery and treating the remaining waste through energy recovery by 2035. Some of the key projects, such as door to door collection, collection of organic waste or creation of a reuse centre (KOLO) have already been successfully implemented. In the next update to this plan, circular economy will be mainstreamed, with a particular focus on circular construction, which can significantly reduce material waste and GHG emissions.

City Master Plan (in development until 2030)

The City has begun the preparation of the new urban master plan following the enactment of new urban planning legislation in April 2024 to replace the current plan dating back to 2007.

One of the key inputs for the new plan will be the "Bratislava 2050" forecast study. This planning document outlines potential scenarios for urban development and its environmental impacts in the city up to 2050. It considers three possible scenarios based on major climate change projections and other demographic, societal and local trends. The analysis includes considerations of ecosystem service availability, the city's and its residents' vulnerability to climate change, and development potential in different areas of the city.

Through the new master plan, Bratislava aims to achieve a more sustainable and organised urban development, focusing on preventing urban sprawl, creating conditions for the 15-minute city, prioritising public transport and enhancing the quality of green-blue infrastructure. Energy planning has traditionally not been a focus of urban planners, therefore the CCC includes pilot decarbonisation measures in new development areas to test out new regulatory tools or voluntary cooperation with developers. The new legislative framework, mandates that all municipalities, including Bratislava, draft new urban plans that will replace the existing ones by April 2032.

Further relevant strategic documents of the City, e.g. Urban Innovation Strategy - 2022; Urban Housing Policy Concept 2020-2030, had been prepared prior to SECAP and CCC. The processes were initiated and therefore do not take into account the emission reduction or adaptation goals. The City's new commitments will thus need to be reflected in their future iterations.

Regional level policies

Sustainable Urban Mobility Plan of the Bratislava Self-Governing Region (2021)

The current Sustainable Urban Mobility Plan (SUMP) for the Bratislava region was developed by the Bratislava Self-Governing Region and includes the municipalities and districts of Pezinok, Malacky and Senec, thus addressing commuter flows within the region to Bratislava. While the SUMP emphasises sustainable transport and reducing CO₂ emissions, it does not use a specific reduction goal as a basis for planning and monitoring. A revision of SUMP will therefore be required reflecting the increased ambition towards climate neutrality, even more clearly prioritising investments in public transport, active transport, and more effective traffic organisation and regulation over road infrastructure.

The Bratislava metropolitan region is a centre of economic development, with the highest traffic intensities in the country and encompassing several international traffic corridors. Thus, many of the key infrastructure investments proposed by the SUMP are to be implemented by the state, with the key player being the national railway operator, Železnice Slovenskej Republiky (ZSR) and the national highways and road operators, Narodná dialničná spoločnosť and Slovenská správa ciest. Therefore, effective coordination between the city, region, national



transport operators and the Ministry of Transport is crucial. However, this has been challenging in recent years due to largely centralised and often unstable planning amidst changing national administrations.

National level policies

Integrated National Energy and Climate Plan of the Slovak Republic (NECP)

In 2024, Slovakia's Integrated National Energy and Climate Plan (NECP) is scheduled for revision to align with the 'REPowerEU' and 'Fit for 55' packages. Slovakia missed the June 30, 2024, submission deadline to the European Commission (EC) and had not begun the required public consultations by July 2024.

The draft NECP submitted to the EC in 2023 targets a 22.7% reduction in greenhouse gas emissions from non-ETS sectors by 2030. However, the European Commission's assessment revealed that the NECP lacked projections for achieving this reduction, as well as targets for final energy consumption, energy efficiency, and GHG removals in Land Use, Land Use Change and Forestry (LULUCF). Furthermore, the renewable energy target was set at only 23%, whereas the recommended target is 35%. Bratislava's climate goals are more ambitious than national policy and depend on significantly boosting solar energy production and overcoming technical barriers in grid infrastructure, which rely on national-level policy. The gap between national and City-level ambition highlights a challenge that the City of Bratislava has to contend with when setting ambitious but realistic targets.

National Adaptation Strategy

The main national strategy document for adaptation to climate change is the 2018 update of the Adaptation Strategy of the Slovak Republic to Climate Change (National Adaptation Strategy). The strategy is aimed at improving Slovakia's overall preparedness for the adverse effects of climate change, raising public and stakeholder awareness about the issue, and establishing coordination mechanisms to ensure the implementation of adaptation measures and synergies between adaptation and mitigation measures. The strategy takes stock of potential climate change impacts on various environmental systems and proposes key measures for each, including risk and crisis management.

Assessment of current policies and strategies

Engagement with the National Government

Bratislava's SECAP planning and implementation process has identified several barriers to executing the bold and transformative actions necessary to address the climate crisis. One significant barrier is the limited authority and capacity of Slovak cities in the energy and transport sectors, which are primarily governed by the national government. Engagement with the national government is crucial, as municipalities in Slovakia have restricted power to independently implement critical climate mitigation measures, such as enforcing more stringent building codes or altering planning and traffic regulations. Given that cities are directly responsible for only a small portion of GHG emissions from their operations or properties, and lack control over key energy utilities—many of which are privately or state-owned—national collaboration is imperative to achieving large-scale climate action.

Quantification of the Residual emissions





According to the SECAP, Bratislava is on track to achieve a 55% reduction in GHG emissions from 2005 levels by 2030, which represents 38% from 2022 baseline. This science-based target was chosen to demonstrate the City's ambition, while reflecting a realistic approach to climate action. Bratislava's submission of the CCC has the same GHG emission reduction goal as the SECAP, given the City's recent adoption of the SECAP (2024) and the challenges the City contends with, particularly when it comes to dependence on the national government to regulate key GHG-emitting sectors.

As explained, policy that serves as the cornerstone for the CCC Action plan is the City's recently approved SECAP. We used the calculation of the baseline emissions, emissions reduction targets and estimates of the emission reduction of the actions from the SECAP-related methodology in this Action plan and actions portfolio. We expect that the projected policies from SECAP and thus also of this Action plan will reduce the City's emissions by 0.63 MTCO₂e.

It follows that significant residual emissions will remain by 2030, corresponding to 1.04 MTCO₂e. However, the City is committed to reaching carbon neutrality before 2050: for the upcoming update to the SECAP, in 2026, the City will design a stakeholder engagement process to define pathways to neutrality in advance of 2050. In addition to the City's efforts, further reducing the residual emissions before 2050 will require substantial support from the European Union and the national government, as well as close collaboration with local private stakeholders in Bratislava.

2030 Climate Neutrality Action Plan of the City of Bratislava

The Bratislava Climate City Contract (CCC) Action Plan outlines the city's comprehensive strategy to reduce emissions by 55% by 2030 and achieve climate neutrality before 2050. Building on the framework established by the Sustainable Energy and Climate Action Plan (SECAP), this document sets forth key measures across various sectors, including buildings, energy, transportation, waste management, and green infrastructure, to reduce greenhouse gas (GHG) emissions and enhance climate resilience.

The plan focuses on five main areas: municipal assets, municipal waste and wastewater, sustainable transport, private building efficiency, and blue-green infrastructure. Key measures include replacing all public lighting with LED to reduce energy consumption, achieving a 35% reduction in energy use in municipal buildings, and installing renewable energy sources to cover 20% of the energy needs of municipal assets. Additionally, the plan includes upgrading the city's waste-to-energy facility to recover more energy and significantly reduce landfill rates.

In terms of transportation, the plan aims to build and modernize 10 km of tram lines and construct 42 km of bicycle infrastructure. For private buildings, the goal is to reduce energy consumption by 23% in residential buildings and by 38% in tertiary sector buildings. Lastly, the plan includes planting 25,000 trees and shrubs to enhance green infrastructure. The City of Bratislava positions itself as a leader and coordinator of climate action, working closely with public and private sector stakeholders, as well as local communities, to accelerate the transition to a sustainable, low-carbon future. As such, the City is intent on leading by example. The EU Mission for 100 Climate-Neutral and Smart Cities by 2030 (Mission) provides vital support, including access to technical assistance and funding, enabling Bratislava to



implement innovative solutions and share best practices with other Europe on Plan of the City of Bratislava

The Bratislava Climate City Contract (CCC) Action Plan outlines the city's comprehensive strategy to reduce emissions by 55% by 2030 and achieve climate neutrality before 2050. Building on the framework established by the Sustainable Energy and Climate Action Plan (SECAP), this document sets forth key measures across various sectors, including buildings, energy, transportation, waste management, and green infrastructure, to reduce greenhouse gas (GHG) emissions and enhance climate resilience.

These resources will enable Bratislava to refine its climate strategies, implement cutting-edge solutions, and engage citizens and stakeholders more effectively in the transition to climate neutrality. Additionally, the Mission's endorsement through the Mission Label can enhance Bratislava's credibility and attractiveness to public and private investors, ensuring crucial additional sources of funding to accelerate the City's path towards its ambitious climate goals.

Bratislava's Decarbonisation Goal

The decision to join the Mission aligns with the City's key document, Bratislava 2030, which aims to create "an accessible, caring, and resilient city." This vision was embedded into the city's first comprehensive climate plan, the Sustainable Energy and Climate Action Plan (SECAP), adopted in April 2024.

Building on Bratislava's emissions reduction trajectory since 2005, the City committed to achieving a science-based 55% reduction in greenhouse gas (GHG) emissions by 2030 compared to 2005 levels, outlining a series of transformational projects and policies aimed at reducing emissions and adapting the City to the effects of climate change.

Although the 2030 goal remains unchanged, this Climate City Contract (CCC) establishes Bratislava's ambition for climate neutrality, building on the SECAP's goal. While the City's adopted goal is not one of climate neutrality by 2030, our evidence-based target establishes a solid foundation to pursue climate neutrality beyond 2030 and before 2050. By joining the "100 Climate-Neutral and Smart Cities" Mission, Bratislava hard-wires a carbon neutrality ambition into its policy framework, and aims to leverage EU support and collaboration to amplify our existing climate actions and foster innovative solutions.

Prior to 2024, the City's climate action focused on fostering the city's resilience through adaptation measures such as revitalisation of parks and public spaces, prevention of logging in city forests and expansion of blue-green infrastructure. In addition, significant investments into the public transport system have supported sustainable mobility choices among residents. Today, the City has begun implementing the SECAP, with a much stronger focus on reducing GHG emissions through key measures in energy consumption and generation. These measures include enhancing energy efficiency, co-creating a plan to decarbonise Bratislava's heating sector, scaling up renewable energy deployment, and further developing transportation infrastructure to promote sustainable mobility. Importantly, the City positions itself as a coordinator and accelerator of climate action, working to unify all stakeholders in the city.

Administrative Territories and Scope/Geographic Boundary and Exclusions

The City's 2030 target encompasses the entire administrative territory of the City of Bratislava, including all urban districts. This comprehensive coverage ensures that every part of our city is involved in the collective effort to reduce emissions and enhance sustainability.



The 55% reduction by 2030 target excludes industrial emissions, which fall under the European Union Emissions Trading System (ETS).

The GHG inventory for Bratislava is based on the entire administrative territory of the city, encompassing all urban districts. This comprehensive coverage ensures that every part of Bratislava is included in the emission reduction efforts. However, there are specific exclusions for industrial emissions (regulated under the European Union Emissions Trading System), emissions from Industrial Processes and Product Use (IPPU), and emissions from Agriculture, Forestry, and Other Land Use (AFOLU).

The Industrial Processes and Product Use (IPPU) sector in Bratislava faces challenges in GHG quantification. Accurate data collection is complex due to limited expertise and the reluctance of industries to disclose emissions information. The lack of comprehensive IPPU inventories adds to this difficulty. Similarly, the Agriculture, Forestry, and Other Land Use (AFOLU) sector lacks specific GHG emission data. To address these gaps, the City of Bratislava's Climate Office is collaborating with the Slovak Hydrometeorological Institute, which collects data for IPPU and AFOLU emissions. This collaboration will be detailed in the next update to the City's SECAP/CCC. It should also be noted that the City of Bratislava is undertaking several climate actions related to green infrastructure (park redevelopment, tree planting, forest protections) which contribute to emissions reductions in the AFOLU sector.

Descriptive Assessment of Current GHG Inventory

The first emissions inventory was carried out in Bratislava for the year 2005, which is considered the baseline year for all of the City's strategic documents, including the Sustainable Energy and Climate Action Plan (SECAP), developed in 2024.

In 2022, the latest year for which comprehensive data is available, emissions in the city totalled 1.67 million tCO₂e. This represents a reduction of 30.3% compared to 2005, the baseline year of the SECAP. Emissions generated by City operations amount to 183,000 tCO₂e, representing 11% of total emissions in Bratislava.

The GHG inventory for Bratislava from 2022 provides a comprehensive overview of emissions across key sectors predefined by the SECAP methodology developed by the EU Joint Research Centre:

- Energy consumption at the city level (City, City organisations, municipal companies),
- Public lighting,
- Landfilling and wastewater management,
- · Public transport,
- Private and corporate transport on the city's roads,
- Residential sector,
- Tertiary sector.



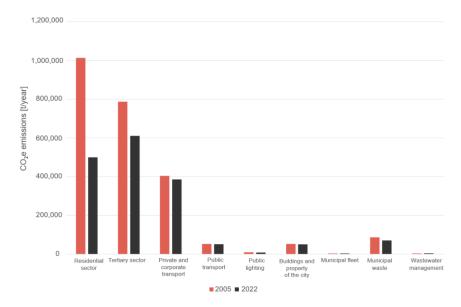


Figure 48. Greenhouse gas emissions change between 2005 and 2022 by sectors.

Relationship with Existing Climate Policies and Strategies

The CCC Action Plan builds on Bratislava's existing climate policy as defined recently in the SECAP, adopted in April 2024. The SECAP sets the science-based goal of a 55% reduction in the City's GHG emissions (compared to 2005 levels) by 2030. The CCC Action Plan, reflects this commitment, and goes beyond it, by reinforcing the City's ambition for carbon neutrality beyond 2030 and by strengthening the overall governance framework including stakeholder engagement and citizen participation.

According to its reporting requirements, the SECAP will be regularly monitored, and a progress report will be submitted every two years to Bratislava's City Council and the Global Covenant of Mayors. As the CCC Action Plan reflects the actions included in the SECAP, it is expected that the two reporting processes will align, ensuring transparency, accountability, and the ability to adapt strategies based on new information and data as well as lessons learned through engagement and participatory processes. With the development of a first progress report two years after the adoption of the SECAP, the City of Bratislava will have gathered more information to develop a science-based carbon neutrality target that matches its ambition and its resources; in this respect, the Mission is instrumental to Bratislava developing a carbon neutrality goal and roadmap in the near future.



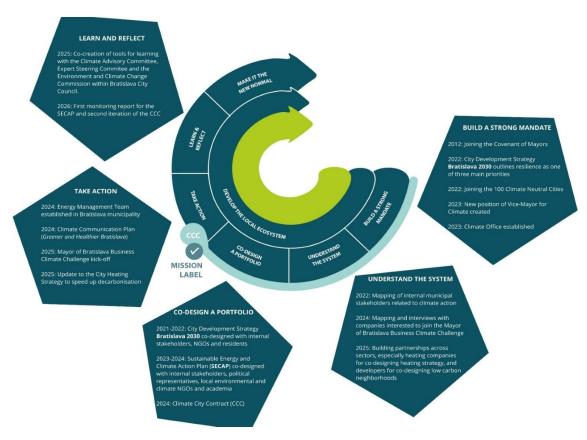


Figure 49. CCC Process in Bratislava.

Master scenario

Based on the energy characterisation of the city performed in D2.6, a Master scenario has been proposed for the city of Bratislava¹¹. This scenario is aligned with the city SECAP for the period 2022-2030, while proposes a carbon neutral path for the city for the 2030-2050 timeframe.

Table 12. Achieved final energy savings in Bratislava Master scenario.

SECTOR	2022 ¹² (GWh)	2030 % reduction compared to 2022	2050 % reduction compared to 2022
Residential	1,844	-22%	-45%
Private tertiary buildings	2,180	-30%	-60%
Municipal buildings	154	-30%	-60%
Street lighting	18	-37%	-37%
Municipal fleet	11	-35%	-70%
Public transport	178	+9%	-35%
Private transport	1,607	-9%	-63%
TOTAL	5,992	-21%	-55%

¹¹ Note that a BAU scenario has not been generated for the city of Bratislava. Bratislava Master scenario is not evaluated and compared with the BaU scenario (as for the rest of the cities) but compared with the baseline year (that could be interpreted as a BaU scenario where every parameter remains constant).



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¹² As new data has been available, base year has been updated from 2017 (in D2.6) to 2022 in this version.



In line with the *Low-Carbon Development Strategy of the Slovak Republic*¹³ the full decarbonisation of the national power grid has been considered by 2050. Similarly, heat supply from local DH is assumed to be carbon-free by the same year. Thus, through the electrification of the end-use sectors, the decarbonisation of the DH network and the implementation of different energy conservation measures, carbon neutrality is reached in the city by 2050.

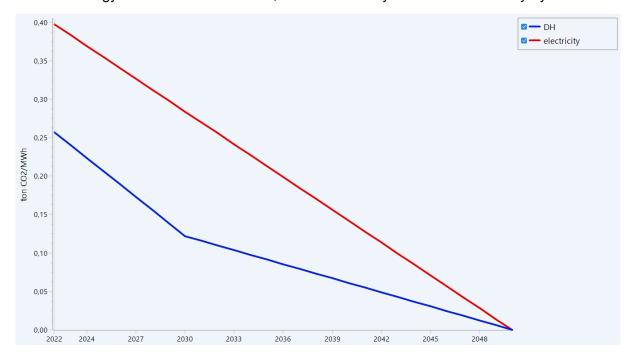


Figure 50. Evolution of electricity and heat supply emission factors in Bratislava Master scenario.

Table 13. Achieved GHG savings in Bratislava Master scenario.

SECTOR	2022 (kton CO ₂)	2030 % reduction compared to 2022	2050 % reduction compared to2022
Residential	498	-45%	-100%
Private tertiary buildings	608	-44%	-100%
Municipal buildings	50	-50%	-100%
Street lighting	7	-55%	-100%
Municipal fleet	3	-33%	-100%
Public transport	50	-25%	-100%
Private transport	384	-9%	-100%
Waste and wastewater management	73	-95%	-95%
TOTAL	1,673	-38%	-100%



¹³ https://ec.europa.eu/clima/sites/lts/lts sk en.pdf



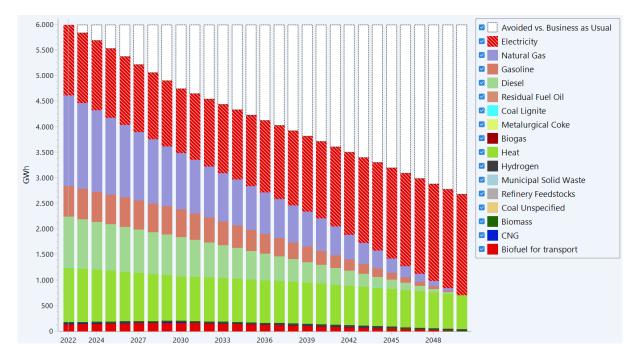


Figure 51. Bratislava final energy consumption by fuel in the Master scenario.

Next sections describe the assumptions and specific sectoral results of the Bratislava Master scenario.

Residential buildings

According to the SECAP, 10% of residential buildings connected to the DH and 50% of all other buildings equipped with individual heating should be renovated by 2030. This makes around 34% of Bratislava residential buildings to be renovated through the 2022-2030 timeframe. The remaining buildings are assumed to be renovated during the next 2030-2050 period. The renovation implies the improvement of buildings envelope, achieving reductions in the energy demand for thermal uses. It should be noted that impact of new buildings is considered to be negligible.

Table 14. Achieved thermal energy savings due to building envelope renovation.

Construction period	Thermal energy savings (%)
Pre 1919	13%
1919-1945	34%
1946-1960	34%
1961-1970	34%
1971-1980	63%
1981-1990	61%
1991-2000	61%
2001-2005	60%
2006-2010	60%
Post 2010	30%



In addition to buildings renovation, it is considered that households renovate their heating systems progressively, switching to less pollutant fuels. Therefore, coal systems are completely removed by 2030, while 30% of households equipped with natural gas boilers replaced them with heat pumps. Remaining natural gas boilers are displaced during the 2030-2050 timeframe, therefore phasing out the use of fossil fuels in the Bratislava residential sector by 2050. Finally, it is assumed that all buildings renovate their lighting and electric appliances by 2030 achieving a 40% reduction in the energy use for these services. Altogether, the combination of energy conservation measures (buildings envelope, heating and electric systems renovation) and the decarbonisation of the heat and power supply achieves a carbon-free residential sector in Bratislava by 2050.

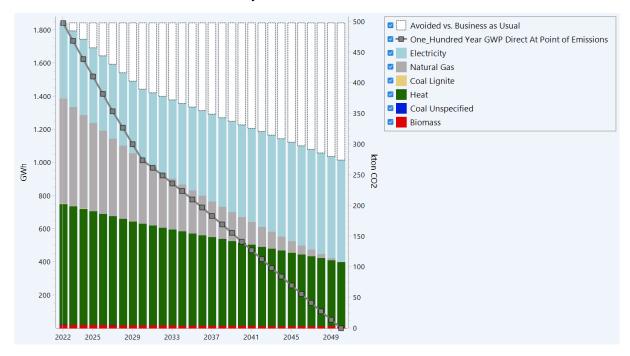


Figure 52. Residential final energy consumption and GHG emissions in Bratislava Master scenario.

Private tertiary buildings

Half of private tertiary buildings in Bratislava are assumed to be renovated by 2030, while the whole stock is fully renovated by 2050. Impact of new buildings and the increase of tertiary activity is considered to be negligible or offset by energy conservation measures. Renovation is assumed to achieve a 60% final energy reduction and includes the improvement of the buildings envelope, lighting and appliances, and heating systems. Indeed, all systems based on fossil fuels are replaced by DH and mostly heat pumps (i.e. electricity) by 2030 with the exception of natural gas which is fully removed by 2050. Considering the decarbonisation of heat and power networks, the private tertiary sector is fully decarbonised by 2050.



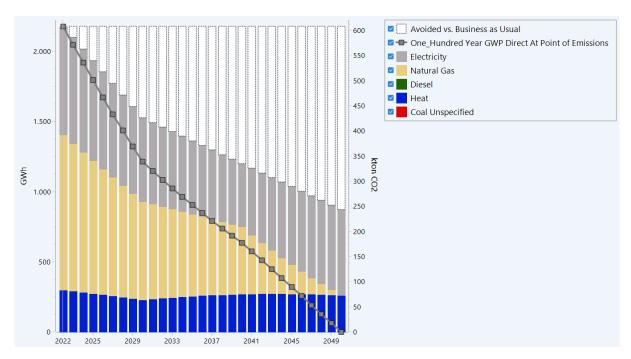


Figure 53. Private tertiary buildings final energy consumption and GHG emissions in Bratislava Master scenario.

Municipal buildings

Similarly to private tertiary buildings, the whole stock of municipal buildings is renovated in two phases: 50% during the 2022-2030 period, achieving the 100% by 2050. No increases in the energy use related to an increase in the demand of municipal services is considered (in any case it is considered offset or negligible). Natural gas boilers for heating are also displaced by DH and heat pumps and completely replaced by 2050, hence achieving a decarbonised stock of municipal buildings by this year.



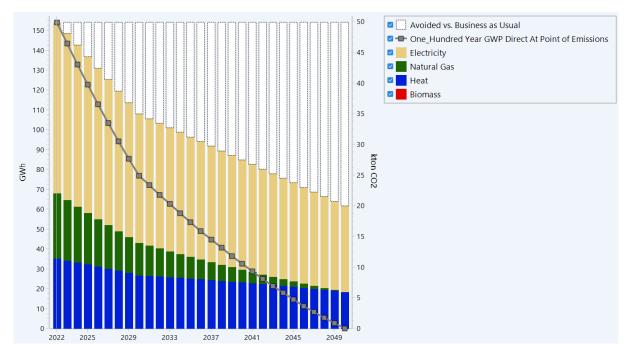


Figure 54. Municipal buildings final energy consumption and GHG emissions in Bratislava Master scenario.

Street lighting

The stock of devices is assumed to remain constant while old street lighting lamps are fully replaced by high efficiency LED lamps by 2030 achieving a total 37% final energy reduction by this year. Thanks to the decarbonisation of the power supply, street lighting is fully decarbonised by 2050.

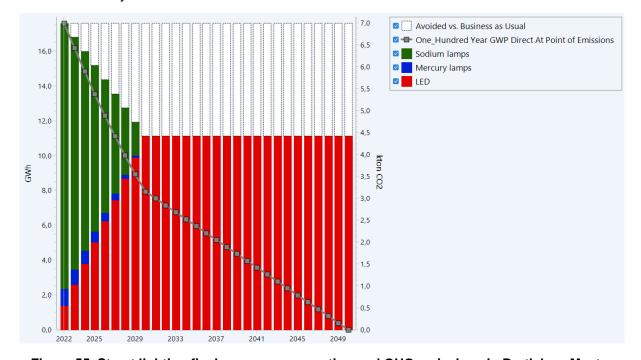


Figure 55. Street lighting final energy consumption and GHG emissions in Bratislava Master scenario.



Municipal fleet

The number of vehicles from the municipal fleet is assumed to remain constant. Existing fossil-fuelled vehicles are progressively replaced by electric vehicles (representing 50% in 2030 and 100% in 2050) achieving the decarbonisation of the fleet by 2050.

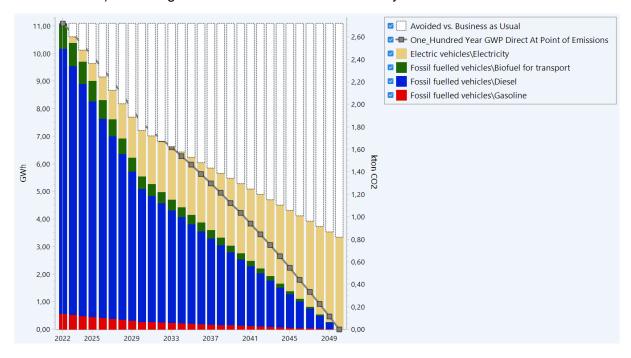


Figure 56. Municipal fleet final energy consumption and GHG emissions in Bratislava Master scenario.

Public transport

Demand for public transport is assumed to increase in the 2022-2030 timeframe and then stabilise until 2050. This results in an initial increase of the consumption for the public transport service demand (especially for the tramways and trolleybuses services derived from the construction of new lines for these means of transport), which is then offset with the further electrification of the bus service until 2050. Indeed, bus fleet is partially decarbonised by 2030 with the introduction of biofuels in diesel and CNG fuelled buses and a small penetration of electric buses, reaching a 50% zero emissions fleet by this year (in line with the city SECAP). Altogether the full decarbonisation of the public transport fleet is achieved by 2050.



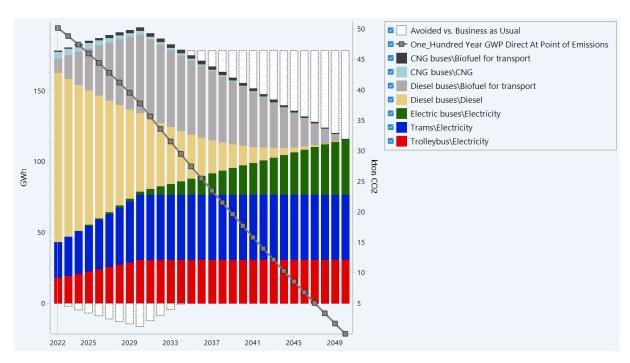


Figure 57. Public transport final energy consumption and GHG emissions in Bratislava Master scenario.

Private transport

Private transport traffic is expected to slightly increase in the 2022-2030 timeframe and then stabilise until 2050. This, however, does not result in a rise in energy use. Conversely, although mobility (slightly) increases, changes in the fuel shares of vehicles towards electric fuelled drivetrains allows to reduce energy consumption and GHG emissions. These are further reduced thereafter until reaching the full decarbonisation of the private transport by 2050, as a result of the development of electromobility and carbon-free electricity supply.

Table 15. Private fleet fuel shares evolution by type of vehicle in Bratislava Master scenario.

Vehicle type	Fuel	2022	2030	2050
Two	Gasoline	100%	70%	0%
wheels	Electric	0%	30%	100%
	Diesel	35%	30%	0%
Coro	Gasoline	63%	58%	0%
Cars	CNG	2%	1%	0%
	Electric	0%	11%	100%
	Diesel	60%	50%	0%
Light utility vehicles	Gasoline	40%	35%	0%
Verlicies	Electricity	0%	15%	100%
	Diesel	100%	71%	0%
Trucks	Electricity	0%	20%	70%
	H ₂	0%	9%	30%



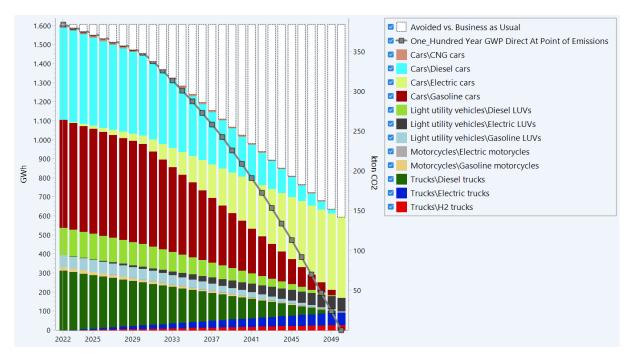


Figure 58. Private transport fleet final energy consumption and GHG emissions in Bratislava Master scenario.

Waste and wastewater management

In line with the city SECAP, impact of these activities is considered to be reduced from 73 to 3 kton CO₂ by 2030. No further changes are assumed thereafter.

Local energy production

In line with the city SECAP, local energy production will increase its rate by 2030 based on the deployment of solar PV and the enlargement of the waste-to-energy CHP plant connected to the DH. These measures contribute to the decarbonisation of the city heat and power supply. No further changes are assumed thereafter.

Table 16. New local energy production (in MWh) in Bratislava Master scenario.

Technology	Sector	2030
	Residential buildings	104,000
Solar PV (electricity)	Private tertiary buildings	26,000
	Municipal buildings	15,500
Wests to operay CHD	Heat produced	53,000
Waste-to-energy CHP	Electricity produced	96,106

Impact assessment of the master scenario

Based on the results of the BaU¹¹ and Master scenarios agreed with the city, the latter achieves an additional cumulative saving of 52,350 GWh of final energy consumption regarding the former through the whole scenario period (2022-2050), in order to fulfil the City Vision set for 2050 by the municipality. The Master scenario also reaches additional cumulative savings of 76,053 GWh and 93,721 GWh of total and non-renewable primary energy respectively compared to the BaU scenario. In the environmental dimension, the quantity of cumulative



emissions additionally abated by the Master scenario regarding the BaU amounts to 24,320 ktonnes CO₂ through the whole scenario period.

Table 17. Bratislava Master scenario energy and environmental indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Savings
Cumulative final energy		173,774	121,424	52,350
	Cumulative total primary energy	301,362	225,310	76,053
Energy	Cumulative non-renewable primary energy	288,432	195,160	93,721
Environmental	Cumulative GHG emissions	46,406	22,086	24,320

The implementation and deployment of the additional measures considered in the Master scenario compared to the BaU require an additional investment of 14,728 M€. In turn, it generates €10,228 M GDP and 130,924 more jobs than the BaU.

Table 18. Bratislava Master scenario socioeconomic indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Additional investment/ Increase in GDP/employment
	CAPEX (M€)	0	14,728	14,728
Socioeconomic	GDP impact (M€)	0	10,228	10,228
	Employment (jobs created)	0	130,924	130,924

Benchmarking of selected solutions

This section includes the benchmarking boards developed for Bratislava according to the information provided to the climate neutral energy system survey. Cities are invited to complete the boards with the information that they consider more relevant to drive the discussion.



2 Bratislava Master scenario





Master scenario impact assessment

Nonrenewable PE*

GWP*

CAPEX

GDP generation

Employment generation

196
MWh saved

/inhabitant

51
tonCO2 eq saved
/inhabitant

31 K€ invested /inhabitant **22**K€ generated /inhabitant

0,275

jobs created /inhabitant

*PE: Primary Energy
*GWP: Global Warming Potential

Figure 59. Bratislava Master Scenario Benchmarking board.



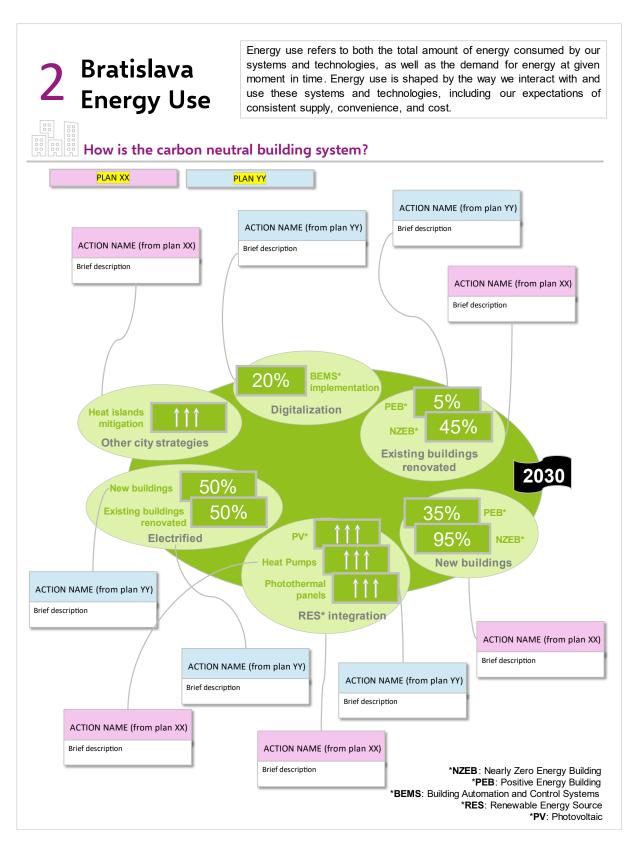


Figure 60. Bratislava Energy Use Benchmarking board.



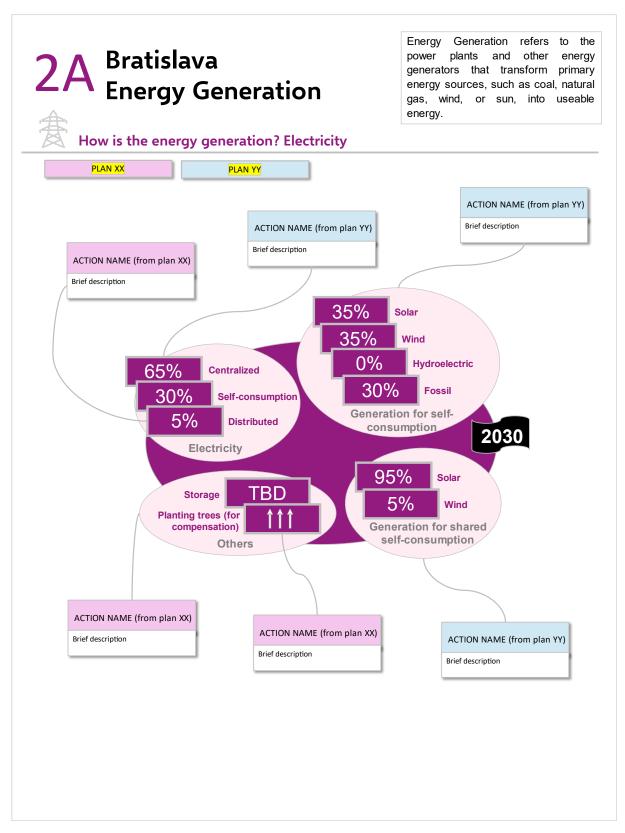


Figure 61. Bratislava Energy Generation "Electricity" Benchmarking board.



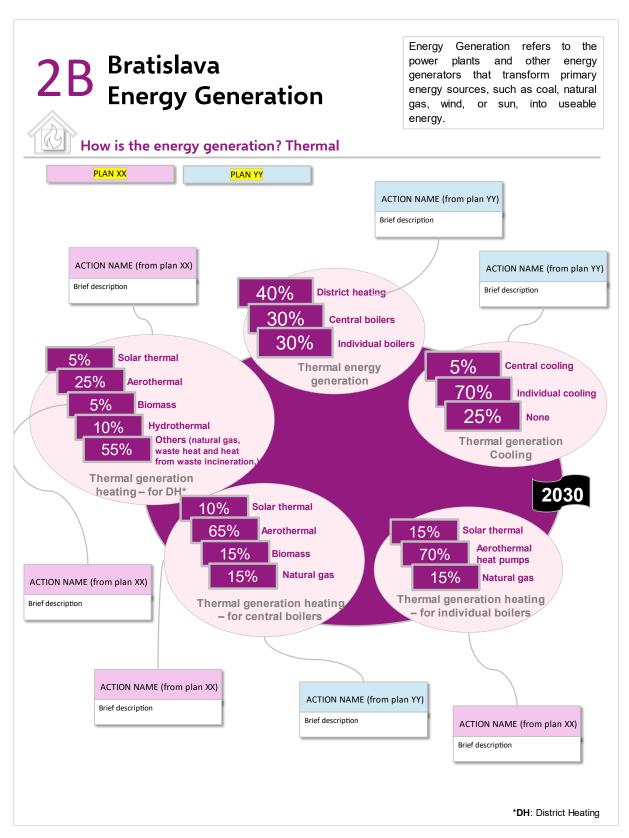


Figure 62. Bratislava Energy Generation "Thermal" Benchmarking board.



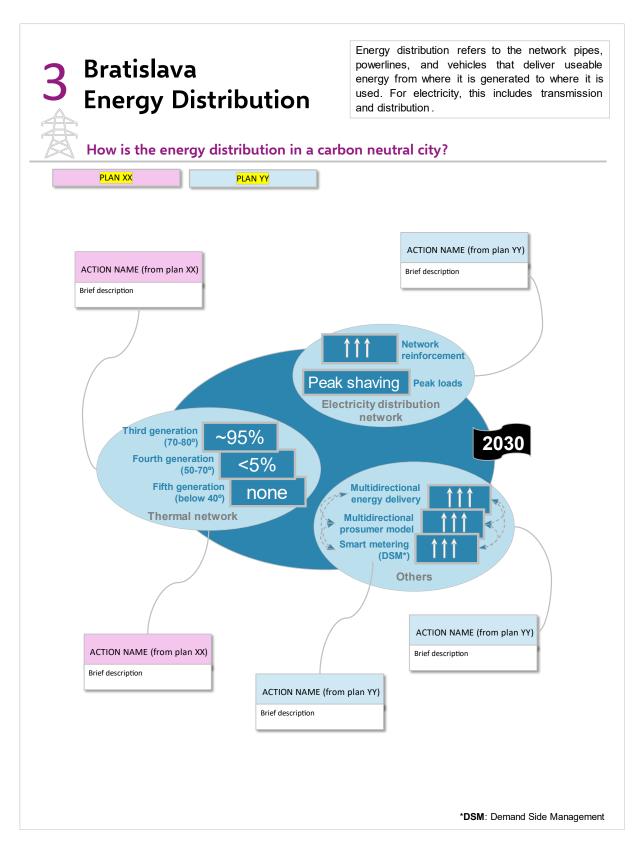


Figure 63. Bratislava Energy Distribution Benchmarking board.



Annex 5: Budapest

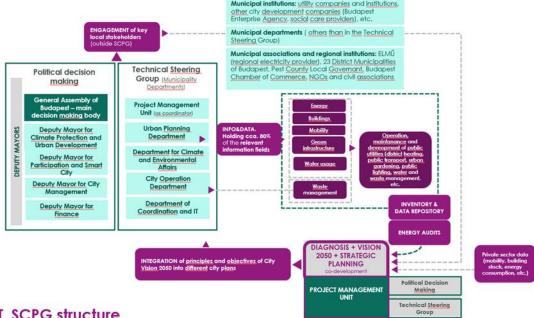
City vision

Process followed for city vision development

The Smart City Planning Group (SCPG) is a versatile and flexible local coordination team established under the Cities4ZERO methodology. Its role is to ensure an appropriate governance structure for the development and execution of a City Vision. The formulation of such an expert group was tasked within the Atelier project. However, since Budapest already had a very similar consortium built, it decided to keep using them, instead of formulating an almost identical group.

The Budapest SCPG is rather an informal group coming from previous works, such as the Climate Strategy or SEAP and SECAP development. The Municipality of Budapest regularly asks citizens' opinions in various surveys, both of a representative nature, as well as informally, via mini questionnaires placed on the website. Both took place when developing the Climate Strategy and SECAP, as well as the Integrated Urban Development Strategy. These serve as a good basis for the city vision creation, since there were specific questions related to the respondents' preferences and future vision of the city.

The SCPG opened in 2020 and is fully operational since then, while being periodically updated. The source of funding for the group comes from municipal and European funds. It consists of well-qualified and experienced professionals from different areas of the municipality, such as mitigation, adaptation, energy, retrofitting, urban and spatial planning, city management dealing with public utility services, public procurers, and project managers. While this group fulfils its roles in the project, it is not fully dedicated to energy transition and decarbonization topic. The following picture shows the Budapest SCPG structure:



BUDAPEST_SCPG structure

Budapest SECAP-2030





The 2021 Budapest SECAP used a very similar methodology to Cities4Zero, and set the goals to be achieved by 2030. For Budapest, SECAP collects the main goals and targets of the City vision. The mandatory revision of the document is in every two years, and this time, with input from ATELIER, we are expanding the goals to be achieved for 2050, and align it with 100 Climate Neutral Cities agreement. The municipality has already formulated a new group in charge of the revision process, and the data collection has already begun. Tecnalia provided input in adjusting the goals from 2030 to 2050, and showcased a scenario where rather than 40% emission reduction, by 2050 Budapest would reach carbon neutrality.

Budapest CCC

Budapest has joined the "100 Climate-Neutral and Smart Cities by 2030" Mission, where it has started to set up the Transition Team, a governance body to achieve the 2030 climate neutrality targets. The Transition Team will be mediated by the Municipality of Budapest and aims to bring together the stakeholders of the net zero targets: companies, NGOs, academia, etc. The result of this joint work will be the City Climate Contract, which will set out the stakeholders' commitments, sector by sector, with the necessary investments and financing needs. Although the document is not legally binding, it will be a strong declaration of intent by the signatories to achieve the objectives. Therefore, we aimed to allign Budapests' city vision with the goals set out in the CCC.

Budapest ASCEND

Budapest joined the HORIZON Europe project called ASCEND, which focuses on Positive Clean Energy District development. The city will build on the knowledge it gained from ATELIER (also Horizon project about positive energy districts) to develop a PCED in the city's 4th district. The role of ATELIER and the vision we set for Budapest within it will be greatly represented through this horizon project. For a while, the two projects will run simultaneously, therefore we are putting extra effort into channelling information gained, into it and vice versa. The PED replication plan will be a very significant document in helping us shape future PEDs and ASCEND in Budapest.

City vision co-development process: methodology applied in the City of Budapest

The development process can be summarized in five steps:

- Foundation of local SCPG Budapest uses the same Climate Platform for various projects, each time with slightly adjusted participants. It's a trusted board of experts who have provided input for many projects before. Therefore, it was much easier to gather them and discuss the issues at hand.
- City information gathering since the city already had a SECAP, the data used there could be applied here as well. Any new data came from the Central Statistical Office
- Strategic City Diagnosis again, a SWOT analysis has already been done for our SECAP, which was used and expanded by the core Atelier team, so that it focuses on the 2050 energy city vision.
- Strategic planning Possible narratives were drawn up with the help of Tecnalia, aiming at achieving the 2040 vision goals. Finally, we have agreed upon a Master Scenario, which incorporates SECAP until 2030, and presumes a carbon free future by 2050.
- Plan the final goal is to have a revised SECAP 2030 with possible aims for 2050





We faced and will continue to face barriers to this process. Due to a volatile environment, we must deal with new challenges and changing circumstances regularly. There is also a general lack of data. We would need continuous monitoring, new methodologies to measure, reorganize and automize data collection, and find a way for faster data processing procedures. Finally, with missing financial and state support, we will face difficulties with the implementation of the results.

We have identified three main facilitators to this development process. First, the stakeholder's involvement, which helped us to grasp the local knowledge and approach of the topic experts. Secondly, municipal commitment, which provided us a supportive environment to deliver effective action plan on a long term. Finally, the committed leadership of the city, because to achieve such ambitious goals, it requires political will and appropriate city governance.

City Vision

In Budapest, the municipality already has a SECAP 2030, which they intend to extend to a SECAP 2050 through the co-generation of the Budapest Vision 2050. This approach is unique among ATELIER cities, extending the strategic planning approach of SECAPs from 2030 to 2050. According to our currently active SECAP, the city planned to have reduced emissions by 40% until 2030. However, in 2023, Budapest joined the "100 Climate-Neutral and Smart Cities by 2030" Mission, by which the city intends to achieve climate neutrality by 2030. The CCC is emphatically not a legally binding, but a political document. First and foremost, it is the revelation of political intent and commitment. The selected cities are primarily experimental and innovation centres, where solutions for urban decarbonization efforts are sought in a holistic approach. The City of Budapest put the improvement of residential energy efficiency as their primary objective, as this sector is responsible for the largest carbon and airborne dust pollution emission. As an effort to set more ambitious goals and formulate an action plan within the scope of the Atelier project, Budapest is revising the e-mobility points of its SECAP, and aims to set more ambitious goals with more concrete steps and objectives.

In a scenario where we imagine a climate neutral Budapest:

- Majority of both renovated and new households will be powered by district heating, electricity, and renewables.
- 90-100% of newly constructed buildings are Nearly Zero Energy Buildings (NZEBs) and all renovated or retrofitted buildings fulfil with NZEBs requirements in the climate neutral scenario.
- According to Budapest's SECAP goals, 100% of the old building stock will be retrofitted by 2050. Retrofitting must be done through a (nearly) zero CO₂ footprint construction with a primary reuse of existing building parts and use of recycled materials, aside of providing nearly zero energy use. Where major energy loss prevention through façade insulation is not possible (such as heritage environment) using RES and using community energy can provide to reach close to positive energy buildings as well.
- 20% of the city's building stock is new buildings that are 100% electrical, and 70-80% of the building stock is made up of existing buildings that have been electrified in the climate neutral scenario.
- All lightning fittings are changed to LED and energy sufficient appliances, controlled by electrical appliances in smart, digital systems to reduce energy use, at the same time reduction and prevention of unnecessary electricity use will be prioritised.



PVs, DH network and thermal energy are the core of the energy sources utilised within the city.

The currently active SECAP or SUMP does not cover a climate neutral transport scenario. It still needs to be elaborated. The active SECAP of Budapest that calls for a 40% reduction in emissions by 2030 compared to 1990 has a Target "Má-2" which addresses transport. Its summary reads as follows:

"Má-2: Improve the energy efficiency of transport infrastructures and promote and develop environment friendly modes of transport.

The energy use of transport is responsible for about 28% of greenhouse gas emissions in the capital. Therefore, reducing GHG emissions from transport (mitigation) is the second most important overarching objective. This requires changes in all three direct elements of transport - infrastructure, vehicles and people (which cannot be rigidly separated). In general, improvements to achieve a more efficient, compact urban form, the use of local (local) facilities and services, and the use of telecommunications in travel planning can effectively reduce mobility demand. Preference is given to increasing the share of public transport, cycling and walking, encouraging the use of electric and other low or zero emission (pure electric) vehicles and micro-mobility, which can be promoted by implementing emission-reducing traffic regulations and designating climate protection zones. This will require the provision of financial support for the development of infrastructure (e.g. bicycle network, P+R and B+R parking) and the targeted renewal of public transport (including taxi services) and the municipal vehicle fleet. In addition, traffic management measures (e.g. entry restriction schemes, designation of low emission zones) are needed, together with public awareness and support."

The official SECAP revision with extended city vision with possible climate neutral aims for 2050 is still to be done. As a reason, the master scenario developed by Tecnalia represent the detailed city vision values for a climate neutral Budapest vision by 2050.

The role of PED in City Vision

City of Budapest is one of the cities in the "100 Climate-Neutral and Smart European cities" mission initiative. This initiative aims at accelerating the energy transition by supporting 100 cities to achieve climate neutrality already by 2030.

PEDs play a crucial role in the City Vision to accomplish an accelerated urban energy transition and decarbonisation of the city on smaller neighbourhood level. As for urban territories in EU, buildings account for 40% of the total energy consumption [Directive 2010/31/EU], however, annually, only 1.3% of the residential building stock is undergoing a medium-to-deep energy retrofit. Energy efficiency refurbishment of the existing building stock and a green energy transition must be accelerated to utilise renewable energy sources in the neighbourhoods, locally. At the same time, new urban developments are ought to follow PED principles, too, in order to prevent the appearance of new neighbourhoods which do not have a positive energy balance. A wide spread of PED transition throughout the city can offer small scale neighbourhood-level solution to reach climate neutrality through improving energy efficiency, integrating renewable energy, improving energy resiliency and reliability, supporting environmental sustainability, providing economic benefits and a better quality of life to its community through innovation and technology, prioritising mixed land-use, sustainable



transportation in the neighbourhood and forming a local community engagement. PED formation requires important regulatory and policy framework changes which will catalyse further sustainable development.

The PED scenario studied within the ATELIER project for Fehérdűlő area relies on a mixed-use development to leverage collective and inclusive interconnected energy network solution, involving all members of the community, in order to provide affordable renewable energy to the members and even produce possibly an energy surplus that can be further available for surrounding neighbourhood, contributing to the achievement of Budapest's climate goals by 2030.

Thanks to the PED concept development study for Fehérdűlő and the connected workshops with local experts Budapest learned how to develop a Positive Energy District in the city and to learn what are the key constrains and barriers that needs to be overcome in order to achieve and implement a PED in practice, too. The key findings are the following:

- Currently, there are national regulatory limitations for creating energy communities, as the main barriers for true utilisation of PEDs.
- It is important to make the banking sector interested in financing PEDs and also initiating investment platforms to bring additional benefits and enable the investment to become more feasible.
- In addition to legal and economic support, it is necessary to create an Energy Use Strategy or Action Plan.
- Storing energy and supplying energy excess can be one of the main technical issue of PED creation.
- The need to establish an Energy Management organization was articulated.
- It is necessary to define exactly what we mean by energy community, what are the exact roles, and create a new business model to run an EC.

Some further realisations have been acknowledged as well:

- Local governments must take the initiative role.
- The local district authorities could take a role in the designation of possible areas.
- Involvement of local SMEs into the PEDs can become a priority aspect.
- Importance of community civil platform creation.
- Informing and educating users is essential.
- There is a need for community obligation related to EC in PED creation.
- PED should be an OPEN system.

Impact assessment of the master scenario

Based on the results of the BaU and Master scenarios agreed with the city, the latter achieves an additional cumulative saving of 328,063 GWh of final energy consumption regarding the former through the whole scenario period (2015-2050), in order to fulfil the City Vision set for 2050 by the municipality. The Master scenario also reaches additional cumulative savings of 543,475 GWh and 693,664 GWh of total and non-renewable primary energy respectively compared to the BaU scenario. In the environmental dimension, the quantity of cumulative emissions additionally abated by the Master scenario regarding the BaU amounts to 113,071 ktonnes CO_2 through the whole scenario period.



Table 19. Budapest Master scenario energy and environmental indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Savings
	Cumulative final energy	1,056,972	728,908	328,063
F	Cumulative total primary energy	1,831,707	1,288,232	543,475
Energy	Cumulative non-renewable primary energy	1,794,882	1,101,218	693,664
Environmental	Cumulative GHG emissions	235,733	122,661	113,071

The implementation and deployment of the additional measures considered in the Master scenario compared to the BaU require an additional investment of €16,087 M. In turn, it generates €15,068 M GDP and 209,204 more jobs than the BaU.

Table 20. Budapest Master scenario socioeconomic indicators results

Dimension	Indicator	BaU scenario	Master scenario	Additional investment/ Increase in GDP/employment
	CAPEX (M€)	27,477	43,564	16,087
Socioeconomic	GDP impact (M€)	16,665	31,733	15,068
	Employment (jobs created)	199,886	409,090	209,204

Benchmarking of selected solutions

This section includes the benchmarking boards developed for Budapest according to the information provided to the climate neutral energy system survey. Cities are invited to complete the boards with the information that they consider more relevant to drive the discussion.





Nonrenewable PE*

GWP*

CAPEX

GDP generation

Employment generation

394

/inhabitant

64

/inhabitant

y K€ inves

/inhabitant

K€ generated /inhabitant 0,119

jobs created /inhabitant

*PE: Primary Energy
*GWP: Global Warming Potential

Figure 64. Budapest Master Scenario Benchmarking board.



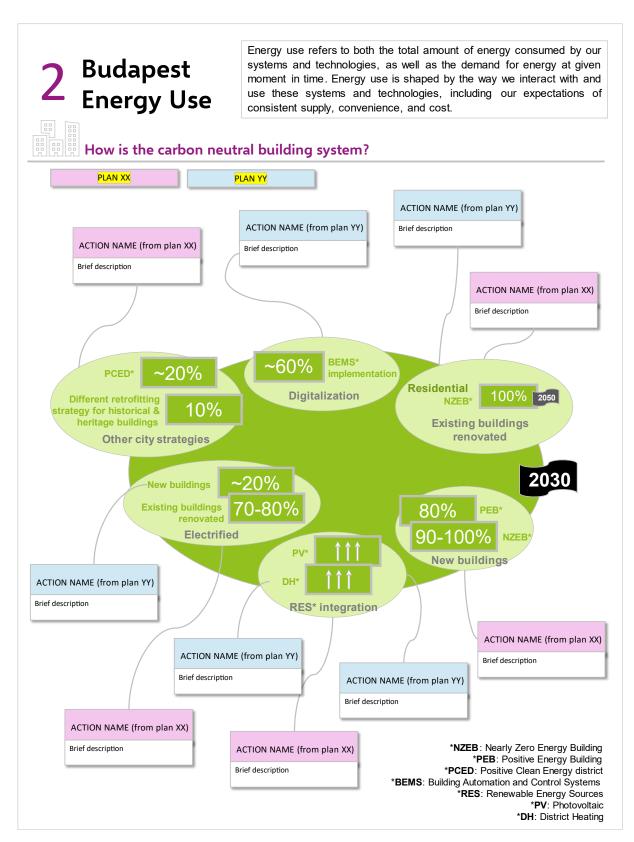


Figure 65. Budapest Energy Use Benchmarking board.



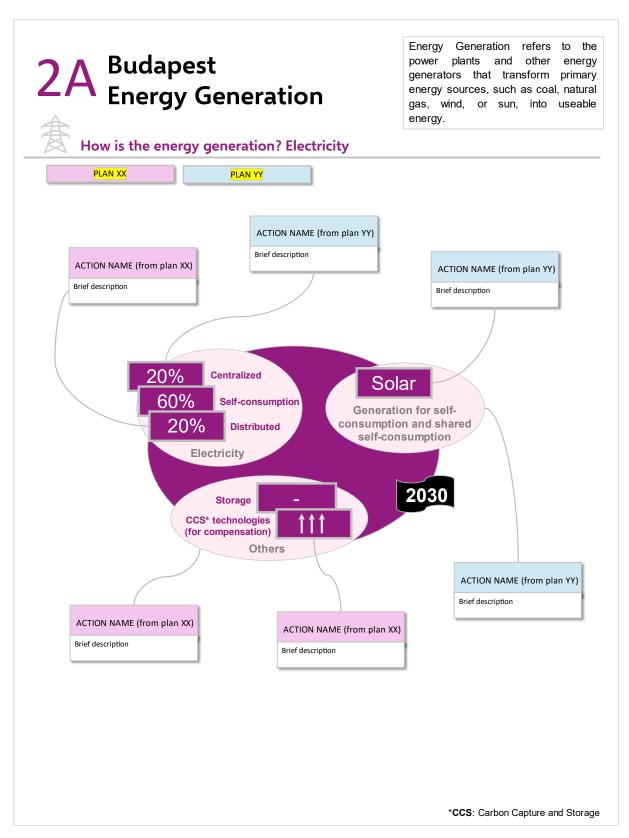


Figure 66. Budapest Energy Generation "Electricity" Benchmarking board.



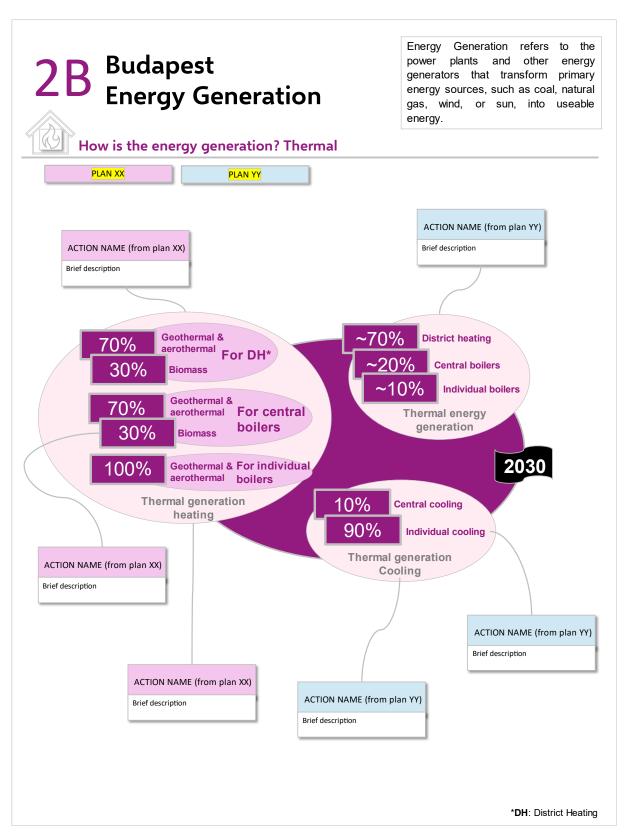


Figure 67. Budapest Energy Generation "Thermal" Benchmarking board.



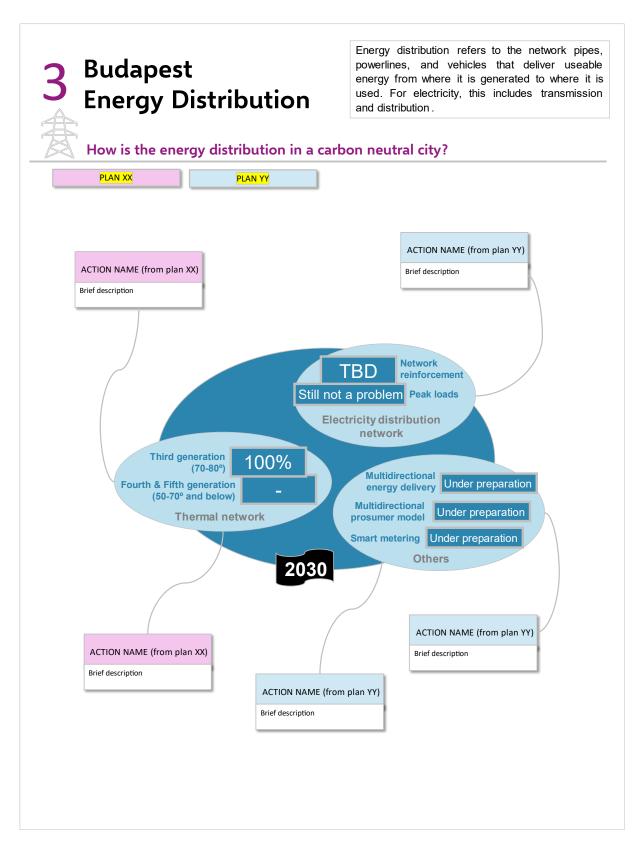


Figure 68. Budapest Energy Distribution Benchmarking board.



Annex 6: Copenhagen

Please note, that the following descriptions have in part been based on excerpt from Copenhagen's draft Climate City Contract.

City vision

The 2021 carbon emission level in Copenhagen was approx. $700,000 \text{ tCO}_2\text{e}$ i.e. $1 \text{ tCO}_2\text{e}$ /capita geographical emissions (and $10 \text{ tCO}_2\text{e}$ /capita related to consumption of goods and services). The main sources of geographical emissions were road transport (353,500 tCO₂e), energy production (182,000 tCO₂e), and non-road machinery (67,000 tCO₂e).

The overall objective of Copenhagen's current Climate Plan 2025, covering the period 2012-2025, was to achieve climate neutrality by 2025. This objective will, however, not be met mainly because mobility related initiatives resulted in less reductions than expected and due to a delay in funding of a planned large-scale CCS facility.

Copenhagen is presently preparing its next climate plan – Climate Strategy 2035 – covering the period 2026-2035.

The city vision for 2035 is to reach carbon positivity by 2035 and includes scope 1,2, and 3 emissions. In addition, the ambition is to realise a 50% reduction in citizen resource consumption and public purchases (see Figure 69).

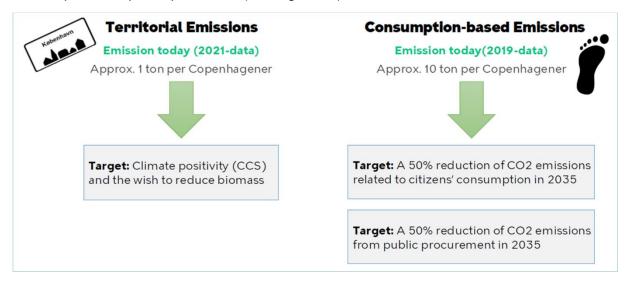


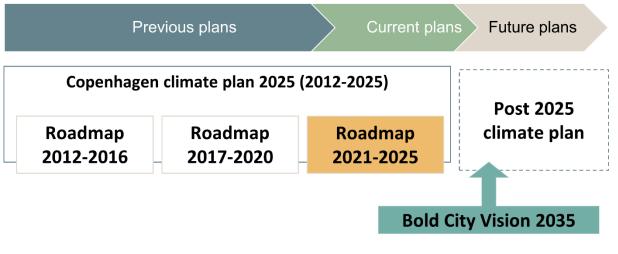
Figure 69. Copenhagen's carbon reduction ambitions for 2035.

Since the work on the new climate strategy is not yet completed, facts relating to the current climate plan are in some of the sections presented instead.

Climate neutral energy system

Some of the existing carbon reduction initiatives launched under the auspices of Climate Plan 2025 will continue beyond 2025, but also new initiatives will be developed and added. These new initiatives are yet to be developed.





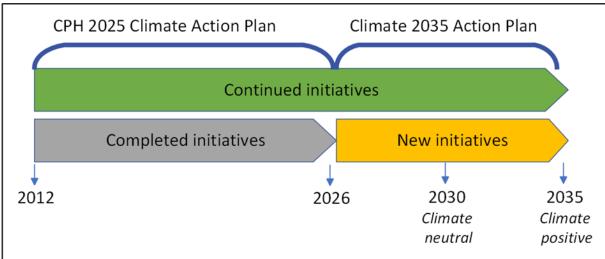


Figure 70. A sketch of Copenhagen's climate action plans, duration, and key targets. The CPH 2025 Climate Plan will be followed by a new plan currently being developed.

The current portfolio of ongoing initiatives is part of the CPH 2025 Climate Plan and further outlined in the 2021-2025 Climate Roadmap. These activities are briefly described below. Furthermore, a provisional sketch of considered key future initiatives for the period after 2025 is given.

CPH Climate Plan 2025 initiatives

The Technical and Environmental Administration manages a portfolio of more than sixty initiatives under the CPH 2025 Climate Plan umbrella. The estimated impact of the portfolio is equal to an almost 80% reduction of Copenhagen's 2025 CO₂ emissions compared to the 2010 baseline. The activities are group in four categories, namely energy consumption (18 initiatives), energy production (15 initiatives), mobility (13 initiatives), and the City of Copenhagen's administration (16 initiatives).

In Table 21 below an overview of ongoing initiatives in the 2025 portfolio is given.

Table 21. Overview of the portfolio of initiatives under the CPH Climate Plan 2025.

Themes	Initiatives
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	T	
Reducing energy consumption	 Energy efficient buildings. Renovation of existing buildings. Proliferation of photovoltaic solar panels. Sustainable public procurement. Intelligent energy control. 	 Funds for energy screening, Energy efficiency improvement through data, Efficient operation of district heating in single-family houses, 'Energy optimization of 500 E, F and G energy rated buildings, Life Cycle Assessments in the public housing sector, Funds for energy efficiency projects in district refurbishment projects, LED street lighting
Fostering green mobility	 Road traffic. Public transportation. Ship traffic. Construction machines. 	 100% zero-emission busses in 2025 (including harbour buses), Reduce carbon emissions from road traffic by 10,000 tonnes*, Shore-side power for cruise ships, Conversion of non-road machinery used in the city to low emissions fuels.
Building a green energy system	 CO₂ neutral district heating. CO₂ neutral power generation. Separation of plastic waste. 	 Continued securing of sustainable biomass, Reduction in the need for peak load production, Renewable energy-based town gas system, Development of district cooling, Afforestation on water catchment areas, Carbon neutral wastewater treatment, Wind power expansion, Establishment of a waste sorting plant (Dirty MRF), Increased waste sorting in households and retail.
Carbon capture activities	Carbon capture & storage.Tree planting.	 Establishment of a carbon capture facility at ARC (on hold due to lack of sufficient funding). Planting of 100,000 trees within Copenhagen.
Cross-cutting activities	 Energy Leap partnership. Awareness raising & education. Climate Task Force. 	 The Climate Task Force aims to help four vulnerable urban areas get started with the green transition through dialogue and networking, Energy Leap partnership focuses on energy savings in buildings and represents currently almost 40% of the building stock in Copenhagen, The Climate Ambassador Study Programme (education of secondary school children). The Energy & Water Science Centre of Copenhagen is an innovative and experimental environmental school, which offers teaching courses within the themes of sustainable energy and water supply in the past, present and future.



Looking towards CPH Climate Plan 2035

A provisional list of initiatives under consideration for inclusion in the CPH Climate Plan 2035 is presented below. The list includes the following themes:

- Reducing energy consumption,
- Fostering green mobility,
- Building a green energy system,
- · Carbon capture activities, and
- Cross-cutting activities.

The final set of initiatives and their implementation schedules are subject to available funding and approval by the City Council and municipality-owned companies.

Reducing energy consumption

The main goal is to further reduce energy consumption in public and private buildings through the application of new technology, information, and knowledge sharing, and by actively cooperating with energy utility companies, property owners, residents, property managers etc. to find efficient and affordable energy reduction solutions.

The City of Copenhagen owns approximately five percent of the building stock in Copenhagen and will continue to reduce energy consumption in existing buildings and to build in accordance with the city's climate and circular economy strategies. Proven activities such as energy efficient operation of buildings, innovative renovation, integrated urban renewal, and the Climate Task Force may therefore be important components of the Climate Plan 2035 and could continue to serve as demonstration and role models for other building owners.

The Energy Leap Partnership, which has turned out to be a successful outcome of the CHP 2025 Climate Action plan, will be continued and strengthened in the Climate Action 2035 plan. The Partnership has demonstrated the value of creating a forum where public and private building owners can develop common objectives, coordinate, and exchange ideas and results.

The Climate Plan 2035 will also include initiatives focusing on enabling residents, individually or jointly, to make climate friendly decisions as regards energy consumption. There is a clear need for finding ways to establish a fruitful dialogue with residents and make energy reduction guidance and information available to non-professionals, probably in cooperation with both utility companies and property managers.

Most buildings in Copenhagen are heated via the district heating system and will need to adapt to the planned introduction of low temperature district heating. This calls for smart digital solutions to optimise the operation of district heating substations and radiators in buildings with the ambition to make the building stock a flexible component of the energy system and in some cases also insulation of buildings.

In this regard, the City of Copenhagen leads the NetZeroCity Pilot City project Flexumers4Future. From primo May 2024 to ultimo April 2026 Flexumers4Forture will focus on contributing significantly to sustainable urban solutions while building on and supporting the goals of the Energy Leap partnership.

Flexumers4Future focuses on how flexible district heating will decrease CO₂ emissions and provide essential knowledge and systemic tools that can be replicated across other energy



sectors, enhancing district cooling and electrical systems. The goal is to implement and test multidisciplinary and cross-sector cooperation, merging diverse expertise from various city administrations as well as external stakeholders including the project partner, HOFOR.

District heating in Copenhagen is almost entirely based on renewable resources — one exception being the oil-based peak load capacity needed during heat demand peaks. Specifically, Flexumers4Future intends to implement flexible heating in 1,000 multi-family buildings including: 300 municipally owned buildings; 400 'professionally run' private buildings enrolled through the Energy Leap partnership that encompasses some of the largest building administrators in Denmark; and 300 'non-professionally run' buildings including private and social cooperative housing associations.

The assumption is that 1,000 flexible buildings will lower the need for using oil-based peak load capacity. The Flexumers4Future project aims to verify this assumption and to develop a business concept that permits activating this flexibility.

Fostering green mobility

Looking toward the year 2030, the City of Copenhagen envisions a shift in its mobility sector. Central to this vision are two key objectives:

- 1. Elevating the use of green transportation modes, including public transport, cycling, and walking; and
- 2. Diminishing the fossil mobility within the city.

To promote green transportation modes, Copenhagen will focus on enhancing the cycling and pedestrian infrastructure as well as pass-ability. This may entail enhancements to the existing trans-municipal bicycle path network.

Furthermore, the City of Copenhagen aims to improve transportation junctions to facilitate transitions between different modes of transportation, thereby fostering a more cohesive mobility infrastructure. In line with a cohesive mobility infrastructure, the City of Copenhagen aims to make a concerted effort to improve public transport within Copenhagen, presumably with a particular focus on increasing the pass-ability of city buses.

In its effort to diminish fossil mobility, Copenhagen will explore strategies to reduce the fossil vehicles driving in the city. First, the city aims to develop a comprehensive strategy to ensure widespread access to charging stations, supporting an increasing number of electric vehicles. Second, the city will examine opportunities to bolster car-sharing initiatives with the aim of expanding its availability and usage.

Building a green energy system

Introduction of new components in the district heating system. Heat pumps, electrical boilers, and energy storage solutions are identified as the technically most viable solutions allowing the required reduction of biomass and replacement of fossil fuel-based peak load installations.

These new facilities must be located where there are suitable heat sources such as wastewater and seawater. The facilities must fit the surrounding environment, e.g., vis-à-vis noise, aesthetics, and urban life and be close to both the electricity and district heating networks. Efforts are being made to integrate these facilities into the city's functions and urban spaces, and to ensure that they become sufficiently attractive for the owners and acceptable for the users of the identified areas. The utility companies and the City of Copenhagen work together



to realise the establishment of these facilities through sharing of goals and coordinated planning.

The City of Copenhagen will proactively facilitate the coordination between neighbouring municipalities, electricity grid companies, heating companies, urban planners (Financial Administration), local planners (Technical and Environmental Administration) and landowners to ensure a medium/long-term alignment of expectations and plans. This could be achieved through setting up a coordination forum.

Extraordinary heat demand is typically met with use of fossil fuel-based peak load production. Other solutions should be explored such as using energy optimized buildings more actively as an integrated part of the energy system, and the use of heat storage and electricity-driven peak load production like electric boilers.

About ten new heat pumps are planned in different places of the city. The two largest heat pumps in Nordhavn and at Lynetten wastewater treatment plant, will together have a production capacity of 170-200 MW – corresponding to approx. 18% of the district heating consumption in Copenhagen.

Three medium-sized heat pump projects will together be able to deliver approx. 70 MW. Together, all the new heat pumps will create a capacity of up to 300 MW of heat.

In the current CHP Climate Plan 2025, HOFOR has a target of 560 MW of wind and solar PV. However, current planning suggests that 370 MW will be established by 2025. The current plan is to install wind farms at Nordre Flint and Aflandshage east of Copenhagen with a total capacity of 460 MW. The two proposed wind farms will supply up to 460,000 households with green power. One of the wind farms, Nordre Flint, is located approximately 12 km east of Copenhagen and is expected to have an output of up to 160 MW. The second park, Aflandshage, is located approximately 10 km from the southern tip of Amager and is expected to have an output of up to 300 MW.

Energinet is responsible for supply of electricity towards Copenhagen. The largest planned expansion towards 2030 is Bellahøj-Ejby, which will provide an additional approx. 180 MW capacity. With this expansion, the capacity towards the city will be approx. 840 MW with a short-term peak capacity of 1,300-1,400 MW.

Radius-Cerius plans to invest in an expansion of the electricity distribution grid capacity within Copenhagen towards 2030.

Carbon capture activities

Reaching climate neutrality by 2030 will require investment in carbon capture capacity,

ARC is working towards making the waste-to-energy plant Amager Bakke carbon neutral. With a full-scale plant for carbon capture, Amager Bakke will be capable of capturing 500,000 tonnes of CO_2 annually.

HOFOR owns Denmark's biggest emitter of biogenic CO₂ (Amagerværket). A CCS facility is estimated to capture up to 900,000 tonnes of CO₂ annually.

The City of Copenhagen will continue to plant more trees in the city.

Cross-cutting activities





Awareness raising activities, efficient coordination and monitoring, information exchange, and strong involvement of citizens and stakeholders will be essential for the successful implementation of Copenhagen's Climate Action 2035 plan. These elements should therefore constitute part of the field of actions and underlying initiatives. Several initiatives are under consideration include those already actively pursued under the current plan:

- The Technical and Environmental Administration aims to ensure close cooperation and coordination of climate actions and related activities across the City of Copenhagen administrations involved in climate actions and urban development,
- The Energy Leap partnership focuses on energy savings in buildings and represents currently almost 40% of the building stock in Copenhagen,
- The Climate Ambassador Study Programme (education of secondary school children).
- The Energy & Water Science Centre of Copenhagen is an innovative and experimental environmental school, which offers teaching courses within the themes of sustainable energy and water supply in the past, present and future.

Benchmarking of selected solutions

A progress report is for all ongoing initiatives is prepared on a six-monthly basis and presented to the Technical and Environmental Committee. A detailed CO₂ inventory for all sectors is produced annually including an overview of the sub-targets' status. The progress is analysed in detail by the Technical and Environmental Administration's Climate Secretariat and the initiatives' content and goals are adapted accordingly. Furthermore, the consolidated progress analysis serves as basis for the development of the Climate Action 2035 plan.

Three road maps have been developed under the CPH 2025 Climate Plan – each covering a five-year period. Prior to the elaboration of each roadmap, the completeness and adequacy of the sub-targets were evaluated and amended if relevant. The sub-targets listed in Table 22, Table 23 and Table 24 are thus those specified in relation to the third roadmap (covering the period 2021-2025). Year 2010 is the baseline year against which the targets are being assessed.

The monitoring methodology, indicators, and the targets for 2035 are currently being discussed. Once the CPH Climate Plan 2035 has been approved by the City Council, the existing methodology and indicators may be adjusted.

Table 22. Status on achieving CPH Climate Plan 2025 sub-targets – Reducing Energy consumption.

Indicator no.	Sub-target	Sub-target values 2025 rel. to 2010	Status per ultimo 2022
	Reducing energy of	onsumption	
CPH2025-1	Reduction of heat consumption.	-20%	Consumption in 2022 was identical to 2010 despite a population increase of 22%
CHP2025-2	Reduction of electricity consumption by service and commerce.	-20%	Consumption is 17% higher (partly due to change of data source)
CPH2025-3	Reduction of electricity consumption by households.	-10%	As planned.



CPH2025-16	City of Copenhagen's buildings built according to low-energy rating from 2015 and building code from 2020		Goal is achieved. New building code supersedes subtarget.
CPH2025-15	Reduce energy consumption in the City of Copenhagen's buildings.	-40%	23% lower.
CPH2025-18	Reduction of energy consumption – streetlights.	-50%	Goal is achieved.

Table 23. Status on achieving CPH Climate Plan 2025 sub-targets – Building a green energy system.

Indicator no.	Sub-target	Sub-target values 2025 rel. to 2010	Status per ultimo 2022		
Building a green energy system					
CHP2025-6	Energy production generated by photovoltaic solar panels.	3% of electricity consumption in 2010	Production reached 0.7%.		
CPH2025-7	Installation of photovoltaic solar panels on the City of Copenhagen's buildings.	60,000 m ²	10,862 m ² .		
CPH2025-5	Energy status of district heating.	Climate neutral	85% climate neutral		
CPH2025-6	Electricity production based on biomass and wind.	Larger than Copenhagen's total electricity consumption	Renewable energy accounted for 69%		
CHP2025-7	Separation of plastic waste from households.	-	33% of household plastic separated in 2022		
CPH2025-8	Bio gasification of organic waste.	-	26% of organic fraction separated in 2022		

Table 24. Status on achieving CPH Climate Plan 2025 sub-targets – Fostering green mobility.

Indicator no.	Sub-target	Sub-target values 2025 rel. to 2010	Status per ultimo 2022		
Fostering green mobility					
CPH2025-9	Fraction of trips carried out by walking, bike, or public transportation.	75% of all trips	74%.		
CPH2025-10	Fraction of trips to work or education carried out by bike.	50% of all trips	45%.		
CPH2025-11	Number of passengers using public transportation.	20% more	9% increase.		
CPH2025-12	Energy status of public transportation.	Climate neutral	51% of all busses.		
CPH2025-13	Use of new sustainable types of fuel by light vehicles.	20-30%	5% (passenger cars); 3.5% (vans)		
CPH2025-14	Use of new sustainable types of fuel by heavy vehicles.	30-40%	Not achievable.		
CPH2025-17	Number of vehicles owned by the City of Copenhagen using electricity, hydrogen, or biofuels.	100%	45%.		



Even though Copenhagen is following their own approach to develop the City Vision, the municipality completed the climate neutral energy system survey. Therefore, it was allowed to develop the benchmarking of selected solutions boards that are presented below.

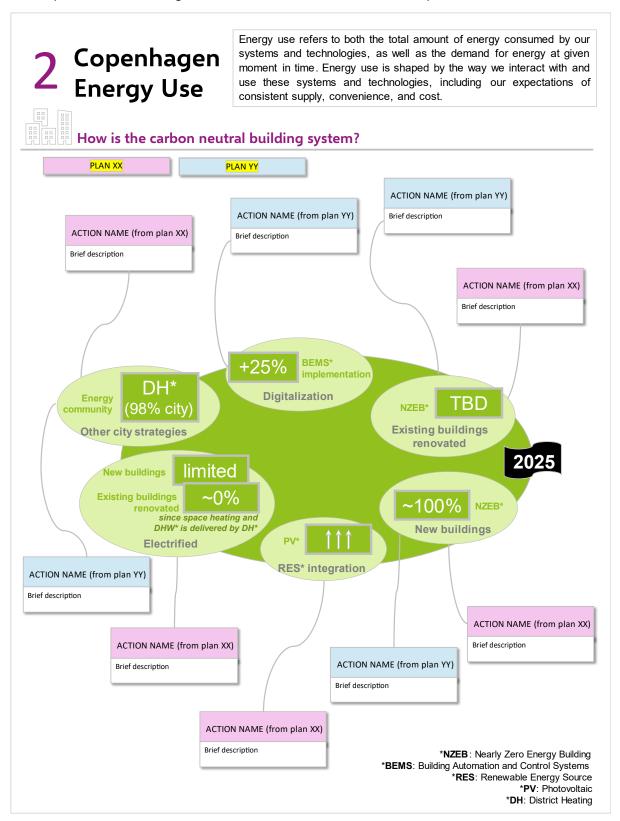




Figure 71. Copenhagen Energy Use Benchmarking board.

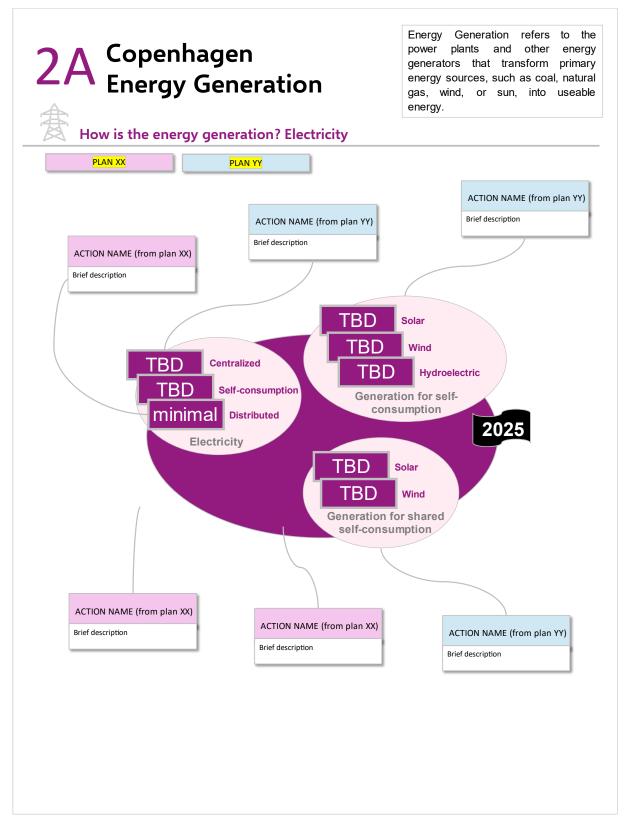


Figure 72. Copenhagen Energy Generation "Electricity" Benchmarking board.



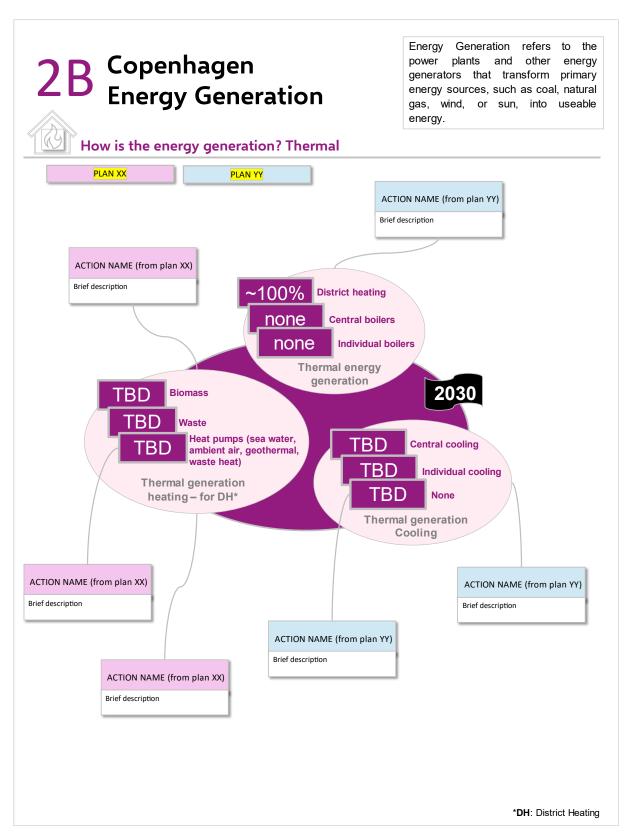


Figure 73. Copenhagen Energy Generation "Thermal" Benchmarking board.



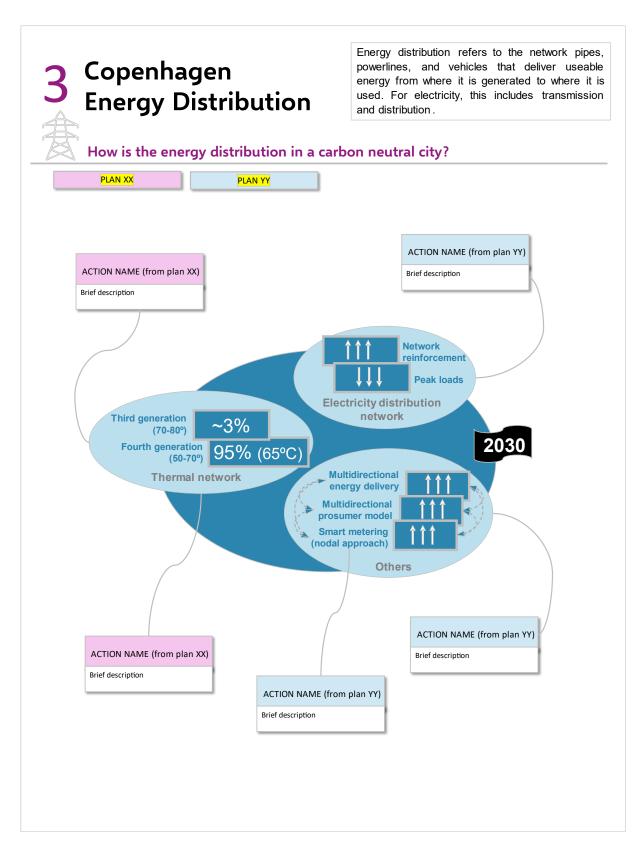


Figure 74. Copenhagen Energy Distribution Benchmarking board.



Annex 7: Krakow

City vision

The inventory of greenhouse gas emissions for the Municipality of Krakow was carried out to identify the main sources of emissions and to determine its volume. The results obtained provide the basis for planning mitigation measures and, at the same time, in a holistic manner, allow for verification of their effect. The Urban Inventory is carried out annually, allowing emissions to be monitored in a systematic way.

Initial assumptions of emission reductions in the 2030 and 2050 perspective were shown in D2.6.

In connection with the qualification of the City of Krakow in 2023 in European Mission for 100 climate-neutral and smart Cities by 2030, and the related necessity to develop a Climate City Contract, the focus was on the development of a plan to achieve climate neutrality by 2030. Assumptions of CO₂ reduction over time have changed and tuned to CCC requirements.

Below is the CO₂ reduction plan included in the CCC submitted to the European Comission, showing the values necessary for reduction.

Table 25. Greenhouse gas emission reduction action plan.

	Baseline emissio ns (BAU 2030)	reduct exis action strate	ssion ions in sting plans, egies,		aining sions		idual sions	Redu emis throug Clin Con Action to clo emis	on gap cing sions gh the nate tract n Plan se the sions
	Total (thousand tonnes)	Total (thousan d tonnes)	(% of baseline emission s)	Total (thousan d tonnes)	(% of baseline emission s)	Total (thousan d tonnes)	(% of baseline emission s)	Total (thousan d tonnes)	(% of baseline emission s)
Transport	595	226	38%	369	62%	234	39%	135	23%
Buildings and heating	1,539	710	46%	829	54%	158	10%	671	44%
Electricity	3,799	2,355	62%	1444	38%	885	23%	559	15%
Waste Manageme nt and CE	94	-35	-37%	129	137%	86	91%	43	46%
Other (mainly industry)	1,580	1,217	77%**	363	23%	157	10%	206	13%



Total	7,607	4,473	59%	3,134	41%	1,520	20%	1,614	21%	
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Based on the adopted plans and strategies and strategic management instruments, greenhouse gas emissions are projected to decrease by 59% by 2030 compared to the base year, which has been taken into account in the existing strategies. The main area of emission reduction is the energy sector, including buildings, heating and electricity generation and industry. Planned changes in this sector are addressed both in national plans, such as the Energy Policy of Poland until 2040 (PEP2040) and the National Energy and Climate Plan until 2030, as well as local plans, e.g. "Assumptions to the Plan for Supplying the Municipality of Krakow with Heat, Electricity and Gas Fuels for the years 2023-2038". In spite of the current actions already included in the existing documents, there is still a 21% emissions gap to be addressed by focusing on new projects and actions in order to achieve the mission objectives.

Closing this gap is essential to meet the goal of the Mission of 100 Climate Neutral and Smart Cities by 2030, which aims for an 80% reduction in emissions over the period in question. The 21% reduction in question translates into a direct emissions reduction target of 1,614,000 tonnes of CO₂e. This reduction is also not evenly distributed. The greatest potential for emission reductions is in the energy, buildings and industry sectors

The Municipality of Krakow faces the challenge of limited opportunities to influence the most emitting — energy sector generation. This is a major constraint as Krakow's transformation depends mainly on domestic investment in the energy sector. The city's current level of indebtedness prevents significant direct infrastructure investments in the energy sector within the city, which could significantly burden the budget.

Therefore, Krakow should focus on measures promoting distributed energy and thermomodernisation of buildings, which can have a significant impact on the city's energy balance. These activities will contribute to reducing emissions and improving the quality of life of the inhabitants and will reduce the costs they have to pay for energy bills. In addition, encouraging private investors to undertake similar activities by providing appropriate financial incentives and tax breaks can accelerate the process of ecological upgrading of infrastructure.

Promoting renewable energy sources is a key aspect that Krakow should undertake in order to accelerate the transition to green energy. The development of appropriate local policies and strategies to support the development of photovoltaic installations, wind power plants and district heating based on renewable energy sources can contribute to a significant reduction in emissions and increase the city's energy independence. Environmental education is an equally important area for Krakow to address. Through educational initiatives, information campaigns and environmental awareness programmes, the city can raise the level of citizens' awareness of the need to take action to protect the environment and support long-term changes for sustainable community development. In this way, despite the limitations on its direct impact on the energy sector, Krakow can actively contribute to reducing emissions and promoting sustainable development, which will benefit both the environment and the city's residents.



The process implemented by the municipality to achieve a future vision for the city

Krakow's journey toward establishing a climate-resilient and sustainable urban vision began with the **Krakow Climate Assembly** in 2021, the city's first citizen assembly dedicated to addressing climate change and exploring pathways to achieve climate neutrality. This assembly was inclusive, involving a representative group of residents across various demographics (gender, age, education, and neighbourhood), which ensured that recommendations reflected the perspectives of Krakow's diverse population. The assembly had multiple objectives:

- Increasing climate crisis awareness, galvanizing public support and understanding of climate issues.
- Fostering a coalition for climate transition by involving residents, experts, community organizations, and local businesses, ensuring a wide-reaching support network.
- Generating ideas focused on energy efficiency and renewable energy use, critical areas for sustainable urban transformation.
- Building consensus on joint climate actions between city authorities and residents, which would be foundational for future steps.

The assembly's outcome was a set of **32 binding recommendations** for the Mayor, which provided strategic guidelines across many intersecting areas of city life. One of the most critical recommendations was developing a **Climate Strategy for Krakow**. This document, grounded in a **participatory approach**, outlines the city's climate goals and maps out paths for action, with ongoing coordination by a designated team or unit. Importantly, Krakow commits to annual progress reports and regular evaluations of the strategy to ensure alignment with scientific advancements and technological innovations.

Krakow has further solidified its commitment by **joining the EU Mission for 100 Climate Neutral and Smart Cities by 2030**, establishing a Climate Contract—an official document setting out the roadmap toward climate neutrality. This contract represents the shared vision Krakow holds with its residents and stakeholders, institutionalizing the city's dedication to sustainability in the upcoming decade.

Stakeholder Engagement and Consultation Process:

Krakow's approach to forming its city vision and action plan is marked by an institutionalized process of public consultations, which are critical when drafting key municipal documents. These consultations, guided by city legislation, involve diverse social groups—residents, NGOs, and businesses. The process entails a transparent mechanism for soliciting input, making information accessible, and engaging stakeholders, all aimed at developing documents that embody residents' collective aspirations.

The public consultation procedure comprises several stages:

- Initiating consultations by city authorities, groups of residents, NGOs, or institutions.
- Requesting consultations with detailed proposals submitted to the Mayor.
- Publicizing the consultation to maintain transparency and openness in decisionmaking.





- Communicating through various channels to reach a wide audience.
- Providing information materials relevant to the consultation topics.
- Conducting consultations for at least 21 days at times convenient for participants.
- Evaluating feedback and compiling a report for public disclosure and City Council review.
- Implementing changes where feasible based on consultation outcomes.

This transparent, inclusive framework ensures Krakow's strategic documents are co-created with its residents, reflecting their ideas and vision for the city's future. These efforts underscore the city's openness to dialogue and its dedication to active resident and NGO participation in urban planning.

Krakow has taken significant steps to **incorporate local businesses** in its climate vision through an initiative called the **Climate Pact**. This Pact, inaugurated during a formal meeting between the Krakow City Hall and business representatives, provides a platform for local enterprises to actively participate in Krakow's climate transformation goals. The initiative encourages businesses to reduce emissions, adopt pro-environmental practices, and share sustainable innovations, contributing directly to the city's broader aim of climate neutrality.

The Climate Pact exemplifies cooperation across sectors and highlights the city's belief in the critical role of businesses in achieving environmental goals. By joining the Pact, businesses commit to integrating climate action into their operations and work collaboratively to exchange best practices for reducing their environmental impact. As of now, several major companies have signed the Pact, including ASTOR, AstraZeneca, BP, BWI Group, InPost, and Shell, representing a collective dedication to making Krakow a greener and more sustainable place.

In line with Krakow's participatory approach, the Climate Pact also aligns with recommendations from the Krakow Climate Assembly, which advocated for inclusive, transparent spaces for cooperation on climate matters. The Pact's launch was a response to this recommendation, creating an ongoing dialogue with businesses to ensure that the city's economic and environmental strategies are complementary.

This enterprise-based cooperation supplements Krakow's climate goals and reflects the city's ambition to leverage the expertise and resources of private sector stakeholders to foster a cleaner, more resilient urban environment. Through these combined efforts of local government, community, and business sectors, Krakow aims to solidify its position as a leading climate-conscious city.

Regional and National Collaboration: Krakow also extends its environmental goals beyond city limits, working closely with the Marshal's Office of the Małopolska Region on projects like the LIFE-IP EKOMAŁOPOLSKA initiative. This initiative aligns Krakow with the Regional Climate and Energy Action Plan (RPDKiE) to foster comprehensive climate action, including deploying climate and environmental advisors across districts to support local governments.

Nationally, Krakow collaborates within frameworks like the **National Urban Policy 2030** and is an active participant in climate-focused working groups under the Union of Polish Metropolises. Through these collaborations, Krakow influences policies that support sustainable urban development, energy efficiency, and climate adaptation.

In summary, Krakow's multi-level, consultative approach involves consistent engagement with stakeholders, collaborative projects, and adherence to robust, transparent procedures. The



city's initiatives demonstrate a strong commitment to sustainable, inclusive urban development, aiming for an equitable and climate-neutral future.

The iteration process and next steps

After completing WP2, the vision-building phase, Krakow's next steps toward climate neutrality will involve continuous updates to its climate strategy and active engagement of key stakeholders. The city's strategy will be regularly evaluated and adapted, reflecting rapidly evolving approaches and new solutions in climate transition. This process will be reinforced through a two-year iterative cycle, with updates to the Climate Contract planned for subsequent years (e.g., the second iteration in 2028, with an evaluation of goal achievement planned for 2030).

Future updates will incorporate input and engagement from various stakeholder groups, including businesses, NGOs, and universities—primarily through the involvement of the Zero Emission Krakow Portfolio Advisory Team. The document will also be subject to extensive consultations within the Climate Pact, enabling the regular expansion of participant groups and engaging a broader network of stakeholders in the transition process. The final decision on adopting the document through the Krakow City Council will be made after the public consultation stage, in compliance with statutory requirements.

Progress will be monitored through the City's Greenhouse Gas Inventory and the STRADOM system, which evaluates project implementation using assigned evaluation indicators. Additionally, Krakow reports its climate action to the CDP (Climate Disclosure Project), providing external assessment and recognition for its neutrality efforts, which enhances transparency and credibility of these initiatives.

Thus, continued stakeholder engagement and regular strategy updates are key components enabling Krakow to respond flexibly to dynamic changes in climate policy and effectively achieve its climate neutrality goals.

Benefits of European Mission for 100 climate-neutral and smart Cities by 2030

The benefits of Krakow's participation in the European Mission for 100 climate-neutral and smart cities by 2030 are multifaceted, involving both financial and non-financial advantages:

Collaboration with other cities: By joining the Mission, Krakow gains the opportunity to exchange experiences and best practices with other cities facing similar climate challenges. The collaboration allows for the development of more efficient solutions tailored to local needs.

Access to experts and knowledge: Krakow benefits from the support of experts within the **NetZeroCities** consortium, which consists of over 30 organizations working on climate-related issues. These experts provide valuable assistance in developing climate strategies, and their knowledge of Polish cities' specific context adds extra value.

Financial support: Although initially, the Mission focused on providing technical support, the **European Commission** and the **European Investment Bank (EIB)** have launched the **Climate City Capital Hub**, which offers financial advisory services for cities. Cities that obtain the Mission Label certification will gain access to a broad range of funding sources, including loans, investments, and innovative financing methods like crowdfunding or issuing sustainability-linked bonds.



Access to funds: Participation in the Mission also opens the door to a €2 billion fund designed to support projects related to climate change mitigation and adaptation. To access these funds, cities must develop an ambitious yet realistic Climate Contract.

In summary, Krakow's involvement in the Mission provides not only access to invaluable knowledge and collaboration but also potential financial resources to support eco-friendly projects.

Krakow CCC refinement - continuous update

Duringthe course of the CCC refinement work for Krakow, assumptions regarding the level of emission reductions were revised. These assumptions are presented above in Table 25. Greenhouse gas emission reduction action plan. The above assumptions are the result of a process of continuous learning, drawing lessons from the ATELIER project and other projects conducted by Krakow, discussions with residents and decision makers, and based on available national and municipal resources.

The adjustment is closely linked to the CCC process and EU guidelines. Measures have been proposed for the assumed emission reductions (a dedicated emission gap of 21%) for each sector, along with estimates of emission reductions and necessary financial resources.

Table 26. Sectoral costs (Net Present Value - NPV) PLN/PLN.

Sector	Sub-sector	NPV Investment costs - CAPEX (2020- 2030)*	NPV Operating cost savings - OPEX (2020- 2040)**	CO₂e* reducti on	NPV Unit costs (PLN / tonne of emission reduction)*	NPV Co- benefits (MEUR 2020- 2040)**
	Transition to public and non-mechanised transport	PLN 5 931 080 131	PLN 5 558 924 636	35,000 tonnes	169 459	PLN 6 248 686 830
	Degree of loading of passenger cars	PLN 90,000,000	PLN 1 929 506 616	28,000 tonnes	3 214	PLN 1 362 629 725
Transport	Electrification of passenger cars	PLN 180,061,649	PLN 188 044 524	56,000 tonnes	3 215	PLN 110,572,732
	Electrification of public transport	PLN 542,467,489	PLN 285 559 106	6,000 tonnes	90 411	PLN 112,228,102
	Optimisation of freight transport logistics	currently no estimates	PLN 2 270 501 225	10,000	-	PLN 1 892 744 890
	Electrification of trucks	available	PLN 383 231 764	tonnes		PLN 560,508,999
Buildings and	Annual building renovation rate	PLN 13 401 457 088	PLN 2 203 594 128	459,000 tonnes	29 197	PLN 339,985,817
heating	Energy efficiency	PLN 30,000,000	PLN 368 625 653	34,000 tonnes	882	PLN 56 874 128



	of new buildings					
	Increased lighting efficiency and upgrading of domestic appliances	included in electricity	PLN 2 317 243 372	included in electricity	-	PLN 200 388 659
	Decarbonisation of the heating industry	PLN 1 947 099 098	PLN 1 532 757 435	178,000 tonnes	10 939	PLN 363,002,520
Electricity	Switching to renewable energy sources	PLN 5 665 750 082	PLN 25 366 095 815	559,000 tonnes	10 136	-
Waste management and CE	Increase in recycling rates and development of a circular economy	PLN 111,204,440	PLN 23 976 312	43,000 tonnes	2 586	PLN 2 273 981
Other	Land reclamation, increased forest cover and blue- green infrastructure and decarbonisatior of industry	PLN 870 225 058	currently no estimates available	206,000 tonnes	4 224	currently no estimates available
Total	-	PLN 28,769,345,035	PLN 42 428 060 962	1 614 thousand tonnes	17 825	PLN 11 245 348 421

^{*}Investment costs and emission reductions included only for actions addressing the emission gap included in the Action Plan.

Impact assessment of the master scenario

Based on the results of the BaU and Master scenarios agreed with the city, the latter achieves an additional cumulative saving of 53,785 GWh of final energy consumption regarding the former through the whole scenario period (2021-2050), in order to fulfil the City Vision set for 2050 by the municipality. The Master scenario also reaches additional cumulative savings of 225,317 GWh and 348,762 GWh of total and non-renewable primary energy respectively compared to the BaU scenario. In the environmental dimension, the quantity of cumulative emissions additionally abated by the Master scenario regarding the BaU amounts to 101,105 ktonnes CO_2 through the whole scenario period.

Table 27. Krakow Master scenario energy and environmental indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Savings
	Cumulative final energy	445,889	392,104	53,785
Enorgy	Cumulative total primary energy	802,451	577,134	225,317
Energy	Cumulative non-renewable primary energy	745,373	396,611	348,762
Environmental	Cumulative GHG emissions	190,292	89,277	101,105



^{**}Savings and co-benefits in terms of zero-carbon city (80% reduction).



The implementation and deployment of the additional measures considered in the Master scenario compared to the BaU require an additional investment of €6,371 M. In turn, it generates €5,351 M GDP and 72,960 more jobs than the BaU.

Table 28. Krakow Master scenario socioeconomic indicators' results.

Dimension	Indicator	BaU scenario	Master scenario	Additional investment/ Increase in GDP/employment
	CAPEX (M€)	2,072	8,443	6,371
Socioeconomic	GDP impact (M€)	1,290	6,641	5,351
Socioeconomic	Employment (jobs created)	15,454	84,414	72,960

Climate City Contract

The ongoing climate crisis is manifested in the increasingly frequent observation of extreme weather events, which have a negative impact on the wellbeing of residents and can have long-term health effects. Krakow's ambitious goal of achieving climate neutrality is to make the city a cleaner and friendlier place to live in every aspect: living, working and relaxing. The city wants to offer everyone, residents and visitors alike, more greenery, clean air and water and more efficient transport. Krakow is continuously working to accelerate a systemic transformation aimed at achieving climate neutrality, which will manifest itself in reducing greenhouse gas emissions to a minimum and implementing solutions for a clean and liveable environment. and resident-friendly environment.

As part of the First Krakow Climate Panel, organised in 2021, 32 recommendations were developed and submitted to the City authorities to tackle climate change in the coming decades. Climate neutrality is fully supported by the Krakow authorities and numerous social, scientific and business communities. The city authorities have announced that they will take all measures leading to the implementation of the recommendations and the achievement of climate neutrality.

The objective of the Climate Contract is to present a pathway for action to reduce greenhouse gas emissions by 80% relative to the base year (2018) by 2030. To achieve this, the following parts of the Climate Contract take into account emission reduction options resulting from policies and strategies already in place at local, regional, national and EU level, and the remaining emissions gap was filled with local actions. All this is under the assumption that the barriers and risks described in the later parts of the document (Action Plan and Investment Plan) can be overcome.

The plan is prepared for emissions within the boundaries of the Municipality of Krakow and does not contain any territorial exclusions. Data for the base year comes from the Urban Greenhouse Gas Inventory developed in accordance with the GHG Protocol for Cities methodology at the BASIC level. The action pathways described in the following sections, on the other hand, refer to the sectors described in the Economic Model developed by the experts.

The target adopted in the Climate Contract for Krakow is to reduce greenhouse gas emissions by 80% by 2030 compared to 2018. A large part of the emission reduction (4,473 thousand



tCO₂e) (carbon dioxide equivalent) will result from actions implemented after 2018 or planned in strategic documents of the City and the Polish government. The contract contains a detailed description of 58 actions that should be taken to achieve additional emission reductions of 1,614 thousand tCO₂ e. The cost of these actions was estimated at 28,769 million PLN. However, the calculations of the Economic Model indicate that the total financial benefits, direct and indirect (reduced energy expenditure, health care, additional jobs, etc.) outweigh the costs of the transformation. Emission reductions will overwhelmingly result from the implementation of national strategies, carried out by private actors: energy companies, businesses and building owners and managers.

Priority 1 - Buildings

One of the priority goals of the City of Krakow in terms of achieving climate neutrality is to introduce thermal modernisation of buildings on a massive scale. This action aims to reduce emissions and improve the energy efficiency of buildings, which are one of the main sources of emissions in the city. In this context, the city is betting on the implementation of the Green Neighbourhood Model, a strategic experiment to implement a business model for deep thermomodernisation of buildings.

To date, programmes offering grants and loans for home renovation have met with limited interest from both individual and institutional building owners, yielding only partial improvements in energy efficiency. To change this, Krakow intends to create a comprehensive thermo-modernisation programme that not only improves energy efficiency, but also unlocks additional benefits such as supply chain innovation, rapid data-driven learning, business development, job creation, health benefits and fuel poverty reduction.

The programme envisages a significant increase in the share of privately financed thermal modernisation, including through the ESCO (Energy Service Company) formula. In this formula, the ESCO finances the modernisation project and then recovers its outlay through staggered payments generated by the energy savings resulting from the project. Krakow is also promoting a comprehensive One Stop Shop (OSS) building retrofit service to speed up and facilitate the retrofit process by offering building owners a full-service investment. The process is to be carried out at no cost to property owners, regardless of the type of ownership and use of the buildings. Large-scale actions also enable additional projects such as building climate resilience, creating co-working spaces and developing green and blue-green infrastructure in shared spaces. In this way, it will be possible to develop entire local communities, ensuring greater impact and citizen involvement, transforming the retrofit programme into a neighbourhood greening programme.

Large-scale thermal modernisation of buildings in Krakow, however, requires a complex approach and a variety of investment financing schemes. The city also plans to develop existing subsidy schemes and create new ones, including schemes using funds from the National Recovery Plan. A key element of the strategy is the NEEST - NetZero Emission and Environmentally Sustainable Territories project, which will bring ready-made technological solutions ready for immediate scaling and implementation in other urban quarters.

Historic buildings, which require special technical solutions, are of particular importance in the process of thermal modernisation. To this end, projects are being prepared to develop efficient and cost-effective methods of modernising these buildings.



Through such a comprehensive approach, Krakow can not only significantly reduce emissions, but also improve the quality of life of its residents by supporting the local economy, public health and social cohesion. Massive thermo-modernisation, as a key element of the zero-carbon strategy, is a fundamental step towards creating a sustainable, friendly and modern city of the future.

Priority 2 - Renewable energy

The second priority objective for the City of Krakow in terms of achieving climate neutrality is to significantly increase the share of renewable energy sources (RES) in the city's energy mix. To achieve this, Krakow plans to develop individual electricity generation using private photovoltaic (PV) panels on the roofs of buildings and heat pumps for heat production.

Krakow should use more than 32% of the roof area of buildings in the city for the installation of PV installations, which includes industrial buildings and brownfield sites. For efficient implementation of PV installations, cooperation with conservationists will be necessary. The city plans to launch a support programme that will enable the preparation of comprehensive project documentation for the installation of RES on historic buildings. Currently, such a project is already being implemented by the municipal unit KEGW in the Nowa Huta Cultural Park.

The Municipality of Krakow actively promotes distributed energy generation by supporting prosumer initiatives, providing subsidies and advisory support. As a result, the growth rate of new PV installations is accelerating year on year. Between 2020 and 2021, more than 19% of newly connected installations had financial support from the Programme for the Development of Renewable Energy Sources in the Municipality of Krakow (PROZE). Significant funding for the intensification of existing programmes and the creation of new ones will come from the National Reconstruction Plan, allowing pilot and innovative RES projects to be implemented in the city. In 2020, only one in sixteen residential buildings in Kraków had PV installed, while in 2021 it will be one in eight. More than 90% of the current PV micro-installations in Krakow (as of 2023) were connected between 2020 and 2023.

Actions to increase the share of RES also include the use of heat pumps for heat production in buildings, with air source heat pumps predominating and some ground source heat pumps.

Many energy companies and enterprises, such as Krakow Municipal Holding, PGE EC S.A., MPEC, Tauron and PSE, are implementing their PV farm projects. However, due to the dense urban development of the city, it is necessary to intensify activities and to search for suitable areas for PV farms. Post-industrial areas such as ash and slag dumps have great potential. The Municipality of Krakow is also looking for new sites for PV farms in neighbouring municipalities, which creates new business opportunities in the metropolitan area. Companies will be established in the surrounding municipalities to lease land for PV installations and resell green energy. These investments are profitable thanks to the favourable conditions for solar energy in the foothills around Krakow.

The city will develop a plan to replicate the concept of Energy Positive Districts in selected areas, increasing resident and stakeholder involvement as a pathway to climate neutrality. Increasing the share of RES in the city's energy mix is a key element of this strategy, contributing to the sustainable development of Krakow and improving the quality of life of its residents.

Priority 3 - Rail transport





The third priority objective for the city of Krakow in terms of achieving climate neutrality is the development of rail transport. A key element of this strategy is the development of a network of collision-free trams that allow rapid and reliable travel around the city without disruption from traffic. The construction of a metro is also planned, which could provide an alternative to the busiest routes and significantly relieve the burden on surface traffic. The increased accessibility of the tram network aims to reduce the need for car transport, which will contribute to reducing emissions and improving air quality. The new tram lines are to be fully integrated into the existing public transport infrastructure, providing convenient transfers and shorter journey times. By investing in modern tram rolling stock, Krakow is betting on ecological and energy-efficient solutions. Collision-free tram routes will allow increased speed and punctuality of journeys, encouraging residents to give up their cars in favour of public transport. The expansion of the tram infrastructure also provides for the development of green tracks, which will further reduce noise and improve urban aesthetics. In addition, the increased availability of trams and the planned metro will contribute to the sustainable development of the city by supporting emission-free mobility. As a result, Krakow is aiming to create a modern transport system that is friendly to both the environment and residents.

Priority 4 - The need for cooperation

The above priorities require cooperation and commitment, but they are also an opportunity to keep Krakow attractive to investors and make it a comfortable place to live. To attract highly skilled professionals, we need to offer development opportunities, a high standard of living and participation in the management and planning of the city's development. One of the biggest challenges of the transformation is to mobilise private capital and develop business models that combine public and private capital. The second key challenge is to ensure broad support and activity of different social groups: residents, entrepreneurs and researchers. That is why we are improving the tools of participation and dialogue: citizen panel, civic budget, financing of social initiatives, workshops with residents, consultation of solutions, education and consultancy.

The biggest group needed to bring about accelerated change are citizens. Developing solutions with civil society to the challenges of achieving climate neutrality for the city is key. The Climate Contract between the City of Krakow and the European Commission requires the involvement of key stakeholders in the city, such as business and industry, the science and technology community, NGOs. Including their perspective on the city's achievement of climate neutrality early in the policy and decision-making processes will provide the city with valuable guidance and identify their role as partners in developing long-term, broad-based support for the Mission of 100 Climate Neutral and Smart Cities by 2030. In order to implement the Mission, it is also very important to develop a collaborative dialogue with the Polish government so that the actions taken are stronger and can gain wider public recognition and support.

Table 29. Krakow Impact Pathways.

	Impact pathways							
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)				
Sector: Buildings and heating.	Measures to decarbonise the	Continued and stable growth of	671 thousand	Increase in the number of jobs				
System leverage: Technology/Infrastructure.	district heating system (heat pumps, biogas, etc.).	RES in the city's energy mix.	tonnes of CO ₂ e	in the RES sector.				





	Impact p	athways		
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)
	Promoting the modernisation of technology and infrastructure used in buildings (e.g. lighting, replacement of valves).	Reducing energy consumption in buildings by replacing appliances with more efficient ones.		Lower energy charges for residents.
	Thermo- modernisation of buildings to improve energy efficiency.	Raising the energy efficiency standard of buildings.		Lower energy bills for residents. Job creation. Reducing the urban heat island.
	Investment in energy storage technologies.	The popularisation of energy storage equipment will increase the efficiency of RES systems and their popularity.		Job growth in the RES sector.
	There is strong support for a change in the structure of energy generation due to EU commitments, the rising costs of exploiting coal from Polish mines and cutting off gas imports from Russia.	The high level of commitment should remain high because of the irreversible actions taken earlier.		Increase in capital invested in climate projects and activities.
Sector: Buildings and heating. System leverage: Governance and Policy.	Generation of system solutions for building thermomodernisation schemes at local, regional and national level.	Implementation of building retrofit schemes involving multiple stakeholder groups (local authorities, businesses, cooperatives, residents, etc.).		Decline in fuel poverty. Engaging citizens in cocreating climate neutrality measures.
	Work to implement energy standards for new buildings.	Construction of new buildings with a baseline high energy standard.		Job creation. Reducing the urban heat island.



	Impact p	athways		
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)
	Developing recommendations and recommendations to the national level to invest in energy companies due to the need to meet EU obligations and ensure national energy security.	Thanks to the increasing share of new technologies, energy generation should become increasingly cheaper, allowing energy companies to allocate more of their own capital to investment.		Increase in capital invested in climate projects and activities.
Sector: Buildings and heating.	Educational campaigns targeting different social groups to raise awareness of energy savings.	Reducing energy demand in buildings.		Lower energy charges for residents.
System leverage: Education and Skills.	Develop schemes and models for thermal modernisation with the participation of multiple stakeholder groups.	Scaling up and replicating the solutions developed.		Development of public participation processes.
Sector: Buildings and heating. System leverage: Finance.	Support for investment in thermal modernisation and RES programmes.	Reducing energy demand in buildings and decreasing the share of supplied energy generated by coal sources.		Job creation. Lower energy charges for residents. Reducing the urban heat island.
	Development of schemes and financing models for thermal modernisation with the participation of multiple stakeholder groups.	Scaling up and replicating the solutions developed.		Development of public participation processes. Engaging citizens in cocreating climate neutrality measures.



	Impact p	athways		
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)
Sector: Buildings and heating. System leverage: Democracy and Participation	Continue to support citizens with energy advice.	Increasing interest in RES solutions among citizens.		Job creation.
Sector: Buildings and heating. System leverage: Social innovation.	Developing district and community energy model solutions with significant citizen involvement.	Developing sustainable urbanism.		Development of public participation processes. Engaging citizens in cocreating climate neutrality measures.
	Development of a network of electric car chargers.	The growing popularity of electric cars.		Less air pollution. Reducing the urban heat island.
	Expansion of the public transport fleet towards zero-emission.	Decrease in emissions from the public transport sector.		Less air pollution. Reducing the urban heat island.
Sector: Transport. System leverage: Technology/Infrastructure.	Expansion of public transport infrastructure.	The creation of new tram depots in previously inaccessible locations (e.g. Mistrzejowice) and the popularisation of public transport.	135 thousand tonnes of CO₂e	Less air pollution. Less noise pollution. Reducing the heat island. Increased road safety.
	Extension of pedestrian and cycle infrastructure.	Increase in proportion of walking and cycling trips.		Improving the fitness and health of residents. Less air pollution. Less noise pollution.
	Energy storage acquisition and cost-effective distribution programmes.	Reduced aggregate energy consumption in transport.		Decrease in the cost of maintaining public transport.
Sector: Transport.	Creation of a Clean Transport Zone.	Displacement of old and carbon-		Less air pollution.



	Impact p	athways		
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)
System leverage: Governance and Policy.		intensive modes of transport and optimisation of freight logistics.		Less noise pollution.
		gg		Increased road safety.
	Development of the functioning of the public transport	A greater proportion of people using		Reducing the urban heat island.
	system.	public transport.		Increase in improved well-being.
	Popularisation of "car-pooling" and alternative	Increasing popularity of alternative modes		Less air pollution.
	modes of transport through regulation.	of transport.		Less noise pollution.
				Less air pollution.
	Change of use of public spaces e.g.	Reduce car		Less noise pollution.
	fewer parking spaces, pedestrian streets.	transport to the city centre.		Reducing the urban heat island.
				Development of green spaces.
	Regulation of freight transport	Increasing the		Less air pollution.
	requirements.	loading of lorries.		Less noise pollution.
				Less air pollution.
Sector: Transport.	Popularise alternative means of	Reduce the need for private cars for		Improving the fitness and
System leverage: Education and Skills.	transport (e.g. scooters).	city centre residents.		health of residents.
				Less noise pollution.
Sector: Transport.	The popularisation of hybrid and remote	Remote working will become		Less air pollution.
System leverage: Democracy and Social Participation.	working reduces the need to commute to workplaces.	increasingly desirable for employees and		Less noise pollution.



	Impact p	athways		
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)
		more companies will start to switch to it for competitive reasons.		Increase in improved wellbeing.
Sector: Electricity. System leverage:	Development of RES-based solutions (photovoltaics, etc.).	Increase of RES in the energy mix of the city.		Lower energy charges for residents. Job creation.
Technology/Infrastructure.	Design of new photovoltaic farms.	Increase of RES in the energy mix of the city.		Job creation.
	There is strong support for a change in the structure of electricity generation at plants in the city due to EU commitments, the rising costs of exploiting coal from Polish mines and cutting off gas imports from Russia.	The high level of commitment should remain high because of the irreversible actions taken earlier.		Increase in capital invested in climate projects and activities.
Sector: Electricity. System leverage: Governance and Policy.	Developing recommendations and recommendations to the national level to invest in energy companies due to the need to meet EU obligations and ensure national energy security.	Thanks to the increasing share of new technologies, power generation should become increasingly cheaper, allowing energy companies to allocate more of their own capital to investment.	559 thousand tonnes of CO₂e	Increase in capital invested in climate projects and activities.
	Purchasing green energy.	This measure will reduce the carbon footprint generated by the city and allow the development of energy companies.		Increase in capital invested in climate projects and activities.
Sector: Electricity. System leverage: Education and Skills.	Educational campaigns targeting different social groups to raise awareness of energy savings.	Reducing energy demand in buildings.		Lower energy charges for residents.



Impact pathways					
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)	
Sector: Electricity. System leverage: Finance.	Financial support for those interested in investing in RES.	Increase of RES in the energy mix of the city.		Lower energy charges for residents.	
Sector: Electricity. System leverage: Democracy and Social Participation.	Continue to support citizens with energy advice.	Increasing interest in RES solutions among citizens.		Job creation.	
Sector: Electricity. System leverage: Social Innovation.	Developing district and community energy model solutions with strong citizen involvement.	Developing sustainable urbanism.		Engaging citizens in co- creating climate neutrality measures. Development of public participation processes	
Sector: Waste management and CE.	Continuation of the "Circular Strategy for Krakow" programme Continuation of the city-wide system the use of materials reusable.	Increase in recycling rates.		Development of a circular economy. Job creation.	
System leverage: Technology/Infrastructure.	Systems for producing energy from waste sources.	Increase in RES sources in total energy consumption.		Increased citizen satisfaction with a cleaner environment.	
	Infrastructure investment for recycling and waste treatment.	Establishment of new recycling and recovery facilities.	43 thousand tonnes of	Increase in recycling rates.	
Sector: Waste management and CE. System leverage: Social innovation.	Local initiatives to implement recycling and ecology initiatives.	Increase in recycling rates.	CO ₂ e	Increased citizen satisfaction with a cleaner environment. Increase in improved well-being	
Sector: Waste management and CE. System leverage: Education and Skills.	Informing people about the benefits recycling and how to recycle waste.	Increase in recycling rates.		being. Increase in recycling rates.	



	Impact pathways					
Sector and system leverage	Early changes (1-2 years)	Late results (3-4 years)	Direct effects (emission reductions)	Indirect effects (co-benefits)		
Sector: Other (mainly industry).	Development of green infrastructure and creation of urban parks.	Increase the proportion of green spaces in the city.		Improving the fitness and health of residents. Increase in improved wellbeing. Environmental restoration and green space development. New structural links of green spaces.		
System leverage: Technology/Infrastructure.	Displacement of carbon-intensive emission and pollution sources.	Environmental restoration.	206 thousand			
Sector: Other (mainly industry). System leverage: Governance and Policy.	Increase in forest cover and urban greenery within the city. Replacing heavy, carbon-intensive industry with activities based on new technologies.	Continued growth of greenery in Krakow contributing to	CO ₂ e	Job creation. Increasing citizens' qualifications and skills. Development of public participation		
Sector: Other (mainly industry). System leverage: Education and Skills.	Introduce educational activities in schools on environmental responsibility and the role of urban greenery.	greater absorption of carbon dioxide from the atmosphere.		processes. Engaging citizens in co- creating climate neutrality measures.		
Sector: Other (mainly industry). System leverage: Democracy and Social Participation.	Holding consultations with residents to obtain their views and ideas on the development of green space.					

The impact pathways indicated above, focusing on five key sectors, simultaneously cover six main system levers. It is noteworthy how a large number of actions are assigned to the Building and Heating and Electricity sectors. These sectors are the main source of emissions in Krakow and also the main factor responsible for the emissions gap. In this context, the levers for change focus primarily on technological investments to increase energy efficiency and a sustainable transformation of the energy system.



Even with state-of-the-art energy efficiency technologies for buildings in the municipal area, achieving climate neutrality on the scale of a large city like Krakow will require significant investment in upgrading the region's energy system, which operates independently of Krakow. Intergovernmental and local government cooperation therefore appears to be a key aspect.

Defining a common pathway for climate and energy transformation at different territorial levels becomes an extremely key element in achieving the mission's goals. With the co-creation of a common pathway of change between the City of Krakow and government authorities, a much stronger message can be developed. By working together, each party can then focus on implementing the actions over which it has real influence, making the effectiveness of such cooperation invaluable.

Benchmarking of selected solutions

Economic and financial indicators for monitoring, evaluation and learning

The Municipality of Krakow has an adopted and developed Integrated Management System STRADOM covering the activities of the City Hall and large Municipal Organisational Units at the strategic and operational level, as well as monitoring indicators and risk management. The STRADOM system contains elements such as: Goals for the Krakow Development Strategy (SRK 2030), Management Domains with a catalogue of domain indicators, current and investment budget tasks with task indicators enabling planning and monitoring of products and services realised by the City of Krakow in terms of their number, quality and cost-effectiveness.

Thanks to STRADOM's well-thought-out structure, the implemented set of indicators and the financial data, we can track the dynamics of change in each Management Domain, i.e. a substantively uniform domain of the Municipality's activities (which is also a key area of residents' lives), the catalogue of which is defined in the relevant ordinances of the Mayor and in the STRADOM System.

In the Integrated Management System of the Municipality of Krakow, the Management Domains are the dimensions grouping, among other things, the domain indicators in the Catalogue of Indicators of Quality of Life and Quality of Public Services (LQ and PSQ). Each Domain contains specific Public Services defined at strategic level, budgetary tasks and their activities. There are currently 15 Management Domains defined.

Catalogue of citizen Life Quality and Public Services Quality indicators (or Catalogue of Domain indicators) - is a set of indicators of the Quality of Life (Life Quality) and Quality of Public Services (Public Services Quality) comprising indicators for diagnosing the state of the Domains (the so-called context indicators) and assessing the City's activities at the strategic level (the so-called strategic indicators). The selected domain indicators are used for parameterisation of the objectives of the Development Strategy of Krakow, the objectives of strategic programmes and are the basis for the development of diagnoses, plans, programmes and reports at the strategic level.

An indicator in STRADOM is information obtained as a result of a function of variables, that is, a mathematical operation using measures. Each indicator consists of a collection of information drawn up according to the definition of the indicator, the rationale for its use, the method of calculation and the desired value. At the strategic level, domain indicators are collected, while at the operational level, task indicators are used to characterise the quantitative and qualitative outputs of the budgetary tasks. Task indicators are used to plan,



monitor and evaluate the degree to which the objectives of tasks and their material and financial plans are achieved (indicators of effectiveness, efficiency, customer satisfaction, plan implementation and others). The data needed to monitor the indicators are collected in the STRADOM System as well as other tools collecting data from source systems and applications, e.g. ISDP, SAS VA.

Each Management Domain has its own Coordinator who identifies, gathers and analyses data necessary for the management of the Domain, monitors - inter alia on the basis of indicators - changes occurring in it, evaluates the activities of the Municipality of Krakow within the coordinated Domain, formulates conclusions and recommendations for the Public Services and Programmes implemented within the Domain. The Domain Coordinators participate in activities related to updating and monitoring the Krakow Development Strategy, as well as in the implementation of indicators in the Domains.

The coordinators of the Domains are directors (or their deputies) of the substantive departments of the Municipality of Krakow or municipal organisational units. The use of the STRADOM System enables the parameterisation and accountability of the Krakow Development Strategy in terms of planned and achieved results, as well as financial outlays. Each of the Strategic Management Instruments (MSIs), i.e. Programmes, Projects and Project Portfolios, is implemented with the support of specific management methodologies.

The following set of indicators (see Table 30) has been adopted for the Climate Change Contract for Krakow. The indicators will be monitored on a continuous basis during the implementation of the Contract's activities, and in addition, every year the degree of their implementation will be reported within the Project Portfolio "Zero Emission Krakow", which is one of the Strategic Management Instruments.

Table 30. Krakow List of indicators for monitoring Climate Change Contract.

Sectors of operation	Activities and projects	Indicator	Indicator unit	Baseline	Target value by 2030
	All activities from the sector	W54_U Greenhouse gas emissions in GMK - City operations	MgCO₂ e	7,921 thousand Mg [2018]	1,521,000 Mg, (80% reduction BAU2030)
Buildings and heating	BIC-1 BIC-2 BIC-3 BIC-4 BIC-8 BIC-9 BIC-11	M19_151 Total surface area of insulation completed in public buildings	m²	-	Increasing trend
	BIC-1 BIC-2 BIC-3 BIC-4 BIC-8 BIC-9 BIC-10 BIC-11 E-9	W25_O Reducing the non- renewable primary energy demand of single- family buildings	MWh	572.49 [2018]	Increasing trend



	1			T	1
	E-12 E-13				
	BIC-1 BIC-2 BIC-3 BIC-4 BIC-8 BIC-9 BIC-11	W24_O Number of single-family buildings which underwent thermomodernisat ion under the Krakow Municipality grant	Number of buildings	22 [2018]	Increasing trend
	All activities from the sector	W54_U GMK greenhouse gas emissions - city operations [tCO ₂ e].	MgCO ₂ e	7,921 thousand Mg [2018].	1,521,000 Mg, (80% reduction BAU2030)
Electricity	BIC-5 BIC-6 BIC-7 BIC-8 BIC-10 E-1 E-2 E-3 E-4 E-5 E-6 E-7 E-8 E-9 E-10 E-12 E-13 E-14 E-15 E-16 E-17 TR-1 GOZ-1	W20_U Share of electricity produced from renewable energy sources in total electricity consumption %	%	2.17% [2018]	Increasing trend
	All activities from the sector	W54_U GMK greenhouse gas emissions - city operations [tCO ₂ e].	MgCO₂ e	7,921 thousand Mg [2018].	1,521,000 Mg, (80% reduction BAU2030)
Transport	TR-2 TR-3 TR-5 TR-6 TR-7 TR-8 TR-9 TR-10	W2_T Share of public transport in the distribution of transport tasks	%	42.1% [2018]	Increasing trend



	TR-14				
	TR-12 TR-13 TR-15 TR-16	W16_T Implementation rate of the number of parking spaces in the P+R system	%	12.6% [2018]	Increasing trend
	TR-1 TR-8 TR-16	W43_O Number of electric vehicle charging stations installed under the grant from Municipality of Krakow	Number of charging stations	8 [2023]	Increasing trend
	TR-4 TR-11 TR-12 TR-14	W45_T Increase in the length of cycle routes	km	9.3km [2018].	Increasing trend
	TR-5 TR-7 TR-10	W4_T Share of tracks in need of upgrading	%	20.7% [2018]	Downward trend
	TR-6	W44_T Share of tram fleet over 15 years old	%	78% [2018]	Downward trend
Waste management and CE	All activities from the sector	W54_U GMK greenhouse gas emissions - city operations [tCO ₂ e].	MgCO₂ e	7,921 thousand Mg [2018].	1,521,000 Mg, (80% reduction BAU2030)
			1		
	All activities from the sector	W54_U GMK greenhouse gas emissions - city operations [tCO ₂ e].	MgCO ₂ e	7,921 thousand Mg [2018].	1,521,000 Mg, (80% reduction BAU2030)
Other	I-1 I-2 I-3 I-4 I-5 I-6 I-7 I-8 I-10	W27_O Number of "pocket" parks	Number of parks	18 [2018]	Increasing trend
	I-1 I-2 I-3 I-5 I-10	W26_O Share of forest in total city area	%	4.22% [2018]	6%



Multisectoral	The increase in the indicator should be the result of all the activities carried out	W23_D Satisfaction with ability to influence city government	%	3.,4% [2018]	Increasing trend
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Beyond the Climate City Contract monitoring plan established to follow the objectives and actions, the benchmarking of selected solutions boards for Krakow are presented below. The boards provide information to reflect about the convenience of proposed pathway, aiming to identify potential areas for improvement.



2 Krakow Master scenario





Master scenario impact assessment

Nonrenewable PE*

GWP*

CAPEX

GDP generation

Employment generation

441

/inhabitant

128
tonCO2 eq saved

8 K€ investe K€ generated /inhabitant

0,092

jobs created /inhabitant

*PE: Primary Energy
*GWP: Global Warming Potential

Figure 75. Krakow Master Scenario Benchmarking board.



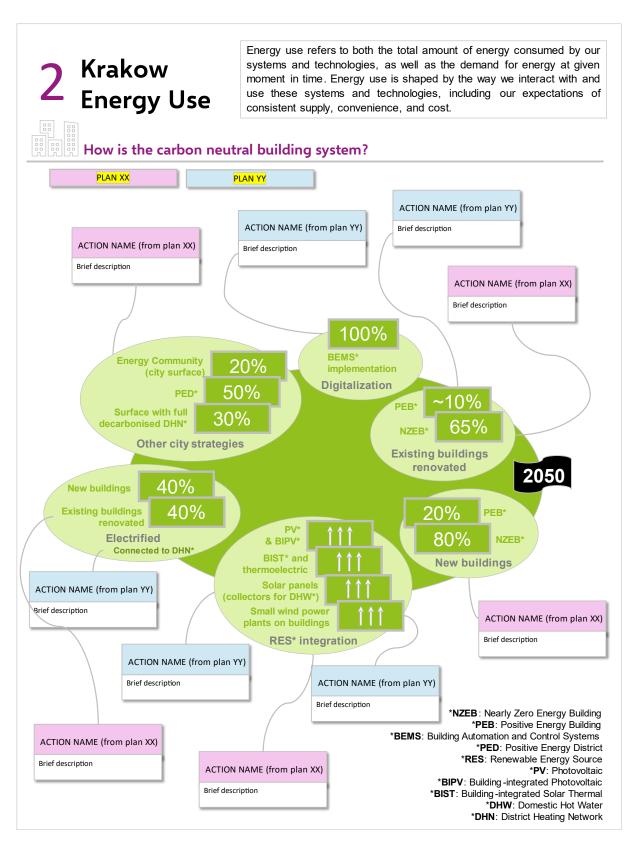


Figure 76. Krakow Energy Use Benchmarking board.



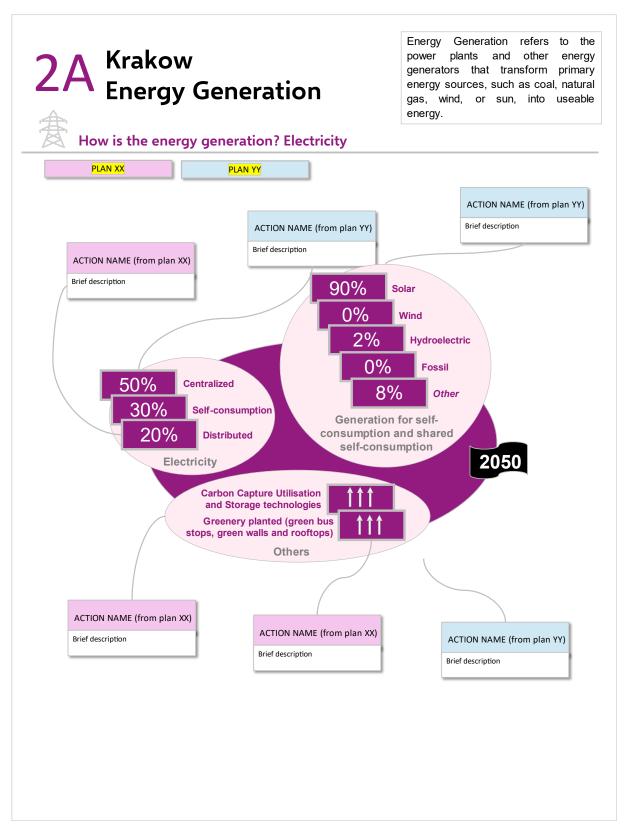


Figure 77. Krakow Energy Generation "Electricity" Benchmarking board.



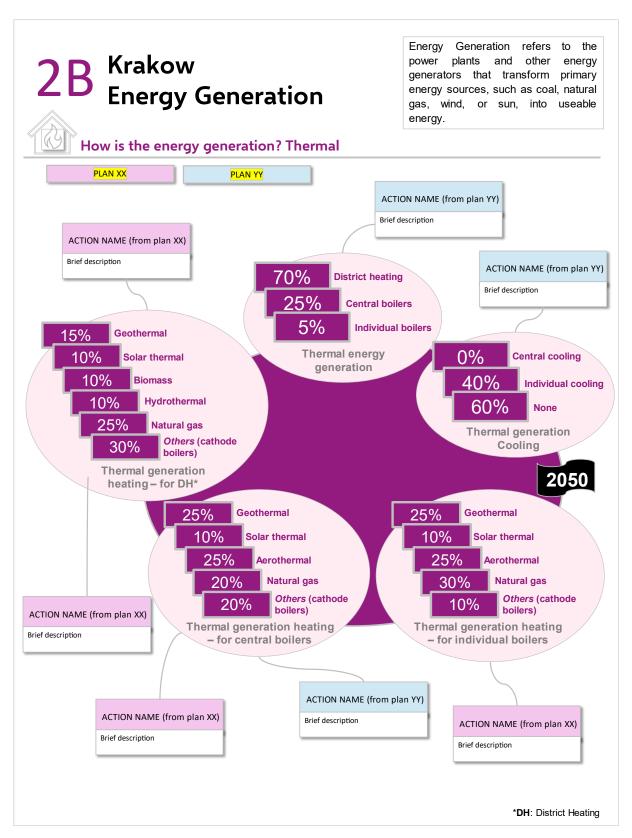


Figure 78. Krakow Energy Generation "Thermal" Benchmarking board.



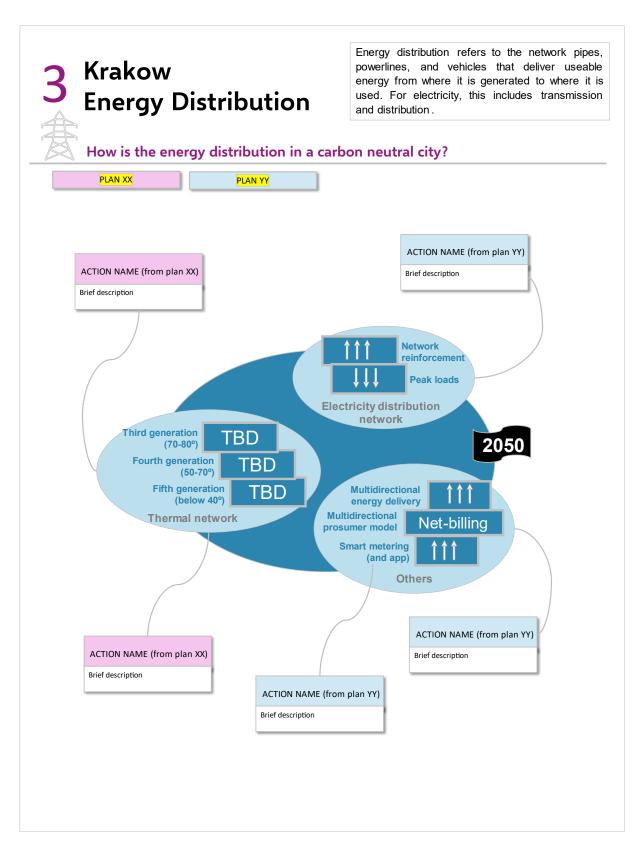


Figure 79. Krakow Energy Use Benchmarking board.



Annex 8: Matosinhos

Impact assessment of the master scenario

Based on the results of the BaU and Master scenarios agreed with the city, the latter achieves an additional cumulative saving of 12,485 GWh of final energy consumption regarding the former through the whole scenario period (2019-2030), in order to fulfil the City Vision set for 2030 by the municipality. The Master scenario also reaches additional cumulative savings of 21,728 GWh and 37,884 GWh of total and non-renewable primary energy respectively compared to the BaU scenario. In the environmental dimension, the quantity of cumulative emissions additionally abated by the Master scenario regarding the BaU amounts to 8,695 ktonnes CO_2 through the whole scenario period.

Table 31. Matosinhos Master scenario energy and environmental indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Savings
	Cumulative final energy	87,548	75,063	12,485
Enorgy	Cumulative total primary energy	101,927	80,199	21,728
Energy	Cumulative non-renewable primary energy	95,286	57,402	37,884
Environmental	Cumulative GHG emissions	22,003	13,308	8,695

The implementation and deployment of the additional measures considered in the Master scenario compared to the BaU, require an additional investment of €3,497 M. In turn, it generates €2,727 M GDP and 36,495 more jobs than the BaU.

Table 32. Matosinhos Master scenario socioeconomic indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Additional investment/ Increase in GDP/employment
	CAPEX (M€)	57	3,554	3,497
G	GDP impact (M€)	37	2,764	2,727
Socioeconomic	Employment (jobs created)	442	36,937	36,495

Benchmarking of selected solutions

This section includes the benchmarking boards developed for Matosinhos according to the information provided to the climate neutral energy system survey. Cities are invited to complete the boards with the information that they consider more relevant to drive the discussion.



2 Matosinhos Master scenario

Master scenario impact assessment

2030

Nonrenewable PE*

GWP*

CAPEX

GDP generation **Employment** generation

220

/inhabitant

51 onCO2 eq saved /inhabitant **20**K€ invested /inhabitant

16
K€ generated
/inhabitant

0,212

jobs created /inhabitant

*PE: Primary Energy
*GWP: Global Warming Potential

Figure 80. Matosinhos Master Scenario Benchmarking board.



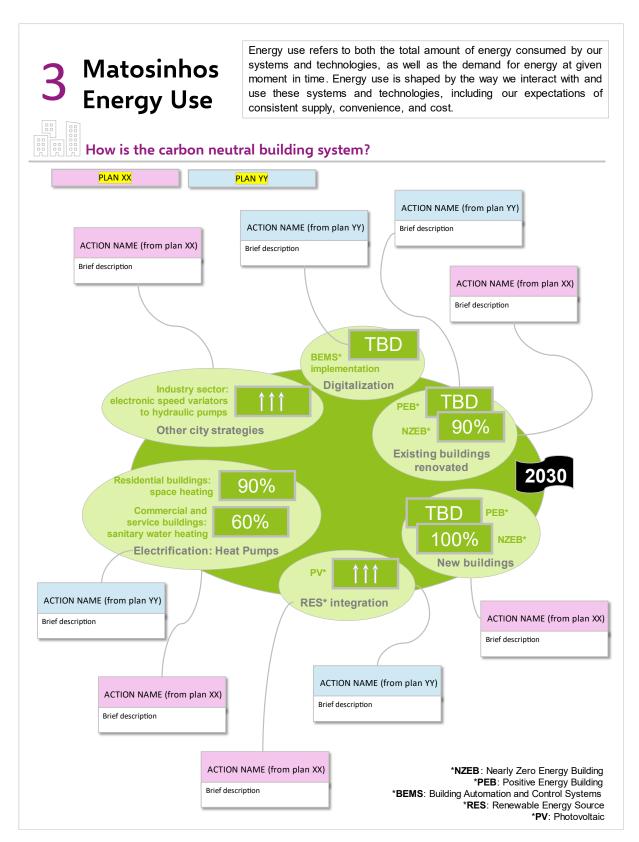


Figure 81. Matosinhos Energy Use Benchmarking board.



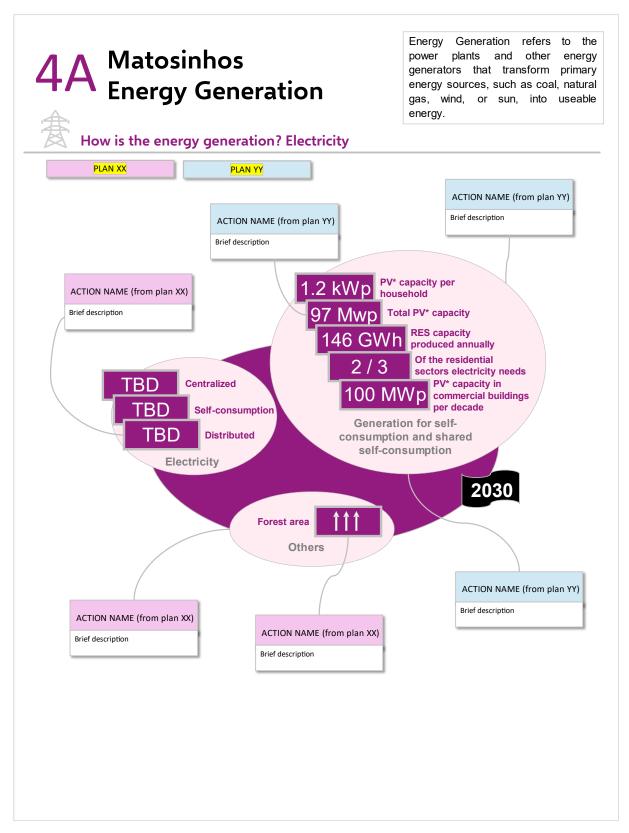


Figure 82. Matosinhos Energy Generation "Electricity" Benchmarking board.



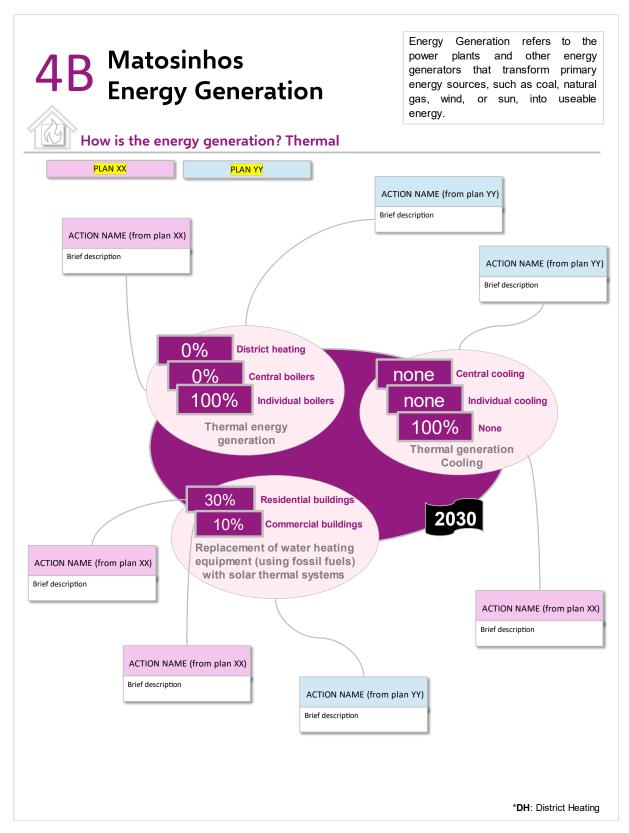


Figure 83. Matosinhos Energy Generation "Thermal" Benchmarking board.



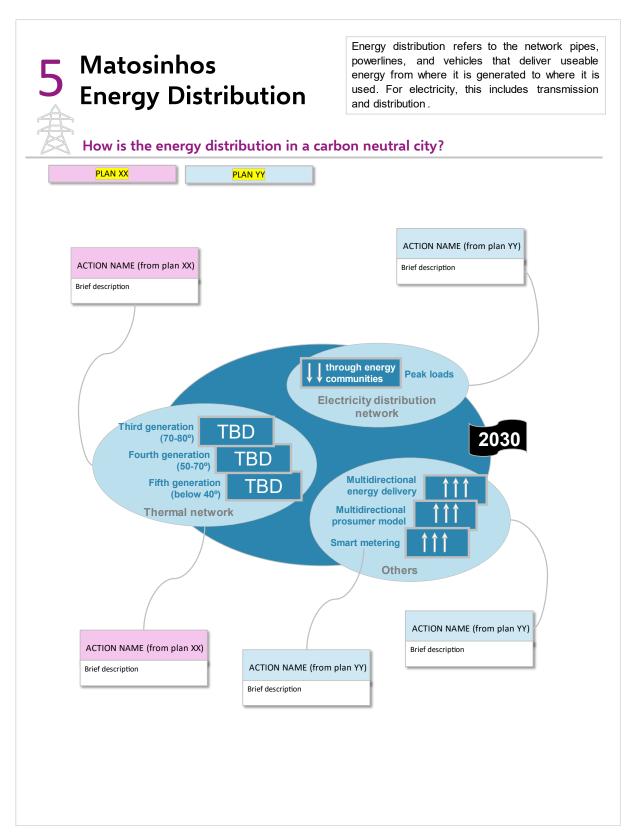


Figure 84. Matosinhos Energy Distribution Benchmarking board.



Annex 9: Riga

City vision

The City of Riga has undertaken the commitment of becoming climate-neutral by 2030, as evidenced by Riga's participation in the EU Mission for 100 Climate-Neutral and Smart Cities by 2030 (Mission) and the ambitions integrated into the city's development planning framework.

Sustainability has been important in Riga since 2008, when it was the first European capital to join the Covenant of Mayors. This commitment served as a catalyst for the municipality to develop its first "Sustainable Energy Action Plan for 2010–2020" in 2010. In the first plan, the city undertook to reduce its CO_2 emissions 20% by 2020, compared to 1990 levels. The 2011 and 2012 progress reports showed that the target had already been exceeded in 2011, with a 51% reduction. This led to an updated in 2014 "Riga Smart City Action Plan 2020", with new, more ambitious targets. The goal was to bring the city closer to smart city status and achieve a 55–60% CO_2 emissions reduction by 2020.

In 2021, Riga signed the Paris Declaration on Climate Change and renewed its commitment to the Covenant of Mayors as part of its continued implementation of climate mitigation and adaptation measures and as a sign of its ambition to continue with them.

Since 1990, the City of Riga has taken significant steps to reduce CO₂ emissions, mainly by replacing fossil fuels that have a high emission factor, resulting in decrease of carbon emissions (2020) by almost 60% compared to 1990.

In 2022, the "Riga Sustainable Energy and Climate Action Plan until 2030" (Riga SECAP 2030) was approved, setting a target of 30% carbon emissions reduction compared to 2019 by 2030, which is equivalent to 70% compared to 1990. In addition to 1990 as the original baseline year, 2019 was chosen as the second baseline year. Also, it was chosen to mitigate the significant impact of Covid-19 on 2020 consumption data.

In 2022 Riga joined the Mission, committing to further increase the target to 80% relative to 1990 and undertook the elaboration of Riga's Climate City Contract (Riga CCC) that will replace the Riga SECAP 2030. Riga CCC builds upon the priority areas and emissions reduction measures already identified in the Riga SECAP 2030, adding a plan for the land use and waste sectors, adjusting the city's target upwards, to 80% compared to 1990, and prescribing measures for the additional sequestration of 16% of carbon emissions.

Process

Over the years Riga has developed good practices for the citizen participation and consultations with the active part of the civil society are an essential part of urban planning. The city understands the important role of different stakeholders in the development of its urban environment. A broad range of measures have been taken to strengthen the development and growth of neighbourhood associations involved in strategic and spatial planning, representing the vision of the residents of each of the neighbourhoods.

ATELIER project facilitated sequential co-creation and co-development process for the development of the Riga City Vision. Already in 2020, the City of Riga established its Smart City Planning Group (SCPG) with aim to facilitate the city vision co-development.



Local residents, national and regional institutions, academia, industry associations, NGOs, and other stakeholders, through the SCPG were extensively involved in the development of Riga City Vision and Action plan, namely, the Riga SECAP 2030, which forms the basis for Riga CCC. During 2021-2022, 11 working group meetings were held with city departments and enterprises, and there were 7 thematic discussions with the participation of external stakeholders. As a result, 163 comments were received during the public consultations.

Further, during the development of Riga CCC, the SCPG was considerably enlarged by considerable number of external participants, and the city publicly encouraged everyone to participate in co-creation workshops to achieve the broadest possible participation. More than 130 stakeholders responded to the call, representing academia and research, national and regional government institutions, industry associations, businesses and start-ups, NGOs, as well as active residents of Riga expressed their interest in participating. Development of Riga CCC was kicked-off during the ATELIER GA held in Riga on June 15, 2023, with the participation of the leading ATELIER experts who provided invaluable support by sharing their knowledge and presenting motivational case studies. Parallel to extensive stakeholder consultations, during 2023-2024, 6 co-creation workshops were held, for which 6 thematic descriptions for each of the CCC sector were prepared. Through facilitated co-development process each sector was discussed, stakeholders proposed the fields of action within each sector and outlined potential short-term (2-3 years), medium-term (4-5 years) and long-term (6-7 years) measures to be implemented. Responsible stakeholders (municipal institutions, businesses, etc) for the implementation of each measure were defined, budget needed for the implementation assessed and implementation timeline elaborated. Draft Riga CCC was circulated to all involved stakeholders, and 347 comments were received from the participants of the co-creation workshops, and these were incorporated into the final version of the Riga CCC.

Detailed outline of the Riga City Vision and Riga CCC development process is provided in ATELIER D2.6 and D2.8.

Motivation

In the initial phase of Riga CCC development, a discourse was initiated among local stakeholders concerning the main reasons for climate action in Riga: "Why Climate-Neutrality is important for Riga City Municipality?"

It was concluded by involved stakeholders that Climate-Neutrality is a state where human activities achieve "net zero" emissions, thus emphasizing the need for the people-centred approach to climate action.

The following **key drivers for climate action in Riga city** were identified and prioritised (among many others proposed by the stakeholders):

- 1. **Energy efficiency** rational energy consumption in buildings, energy renovation...
- 2. **Renewable energy resources** energy transition to resources which recover fast...
- 3. **Energy security** Latvia does not own oil or natural gas deposits...
- 4. **Economic growth** less imported fossil fuels, less money transferred to others, more jobs…
- 5. **Circular economy** efficient use of materials in all sectors...
- 6. **Reduction of air pollution** electrification, efficient energy production, energy efficiency...





7. **Adaptation to climate change** – greener city, less heat islands, less load on rainwater sewage systems...

Through facilitated co-development process these drivers were transformed into strategic goals and horizontal priorities and latter, within the co-creation workshops, these priorities were further detailed, setting specific fields of action, short-term (2-3 years), medium-term (4-5 years) and long-term (6-7 years) measures and targets to achieve «net zero» emissions.

Role of Stakeholders

Riga climate framework – Riga City Vision, Riga SECAP 2030, and, subsequently, Riga CCC – was elaborated, applying a strategic, participatory and multi-sectorial energy planning approach based on a long-term system thinking, bringing stakeholders together to achieve a common vision for future urban decarbonisation strategies, mutually agreed targets, priority areas and appropriate measures with airmarked funding for their implementation. Codevelopment was accomplished in a joint effort by building common vision, creating a consensus, mobilising joint actions, shaping the city's development path as well as promoting a sense of ownership and commitment among the involved stakeholders towards the achievement of the common climate goals.

The key role of over 130 stakeholders was related to leveraging feedback to co-develop the Riga City Vision, defining strategic goals and priorities, proposing and evaluate transition pathways and policy scenarios towards the final, mutually agreed Master scenario for climateneutral Riga by 2030.

The municipal enterprises, including the Riga district heating operator "Rīgas siltums", and Riga public transport operator "Rīgas satiksme", are important stakeholders. The majority of emissions generated in the city are the responsibility of these and other municipal services providers, so they can have a considerable direct impact on reducing the emissions.

The measures initiated as part of the participation and co-creation process have been validated by local stakeholders and integrated in the final Master scenario of Riga CCC.

Riga City Vision

The new target for the achievement of the 2030 climate goals outlined in the **Riga City Vision** is a 53% CO₂ emissions reduction compared to 2019, which at the same time means a CO₂ emissions reduction of 80% compared to 1990, and reaching climate neutrality in municipal infrastructure. Forest areas belonging to the City of Riga are planned to be used to provide a constant sequestration of CO₂ of over 300 ktCO₂ per year by 2030. This provides additional 16% offset in CO₂ emissions compared to the total emissions in 2019.

Riga City Vision encompasses the entire administrative territory of the City of Riga, including CHP-2, which is physically located outside the city's administrative territory, but supplies heat energy to the city. The emissions records cover all CO₂ emissions resulting from the energy consumed within the administrative territory of Riga, as well as emissions resulting from Riga municipal waste management enterprise, landfill "Getliņi" adjacent to Riga border, and carbon sequestration in forests outside the administrative territory of Riga, as these forests are owned by the Riga City Municipality and managed by the municipal enterprise "Rīgas meži". The vision also covers companies in the ETS sector, and it considers the following areas:

- Heat energy generation and consumption.
- Electricity consumption.
- Transport energy consumption.





- Land use, urban greening and forestry.
- · Waste management and circular economy.

The key **strategic priorities** for the City of Riga **to achieve the target set in the City Vision** are as follows:

- **energy efficiency first**: renovation and improved energy efficiency of all buildings (residential, municipal, commercial).
- **sustainable mobility**: provision of electric vehicles infrastructure and decarbonisation of public and private transport.
- renewable energy sources: switching to renewable energy sources such as zeroemission heat sources in heat supply, solar and wind power for the generation of electricity.

Other **priorities** include cross-sectorial circularity, highest quality and sustainability of urban environment, affordable housing, convenient mobility in the city, sustainable lifestyle, life-long education of citizens, etc.

Riga City Vision defines the following **horizontal priorities** for Riga to achieve its climate goals:

- Stakeholder participation: in order to involve as many or as diverse stakeholders as possible in the implementation of the measures already identified and in the planning of new measures, representatives of the institutions in charge of each sector shall identify and approach the main stakeholders, including representatives of neighbourhood centres and communities that combine and represent the interest of various social groups, as well as businesses and associations representing business interests, NGOs and other stakeholders, which can disseminate information to an even broader share of the public.
- Social innovations: the opportunities that are assessed and developed shall include support for the creation of innovation centres and incubators; opening up of data to foster innovation; strengthening the cooperation with academia and research institutions; setting up of climate innovation funds; development of education programmes; organisation of regular networking events, etc.

Riga City Vision highlights the Riga's motivation for participating in the Mission, encompassing practical benefits for the city and its residents, which will help the city mitigate various energy and climate change risks, and contribute to the economic development of the city and to the health and prosperity of its residents.

Through facilitated co-creation and co-development process (see also ATELIER D2.6) Riga City Vision strategic priorities were further detailed in joint effort of over 130 stakeholders, setting specific fields of action, short-term (2-3 years), medium-term (4-5 years) and long-term (6-7 years) measures and targets to reduce emissions.

Master scenario

Master scenario includes the following 6 sectors with 47 fields of action:

(P) Municipal infrastructure and facilities (measures included will contribute 7% of the total CO₂ reduction):

P1: Continuous improvements in the energy management system.

P2: 100% renewable heat energy share in municipal buildings.

P3: 100% renewable electricity share in municipal buildings.





P4: Development of a plan for the renovation of municipal buildings until 2030 and consistent renovation of buildings

P5: Upgrading of street lighting.

P6: Achieve a 100% renewable electricity share for streetlights, traffic lights, and clocks in 2030.

P7: Creation of a data records system for the municipal vehicle fleet and improvements in the efficiency of vehicle use.

P8: Promotion of the use of public transport for work among employees of the Riga municipal government.

P9: Transition to zero-emission vehicles in companies, municipal institutions.

P10: Energy efficiency and RES use in wastewater treatment plants.

(E) Energy production (measures included will contribute 37% of the total CO₂ reduction):

E1: Promotion of zero-emission technologies and RES in district heating.

E2: Ensure the connection of new clients to DHS of Riga.

E3: Increases in the efficiency of heat generation and management, and digitisation of the heating system.

E4: Gradual transition to the 4th generation heating supply system.

E5: Implementation of innovative pilot projects.

E6: Promote electrification, use of RES in decentralised heating, or connection to DHS.

E7: Promote the use of RES in the generation of electricity for Riga's needs.

(Dz) Multi-apartment residential buildings (2% reduction in CO₂ emissions):

Dz1: Improvement of the availability of information and data about the energy efficiency of multi-apartment residential buildings.

Dz2: Revision of laws and regulations to increase the rate of multi-apartment residential building renovation in Riga.

Dz3: Involvement of local residents in the renovation of multi-apartment residential buildings.

Dz4: Establishment of the Riga Energy Efficiency Fund (REEF).

Dz5: Research and implementation of new standardised solutions for the renovation of buildings, reducing building renovation costs.

(T) Transport (largest CO₂ reduction: 54% of the total amount):

T1: Urban planning aimed at creating a city where local residents and guests are less dependent on private cars.

T2: Measures to promote distance working and increase the availability of online services.

T3: Promotion of active lifestyle and cycling.

T4: Increase the share of public transport in everyday passenger trips.

T5: Restrictions on private transport.

T6: Other measures to reduce car use.

T7: Promotion of electrification in private transport and provision of services.

T8: Gradual transition to clean technology in vehicles that enable municipal functions.

T9: Collection of mobility data and monitoring of measures implemented.

(A) Waste management and circular economy:





- A1: Develop and improve the data records system and mapping of infrastructure.
- A2: Waste prevention.
- A3: Improving of the amount and quality of household waste sorting.
- A4: Development of sorted waste collection infrastructure.
- A5: Promotion of waste recycling.
- A6: Development of a Riga circular economy action plan for 2026–2030.
- A7: Development and implementation of an integrated municipal wastewater management plan.
- A8: Provision of information and education, awareness-raising for waste generators.

(ZM) Forestry and CO₂ sequestration:

CO₂ sequestration in the forest areas owned by the City of Riga (municipal forest management enterprise LLC "Rīgas meži"):

ZM1: Targeted creation of uninterrupted forest coverage, selection of sustainable planting material for forestry activity zones.

ZM2: Development of research and innovation to improve CO₂ sequestration in the urban environment.

ZM3: Sharing knowledge on new forest management methods.

Reduction of GHG emissions in the city's forest areas:

ZM4: Develop and improve the data records system and emissions calculations.

ZM5: Compliance with forest certification conditions for long-term afforestation area restrictions.

ZM6: Improvement of the company's forestry risk assessment, assessing the threats and opportunities for developing forest stands.

ZM7: Investigation and implementation of measures to reclaim peat bogs and manage these areas otherwise.

ZM8: Greening of Riga's urban environment (rest of Riga's administrative territory).

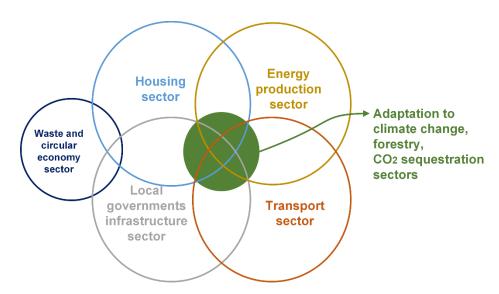


Figure 85. Riga CCC Master scenario sectors.



Corresponding to the strategic priorities of the Riga City Vision, each sector has a clear goal of emissions reduction and an outline of the core list of actions.

Master scenario

Previous version of the city model included two scenarios with a 2030-time horizon (see D2.6). On the one hand a scenario based on the measures included in the Riga SECAP 2030, and on the other hand a scenario aiming for climate neutrality by 2030 (Riga Climate Neutral Scenario in D2.6). The latter has been refined and aligned with the assumptions considered within Riga CCC. This new scenario is considered the final Riga Master scenario (or Riga CCC scenario).

The main differences between this final Master scenario of Riga CCC and the former Riga Climate Neutral scenario (CN scenario) are the following:

• One of the most relevant assumptions in this final Master scenario regarding the previous CN scenario is the non-consideration of the full decarbonisation of both power and heat supply networks. Indeed, renewable contribution to DH network only reaches 56% yielding a 0.09 ton CO₂/MWh emission factor for heat produced within the city. Whereas a 0.05 ton CO₂/MWh emission factor is assumed for the electricity consumed within the city resulting from both the decarbonisation of the national grid and the contribution of local electricity generation. It should be noted that these emission factors do not apply to municipal assets (i.e. municipal buildings, street lighting, water supply and sewage system, and municipal fleet) since it has been considered that heat and electricity purchased for these has to be green-labelled (i.e. carbon-free) according to the Riga SECAP 2030 document.



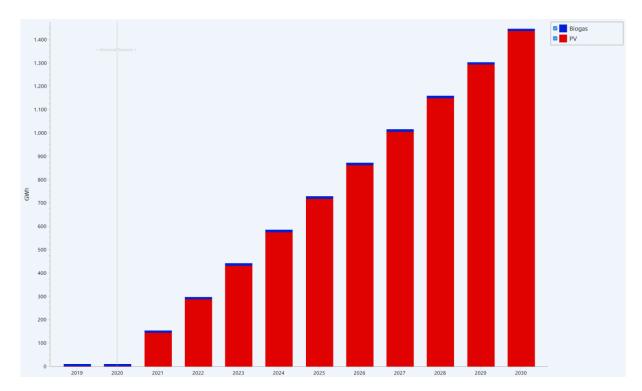


Figure 86. Evolution of local RES electricity generation by feedstock fuel in Riga Master scenario.

• While the CN scenario considered the renovation of the whole residential building stock, the final Master scenario assumes that 90% of the stock is renovated by 2030. In addition, achieved savings by the renovation of residential buildings are also diminished from 60% to 50%, while new buildings achieve a 73% energy demand reduction regarding current standards, instead of 90% assumed in the CN scenario. Fuel mix also changes, with a small portion of natural gas remaining in the final Master scenario by 2030, but with and increase in the consumption of DH regarding the CN scenario. The residential sector is not fully decarbonised in the final Master scenario.



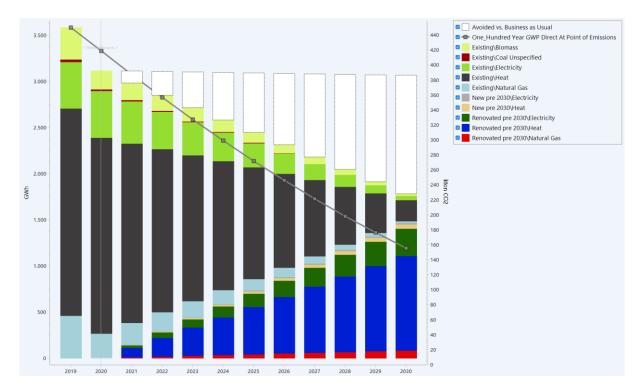


Figure 87. Residential final energy consumption (by household type and fuel) and GHG emissions in Riga Master scenario.

 As in the CN scenario, public transport in the final Master scenario is fully electrified by 2030. Moreover, the demand for public transport services is slightly increased (regarding CN scenario) to the detriment of private transport. However, since the electricity supply is not fully decarbonised in the final Master scenario, public transport is not carbon-free in this scenario.



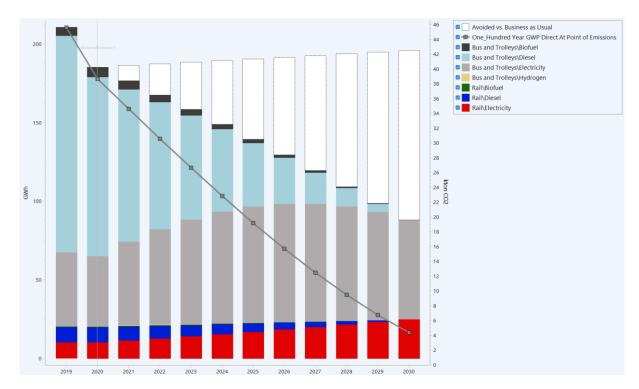


Figure 88. Public transport final energy consumption (by vehicle type and fuel) and GHG emissions in Riga Master scenario.

• Concerning the use of private transport, the share of electric vehicles is increased comparing to the previous CN scenario. Electric cars and electric vans reach 85% of their respective stocks, while trucks and other vehicles also experiment a further electrification (from 20% in the CN scenario to 50% in the final Master scenario). In addition, due to the increase in the use of public transport and the larger promotion of active mobility measures in this final Master scenario regarding the CN scenario, greater energy and emissions reductions are achieved in this sector.



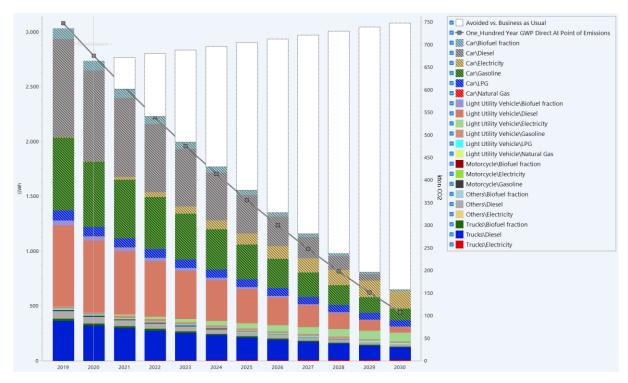


Figure 89. Private transport final energy consumption (by vehicle type and fuel) and GHG emissions in Riga Master scenario.

No changes regarding the CN scenario have been considered within the municipal assets (municipal buildings, street lighting, water supply and sewage system, and municipal fleet), private tertiary buildings, nor the industry sector.

Altogether, the City of Riga manages to halve its final energy consumption regarding 2019 in the final Master scenario. The reduction is mainly driven by changes in the city mobility: switch towards public transport and active mobility, and electrification of the vehicle fleet. Buildings also halve their energy use regarding the base year thanks to renovation and other efficiency measures.

Table 33. Achieved final energy savings in Riga Master scenario.

SECTOR	2019 ¹⁴ (GWh)	2030 % reduction compared to 2019
Residential	3,585	-50%
Private tertiary buildings	2,077	-40%
Municipal buildings	308	-50%
Street lighting	30	-72%
Water supply and sewage system	35	-50%
Industry	1,633	+0%
Municipal fleet	17	-81%

¹⁴ Base year used in the model has been changed regarding the BaU version in D2.5. In line with the reference used in the Riga SECAP 2030 document, new base year is 2019. Moreover, 2020 has been also calibrated with historical data. Nevertheless, data should be revised since inconsistencies are still found. The breakdown of data by sector and fuel has been difficult in some cases and has been performed based on assumptions or skewed data.



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Public transport	211	-58%
Private transport	3,031	-79%
TOTAL	10,928	-49%

Concerning GHG emissions only municipal assets are fully decarbonised due to mandatory purchase of green energy to cover their demand. Transport sector achieves a significant reduction of GHG emissions due to modal changes and electrification (though electricity is not fully decarbonised). Fossil fuels are nearly phased out with small remnants of gasoline and diesel in the private vehicles fleet and natural gas in residential buildings. On this concern, residential and private tertiary buildings are not fully decarbonised because of DH still fuelled by a 44% share of fossil sources. All in all, the city should compensate 400 ktonnnes of CO₂ to become carbon neutral by 2030.

Table 34. Achieved GHG¹⁵ savings in Riga Master scenario.

SECTOR	2019 (kton CO ₂)	2030 % reduction compared to 2019
Residential	450	-65%
Private tertiary buildings	285	-72%
Municipal buildings	39	-100%
Street lighting	3	-100%
Water supply and sewage system	4	-100%
Industry	151	-69%
Municipal fleet	5	-100%
Public transport	46	-90%
Private transport	747	-86%
TOTAL	1,730	-77%



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¹⁵ Note that GHG emissions in all figures and tables for Riga Master scenario reflect a scope 2 assessment. That is, power and heat generation emissions are allocated to the final energy consumption of electricity and heat in end-use sectors.



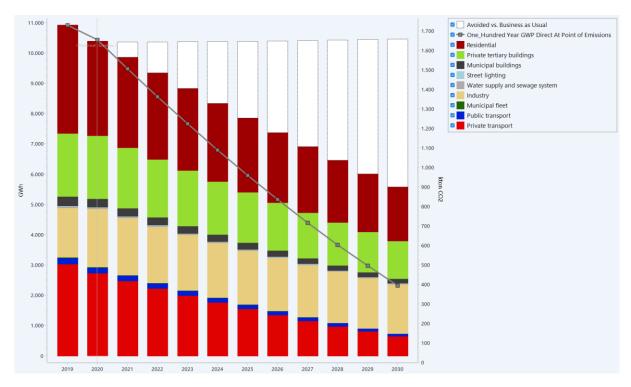


Figure 90. Riga final energy consumption and GHG emissions by sector in the Master scenario.

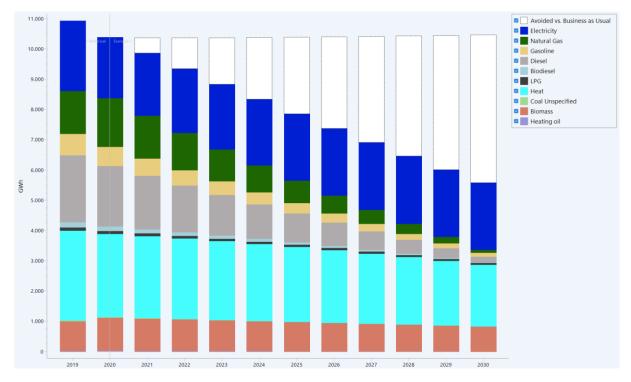


Figure 91. Riga final energy consumption by fuel in the Master scenario.



Impact assessment of the master scenario

Based on the results of the BaU and Master scenarios agreed with the city, the latter achieves an additional cumulative saving of 27413 GWh of final energy consumption regarding the former through the whole scenario period (2019-2030), in order to fulfil the City Vision set for 2030 by the municipality. The Master scenario also reaches additional cumulative savings of 30979 GWh and 35179 GWh of total and non-renewable primary energy respectively compared to the BaU scenario. In the environmental dimension, the quantity of cumulative emissions additionally abated by the Master scenario regarding the BaU amounts to 7187 ktonnnes CO_2 through the whole scenario period.

Table 35. Riga Master scenario energy and environmental indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Savings
Cumulative final energy		125,266	97,853	27,413
Energy	Cumulative total primary energy	167,123	136,144	30,979
	Cumulative non-renewable primary energy	121,201	86,022	35,179
Environmental	Cumulative GHG emissions	19,767	12,579	7,187

The implementation and deployment of the additional measures considered in the Master scenario compared to the BaU require an additional investment of €5,996 M. In turn, it generates €4,685 M GDP and 62,570 more jobs than the BaU.

Table 36. Riga Master scenario socioeconomic indicators results.

Dimension	Indicator	BaU scenario	Master scenario	Additional investment/ Increase in GDP/employment
Socioeconomic	CAPEX (M€)	689	6.685	5,996
	GDP impact (M€)	429	5,113	4,685
	Employment (jobs created)	5,139	67,710	62,570

Climate neutral energy system

Since 1990, the City of Riga has taken significant steps to reduce CO₂ emissions, mainly by replacing fossil fuels that have a high emission factor, resulting in decrease of carbon emissions (2020) by almost 60% compared to 1990. However, the biggest challenge in the energy production sector is to achieve coordinated decision-making among all stakeholders, especially those not being part of the Riga City Municipality.

In the field of electricity and heat generation and consumption, the City of Riga aims to achieve a balanced development of solar and wind farms and to start using energy storage solutions. In district heating, the emphasis is put on the role of electrification, use of residual heat and plans to modernise infrastructure. Biomethane production is being promoted, and natural gas traders will be required to achieve an annual RES share of at least 3%. Restrictions are already in place on the installation of new fossil fuel systems. In the near future biogas/biomethane extraction in the Riga municipal water and wastewater enterprise "Rīgas ūdens" will be launched. This measure is also linked to the future requirement for other municipal services



providers (public transport operator district heating operator, waste management companies, etc.) to adopt RES technologies and to provide in-house sources of energy.

Equally important is the involvement of energy consumers, supporting active users, developing the net system and launching the first energy community initiatives in Riga city.

In 2021, the City of Riga introduced an energy management system (EMS) covering 355 municipal institutions. The implemented EMS was certified according to ISO 50001:2018 in 2023. The system was developed to consistently reduce energy consumption in municipal infrastructure (buildings). The implementation of this system is bringing significant results. The energy cost savings have been allocated to the climate programme to help finance the measures planned for municipal buildings outlined in Riga SECAP 2030 and Riga CCC.

The energy crisis after the 2022 invasion of Ukraine clearly showed that reducing energy consumption in municipal infrastructure, through energy management system and other climate programmes, could reduce costs, while the resulting savings could be utilised to fund climate neutrality measures.

One of the key measures in municipal infrastructure energy savings in winter 2022 was public lighting. Replacing the lights with LEDs, dimming the lighting, and reducing the illumination of building facades, the city reduced the energy consumption of public lighting by 16% in the winter of 2022. City of Riga also focused on saving energy by reducing indoor temperatures in public buildings on off-days. In that way, city saved between 15 and 18% of the heat energy consumed by the municipality's buildings. The energy savings from these measures resulted in cost savings of around EUR 4 million compared to 2021. These EUR 4 million were made available for the implementation of the measures defined in the Riga SECAP 2030.¹⁶

In 2024, a long-term programme is being developed to measure and monitor the CO_2 emissions and energy cost reductions of the measures implemented. To ensure the suitability and added economic value of the measures, regulations were created in Riga that gave a value of EUR 1,00 for every tonne of CO_2 saved or reduced across the lifecycle of the project. This approach represents Riga's commitment to assessing and planning environmental investments in real economic terms.

Benchmarking of selected solutions

In the City of Riga benchmarking – the evaluation of the suitability of proposed measures of the Master scenario of Riga CCC was performed through participatory workshops with involved stakeholders. Each sector of Riga CCC was discussed with the relevant sectorial group of stakeholders and active part of society. Strengths and weaknesses, enablers and barriers were discussed for each Riga CCC sector, field of action and measure. Budget, timeline and responsible stakeholders for the implementation of each proposed measure were codeveloped and mutually agreed. Summary of enablers and barriers for each Riga CCC sector are highlighted, specifically, energy production, electrification of transportation, renovation of multi-apartment residential buildings and urban greening measures. Qualitative indicators are quantified. Thus, it is believed that co-developed and mutually agreed Master scenario of Riga CCC is the optimal path to climate-neutrality. Riga CCC will be reviewed on a regular basis – every 2 years – and amended upon the necessity.

Implementation



¹⁶ Source: https://eu-mayors.ec.europa.eu/en/how-riga-reinvests-its-energy-savings-into-long-term-sustainable-energy-and-climate-action



Although the Riga CCC is in final approval phase, the implementation already has been launched. The following measures, defined as short-term measures, are expected to be implemented in the next 2–3 years:

- In the **housing** sector, which is the largest energy consumer in the city, promotion of energy efficiency and renovation of housing are the municipality's key priorities. Riga has set up a one-stop-shop agency to provide critical support to local residents to facilitate the renovation of multi-apartment residential buildings. Binding regulations have been approved for prioritising district heating and zero-emission heat pumps. The European Investment Bank's ELENA project has been launched, expanding support and the scope of services provided to renovate more multi-apartment residential buildings, and neighbourhood renewal pilot projects are taking place.
- By 2027, in the field of sustainable mobility, it is planned to create an extensive lowemission zone in Riga city centre, develop park-and-ride car park and mobility points, as well as cycle path connections with the suburbs, expand the electric charging network, and replace the existing public transport vehicle fleet.
- In the field of energy production, it is planned to develop zero-emission technologies and continue increasing the share of renewable energy in district heating in the coming years. Pilot projects will be carried out to introduce new technologies and modernise the heating supply system, gradually transitioning to a 4th generation heating system.
- In waste management, priority will be given to measures aimed at improving the quantity and quality of household waste sorting through the development of separate waste collection infrastructure. At the same time, extensive waste prevention measures will be implemented in households, as well as the public and private sectors.
- A comprehensive action plan for 2026–2030 is currently being developed for the field
 of circular economy, intended to foster a systemic shift towards a circular economy
 by integrating its principles across sectors and fields, raising public awareness and
 support, and working towards a shift in consumer culture.
- In the field of **greening the urban environment**, an action plan is being developed, and the rehabilitation of green spaces outside the Riga city centre will continue.

Impact

The measures outlined in the Master scenario of Riga CCC are expected to lead to significant improvements in areas such as:

- **energy efficiency**, ensuring the efficient consumption of energy, helping finance the rehabilitation and renovation of buildings,
- renewable energy sources that renew quickly or are available for free, are inexhaustible, and are locally available,
- **energy security**, reducing consumption and producing energy using renewable sources significantly reduces the risks caused by various external factors (Latvia does not have its own sources of natural gas, diesel fuel, etc.),
- circular economy, which envisages sharing, exchanging, reusing, refurbishing, renewing, and recycling existing materials and products over the longest possible period of time, extending the product life-cycle,
- economic development through less energy import, which will create jobs locally and boost the economy,
- **air quality improvements**, prioritising district heating and emission-free heating sources and replacing ageing combustion plants, especially in the decentralised heating sector,





• adaptation to climate change, strengthening infrastructure to mitigate the impacts of climate change and anticipate potential risks.

Even though Riga already performed a workshop aiming to evaluate the suitability of proposed measures, the benchmarking of selected solutions boards is presented below.



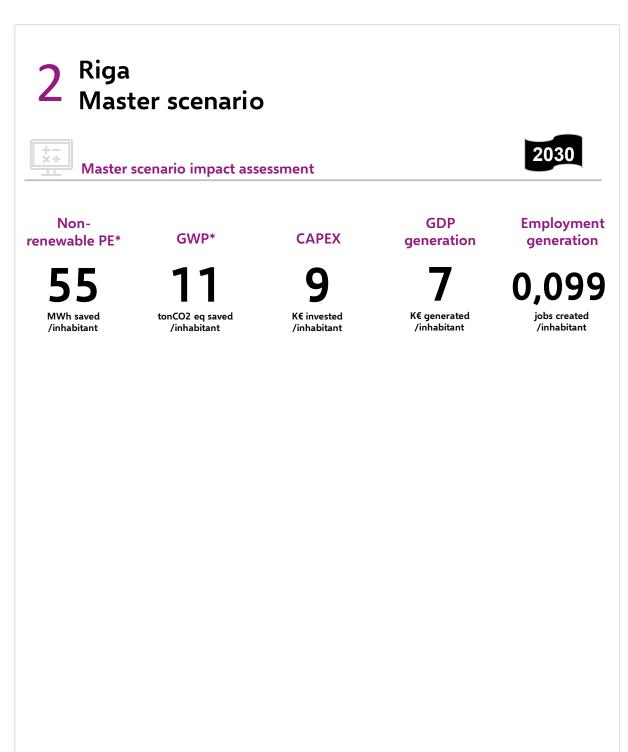


Figure 92. Riga Master Scenario Benchmarking board.

*PE: Primary Energy

*GWP: Global Warming Potential



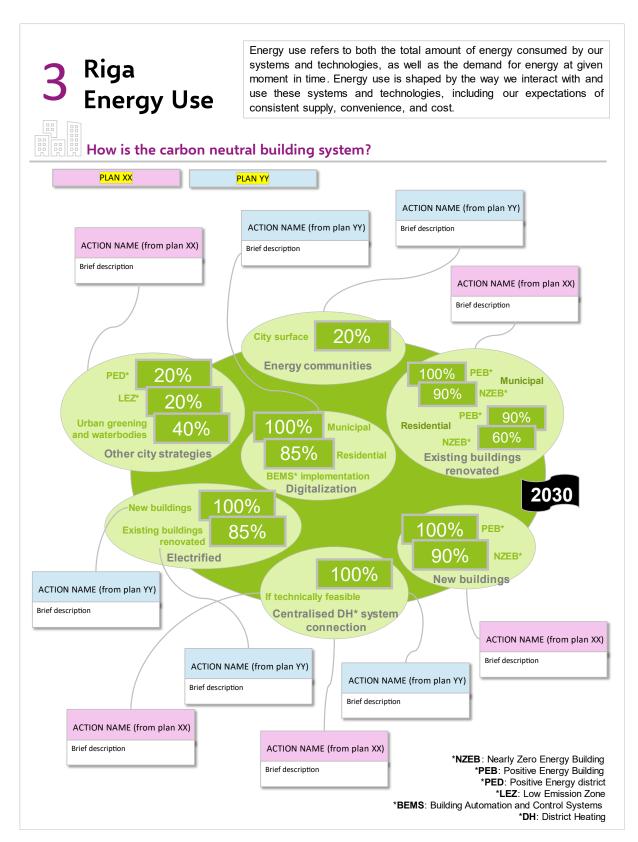


Figure 93. Riga Energy Use Benchmarking board.



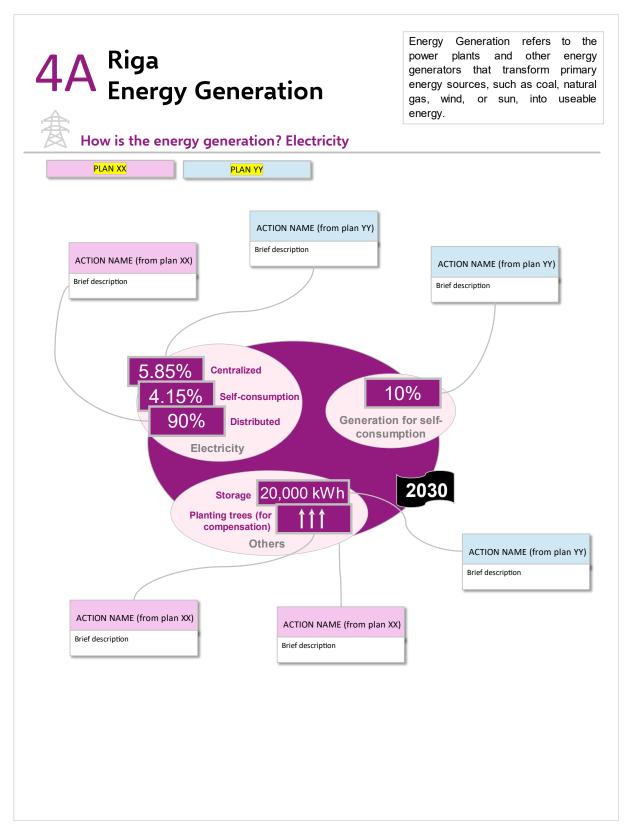


Figure 94. Riga Energy Generation "Electricity" Benchmarking board.



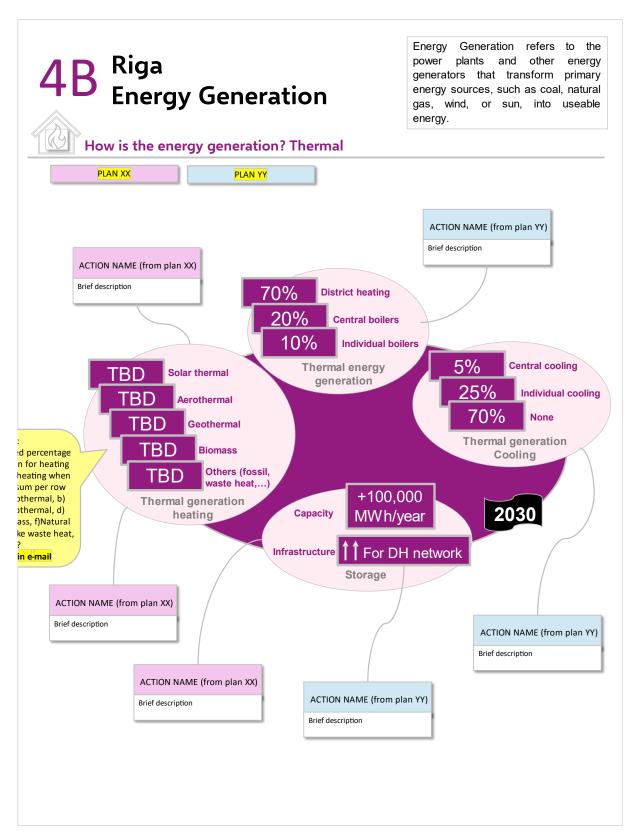


Figure 95. Riga Energy Generation "Thermal" Benchmarking board.



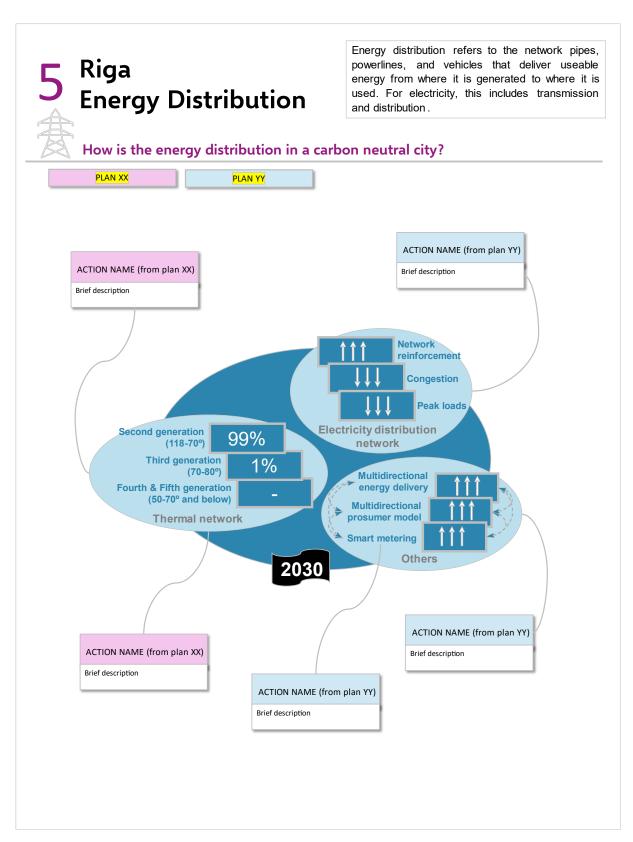


Figure 96. Riga Distribution Benchmarking board.