The opportunity for smart city projects at municipal scale: Implementing a positive energy district in Zorrozaurre[*]

The urgency of climate change is demanding new urban energy transition processes that will be accelerated by the implementation of innovative urban solutions. This paper proposes a three-step methodology to encompass the energy transition in cities. Firstly, the design of urban spaces in accordance to Positive Energy District (PED) concept is defining a very ambitious objective that will lead the development and implementation of innovative urban approaches. Secondly, the implementation of Urban City Labs is proposed for testing and demonstrating urban innovations at real scale as reasonable approach for consolidated urban landscapes. Thirdly, energy transition is demanding new governance mechanisms where top-down and bottom-up perspectives are continually combined and harmonized. ATELIER H2020 is accelerating the demonstration of this methodology at the recently defined PED in Zorrozaurre (Bilbao, Basque Country).

La urgencia del cambio climático está demandando nuevos procesos de transición energética que acelerarán el desarrollo soluciones innovadoras. Este artículo propone una nueva metodología en tres pasos que acompañará procesos de transición energética. En primer lugar, el diseño de espacios urbanos de acuerdo al concepto de Distrito de Energía Positiva (DEP) define un objetivo muy ambicioso que liderará el avance de nuevas perspectivas de desarrollo urbano. En segundo lugar, se propone el concepto de City Lab para el testeo y demostración de soluciones a escala real en ciudades de estructuras urbanas muy consolidadas. Por último, la transición energética está demandando nuevos mecanismos de gobernanza donde se combinen y armonicen estrategias de largo plazo con procesos participativos bottom-up. El proyecto europeo ATELIER – H2020 acelerará la demostración de esta nueva metodología en el DEP de Zorrozaurre (Bilbao, Euskadi).

Klima-aldaketaren larritasuna dela eta, energia-trantsizioko prozesu berriak behar dira, irtenbide berritzaileen garapena bizkortzeko. Artikulu honek hiru urratseko metodologia berria proposatzen du, energia-trantsizioko prozesuekin batera. Lehenik eta behin, Energia Positiboaren Barrutiaren (EPB) kontzeptuaren araberako hiri-espazioen diseinuak asmo handiko helburu bat definitzen du, hiri-garapenerako ikuspegi berrien aurrerapena gidatuko duena. Bigarrenik, City Lab kontzeptua proposatzen da garapen urbanoa oso finkatua duten hirietan eskala erreraleko soluzioak probatu eta erakusteko. Azkenik, trantsizio energetikoak gobernantza-mekanismo berriak eskatzen ditu, epe luzeko estrategiak eta bottom-up partehartze prozesuak konbinatu eta bateratzeko. Europako ATELIER – H2020 proiektuak bizkortu egingo du metodologia berri horren erakustaldia Zorrotzaurreko EPBn (Bilbao, Euskadi).

* Spanish version available at https:/euskadi.eus/ekonomiaz.

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Table of contents

Keywords: positive energy district, smart cities, city labs, two-way governance, bottom-up collaborative approaches, quadruple helix methodology.

Palabras clave: distrito de energía positiva, ciudades inteligentes, gobernanza bidireccional, modelos de participación ciudadana, metodología cuádruple hélice.

JEL codes: O18, O21, O31, O35, O44

Entry date: 2020/11/17 Acceptance date: 2021/02/18

Acknowledgements: We thank our colleagues; on the one hand, Ainhoa Alonso-Vicario and Cruz E. Borges from Deusto Tech-Universidad de Deusto; and of the other Laura Baselga and Virginia Gómez from Deusto Business School-Universidad de Deusto; who provided insight and expertise that greatly assisted the research. This paper builds on Bilbao City Council's perspectives and experience with respect to decarbonisation objectives and development of new strategies for energy transition. The ATELIER project is co-funded by the European Commission's Horizon 2020 Programme under grant agreement No. 864374 and provides important mechanisms for accelerating the objectives of Bilbao as a city and the Basque Country as a region.

1. INTRODUCTION

Europe has a strongly consolidated urban structure, which is generally linked to the history of the territory, the landscape and environmental conditions, and of course, to geographical boundaries (González Medina and Fedeli, 2015). Many European cities have few opportunities to test or deploy any real-scale urban innovations that can be extended beyond the scale of individual buildings to neighbourhood or district level. At the same time, the world has become increasingly urban with the great majority of the population now living in built-up areas. It is estimated that 54.5% of the world's total population of 7.4 billion now live in urban areas, and by 2030, this proportion is projected to rise to 60% (Pérez *et al.*, 2019).

Cities now account for approximately two-thirds of global energy consumption and about 75% of worldwide CO_2 emissions. These emissions result in a deterioration of air quality and speed up the climate change, contributing to its detrimental effects and posing a enormous stress on cities. Air pollution causes an estimated 4.2 million premature deaths worldwide, while over 91% of the world's population is exposed to toxic air (Kusch-Brandt, 2019), (Petrillo *et al.*, 2016), (Castillo-Calzadilla *et al.*, 2018). As a consequence, over the last decade, a number of global targets have been set for cutting greenhouse gases and pollutant emissions, with a view to tackling climate change and ensuring better air quality in cities. These include the goals established in the Paris Agreement (United Nations, 2015) and more recently, in the European Green Deal (European Commission, 2019a). The European Green Deal provides a holistic framework for resource efficiency, clean and circular economy, low environmental impact and pollution reduction. Its ultimate aim is to achieve climate neutrality in the EU by 2050. The smart city concept has been developed to provide new answers for the European agenda.

Smart Cities are becoming one of the cornerstones of the push for energy neutrality, resource efficiency and high standards of well-being (European Environment Agency, 2015)major environmental challenges remain which will have significant consequences for Europe if left unaddressed. What differs in 2010, compared to previous EEA European environment – State and outlook reports, is an enhanced understanding of the links between environmental challenges combined with unprecedented global megatrends. This has allowed a deeper appreciation of the human-made systemic risks and vulnerabilities which threaten ecosystem security, and insight into the shortcomings of governance. The prospects for Europe's environment are mixed but there are opportunities to make the environment more resilient to future risks and changes. These include unparalleled environmental information resources and technologies, ready-to-deploy resource accounting methods and a renewed commitment to the established principles of precaution and prevention, rectifying damage at source and polluter pays (Martin, Henrichs and Eea, 2015. They can significantly improve energy savings, close the circle of resources (including materials and water) and foster healthier lifestyles, with open spaces becoming more abundant and connected to classic infrastructures. Smart and sustainable cities are expected to be a key feature in achieving energy transition and resource efficiency in Europe. They can potentially deliver significant energy savings and increased resource efficiency, in harmony with the cultural aesthetics of the urban and natural landscape. Technological and scientific advances –especially when integrated with one another– offer a rich pool of solutions that can help make cities a more sustainable place to live (Angelakoglou *et al.*, 2019).

At the same time, the scope of energy transition and smart city projects is increasing, with an ever-increasing use of terms such as 'zero building blocks', 'zero energy buildings', 'zero net energy' and 'zero energy districts' (Charron, 2008); (Pandey *et al.*, 2015); (Cao, Dai and Liu, 2016); (Taherahmadi, Noorollahi and Panahi, 2020). In recent years, the ambition behind such projects has widened and Europe is now championing Positive Energy Districts as a fundamental unit for the design and planning of smart cities. The concept of the Positive Energy District (which is still under development) entails defining a set of inter-connected buildings that can together achieve a positive energy balance.

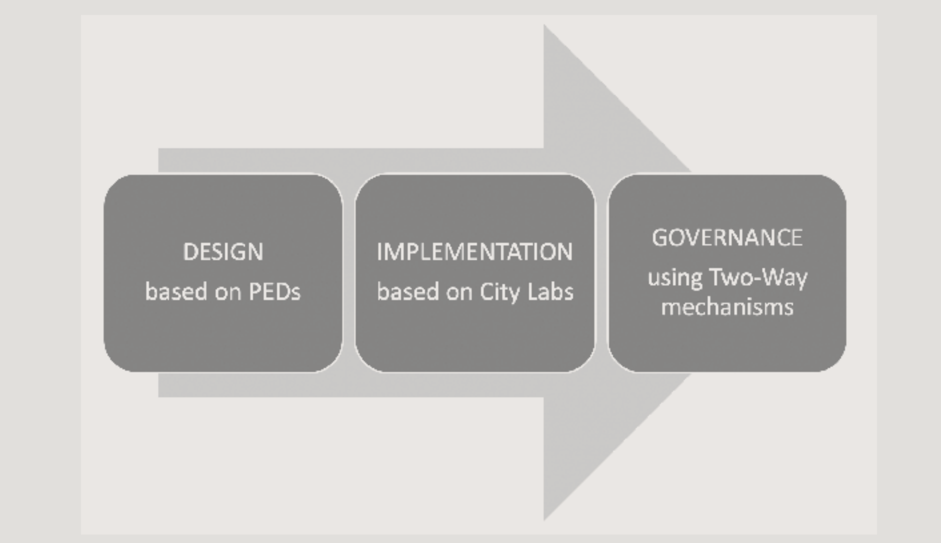
This evolution in smart city projects must go hand in hand with the definition of new strategies of governance. City governance is immensely complex, with a multi-faceted and multi-level ecosystem of agencies and stakeholder groups (e.g. local governments, citizens and urban planners), often driven by conflicting interests. As a result, (smart) cities require a proper system of governance to connect all the different forces at work, enable knowledge transfer and facilitate decision-making in order to maximize their socioeconomic and environmental performance (Ruhlandt, 2018).

The main objective of the paper is to propose a new methodological approach to guide the design, implementation and governance of cities in view of leading an energy transition process. The paper includes four main sections. After introducing the main international concerns and demands, Section 2 defines the main methodological proposal that would guide future cities in leading energy transition processes. Section 3 details the case study presenting ATELIER H2020 project and the Positive Energy District proposal in Zorrozaurre island (Bilbao). Section 4 presents the main results organised according to the three methodological steps. Finally, Section 5 draws out the main conclusions of this research and provides some policy feedback in view of inspiring similar initiatives in the Basque Region.

2. METHODOLOGY

This paper proposes a new methodology that would pave the way transforming cities and comply with energy transition strategies. The new methodology (Figure 1) includes three main stages for the design of new urban areas, the implementation of innovative solutions and the governance of cities where citizens are at the centre. This new methodology assumes a continue calibration of citizen requirements that will be naturally embedded and articulated all along the city building process:

Figure 1. **THREE-STEP METHODOLOGY FOR ENERGY TRANSITION IN CITIES**



Source: Own elaboration.

- Design: Innovative urban designs based on the definition of Positive Energy Districts (PEDs) are defined as a group of connected and neighbouring buildings that produce more energy than required, in terms of lighting, heating, cooling and ventilation (see Section 4.1). The challenge in terms of energy efficiency, uptake of renewable energies, and integration of systems and solutions that allow energy flexibility is huge, but also required given the effects of climate change. On the other hand, the definition of PED as a main functional unit for urban development is a promising idea since PEDs may work as operational units that are completed (design of open spaces, buildings, iteration of neighbours) and easily replicable along the entire city.
- Implementation: Testing and demonstrating innovative solutions in City Labs. The deployment of smart and integrated solutions in European cities is a challenging objective given the consolidation of urban areas, the average age of the population, and the investment costs of the solutions. Urban City Labs (see Section 4.2.1) are conceived as urban laboratories where innovative solutions can be deployed and tested in relatively controlled environments because of the scale, the number of people affected, or the geographical situation of the area. This methodology presents City Labs of different scales that move from building scale to city scale, which makes the proposal valid for any city independently of the degree of urban development or urban consolidation.

- Governance: Smart collaborative schemes keep cities alive and connected. The success of any innovative urban design or development is going to be connected to the extent to which citizens are being involved all along the process of design, implementation and governance of the urban areas, i.e. they need to become active part of the solution. Cities need to combine top-down and bottom-up collaborative approaches where strategic objectives are analysed and assessed with respect to particular perspectives and feelings. At this point, we propose a two-way governance mechanism (see Section 4.3) that provides a flexible and comprehensive approach where all stakeholders can easily identify where they are, what they can do, and how they will be able to proceed.

3. CASE STUDY

ATELIER is an H2020 innovation action (Grant Agreement: Nº 864374) that belongs to Smart City and Communities (SCC) cluster of innovation projects. The ATELIER operative includes 30 partners from 11 countries that will collaborate and work together for a period of five (5) years. The action has a total budget of 21 million that will serve to deploy and validate new methodologies, urban designs and smart solutions that will be monitored and evaluated showing that positive energy districts are possible.

3.1. Smart cities and communities partnership

ATELIER has been founded by SCC1 – Smart Cities and Communities open call (of H2020 program) and therefore it becomes automatically part of the European Innovation Partnership on Smart Cities and Communities (EIP-SCC) (Smart City Expo World Congress, 2016). This initiative is supported by the European Commission and brings together cities, industry, SMEs, banks, research facilities and other smart-city actors. EIP-SCC provides action clusters, guides and toolkits, marketplaces for investors, etc. with the ultimate goal of improving the quality of life of European citizens. The partnership builds up a wide network of European cities that share knowledge and gain support in finding solutions that will improve the social, environmental and economic performance of their cities. The SCC partnership activity is geared towards strengthening the links between existing European smart city networks and platforms, especially those that have been funded under the SCC1 H2020 programme. Table 1 lists the projects funded since 2015.

Table 1. **LIST OF HORIZON 2020 SMART CITIES AND COMMUNITIES SINCE 2015**

Call ID	Call focus	Project Names	Duration	Project Website
H2020-SCC-2014-2015	Solutions integrating energy, transport, ICT sectors	RemoUrban	2015-2019	http://www.remourban.eu/
		GrowSmarter	2015-2019	https://grow-smarter.eu/home/
		Triangulum	2015-2020	https://www.triangulum-project.eu/
		Sharing Cities	2016-2020	http://www.sharingcities.eu/
		SmartEnCity	2016-2021	https://smartencity.eu/
		Replicate	2016-2021	https://replicate-project.eu/
		Smarter Together	2016-2021	https://www.smarter-together.eu/
SCC-1-2016-2017	Solutions at district scale: smart homes and buildings smart-grids, EVs and ICT tools	RuggedISED	2016-2021	https://ruggedised.eu/home/
		MySMARTLife	2016-2021	https://www.mysmartlife.eu/
		MAtchUP	2017-2022	https://www.matchup-project.eu/
		IRIS	2017-2022	https://www.irissmartcities.eu/
		StarDust	2017-2022	https://stardustproject.eu/
LC-SC3-SCC-1-2018-2019-2020	Positive energy blocks/districts	CityxChange	2018-2023	https://cityxchange.eu/#
		Making City	2018-2023	http://makingcity.eu/
		POCITYF	2019-2024	https://pocityf.eu/
		SPARCS	2019-2024	https://www.sparcs.info/
		ATELIER	2019-2024	https://smartcity-atelier.eu/

Source: Own elaboration.

3.2. ATELIER Innovation Action

ATELIER is a smart city project that demonstrates Positive Energy Districts (PEDs) within eight European cities with sustainability and carbon neutrality as guiding ambitions. Amsterdam and Bilbao are the Lighthouse cities that will generate an energy surplus of 1,340 MWh measured in terms of primary energy and prevent 1.7 kt of CO_2 and 23 t of NOx emissions. Together with district users, ATELIER will showcase innovative solutions that integrate buildings with smart mobility and energy technologies to create a surplus of energy and balance the local energy system. Bratislava, Budapest, Copenhagen, Krakow, Matosinhos, and Riga are the Fellow cities that will replicate and adapt successful solutions.

All cities will establish a local PED Innovation Atelier to co-produce locally embedded, smart urban solutions. In the ateliers (see Section 4.3.3), the local innovation ecosystem (authorities, industries, knowledge institutes, citizens) is strengthened, enhancing embeddedness and removing any obstacles (legal, financial, social, etc.) for implementation of the smart solutions. The ateliers are engines for upscaling solutions within the ATELIER-cities and replication to other EU-cities. ATELIER integrates a high degree of citizen engagement throughout the project, by actively involving local residents, local initiatives, and energy communities in activities to align the technical solutions with citizens' objectives and personal perspectives. Each of the cities will develop a City Vision 2050 (see Bilbao Bold City Vision in Section 4.2.2) that creates the roadmap for upscaling the solutions to the entire city.

ATELIER has the ambition to pave the way for «energy positive cities» in Europe. All ATELIER activities will be monitored (socially and technically), and lessons learned are systematically drawn and disseminated to relevant stakeholder groups, city networks, and innovation forums.

3.3. **Positive Energy District (PED) in Zorrozaurre island**

ATELIER defines two Positive Energy Districts in Bilbao and Amsterdam, respectively. The Positive Energy District of Bilbao is defined as the sum of specific interventions in Zorrozaurre, located in specific areas in the North, Centre and South of the island (Figure 2). Three sets of connected buildings will be deployed conforming the PED of Bilbao demonstration site. These three specific areas will be continually monitored in terms of energy consumption and generation, electro-mobility uptake, ICT integration, citizen participation, etc. This system represents a very special City Lab and a major step forward for the decarbonisation of the island. The outcomes of PED implementation will be scaled up to the entire city of Bilbao according to the Bilbao Bold City Vision.

The district has a 5th generation district heating based in low temperature geothermal energy, photovoltaic panels, a smart-grid, increased e-Mobility capacity, energy storage capacity, smart street furniture and smart lighting systems. New-generation smart meters will be installed in the three areas of the PED demo. Demand response solutions and energy community self-generation sharing will be implemented and validated. The aim is to continue developing functions that provide added value for clients, including services that increase flexibility and allow active demand management.

Figure 2. **SATELLITE VIEW OF ZORROZAURRE ISLAND SHOWING PED LOCATION**

Source: Bilbao City Council.

Energy flexibility will be enabled through the use of smart metering devices, Smart Building Energy Management Systems (smart BEMS) and an overarching Energy Management System (EMS) that will aggregate BEMs and other smart district consumption (public services, storage systems, heat pumps, EV operators, etc.). The EMS will work as an 'Energy Trading Coordinator', providing prosumers and energy communities with an active demand response approach that effectively coordinates and deploys local resources to balance energy supply and demand, while at the same time activating different flexibility business models.

New substations with advanced control capability will be installed. Inter alia, these will have new functions for managing a Low Voltage (LV) network, a high penetration of flexible distributed resources and new services to improve flexibility, etc. The smart secondary substation will introduce supervisory architecture and advanced control for network optimization (reduction in losses and saturation level) which will provide services for customers that give them increased flexibility.

All the actions and smart solutions to be deployed in Zorrozaurre can be summarized as seven strategic interventions (Figure 3). The first three ones refer to the deployment of the North, Centre and South areas of Zorrozaurre whereas the other four ones provide the connectivity and integration of the operational strategies that will be implemented along the entire island. In this sense, the deployment of the 5th generation of geothermal network, the inclusion of renewable energy sources, the advanced operation of the smart-grid, the electro-mobility, and deployment of smart street furniture bring an important added-value to the Zorrozaurre neighbourhood.

The PED in Zorrozaurre is defined as the sum of the deployments at the North Area, the Centre Area and the South Area in the island, which include new and retrofitted buildings; private and public buildings (own by public entities), as well as residential or public-used buildings (mostly service oriented). With this definition, ATELIER ensures an equilibrated portfolio of buildings in terms of isolation profiling, ownership and usage. The transversal interventions are implemented along the entire island. They include:

Geothermal Network

The geothermal network is built by 19 rings that will be connected in a flexible manner to optimize the different energy needs. The establishment of a 5th generation district heating implies a reduction in distribution losses, thanks to the possibility of using low temperature fluid network. Moreover, the district heating system is ready to be fuel by other alternative renewable energies (apart from geothermal) or waste heat. The geothermal network is formed by a mix of boreholes and groundwater wells that will be designed and implemented to provide a steady 14 ºC throughout the year. The PED (the sum of the North, Centre and South areas) are connected only by four rings.

Smart Grid

The smart grid integrates the following elements:

- Smart metering devices will provide new functionalities that offer added value to end-users, including the flexibility for the consumer to provide services, mainly in terms of active demand management.
- Energy storage systems will include virtual storage and second life Li-Ion batteries that will ensure energy supply to the entire neighbourhood, balancing the periods with lower Renewable Energy Sources (RES) generation.
- Smart Buildings Energy Management Systems (BEMS) will be implemented to optimise the energy flows and services at building scale. The individual systems deployed at the South, Centre and North area will be connected in view of providing an integrated and optimised management at the PED as a whole.
- Intelligent Secondary Substation for flexible distributed energy resources management will implement advanced control capabilities with new functionalities to manage a low voltage (LV) network. The secondary substation will introduce supervisory architecture and advanced control for network optimisation which includes sufficient intelligence to autonomously perform operations and optimization functions of the LV network.

Electromobility

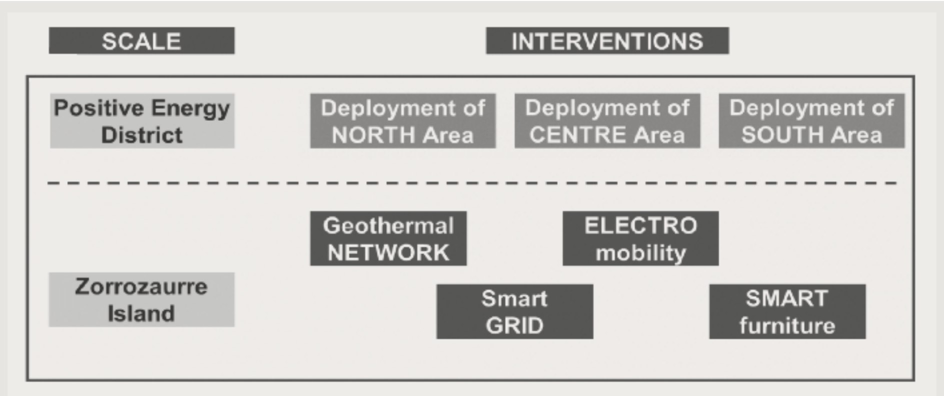
New e-mobility concepts will be integrated within the demonstration area running in parallel with the progressive elimination of surface parking areas for non-electric vehicles. The e-mobility will be facilitated by smart charging systems that include two fast rechargers (around 50 kW each) and two fast-medium rechargers (around 22 kW each); as well as an EV charger (7.2 kW) for an electric boat. The impact of EVs charging in the grid will be minimised with an adequate management of the smart grid operation and the use of energy storage systems.

Smart furniture

The Big Data system at Bilbao is designed under a citizen-centre approach. The Zorrozaurre City Lab will progress it by providing innovative big data mechanisms to relate energy data at municipal and district level. Indeed, the possibilities of iteration and the data commons of Bilbao will be enlarged by the deployment of:

- Smart lighting system: city light poles will be acquired and installed allowing the provision of public lighting system fully remotely and automatically monitored and controlled under energy efficiency criteria.
- Interactive bus shelter information points: bus shelters will be equipped with information points in order to inform them about the main sustainability variables (energy flows, storage, renewable generation, etc.) and provide interaction functionalities.

Figure 3. **STRATEGIC INTERVENTIONS TO BE TESTED AND DEMONSTRATED IN ZORROZAURRE POSITIVE ENERGY DISTRICT**



Source: Own elaboration.

4. RESULTS

This section summarizes the results obtained when applying the new three-step methodology for Energy Transition in Cities to Bilbao, and more specifically, to the already presented Case Study: the Positive Energy District of Zorrozaurre.

The results are organised in three sections accordingly to the methodology: design (and motivation) of Positive Energy Districts, implementation of PEDs as City

Laboratories, and the two-way governance mechanism as main instrument for dynamic co-design and co-implementation of the solutions.

4.1. **Design based on Positive Energy Districts (PED)**

The concept of Positive Energy District is a direct consequence of the new European energy strategies and commitments. However, this is a very new concept that is still under debate and will continue evolving during next years. First generation of innovation projects based on PEDs are currently being deployed and they will still need three to four years to be assessed in terms of performance, bankability of solutions, integration and collaboration of citizens, etc.

This section analyses both, the evolution of the European energy and climate policies, and the concept behind the term 'Positive Energy District'.

*4.1.1. **European energy and climate policy***

From its origins as the European Coal and Steel Community (ECSC) in 1952, energy always formed part of the agenda of what was to become the European Union, although in the early years –up to the 1970s– relatively little work went into developing a common energy policy.

The two crises of 1973 and 1979 posed a serious challenge to global oil supplies and highlighted Europe's enormous dependency on crude oil exporting nations (Mitchell, 2010). It was from that point on that the foundations for a common energy policy began to be laid, albeit not without difficulty. This new departure was bolstered by the relationship between energy and environmental policy; while many Member States considered energy to be an issue of strategic national importance, they did not hold the same view of environmental policy and the Council therefore had greater freedom to legislate in this area.

It was against this backdrop that the European Union signed the Kyoto protocol in New York on 29 April 1998 (Howell et al., 2017)and transitioning towards distributed energy systems, facilitated by advances in power system management and information and communication technologies. This paper elaborates on these generations of energy systems by critically reviewing relevant authoritative literature. This includes a discussion of modern concepts such as 'smart grid', 'microgrid', 'virtual power plant' and 'multi-energy system', and the relationships between them, as well as the trends towards distributed intelligence and interoperability. Each of these emerging urban energy concepts holds merit when applied within a centralized grid paradigm, but very little research applies these approaches within the emerging energy landscape typified by a high penetration of distributed energy resources, prosumers (consumers and producers, under which industrialised nations committed to implementing a series of measures aimed at reducing greenhouse gas emissions by an average of 5% over the period 2008–2012, compared to 1990 levels. The EU ratified the Protocol on 31 May 2002 (EU ratifies the Kyoto Protocol, 2002), committing to an 8% reduction in emissions, to be shared out among the fifteen states that formed the Union at the time. Ratification therefore entailed a dual process of commitment: on the one hand, the European Union accepted an overall, legally binding commitment; at the same time, each Member State accepted its own individual commitment in accordance with the burden-sharing agreement.

The definitive step in the development of a common energy policy came with the enactment of the Lisbon Treaty, which set the legal basis for energy to be considered as one of the 'shared competences'. From then on, the EU set itself the task of 'leading a new industrial revolution and creating a high efficiency energy economy with low CO_2 emissions' (Calleja and Caballero, 2014), (Pearson and Foxon, 2012) by drawing on recent thinking on the technological, economic and institutional factors that enabled and sustained the first (British, defining targets, adopting commitments and identifying priority sectors for action.

This new strategy was reflected in the 2008 'Climate and Energy Package' (European Commission, 2014) which sets the following targets for 2020, based on the Union's commitments: to reduce emissions of greenhouse gases by 20% compared to 1990 levels; to increase energy efficiency by 20% and to reach 20% of renewables in total energy consumption. In 2015 the European Union played a key role in the achievement of a new global milestone, when 195 states signed up to a binding agreement at the Paris climate conference (United Nations, 2015). The agreement represented a global plan for adopting measures to prevent global climate change reaching dangerous proportions, by limiting global warming to below 2 °C.

Arising out of these commitments, the EU's current agenda for action is based on an integrated climate and energy policy framework (European Commission, 2014) adopted by the Council on 24 October 2014 and revised in December 2018, which set the following targets for 2030:

- A reduction of at least 40% in greenhouse gas emissions compared to 1990 levels.
- An increase to 32% of the share of renewable energies in energy consumption.
- An improvement of 32.5% in energy efficiency.
- The interconnection of at least 15% of the EU's electricity systems.

In 2016, the Commission proposed a package entitled 'Clean energy for all Europeans' (European Commission, 2019b), whose aim is to keep the EU competitive as global energy markets are changed by the transition towards clean energy. This package includes eight legislative proposals in areas of governance, design of the electricity market (the Electricity Directive, the Electricity Regulation and Risk-Preparedness Regulation), energy efficiency, energy performance in buildings, renewable energy and rules applying to energy regulators.

Since 2019 the European Commission has been working on the Green Deal (European Commission, 2019a), a major project to stimulate the European economy. This ambitious strategy is intended to achieve a low-carbon economy in coming decades and places the energy transition at the centre of political action. The strategy, which planned to mobilise one trillion euros to 2027-2030, has been further accelerated by the Covid-19 crisis, affecting the recently announced post-pandemic recovery fund, which will have to conform to the targets set in the European Green Deal roadmap.

The urban areas (such as cities) of the EU account for nearly two-thirds of energy consumption and generate roughly 80% of European GDP (Kusch-Brandt, 2019). This makes cities the fields in which compliance with the political commitments acquired at a European and global level is being played out. One result was the announcement in 2008 of the Covenant of Mayors initiative (*The Covenant of Mayors initiative for local sustainable energy (E3P)*, 2020), under which local governments voluntarily committed to implementing EU climate and energy targets. To achieve this aim, signatories prepare and implement a Sustainable Energy and Climate Action Plan (SECAP) setting out the key actions they plan to undertake.

4.1.2. ***Positive Energy Districts (PED) definition and concept***

The concept of the PED can be seen as growing out of the notions of the ‘zero energy building’ and the ‘positive energy block’, which have been the subject of intense discussion in recent decades (Cao, Dai and Liu, 2016); (Hirsch, Parag and Guerrero, 2018); (REN21, 2018); (Buonomano *et al.*, 2019). The earliest definitions of zero energy buildings, were in fact for ‘zero heating’ buildings, such as the 1939 MIT Solar House I, which included a large solar thermal collection area and water storage, or the 1955 ‘Bliss House’ (Taherahmadi, Noorollahi and Panahi, 2020). More recent definitions of ‘net-zero energy’ and ‘positive energy’ buildings have generally included domestic hot water, cooling, and ventilation (Montava M., 2014).

The ‘positive energy block’ concept developed as part of the EU Smart Cities initiative, extended the definition to groups of connected and neighbouring buildings that annually produce more energy than they require, in terms of lighting, heating, cooling and ventilation. JPI (Joint Programming Initiative) Urban Europe has further developed the definition and framework for PEDs, emphasising three principles on which they should be based: energy efficiency, renewable energy, and energy flexibility.

The JPI White Paper on a Reference Framework for Positive Energy Districts and Neighbourhoods, defines Positive Energy Districts as ‘energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability.'

When it comes to setting goals and designing strategies for PEDs, and trying to align them with the proposed JPI (Joint Programming Initiative) definition, there are a number of issues that need to be considered:

- Final energy uses: A positive energy balance can be achieved for different final energy uses, both within the buildings (heating, cooling, hot water, lighting, appliances), and for services and other energy uses outside the buildings (public lighting, water and waste management, mobility).
- Boundaries of the analysis: In many cases, it can be very difficult to achieve a positive energy balance within the confines of a geographical district (particularly in high density urban areas). When defining a PED, therefore, it may be useful to establish functional PED boundaries, such a specific district heating network or micro-grid connecting the different buildings and through which a positive energy balance can be achieved. The concept of virtual PED boundaries has also been introduced in the form of contractual boundaries (EU Smart Cities Information System, 2017), for example for cases where there is some energy generation outside the district, but it is owned by –or directly supplies its output to– the district.
- Indicators used for the energy balance: A positive energy balance means that more energy is produced than used in the district. Further clarification is needed on the energy accounting used. Any final energy balance should be achieved across all the different energy carriers. With a primary energy balance, imported and exported energy are multiplied by primary energy conversion factors, thus allowing for some flexibility in the energy carriers. The total primary energy factor indicates the amount of primary energy used to generate one unit of final energy, whilst the non-renewable primary energy factor includes only the non-renewable portion of the primary energy used. A PED with a positive non-renewable primary energy balance, therefore, allows for potentially unlimited importation of renewable energy into the district, whereas a PED with a positive total primary energy balance needs to generate as much energy as is used within the defined boundaries. CO_2 emissions can be an additional indicator, generally closely related to the non-renewable primary energy indicator.
- Energy balancing period: The most common requisite for classification as a PED is the achievement of a positive annual energy balance. However, energy flexibility is another important characteristic of a PED that is not taken

into consideration in an annual energy balance. Performing energy balances for shorter time periods can offer a better insight into the district's performance at different times of day, and over different days or months. A district might have a 'positive energy' rating solely in specific hours of the day in certain months – for example during the central hours of the day in summer in the case of a PED focusing on the use of solar energy. Storage or demand management may help increase the number of hours or days in which a positive energy balance is attained and reduce peak loads for the district. A detailed hourly or sub-hourly balance is therefore important in assessing the interactions between the district and the energy grids, and to evaluate specific strategies for increasing energy flexibility.

4.2. **Implementation of PED based on Urban Labs**

This section provides the context for the deployment of Zorrozaurre PED as an innovative City Lab. The city of Bilbao has deployed several city labs at different scales and therefore, the deployment of ATELIER demonstration site is not an isolated initiative but, on the contrary, perfectly exemplifies the city ambition and commitment of innovation. In this case, and thanks to the ATELIER project, the deployment of the PED directly connects with the definition of Bilbao Bold City Vision that will facilitate moving from a PED scale to a city scale.

*4.2.1. **Bilbao Urban City labs***

Bilbao is the largest city in the Basque Country and the tenth largest in Spain, with a population of 345,000 inhabitants and a density of 8,300 inhabitants per square kilometre. Since the 1990s, it has seen major urban regeneration, with former industrial areas being turned into open areas. The process has transformed the city and its environs. The regeneration of Zorrozaurre will (probably) be the last major urban transformation project at a neighbourhood scale in the city.

Since the final Master Plan (DUSI strategy) was approved in 2012, the development has already seen completion of the Deusto Canal, making Zorrozaurre a true island, and construction and renovation of buildings at the northern and southern ends. The transformation of Zorrozaurre is in line with the smart city concept, which will be demonstrated using an inter-sectorial and trans-disciplinary approach.

Like many other European cities, Bilbao has a very consolidated and well-defined urban landscape, and the existing districts and neighbourhoods leave very little space for new innovative regeneration approaches. Moreover, the existence of an aging population is not generally conducive to major urban transformation. In this scenario, Bilbao has chosen to promote a Living-Lab approach (Figure 4) where innovative solutions are tested at different scales: building scale, set of connected buildings scale (PED), district (or neighbourhood) scale, and city scale.

Figure 4. **LIVING-LAB APPROACH DEVELOPED IN THE CITY OF BILBAO**

Source: Own elaboration.

The aim of the Living-Lab approach is to try out innovative urban solutions in a controlled and effective form that can be gradually upscaled, thus guaranteeing two premises: non-intrusiveness with city life, and economic feasibility. Bilbao City Council is committed to guaranteeing citizen wellbeing without hampering regular day-to-day life, i.e. without invading its citizens' everyday activities and without requiring any additional economic investment. Bilbao's living-labs are co-created with local stakeholders and offer an opportunity for exploring and evaluating new concepts and solutions. Pursuing the general objective of decarbonisation, energy transition and smart city development, several living-labs have been created in the city in four different scales (Figure 4):

Scale 1: Single buildings

An example of an action undertaken in an individual urban development is the city's new central coach station, Termibus. The 3,200 square-metre site with 4 underground levels will be climate-controlled using geothermal energy, offering greater ecological and economical savings than traditional heating/cooling systems. The geothermal pipes will provide a constant year-round temperature of 14 Cº, sharply reducing the difference that needs to be overcome to reach 20 Cº from January to December. The installation was presented in December 2019 and marks a small step forward in the city's sustainable development policy.

Scale 2: Limited set of connected buildings (and/or PED)

The City of Bilbao is working on the design of a Positive Energy District in which it will trial the introduction of renewable energy, the roll-out of new connectivity systems, smart monitoring of energy generation and consumption, and a model of citizen participation (see Section 4.3). The first City Lab in this second phase is being demonstrated in specific areas of Zorrozaurre where a set of well-connected actions are being undertaken from 2020 to 2024. The ATELIER project will accelerate demonstration of Positive Energy Districts and the roll-out of solutions across the entire city. The main challenge of promoting City Labs at this scale is that when connecting buildings of different nature, the inclusion of residential areas implies the participation of citizens with very sensitive aspects, as they are their dwellings.

Scale 3: Entire districts or neighbourhoods

The City of Bilbao is formed as the sum of 8 districts and 40 neighbourhoods, in each of which citizens have access to all municipal services: schools, libraries, sport centres, commercial areas, cultural centres, etc. Indeed, each neighbourhood is a complete unit of urban development where urban transformation follows a holistic and citizen-centred approach.

As an example, the City Council has a strategic plan (DUSI Strategy) for the Zorrozaurre area that seeks to turn a degraded industrial area into a major new neighbourhood in which businesses will share public and open spaces with new homes, public facilities and playgrounds. The strategic plan envisages the island as a consolidated area of interest for attracting business projects, investment in a new model of economy, high added-value activities, etc. Of course, the upscaling of the Zorrozaurre PED (City Lab at scale 2) will accelerate the urban development of the entire district.

Scale 4: Bilbao City

The intention is for the Living-Labs to be replicated throughout the different districts and neighbourhoods and ultimately upscaled to the entire city. The individual actions are not intended to be perfectly organised in time or in any geographical scale but will respond to the specific requirements of citizens and neighbourhoods. The City Council is working on a bold city vision for 2050 (Section 4.2.2), defining strategic plans that are in line with urban commitments, European strategies, and sustainable development goals.

4.2.2. ***Bilbao Bold City Vision***

In the current legislative context (see Section 4.1.1), it seems reasonable that each city must contribute responsibly (in line with their city energy vision and according to their capabilities) to meeting the decarbonization targets established at a higher (regional, national and European) level. However, defining city strategies and plans in such a way that they are aligned with the targets undertaken at a higher level is neither simple nor immediate. In many cases, a lack of connection has been identified between regional energy planning and the deployment of specific technologies and measures at city level. This makes it difficult to tell whether the aggregation of measures from different cities will enable the targets committed to at the higher level of governance to be fulfilled.

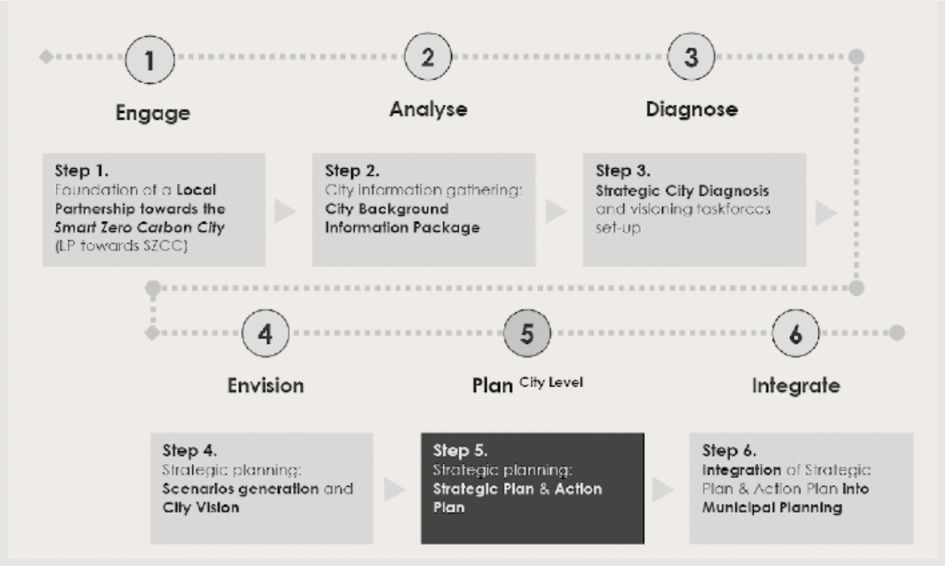
In any case, each city has to define its own energy vision and decarbonization pathway. That is to say, most cities tend to establish a series of general objectives that are complemented by a list of measures to be implemented in a distributed manner throughout the city over the following years. This approach tends to create a major disconnect between the city's general objectives and the realistic capabilities for the deployment of measures in the different zones which is basically demanding new governance mechanisms (see Section 4.3). This situation is further exacerbated by the lack of integrated (energy, economic, environmental and social) prospective methods and models to allow simultaneous evaluation of both levels, i.e. the city as a whole and the specific measures implemented at district level.

This will be a recurrent problem as cities become more complex in terms of energy use and generation in coming years. Cities will have to deal with issues such as an increasing use of energy production from local and distributed renewable sources, accompanied by a gradual 'smartening' of distribution networks. In addition, thermal and electrical storage will become more significant in distributed energy generation, which is expected to cover a significant proportion of the space currently occupied by large-scale energy generation. New integrated capabilities will therefore be required by municipalities to allow optimum analysis of their cities' energy systems. In this context, it will be essential to develop new integrated and multi-scale models and methodologies to support local authorities during the planning process by providing them with relevant quantitative data and criteria.

The city vision approach proposed in the ATELIER project takes into account the Strategic Stage, consisting of the six main sequential steps proposed by (Urrutia-Azcona *et al.*, 2020), shown in Figure 5. Starting from this general view, the various tools and methods proposed in the project seek to overcome the main difficulties mentioned above with regard to city-integrated energy planning.

In this case, the focus is mainly on the specific advances proposed in the project for Steps 3 (Diagnose) and 4 (Envision), which are those most closely related to quantitative analysis and modelling. Step 3 focuses on developing a strategic city diagnosis that will include the data collection process and a detailed analysis of the baseline situation in the different departments of the City Council. Step 4, on the other hand, focuses on an analysis of alternative long-term energy scenarios (2030/2050) that can guide the city's transition towards a low-carbon future.

Figure 5. **GENERAL VIEW OF THE CITY VISION APPROACH FOLLOWED IN THE ATELIER PROJECT FROM THE STEPS OF CITIES4ZERO STRATEGIC STAGE**



Source: Urrutia-Azcona *et al.*, 2020.

To address the analysis required in steps 3 and 4, the ATELIER project establishes an integrated methodology which seeks to guide cities by using a combination of different tools and methods that will support the integrated energy planning process. In this integrated methodology, the conventional city energy analysis is complemented by a prospective analysis (as proposed by (Arrizabalaga *et al.*, 2020)), an ex-ante impact assessment, and various methods of multiple-criteria decision analysis (MCDA) to facilitate the definition and evaluation of various future alternatives or scenarios that can guide the transition process of the city in question towards the desired low-carbon future. Additionally, the most relevant stakeholders in the city participate in the decision-making process via Innovation Atelier Bilbao.

The next stage entails modelling the city's energy demand and supply, as required by Step 3 (Figure 5). This involves an assessment of its energy situation from both a bottom-up and top-down perspective. The bottom-up part entails detailed characterisation of the city's building stock; the top-down perspective analyses energy flows from both the demand side (including all sectors of the city ranging from residential to services, transport, industry, etc.) and the generation side (conventional and distributed and/or renewable energy generation, available resources and energy imports and exports).

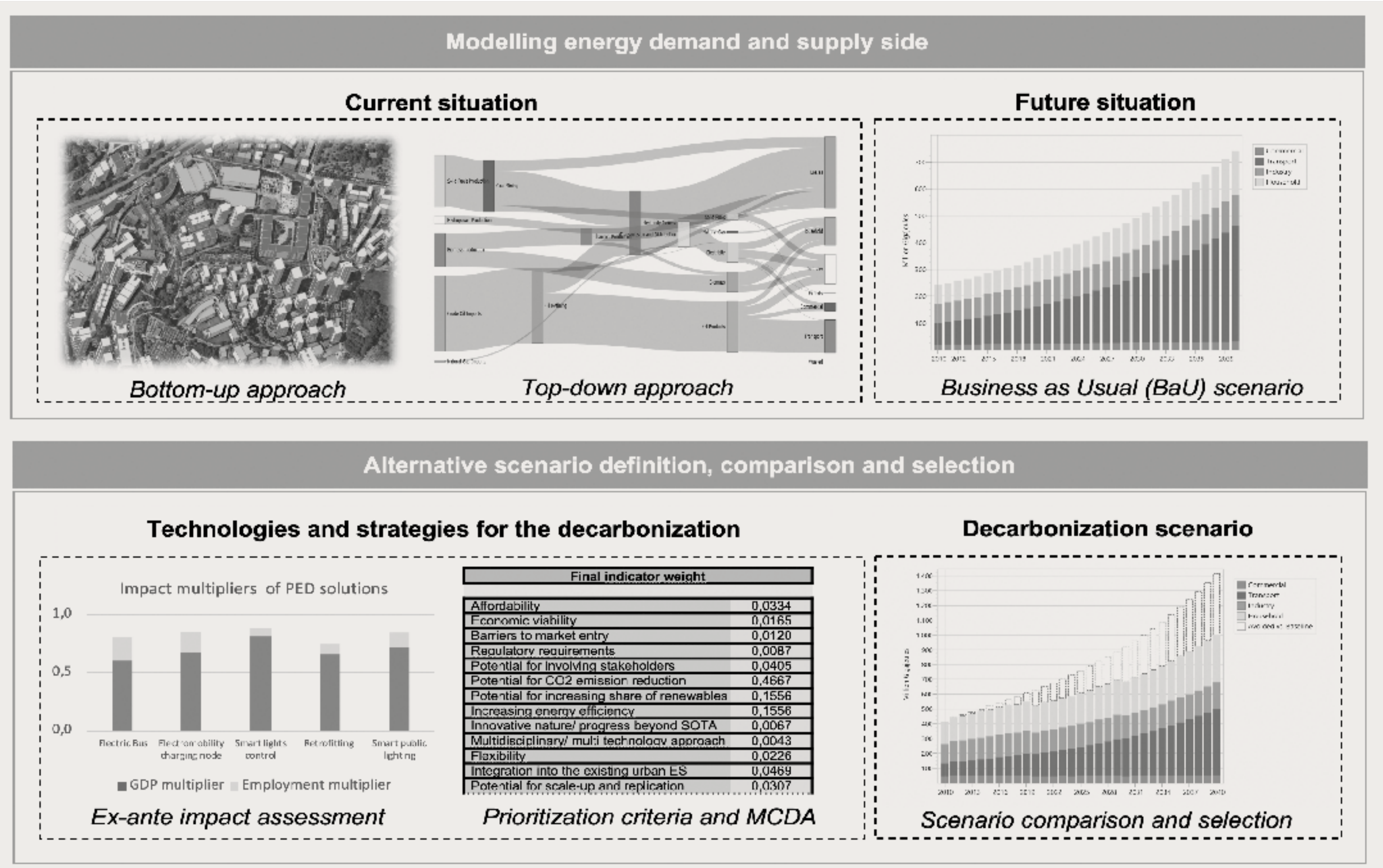
This makes it necessary to integrate tools (Figure 6) for energy characterization of building stock such as (*Enerkad*, 2019) with others for energy system modelling (ESM) such as LEAP (*LEAP*, 2020), which are generally used for larger scales. In order to ensure proper integration, differing aspects between the two perspectives must be combined. These include the sectors evaluated, the minimum resolution required, both at a spatial level (building blocks vs complete building stock) and at a temporal level (hourly-basis analysis vs annual analysis) level and the limits of the system used in each case.

Once the current situation of the city has been characterised, the way in which it may evolve in the long term can be assessed, using energy system modelling tools such as LEAP. The eventual evolution of a continuing situation can be depicted in the Business as Usual (BaU) scenario. This provides clues about the future difficulties and needs each city will face in a specific timescale (to 2050 in the case of this project). Subsequently, alternative scenarios can be defined, factoring in the deployment of certain decarbonisation technologies and strategies. These scenarios are shaped through the progressive deployment of an optimal combination of previously evaluated measures, using ex-ante impact assessment methodologies.

The assessment as a whole will be performed using innovative energy modelling approaches and the ex-ante impact assessment (environmental, energy and socio-economic). This includes a prospective energy analysis applied to cities, a life cycle perspective applied to transition scenarios, a supply-chain analysis of deployed technologies, and macroeconomic impact assessment methods such as those based on input-output theory. This will make it possible to predict the impact associated with each measure based on multiple impact indicators that will be used as criteria for prioritisation. Finally, using MCDA (Multiple Criteria Decision Analysis) theory, these measures can be prioritised to define decarbonisation scenarios that will again be modelled in the ESM tools. This process gives a large number of plausible scenarios for decarbonisation, which can be compared to determine the optimal scenario for each individual city.

At this point, in addition to the tools and methods, concepts such as Positive Energy Districts (PEDs) can help simplify the problem, provided they are properly integrated into the broader city vision. Identifying and designing districts that can provide a positive energy balance can facilitate the process of structuring the city's transformation. Replication and upscaling PEDs can contribute by aggregation to achieving the city's overall objectives. Moreover, projects such as ATELIER, which focuses on developing pilot schemes that allow different areas of cities to become PEDs, should serve as demonstrators, facilitating replication of the PED concept in other cities.

Figure 6. **TOOLS AND METHODS OF THE INTEGRATED MODELLING VISION OF THE ATELIER PROJECT**



Source: based on Arrizabalaga *et al.* (2019)

4.3. **Smart governance approach**

All departments of Bilbao City Council are currently promoting participatory approaches that engage with citizens from the very earliest stage in new initiatives. The development of new strategic frameworks, the design of cultural agendas, and innovative urban developments are all submitted for citizen proposals and adjustments. With regard to the agenda for urban regeneration, the city council has proposed an innovative approach based on the development of Urban City Labs (Section 4.2), with citizens and stakeholders placed at the core of the proposals.

*4.3.1. **Two-way governance mechanism***

Traditional models of governance use a top-down approach, with governments drafting strategic plans that guide cities (regions, or countries) on the objectives and ambitions of coming years. However, Europe is making advances in this respect, proposing more participatory bottom-up approaches in which citizens are called on to take an active part in the decision-making processes (Calzada, 2018).

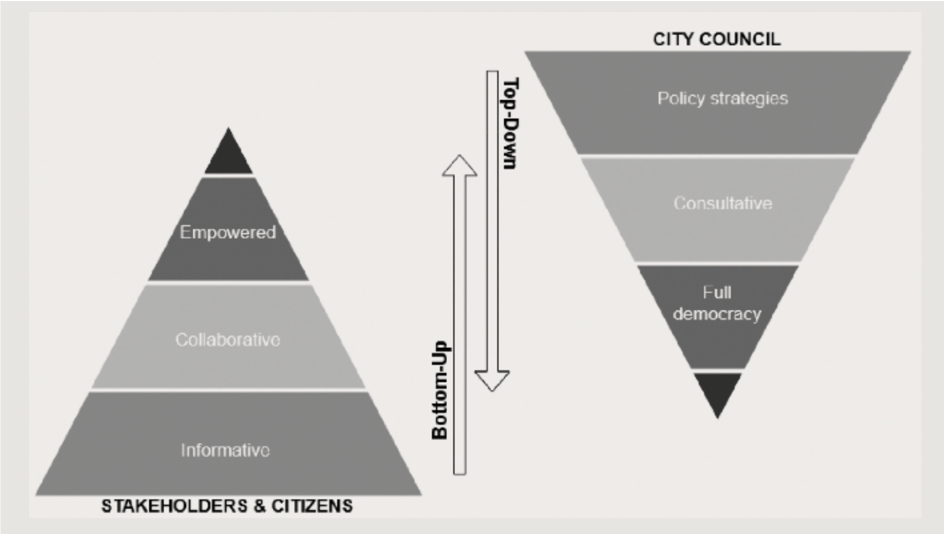
Both top-down or bottom-up approaches may be used, depending on the nature of the policy and the context in which it is being implemented. Top-down governance, in particular, entails the implementation of a policy decision (by statute, executive order, or court decision) in which decisions are taken by public authorities in order to produce certain desired effects. Bottom-up implementation, on the other hand, begins with the requirements of certain stakeholders (industries, service providers, clusters, civil associations, etc.) and citizens, who are the ultimate backers of the policies or strategic plans.

The top-down approach is a rational, comprehensive way of planning. It is consistent with overhead democracy, strategic plans, and policies, and is generally well-connected to higher level transversal policies and legislations. The decision-making process can be very efficient, innovative, and disruptive, depending on the visionary perspectives involved. On the downside, top-down policy making may be disconnected from the perspective, feelings, and desires of the community and as a result, may not enjoy support from citizens.

The bottom-up approach builds from citizen perspectives and ideas up to strategic plans by delivering scattered drops of well-connected needs, requirements, and desires. The bottom-up model is, by definition, closely connected to the general public's actual perspective but it may fail to generate cutting-edge proposals that make the leap into a long-term perspective.

The Two-Way Governance mechanism has been developed naturally by combining elements from both the top-down and bottom-up models (Figure 7). It is not an ex-ante static governance model; rather, it is continually and dynamically self-calibrated with elements combining the highest-level perspectives and demands (SDGs, EU legislation, SEAP plans, etc.) and citizen-driven co-generation of solutions. This innovative instrument combines interdisciplinary and transdisciplinary working mechanisms that structure the generation of urban communities, definition of strategic visions, co-implementation of innovative energy systems, integration of ICT tools, empowerment of communities working as prosumers, etc.

Figure 7. **TWO-WAY GOVERNANCE MECHANISM**



Source: Own elaboration.

The implementation of such as innovative City Lab, as it is the Positive Energy District of Zorrozaurre, demands the articulation of two-way governance mechanisms that ensure its long-term acceptance and success. The ATELIER project accelerates the implementation of this governance approach in an implicit manner. On the one hand, the design of top-down strategies is articulated thanks to the design of Bilbao Bold City Vision (Section 4.2.2). This strategic document will define the planning framework, methodological vision and roadmap for the coming years providing the long-term ambitions in terms of energy transition. On the other hand, the implementation of the PED in Zorrozaurre and the Roadmap for the entire city should be accompanied by bottom up mechanisms that facilitate the dialogue among all the stakeholders.

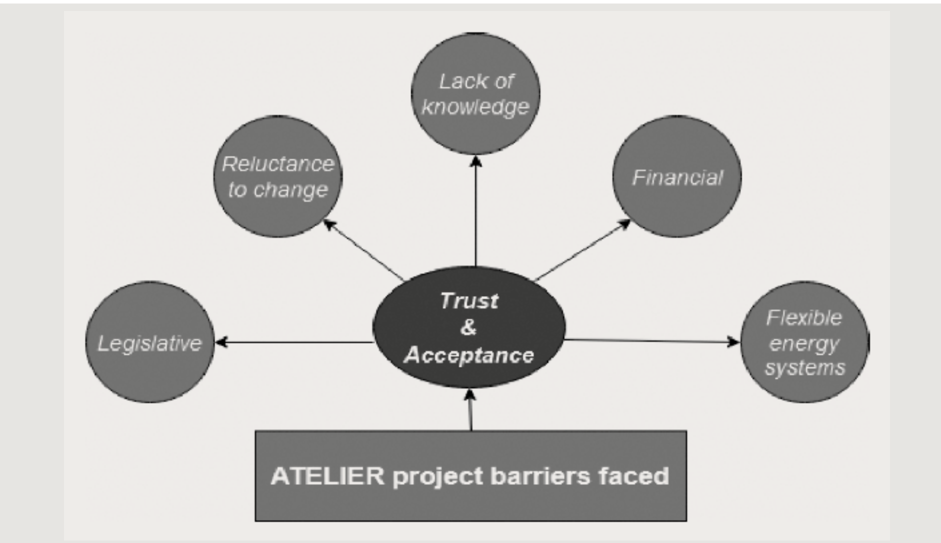
ATELIER supports the generation of a dynamic urban participatory strategy called ‘innovation ateliers’. Currently, the innovation ateliers are working on the smooth deployment of the PED in Zorrozaurre. However, the ambition is that they were self-sustainable and maintained their activity after the project life (after 2024) so that they would support many other innovative City Labs that the municipality would lead in accordance with the implementation of the Bilbao Bold City Vision.

4.3.2. *Main barriers faced for the deployment of PED City Lab*

The deployment of the Positive Energy District (see Section 3.3) implies very ambitious interventions (see Section 3.3) that come together with important challenges. Indeed, the PED is a new concept that needs to be tailored to the local situation and context. Moreover, the associated benefits cannot be fully known beforehand but require some research. As with many innovations, the deployment of the PED faces many uncertainties and risks, and many obstacles. The development of new decision-making instruments and participatory mechanisms is the most promising way of overcoming them.

On the one hand, a general lack of experience in designing, engineering, building, and operating highly energy efficient buildings, technologies and energy systems means that many chain-partners do not have enough familiarity or expertise to make well informed decisions in the process of implementing a PED project (Figure 8). At the same time, end-users tend to be reluctant to change. The uncertainty surrounding any new commodity or in-house facility engenders a significant degree of inertia, which affects attitudes towards the adoption of new solutions. In addition, there is a significant risk associated with investment in innovation, as there can be no guarantee that more efficient solutions may not emerge in the short term.

Figure 8. **MAIN BARRIERS FACED BY THE ATELIER PROJECT**



Source: Own elaboration.

Therefore, the most important barriers identified so far are related to social acceptance of and trust in smart solutions. These are directly connected to the lack of knowledge, reluctance to change, adoption of more flexible energy systems, design of new legislations or new financial structures, etc.

4.3.3. ***Innovation ATELIERS as smart governance process***

Given their systemic nature, PEDs require support from the local innovation ecosystem in tailoring and implementing smart urban solutions. Many European cities still do not have the 'governance capacity' (capacity of local actors to work together on a societal challenge and implement solutions) required for smooth implementation of innovative solutions. It therefore needs to be boosted.

In ATELIER smart city project, the design of new participative mechanisms is based on the Quadruple Helix methodology (Figure 9), an inter-sectoral approach where governance, academia, industry, and citizens build up new decision-making processes.

Figure 9. **INNOVATION ATELIERS FOLLOW QUADRUPLE HELIX METHODOLOGY**

Source: Värmland Country Administrative Board, 2018.

Bilbao Innovation Atelier was created as a forum for local, regional and related stakeholders with a clear vocation for innovation and continuity beyond the lifespan of the H2020 project and as an instrument of collaboration with other cities and areas of government beyond Bilbao city and the ATELIER innovation action.

The objectives were as follows:

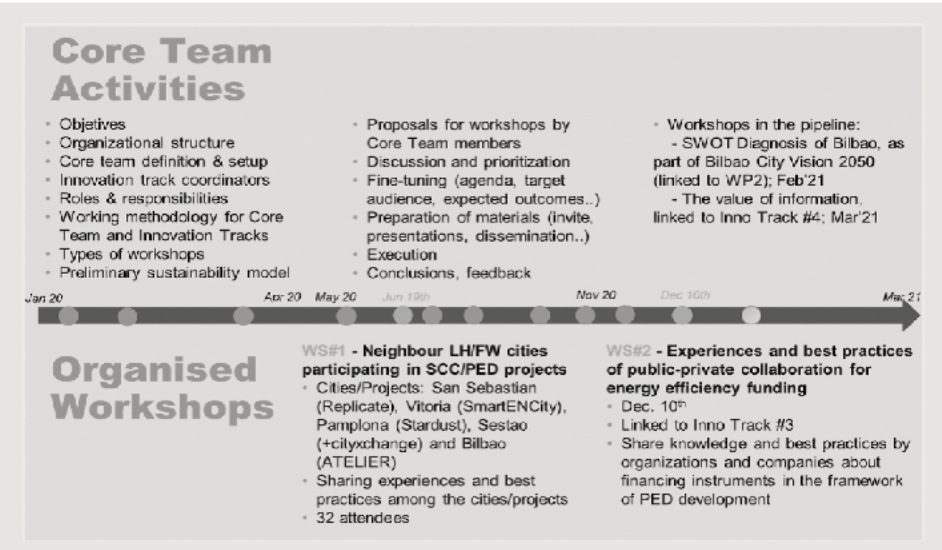
- To create a forum for ATELIER Bilbao partners and the local stakeholder community to foster open innovation in PEDs
- To disseminate progress on the development of ATELIER smart urban solutions and showcase its results
- To involve the local innovation ecosystem (quadruple helix) in tailoring and implementing the solutions in Bilbao, by:

  - Identifying local particularities and barriers and potential solutions
  - Exploring and fine-tuning business models for the innovations proposed

- To share knowledge and gain experience in four thematic tracks: #1 Integrated energy systems and e-mobility; #2 Governance, Integrated Planning and Law; #3 New financing instruments; #4 Data, privacy and data platforms
- To deliver useful feedback and best-practices to upscale the solutions to other districts of Bilbao and other cities in the Basque region and to support replication elsewhere in Europe.

The core group of the innovation ateliers meets regularly for the organisation of the workshops, which will always answer a research question, would identify the stakeholders to be involved, and would design the type of workshop (number of participants, type of participation, etc.). The innovation ateliers were stablished in Bilbao. Two workshops have been organised from the beginning of the project (from November 2019 to December 2020) (see Figure 10). The objective is to increase the intensity of the activity and to organise around five workshops per year.

Figure 10. **ACTIVITY OF INNOVATION ATELIERS IN BILBAO**



Source: Own elaboration.

Workshop 1: Neighbour LH/FW cities participating in SCC/PED projects

The first Innovation Atelier was held in June 2020. The aim was to draw on the experience of other Basque smart-city projects (Lighthouse and Fellow cities) to pool knowledge, experiences and best practices from their H2020 projects, and thus identify potential collaboration opportunities.

The Basque region has enormous potential as a smart city region since there are five SCC1 funded smart city projects. A panel of representatives from REPLICATE (Donostia-San Sebastian), SMARTENCITY (Vitoria-Gasteiz), STARDUST (Pamplona), +CITYXCHANGE (Sestao) and ATELIER (Bilbao) projects presented their smart vision of their respective cities, sharing many of the experiences, best practices and lessons learned in their H2020 projects to foster a joint understanding of the roll-out and take-off phases. The session allowed all the participants to reach a common understanding of the projects and initiatives proposed and implemented in the five cities. It also facilitated an exchange of experiences, lessons learned and recommendations on a series of subjects in an open and fruitful discussion between panellists and participants. The three main lines of debate focused on the governance model and tools made available in each city for the initiatives of the projects, how the best technical solutions were defined in each case, and the citizen communication strategy and participation mechanisms put in place.

In terms of the principal strengths, a good communication and citizen engagement strategy was seen as being key to achieving support from neighbourhood communities in adopting the solutions designed under the projects. A great effort must be made —even before the project is begun— to deliver clear, simple and accurate messages on planned actions and their expected benefits, including door-to-door campaigns, tailored to wide-ranging groups of citizens in an understandable way, avoiding too much technical detail and fostering an environment of trust.

Some difficulties were also raised, such as the complexity of harmonizing and coordinating work between different municipal areas and services, each of which has different objectives, teams and working schedules. A flexible and efficient governance model would be helpful, with a clear commitment from all municipal areas involved to meet project targets and execution milestones.

Most of the panellists agreed on the advisability of defining and implementing on-site pilot schemes or demonstrations in the neighbourhoods, following a bottom-up strategy, since this is the most practical way of showing the different technologies in place and the benefits of the selected solutions. This kind of action could be extremely helpful in making citizens understand the impact of the projects' results in terms of energy efficiency, sustainability, and comfort, thus encouraging the communities to adopt them. As a result of this workshop, the panellists were quite positive about establishing a collaborative framework between the five projects and cities to build on the issues discussed, analyse others of common interest and identify joint initiatives to be undertaken within the framework of Bilbao Innovation Atelier.

Workshop 2: Financing energy saving: experiences and alternatives

The second innovation workshop took place on the 10th of December 2020, under the topic «Financing energy saving: experiences and alternatives», organized by Deusto Business School (DBS). The workshop featured an outstanding panel of representatives from the Basque Government: Ignacio de la Puerta Rueda. Director of Territorial Planning, Urbanism and Urban Regeneration, Greenward: Fernando de Roda. Founder & Managing Partner, Stratenergy, Velatia: Alejandro Sánchez Palomo. Managing Director, Triodos Bank: Daniel Pascual Pascual. Director of the Basque Country, Smart Energy-Iberdrola: Jose Ignacio Leonet. Product Manager. Smart Solar, GoiEner: Jokin Castaños González. Generation Area Coordinator, EVE: Luis de Velasco. Department of Studies and Planning and the participation of ATELIER «Opengela» experience was shared. It was focused on partners. The workshop was attended and participated by a total of 25 people.

The seven panellists addressed the issue of financing energy saving and CO_2 emission reduction projects from their respective organizations. The main conclusions were:

- The decarbonisation challenge set for 2050, which involves an intervention in nearly 1,100,000 homes in the Basque Country. Financing is key and is part of the solution and must be 1) Easy to access 2) Affordable and 3) Fair and generate 4) Trust. The presenter shares the «Opengela» experience that focuses on intervention in the most vulnerable neighbourhoods.
- Financing is an important barrier, especially in the most vulnerable neighbourhoods. It is important to simplify the information, make it easy to communicate. An example of good practice is related to the «Opengela» project and the «Neighbourhood Offices».
- It is important to talk about energy saving, but it is also important to talk about improving the quality of life of citizens and the right to have a decent home in terms of light, energy, heating, etc.
- Public-private collaboration is essential in building rehabilitation projects. The public part should offer guarantees to the private sector (i.e. clear rules and regulations). As an example, it should be possible to extend the repayment terms of loans for financing energy savings (15-25 years) to make it affordable for the most vulnerable people.
- The role of ESCOs as motivator/facilitator of the energy transition process was highlighted. Example of good practice of public-private collaboration in TxominEnea in Donostia was presented by Stratenergy.
- New financing formulas through PPAs services (Smart Solar-Iberdrola case), energy cooperatives for self-generation and self-consumption projects (Goiener case) were presented.

There are no public resources to subsidize 70-80% of the retrofitting/renovation projects. It would be necessary to refine the recipients of the aid, who are those who really need it. The challenge would be for public funding to cover people who are not eligible by the private sector.

5. CONCLUSIONS AND POLICY FEEDBACK

This article presents an innovative three-step methodology that will pave the way for energy urban transition in cities. It combines: an innovative design approach based on the definition of Positive Energy Districts, a real-scale implementation using the City Labs, and the definition and implementation of new governance mechanisms that combine long-term strategic perspectives with bottom-up participatory schemes. ATELIER H2020 project has accelerated the demonstration of this innovative methodology that has already provided the following results:

- The definition of Positive Energy District (PED) is still under debate; however, it seems to be an appealing concept that is very well suited to the requirements of the integrated climate and energy policy framework (European Commission, 2014). A PED is defined in Zorrozaurre including specific areas at the North, Centre and South of the island.
- The implementation of the Positive Energy District in Zorrozaurre is not seen as an isolated initiative but, on the contrary, it is one of the City Labs promoted by the council of Bilbao. It will serve to define and illustrate the Bilbao Bold City Vision, the strategic plan for urban transition that defines the roadmap for 2050.
- The success of new urban developments motivated by energy transition requirements depends on citizens and all stakeholders: the acceptance of the solutions, the difficulty that poses the resistance to changes, the trust on the community, etc. will be clue elements for the integration of measures and the success of integrated developments. Innovative governance mechanisms that boost bottom-up participatory approaches have been recently adopted in Bilbao, they have been called innovation ateliers and will work on four thematic tracks: integrated energy systems and e-mobility; governance, integrated planning and law; new financing instruments; and data, privacy and data platforms.

The Basque region has great potential to be a reference in Europe with respect to the energy transition and smart-city region development. The Positive Energy District supported by ATELIER – H2020 innovation project will provide new insights for policymaking. The support of Smart Cities and Communities (SCC) as well as the experience of the Basque smart cities will facilitate the rapid roll out of solutions all along the Basque Region.

REFERENCES

ANGELAKOGLOU, K. *et al.* (2019): «A methodological framework for the selection of key performance indicators to assess smart city solutions», Smart Cities, 2(2), pp. 269-306. doi: 10.3390/smartcities2020018.

ARRIZABALAGA, E., GARCÍA-GUSANO, D., HERNÁNDEZ, P. *Toward sustainable long-term energy planning for cities: an economic and environmental assessment of sustainable fuel technologies in the city of Donostia-San Sebastián.* En: Sustainable Fuel Technologies Handbook. Eds.: Dutta S., Hussain C.M. Academic Press, 2021, pp. 483-510, ISBN 9780128229897. https://doi.org/10.1016/B978-0-12-822989-7.00017-2

ARRIZABALAGA, E., MUÑOZ, I., NEKANE, H., URCOLA, I., IZKARA, JL., PRIETO, I.; PEDRERO, J. HERNÁNDEZ, P., MABE, L., (2019): Methodology for the advanced integrated urban energy planning. Proceedings 2019, 20(1), 17; https://doi.org/10.3390/proceedings2019020017

BUONOMANO, A. *et al.* (2019): «Dynamic analysis of the integration of electric vehicles in efficient buildings fed by renewables», Applied Energy. Elsevier, 245(March), pp. 31-50. doi: 10.1016/j.apenergy.2019.03.206.

CALLEJA, D.; CABALLERO, F. (2014): «A new industrial policy for Europe: Reinforcing Europe's industrial base to create employment and growth», Manufacturing Renaissance, 145(1), pp. 155-180. doi: 10.4000/rei.5769.

CALZADA, I. (2018): «(Smart) citizens from data providers to decision-makers? The case study of Barcelona», Sustainability (Switzerland), 10(9). doi: 10.3390/su10093252.

CAO, X.; DAI, X.; LIU, J. (2016): «Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade», Energy and Buildings. Elsevier B.V., 128, pp. 198-213. doi: 10.1016/j.enbuild.2016.06.089.

CASTILLO-CALZADILLA, T. *et al.* (2018): «Analysis and assessment of an off-grid services building through the usage of a DC photovoltaic microgrid», Sustainable Cities and Society. Elsevier, 38(December 2017), pp. 405-419. doi: 10.1016/j.scs.2018.01.010.

CHARRON, R. (2008): «A review of low and net-zero energy solar home initiatives», Open House International 33(3) pp. 7-16. doi: 10.1108/OHI-03-2008-B0002

ENERKAD (2019): Available at: https://www.enerkad.net/ (Accessed: 30 October 2020).

EU RATIFIES THE KYOTO PROTOCOL (2002). Press note IP/02/794, Brussels, 31 May 2002. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_02_794 (Accessed: 30 October 2020).

EU SMART CITIES INFORMATION SYSTEM (2017): Upscaling urban residential retrofit for the EU's low carbon future: Challenges and opportunities. Available at: www.smartcities-infosystem.eu.

EUROPEAN COMMISSION (2014): «2030 climate and energy goals for a competitive, secure and low-carbon EU economy», Press Release. Brussels: European Commission. Available at: http://ec.europa.eu/clima/policies/2030/documentation_en.htm.

EUROPEAN COMMISSION (2019a): The European Green Deal, European Commission. Brussels. doi: 10.1017/CBO9 781107415324.004.

EUROPEAN COMMISSION (2019b): Clean energy for all Europeans, Euroheat and Power. doi: 10.2833/9937.

EUROPEAN ENVIRONMENT AGENCY (2015): The European Environment: State and Outlook 2015: Synthesis Report. Available at: https://www.eea.europa.eu/soer/2015/synthesis/report.

GONZÁLEZ MEDINA, M.; FEDELI, V. (2015): «Explorando la Política urbana europea: ¿Hacia una agenda urbana nacional-europea?», Gestión y Análisis de Políticas Públicas, 7(14), pp. 8-22. doi: 10.24965/gapp.v0i14.10287.

HIRSCH, A.; PARAG, Y.; GUERRERO, J. (2018): «Microgrids: A review of technologies, key drivers, and outstanding issues», Renewable and

Sustainable Energy Reviews. Elsevier Ltd, 90(March), pp. 402-411. doi: 10.1016/j.rser.2018.03.040.

HOWELL, S. *et al.* (2017): «Towards the next generation of smart grids: Semantic and holonic multi-agent management of distributed energy resources», Renewable and Sustainable Energy Reviews. Elsevier Ltd, 77(March), pp. 193-214. doi: 10.1016/j.rser.2017.03.107.

KUSCH-BRANDT (2019): Renewables 2019 Global Status Report, Resources. Athens. Available at: https://www.ren21.net/wp-content/uploads/2019/05/REC-2019-GSR_Full_Report_web.pdf

LEAP (2020): Available at: https://leap.sei.org/Default.asp (Accessed: 30 October 2020).

MITCHELL, T. (2010): «The Resources of Economics making the 1973 oil crisis», Journal of Cultural Economy, 3(2), pp. 189-204. doi: 10.1080/17530350.2010.494123.

MONTAVA, J. (2014): Smart Cities. Criterio, análisis y aplicación de la ciudad inteligente. Caso de estudio la ciudad italiana de Matera: Patrimonio de la Humanidad. Proyecto Fin de Grado, Universidad Politécnica de Valencia. http://hdl.handle.net/10251/44000.

PANDEY, G. *et al.* (2015): «Smart DC Grid for Autonomous Zero Net Electric Energy of Cluster of Buildings», IFAC-PapersOnLine. Elsevier B.V., 48(30), pp. 108-113. doi: 10.1016/j.ifacol.2015.12.362.

PEARSON, P.J.G.; FOXON, T.J. (2012): «A low carbon industrial revolution? Insights and challenges from past technological and economic transformations», Energy Policy. Elsevier, 50, pp. 117-127. doi: 10.1016/j.enpol.2012. 07.061.

PÉREZ, J. *et al.* (2019): «A methodology for the development of urban energy balances: Ten years of application to the city of Madrid», Cities. Elsevier, 91(June), pp. 126-136. doi: 10.1016/j.cities.2018.11.012.

PETRILLO, A. *et al.* (2016): «Life cycle assessment (LCA) and life cycle cost (LCC) analysis model for a stand-alone hybrid renewable energy system», Renewable Energy. Elsevier Ltd, 95, pp. 337-355. doi: 10.1016/j.renene.2016.04.027.

REN21 (2018): Renewables 2018 Global Status Report (Paris: REN21 Secretariat), Paris: Renewable energy policy network for the 21st Century. doi: 978-3-9818911-3-3.

RUHLANDT, R.W.S. (2018): «The governance of smart cities: A systematic literature review», Cities. Elsevier, 81(October 2017), pp. 1-23. doi: 10.1016/j.cities.2018.02.014.

TAHERAHMADI, J.; NOOROLLAHI, Y.; PANAHI, M. (2020): «Toward comprehensive zero energy building definitions: a literature review and recommendations», International Journal of Sustainable Energy. Taylor & Francis, pp. 1-29. doi: 10.1080/14786451.2020.1796664.

THE COVENANT OF MAYORS INITIATIVE FOR LOCAL SUSTAINABLE ENERGY (E3P) (2020): Available at: https://e3p.jrc.ec.europa.eu/node/188 (Accessed: 30 October 2020).

UNITED NATIONS (2015): Climate change agreement - PARIS. Available at: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf.

URRUTIA-AZCONA, K. *et al.* (2020): «Cities4ZERO: Overcoming carbon lock-in in municipalities through smart urban transformation processes», Sustainability (Switzerland), 12(9). doi: 10.3390/SU12093590.

VÄRMLAND COUNTY ADMINISTRATIVE BOARD (2018): *A Quadruple Helix guide for innovations.* Sweden https://vb.northsearegion.eu/public/files/repository/20180924154616_QuadrupleHelixguide.pdf