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# Cities4ZERO: Overcoming Carbon Lock-in in Municipalities through Smart Urban Transformation Processes

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**Abstract:** How can local authorities effectively address the decarbonization of urban environments in the long run? How would their interests and expertise be aligned into an integrated approach towards decarbonization? This paper delves into how strategic processes can help to integrate diverse disciplines and stakeholders when facing urban decarbonization and presents Cities4ZERO, a step-by-step methodology for local authorities, able to guide them through the process of developing the most appropriate plans and projects for an effective urban transition; all from an integrated, participatory and cross-cutting planning approach. For the development of the Cities4ZERO methodology, plans, projects, and strategic processes from five European cities that are part of the Smart Cities and Communities European Commission program have been monitored for 4 years, in close collaboration with local authorities, analyzing ad-hoc local strategic approaches to determine key success factors and barriers to be considered from their transitioning experiences. The study indicates that an iterative strategic approach and a project-oriented vision, combined with a stable institutional commitment, are opening a window of opportunity for cities to achieve effective decarbonization.

**Keywords:** decarbonization; urban transformation; cities; energy transition; strategic planning; Smart cities; Smart zero carbon city

## 1. Introduction

Urban environments are suffering the increasing impact of climate change; thus, mitigation policies are becoming an urgent task for local authorities. By 2050, more than 70% of the global population will live in cities, a figure that shows the potential of municipalities for reducing greenhouse gas (GHG) emissions [1]. Furthermore, engaging cities in this fight can result in an even greater benefit to their citizens, such as reducing the unacceptable pollution at local levels: 9 out of 10 human beings live in places where air quality levels exceed the limits stated by the World Health Organization [2], causing 800,000 extra deaths a year in Europe, and 8.8 million worldwide, according to the latest study by the European Society of Cardiology [3].

Searching for the crucial elements to be addressed by cities to effectively transition towards urban decarbonization, a previous study by the authors points out a real integration of energy planning into urban planning processes as a key factor [4], suggesting the need for an innovative strategic municipal approach capable of integrating diverse disciplines and stakeholders, to identify and develop the most appropriate plans and projects for an effective urban transition.

In Europe, during the last decade, several initiatives have focused on this topic, building upon the studies and growing interest in urban planning aspects of energy, derived from the energy crisis in the 1970s [5–8]. In 2012, the Energy Efficiency Directive (2012/27/EU) encouraged the adoption of integrated urban planning strategies to take advantage of all the energy savings potentially present in urban areas. In line with this, the CONCERTO European Commission (EC) initiative delved into this strategic approach, bringing together all relevant stakeholders while integrating a variety of urban systems and technologies: “the CONCERTO initiative proves that if given the right planning and if all necessary stakeholders are included from the beginning until the end of the project, cities and communities can be transformed into sustainable energy pioneers” [9]. Putting this approach into practice, the STEP-UP (Strategies Towards Energy Performance and Urban Planning), PLEEC (Planning for Energy Efficient Cities) and InSMART (Integrative Smart City Planning) projects (FP7-ENERGY-SMARTCITIES-2012 EC call) examined an integrated approach to urban energy planning, testing diverse tools, methods, and levels of engagement, again, with the focus being on energy savings [10–12]. As a continuation of this evolution, since 2012 the EC has fostered the interaction of cities, industries, small and medium-sized enterprises (SMEs), investors and researchers, through the European Innovation Partnership on Smart Cities and Communities (EIP-SCC) platform, bringing them all together to design and deliver smart-sustainable solutions and projects [4]. In this case, the projects derived from this platform targeted the decarbonization of cities through the formulation of integrated urban plans, and more recently through the concept of positive energy districts (PEDs), intending to tackle the integration of energy and urban planning at both city and district levels. This is the case for the SmartEnCity project—Towards Smart Zero CO<sub>2</sub> Cities across Europe, where the authors have developed the decarbonization Cities4ZERO methodology, presented in this article.

As of 2008, running in parallel, the EC launched The Covenant of Mayors (CoM) initiative, which has engaged up to 10,075 European municipalities in the reduction of their CO<sub>2</sub> emissions [13], fostering local strategic processes through the development of Sustainable Energy Action Plans (SEAPs) and Sustainable Energy and Climate Action Plans (SECAPs, introducing the climate adaptation dimension in 2016). Over the last decade, SEAPs and SECAPs have been “considered the unique tool to manage and act on the Urban-Energy field” regarding mainstream strategic methods for urban decarbonization [14], in many cases replacing national initiatives, thanks to the European funds connected to the signature of the CoM.

However, municipalities present issues when facing these strategic processes of integration; issues that SEAPs/SECAPs are not able to solve in general terms. First, municipalities present, in general, the absence of a strategic dimension in the urban planning system, opting for short-term sectorial actions oriented towards fast results [14]. Second, there is currently a wide gap between theoretical efforts and practical implementation, suffering, in some local cases, from a lack of political commitment, coordination, and funding; all of this worsened by the perverse effects of a marketing use of the SEAP brand [14]. Besides all this, general urban plans do not yet include energy as a dimension to consider.

In the meantime, reality is stubborn, and climate action is urgent. In 2015, the Conference of Parties of Paris (COP21) achieved a binding agreement among all signatory countries, which did not include cities, although it encouraged them to cooperate and support emission reduction efforts [15]. The subsequent COPs (most recently COP25 in Madrid, 2019), as well as the Intergovernmental Panel on Climate Change (IPCC) reports, have stressed the crucial importance of cities in this task, inviting them to take urgent climate action.

To cope with this decarbonization task, cities need a strategic framework able to bundle different elements into a concise, pragmatic, project-oriented approach, based on a long-term strategic vision with a stable-in-time and committed institutional structure, able to integrate disciplines and stakeholders into one single sequence that fits in with the urban planning procedures of each local context. There is still no strategic method that allows cities to cope efficiently with this challenge. How can local authorities effectively address the decarbonization of urban environments in the long and short-run? How would their interests and expertise be aligned into an integrated approach towards decarbonization?

This question is what the Cities4ZERO theoretical approach addresses, based on the experience of a close collaboration with the local authorities of Vitoria-Gasteiz (ES), Tartu (EE), Sonderborg (DK), Asenovgrad (BG) and Lecce (IT), analyzing ad-hoc local strategic approaches, plans, and projects towards decarbonization. The methodology presented in this article is the result of a close analysis of the real planning dynamics in these cities; however, it has not yet been fully implemented, so it remains as a theoretical framework, while the real effects of its full implementation will take several years of monitoring progress towards effective decarbonization. Nevertheless, the application of this theoretical approach in these five cities has already been able to mobilize their local communities towards shared diagnosis, visioning, and planning processes; a cornerstone towards a promising urban transition.

In the rest of this research article, Section 2, the Materials and Methods section, presents the Smart Zero Carbon City guiding concept, while raising the question of how to implement this concept in real urban contexts. Section 2 also describes the method followed in this research, starting from a “beta” version of the strategic approach through to the final version of the Cities4ZERO methodology, which is presented step-by-step in Section 3, Results. Finally, the Discussion and Conclusions sections highlight the importance of supporting cities in this transition, fostering deeper horizontal and vertical integration, and sharing methodologies and tools for cities across a community of practice towards decarbonization.

## 2. Materials and Methods

### 2.1. Smart Zero Carbon City: the Concept Underlying the Methodology

Cities4ZERO methodology intends to align cities’ decarbonization and Smart City solutions implementation, through a concept able to steer this urban transformation process: The Smart Zero Carbon City concept.

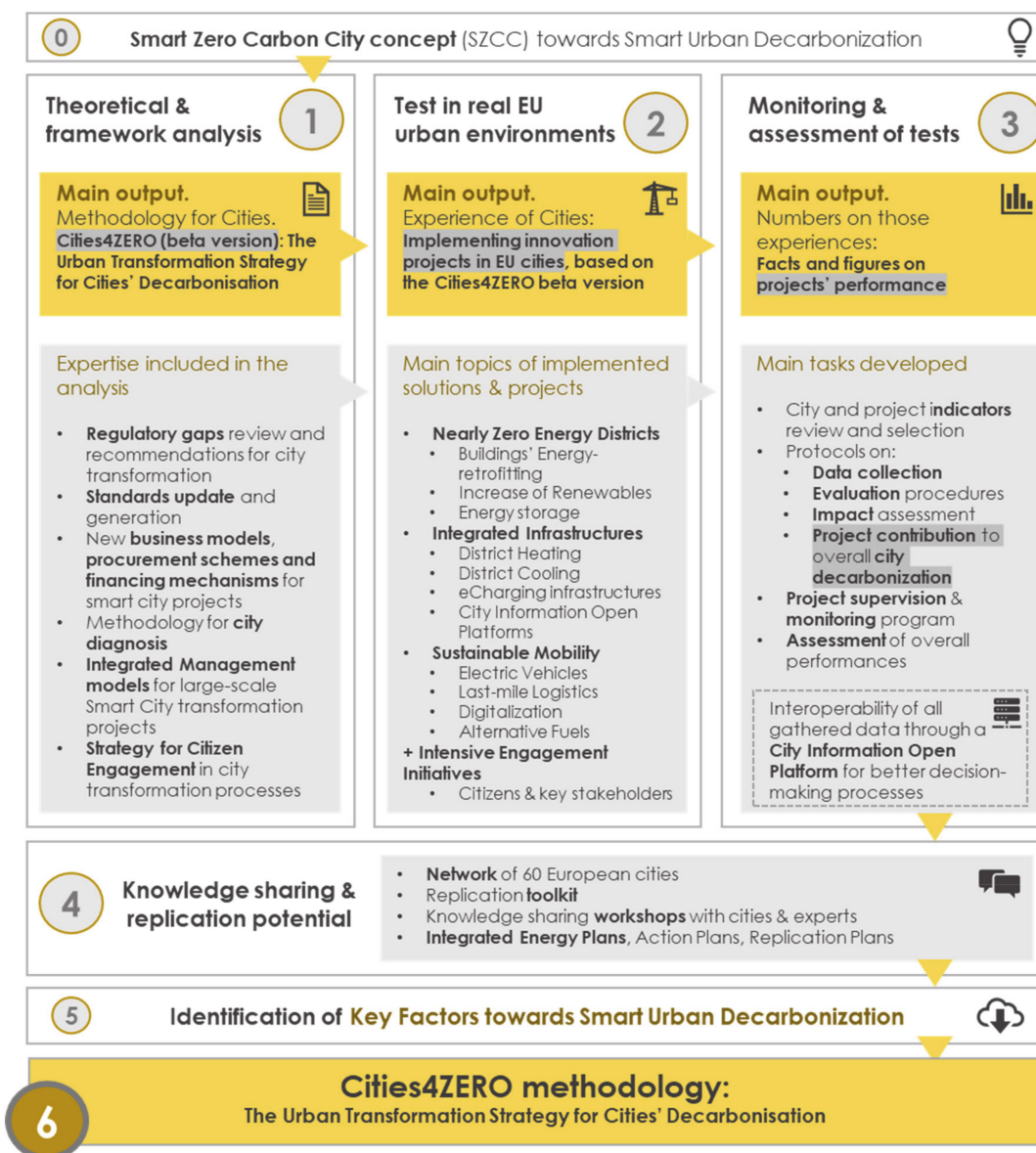
A Smart Zero Carbon City (SZCC) is a resource-efficient urban environment where carbon footprint is nearly eliminated; energy demand is kept to a minimum through the use of demand control technologies that save energy and promote raised awareness; energy supply is entirely renewable and clean; and resources are intelligently managed by aware and efficient citizens, as well as both public and private stakeholders [4].

This concept targets the main decarbonization elements from a participatory and technology-supported approach, and works as the ultimate goal to be achieved by cities on board of this transitioning process. With this guiding concept as an overarching goal for cities, the following method was developed to enable effective action in municipalities, both in planning and implementation terms. This method builds upon the previous work of the authors on the article “Smart Zero Carbon City: Key Factors towards Smart Urban Decarbonization” [4], which is here briefly summarized, further developed and finalized, answering one of the key factors identified: “Strategic municipal processes towards Smart Urban Decarbonization in the mid-long term”, asking for a strategic process able to guide the commitment of municipalities in the mitigation of GHG emissions through urban transformation processes in the mid-long term. This strategic process, Cities4ZERO, is presented in the Section 3, Results, and the method to obtain it, described in the following diagram and lines of this section (Figure 1).

### 2.2. Cities4ZERO Beta\_0 Version: a Methodology from the Lab

Based on the SZCC concept (-0- in Figure 1), the research thoroughly reviewed urban transformation procedures, tools, and best practices in the last decades, delving on city systems and the way in which these interact with each other at the different urban scales [16]. This review was complemented by a framework on urban transformation processes, including studies on city diagnoses [17], regulation [18], financing, procurement schemes and business models [19], standards [20], an integrated management model [21] and a citizen engagement strategy [22].

This thorough theoretical and framework analysis in the lab (-1- in Figure 1) enabled the development of a beta\_0 version of Cities4ZERO methodology, ready to be tested in real urban environments.



**Figure 1.** Wrap-up diagram presenting the method followed to develop Cities4ZERO methodology.

### 2.3. Contrast of Cities4ZERO Beta\_0.1 - From the Lab to the Urban Lab

The Cities4ZERO beta\_0 version was applied in five European cities with a formal commitment of reducing their GHG emissions, supported by an interdisciplinary consortium and the partial funding of the EC to develop strategies, plans, and interventions in their path towards carbon neutrality. Those cities were divided into two groups; the “lighthouse” ones were Vitoria-Gasteiz (ES), Tartu (EE), and Sonderborg (DK), willing to intervene through pilot projects in specific districts, as well as updating their city strategies; and the “follower” ones, Asenovgrad (BG) and Lecce (IT) [23], willing to learn from the experiences of lighthouse cities to update their city strategies, and start with specific district interventions in a later stage. The five cities were small and mid-sized, showing that this significant group of cities (83.43% of EU cities, according to Eurostat data [24]) can also move forward in this transition, far from big numbers and budgets of main European capitals. More specifically, the

three leading cities were chosen as they were considered pioneers in different decarbonization fields (Vitoria-Gasteiz—sustainable mobility and green infrastructures; Tartu—ICTs deployment in the urban environment; Sonderborg—strategic roadmaps towards decarbonization), sharing a solid background and able to offer lessons to other cities from a collaborative approach (Table 1).

**Table 1.** Vitoria-Gasteiz, Tartu, and Sonderborg main features of value to Cities4ZERO research study.

<b>Vitoria-Gasteiz</b>	This administrative capital of the Basque Country, in northern Spain, has a population of 240,000 inhabitants, with an extension of 276.81km <sup>2</sup> . A compact, moderately dense city, Vitoria-Gasteiz has an extensive background in the planning and implementation of environmental policies, being awarded the European Green Capital appointment in 2012. A flat and walkable city surrounded by a "green belt", and often regarded as a model in sustainable mobility planning, Vitoria-Gasteiz is committed to becoming a carbon-neutral city by 2050.
<b>Tartu</b>	Tartu is the second-largest city in Estonia, with a population of 100,000 inhabitants and a total area of 38.86km <sup>2</sup> . The home of several knowledge-intensive organizations (University of Tartu, Estonian University of Life Sciences), it is better known for its extensive implementation of Smart technologies in the Urban Environment. Tartu implemented public Wi-Fi areas throughout the city and was the first city in the world to enable a mobile-payment system for street parking in 2000. Paperless government was implemented in 2003, e-elections in 2005 and 2011 (EU Parliament), and fully electric taxi service and charging grid were implemented in 2012.
<b>Sonderborg</b>	Sixteenth largest municipality in Denmark, with approximately 77,000 inhabitants, included in the Southern Denmark region. The municipality holds an extensive agriculture sector, some of Denmark's largest industrial companies (i.e., Danfoss), and some of the most beautiful natural resorts of the country, with a cost of approximately 200km (offshore wind potential) and vast forests (local biomass potential). The city of Sonderborg has been working with the "ProjectZero" roadmap since 2007, aiming to become carbon neutral by 2029; one of the worldwide pioneer cities in this regard.

Within this collaborative framework among municipalities, the pilot interventions in the lighthouse cities targeted three main interventions fields, closely connected to urban decarbonization: nearly zero energy districts; integrated infrastructures, and sustainable mobility; facilitated by citizen and stakeholders' engagement activities (-2- in Figure 1). These interventions were intended to trigger additional low-carbon investments in the cities, fostering local replication, as well as inspiration for other cities based on these best practices. Table 2 summarizes these interventions, where energy savings were calculated according to BEST (building energy specification table) and TEST (transport energy specification table) standards.

Aligned with all those strategies, plans, and interventions, a project supervision including a monitoring program and later performance measurements and assessment of interventions was developed (-3- in Figure 1). In line with this, key performance indicators let researchers know what was working and what was not as expected, and to what extent the interventions were contributing to decarbonization targets, besides other complementary measurements. Through this contrast in the five cities, Cities4ZERO methodology was fine-tuned to achieve its beta\_0.1 version.

**Table 2.** Vitoria-Gasteiz, Tartu, and Sonderborg interventions during SmartEnCity project. Savings overview in pilot projects (2016–2021).

		Energy Savings (kWh/Year)	CO <sub>2</sub> Emission Reduction (Tn/Year)	
DISTRICT INTERVENTIONS	<b>Building Retrofitting</b>	<ul style="list-style-type: none"> <li>• 450 dwellings/36,000m<sup>2</sup></li> <li>• Envelope insulation (roof and façade)</li> <li>• Connection to district heating network</li> </ul>	6,099,700	
	<b>Integrated Infrastructures</b>	<ul style="list-style-type: none"> <li>• New biomass-powered district heating network</li> <li>• Integrated electrical and thermal network Energy Management Systems, at Home/Building/District levels (HEMS/BEMS/DEMS)</li> </ul>		2149
	<b>Sustainable Mobility</b>	<ul style="list-style-type: none"> <li>• Deployment of 100% electric bus line</li> </ul>		
	<b>ICTs</b>	<ul style="list-style-type: none"> <li>• Urban management systems (UMS)</li> </ul>		
CITY STRATEGY	<ul style="list-style-type: none"> <li>• <i>Integrated Energy Transition Action Plan 2030</i></li> </ul>	Baseline 2006: 841,068 CO <sub>2</sub> tn/yr 2020: 624,728 CO <sub>2</sub> tn/yr <b>Next target by 2030 (-40%): 504,640 CO<sub>2</sub> tn/yr</b>	<b>VITORIA-GASTEIZ</b>	
DISTRICT INTERVENTIONS	<b>Building Retrofitting</b>	<ul style="list-style-type: none"> <li>• 900 dwellings/39,500m<sup>2</sup></li> <li>• Envelope insulation (roof and façade)</li> <li>• New low-energy windows and doors</li> <li>• PV (Photovoltaic) panels in the south facades</li> <li>• Connection to the district heating and removing old electric boilers</li> <li>• Heat recovery ventilation system</li> </ul>	16,080,829	
	<b>Integrated Infrastructures</b>	<ul style="list-style-type: none"> <li>• Integrating heating and cooling in the current District Heating Through a new heat-pump</li> <li>• Smart public lighting</li> </ul>		12,244
	<b>Sustainable Mobility</b>	<ul style="list-style-type: none"> <li>• Extending the recharging network for electric vehicles (EVs)</li> <li>• Bikeshare</li> <li>• Biogas buses</li> <li>• Reuse of EVs batteries as a storage system for PV panels</li> </ul>		
	<b>ICTs</b>	<ul style="list-style-type: none"> <li>• Urban management systems (UMS)</li> </ul>		
CITY STRATEGY	<ul style="list-style-type: none"> <li>• <i>Tartu 2030 Energy + Plan</i></li> </ul>	Baseline 2010: 540,794 CO <sub>2</sub> tn/yr 2020: 432,635 CO <sub>2</sub> tn/yr <b>Next target by 2030 (-40%): 324,477 tn/yr</b>	<b>TARTU</b>	

Table 2. Cont.

		Energy Savings (kWh/Year)	CO <sub>2</sub> Emission Reduction (Tn/Year)
	<ul style="list-style-type: none"> <li>• 844 dwellings/66,181 m<sup>2</sup></li> <li>• Envelope insulation (roof and façade)</li> <li>• New low-energy windows and doors</li> <li>• PV panels in roofs</li> <li>• LED outdoor lamps</li> <li>• Lighting control</li> </ul>		
DISTRICT INTERVENTIONS	<b>Building Retrofitting</b>		
	<b>Integrated Infrastructures</b>	16,080,829	12,244
	<b>Sustainable Mobility</b>		SONDERBORG
	<ul style="list-style-type: none"> <li>• 44 biogas buses fleet and biogas filling station</li> <li>• Extending the recharge network for EVs</li> </ul>		
	<b>ICTs</b>		
	<ul style="list-style-type: none"> <li>• Urban management systems (UMS)</li> </ul>		
CITY STRATEGY	<ul style="list-style-type: none"> <li>• <i>Roadmap2025—50 steps towards a carbon-neutral Sønderborg</i></li> </ul>	Baseline 2007: 701,044 CO <sub>2</sub> tn/yr 2018: 432,336 CO <sub>2</sub> tn/yr <b>Next target by 2025 (-75%): 175,261 tn/yr</b>	

#### 2.4. Contrast of Cities4ZERO beta\_0.2—From the urban lab to the real world

At this stage, Cities4ZERO beta\_0.1 version and all the complementary materials and tools were packed into a replication toolkit, which was offered to municipalities with a decarbonization interest, within a pool of 60 cities from different countries that signed up as members of the SmartEnCity Network on their own will and interest [25], intending to learn about the experiences of the 5 pilot cities. Multiple workshops with municipalities and experts were organized in several European countries, where an intensive knowledge exchange allowed the testing of contents, interest, and replication potential of Cities4ZERO methodology, achieving the fine-tuned beta\_0.2 version (-4- in Figure 1). Finally, the identification of the key factors towards smart urban decarbonization [4], based on the lessons learned along this process, and a final review by the authors allowed to achieve Cities4ZERO methodology, presented in the Section 3, Results (-5 and 6- in Figure 1).

### 3. Results

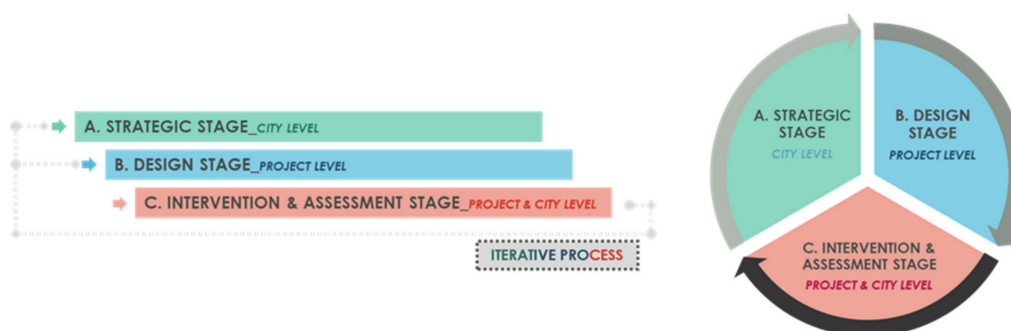
This section presents Cities4ZERO—the urban transformation methodology for cities' decarbonization—a step-by-step methodology for a smart urban decarbonization transition, guiding cities through the process of developing the most appropriate strategies, plans and projects, as well as looking for the commitment of key local stakeholders for an effective transition; all from an integrated planning approach.

Bearing in mind the critical situation regarding the need for mitigation actions, the important question is how to effectively deploy the SZCC concept in our cities. In line with this, Cities4ZERO suggests a pragmatic approach for municipalities structured on 3 stages and 16 steps. Stage A will deal with the development of the city strategy towards decarbonization, while stages B and C will develop the key projects identified in that city strategy (Table 3).

**Table 3.** Cities4ZERO value proposition for local authorities.

<b>A. Strategic Stage</b> <small>City Level</small>	<b>CITY STRATEGY</b>
<p><b>STEPS 1–6.</b> They provide a strategic planning framework which enables the city administration to perform an effective transition towards the Smart Zero Carbon City (SZCC), including:</p> <ul style="list-style-type: none"> <li>• Key city stakeholders' engagement and institutional analysis</li> <li>• Analysis and diagnosis of city strengths and opportunities</li> <li>• Co-visioning process for urban transformation towards energy transition, including potential future scenarios</li> <li>• Development of strategic plans to deploy that vision and identification of key projects, ensuring integration in local authorities' processes, commitment of engaged stakeholders and municipal support</li> </ul>	
<b>B. Design Stage</b> <small>Project Level</small>	<b>DEVELOPMENT AND IMPLEMENTATION OF KEY PROJECTS</b>
<p><b>STEPS 7–11.</b> They guide municipalities through the development of key projects identified in Stage A, according to the strategic plans of the city, paving the way for tangible interventions towards the SZCC, including:</p> <ul style="list-style-type: none"> <li>• Project prioritization and selection based on city needs</li> <li>• City transformation framework with policies, plans, best practices, regulation, etc.</li> <li>• Funding and financing mechanisms</li> <li>• Citizen engagement strategies for project development</li> <li>• Project design and tools</li> <li>• Project implementation plan and indicator systems</li> </ul>	
<b>C. Intervention and Assessment Stage</b> <small>Project and City Level</small>	
<p><b>STEPS 12–16.</b> They structure the implementation and assessment of key projects identified in Stage A and designed in Stage B, finally transforming the urban environment; including:</p> <ul style="list-style-type: none"> <li>• Intervention works, solutions deployment, and commissioning</li> <li>• Monitoring, maintenance, and users training</li> <li>• Interventions' performance and impact assessment</li> <li>• Post management and communication through city information open platforms</li> <li>• Project and strategy validation</li> <li>• Up-scaling of successful experiences</li> </ul>	

This step-by-step methodology is not conceived as a linear process, but as a circular one. The whole process (Stages A, B, and C) cyclically iterates when felt partially obsolete to readjust the focus of strategies, plans, and key projects towards the final decarbonization goal, according to the co-formulated city vision (Figures 2 and 3).

**Figure 2.** Stages from Cities4ZERO methodology and circularity of the process.



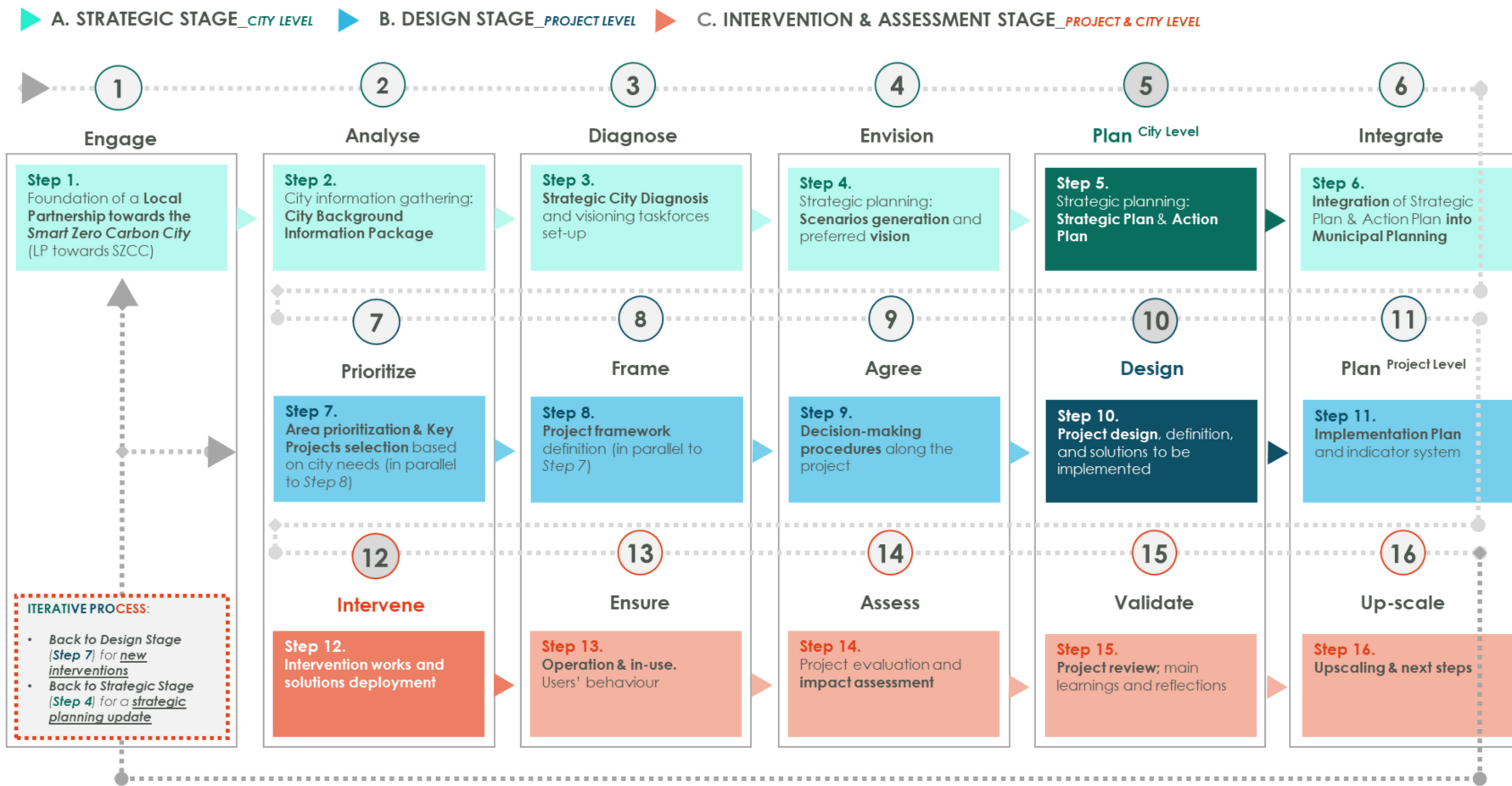


Figure 3. Wrap-up diagram from Cities4ZERO methodology.

Depending on the current status of each municipality, the point of departure can vary, as some methodological steps might be already fulfilled. The first exercise for cities consists of evaluating their situation regarding this process and which steps from Stage A will be a priority for them. As a starting point, the SmartEnCity team has developed the City Check-up Assessment tool [Supplementary Materials]. By filling a questionnaire, cities can self-assess regarding this urban transformation process.

Finally, step-by-step does not always mean that it must be a straight line; reality is usually more complex than plans. Either way, this methodology will work as a solid reference framework. The final aim of Cities4ZERO is to involve European cities on the path towards decarbonization, mainly targeting the wide range of small and mid-sized cities in the region (83.43% of cities) [26]. As the SmartEnCity project slogan states, “you don’t have to be a capital city to make a major difference!”.

### 3.1. A. Strategic Stage at City Level – CITY STRATEGY

The main objective of the strategic stage is to provide a framework that enables the city to perform an effective transition towards the SZCC (Figure 4). In later stages, the strategy delves into concrete projects’ definition (B. Design Stage) and implementation (C. Intervention and Assessment Stage), landing on specific projects identified in this strategic stage at the city level.

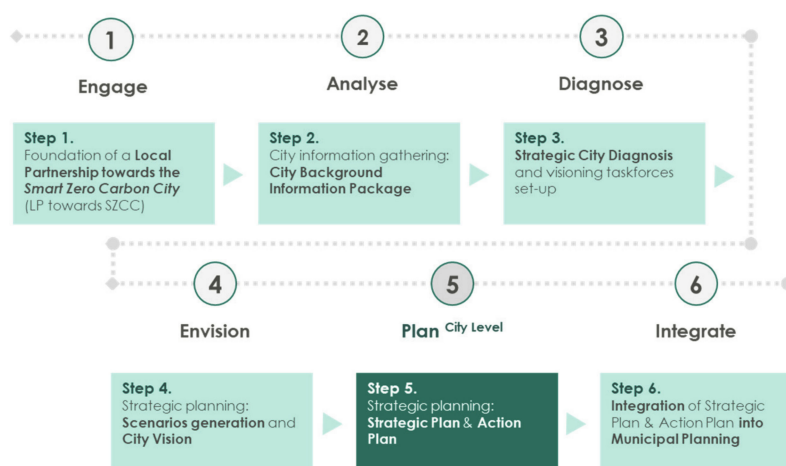


Figure 4. Steps of Cities4ZERO Strategic Stage.

The framework of this strategic stage consists of six steps, focusing on the main activities to be performed at the city-planning level. The first step (1. ENGAGE) describes the foundation of a permanent local steering group (local partnership towards the SZCC) led by the local authority for this transition towards the SZCC, suggesting an alternative governance model with key local stakeholders on board. With this group in place, the city needs to perform a thorough city characterization (2. ANALYSE) and a strategic city diagnosis (3. DIAGNOSE), to understand what the point of departure for the city transition is. This comprehensive background analysis allows one to perform a strategic planning process, starting with the co-development of a city vision (4. ENVISION), based on potential decarbonization scenarios for the city. That resulting vision will provide an umbrella to develop a strategic plan, which will steer the city towards the achievement of that agreed vision, also defining an action plan to perform specific actions with that purpose (5. PLAN<sup>City level</sup>— key step of Stage A). The last step of the strategic stage (6. INTEGRATE) fosters the integration of strategic plan contents into municipal planning instruments, ensuring the alignment and official approval of all processes to avoid legal, administrative and land-use barriers, while leveraging synergies among municipal departments and competences, all carefully steered by the local partnership towards the SZCC.

Before facing this strategic stage with Step 1, it is highly recommended for cities to use the City Check-up Assessment tool (Supplementary Materials), so that the reader has an overview of the process, contextualized to his/her specific local environment.

### STEP 1. ENGAGE. Foundation of a local partnership towards the SZCC

The first cornerstone in this journey requires the foundation of a local group headed by the local authority (local partnership towards the SZCC), which will steer the urban transformation towards the SZCC, providing stability to the process in the mid-long term. This local steering group must map and engage key local stakeholders, including representatives from all quadruple helix branches (government, industry, academia, and citizenship), as well as defining the governance model for this urban transformation process. This local group can eventually be supported by external consultancy if some competences are missed within the municipality.

Before starting with the urban transformation strategy, preplanning tasks of this group must reflect on the overall strategy requirements and approvals such as timeline, coordination with other partners and municipal departments, potential institutional adaptations [27], budgetary needs, inventories and data repositories, (. . .); determining the needs for the shaping, regulating, stimulating and capacity building of potential projects or initiatives framed within this urban transformation process. A wide commitment of the local authority is key to a potential city decarbonization.

### STEP 2. ANALYSE. City information gathering: the city background information package

When facing a strategic urban transformation process, a thorough analysis gathering comprehensive information on the current state of the city is crucial for successful regeneration.

A pre-analysis must perform a literature review at the city level, delving on existing policies, regulations, strategies, and plans, complemented by semi-structured interviews with experts and surveys on citizens' perception. On that basis, a city characterization provides a deeper understanding on the socioeconomic and sectorial features (energy, building stock, mobility, public space, ICTs—Information and Communication Technologies—engagement, waste, water, etc.) and the status of the city, where city indicators (SZCC readiness level in [26]) can provide a desirable quantitative approach to this characterization. Here, a carbon emissions baseline is key to perform further strategies and projects towards energy transition. In line with this, a comprehensive model of the local energy system is key to draw the carbon emissions baseline, to be performed by tools like EnergyPLAN [28] or Energy Balance [29].

All gathered information within this step can be bundled into a city background information package (CBIP), as a solid reference for further steps in this methodology (e.g.: Steps 3, 8).

### STEP 3. DIAGNOSE. Strategic city diagnosis and visioning taskforces set-up

Once key stakeholders are initially engaged within the local partnership towards the SZCC (Step 1) and city information is gathered on the CBIP (Step 2), it is time to organize those stakeholders in working groups, to provide valuable input for the strategic planning tasks; namely: strategic city diagnosis (Step 3); scenarios and city vision generation (Step 4); strategic plan and action plan (Step 5). In the SmartEnCity project, the flow of these three strategic planning tasks has been supported by a participatory foresight exercise, which consists of gathering future insights and building common visions for making present-day decisions and mobilizing joint actions in the city.

This foresight exercise starts with the strategic city diagnosis (method in [17]), which consists of a thorough SWOT (strengths/weaknesses/opportunities/threats) analysis of the city, supported by CBIP (Step 2; internal drivers of SWOT including GIS data—geographic information systems), and a city-trends analysis (external drivers of SWOT), exploring relevant connections to regional/national/international targets, policies, and institutions in the field of SZCC. Within this SWOT, after identifying the main "external opportunities and threats", and "internal strengths and weaknesses" of the city, they can both be combined to assess the probability (likelihood to become a reality) and relevance of each element. The logic is that the "highly relevant, but uncertain drivers of change" should lead to defining the main strategic actions to be taken in the next steps (Step 4. ENVISION/ Step 5. PLAN). Furthermore, a PESTLE analysis (political, economic, social, technological, legal, environmental) can be useful for performing an in-depth analysis of external factors.

This strategic city diagnosis must be supported by the collaboration and contribution of local stakeholders organized in thematic working groups by the local partnership towards the SZCC, and it will provide critical topics and main input for scenarios and city vision generation (Step 4).

#### STEP 4. ENVISION. Scenarios generation and preferred vision

Building upon main outputs from the strategic city diagnosis (Step 3), local working groups will face a city visioning workshop with the assistance of a moderator expert in prospective, co-developing an agreed vision for the future of the city.

Assuming the role of city managers, the working groups will generate different future scenarios for the city based on the SWOT analysis of Step 3, while facing the formulated strategic question within the agreed timeframe; e.g.: How are we transforming our city to become carbon neutral by 2040? What can we do by 2030 as a mid-way milestone? The stakeholders will contrast the analysis on probability and relevance of the trends performed in the strategic city diagnosis, before generating the different future scenarios.

The local steering group must gather all those inputs and further develop each of the scenarios suggested by each of the working groups. Once all this input is structured, those final scenarios are presented to the local stakeholders, starting a discussion to select a preferred “master scenario”, which can be one or a combination of those final scenarios. According to that master scenario, the group will develop a city vision, ideally as a result of reaching consensus among all stakes, being the basis of developing the strategic plan for the city (Step 5). After all these processes, the stakeholders in Vitoria-Gasteiz agreed on a master scenario for 2030, summarized in the following city vision, which guided the content of their strategic plan and action plan (Step 5):

Vitoria-Gasteiz 2030; a resilient, safe, healthy, metabolic efficient, circular and high-quality environmental municipality; a benchmark for distributed energy production from renewable sources, for an effective energy-retrofitting model of the built environment, for its determined commitment to the active mobility modes, complemented by a high-quality electrified public transport system. A municipality with institutions that exercise powerful leadership and act in an exemplary way together with a co-responsible citizenship with a high level of awareness, reinforced by a model of community cooperation capable of facing the challenges of the energy transition at the local level. All this within a prosperous, innovative, and competitive economic environment, which ensures a collaborative social model in which no one is left behind.

#### STEP 5. PLAN <sup>CITY LEVEL</sup>. Strategic plan and action plan

All materials and activities performed in Steps 1-4 provide a comprehensive background to develop a strategic plan and an action plan for the city, whose main goal is to pave the way, with specific actions towards the city vision achievement within the agreed timeframe.

The strategic plan of the city will transform the city vision (Step 4) into specific goals. From those goals, strategic axes and lines will structure the strategic plan, which will be further landed into an action plan. The action plan is the document in which specific actions and key projects are identified, appointing stakeholders, budget, impact indicators such as emissions reduction, and timeframe for their development. The desirable implementation timeframe of those key projects is less than five years, when the action plan must be updated, to readjust the focus to the evolving urban situation. Regarding the format of a strategic plan and action plan, the following summarized and generic example can be followed, based on the experiences of the SmartEnCity project [30]:

- a) City vision: carbon neutrality for 2030, based on green economic growth
- b) Strategic axis 1 (1 out of 3 axes): sustainable energy
- c) Strategic line 1.3 (out of 5 lines): positive energy districts

- d) Action 1.3.1 (out of 3 main actions): city diagnosis for vulnerable energy districts identification, promoting the “retrofitting pack” based on local businesses
- e) Key project from action 1.3.1: Integrated retrofitting of 350 dwellings in old town district, including connections to district heating network, powered by local renewable energy sources

For the identification of key projects, it is recommended to involve the thematic working groups engaged in Steps 3 and 4, as those stakeholders, besides being experts in each field, will be more committed in the future implementation of those projects. In case there are conflicting interests, the local partnership towards SZCC will have to make decisions, which may imply a political component. In terms of the development of key projects within Cities4ZERO methodology, the DESIGN STAGE delves on them from Step 7 on.

Regarding the approach local authorities have to this kind of strategic actions, they usually tend to focus on isolated energy actions, whilst the complexity of urban decarbonization challenge requires an integrated and participatory approach, where urban planning and all city systems converge into one single path, and local stakeholders can influence the generation process, as they will later be protagonists in the implementation stage. In line with this, the integrated energy planning concept can be valuable to steer this process:

Integrated energy planning (IEP) is an approach to find environmentally friendly, institutionally sound, socially acceptable, and cost-effective solutions of the best mix of energy supply and demand options for a defined area to support long-term regional sustainable development. It is a transparent and participatory planning process, an opportunity for planners to present complex, uncertain issues in structured, holistic, and transparent ways, for interested parties to review, understand and support the planning decisions. Furthermore, Integrated planning entails defining the goals and the problems to implement the appropriate solutions. [31]

Finally, it is strongly recommended to define an indicator system at the city level that monitors the progress towards the city vision and objectives fulfilment, trying to match the impact each of those key projects has on the overall city scale and decarbonization goals. Here, the model of the local energy system developed in Step 2 can show the potential carbon emissions reduction of each of those key projects, being able to quantify and prioritize each of those actions depending on their impact.

**STEP 6. INTEGRATE.** Integration of strategic plan and action plan into municipal planning and strategies

The local authority needs to guarantee the legal, administrative, and physical conditions to deploy the actions and key projects identified in the strategic plan and its action plan (Step 5), ensuring full integration in the municipal planning instruments. In the city of Sonderborg, the commitment of the local authority with the process allowed to review each of the 50 key projects identified in the action plan to analyze how to engage on them or support them from the public administration side to maximize their impact, releasing an internal steering booklet for politicians and municipal employees. Regardless of the internal steering booklet, this process should be a standard for any municipality producing a strategic document, but unfortunately, it is not.

In this regard, an update or modification of the land-use city masterplan it is essential, ensuring legal viability and land-use provision for identified actions. Furthermore, a review and acknowledgment of the strategic plan and action plan contents by local legislation and municipal competences is crucial, avoiding foreseen barriers. This acknowledgment by all municipal departments and strategies will enhance cross-cutting collaboration among disciplines, fostering synergies and breaking sectorial silos at the same time.

This integration process must be carefully steered by the local partnership towards the SZCC (Step 1), ensuring the alignment among existing and foreseen initiatives for a soft transition, as well as a more integrated approach to traditional land-use planning.

A wrap-up diagram of the Cities4ZERO strategic stage is presented in Figure 5.

A. STRATEGIC STAGE\_CITY LEVEL

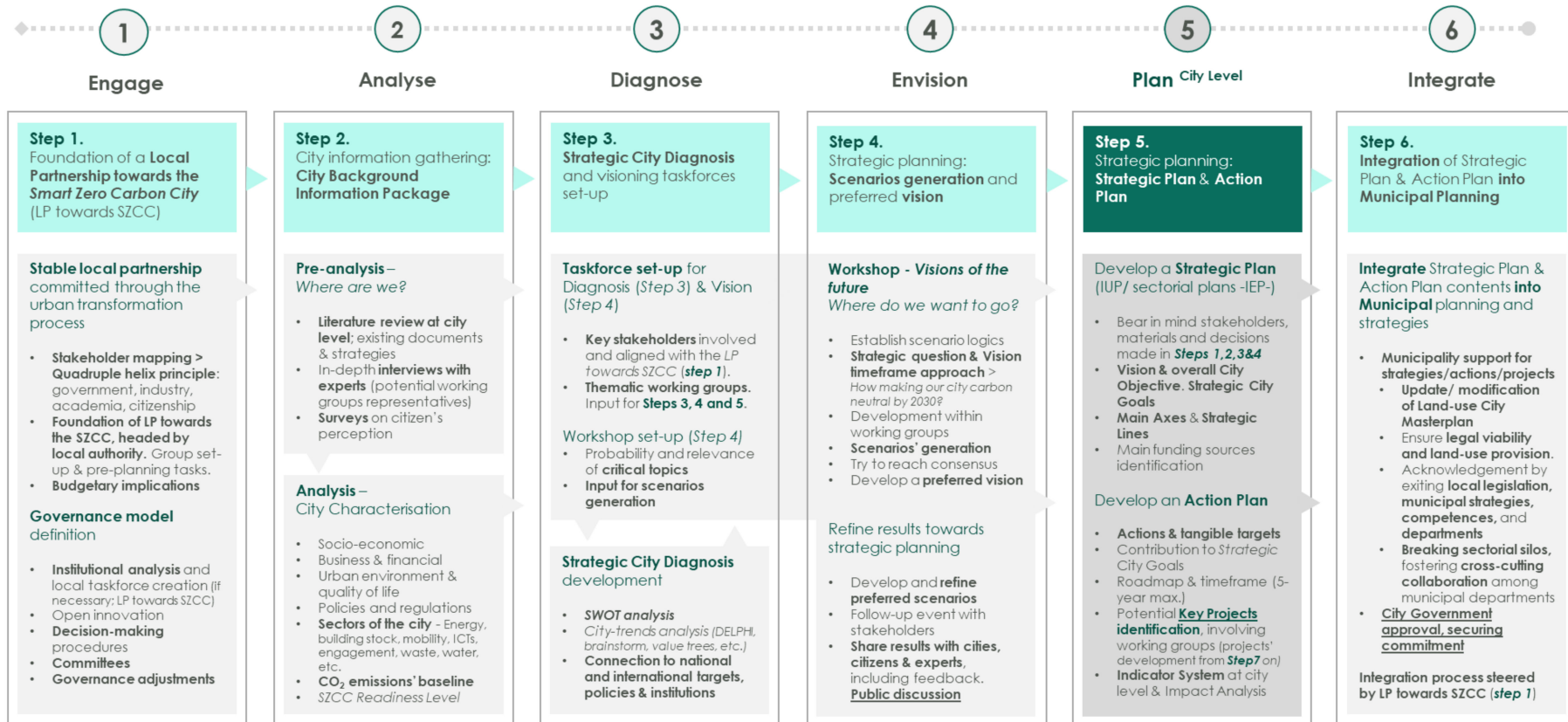


Figure 5. Wrap-up diagram from Cities4ZERO strategic stage.

### 3.2. Design Stage—DEVELOPMENT OF KEY PROJECTS

This stage aims to take a step beyond the strategic plans of the city (Step 5. PLAN<sup>CITY LEVEL</sup>; strategic plan and action plan), through the development of key projects identified as enablers for those strategic plans (Figure 6). This stage (B. Design Stage) will prioritize, frame, carefully co-design, and plan those projects, while the last stage (C. Intervention and Assessment Stage) will bring them to reality, monitoring and evaluating their performance and impact for further research and plans. Through the iterative development of all key projects identified, the transition towards the SZCC will become a closer reality.

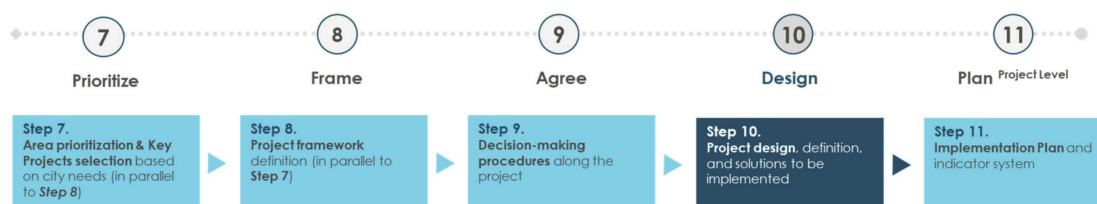


Figure 6. Steps of Cities4ZERO Design Stage.

The framework of this Design Stage consists of five steps that fall into the specificities of the project level, always bearing in mind all main lines previously agreed upon at the city level (A. strategic stage). The stage will start with a prioritization based on city needs, choosing the most relevant projects and city areas (7. PRIORITIZE), defining the objectives and a rough draft for a district integrated intervention. In parallel to Step 7, it is crucial to build a city transformation framework (8. FRAME), analyzing the local context for implementation regarding the city-systems entailed in the intervention, including potential financing mechanisms and business models for all solutions. Once the project is framed, key agreements are needed (local partnership towards the SZCC, industry, academia, citizens), according to our governance model developed in Step 1 (9. AGREE), to hence carefully co-design and co-define the project and all solutions entailed, making use of a suitable design toolbox (10. DESIGN—key step of Stage B). Finally, in this stage (11. PLAN<sup>PROJECT LEVEL</sup>), the result will be transformed into an implementation plan, which, assisted by an indicator system, will ensure the effective deployment, quality, and evaluation of the project to be implemented in its final stage (C. Intervention and Assessment Stage).

#### STEP 7. PRIORITIZE. Area prioritization and key projects selection based on city needs

In this second stage, from those key projects identified in the strategic plan and action plan (Step 5), a project prioritization performed by the local authority (local partnership towards SZCC) will select and combine the most promising initiatives for the city, focusing on those city areas where the benefits of those initiatives will have the most impact for the citizens. This prioritization will build upon the strategic city diagnosis performed in Steps 2 and 3, using GIS tools for spatial analysis and reduction emissions potential, identifying priority areas and bottlenecks, as well as demarking the area of intervention of the project. In this process, the local partnership towards SZCC will work as a coordination node among municipal departments, agencies, and external stakeholders, to reach a wider consensus on the decisions to be made. In case conflicting interests do not allow one to reach a consensus, the local partnership will decide the most beneficial intervention for the municipality, according to the strategic and action plan developed in Step 5, considering all stakes in the table.

For this choice, it is recommended to focus on social, economic, or environmental vulnerable urban areas, those that experience a lower quality of life in comparison to other urban areas, with a specific look at emissions reduction potential. Both area and projects' selection would be ideally chosen in a parallel process, feeding one another. In the case of Vitoria-Gasteiz, the energy-efficiency, energy supply, age, and accessibility of the building stock, the socio-economic and demographic characteristics, and the quality of the public space connected to mobility and access to green areas

were the key reasons to choose the Coronación district as the area of intervention with the highest potential of emissions reduction and upgrade of the quality of life standards.

Finally, a rough draft for a district integrated intervention project at this stage (pre-definition) will provide a good overview to enrich the following steps (8, 9 and 10), allowing more accurate analyses in this Design Stage (funding, regulation, standards, engagement, communication, etc.). In return, analyses on funding/ financing mechanisms and a city transformation framework (Step 8) will support this process.

#### STEP 8. FRAME. Project framework definition

The main objective of this step, together with step 7, is to ensure project viability in institutional, legal, and economic terms, leveraging potential opportunities, whilst tackling foreseen barriers in the development process.

In parallel to the pre-definition of the project in Step 7, Step 8 will support the process with the development of a city transformation framework, building upon city background information package developed in Step 2. This framework will consist of an analysis of local plans, policies, regulations, standards, barriers, good practices, and potential risks regarding city transformation processes and how they affect the city-systems entailed in the future intervention. This analysis will allow the identification of synergies, boundaries, and barriers for the selected interventions in the project.

As part of the city transformation framework, potential funding and financing mechanisms will explore how to cope with the required investments for the project. With that purpose, an overall budget will be estimated, fostering public-private partnerships and sources (European, national, regional, local, multilateral, NGOs, etc.). In line with this, business models will be drafted for each solution to be implemented, fostering the economic sustainability of the overall intervention.

#### STEP 9. AGREE. Decision-making procedures along the project

The success of planned interventions will depend very much on the level of agreement achieved among all parts at stake in the city (and district). That's why it is important to carefully engage all key stakeholders to ensure their alignment during and after the project.

The city governance model already defined in Step 1 will now be transferred into the project level, defining decision-making procedures along all steps of the project. An integrated management Plan will be accordingly defined, including decision-making roles for all stakeholders:

- Strategic, tactical: local partnership towards SZCC,
- Operational: technical committee (with main experts, including industry and academia),
- Collaborative: citizens committee, representing their interests and insights.

Special attention must be paid to an effective citizen engagement strategy, defining a model able to incorporate an interesting and well-communicated value proposition for the citizens, allowing social innovation practices and collaborative approaches. There is no unique recipe to develop a citizen engagement strategy; the design process must be adapted to each local reality. It is about developing proposals following the required project specifications, while creating tangible touchpoints that can be reshaped by the citizens.

#### STEP 10. DESIGN. Project design, definition and solutions to be implemented

Once the project and the city-area have been selected (Step 7), the contextual framework—including financial requirements—has been met (Step 8), and consensus about the integrated intervention is as wide as possible among all parts at stake (Step 9), it is time to carefully co-define and co-design project solutions to be finally implemented. This process will be built upon the pre-definition of the interventions developed in Step 7.

Firstly (A), the optimal solutions and technologies must be selected for each sector of the district integrated intervention. As an inspiration, EC funded projects (SCC-1 Smart Cities and Communities) have been developing more than 500 innovative city solutions in 93 European cities since 2014, all



gathered and sustained in the EC Smart Cities Information System [32]. The main categories gathering these city solutions are (Table 4):

**Table 4.** Categorization of SCC1 solutions [32].

<b>A. Energy</b>	
<ul style="list-style-type: none"> <li>• Building-integrated renewable energy sources</li> <li>• Building envelope retrofitting</li> <li>• Building services (Lighting and HVAC—Heating Ventilation Air Conditioning)</li> <li>• Heat pumps</li> <li>• Small energy storage</li> </ul>	<b>Energy efficiency in buildings</b>
<ul style="list-style-type: none"> <li>• District heating and cooling</li> <li>• Co-generation (CHP—combined heat and power)</li> <li>• Electrical energy storage</li> <li>• Thermal collectors</li> <li>• Biomass boiler</li> <li>• Photovoltaics</li> <li>• Waste heat recovery</li> <li>• Near-to-surface geothermal energy</li> <li>• Waste-to-energy</li> <li>• Large scale storage</li> <li>• Deep geothermal energy</li> <li>• Thermal storage</li> </ul>	<b>Energy system integration</b>
<b>B. Mobility and transport</b>	
<ul style="list-style-type: none"> <li>• Clean fuels and fuelling infrastructure</li> <li>• Electric, hybrid and clean vehicles</li> <li>• Bicycle infrastructure</li> <li>• Car-sharing</li> <li>• Intermodality</li> <li>• Urban freight logistics</li> <li>• Car-pooling</li> </ul>	
<b>C. ICTs</b>	
<ul style="list-style-type: none"> <li>• Building energy management systems</li> <li>• ICTs as planning support</li> <li>• Mobile applications for citizens</li> <li>• Smart district heating and cooling grids—demand</li> <li>• Smart electricity grid</li> <li>• Traffic control systems</li> <li>• Demand response</li> <li>• Neighbourhood energy management systems</li> <li>• Travel demand management</li> </ul>	

Secondly (B), the intervention area will probably require a public space reconfiguration through a detailed project definition. A design team will include experts on the fields regarding solutions to be implemented, fostering collaborative design while defining the project. This project will fulfil all requirements of the integrated management plan developed in Step 9.

Both definition processes, (A) and (B), should be supported by the positive energy district's concept [33] and a comprehensive design toolbox able to integrate GIS, BIM (Building Information Modeling), system-illustrative tools and simulation models. These tools will significantly optimize the

effectiveness of interventions as well as maintenance, operation, and monitoring of all solutions during their lifespan (e.g.,: models, building and city digital twins). Project design and solutions from this step will define key issues related to Step 11 (implementation plan) and Step 12 (intervention works and solutions deployment).

#### STEP 11. PLAN <sup>PROJECT LEVEL</sup>. Implementation plan and indicator system

The project design developed in Step 10 will be included in an implementation plan, which will provide measures to control the outcome and development of interventions, such as a quality management plan, a risk management plan, a description of the sequence of activities, and an execution plan for all solutions.

Concerning procurement and contracting, both local and national contexts of each city will have specificities that need to be met. In some cases, public procurement for innovation (PPI) processes can be helpful, as some problems might need deeper reflections, avoiding straightforward market solutions that may not meet the expectations for the problem at focus.

As aforementioned in Step 5 for the city level, it is recommended to implement an indicator system at the project level, connected to an evaluation plan, a data collection plan and a monitoring Program (Step 13), defining a baseline for the interventions and the expected performance of those, hence, it is possible to assess the results and impacts towards decarbonization after processing all the data (Step 14). All that data will be also valuable in case the city develops a city information open platform (CIOP), to analyze and visualize all the data for better decision-making. This online platform can also improve transparency with citizens, setting different levels of access depending on the user (decision-maker/technician/citizen).

A wrap-up diagram of the Cities4ZERO Design Stage is presented in Figure 7.

#### Intervention and Assessment Stage—IMPLEMENTATION OF KEY PROJECTS

The last stage of Cities4ZERO methodology (C. Intervention and Assessment Stage, Figure 8) deploys the integrated intervention, through the implementation of key projects previously identified in the first stage (A. Strategic Stage) and designed in the second stage (B. Design Stage).

The Intervention and Assessment Stage consists of five final steps, focusing on implementing, assessing, and upscaling the solutions, all of them aligned with the strategic plans of the city (Step 5. PLAN). The first step of this stage implements all solutions (12. INTERVENE—key step of Stage C), including construction works. The intervention will leverage potential synergies among city systems and include strong engagement activities, while works are appropriately commissioned by experts. Step 13 will take care of the operation and in-use period (13. ENSURE), ensuring a healthy lifespan of interventions, mainly through on-going commissioning, monitoring, users' training, and community-based initiatives. Once all data and performance results have been collected and analysed, it is time to assess the project and its impacts (14. ASSESS), according to performance indicators generated in Step 11. All data generated during the project can feed the city information open platform mentioned in Step 11, where the city can perform analyses for better decision-making as well as visualize data to inform the citizens. Step 15 will perform a project review (15. VALIDATE), checking the fulfilment of the project objectives and asking for feedback to key stakeholders, including citizens and end-users, industry, and academia. Through this review and the assessment of Step 14, the steering group (local partnership towards the SZCC) will be able to check if the interventions were aligned with the strategic plan and action plan at the city level (Step 5), and to what extent they have been successful and replicable. The final step of this third stage explores the replication potential of the process and implemented SZCC solutions, through local up-scaling strategies for the city (16. UP-SCALE), considering urban labs for replication and exploitation paths for local partners. The connection to European sources such as the SCC-1 solutions portfolio and SCIS (Smart Cities Information System, mentioned in Step 10), or initiatives such as C40 Cities [34] will always be helpful for further inspiration.

**B. DESIGN STAGE PROJECT LEVEL**

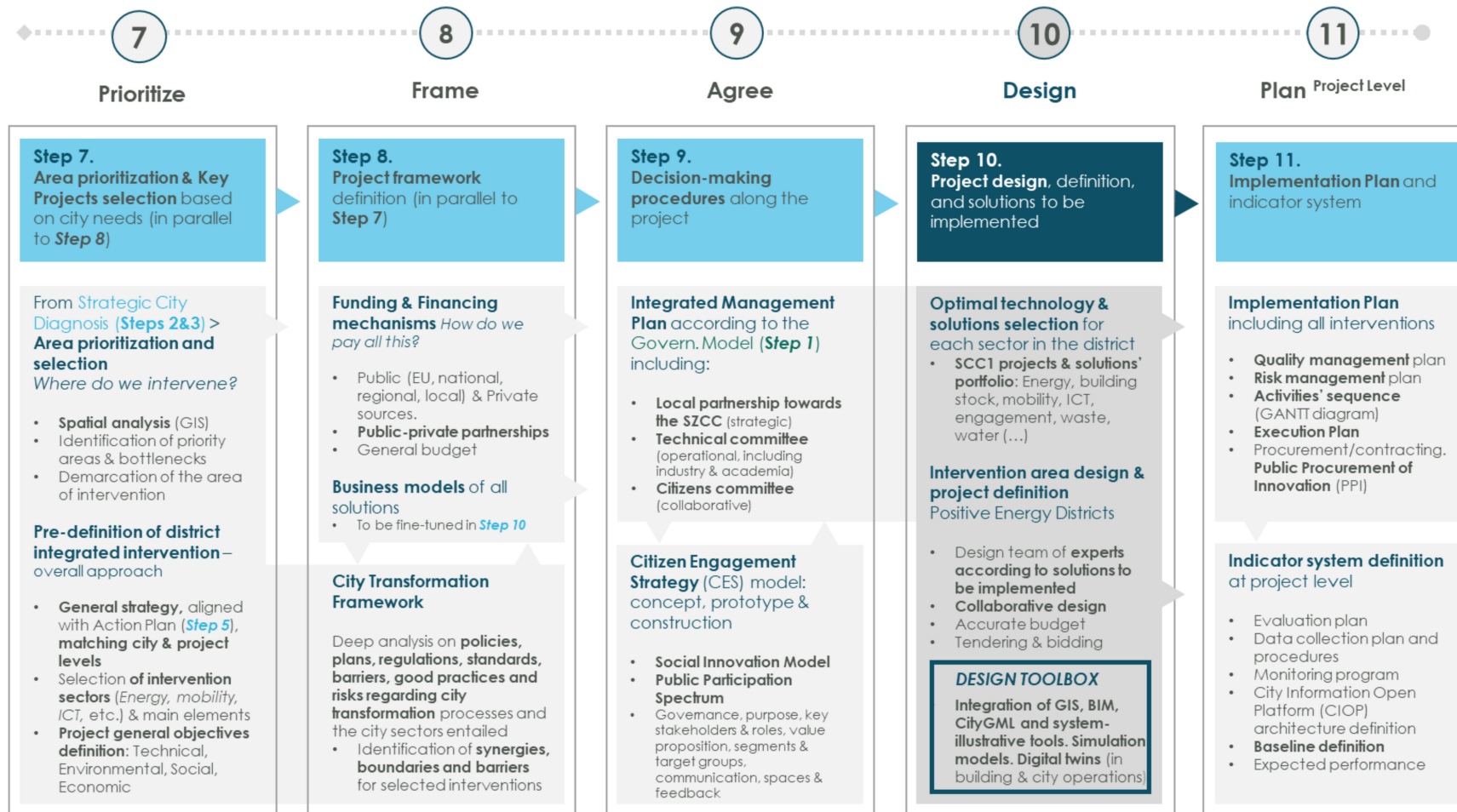


Figure 7. Wrap-up diagram from Cities4ZERO Design Stage.



**Figure 8.** Steps of Cities4ZERO Intervention and Assessment Stage.

This methodology will end with a final workshop steered by the local taskforce (LP towards the SZCC), reflecting on the next steps and future interventions. This workshop ensures the iteration of the whole process depending on city needs:

1. If the strategic plan and action plan are still considered valid after this process, and if an update is not yet necessary, the city can pick and develop new key projects coming back to Step 7 (7. PRIORITIZE), selected from the project list published in the action plan (Step 5).
2. In case the strategic plan and/or action plan are considered as partially obsolete, where an update is appropriate for a better project focus, the city can come back to Step 4 (4. ENVISION) and update its strategic planning process for a reconsidered planning umbrella (strategic plan and action plan).

This continuous iteration will readjust the focus of city projects and strategies towards the final SZCC goal.

#### STEP 12. INTERVENE. Intervention works and solutions deployment

After the strategic planning process and design of interventions, Stage 3 starts with the district integrated intervention, entailing execution works and the implementation of solutions according to planned schedules and requisites. Both for design, implementation, and assessment stages, BIM principles are highly recommended, fostering an integrated and effective deployment.

This intervention step, where the implementation plans become reality, involves a large variety of experts and technicians. Additionally, the coordination team at the city level will have to guard the correct deployment of the works and the overall economic control. At this stage, those experts appointed to follow-up the interventions will also take care of the adequate installation of the monitoring equipment and the data acquisition systems, to be able to measure performance and hence, appropriately assess interventions in the following steps. Regarding implementation expertise, the more prepared and skilled the workers and technicians taking the actions are, the bigger will be the guarantee of attaining the envisaged objectives. As in previous Step 11, suitable experts should be selected, internal or external, with the competences to address each action (energy, mobility, LCA—life cycle assessment, etc.).

Management aspects in this step are crucial. Works must be deployed on time and they need to comply with the requirements defined in previous steps to achieve the energy and emissions targets. Furthermore, the schedule and cost aspects must be guarded. Those are parallel aspects that have mutual implications, since delays on some works usually go hand in hand with cost increases. Delays in this step as well as in the tendering process are likely to happen—permits, potential industry/social resistance, saturation of the local market, etc., where predefined mitigation and contingency plans will be of considerable support.

In parallel to intervention works, intensive engagement and communication activities are highly recommended, according to the citizen engagement strategy developed in Step 9. This is identified as a key success factor, or even as an enabler, as in some cases, projects and solutions might not be feasible without the agreement of potentially affected citizens.

#### STEP 13. ENSURE. Operation and in-use; users' behaviour

Right after interventions are in place, the operation and in-use period starts. Here, ensuring a healthy lifespan of interventions is the main priority.

An ongoing commissioning will determine roles and responsibilities for each intervention. In this task, BIM models (digital twins) can significantly improve the operation and maintenance works, if we appropriately deploy sensors on buildings, infrastructures, vehicles, etc., as technicians will have a virtual update of all elements, simulating improvements or corrections, and finally implementing them in reality if considered beneficial. Furthermore, facilities management plans will provide protocols, key maintenance information, and end-user manuals, for an effective performance of all buildings and infrastructures deployed.

In line with this, the effectiveness of interventions may depend on end-user behaviour, which must be tackled by engaging them through training and communication activities. Here, community-based initiatives, economic incentives (or disincentives), and regulation modifications considering exemptions, agreements, pricing, etc., can be good tools for the correct use of interventions.

At this step, just right after the interventions, it is important to run performance tests and to start the monitoring period, which will allow data availability for assessment in Step 14. This will also allow one to certify the quality assurance of interventions.

#### STEP 14. ASSESS. Project evaluation and impact assessment

At this point, all interventions are finished and the data from each of them have been gathered for a significant period. Now it is time to find out if the actions have reached the expected results and the project goals in terms of energy performance or emissions savings; to calculate the LCA and the economic impacts; and to evaluate the social acceptance, among other parameters.

The process of assessing implemented actions needs the involvement of different experts on the different fields of evaluation for correct reporting and comparison. It is useful that, for some calculations, the experts are certified on an evaluation methodology (such as the International Performance Measurement and Verification Protocol—IPMVP, for example), to assure the quality of the work.

This assessment must go back to the set of key performance indicators (KPIs) already defined in Step 11, and using the data collected on the data-gathering period to calculate their values. These results can support an evaluation report, focusing on all key aspects, comparing the KPIs values before and after the intervention. At the city level, the obtained data can be contrasted with the indicators defined in Step 5. This comparison between before and after the interventions (PRE vs. POST interventions) will provide a good evaluation measure. It is important to stress that not all indicators are based on data gathered by technical equipment, but also from the citizens, tenants and the services' users. Data has been gathered, for example, through surveys, and needs to be analysed accordingly.

As a result of this process, a positive assessment supports the interventions developed, in case they have been correctly finished and good evaluation results obtained. But even if the results are not as expected, a correct assessment is still valuable, as it is the way to ensure better results in future interventions and corrective actions, if possible. The main challenge at this step is to have a complete and good quality set of data. This means a significant workload in previous stages.

All generated data in this step can feed the city information open platform (CIOP) described in Step 11. Through this new city tool, a CIOP catalogue of potential services can explore the applicability of the integrated data generated in the project.

#### STEP 15. VALIDATE. Project review; main learnings and reflections

Finally, after planning a healthy lifespan for interventions as well as assessing them, the project has come to its end. It is time to reflect and perform a project review. This review will check if the project objectives stated in Steps 7 and 10 have been fulfilled. For instance, the SmartEnCity project objectives were split into four main categories: technical, environmental, social, and economic objectives.

For a comprehensive review, general and specific feedback from key stakeholders can reveal critical factors; successful ones as well as barriers. The main groups to be asked are citizens and end-users; practitioners and experts; city administration; private sector; and academia.

With all this information, after assessment on Step 14 and project review, the local partnership towards SZCC will be able to check and validate if the interventions were aligned with the strategic plan and action plan at the city level (Step 5), and to what extent they are successful and replicable. What was successful? What might have been done better? From this reflection, key barriers, success factors, regulatory inputs, and potentially exploitable results can be extracted for future projects in the city.

#### STEP 16. SCALE-UP. Up-scaling in the city and next steps

The final step of this third stage and Cities4ZERO methodology explores the replication potential of the process and its implemented SZCC solutions. This is done through local up-scaling strategies for the city, considering urban labs for replication in other areas of the city (prioritization in Step 7/citizen engagement strategy in Step 9), and through exploitation paths for local partners (business models, incubators, accelerators, public-private partnerships, etc.).

As mentioned in the introduction of this third stage, Cities4ZERO methodology will end with a final workshop steered by the local partnership towards SZCC, reflecting on the next steps and future interventions. The thematic working groups set in Stage A for city diagnosis and envisioning processes (Steps 3 and 4) can provide valuable sectorial input. This workshop ensures the continuous iteration of the whole Cities4ZERO strategic process depending on city needs, readjusting the focus of city strategies and projects towards the final decarbonization goal and the evolving urban context:

1. If the strategic plan and action plan are still considered valid after this process, and if an update is not necessary, the city can pick and develop new key projects, coming back to Step 7 (7. PRIORITIZE), selected from the project list published in the action plan (Step 5).
2. In case the strategic plan and/or action plan are considered to be partially obsolete, where an update is appropriate for a project's improved focus, the city can come back to Step 4 (4. ENVISION) and update its strategic planning process for a reconsidered planning umbrella (strategic plan and action plan).

A wrap-up diagram of the Cities4ZERO Intervention and Assessment Stage is presented in Figure 9.

C. INTERVENTION & ASSESSMENT STAGE *PROJECT & CITY LEVEL*



Figure 9. Wrap-up diagram from Cities4ZERO Intervention and Assessment Stage.

## 4. Discussion

### 4.1. Wider Support for Cities

In this environmental crisis, supporting cities is the priority, as local governments are uniquely positioned to enable urban decarbonization, according to their various capacities: as planners and regulators, as facilitators of finance, as role models and advocates, and as large consumers of energy and providers of infrastructure and services [35]. If they are stably committed, the rate of potential success is high for the following decades.

As mentioned above, the Covenant of Mayors being one of the most known initiatives to tackle climate change through reducing CO<sub>2</sub> levels in territories, brings together local and regional authorities across Europe, who give a voluntary commitment to implement energy, climate mitigation and sustainability policies on their territories, has already over 10,075 signatories, with over 6447 SEAPs/SECAPs submitted. Signatories already use the SEAP/SECAP, not only as an energy planning instrument, but also as the basis for an all-encompassing approach to urban planning, as highlighted in the Covenant of Mayors' evaluation report [36]. However, several evaluations of SEAPs and later SECAPs agree that more guidance could be provided to cities to help them address in a more effective way; all the key sectors of activity as the strategic dimension in the urban planning system is still often missing or weak [36–40]. Additionally, evaluations show that especially regarding aspects related to governance (e.g. the adaptation of administrative structures, the mobilization of civil society, or the SEAP monitoring process) and to the financing of actions, municipalities' plans generally show some weaknesses and are lacking tailor-made strategies to ensure citizens' and stakeholders' participation or assigning clear roles and responsibilities to municipal officers. Weaknesses also lay in how the plans are implemented and monitored and in the inconsistency of data [36]. There is room for supporting municipality representatives, planners or developers for a carbon-free urban transition and to provide them with the necessary tools to help cities and local governments reach their own goals of decarbonization in the near future.

Considering the challenges related to cities' high energy demand and carbon production, ways related to the development of energy-efficient urban areas are searched for everywhere; we need cities that are sustainable, smart and resource-efficient and, as argued in this article, who are willing to transform into Smart Zero Carbon Cities. Moreover, climate change is not only the issue for megacities and big urban centres; climate targets, and the need to implement sustainable development goals, are challenging each local government, despite their size [38]. As also admitted by an in-depth analysis of SEAP/SECAPs in the EU [36], smaller municipalities present a more accurate evaluation of the reality of the city and may therefore produce more efficient measures. Smaller municipalities may also benefit from more direct contact with the public and stakeholders and run more successful awareness-raising campaigns, which are an important part of every holistic approach to the city transformation process [36].

In particular, it is important for municipalities to focus on proper engagement activities for creating a sense of joint ownership of the whole transformation process. This exactly addresses the weaknesses that have been identified in numerous SEAPs and SECAPs [36]. As quoted by the representative of the city of Tartu, that is currently finalizing its integrated energy action plan following Cities4ZERO methodology:

The main value for Tartu in this process has been in creating a community of similarly motivated stakeholders. The process demands a lot of effort and communication and may prolong the planning process. But at the same time, it creates an emotionally and intellectually invested group of stakeholders. It will eventually give a planning document the stakeholder support it needs to succeed.

By following Cities4ZERO, Vitoria-Gasteiz ended up with a very detailed baseline analysis and successful engagement of key stakeholders to jointly work towards the vision. Sonderborg involved



almost 100 stakeholders from different sectors, who participated to create a concept that will drive the entire decarbonization process. All cities in the project are outstanding examples of how a local authority can take the lead in mobilizing different stakeholders to find mutually advantageous solutions for transformation. Cities4ZERO methodology also helps to address the need for coordination with other local strategies, initiatives, projects, and departments, to avoid foreseen barriers, as well as to leverage potential synergies in the local context.

All municipalities that were part of this research were facing common challenges and solutions in this urban transition and all concluded that integrated planning implies the commitment of different stakeholders, and the consideration of all dimensions of a problem (social, environmental, technological and economic parameters) is vital to determine the most appropriate solutions. In particular, it is critical to consider at all stages how different social profiles might be engaged in the process, concerning their socio-demographic, socio-economic, and cultural profiles. Some groups will be more difficult to engage than others, so messages and media will have to be tailored to different cultural standards, languages (i.e., for immigrants), formats (i.e., digital or analogical for the elderly), etc. Moreover, different interest groups will emerge (for example, those willing or not willing to retrofit their residential buildings, those willing to foster electric mobility infrastructure, etc.), and conflicting interests will have to be tackled and discussed. In terms of environmental parameters, not only energy will come into the equation, but also air quality and noise issues, ecology, and footprint of materials, as well as their contribution to higher resilience to climate change, for example.

At the time of revising this article, a global pandemic outbreak, namely COVID-19, has completely changed our perspective as a species. All aspects of our living will need revision, urban planning for energy transition certainly being one of them. In general, we are rapidly learning that qualitative analysis will need to be made quantitative, to provide a definitive assessment of the phenomena and their impacts, to be prepared in the future.

#### *4.2. Towards Deeper Integration (Horizontal and Vertical)*

Local authorities are experiencing increasing pressure to develop and implement innovative solutions to provide high-quality services and living environment with less resources, but their capacity to do so remains limited. In order to move towards the zero-carbon vision, it is not enough to implement individual solutions or single improvements without a wider vision. Success rather lies in an integrated approach as a system of interlinked actions—profiting from modern ICT tools, massive data production and analytical capacities, diversifying energy production with renewable energy systems, transforming the structure of energy production for enabling small-scale production, identifying the right business models, supporting changes with administrative and taxing practices, shaping user behaviours, etc. Decarbonizing cities involves numerous interrelated challenges and requires systemic and interconnected solutions.

Although the concept of integrated urban development is not new, “thinking in silos” is still common in too many municipal administrations. Often, individual sectorial strategies do not consider co-dependencies or interdependencies with other city systems. This not only leads to conflicts of interest, but also falls short of addressing cross-sectoral challenges [39]. Consequently, to address these challenges, a holistic strategic approach is vital. This can address each challenge individually and systematically. It could take the form of a city journey where a city would begin with basic steps, for example by defining a framework strategy, and advancing with time to address the more difficult challenges. “The city journey should preferably be underpinned by a long-term vision, designed as a shared roadmap to break through both time and human-related barriers.” [40]. Such a strategy would need the approval of the relevant city systems, actors, governance levels, and territories, and would be jointly developed by these different actors. Making sure that everyone is on board is important, because integrated urban development goes beyond merely coordinating sector policies and interest groups. It presumes a common understanding of the mid- and long-term development goals, which should be jointly developed. Such processes beyond administrative boundaries require political and institutional

changes. At the same time, local governments need to be provided with incentives that promote integrated approaches and strengthen their capacities, so that they can deal with interdisciplinary tasks [39].

As can be recalled from the name, Cities4ZERO proceeds from an integrated urban regeneration model that focuses on the concept of Smart zero carbon cities, i.e., cities that have zero carbon emissions on an annual basis. This article releases this novel, simple and iterative integrated approach for local governments, by explaining the essence of each step. Each step, as described in more detail in the Section 3 “Results”, has its unique setting and elements which should be considered, but all are also very much interconnected. Moreover, experience among cities in the SmartEnCity project shows that this model effectively helps to achieve integration in urban planning, especially 1) through an important emphasis on stakeholder engagement; 2) among city systems and within planning structures; 3) with other government scales (Table 5).

**Table 5.** Cities4ZERO reinforcing energy planning and urban planning local integration for cities decarbonization.

<b>INTEGRATION THROUGH LOCAL STAKEHOLDERS’ ENGAGEMENT</b>
<b>STEP 1.</b> Governance model definition and local taskforce foundation (institutional analysis)
<b>STEPS 3–5.</b> Shared vision and strategic planning among key local stakeholders
<b>STEP 9.</b> Decision-making procedures and agreements along each project (local community)
<b>STEPS 12–13.</b> Engagement activities during implementation and end-users’ training
<b>STEP 16.</b> Shared reflection for next steps and future decarbonization interventions
<b>HORIZONTAL INTEGRATION AMONG CITY SYSTEMS AND WITHIN CITY PLANNING STRUCTURES</b>
<b>STEP 1.</b> Foundation of a local task force, stable in time engaging diverse expertise
<b>STEPS 2–3.</b> Shared sectorial analysis and diagnosis from an integrated perspective
<b>STEPS 4–5.</b> Strategic planning, integrating all sectorial perspectives from vision to action plan
<b>STEP 6.</b> Integration of action plan outcomes into city planning procedures (integration booklet)
<b>STEPS 7–11.</b> Design stage is conceived as an integrated process where all city systems and stakeholders converge once the project and the area of intervention are selected: general strategy (7), financing and overall framework (8), design and solutions (9) and implementation plan (10)
<b>STEPS 12–14.</b> Interventions are planned and executed, considering potential synergies and barriers among sectorial projects (12); commissioning, and assessing the project as one package.
<b>STEPS 15–16.</b> The integration becomes multi-scale, when project validation means a partial city strategy validation (15), and successful interventions can be applied transversally in the city, stimulating even different sectors of the city (16)
<b>VERTICAL INTEGRATION AMONG PUBLIC AUTHORITIES FROM OTHER GOVERNMENT SCALES (REGIONAL, NATIONAL, EU)</b>
<b>STEP 1.</b> Governance model definition, including multi-level governance mechanisms
<b>STEPS 2–3.</b> Analysis of regional, national and European strategies, including the external global city trends that may affect the city in the coming years as part of the diagnosis
<b>STEP 4.</b> Involve regional agencies’ stakeholders in the visioning task
<b>STEP 5.</b> Local planning considering regional, national and EU initiatives, looking for synergies that potentially enable a more straightforward implementation of the actions identified
<b>STEP 6.</b> Municipal integration involving regional agencies when urban competences require this
<b>STEPS 7–12.</b> Project collaboration of regional agencies when urban competences require this
<b>STEPS 15–16.</b> Involvement of regional agencies in the upscaling task. Coordination with national and European best-practices repositories, facilitating the exchange of knowledge among cities. This contrast will enrich the iterative city strategic planning process

Moreover, while inevitably posing a considerable challenge for cities, successful integrated urban planning leads to many benefits [39]:

- It allows cities to formulate cross-sectoral goals and to develop monitoring systems for cross-cutting policy fields, such as how to efficiently use natural resources, or reduce socio-economic disparities;

- It enables cities to develop strategies and projects that involve the knowledge and perspectives of different disciplines and actors from the civil and private sector;
- It helps cities with limited budgets and capacities to implement their goals more efficiently by joining capacities and funds, and by reducing trade-offs between sectors and neighbouring municipalities.

## 5. Conclusions

Considering the importance of cross-sectoral solutions and coordination, the inclusion of relevant actors, coordination between different levels of government, and balanced territorial development, this article presented Cities4ZERO methodology—a theoretical framework for decarbonizing cities through a valuable holistic and system-thinking approach. Within the SmartEnCity project, five cities have worked closely towards developing and putting the approach into practice, and almost 60 cities through the SmartEnCity Network have already started implementing the approach in their local settings. The application of this theoretical framework is mobilizing all these cities towards their potential decarbonization in the coming years, allowing further studies from the diverse local degrees of application and results obtained. So far, Cities4ZERO has proved the ability to engage cities through this solid theoretical framework; a framework cities find understandable and applicable, as well as valuable for them, according to the number of cities already following its steps [25].

### 5.1. A Community of Practice with Shared Methodologies and Tools

As zero carbon transition should be on the agenda of almost every municipality in the world, there are many initiatives supporting this transition. Next to the mentioned Covenant of Mayors, the EU initiative EIP-SCC platform intends to engage cities, industries, SMEs, investors, and researchers, bringing them all together to design and deliver smart-sustainable solutions and projects. From a narrow techno-economic perspective, a smart city programme aims to encourage the replication of technological solutions, but

smart city solutions are rarely a simple product or service. They often consist of complex urban interventions involving many different parties, each one with specific interests, agendas, and capacities. Everything must be there, at the right place, in the right moment: the technologies, the business models, the favourable legal context, the governance structure, social acceptance, user motivation, capacities and knowledge, budgets, aligned agendas, etc. [40]

This is exactly why the SmartEnCity project focused more on creating a comprehensive strategic toolbox for municipalities through examining planning, implementation, monitoring, and replication works, to identify the key factors playing a most important role towards smart urban decarbonization, reviewing an ongoing process of five years of coordinated initiatives in the cities of Vitoria-Gasteiz (ES), Tartu (EE), Sonderborg (DK), Lecce (IT) and Asenovgrad (BG) and ended up with Cities4ZERO. Applying a strategic and integrated urban planning approach in the city can be an efficient way to create a platform that supports increased connections and relations between the relevant stakeholders of the community and energy system, and to support the implementation of integrated solutions. As learned from the research, a key functionality of such a process is to activate and engage relevant stakeholders, to enhance cross-sectoral thinking among the stakeholders, and to expose varying interests and agendas. All of this has a central position in Cities4ZERO. Acceptance and support from the local stakeholders as well as generating a common reference point (i.e., energy plan and /or integrated urban plan agreed among stakeholders) for the transition of the city energy system are two of the main aims of the process, as this is necessary to form a basis or platform for increased co-operation in interconnected zero-carbon transformation processes.

### 5.2. The Way forward: Local Stakeholders Engagement and Digital Technologies for Improved Energy Planning

As already evident, the concept of Smart Zero Carbon Cities is a complex and multi-layered one, involving a lot of planning, risk analysis, public sector initiative, and stakeholder involvement to truly benefit the city. Transition in practice also requires large-scale investments for replacing the infrastructure and capital goods; all of these efforts are crucial as European cities are at the forefront in the shift to a low-carbon economy. Bulkeley et al. note the criticality of municipalities' actions to low-carbon transition, especially being dependent on some new starting points [41]:

1. We cannot invent our way towards a low carbon future without also engaging society—the sorts of changes that are required to urban infrastructure networks require not only new technologies, but also new forms of investment, new practices of energy use and new ways of working between the public and the private sector.
2. Responding to these challenges requires not only capacity at the urban level and a proactive political climate, but also a willingness to create new forms of knowledge about cities and to operate beyond established practices and ways of doing things.
3. Bringing transition to the city reminds us that what is at stake is not a simple choice between different paths to the future, but rather a complex and negotiated process—creating spaces in the city where diverse social interests can articulate and experiment with their visions for the future is a pressing policy challenge.

Regarding this engagement process, Steps 3 to 6 in Cities4ZERO are key (DIAGNOSE, ENVISION, PLAN CITY LEVEL, INTEGRATE), as they steer the co-development of the long-term city strategy, identifying the key projects to be developed, involving key local stakeholders in the visioning and planning process, and ensuring their commitment in a potential implementation and its integration in the planning procedures of the city. An in-depth analysis and further development of these steps will allow one to reinforce the whole transition, spreading the shared commitment feeling among the local community.

Furthermore, focusing on city modelling for decision-making processes, municipalities would benefit from an ICT tool able to integrate energy and decarbonization mapping with spatial planning (GIS-based), helping to visualize the affection and spatial implications of decarbonization actions, so that they can be better integrated in future local policies, general/sectorial plans and projects. This is a future research line for the authors, as it would be of great support in the Cities4ZERO steps dealing with the diagnosis (2, 3), planning (5), integration (6), prioritization (7), design (10), assessment (14) and up-scaling of solutions (16), significantly supporting the decarbonization process of the city.

Finally, as participants in the SmartEnCity project, research will still gather valuable experience and new evidences of Cities4ZERO performance during the coming years, especially through Cities4ZERO Steps 7-16, an in-depth analysis of the whole methodology in practice will be considered. This theoretical framework developed over the years working with different cities will continue its implementation, monitoring, and evidence collection, which will enable its further refinement and consolidation.

**Supplementary Materials:** The City Check-up Assessment methodology for municipalities is available at <http://www.mdpi.com/2071-1050/12/9/3590/s1>, Figures S1–S9: Cities4ZERO final Diagrams.pdf, Tables S1–S5: Cities4ZERO final tables.pdf.

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