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Towards an Integrated Approach to Urban Decarbonisation in Practice: The Case of Vitoria-Gasteiz

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Abstract: How can local authorities effectively approach the decarbonisation of urban environments? Recent efforts to redirect cities into a less energy-intensive model have been mostly approached from a sectoral perspective, with specific energy policies and plans being issued without deeply considering their ties with other urban aspects. In this sense, well-established urban planning procedures have not been part of those, with the consequence of barriers in the implementation phase of those energy plans. The Cities4ZERO methodology was developed to guide effective integration between urban planning and energy policies, plans, and practices. It provides a holistic approach to strategic municipal processes for urban decarbonisation in the mid-long term, which includes key local stakeholders' engagement into integrated energy planning processes, as well as tools for effective energy decarbonisation modelling. This paper analyses the application of the Cities4ZERO decarbonisation methodology on its strategic stage in the development of Vitoria-Gasteiz's Action Plan for an Integrated Energy Transition 2030 (APIET 2030). It suggests that in order to accelerate urban decarbonisation, it is critical to: (a) foster interdepartmental collaboration; (b) allow for flexibility on the land-use planning regulations; (c) back decisions with detailed urban-energy models; and (d) truly engage key local stakeholders in the planning and implementation processes.

Keywords: decarbonisation; urban transformation; energy transition; integrated planning; smart cities; smart zero-carbon city; foresight; climate change mitigation

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1. Introduction

Scientific evidence confirms that climate change is increasingly affecting our planet, so it is essential to accelerate adaptation and mitigation actions. Cities are at the forefront of this battle, being part of both of the problem and the solution, as urbanisation is accelerating, and it is estimated that 70% of the world's population will live in cities by 2050 [1]. Local pollution is a clear example of this entrenched problem, as cities account for 70% of GHG emissions [2], and 92% of the world's population lives in polluted environments, with serious health consequences [3].

Mitigating climate change is key to avoid reaching a point of no return. Bold, transformative action is needed in our cities, both new and old, to transition towards a new urban model that is compatible with caring for life on the planet.

Goals seem to be clear, but the question of how to put them into practice remains unclear. How can local authorities effectively approach the decarbonisation of urban environments through pragmatic and concrete actions? Transforming complex urban ecosystems requires a systemic approach, cooperative leadership, and clear pathways

for cities to follow [4]. Moreover, transformative action needs to be multi-dimensional, multi-scalar, and multi-stakeholder [5–7].

Recent efforts to redirect cities into a less energy-intensive model have been mostly approached from a sectoral perspective, with specific energy policies and plans being issued without deeply considering their ties with other aspects [8]. In particular, well-established, consistent urban planning procedures appear not to exist to aid these efforts [9], with the consequence of creating barriers in the implementation phase of those energy plans.

The Cities4ZERO methodology [10] was developed as a consistent guide to effectively integrate urban planning and energy policies, plans, and practices. It provides a holistic approach to strategic municipal processes for urban decarbonisation in the mid-long term, which includes key local stakeholders' engagement into integrated energy planning processes (for Vitoria's foresight case, see [11], as well as tools for effective energy decarbonisation modelling (such as ENER-BI; see [12]).

The strategic stage of this framework has been comprehensively applied for the first time in Vitoria-Gasteiz, focusing on the key factors towards a smart urban decarbonisation [13], and covering the main governance and planning milestones to accelerate urban decarbonisation from municipal action.

This paper delves into this approach through an in-depth analysis of the process of developing Vitoria-Gasteiz's Action Plan for an Integrated Energy Transition 2030 (APIET 2030) in order to determine if Cities4ZERO works as an effective and pragmatic framework for such strategic processes. Does it really provide a strategic framework able to accelerate Smart Urban Decarbonisation processes in the mid-long term?; Does Cities4ZERO effectively engage key local stakeholders while using energy and decarbonisation modelling tools in such a process?; Is it a useful governance mechanism to draft a decarbonisation strategy for the city, complemented by a set of key transitioning projects? The paper also reflects on the need for flexibility from municipal planning structures to adapt to evolving challenges, advocating for urban-energy models as a crucial element of decarbonisation planning.

In Section 2, the detailed process followed in Vitoria-Gasteiz for the development of the APIET 2030 is presented, following the main steps of the strategic stage of the Cities4ZERO methodology. Section 3 delves into the results of each step, raising important findings that are further discussed in Section 4, which finally outlines future lines of research.

2. Materials and Methods

2.1. Cities4ZERO for Vitoria-Gasteiz Planning Process

The development of the Action Plan for an Integrated Energy Transition 2030 (APIET 2030) in Vitoria-Gasteiz follows the Cities4ZERO urban decarbonisation methodology, "*a step-by-step methodology able to guide local authorities 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*" [10]. This methodology builds upon the smart zero-carbon city (SZCC) concept, which defines a resource-efficient urban environment where the carbon footprint is nearly eliminated [14]. Both Cities4ZERO methodology and SZCC concepts are based on the theoretical and empirical analysis developed in research pilot projects in European cities within the smart cities and communities programme of the European Commission (EC); such an analysis resulted in the definition of the key factors towards smart urban decarbonisation, linking the smart cities and the climate mitigation action movements [13]. This methodological and conceptual framework was presented to Vitoria-Gasteiz representatives, meeting their expectations and the city transitioning needs, and it was therefore applied to the specific case of the APIET 2030, coordinated by the authors of this research.

The development of the APIET 2030 follows the strategic stage at the City Level (Stage A of Cities4ZERO, Figure 1), focused on providing the most suitable planning framework for effective urban decarbonisation. In particular, the strategic stage consists of 6 steps, all of which are applied to the Vitoria-Gasteiz case:



Figure 1. Strategic Stage (A) of Cities4ZERO urban decarbonisation methodology.

2.1.1. Step 1. ENGAGE. Foundation of a Local Partnership with the SZCC

In 2019, Vitoria-Gasteiz created the new transversal energy and climate municipal service, intending to lead and coordinate the climate action programme in the city. This internal reorganisation is a consequence of municipal elections and the structural update of the incoming administration, which can be considered as an exercise of *Institutional Transformation* [15], to more consistently steer the challenging climate action agenda. In the case of the APIET 2030, the incoming Energy and Climate Department has been supported by the external consultancy of research and technology organisations (RTOs), to which the authors of this study belong, to be able to develop this strategic planning process.

2.1.2. Step 2. ANALYSE. City Information Gathering; City Characterisation

Once the leading team is in place, the first task to develop the APIET 2030 consists of collecting all necessary data for an integrated planning process; building a city background information package (CBIP). This process required a literature review on the existing policies, regulations, strategies, and plans on the field, providing a deeper understanding of the socio-economic and sectorial characteristics of the city. Furthermore, this analysis was complemented by a set of city indicators, described on the SZCC readiness level framework [14], and an urban-energy model able to calculate a carbon emissions baseline (More information about the model is included in Section 2.2 Principles for urban-energy modelling).

2.1.3. Step 3. DIAGNOSE. Strategic City Diagnosis and Visioning Taskforces Set-Up

To extract some conclusions of the city analysis performed, the steering group firstly identified and later coordinated the key stakeholders of the city to develop a shared strategic city diagnosis. These stakeholders were summoned by personal email invitations to a first workshop on 29 January 2020, at Vitoria-Gasteiz's Europa Congress Hall, gathering more than 40 representatives coming from 4 main social groups: public practitioners, private businesses, civil associations, and research institutions. Through this event, the participants were able to discuss and identify the city's global trends that might externally affect the city

in the coming years, as well as the internal characteristics of the city, finally co-developing the SWOT (strengths, weaknesses, opportunities, and threats) analysis of Vitoria-Gasteiz.

2.1.4. Step 4. ENVISION

Building upon the strategic city diagnosis co-developed during the first workshop, the same representatives of the main social groups gathered again at the same venue on 12 February 2020, this time with the aim of co-creating the future vision for Vitoria-Gasteiz by 2030, supported by the assistance of sectorial experts (energy, mobility, building renovation, public lighting, water and waste management, etc.) and a moderator expert in prospective exercises (detailed *foresight* method described in [11]). Divided into four groups, assuming the role of city planners, and based on the SWOT analysis, the participants generated four different scenarios by 2030, which was then converted into one "master scenario", taking diverse elements of each scenario. According to that "master scenario", the participants co-developed a city vision for Vitoria-Gasteiz 2030, which resulted from reaching consensus among all participants (see the development process in Figure 2).

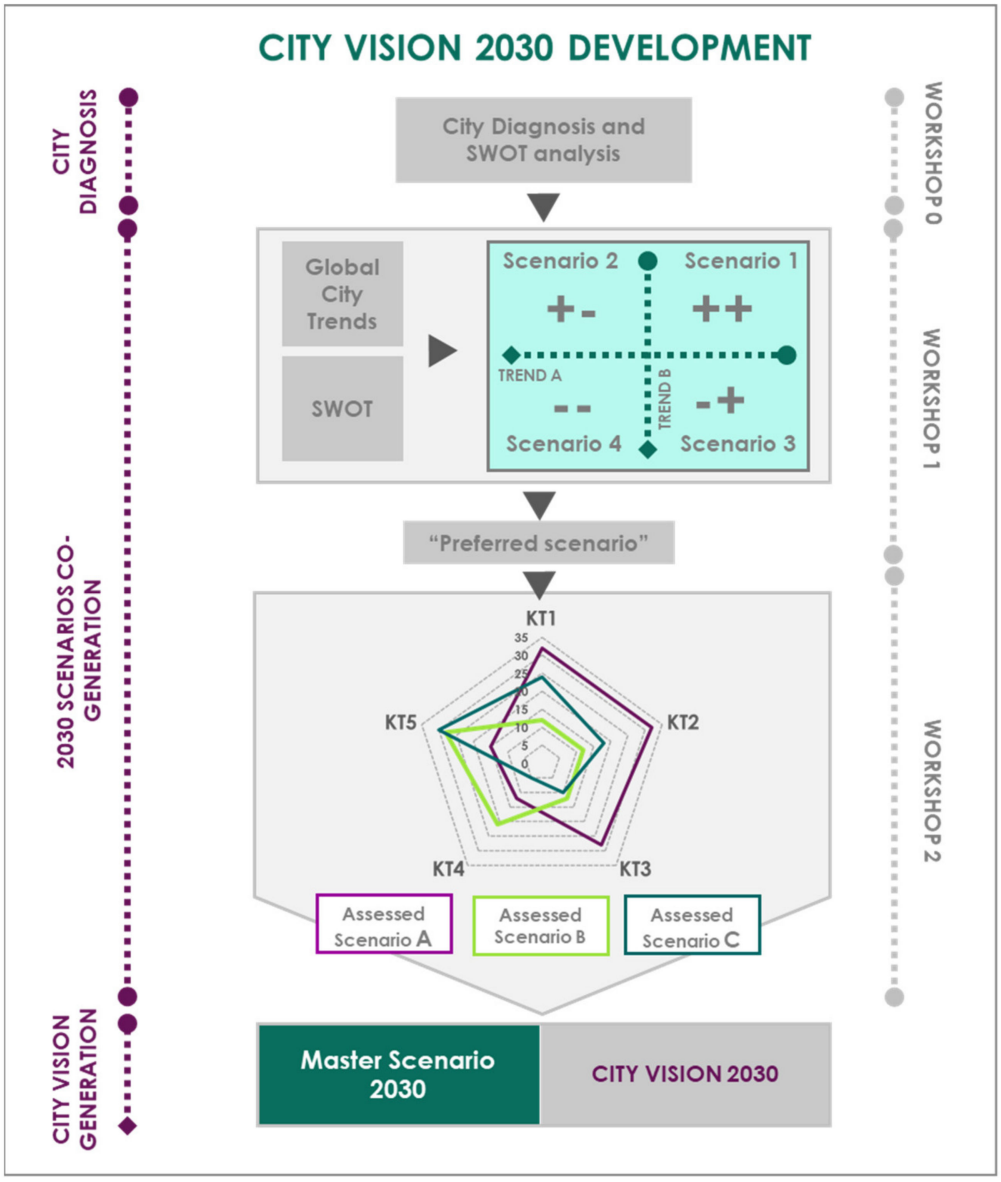

Figure 2. City Vision co-development process in APIET 2030.

2.1.5. Step 5. PLAN CITY LEVEL

Based on the City Vision 2030 and the co-generated master scenario, the leading energy and climate municipal service started the development of the APIET 2030 document. This process consisted of a thorough analysis of the input gathered in the workshops, identifying the objectives of the APIET 2030, as well as structuring all contents into a detailed breakdown of strategic areas, strategic lines, and key actions. This content was contrasted by local sectorial experts, supported and aligned with the urban-energy model, and presented in a final draft document, which was opened to the citizenship in a public participation process before its final publication.

2.1.6. Step 6. INTEGRATE

Once the APIET 2030 was published, the municipal service of energy and climate made a reflection on how to integrate the outcomes of the APIET 2030 into municipal planning dynamics and instruments. In this regard, integration was considered in terms of horizontal integration (cross-cutting collaboration among municipal departments and their sectorial strategies), looking more specifically to the ongoing update of Vitoria-Gasteiz urban plan; and vertical integration, looking for alignment with existing initiatives at regional, national, and European level.

2.2. Principles for Urban-Energy Modelling

According to the Cities4ZERO methodology, the decarbonisation planning process needs the support of an urban-energy model able to calculate the potential impact of the actions defined on the local energy system. With that purpose, the urban-energy model must set a baseline (2017 in the case of Vitoria-Gasteiz) upon which to introduce city actions, checking to what extent the objectives defined can be fulfilled and in what timeframe.

In this sense, the ENER-BI research project presented the desirable characteristics of an urban-energy decision support system (DSS) able to integrate energy and spatial data for cities' decarbonisation planning [12]. This research project set specific requisites on information gathering procedures, information storage (both static and dynamic data), data integration and treatment, key performance indicators' calculations, necessary outputs for decision-makers, and dashboard visualisation. All these requisites were oriented to enable the three main functionalities of an urban-energy DSS, also described in [12]:

- Module 0—Inventory, characterisation, and monitoring.
- Module 1—Scenarios generation for decarbonisation planning.
- Module 2—Decarbonisation follow up.

In the case of APIET 2030, the developed urban-energy model integrates these three items. Based on the gathered information at the city level (Section 2.1.2 *Step 2. ANALYSE*), the model can process the characterisation of the urban-energy system (Module 0). The end-use sectors of the city and the supply technologies are both portrayed in the LEAP modelling framework [16]. Demand-side sectors are detailed as much as possible (according to the available information) to accurately model the energy actions that will be enacted.

The characterisation of the baseline year serves as the starting point from which scenarios are created. Indeed, the main goal of the urban-energy model is to generate different future situations that the city could face in order to assist in the generation of the city vision (Module 1). Scenarios are modelled through the combination of global city trends, past and future socio-economic and demographic tendencies, as well as the impacts of implemented energy actions. The first business as usual scenario is created, serving as a benchmark for the generation of the alternative scenarios, to be discussed by local stakeholders (Section 2.1.4 Step 4. ENVISION). As a result of this exchange, a master scenario is modelled, representing the 2030 city vision.

The model can be updated, and new scenarios generated, allowing the follow-up of the city decarbonisation process, as well as the rework of the energy plans and targets (Module 2).

3. Results

Once the process has been described, this section presents the results of the application of the Cities4ZERO methodology to the case of Vitoria-Gasteiz's APIET 2030 development.

3.1. A New Energy and Climate Action Cross-Cutting Department

Ten years after starting the implementation of the first climate change adaptation and mitigation plan in Vitoria-Gasteiz [17], and once the new government municipal structure was defined as a consequence of the 2019 elections, the new political board decided to make a decision that had been under consideration for some years: the creation of the energy and climate department. At the end of 2019, with the APIET 2030 in its preparation phase, the municipality agreed on the need for an institutional analysis leading to an internal reorganisation of resources to better cope with the challenging complexity of implementing Vitoria-Gasteiz's climate action agenda.

Managed by the former environment department director, the role of the energy and climate department mainly consists of:

- Leading the climate action agenda from the municipality, complying with the covenant of mayors and sustainable development goals municipal commitments; strategic coordination, tendering processes, climate innovation fundraising, and strategic roadmapping and documents' development. Furthermore, the department must ensure the municipality complies with the sustainable energy regional regulations [18], in line with the energy performance of buildings (EPBD; 2018/844) and energy efficiency (EED; 2018/2002) EU Directives, and tightly linked to the decarbonisation of our energy systems.
- Coordinating a cross-cutting collaboration within the municipal departments and agencies (internal), as well as with external stakeholders that are engaged in specific climate action strategies or initiatives (private sector, academia, citizenship).
- Managing the competencies of some relevant climate-related municipal areas, absorbed from the former municipal structure: energy, environment, green infrastructure, waste management, and urban planning.

In order to fulfil the expectations of these competencies, the new department has needed a reallocation of former workers from other departments, as well as the recruitment of two new profiles for the staff.

3.2. A City Background Information Package for Energy and Climate Action

One of the first new department's tasks was performing a city characterisation in energy and decarbonisation terms, which can be an evolving repository that grounds any strategic work connected to this topic. This characterisation, appointed as Vitoria-Gasteiz background information package, consists of:

1. A repository of strategic documents of the municipality, both general and sectorial, that can affect the decarbonisation strategy; hence they can be more efficiently coordinated and aligned in the future. In this case, the documents reviewed were: former sustainable energy action plan (SEAP) 2010–2020 [17], former carbon neutrality strategy 2050 (Vitoria-Gasteiz's "Carbon Neutrality" understanding goes in line with Scope 2 of greenhouse gas protocol: *"GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary"*. In this sense, emissions offsetting by exporting renewable electricity is considered.), analysis of solar energy potential in rooftops, energy strategy for municipal buildings, agri-food municipal strategy 2025, Basque energy transition strategy, study for a municipal energy-marketer, a comparative study on cities energy transition 2030 including Vitoria-Gasteiz, sustainable urban mobility plan (SUMP), water management strategy, waste management strategy, green infrastructure strategy, sustainable energy regional regulation, national plan for energy and climate, and the diverse local ordinances on energy and urban planning.

2. An urban-energy model portraying the energy system of the city and its performance. The urban-energy model integrates both Vitoria-Gasteiz's end-use sectors and energy supply infrastructures, accounting for the energy consumption and related carbon emissions for the baseline year. The urban-energy model allows the simulating of future energy scenarios supporting further strategic planning and decision-making (Section 2.2 Principles for urban-energy modelling).
3. A set of city indicators related to decarbonisation, already published in [14], provides an overview of the key metrics to be monitored in a city decarbonisation process. In this sense, both the urban-energy model data and this set of city's decarbonisation indicators can be integrated into an urban management dashboard, altogether with multiple georeferenced data sets that allow an integrated analysis, as Figure 3 shows.

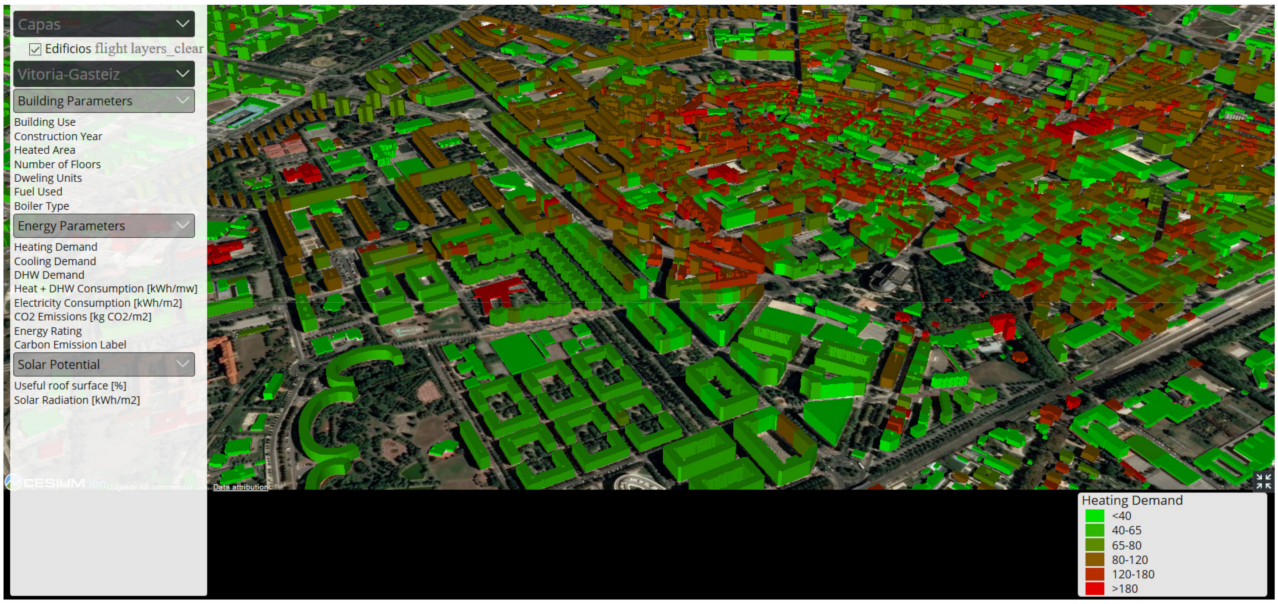

Figure 3. Vitoria-Gasteiz's management dashboard (i.e., overview on buildings' heating demand; kWh/m^2).

3.3. A Working Group of Key Local Stakeholders Engaged in Energy and Climate Action Strategic Processes

A core element in Cities4ZERO methodology is its alignment with integrated planning governance principles, namely, (a) integration through local stakeholders' engagement; (b) horizontal integration among city systems and within planning structures; and (c) vertical integration among public authorities from other government levels. A working group of local stakeholders engaged in energy and climate action strategic processes is, therefore, a cornerstone of the APIET 2030.

During the APIET 2030 development, working groups were constantly engaged (Table 1); with a twofold purpose. First, the intensive co-creation process significantly enriches the result of the final plan, thanks to the variety of knowledge brought by the diverse set of stakeholders. Secondly, most of the local stakeholders involved own the key competencies, resources, and knowledge relevant for implementing the APIET 2030 projects; bringing them on board since the beginning of the process increases their commitment in a future implementation, as well as in overcoming potential barriers.

Table 1. Involvement of working groups in APIET 2030.

		NOVEMBER 2019/ MARCH 2020 Validation of Global City Trends, City Diagnosis, Scenarios' Generation, and City Vision Development	**APRIL 2020/ FEBRUARY 2021 Identification and Description of Key Projects for APIET 2030**
Public Administration	**Political**: deputy mayors **Technical**: municipal department directors, municipal agencies, regional agencies; city/regional managers and practitioners the on environment, energy, built environment, urban planning, active mobility, public transport, digital transition and administration, waste management, economic development	Co-leading the process (leading municipal department) Invited to two co-creation workshops, covering the whole process (rest of public administration staff)	Co-leading the process (leading municipal department) Coordination of APIET 2030 actions with each departmental strategy
Private companies	**Representatives** from companies and cooperatives with expertise in energy management, water management and solutions, construction, urban infrastructures, PVs, geothermal solutions, mobility, urban participatory processes, and district heating	Invited to two co-creation workshops, covering the whole process	Suggestion of key projects and contrast of APIET 2030 actions
Academia/RTOs	**Experts** on urban planning, construction, energy, and environment	Co-leading the process Involved in the design of the co-creation process, moderation of workshops, and background materials for participants. Invited to two co-creation workshops, covering the whole process	Co-leading the process. Coordinating actions' files and APIET 2030 document. Sectorial contrast in scientific and innovation terms
Civil associations	**Representatives** from neighbours' associations	Invited to two co-creation workshops, covering the whole process	Suggestion of key projects and contrast of APIET 2030 actions

3.4. A City Diagnosis on Energy and Climate Action

Based on the city background information package of Vitoria-Gasteiz (Section 3.2), and the working group of key local stakeholders engaged in energy and climate action strategic processes (Section 3.3), a city diagnosis on the topic was developed. As described in Section 2.1.3, this city diagnosis involved local stakeholders in the identification of global city trends for Vitoria-Gasteiz 2030, considering potential external affections (opportunities and threats), and performed a SWOT analysis to contrast those external affections with the internal characteristics of the city (strengths and weaknesses). First, regarding the global city trends identification, the stakeholders voted the "relevance" and "uncertainty" of each of those (Table 2, Figure 4); on the one hand, the potential impact of those trends by 2030 is what makes them relevant; on the other hand, the uncertainty of such impact is what generates different scenarios by 2030 depending on whether those trends follow one or another direction.

Table 2. Global city trends. Votes of Relevance and Uncertainty in APIET 2030 workshop 0 (process diagram on Figure 2).

	Global City Trend	Code	"Relevance" Votes	"Uncertainty" Votes
Building stock	Decarbonisation 2050	Ed1	2	2
	Building stock renovation	Ed2	13	10
	Smart Devices implementation	Ed3	0	0
	3D printing	Ed4	0	1
Sustainable mobility	E-mobility	Mo1	7	6
	Connectivity	Mo2	0	0
	Autonomous driving	Mo3	0	3
	Mobility as a service	Mo4	1	0
Governance	Long-term planning	Go1	2	2
	Co-design/co-creation processes	Go2	4	2
	Supra-municipal funding in climate action	Go3	1	5
	Institutional and citizenship awareness	Go4	16	20
Energy	Renewable energies	En1	11	2
	Local energy communities	En2	1	1
	Energy system's monitoring	En3	0	0
	EU Green Deal	En4	4	3
ICTs	Data access	TIC1	0	2
	Virtual reality, augmented reality, digital twins	TIC2	0	1
	Smart city apps and 5G	TIC3	0	0
	Increasing inequalities	TIC4	1	2
Social	Responsible consumption	So1	2	7
	Demographics and aging population	So2	2	0
	Individualism and consumerism	So3	10	8
Others	Telework and reduced commuting	Otro1	3	4
	Active mobility	Otro2	0	2
	Increasing legislation	Otro3	4	3
	Education and leading societal patterns	Otro4	1	1
	Impact of climate change	Otro5	2	0
	Industry 4.0	Otro6	2	0
	Globalisation and big capitals attraction	Otro7	3	1

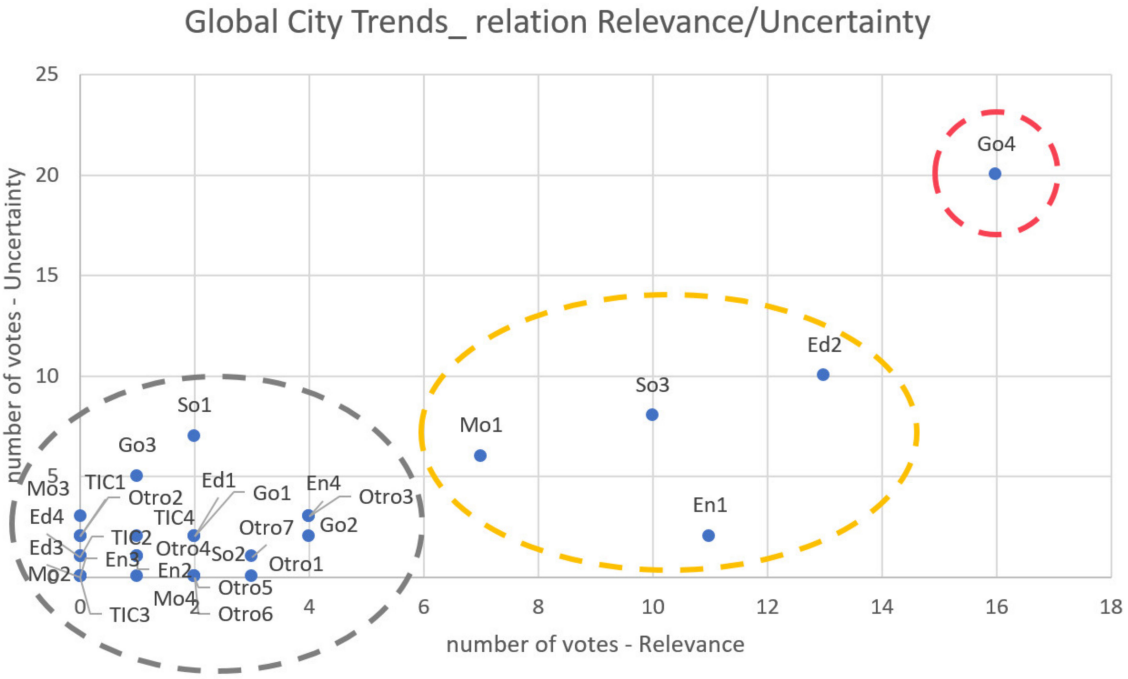

Figure 4. Scatterplot diagram showing the relation Relevance/Uncertainty of global city trends in APIET 2030 workshop 0 (process diagram on Figure 2/acronyms in Table 2).

Derived from the global city trends assessment, the stakeholders identified the main external opportunities and threats; derived from the CBIP (city characterisation; Section 3.2), the main internal strengths and weaknesses of Vitoria-Gasteiz in energy transition terms were identified, assembling a SWOT analysis focused on qualitative input. This SWOT exercise was supported by the urban-energy model, which provided a deeper quantitative input (Sankey diagram on Figure 5, summarising Vitoria-Gasteiz's energy system).

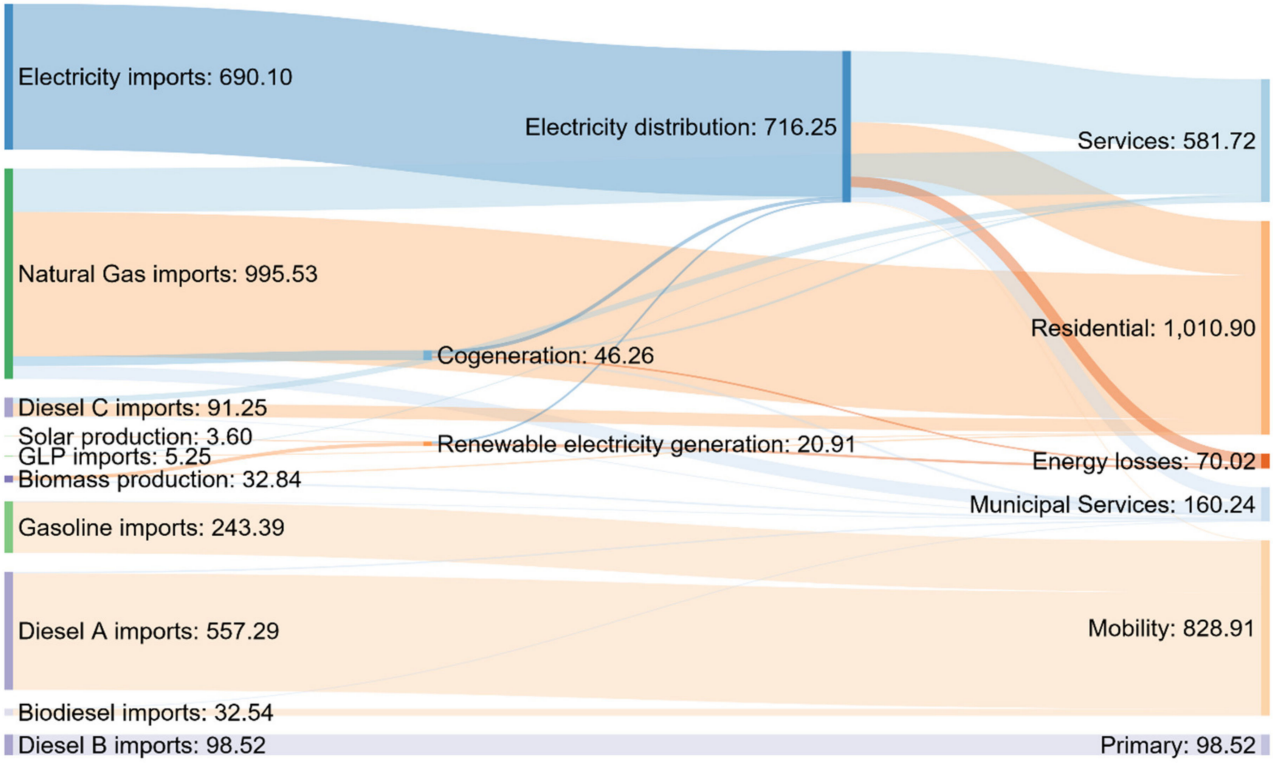

Figure 5. Sankey diagram of Vitoria-Gasteiz's energy balance, part of APIET 2030 city diagnosis (GWh).

Finally, the resulting SWOT was contrasted and complemented by the key local stakeholders' group (Section 3.3), finding in this city diagnosis a common ground to build the strategic planning process of Vitoria-Gasteiz (city vision 2030; Section 3.5 and action plan 2030; Section 3.6).

3.5. City Scenarios Generation and a City Vision for Vitoria-Gasteiz 2030

Once the city diagnosis development and global city trends identification processes were finalised, the ground for co-generating a city vision 2030 was ready (Figure 2). First, taking the CO_2 reduction and climate adaptation institutional goal, together with the most "relevant" but "uncertain" global city trend voted by local stakeholders ("Institutional and citizenship awareness"; Table 2), four different 2030 scenarios were co-generated by four stakeholders' groups (workshop 1 in Figure 2). Each of those scenarios was developed according to a prospective exercise performed by each group [11], where the stakeholders identified the main elements that would lead to such a situation in 2030, all categorised by city system (energy and renewables; built environment; mobility; governance; others). At this point, all SWOT elements and main global city trends identified were kept in mind for each scenario generation. Each of those four scenarios consisted of a prospective narrative and an urban-energy model, and they were complemented by a summarising diagram and a title proposed by the participants, aiming for a better common understanding for the whole stakeholders' group (Figure 6):

- "Haec est Victoria quae vincit", where institutional and citizenship awareness would be high, and CO_2 reduction targets would be achieved (+/+).
- "Vitoria-Gasteiz is frustrated", where institutional and citizenship awareness would be high, but CO_2 reduction targets would not be achieved (+/−).
- "ECO-nomic despotism", where institutional and citizenship awareness would be low, but CO_2 reduction targets would be achieved (−/+).
- Vitoria-Gasteiz Grey Capital, where institutional and citizenship awareness would be low, and CO_2 reduction targets would not be achieved (−/−).



Figure 6. Synthetic diagrams of the four scenarios in APIET 2030.

After an intense debate among local stakeholders, they tried to reach a consensus on the key elements for a "preferred scenario" (Table 3), which must be ambitious enough to reach CO_2 reduction 2030 goals and achievable to not generate wrong expectations among the local community. Furthermore, the key elements of that "preferred scenario" were introduced in the urban-energy model, generating slightly different technical proposals to achieve those 2030 goals. Finally, the members of the energy and climate department, with the support of the urban-energy modellers, were able to refine the outputs of the co-creation process to present the "master scenario 2030".

Table 3. Summary of key elements of Vitoria-Gasteiz's master scenario 2030.

Energy and Renewables	Building Stock	Mobility	Governance	Others
High renewables share	Increasing energy-renovation	Active mobility	CO_2 reduction and resilience targets achieved	Diversified economic drivers, with high added value and based on a circular economy
Local energy communities (residential and industrial)	Building stock adaptation to climate change impacts	Impact of "superblocks" concept and proximity services	High institutional awareness. Public administration as a role model	Services vs. production
Energy exchange (waste energy management	Renovation solutions with clear and shared financing models	New mobility services: micromobility, shared mobility	High citizenship's awareness; empowerment	Industrial regeneration
Distributed energy generation	Systemic renovation actions; no more pilot projects	Last-mile logistics revolution	Political multi-level alignment (local/regional/Europe)	High-quality employment
Energy self-sufficiency	Reduction of heating demand	Electrification of private vehicles and public transport	Flexible regulatory and taxation frameworks	Higher food and logistics self-sufficiency
Energy storage systems upgrade	Urban regeneration of vulnerable areas; "superblocks" concept	Integration of technology companies into urban areas, avoiding commuting to industrial areas	One-stop-shop for energy and renovation projects and local energy communities	New waste-management model

Furthermore, the essence of the master scenario 2030 was condensed into Vitoria-Gasteiz 2030 city vision, a statement with the main headlines the city intends to achieve after the implementation of the APIET 2030 plan, finding a consensus among the group of local stakeholders:

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-renovation 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 is within a prosperous, innovative, and competitive economic environment, which ensures a collaborative social model in which no one is left behind [10].

3.6. APIET 2030—The Action Plan for an Integrated Energy Transition in Vitoria-Gasteiz

As a result of the co-development planning process, the APIET 2030 was finalised. The document describes the co-generation process at all stages, achieving an unprecedented level of agreement among the local community. Furthermore, it presents the city diagnosis, the master scenario, and the city vision 2030, leading to the final action plan 2030 (summary on Table 4), consisting of strategic objectives (2 general; 7 specific), strategic areas (5), strategic lines (10), and key actions (41).

Table 4. APIET summary; strategic objectives, areas, lines and key actions.

STRATEGIC OBJECTIVES (Overall - OSO/Specific - SSO)	
OSO1. Improvement of carbon footprint	**OSO2.** Local partnership for the energy transition
SSO1. Decentralised energy production and Local Energy Communities promotion	
SSO2. Social-fair energy-renovation of the building stock	**SSO3**. Sustainable Mobility
SSO4. Exemplary municipal leadership on energy transition	**SSO5**. Local community empowerment
SSO6. Industrial ecology and circular economy	**SSO7**. Digital transformation
STRATEGIC AREAS (SA), STRATEGIC LINES (SL), KEY ACTIONS (A)	
SA1. ENERGY GENERATION & RENEWABLES	
SL1. Implementation of distributed energy generation and electrification [19]	
A1.1.1 Renewable energy in public buildings/infrastructures	A1.1.2 Electrification of energy demand
A1.1.3 Waste and sustainable forestry maintenance as energy source	
SL2. Self-consumption potential management	
A1.2.1 Study on suitable urban locations	A1.2.2 Plan for self-consumption installations
A1.2.3 Fostering energy exchange among prosumers	A1.2.4 Energy Transition Plan for industry sector
A1.2.5 Partnership with energy and climate research/innovation institutions	
SA2. INDUSTRIAL, RESIDENTIAL, AND TERTIARY BUILDING STOCK	
SL3. Proactive management of renovation solutions; energy demand/consumption reduction in buildings	
A2.3.1 Creation of a municipal renovation institution	A2.3.3 Urban regeneration master plan
A2.3.3 Director Integrated Plan for housing renovation	A2.3.4 Reducing energy consum. in services sector
A2.3.5 Programme for energy meters deployment in buildings. Control of electric and thermal energy demand	
SA3. SUSTAINABLE MOBILITY	
SL4. 15 min mobility and shared mobility	
A3.4.1 "Superblocks" urban concept implementation	A3.4.2 Capacity building and promoting cycling
A3.4.3 Plan for school and work commuters	A3.4.4 Regulated parking plan
A3.4.5 Services of shared mobility	
SL5. Vehicles and infrastructures electrification	
A3.5.1 Electrification of public transport	A3.5.2 Last-mile logistics hubs
A3.5.3 Electrification of municipal fleets	A3.5.4 E-chargers deployment programme
SA4. GOVERNANCE	
SL6. Institutional leadership on energy transition	
A4.6.1 Transversal governance activities	A4.6.2 Adaptation of urbanistic instruments
A4.6.3 Public-private financing system	A4.6.4 Green taxation programme
A4.6.5 Participation in global city networks on energy and climate neutrality	
SL7. Fostering Local Energy Communities (LECs)	
A4.7.1 Fostering local stakeholders' interest/cooperation	A4.7.2 Open capacity building on energy transition
SA5. MUNICIPAL SERVICES AND FACILITIES	
SL8. Efficient municipal services	
A5.8.1 Creation of an energy transition one-stop-shop	A5.8.2 Energy efficiency on waste management
A5.8.3 Energy efficiency on the water cycle management	A5.8.4 Circular economy on municipal activity
A5.8.5 Environment criteria on municipal energy contracts	A5.8.6 Municipal website on energy & climate action
A5.8.7 Participatory budgeting for prioritisation of lines	
SL9. Exemplary and efficient municipal facilities	
A5.9.1 Energy-renovation plan for municipal buildings	A5.9.2 High-efficiency public lighting deployment
A5.9.3 Fostering low-carbon procurement	A5.9.4 Raise awareness of public admin. employees
SL10. Increase of CO_2 sinks. Green infrastructures and local food production	
A5.10.1 Increase of municipal CO_2 sinks capacity	A5.10.2 Emissions reduction on food production
A5.10.3 Implementation of food self-sufficiency plan 2025	A5.10.4 Municipal strategy on green-circ. economy

Regarding key actions, each of them was defined according to a systematised layout, enabling the potential of performing a joint analysis through a digital dashboard (Figure 3), visualising overall APIET 2030 figures and interconnections. Furthermore, the potential impact of each key action was introduced into the urban-energy model, quantifying the impacts of its implementation on a yearly basis, setting evolution rates, and calibrating overall consumption and emissions goals. All elements considered for the definition of each key action are presented in Table 5.

Table 5. Elements considered in the description of each APIET 2030 key action.

Description of the Key Action:
Title and description of the action—free text
Alignment with sustainable development goals (SDGs), APIET 2030 elements (strategic objectives, strategic area, strategic line, other key actions)—multiple choice, and connection to municipal/regional/national plans—free text
Specific objective of the action—free text
Implementation period and follow-up indicators—period choice, by year
Kind of action and potential barriers entailed—multiple-choice
Best practice on the field—fill out a systematised table, including an online link
Responsible department and position/competence owner/stakeholders involved—free text
Environmental, socio-economic, budget, and energy parameters:
Climate proofing description (analysis on the potential impact of climate change on the action)—free text + Other environmental elements—checklist
Socio-economic elements—checklist
Budget (total approximate budget, payback time, annual savings once payback is finalised, budget description)—free digits + free text
Energy savings/year, CO_2 savings/year, the evolution of CO_2 emissions' reduction—free digits

Depending on the key action, this level of information was not always possible to be provided, as was the case in most of the quantitative energy and emissions' impacts of the strategic governance area (SA4, Table 4). In terms of stakeholders' engagement, all actions were contrasted with local sectorial experts, which significantly enriched the outcome of the plan, as well as the alignment with ongoing initiatives in each field.

Based on the foreseen impact of APIET 2030 key actions, quantified by the urban-energy model, the following tables show the distribution of energy consumption and CO_2 emissions by energy source (Table 6) and city system (Table 7) by 2030.

Table 6. Energy consumption and emissions by energy source; 2030 scenario.

Energy Source	**2006**		**2030**		**Variation 2006/2030**	
	Consumption (GWh)	**Emissions ($ktCO_{2e}$)**	**Consumption (GWh)**	**Emissions ($ktCO_{2e}$)**	**Consumption (%)**	**Emissions (%)**
Electricity	686.2	306.3	683.7	41.4	17.6%	−86.5%
Electricity self-consumption (PVs)	-		123.4	0.0		
Natural gas	709.9	144.0	500.0	101.5	−29.6%	−29.5%
Fossil-fuels based	1253.9	388.1	461.3	172.4	−63.2%	−55.6%
Biofuels			42.2	7.4	-	-
Other (biomass/waste-heat)	0.0	0.0	54.9	0.0	-	-
TOTAL	**2650.0**	**838.3**	**1865.6**	**322.8**	**−29.6%**	**−61.5%**

Table 7. Energy consumption and emissions by city system; 2030 scenario.

City System	2030		Variation 2006/2030		Variation 2017/2030	
	Consumption (GWh)	Emissions ($ktCO_{2e}$)	Consumption (%)	Emissions (%)	Consumption (%)	Emissions (%)
Housing	775.4	99.6	−19.7%	−63.1%	−22.7%	−56.5%
Services	453.1	37.5	−17.6%	−81.5%	−20.8%	−74.3%
Mobility (internal)	453.0	106.7	−51.0%	−56.3%	−45.4%	−50.8%
Primary	81.2	72.9	−4.6%	−8.2%	−17.6%	−19.6%
Water cycle	9.8	0.0	−16.2%	−100.0%	0.0%	−100.0%
Municipal services	89.9	2.8	−23.8%	−92.6%	−36.3%	−83.7%
Waste management and street cleaning	20.4	3.3	90.7%	16.4%	0.0%	−31.2%
TOTAL	**1865.6**	**322.8**	**−29.6%**	**−61.5%**	**−29.7%**	**−54.0%**

The tables above refer to years: 2030, as the implementation timeframe of APIET 2030; 2006, as the baseline date for CO_2 reduction calculation; and 2017, as the last year with energy consolidated data introduced in the urban-energy model, indicating approximately the estimated impact of APIET 2030 implementation, from 2017 to 2030.

3.7. APIET 2030—A Plan Integrated into Municipal Planning Dynamics

The main risk of the APIET 2030 was not transcending to the right fields of action for its correct implementation. With that purpose, the energy and climate department promoted the following integration lines of APIET 2030 into municipal planning dynamics:

- At the coordination level of APIET 2030, the new energy and climate department will act as an interdepartmental facilitator, working as a municipal hub for APIET 2030 deployment, ensuring a suitable governance scheme.
- At the strategic level on energy and climate, the APIET 2030 is considered the evolution of SEAP 2020 [17] and an intermediate milestone of Vitoria-Gasteiz's strategy on carbon neutrality 2020–2050.
- Regarding municipal commitments, the APIET 2030 (complying with climate change *mitigation* requirements) in coordination with the action plan for climate change adaptation 2030 (APCCA 2030, complying with climate change *adaptation* requirements), works as a solid background for the next sustainable energy and climate action plan (SECAP 2030). The publication of SECAP 2030 in the fall of 2021 will mean the official renewal of Vitoria-Gasteiz's adhesion to the covenant of mayors' initiative (Figure 7). During the implementation stage of those three documents, the coordination will be managed by the energy and climate department, ensuring an overall common understanding and an efficient deployment process.
- Regarding urban planning instruments, specific outcomes from APIET 2030 will generate modifications as part of the ongoing review of the general land use plan of Vitoria-Gasteiz. In this sense, local regulation (*ordenanzas*) will incorporate specific modifications for a suitable APIET 2030 implementation.

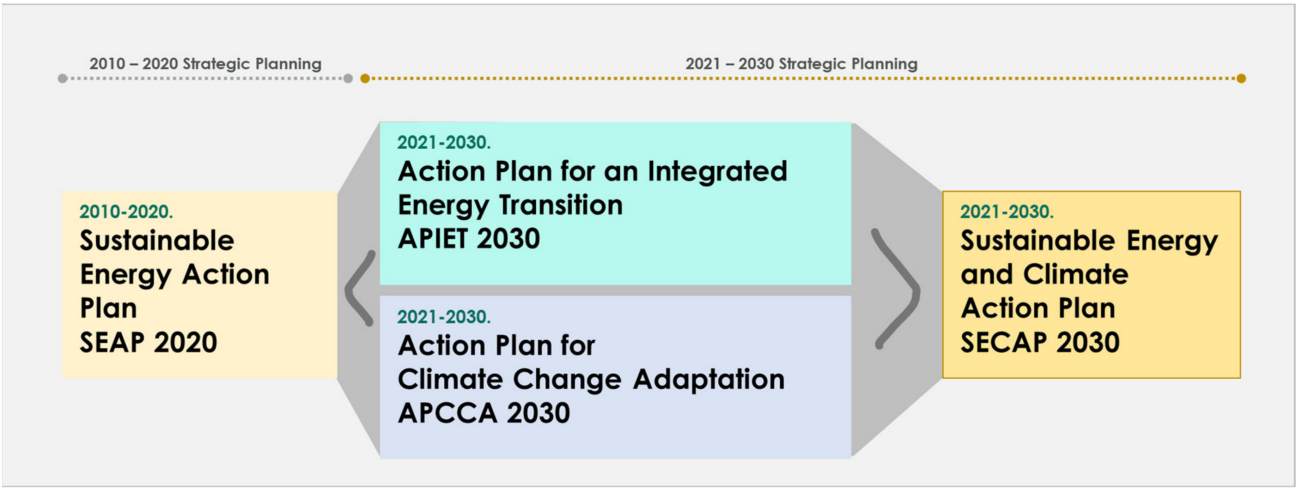

Figure 7. Energy and climate strategic planning process 2010–2030.

4. Discussion

As presented in the Results section, the Cities4ZERO methodology has been followed step by step in Vitoria-Gasteiz's APIET 2030 development. In this case, all theoretical steps have been applied in the field, showing its capacity to guide urban decarbonisation planning processes. This approach has fostered the creation of a new cross-cutting municipal department, enabling an effective public leadership on climate action. The Cities4ZERO methodology, together with this institutional adjustment, have both triggered a suitable planning ecosystem to effectively involve the key local stakeholders in the generation of each of the necessary planning steps towards the definition of the APIET 2030. Furthermore, the urban-energy model has supported the whole process and the engagement dynamics, from city characterisation, diagnosis, and 2030 scenarios' generation, to the definition of the 41 key actions of the APIET 2030. Cities4ZERO's strategic stage objective is to provide "*a strategic planning framework* (strategies, plans, actions) *which enables the city administration to perform an effective transition towards a Smart Zero Carbon City*" [10]; this "*strategic planning framework*" has been developed in Vitoria-Gasteiz. During the coming years, thorough monitoring of the APIET 2030 fulfilment will determine if the Cities4ZERO approach is also valid for the development of key actions (design stage/intervention and assessment stage), as well as for achieving decarbonisation goals after their implementation.

4.1. Interdepartmental Flexibility

One of the main learnings of this planning process is the importance of accommodating the development of a decarbonisation plan to the development of the ongoing sectoral strategies of the city as much as possible; timing must be established depending on the context favouring crossed influences and synergies. The aim of having an integrated cross-cutting approach when developing APIET 2030 forced the leading energy and climate department to look at other departments, setting a dialogue to coordinate their sectorial strategies' outputs in terms of contents and timing with APIET 2030.

In this sense, one of the main findings from this process is that it may be beneficial to adapt processes and align timings among plans to achieve the required development maturity of some sectoral plans, then aligning and integrating their outputs into the decarbonisation plan. In the case of the APIET 2030 development, the sustainable mobility and public space plan was in its final draft phase, and the integration of both was straightforward. However, the urban regeneration and renovation master plan was under development; in this case, the APIET 2030 development process delayed its progress for three months to integrate those outputs, which were crucial in the SA2 (building stock strategic area, Table 4), targeting the energy-renovation initiatives. In the case of the municipal water agency, they reviewed and updated the energy implications of their water cycle

management plan for its integration in the APIET 2030, increasing their last consumption data by 0.9GWh, whilst not affecting CO_2 emissions as it would be covered by renewable energy sources.

These examples give an idea of the alignment intention, hoping that the interdepartmental flexibility effort of integrated planning practices will pay back with future increased efficiency and effectiveness in the implementation process, as well as with more coherent and synergic municipal policies. In this sense, it is important to highlight that the whole APIET 2030 development process, which has involved personnel from different departments, has significantly supported interdepartmental interaction and collaboration.

4.2. Permeability of Strategic Requirements on the Land-Use Planning Cascade

There is a hierarchy and sequential conception of planning instruments, from the EU territorial agenda 2030 to the municipal masterplans, detailing the land use of the territory and the city, both in graphic and text-regulatory terms. However, strategic plans, such as APIET 2030 do not belong to that operative urban planning cascade. Is this a barrier when implementing APIET 2030 key actions? For some decarbonisation initiatives, it seems clear the need to delve into that operative level (land ownership, rights and obligations, municipal regulation, land-use incompatibilities, etc.) if they are meant to be implemented. Let us imagine a renewable energy project that intends to install solar panels in the rooftops of both a public school and a new pergola within the public space, by the initiative of a private cooperative of investors (citizens), who will exploit the energy-generation business by selling electricity to the grid and heat to the surrounding housing area. The multiple affections to land-use rights and incompatibilities make the initiative close to utopian unless there is a deep reflection on the operative urban planning dimension. Furthermore, which kind of document shall reflect on that integration? City masterplans seem very stable in legal terms, but they may not be agile enough for such a purpose, while urban agendas may lack the operational aspect. Probably, the local context of each city, bound to its national and regional regulation, will determine the best solution for each case; what seems clear is that these potential barriers must be addressed, and urban planning stakeholders must be engaged. In the case of the APIET 2030, the involvement of the urban planning department was scarce, mainly due to the extremely slow updating process of the city masterplan, which takes several years of rigid bureaucracy, making the integration of APIET 2030 outputs in such a document a significant challenge.

4.3. The Role of Urban-Energy Models in Decarbonisation Planning

Looking at current cities' decarbonisation planning processes, there is a consensus on the crucial importance of urban-energy models and their quantitative support to set goals and define actions. However, one should not lose sight of the main purpose of the urban-energy model, i.e., the prospective analysis. The defined urban-energy model does not aim to translate already decided actions or objectives, although it can be used for that end, but to generate different alternative pathways that may support the definition of these measures and targets. In this sense, APIET 2030 can be considered as a forecasting approach, where urban-energy modelled scenarios were used to analyse the potential impact of diverse actions in the city, hence setting CO_2 reduction targets; it is an explorative vision in line with the city's potential. In the coming years, when following up APIET 2030 and generating the updated scenarios in the future, the method could link forecasting and backcasting (just objectives are defined; not actions) approaches. The urban-energy model should be used to feed the discussion and support the decision-making, rather than to justify already defined strategies, forming so-called socio-technical scenarios [20]. In the same line of inconsistency, there is no point in refreshing the base year of the model from year to year without generating updated scenarios to refine the mid/long-term visions, as that approach implies updates neither on actions nor on targets. Furthermore, looking for future updates, it would be interesting to link Vitoria-Gasteiz modelling to what the rest of the Basque region and Spain are planning, which also has significant effects on the energy

balance and carbon outcomes of the city and vice versa [7]; the city is likely not going to be a disconnected energy island in the future.

Regarding that follow-up process, urban-energy modelling should be combined with assessment methodologies to evaluate results based on diverse criteria. Furthermore, the update of all necessary data can be a challenge for most municipalities, still a significant problem even in the planning phase, where the effort to provide enough detailed information to the urban-energy model is an issue. Finally, the depth of the analysis must determine some characteristics of the data to be gathered and the urban-energy model structure. The level of detail will not be the same if planners just want some rough numbers to orientate their decisions, or if they really want to check the exact potential impact of each proposed action; in this sense, both data and model characteristics must be considered.

4.4. Key Local Stakeholders at the Core

In APIET 2030 development, key local stakeholders have been at the core of the planning process since the beginning, contributing to diagnosis, envisioning, and action planning phases. This fact has been, for sure, a significant effort for the management team, which sometimes can be perceived as a toll against an agile planning process. However, to the eyes of APIET 2030 planners, this intensive engagement has reinforced the quality of the final output, and it has improved the alignment with other departmental strategies and other local public-private initiatives. Furthermore, it seems reasonable to think that the potential barriers at the implementation stage may be reduced due to this early engagement, and probably more synergies will be found at that stage due to the exchange of views during the planning process. In APIET 2030 case, a more intensive engagement of the local industry and some economic sectors would have been preferable (i.e., Mercedes, Michelin); hence the management team must reflect on how to present attractive processes for such stakeholders to participate. Local authorities must design participatory processes where every relevant local stakeholder finds an interest, branding their participation and climate action efforts as support to the local community development.

This scarce involvement in practice of the private sector in the case of APIET 2030 can be considered as a limitation of the Cities4ZERO methodology. However, when applying the methodology to the case of Sonderborg's climate neutrality roadmap 2025 (Denmark, [21]), the private sector took a key role in the process. Definitely, it is an aspect to take care of; otherwise, the final plan will find difficulties to become transversal among the local community.

Another potential limitation in the Cities4ZERO application is the lack of technical and economic support when applying the methodology. The APIET 2030 and other ongoing local plans following the methodology are supported by the European Commission's funding, which significantly helps municipalities to develop the ambitious steps and evolvements of Cities4ZERO framework implementation. It seems challenging to keep the level of ambition without such technical and economic support. In this sense, cities in the Basque region are facing the fulfilment of their Law 4/2019 on energy sustainability by opening their own procurement processes to find the necessary technical support with their own funds. However, this is only feasible if their initial commitment towards decarbonisation is solid.

Regarding the applicability of this research to other urban contexts, as the methodology has been developed by following strategic processes from different European cities, Cities4ZERO fits with the interest and needs of those, even if it represents an innovative approach to their traditional planning mechanisms. It is true that each local context is different, but most potential barriers, limitations, and solutions are common to most cities regarding decarbonisation. In this sense, the Cities4ZERO approach provides enough flexibility to be adapted to each local paradigm, and of course, APIET 2030 outcomes can be interpreted as a result of that local adaptation process.

Finally, in terms of APIET 2030 vertical integration, the development of the plan has kept an interest in the institutional and strategic multi-level alignment, a fact that

will probably support the implementation process. The APIET 2030 fulfils the regional Law 4/2019 on energy sustainability of the Basque community [18] requirements and acknowledges EU directives in the field (2018/844-Energy Performance of Buildings and 2018/2002-Energy Efficiency); the plan is in line with Basque's research and innovation smart specialisation strategy (RIS3, Urban Habitat), as well as with the energy transition and climate change Spanish law 7/2021 [22], and EU initiatives such as the European city facility, the covenant of mayors and the horizon Europe innovation programme. Through this alignment, two of the main struggles in the implementation stage, such as regulatory barriers and the search for funding, will both be better addressed.

Once the APIET 2030 has been developed, the research team will focus on future lines of research. Firstly, a thorough APIET 2030 follow up and monitoring process, together with Cities4ZERO application to other cities (Bilbao, Amsterdam, Copenhagen, Riga, Matosinhos, Budapest, Bratislava, and Krakow), will provide both enough data to fine-tune the methodology and create an updated Cities4ZERO 2.0 version, as there is still room for evolving it in several aspects (i.e., co-governance, urban-energy modelling, real-time data and management, etc.). Secondly, and regarding urban-energy modelling, there is ongoing research on better supporting the envisioning engagement process (2030/2050) with better quantitative energy-modelled scenarios; there is a thin line between being too technical or too superficial regarding quantification in those engaging workshops. Hence an effort is still necessary in this regard, as it represents a crucial part of a decarbonisation plan. In this sense, a tool able to show the participants the potential affections of the different scenarios would reinforce the quality of the envisioning engagement process [23]. Furthermore, as requested by some pioneer cities in climate neutrality terms (i.e., Copenhagen), the modelling, visioning, and planning processes must offer the opportunity of accounting not just the impact of energy consumption within the city but also all other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary (i.e., supply chains of non-energy good, such as food, water, building materials, clothing, products, etc.) [24]. In this sense, LCA approaches and extended input/output tables will be explored.

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