

Perspective

Sustainable Urban Areas for 2030 in a Post-COVID-19 Scenario: Focus on Innovative Research and Funding Frameworks to Boost Transition towards 100 Positive Energy Districts and 100 Climate-Neutral Cities

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Abstract: Cities generate about 85% of the EU's GDP. As such, they are key players in shaping and providing technological and social innovations but also environmental impact. Thus, they must urgently engage in unprecedented systemic transformational and bold transitions towards sustainability and climate neutrality. The contribution—taking into account that the concepts of community resilience and urban transition have changed as a consequence of COVID-19—critically discusses innovative frameworks and funding opportunities that Horizon Europe will put in place to boost sustainable urban areas in Europe, driving a transition to 100 Positive Energy Districts and 100 climate-neutral cities by 2030.

Keywords: positive energy district; climate-neutral cities; 15-minute city; downsizing district; doughnuts; post-COVID-19 scenario for RD&I funding



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1. Introduction

The discussion about sustainable development of urban areas started worldwide more than 30 years ago when the European Commission began to foster sustainable urban development through the Framework Programs FP5–FP6–FP7 (Appendix A), supporting urban areas to become Actors of Open Innovation, thus accelerating the transition to sustainable, low-carbon societies.

The H2020 Framework Program addressed Major Urban Challenges, stimulating cities to be Actors of Open Innovation and calling municipal authorities to be active participants in Research and Innovation (R&I) projects, thus designing a new role for city authorities compared with previous framework programs where cities were only the place and the object where research took place.

Sustainable development of urban areas has become the prime challenge in the area of “Secure, clean and efficient energy”, promoting transition to a competitive energy system around specific objectives such as energy consumption and carbon footprint reduction; low-cost and low-carbon electricity supply; a smart European electricity grid; alternative fuels and mobile energy sources; innovative knowledge and technologies; market uptake of energy and ICT innovation; robust decision making and public engagement.

Several funding schemes in the H2020 Framework Programme such as Smart Cities and Communities, European Structural and Investment Funds, European Fund for Strategic Investments, Urban Innovative Actions, Urbact, Life, and Jaspers have supported critical and ambitious urban dimensions.

As a consequence, the European Commission has been paying, for 30 years, significant attention to both urban dimensions and sustainable development, which are also cornerstones in its funding strategies; this trend seems to continue through the forthcoming Horizon Europe Framework Programme with a set of instruments and actions such as:

- Horizon Europe Cluster 5 [1]: Climate, Energy, and Mobility—Destination 2, Cross-sectorial solutions for the climate transition;
- European Partnership Driving Urban Transition to a sustainable future (DUT) partnerships [2];
- European research and innovation missions (European Green Deal) delivering solutions to some of the greatest challenges facing our world, among which is 100 climate-neutral cities by 2030—by and for the citizens [3].

In this broad picture, the SET Plan, which is the technology pillar of the EU's energy and climate policy adopted by the European Union, boosts the transition towards a climate-neutral energy system, promoting the development of low-carbon technologies in fast and cost-competitive ways. Thanks to new technology improvements and reducing costs with coordinated national research efforts, the SET Plan facilitates cooperation among EU countries, companies, and research institutions, delivering on the main challenges of the Energy Union.

The implementation of the SET Plan started with the establishment of the European Industrial Initiatives (EIIs) and of the European Energy Research Alliance (EERA), both promoting alignment of the Research and Development activities of individual research organizations to SET Plan challenges and creation of a joint programming framework at the EU level involving national delegates in Implementation Working Groups. Among the Implementation Working Groups, a specific one for Action 3.2 “Smart Cities and Communities” has been created, boosting planning, deployment, and replication of 100 Positive Energy Districts (PEDs) by 2025 for sustainable urbanization, thus anticipating the concept of PEDs highlighted in the European Partnership DUT.

On the same line, the EERA Joint Programme on Smart Cities (a network of universities and research institutes from across Europe that cooperate with industry, cities, and citizens to support innovation and demonstration projects) contributed to the development and mainstreaming of the Positive Energy Districts concept. The EERA Joint Programme on Smart Cities re-orientated its structure in 2018 to better investigate and progress the underlying PED concepts and to stimulate discussion around them.

With the aim to support capacity building for new generations of PED professionals, early career investigators, experienced practitioners, and policy makers, the EERA Joint Programme on Smart Cities has been leading the submission of a Cooperation in Science and Technology (COST) Action proposal to establish a European PED network. As a result, the Cooperation in Science and Technology (COST) Action CA19126 “PED-EU-NET Positive Energy Districts European Network” (Appendix B), supporting open collaboration among researchers, innovators, and other relevant stakeholders across different domains and sectors and giving impetus to research advancements and innovation on Positive Energy Districts in Europe—formally started its activities on 10 September 2020, under EU funding.

Cities with their surroundings areas have become the epicenter of the pandemic with ninety percent of all reported COVID-19 cases [4], exacerbating risks and taking extraordinary measures to support the local economy and protect the population, in some way losing the priority of persisting climate and ecological crisis [5]. Therefore, the COVID-19 pandemic clearly demonstrates interrelations between natural and societal systems; indeed, societal resilience strictly depends on a resilient and robust environmental support system [6].

As a consequence, with the outbreak of the COVID-19 crisis, emerging issues and related questions with respect to mainstreaming urban transition, sustainability, and climate neutrality arise spontaneously: How did societal challenges and related priorities change in the post-COVID scenario? Should the Urban Transition framework change as well? How

much do innovative research and funding frameworks to boost transition already take those changes into account? How can addressing the challenges of climate neutrality help with respect to post-COVID 19 urban transition?

According to authors' point of view, tentative answers are provided in section "Discussion and Conclusions".

The COVID-19 crisis has had a deep economic impact on several sectors; indeed, the activity in construction decreased by 15.7% in 2019, as well as investment in the energy efficiency sector which decreased by 12% in 2020. Even if the European recovery plan is coming, a new impact on the building sector is expected which could be limited, somehow, by 2030, creating 160,000 green jobs for the EU construction sector thanks to the renovation wave. This would be a key opportunity to overcome the COVID-19 crisis, not forgetting about climate neutrality issues; restructuration and renovation offer a key opportunity to rethink, redesign, and modernize buildings to adapt them for a greener and digital society while sustaining economic recovery [7].

The following sections describe the most recent innovative research and funding frameworks—such as 100 Positive Energy Districts, 100 climate-neutral cities, Horizon Europe, and the Green Deal—aiming at offering critical perspectives taking into consideration the above dilemmas.

2. Materials and Method: A Review of the Most Recent Innovative Research and Funding Frameworks on 100 Positive Energy Districts and 100 Climate-Neutral Cities

More than half of the world's population nowadays is located in urban areas; people living in cities and their surrounding areas are expected to be 80% of population by 2050. Cities and urban areas are centers of economic activities, knowledge generation, innovation and new technologies, and places where the quality of life is immediately tangible. That is why Horizon Europe will promote the mission of "100 Climate-Neutral Cities by 2030—by and for the citizens" and will support sustainable urban transition with the DUT Partnership.

At the time of this article's writing, the definition of the contents relating to the 100 Climate-Neutral Cities Mission seems to have been fully outlined and defined, while the process of the DUT Partnership is still ongoing and it is assumed that it will not be completed before the second half of 2021. The process for understanding the aim, objectives, and priorities of the DUT Partnership is a co-creation process that has involved, and still involves, main urban stakeholders. Management of the DUT Partnership is entrusted to JPI Urban Europe, which, due to its role and skills, is also the management delegate for the Implementation Working Group of SET Plan 3.2.

In addition to many other urban stakeholders, two research networks participate in the co-creation process for DUT Partnership, mainly related to PEDs: the EERA Joint Program on Smart Cities and the COST Action CA19126 "PED-EU-NET".

Thanks to Horizon Europe and the co-design process, European cities will have a unique chance to promote the sustainability dimension at an urban scale, according to their own needs—this will help to fulfil the goals set out by international policy frameworks such as the Urban Agenda for the EU, the COP21 Paris Agreement, the Habitat III New Urban Agenda, and, last but not least, the UN's Sustainable Development Goals (notably SDG 11) of the DUT Partnership.

2.1. 100 Positive Energy Districts: Driving Urban Transition (DUT) Partnership

The aim of the European Partnerships in Horizon Europe is to address global challenges and modernize industry. The European Partnerships will contribute to multiple Sustainable Development Goals (SDGs) and are an integral part of Horizon Europe's strategic planning process that identifies three types of partnership: (a) Co-programmed European Partnerships, which are partnerships between the Commission and private and/or public partners; (b) co-funded European Partnerships using a program to co-fund action—this is the case for Driving Urban Transition (DUT) Partnership to a sustainable fu-

ture; and (c) institutionalized European Partnerships with research and innovation funding programs that are undertaken by EU countries (e.g., the EIT KICs).

The Driving Urban Transition to a Sustainable Future (DUT) Partnership is the proposal for an urban partnership under Horizon Europe, led by JPI Urban Europe [8], and focuses specifically on fostering actions in Cluster 5 “Climate, Energy and Mobility”, whose scope is to create impact in three urban dimensions: (a) urban areas, (b) urban policy, and (c) urban innovation, and the European Research Area (ERA).

The DUT Partnership addresses a complex set of urban challenges [9] and aims to support decision making in municipalities, companies, and society by acting and enabling:

1. Actions for capacity and community building for urban transformations to drive and to shape a quadruple-helix innovation eco-system on urban transitions. Targets: (a) City authorities and urban municipalities mobilized in projects, urban living labs, and other partnership activities; (b) Urban living labs and similar formats; (c) Multi-stakeholder engagement.
2. Efforts towards integrated approaches to tackle complex urban issues and to increase effectiveness of urban solutions, approaches, and processes. Targets: (a) R&I calls opened for participation of all stakeholder groups (challenge-driven); (b) Urban research and innovation considering urban dilemmas and engaging relevant stakeholders in the process.
3. Join forces—at local and international scales—to tap the full potential of urban Research and Innovation, bringing knowledge to action across Europe to create benefits for neighborhoods and urban areas across Europe. Targets: (a) Policy briefs and recommendations, with and made available for urban governance and city networks; (b) Widened participation and international relationships; (c) Results and solutions from R&I projects and/or urban living labs available for local urban policy and public administrations.

According to this approach, the Partnership will create a portfolio of measures to enhance its impact, build capacities in all stakeholder groups, and contribute to the European mission on climate-neutral and smart cities. On the other hand, the Partnership will engage and enable the whole spectrum of urban stakeholders (local authorities, municipalities, businesses, and citizens) to co-create innovative, systemic, and people-centric approaches, tools, methods, and services in support of urban transformative transitions. This will boost a more efficient and decarbonized use of energy, sustainable and people-friendly mobility systems, and circular and environmental-friendly use of resources for the well-being of citizens and preservation of biodiversity.

With this vision, the DUT Partnership is likely to contribute to global and European policies, in particular the Agenda 2030 and UN Habitat’s New Urban Agenda, the strategic priorities of the European Commission’s Strategic Plan for Horizon Europe, with a special focus on the European Green Deal, the Paris Agreement, the Leipzig Charter, and the Urban Agenda for the EU (UAEU). To achieve these objectives and to assess the sub-targets of the Sustainable Development Goal (SDG) no. 11 (Make cities inclusive, safe, resilient and sustainable), the DUT Partnership builds upon the Strategic Research and Innovation Agenda (SRIA) 2.0, developed by JPI Urban Europe, where three innovation pillars (and their inter-relationships) are considered as prioritized sectors along the Green Deal for sustainable urbanization:

1. The 15-Minute City as a concept for rethinking the urban mobility system and space;
2. Downsizing District Doughnuts as an integrated approach for urban greening and circularity transitions;
3. Positive Energy Districts and Neighborhoods, aiming at transforming the urban energy system.

2.1.1. The 15-Minute City: Rethinking the Urban Mobility System and Space

The concept of the 15-Minute City (Table 1) provides a framework for the mobility of people and goods that directly and indirectly affects urban livability, health, the spatial

configuration of cities, air quality, and other aspects of the living environment and sustainable urbanization. The transformation of urban mobility systems will not be achievable by relying on technologies or providing more sustainable mobility offerings alone but calls for fundamental rethinking of space and the re-organization of all daily activities.

Table 1. The 15-Minute City concept.

15-Minute City
Rethinking urban mobility system and space:
<ul style="list-style-type: none"> - Fundamental rethinking of space and the re-organization of our daily activities - Different mobility options at various scales (from neighborhoods up to regional scale) - Different urban settings (city size, available mobility infrastructure, mobility supply/service patterns, etc.) - Different mobility options at various scales (from neighborhoods up to regional scale) - More flexible transport options along a broad set of innovations

The 15-Minute City approach addresses different urban settings (city size, available mobility infrastructure, mobility supply/service patterns, etc.) and mobility options at various scales (from neighborhood up to regional scale), taking into account how people move and how goods and services are delivered, hence creating more flexible transportation options along a broad set of innovations—social, organizational, technological, and institutional. For these reasons, this concept offers a clear focus for the mobility pillar and a holistic, people-oriented, and challenge-driven perspective for distinct aspects of the doughnut economy and the overarching ambition of regenerative cities according a wider PED/PEN concept.

2.1.2. The Downsizing District Doughnuts

Cities and urban areas are attractive starting points for making the global transition to livable societies and circular economies. The Downsizing Districts Doughnut (DDD) Pillar (Table 2) aims at operationalizing a dilemma-based approach to urban greening and circularity objectives of the Green Deal by supporting urban robustness through doughnut strategies in urban districts. The DDD approach holds a dual circles system concept of city doughnuts based on the exchanges/balance between an external ring—representing the nine “planetary boundaries”—and an inner ring including the city doughnuts’ nine sectors. Between these two sets of boundaries, there is the ecologically safe and socially just space [10].

Table 2. The Downsizing District Doughnuts concept.

Downsizing District Doughnuts (DDD)
Doughnut strategies in urban districts:
<ul style="list-style-type: none"> - Dual circles system concept of city doughnuts - External ring representing the nine “planetary boundaries” - Inner ring including the city doughnuts’ nine sectors

According to this approach, the transitions driven by the Downsizing District Doughnuts paradigm can contribute to and promote a systemic change at all of the following four levels of urban transformation:

- Governance and mobilizing people for change, by supporting existing networks, groups, initiatives, and “urban doers” engaged in urban transformation activities.
- Circularity, by supporting transitions of metropolitan industries and new urban economies with circular growth.
- Sustainable spatial planning, by translating land-use and spatial/territorial planning into integrated urban development, by developing and improving Green-Blue Infrastructures (GBIs) and Nature-Based Solutions’ (NBS) overall urban livability, public

health, and urban robustness together with cutting-edge approaches to clean-tech and entrepreneurial creativity.

- Urban design, by supporting the (re-)development of attractive built environments concerning livability and well-being as well as the urban design aspects of “high quality” public spaces.

2.1.3. Positive Energy Districts

The PED concept, as said, implies an integrated approach for designing urban areas, districts, or groups of connected buildings producing net zero greenhouse gas emissions, managing an annual local/regional overflow production of renewable energy. The PED/PEN approach (Table 3) emphasizes the flexibility dimension of urban districts in the regional energy system based on renewable energy and addresses the ecological and energetic footprints of goods and services. Otherwise, PEDs include a proper consideration of user behavior and people’s lifestyles without contradicting the guiding principles of cost efficiency, affordability of housing, and energy poverty.

Table 3. The PED concept.

PED
<p>This approach emphasizes the flexibility dimension of urban districts in the (renewable) regional energy system and addresses the energetic and ecological footprint of goods and services:</p> <ul style="list-style-type: none"> - Energy efficiency - Energy flexibility - Energy production - Quality of life, inclusiveness, sustainability, resilience and security of energy supply

The PED Reference Framework [11] identifies three key functions for urban areas, related to context of their urban and regional energy system, that cities need to consider in their long-term urban strategies: energy efficiency, energy flexibility, and local/regional energy production. Therefore, the neighborhood scale will foster economic sustainability (e.g., economies of scale), aggregation synergies (e.g., efficiency deployment, flexibility, and integration), and governance in distributed resources through a considerable involvement of all stakeholders and communities. It means that each PED will design its own balance between the above-mentioned functions, figuring their own way towards climate neutrality and energy surplus. To make PEDs attractive for cities and citizens, their development should follow four guiding principles, namely: (a) quality of life, (b) inclusiveness (with special focus on the affordability and prevention of energy poverty), (c) sustainability, and (d) resilience and security of energy supply.

These three key priority areas—The 15-Minute City, The Downsizing District Doughnuts, and Positive Energy Districts—in turn, imply three integrated approaches that impact each other as well as most the other urban grand challenges, while revealing multiple interlinkages with the sectorial priorities [12]. The three DUT pillars can be considered complementary driven strategies (Tables 4–6) aiming at supporting climate neutrality and energy autonomy achievement in cities considering urban physical, functional, and socio-economic vulnerability. They create strong interfaces and cross-cutting potential towards each DUT pillar and suggest transversality, therefore overcoming a strictly silos vision (“breaking silos”)—neighborhoods cannot produce more energy than they consume without new mobility solutions and more circular use of resources. New mobility solutions necessitate innovative energy technology and design thinking. Sustainable energy systems and smart mobility solutions are mandatory, should cities obtain circularity and secure well-being while respecting planetary boundaries. Otherwise, some commonalities across the three pillars suggest the renewal of the existing city by providing a new urban governance based on considering the expertise of residents/inhabitants. A change in the

governance structures is required and can be improved by co-designing inclusive public spaces as different ways for people to interact with technology and nature.

Table 4. Interface of the 15-Minute City with the other two Driving Urban Transition (DUT) pillars.

PED	Downsizing District Doughnuts (DDDs)
Developments on neighborhood scale.	Contribution to greening of urban areas and economies.
<ul style="list-style-type: none"> - Energy demands for mobility - Infrastructure requirements - Functional design and planning of neighborhoods 	<ul style="list-style-type: none"> - Impact on material flows and circularity - Mixed use of neighborhoods and link to green-blue infrastructure - Shared economy

Table 5. Interface of the Downsizing District Doughnuts with the other two DUT pillars.

Positive Energy Districts	15-Minute City
The role of energy in doughnut districts:	Interplay of the 15-minute city and doughnut district:
<ul style="list-style-type: none"> - Refurbishment and upgrade of built environment - Energy and resource efficiency and circularity of PEDs - Integration of GBIs and NBS in PEDs - Energy solutions for new urban manufacturing 	<ul style="list-style-type: none"> - Contribution of new mobility systems and services to circular urban economies - Mobility solutions for metropolitan industries - Consideration of the urban-rural continuum - Multi-functional public spaces

Table 6. Interface of Positive Energy Districts with the other two DUT pillars.

Downsizing District Doughnuts	15-Minute City
PED contribution to DDD:	Mobility in PEDs:
<ul style="list-style-type: none"> - Integration of green-blue infrastructure in PED concepts - Impact of PED on circularity, material flows, and resource efficiency - Economic dimension of PEDs 	<ul style="list-style-type: none"> - Integrated energy and mobility planning - Developing attractive, inclusive, and accessible neighborhoods or districts - Strengthen the role of mobility in neighborhood concepts

The PED concept itself represents the result of several working groups and ongoing initiatives at the European level that involve members from the EERA, JPSC, and JPI UE network. Even if an accurate concept of PEDs is still under discussion, an extensive range of different approaches and actions at the European and international levels are currently focusing on the definition and the implementation of the PED strategy for energy transition and climate mitigation in the urban context, among which are:

- The International Energy Agency EBC Annex 83 “PEDs”, launched in February 2020 and focused on developing an in-depth definition of PEDs and the technologies, the planning tools, and the decision-making processes related to Positive Energy Districts;
- The already mentioned COST Action CA19126 “PED-EU-NET” (Positive Energy Districts European Network) supporting open collaboration among researchers, innovators, and other relevant stakeholders across different domains and sectors to drive the deployment of Positive Energy Districts in Europe;
- The Positive Energy District Booklet which contains more than 60 examples of PEDs existing, ongoing, or in transition, showcasing different aims and challenges, approaches, and factors of success.

2.2. 100 Climate-Neutral Cities by 2030: Innovation Mission European Green Deal

The European Commission has recently introduced its own strategic long-term vision for a prosperous, competitive, and climate-neutral economy by 2050. The “European Green Deal” makes the case for a mission-oriented R&I component in the Horizon Europe

program to give answer to the question of how Europe can help cities become climate-neutral as fast as possible; supporting, promoting, and showcasing hundreds of European cities in their structural change towards climate neutrality by 2030, transforming urban areas and districts into hubs of experimentation and innovation and being able to lead on the European Green Deal and on Europe's efforts to be climate neutral by 2050.

To achieve in ten years within European cities what Europe plans to achieve in 30 years is a huge challenge that requires a systemic transformation for acting on the global climate emergency and for delivering co-benefits that will improve the health, well-being, and prosperity of citizens. This transformation will be feasible because technologies and innovative solutions for sustainable energy, transport, food, water, and material systems already exist thanks to R&I programs of last decade and in the years to come due to Horizon Europe and national R&I programs.

Moreover, green technology prices and market conditions are fast moving towards climate-friendly investments and will continue to strengthen incentives to transition. The European Green Deal, including a revision of EU directives for 2030, and the new role of the European Investment Bank will, thus, further strengthen this trend.

The mission (Table 7) is based on two main pillars:

- The Multiannual Financial Framework MFF 2021–2027 and Next Generation EU proposals which will impact the European and national frameworks for the funding of climate action, including the Horizon Europe program where the mission is anchored in terms of objectives, R&I agenda, and societal challenges and priorities;
- The European Green Deal which sets an unprecedented level of ambition and reach for climate and environmental action and for the financing and inclusiveness of the transition.

Table 7. The Climate-Neutral Cities concept.

Climate Neutral Cities
To set new standards for climate and urban agendas and for their implementation, addressing the challenge of climate neutrality:
- Cities will act as innovation hubs and national, European, and global forerunners
- Climate City Contract
- Climate neutrality should explain the starting point in its societal, economic, ecological, and political dimensions
- Connection with the local/regional or national strategy for carbon neutrality by 2050
- The “cross-border” issue: the participating city should ensure that measures taken will not be physically unconnected or stop working at the borders of the selected site

The innovation Mission Green Deal is designed as a flagship initiative that complements and blends the two mentioned pillars, aiming to set new standards for climate and urban agendas and for their implementation. While connected to a wide range of European policies and strategies (e.g., the Climate Law and the Climate Pact, the EU plan for circular economy, the European long-term strategy for 2050 and the National Energy and Climate Plans, the Urban Agenda for the EU, the European Digital Strategy, the Smart Specialization Strategies and platform, and the Smart and Sustainable Mobility Strategy), the mission will also connect these policies and strategies at the local level. The participating cities will act as innovation hubs and national, European, and global forerunners. They will inspire additional urban areas, and eventually, the whole of Europe, to accelerate their policies for climate action and transition.

To address the challenge of climate neutrality, the mission proposes a multi-level co-creation process through the introduction of a Climate City Contract. The purpose is to (a) express the ambition and commitment of all involved parties to the mission objectives; (b) identify the policy and implementation gaps as a basis for a strategy for transition; (c) coordinate stakeholders and empower citizens in the city around a common climate goal; (d) coordinate national/regional and EU authorities to deliver the necessary legal,

governance, and financial framework conditions to support each city; (e) create a one-stop shop for multi-level negotiations to facilitate city action for transition.

Adapted to the specific circumstances of each city, a Climate City Contract will include the goal and targets, specify the strategy and the action plan for transition, and identify stakeholders and responsibilities.

The Contract is not meant as a closed document that only binds a city legally to a course of action up to 2030. Instead, it emphasizes the high ambition, the participatory approaches, and the multi-level governance collaboration that will trigger innovation and change towards climate neutrality.

Participating cities will be encouraged to design and implement a multi-sector governance model where local stakeholders such as business, universities and the civil society are part of the Climate City Contract and contribute to its design and implementation in and for the city (Table 8). Similarly, regional or national stakeholders that can ensure the success of the Contract (e.g., regional transport companies, national energy producers, national research institutions etc.) should be encouraged to join by the relevant regional or national signatory.

Table 8. Interface of Climate-Neutral Cities with two DUT pillars.

PED	15-Minute City
CNC contributions to PED:	CNC contribution to 15-Minute City:
- Connection with local/regional dimensions	- Identify the policy and implementation gaps
- Impact not only on areas physically connected	- Coordinate stakeholders and empower citizens
- Multi-sector governance model	

Thanks to the Innovation Mission Green Deal, the current system for funding and financing climate innovation and investment at city level—now too fragmented—will be innovated; the commitment by the European Commission to a Sustainable Europe Investment Plan offers a new ambitious framework with a strengthened role for the European Investment Bank (EIB). Furthermore, the new EU Multiannual Financial Framework (MFF), reinforced by the recovery plan, will be an enabler and accelerator of the needed shift, combining financing from different European, national, and local resources and the whole value chain from Research and Innovation to planning, investment, and implementation.

When ready for investment, cities will be able to apply for a variety of instruments/funds/facilities, mainly involving EIB funds. In fact, the estimated urban lending by EIB for 2012–2018 is EUR 152 billion, out of which nearly EUR 26 billion were invested in climate mitigation actions which include Natural Capital Financing Facility and Municipal Loans. Other instruments, i.e., Connecting Europe Facility, can provide guarantees and bonds, whereas the European Energy Efficiency Fund (a PPP with international banks) can provide cities with market-based junior debt, guarantees, equity, mezzanine instruments, leasing structures, and forfeiting loans.

3. Discussion and Conclusions

A strong global European leadership in renewable energy technologies coupled with circularity, resilience, and sustainability will pave the way to increase energy security and reliability in times of crisis, as can be seen today during the COVID-19 crisis, and beyond [13]. It will also lead to achieving the objectives of the European Green Deal as well as to sustain economic recovery and growth in the long term while ensuring a sustainable future for European citizens. Both the EU long-term climate strategy and the European Green Deal highlight the importance of renewable energies for a future clean European Energy System with achievement of the zero-emission target. Although a broad range of technologies for climate neutrality are already expected, European Commission programming for Research and Innovation should also leave space for those emerging and break-through technologies with a high potential to achieve climate neutrality. These

technologies will have a significant role in reaching the EU's goal to become climate-neutral by 2050.

Nevertheless, the challenge is not just technical—it calls for wide-ranging societal transformations and the adaptation of lifestyles and behaviors, even more so after the experienced COVID-19 pandemic, also to cope with the expected economic emergency during the next few years [14].

The COVID-19 crisis has highlighted the significance of homes and buildings for our lives as well as their congenital fragilities. In the pandemic period, the home has been the core of daily life for Europeans, an office for those teleworking, a nursery or classroom for children, and a hub for online shopping or downloading entertainment. During the pandemic, buildings with a proper destination were empty as schools had to start experimenting with distance learning, private business companies had to rearrange to social distance, and public offices had one side implementing smart working and the other side managing social distancing to provide public service. Last but not least, hospital infrastructures have been under hard pressure. Some effects of the pandemic will continue in the longer term, stimulating growth for new demands on existing buildings and their energy and resource profiles, adding the need to deeply renovate European building stocks.

Emphasis must be given to place-based approaches and experimentation capitalizing on citizens' engagement, social innovation, and user-led and citizen science for shared ownership of solutions that are tailored to local specificities and thus ensure that envisaged transition pathways are human-centered and just. Important gaps in knowledge, evidence, innovation, technology, data, capacity, and skills, lack of integrated approaches, and deficit in applying research and innovation results to actions exist and prevent successful implementation of such transitions. Furthermore, institutional fragmentation and non-inclusive and non-participatory governance structures lead to a lack of shared vision, goals, and direction regarding the transition process, incoherence in policies and strategies, uncoordinated planning and decision-making, ineffective measures, and inefficient use of resources.

Climate neutrality and good environmental conditions, accessibility to qualitative urban open space, and a more inclusive urban economy appear even more necessary in a post-COVID-19 scenario [15]. Recent research has highlighted that “the specificity of an increase in the number of cases of contagion that affected some areas of Northern Italy in particular could be linked to the conditions of pollution by atmospheric particulate matter which carried out a carrier and boost action” [16].

The COVID-19 crisis drove attention to the importance of improving cities' resilience attitude; the pandemic highlighted not only the connection between air quality and well-being to health crises but also between food/medicine freight transport and survival, between health services and citizens, and between employment and living in cities; the COVID-19 crisis also emphasized the importance of buildings and the urban shell which support our lives and defend our fragilities.

What emerged after the past nine months and is new to come is that it seems that citizens, while continuing to assess as very important the actions necessary to protect the environment, ask more for an economic and employment recovery, which appears to be vital for everyone.

It seems equally necessary to clearly focus on sustainability in the urban dimension as a factor of economic growth, as the need to renovate cities and their dynamics can offer a unique opportunity to redesign our cities and their social services, urban planning, public transport, health services, and urban food logistics, integrating sustainability strategies from the early beginning.

Our reaction to the COVID-19 crisis, which somehow brings our mind back to the 2008–2009 recession, can now benefit from ten years of technological development, which could facilitate a joint goal of economic recovery and environmental and health protection, responding to the now impellent choice for sustainability.

The choice for sustainable development, only a few months ago, was seen by scientists, politicians, the world of finance, and business leaders as the only possible one. Now, due to the COVID-19 crisis, the transition towards a sustainable and more affordable urban model is not a possibility but a compulsory target, as the EU already included resilience as a priority in all urban long-term strategies.

The Horizon Europe Framework Programme—thanks to Destination 2 Cross-sectoral solutions for the climate transition, Communities and Cities; Positive Energy Districts paradigm; DUT Partnership, and Innovation Mission 100 Climate-Neutral Cities—will boost the transition towards a climate-neutral energy system in cities promoting the quadruple-helix innovation eco-system for urban transitions [16,17]. This goal appears, in principle, to be possible thanks to the innovative system for funding climate innovation and investment at the city level.

Now that technologies and innovative solutions for sustainable energy, transport, food, water, and material systems already exist, thanks to Research and Innovation programs developed over the last decade, what is left to tackle the climate-neutrality challenge is to have relevant stakeholders from academia, industry, cities, and communities to actively participate in the open innovation process transcending disciplinary, administrative, hierarchical borders and, mostly, municipalities able to address these “wicked dilemmas” [18].

Among the key concepts highlighted in the previous sections such as the re-organization of our daily activities and mobility supply/service patterns (15-minute cities), the resilience and security of energy supply (PEDs), and, last but not least, climate neutrality (Climate-Neutral Cities) will certainly be at the core of the forthcoming Horizon Europe Programme, as well as among the top priorities for cities and communities alike.

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Appendix A. Framework Programs 5, 6, and 7

The Fifth Framework Programme (FP5) focused on a problem-solving approach thanks to “key actions”, among which was one on “The City of Tomorrow and Cultural Heritage” as a first integrated and systemic R&I approach to urban challenges. The City of Tomorrow and Cultural Heritage Key Action aimed to improve urban sustainability through delivering benefits to citizens by concentrating resources on specific areas of city planning and management, cultural heritage, built environment, and urban transport. The Key Action was specifically designed to ensure rapid, EU-wide take-up of practical new approaches to urban governance, planning, and management. Total FP5 EC Contribution to Urban Research projects 1998–2002: circa EUR 479.0 million.

The Sixth Framework Programme (FP6) introduced funding for smart cities and supported the European Research Area and the ERA-NETs with EU top-up funding to joint calls and other coordination activities among national programs. The Joint Programming Initiative Urban Europe (JPI UE) is the output of such an ERA-NET on urban issues. Total FP6 EC Contribution to Urban Research projects 2002–2006: circa EUR 400.3 million.

The Seventh Framework Programme (FP7) deepened comprehension on urban challenges and has been fundamental for the development of technology as well as the de-

velopment of strategies for sustainable urban development in different areas, notably energy efficiency and climate action. Total FP7 EC Contribution to Urban Research projects 2007–2013: circa EUR 1.9 billion.

Appendix B. COST Action CA19126 “Positive Energy Districts European Network—PED-EU-NET”

In the last decade, building in Europe has significantly supported the level of innovation as seen in the development of Nearly Zero-Energy Buildings (NZEBS). It is now time to step up efforts towards city-wide transformation with the pioneering concept of Positive Energy Districts (PEDs), which builds on the paradigm of smart cities.

A Positive Energy District has been defined 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” [9].

This represents a major challenge that crosses sectors and domains whose solutions would only be found through collective innovation. “Innovation” implies opening up the relevant processes to all active players so that knowledge can flow across the entire economic and social environment [19]. The deployment of 100 Positive Energy Districts and Neighborhoods and 100 Climate-Neutral Cities requires innovation in multiple domains, encompassing interconnected technological, social, cultural, political, spatial, economic, and regulatory aspects. Each domain has its own set of embedded challenges that need to be addressed in order to foster the innovation process. In terms of technological challenges, innovative concepts, products, and services are needed to produce optimal PED/Climate-Neutral City solutions customized to local circumstances. Moreover, companies in the building, energy, mobility, and ICT sectors need to develop new business models for the emerging PED/Climate-Neutral Cities market. They need to draw on flows of knowledge outside their boundaries to boost the internal innovative processes [20]. In the social aspect, the processes of societal innovation, social entrepreneurship, and citizen participation must be integrated synergistically in the transformation [21]. In the financial aspect, robust investments and creative funding models are needed to support innovative energy solutions and establish new energy markets. With respect to legal aspects, regulatory sandboxes are needed to test novel solutions on PED/Climate-Neutral Cities. Requirements for the certification and standardization of PED/Climate-Neutral Cities need to be defined to ensure quality and facilitate replication.

The concept of PEDs is evolving and it still needs to be refined, advanced, demonstrated, implemented, and replicated [22]. Europe is poised to enable transitions towards a climate-neutral economy and the concept of PEDs will be incrementally introduced in the energy planning of many cities and communities in the coming years [23]. According to the SET Plan Action 3.2, 100 PEDs are expected, as said, “to be in concrete planning, construction or operation, synergistically connected to the energy system in Europe by 2025” [24].

Within this framework, the main aims and objectives of the COST Action CA19126 “PED-EU-NET” have been set to “drive the deployment of PEDs in Europe by harmonizing, sharing and disseminating knowledge and breakthroughs on PEDs across different stakeholders (academia, industry, cities and communities), domains (technological, social, economic, financial, legal and regulatory) and sectors (buildings, energy, mobility and ICT) at the national and European level. [The PED-EU-Network aims at supporting] cities and empower communities to achieve city-wide positive energy transformation with pioneering ideas, methods and solutions. It will mobilize the relevant actors from and across Europe to collectively contribute to the long-term climate neutral goal” [25].

This COST Action is structured into four interlinked Working Groups: three are scientific Working Groups focusing on a variety of topics related to PEDs (WG 1, 2, and 3) and a dissemination Working Group (WG 4) that oversees the communication, education, outreach, and exploitation of this Action's outcomes.

The COST Action CA19126 PED-EU-NET builds on a holistic approach, bringing together stakeholders from different backgrounds. This initiative represents a strong commitment to pooling resources, experimenting with new methods, co-creating original solutions, and advancing science and building solutions so as to enable neighborhoods and cities to integrate different functions and guiding principles and find the balance that represents the best renewable energy resources usable in their respective climate zones, according to their communities' specific ambitions and needs [26].

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