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Technological Imagination in the Green and Digital Transition

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Foreword by Antonella Polimeni

Good afternoon to all participants, ladies and gentlemen, and welcome to Rome.

On behalf of the Community of Sapienza University of Rome, it is a real pleasure to welcome all of you to the first edition of the International Conference "Technological imagination in the green and digital transition". I am also pleased to give my best welcome to Dr Antonio Parenti, Head of the European Commission Representation in Italy, and to Prof. Mario Losasso, President of the Italian Society of Architectural Technology, as well as to all guests, students and colleagues.

The conference that we are about to open, organised by the Department of Architecture and Design and directed by Prof. Alessandra Capuano in cooperation with Sapienza Foundation, is to be a moment of methodological debate about built environments and the rise of contemporary urban challenges, so engaging for public and private institutions at national and international level.

The proposed key points of this conference—namely Innovation, Technology, Environment, Climate Changes and Health—are all interconnected priorities that cannot be further postponed, representing in the meantime strategic research and education activities for our University, perfectly aligned with the Italian National Recovery and Resilience plan, to be implemented in Italy as well as European member States, in order to overcome the present financial and social challenges.

I truly believe that Universities are, by definition, places of imagination, where planning the future is intended as an unavoidable "existential condition" as well as an essential moment of collective participation for an accomplished society.

Thank you for your attention, and I wish you a fruitful continuation of the conference.

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Foreword by Eugenio Gaudio

My warmest greetings to Dr. Antonio Parenti, Head of the European Commission Representation in Italy, to the President of the Italian Society of Architectural Technology Mario Losasso, to the Director Alessandra Capuano, and to Pietro Montani who will open with a Philosophical Lecture the Conference "Technological imagination in the green and digital transition".

A special greeting to Prof. Anna Maria Giovenale, my dear colleague and friend, who invited me to be here today. Thank you Anna Maria.

Let me also greet all other speakers as well other participant that will follow this Conference organized by the Department of Architecture and Design, together with the Fondazione Roma Sapienza.

From the very beginning, as President of the Fondazione Roma Sapienza, I supported the initiative of an international Conference on the theme of "Technological Imagination" having clear in mind that human imagination is inseparable from the "technical practice" with which it is entangled from the earliest origins of mankind, as Pietro Montani states in his book, *Technological destinies of the imagination.*

When the contents of the Conference were increasingly defined and focused around the areas of the green and digital transition, I realized that the very core of the Conference was becoming an attempt to respond to the contemporary challenges of the National Recovery and Resilience Plan, in their key role of revitalization for Research and University.

In this sense, the potential of technological culture is reaffirming its role of strategic tool for the conceiving, design and validation of future scenarios.

The sessions into which the Conference is structured, namely: Innovation, Technology, Environment, Climate Changes and Health, identified in order to outline the evolutionary scenarios of architectures and cities, allowing us to reflect at different levels on innovative models of building and management process, as well as design and products.

The goals of promoting digital transformation, supporting innovation in the production system, improving sustainability and ensuring an equitable environmental transition, find their clarification in the elaborations and experimentation presented through the contributions in the different sessions.

Modern technological innovation allowing multiple possibilities in all areas: nowadays digital technologies are enabling us to interact with people and things, all over the world.

There are astonishing, yet untapped potentials, suggesting that digitization, rather than a strict sense adaptive development, should be seen as an important evolutionary phenomenon and in the meantime a great opportunity.

Innovations connected with new technologies can provide to civil society a better quality of life, both at indoor and urban scale settings, addressing scientific development toward an effective culture of sustainability, reuse and security.

The employment of new technologies, a careful approach to the containment of land consumption as well as a careful consideration towards soil coverage modality and urban density, the recycling strategies and technological and typological redevelopment of degraded areas and buildings applying an energetic and eco-systemic approach, are the key elements for the conception of healthy and resilient urban habitats, able to adapt to the present global changes, as well as promoting prosperity, inclusiveness and social equity.

Last but not least, "health" issues, that need to be conceived at the very core of the potential determined by 'technological innovation and processes of ecological and digital transition.

The structure of the Conference is rooted on all these interrelated themes, and on that same basis also research needs to be reoriented.

I am confident that this first edition of the Technological imagination conference will contribute to pave the way of an innovative and interdisciplinary scientific approach to technology and policies for built environments, considered the real human challenge of the twenty-first century.

Thank you so much for your attention and enjoy the Conference.

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Foreword by Antonio Parenti

New European Bauhaus

Good morning,

Magnificent Rector of Sapienza University of Rome Professor Antonella Polimeni
President Fondazione Roma Sapienza Professor Eugenio Gaudio,
Director Department of Architecture and Design Professor Alessandra Capuano
and others.
Ladies and Gentlemen,

It is my pleasure to address you today and to open this International Conference "Technological Imagination in the digital and green transition" organized by Sapienza University of Rome.

Let me say that the title, the contents, and the proposals envisaged by the Conference match perfectly with the main pillars of the flagship initiative shaped by the President Ursula von der Leyen and launched in September 2021: the New European Bauhaus.

The New European Bauhaus is by nature transdisciplinary: it invites architects, designers, artists, scientists, engineers, artisans and citizens to share their expertise in preparing for the future.

With the New European Bauhaus, we want to make the European Green Deal tangible and "palpable".

We want to add a cultural dimension to the economic and technological transformation. This is essential to achieve our overarching goal: making Europe the first climate neutral continent by 2050. And thus reconciling our way of life with nature.

To get there, we need both: a real transformation of our economy and society, and a debate about how we can live in respect of nature and our planet.

The historical Bauhaus was founded in Weimar and Dessau. It turned into a worldwide movement. This did not happen by chance. Some ingredients of what made the historical Bauhaus a success can also be an inspiration for the New European Bauhaus.

Let me mention three.

The first ingredient: The historical Bauhaus was created in a time of **profound transformation**. People were facing the challenges of industrialisation. Gropius and the founders wanted to respond to the emerging needs of a new era. They aimed for solutions that were functional, affordable, but also beautiful. With this principle in mind, they shaped buildings, fabrics and furniture. They always aimed higher than just innovative design. The New European Bauhaus is also striving for this mix of aesthetics and affordability. But we want to add another element: sustainability. Because the New European Bauhaus wants to match sustainability with style.

Now, the second ingredient: **The historical Bauhaus boldly promoted new materials like steel and cement**. Today, we also need to look into new building materials. But this time, it is about sustainability. It is about materials that need less CO_2 in their production process. The New European Bauhaus wants to accelerate the transition of the built environment. It wants to scale up nature-based materials, to support circular design and architecture. Buildings are responsible for 40% of our energy consumption. And if we manage to change this, we have a chance to keep global warming below 1.5 degrees.

The third important element from the historical Bauhaus is **interdisciplinarity**. We want to convene people from different backgrounds and with different competences to share and grow their ideas and visions. We can create a better tomorrow, if culture and technology, innovation and design go hand in hand.

For our New European Bauhaus, the European Commission needs scientists, activists, artists, designers, architects and entrepreneurs. We want to include the ideas and perspectives of all ages and all backgrounds.

Today, at this conference we can contribute to this evolving New European Bauhaus network.

This project is a project of hope. It is a project of change and of economic transformation.

So I hope that this conference can contribute further to making the transformation happen and to connecting more and more people who want to make it happen.

Thank you very much and have a great conference.

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Foreword by Mario Losasso

Presentation of CONF.ITECH 2022

The green and digital transition represent in the contemporary research field the two new challenges for the evolution of technology within the themes of sociotechnical innovation. Consequently, technology and innovation in contemporary world must adapt to this general objective. Innovation in its hard and digital components once again becomes a central factor in the experimental propulsion that the project is assuming within a processuality and technologies that enable its conception and implementation.

Today, research is increasingly characterised by the need to focus on specialisms that lead to and contribute to the advancement of knowledge and the predictive value of what is studied in the disciplinary fields. However, with respect to the evolving complexity of phenomena, research requires continuous disciplinary interactions to be developed because we understand that one disciplinary field cannot alone address the most important challenges of contemporary society.

New forms of coexistence must be organized in a vision of interdependence and connection, while the green transition requires the definition of the limits of design action and the characteristics of the transformation processes. The new perspective of co-evolution will have to express a design attitude that allows to repair and, where necessary, rebuild the lost links between man, technology and nature.

The green and digital transition represent the two new challenges for the evolution of technology within the themes of social innovation. The Italian society of architectural technology SITdA has been working for a long time on the topics of the relationship between technology and urban and building development within a process-oriented and eco-systemic approach. In the field of technological design of architecture, the scientific society of the technology of architecture has activated research and training sensitivities on the themes of design experimentation framed within process and ecosystem dynamics, aimed at optimising the efficiency of products and processes by reducing inefficiencies and waste.

The SITdA supports research and spin-off outcome on territories through the activities of its scientific clusters. The Scientific Society SITdA has granted its patronage to the CONF.ITECH 2022 Conference, sharing its importance and topicality in view of the new challenges identified in the urban construction and environmental fields by the Next Generation EU Programme and the implementation programmes in the various nations of the European Union.

The topics that will be addressed during the three-day conference are fascinating and challenging, linking innovation, technology, environment, climate change and health.

These topics are strongly interrelated themes in which we are realising that it is impossible to deal with them separately, arriving in the most recent reflections at considering a single health for human beings and for the entire environment which is their living environment.

I would like to remind that the topic of digital culture, nature and technology was the central topic of the SITdA Naples 2020 Conference held last July with a delay due to pandemic difficulties, while the 2022 Conference of the Scientific Society is focused on the topic of the centrality of processes. As we can see, the work carried out in the Departments of Architecture and by the Scientific Societies in the area of architecture is an activity that has picked up significantly, foreshadowing new approaches, new fields of enquiry and new paradigms necessary for the new complexities that constitute the reference scenario of the future.

The experience of this Conference can provide a significant contribution to the sustainable and environmental evolution of the design area in its trans-scalar, multidisciplinary and challenging dimension, overcoming technocratic responses to a demand that requires the integration of the humanistic and technical-scientific dimensions.

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Foreword by Orazio Carpenzano

Welcoming Address from the Dean

On behalf of the Faculty, I wish to thank the organisers for asking me to give this opening address, while congratulating them on their efforts to bring together, in an international encounter, various perspectives on topics of such decisive importance for the future of our respective territories, as well as their people, living organisms and architecture.

My thanks go to Anna Maria Giovenale, Fabrizio Cumo, Eugenio Arbizzani, Carola Clemente, Eliana Cangelli and Francesca Giofrè, who will be giving talks on technological innovation, the environment, climate change and public health.

Thinking of energy in terms of how it relates to architecture during the green and digital transition means cultivating a *technological imagination*, a topic which leads to the broader question of the man–nature relationship and the possibility that architecture, by applying innovative ideas and concepts while promoting a growing social and emotional intelligence of its own, can contribute to inventing of new types of habitat for mankind on the planet earth, under a new pact for survival that allows all elements, both artificial and natural, to coexist in a sustainable balance which can serve as a preventive measure against the intrinsic destructive force of the Cosmos, an especially pressing problem where mankind has neglected certain methods for dissipating the energy of calamitous events made available by both ancient wisdom and scientific advances.

The 2021 Architecture Biennial, entitled "How Will We Live Together?", implicitly drew the attention of visitors to the need for a new approach to the man–nature relationship, following a thorough review of its historical and ethical premises. Hashim Sarkis, the curator of the exposition's seventeenth edition, passed on the following message: "In a scenario of exasperated political divisions and growing economic inequality, we call upon architects to imagine spaces in which we can all live in fruitful fellowship".

The man–nature relationship has always been a distinctive feature of humanistic and artistic thought on things technical, expressed in the construction of the *civitas*, the physical and political synthesis of civilisation. Medieval mysticism viewed nature as a foreboding wilderness, while the Renaissance redeemed the sense of *technè*, and the Romantic Period, with its high-strung, emotive outlook, led to the elaboration of the concept of the sublime.

Controlling and putting to use the energy generated by nature through sources of heat and movement (wind, sun, water), first through manual effort and then using the tools and machines produced by human ingenuity, was also a topic and challenge that led architecture to express, during the Modern Movement, boundless enthusiasm for the theories of Taylorism, which Corbusier summed up by interpreting human dwellings as machines of habitation.

But it is from the time of Vitruvius that architecture, engaged more or less explicitly with the triad of *utilitas-firmitas-venustas*, has addressed the problem of dissipating heat (or thermal inertia), as well as kinetic and elastic energy (in the case of earthquakes), at various latitudes of the globe, drawing on the available resources and raw materials. Historic Italian buildings, for example, built with walls roughly a metre thick and a structural layout measuring 4×4 or 5×5 m, have offered excellent thermo-hygrometric performance (in terms of energy consumption), as well as structural dependability (against seismic risk). In both cases the objective is to "mitigate", a term used by many modern-day scholars, the dissipation of different types of energy.

The history of architecture is filled with archetypes that need to be updated and reinvented. Think of the ingenuity it took to build Venice atop a giant underwater forest, or the aesthetic quality of the Tu'rat walls constructed by Southern Italian peasants, the windmills of Northern Europe and countless other magnificent examples of *swarm intelligence* collected by Bernard Rudofsky in his well-known book *Architecture without Architects: a short introduction to non-pedigreed architecture*, published by Doubleday & Company Inc., Garden City, (in 1964), following an exhibition at New York's Museum of Modern Art. Though, in truth, Roberto Pane and Gino Capponi had already touched on the topic in articles on the architecture of Ischia published in "Architettura e Arti decorative" in 1927, as did Giuseppe Pagano at the Milan Triennial "Rural Italian Architecture", published in the Notebooks of the Milan Triennial by Hoepli in 1936.

Looking beyond the confines of architecture, a recent reconsideration of the topic of Cinema and Energy can provide potentially useful points of affinity with architecture, especially in the collection of essays found in issues 7 and 8 of the periodical Imago, under the title *Cinema & Energy. Interdisciplinary Outlooks Combining Science, Aesthetics and Technology*, edited by Marco Maria Gazzano and Enrico Carocci (and published by Bulzoni in 2013). In an essay entitled *Dissipation and Aesthetic Experience*, the physicist Giuseppe Vitiello, in commenting on the film Transeurope Hotel by Luigi Cinque, writes: "The brain [which leads me to think of *swarm intelligence*] is described as an open system engaged in continuous exchanges

with its surrounding environment. In both models and films, antinomies such as information/knowledge, feeling/knowing, blend with each other in the aesthetic experience, the favourable connection between 'me and the object' that characterises our existential dimension."

Dissipation, therefore, should be seen as part of the evolution of our ecosystem, of our contemporary habitat. It gauges the possibilities for losing and exchanging, through a rekindling of collective emotional intelligence and technical and intellectual micro-revolutions. It is a risk that we must continue to face, as otherwise architecture will die, depriving man of an indispensable tool for managing the complexity of the physical habitat through creativity, in order to transfigure energy in a way that, at times, can prove so unreal, and yet so effective and indispensable, that it leads to the construction of new values and sublime beauty.

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Chapter 44
Towards Climate Neutrality: Progressing Key Actions for Positive Energy Districts Implementation

Rosa Romano, Maria Beatrice Andreucci, and Emanuela Giancola

Abstract Positive Energy Districts (PEDs) represent an emerging urban transition paradigm, an advanced framework to effectively attain decarbonization targets, as well as a holistic approach to foster more resilient and livable cities. However, implementing PEDs is challenging, demanding substantial planning, design, and operations changes. Mainstreaming PEDs calls for innovative legal, institutional, business, and organizational frameworks, as well as an active involvement of the main actors (i.e., cities, municipalities, communities, investors, industry players, and service providers), to co-design and jointly progress ambitious agendas, multiscale plans, flexible instruments, and adaptive structures. Benefitting from the authors' cooperation within the Horizon 2020 project, Cooperation in Science and Technology COST Action 'Positive Energy Districts European Network' (PED-EU-NET in PED-EU-NET | COST ACTION CA19126, 2020), the proposed contribution addresses relevant issues and opportunities characterizing the development of PEDs in Europe, relating attention to effective implementation, context-specificity, replicability, and upscaling. Among the results achieved in the first year of the COST research activities, the authors present an understanding of the PEDs policy landscape in Europe, and a catalogue of the key lessons learned from PEDs in progress. In detail, some comprehensive and interrelated aspects (stakeholder-oriented strategies and technological and system innovation) that have emerged towards enabling conditions for upscaling PEDs structure are analyzed. Through the investigation of existing framework conditions, barriers, and enablers of piloting projects, as well as emerging impacts at international level, the authors provide original insights, and formulate key recommendations for take-up and advancement towards climate neutrality, making a timely and original input to enhanced scholarly understanding of PEDs.

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44.1 Introduction

This document The European Union's SET-Plan Action 3.2 introduced, in 2018, the acronym PEDs, to describe 'Energy-efficient and energy-flexible urban areas, or groups of connected buildings, which emit net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy.

They require integrating different systems and infrastructures, as well as 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' (EU Commission 2018). Accordingly, in the last years, ongoing initiatives such as the EU's Horizon 2020 'Smart Cities and Communities (SCC) Lighthouse Projects', the Joint Programming Initiative Urban Europe (JPI UE), and the European Energy Research Alliance–Joint Program Smart Cities (EERA–JP SC) have been active to increase the knowledge about the integration of innovative solutions for the planning, deployment, and replication of PEDs. PEDs are already a common objective of ongoing EU research projects (e.g., SPARCS, POCITYF, ATELIER, +CityxChange, Making City, etc.) that have joined the discussion on key issues, such as a commonly shared definition, or the role and relevance of different stakeholders towards implementation, as recently highlighted by the Horizon 2020 project Cooperation in Science and Technology COST Action PED-EU-NET (2020–2024).

In detail, PED-EU-NET aims to drive the deployment of PEDs by harmonizing, sharing, and disseminating knowledge and breakthroughs on this innovative urban and sustainable model across different stakeholders, domains, and sectors, at national and European levels. The Action has been structured in four interlinked thematic Working Groups (WGs) around the core PED vision that are focused on: (WG1) mapping existing concepts, strategies, projects, socio-technical innovations related to PEDs in Europe; (WG2) developing guides and tools to support the implementation of PEDs; (WG3) exploring the success factors of PED Labs, working up common protocols for monitoring and evaluation of PEDs and PED Labs across Europe; (WG4) ensuring the transfer of knowledge and the translation of experience beyond the network. The goal is to establish a PED innovation ecosystem to facilitate open access of knowledge, exchange of ideas, pool resources, experimentation of new methods, and co-creation of novel solutions across Europe. Additionally, this COST Action wants to support the capacity building of new generations of PED professionals, early-career investigators, and experienced practitioners, mobilizing relevant actors from and across Europe to collectively contribute to the long-term climate-neutral target (PED-EU-NET 2020).

Starting from the results achieved in the first year of this scientific cooperation—and in particular during the 1st PED-EU-NET Urban Stakeholder Workshop held

in Rome in October 2021—the paper presents some comprehensive and interrelated aspects of enabling conditions for mainstreaming and upscaling PEDs, focusing on stakeholder-oriented strategies, and technological innovations to ensure energy production, efficiency, and flexibility at the district scale. The objective is twofold, i.e., to explore existing framework conditions, barriers, and emerging impacts at international level, and provide key recommendations for uptake and advancement towards climate neutrality, making a timely and original contribution to enhanced scholarly understanding of PEDs.

44.2 Stakeholder-Oriented Strategies and Innovative Governance Model for PEDs

Among the key aspects suitable to describe the characteristics of a PED project, the implementation phase ('PED phase') is considered particularly relevant, as challenges and barriers for PED related projects vary from the planning stage to the implementation stage. For this reason, a 'PED phase' can be defined according to the ambition and the development stage it is experiencing (i.e., 'planning', 'implementation', 'implemented/in operation') (Zhang et al. 2021). This categorization refers to projects where the construction of the energy systems has been completed (e.g., in Drammen and Stor-Elvdal Municipality, in Norway, already in operation), or not yet commissioned (e.g., in Turku, in Finland, and Bergen in Norway, currently under planning), or integrated into existing energy networks (e.g., in Lund in Sweden, and Odense in Denmark, currently under implementation). Accordingly, previous studies have highlighted some conditions that seem to facilitate inter-organizational collaboration and presented them as critical factors to ensure the PED process a lasting commitment to collaboration and coordination between interested parties and other actors. The initiators must facilitate engagement throughout the process and be enabled by profitable and innovative business models, well-conceived governance structures, and information and communication technologies (Civiero et al. 2021).

The PED project is, in fact, a complex process that requires a high degree of coordination, considering that some actors tend to shift their positions, or rethink their involvement, when moving from one phase to another (Hamdan et al. 2021). From a governance perspective, PEDs offer an appropriate arena for collaboration between different sectors (residential, manufacturing, commercial, public, etc.) and users (owners and tenants, intervening as individuals or as members of communities) to enable a holistic and inter-sectoral approach to energy planning as a key integrative part of sustainable urban development (Bhowmik 2020). For this reason, one of the crucial challenges and barriers to implementing a PED project also depends on the engagement of the different stakeholders in its planning and implementation, and not only in the adaptation of the technical solutions (Bossi et al. 2020).

In that direction, the experiences, and cases studies on 'PED Gaps' presented during the recent 1st PED-EU-NET Urban Stakeholder Workshop confirmed how the implementation phase of PEDs can be envisioned as a direct function of active collaboration between cities, private actors, and citizens. Those findings suggest a potential for strengthening the levels of cooperation and mutual trust between all stakeholders, and especially the energy and buildings sectors. Shifting the focus of private stakeholders from pure profit to mutual benefits appear crucial to strengthen this inter-sectoral cooperation, even if this requires significant changes in current practice and business models, as well as the introduction of new technologies, especially the ones that would allow energy storage for a flexible energy supply and use. In addition, the PED-EU-NET Urban Stakeholder Workshop results also suggest that the technologies that target flexible energy demand in buildings are considered very important features by the stakeholders. The high costs of technologies and the weak financial incentives in today's context were identified as the strongest barriers to the adoption of PEDs. Consequently, the introduction of new business models that reduce costs and mitigate investment risks is considered vital to support PEDs deployment.

The removal of the existing legal and regulatory barriers, which were identified to particularly impact the development of PEDs in Italy, was, also considered crucial to create stronger incentives for mainstreaming districts and neighborhoods able to produce and use energy in a more flexible and 'smarter' way, thus paving the way to a wide-scale adoption of PEDs in cities (Fig. 44.1).

Considering the large variety of stakeholders who are meant to participate in this process (end-users; public authorities; financial institutions, and property developers, etc.), it is also imperative to identify both the desired configuration of the energy systems, and the different roles the actors are willing to take (Ahlers et al. 2019).

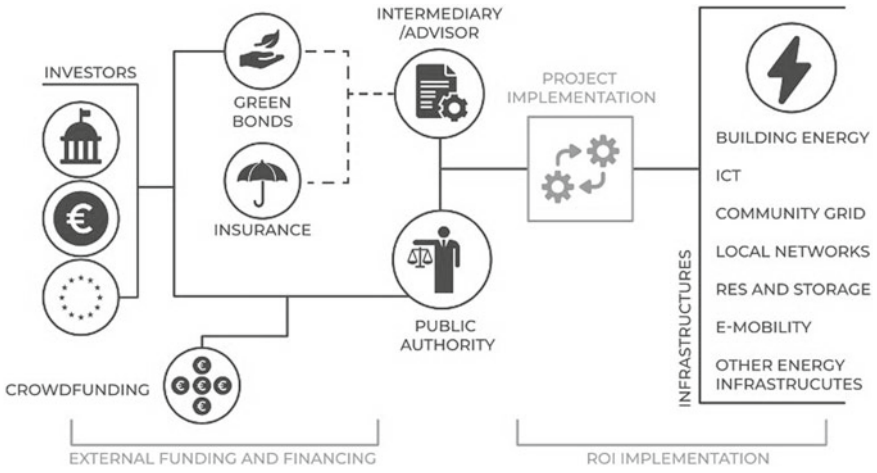

Fig. 44.1 Power distribution of channel at 1555 nm along the link of 383 km (Ahlers et al. 2020)

The different roles of the various stakeholders in all phases of PEDs implementation may be attributed to factors such as the challenges of building refurbishment, the integration of new energy systems, and the surrounding regionals and urban energy infrastructures. However, with the development of PED projects, the stakeholder constellation has been changing according to the different interests, with a consequent transfer of the responsibilities. This point is critical since users need to become more involved in the management of neighborhood systems and may also be exposed to technical challenges. All this requires a major global planning exercise from a technical and spatial planning point of view, a well-conceived governance structure, as well as solid stakeholder engagement strategies (Cheng et al. 2022).

In that direction, the project Sustainable energy Positive and zero cARbon CommunitieS (SPARCS) demonstrates and validates technically and socioeconomically viable and replicable, innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen-centered zero carbon and resource efficient economy. Among the examples currently in progress, SPARCS is developing and piloting new models for co-creation, energy communities and stakeholder engagement to bring residents in the new Kera district in Espoo (Finland), to the center of the energy ecosystem, maximizing local production and encouraging prosumer models to enhance the utilization of distributed power generation (Hukkalainen et al. 2020).

Another interesting example is the project +CityxChange (Fig. 44.2) that is finalized towards the co-created Europe-wide deployment of PEDs through integrated planning and design, creation of a common energy market, and community exchange with all urban stakeholders. In detail, this experimental approach establishes mechanisms that need to be followed up to better understand local needs and develop tailored actions to engage citizens and stakeholders in an open innovation process finalized to optimize the energy consumption of the urban district (Ahlers et al. 2019).

44.3 Technological Innovation to Ensure PEDs Energy Self-sufficiency

PEDs can generally be defined as parts of a city that generate more energy than they consume annually and that promote higher self-consumption and self-sufficiency (Hedman et al. 2021).

This increased dependence on intermittent RES intensifies the need for flexible options to ensure reliable power system operations via integrated solutions consisting of energy storage, smart urban energy networks, ICT, and e-mobility (European Commission 2018). Consequently, it is necessary to optimize the building integration within the district, local, and distant renewable and low carbon energy sources into a resilient energy system, moving beyond nZEBs. Therefore, in the framework of PEDs, the building systems should be specifically designed and should present tailored load profiles (e.g., the long-term load forecast cannot be based on its

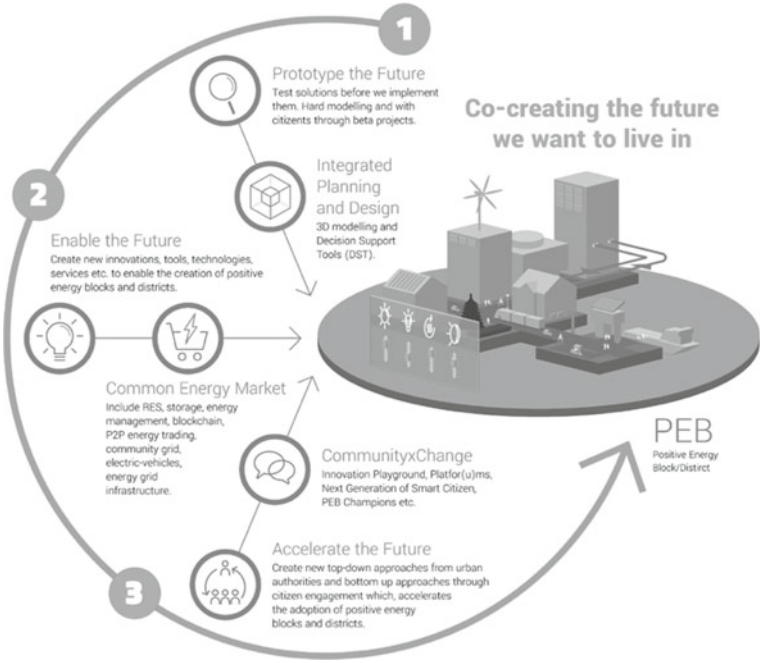

Fig. 44.2 +CityxChange integrative approach and framework for the development of positive energy blocks (Ahlers et al. 2020)

historic pattern anymore) that will enable a high penetration of carbon-free renewable sources such as wind and photovoltaics (PV) for the electricity demand as well as heat pumps, thermal waste, geothermal, solar thermal, etc. for heating and cooling. Additionally, district-scale buildings, should use 'energy cooperation' or 'energy pooling' to empower communities to own the locally produced renewable energy. Consequently, a building designed to be a functional unit of a PED must be built, or refurbished, according to the possibility of integrating a series of technical solutions, such as batteries, electric vehicles (EV), and grid-responsive control systems (Zhou et al. 2021). Equally, smart grids and digital tools for demand-side management such as smart meters, smart chargers, and Building Automation and Control Systems (BACSs) can facilitate flexibility in the PED energy system, which can help align energy demand with supply (Lyons 2019).

According to this innovative and sustainable urbanization concept (Fig. 44.3), the construction and renovation process should also be increasingly accompanied by digital solutions, such as building information modeling (BIM), 3D printing, digital twins, Internet of Things, or augmented reality. These innovative digital technologies help save costs and time and require suitable novel skills and the latest available software to be most effective.

Moreover, digitalization enables the uptake of smart energy services for building users of a PED, allowing the development of demand-side management strategies

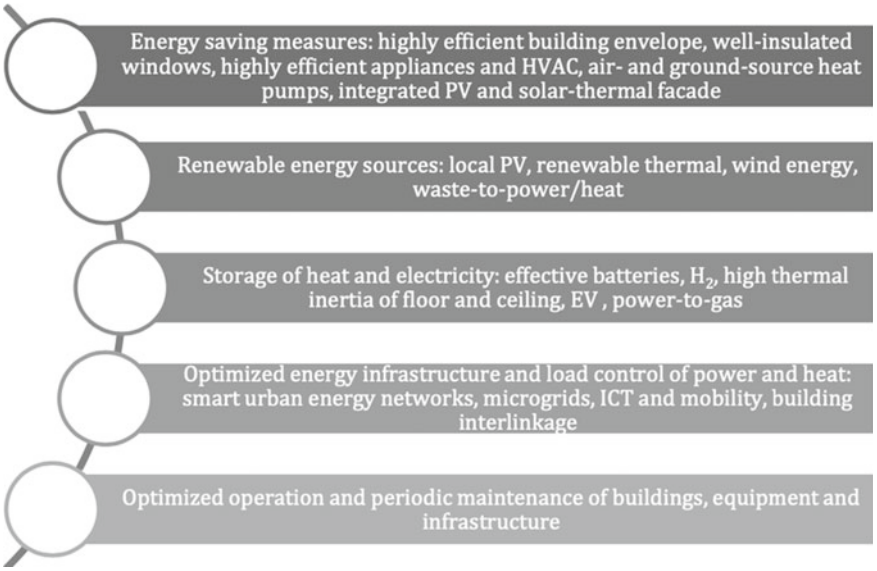

Fig. 44.3 Key research fields of technological innovations needed for deploying PED (EU Commission 2018)

to integrate flexible and decentralized renewable energy systems into its energy structure (Fig. 44.4).

Some interesting case studies of innovative technologies and system integration have been developed in numerous European Projects such as ZenN, Syn.ikia, Sharing Cities, MAtchUP. In all these examples the energy demand in the district cluster is low

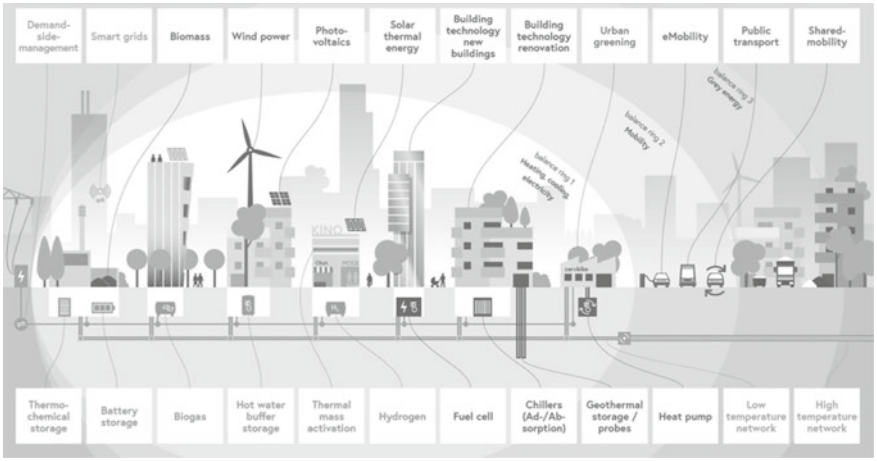

Fig. 44.4 Positive energy district model (BMVIT 2022)

and partly met by renewable energy self-produced within the neighborhood. Another measure applied to achieve the target PED is an enhanced envelope/insulation, followed by real-time measuring of consumption and heating controls reduction of the DHW supply temperature with heat recovery. Furthermore, energy management systems (Neighborhood/Building) and boiler upgrades are widely utilized. Regarding the RES, the technologies most utilized are Heat Pumps and PV. Finally, concerning the Energy storage solutions, EV, Vehicle to Grid (V2G), and Vehicle to Building (V2B) concepts, including smart charging stations implementation, are the major solution employed, followed by batteries and thermal storage (Castellanos and Oregi 2021).

44.4 Conclusion

Increasing evidence from science, governance, and practice show that climate change adaptation and mitigation and the decarbonization of our environment are of greatest urgency and should be targeted at the macro, urban, and district levels. Cities are consequently required to take an active role in adopting sustainable energy production and use for people and the environment (Saheb et al. 2018). It is now stepping up efforts towards city-wide transformation with the pioneering concept of PEDs, which builds on the paradigm of smart cities, supporting municipalities that make energy savings and provide it with a good and sustainable metabolism (Ruhlandt 2018). For achieving this relevant goal PEDs design should equally be considered powerful opportunities for users and stakeholders to promote equity and inclusion, favoring vulnerable communities where far too many people still struggle facing energy poverty (Jessel et al. 2019). At the same time, it will be necessary to develop innovative envelope and plant technologies capable of transforming existing urban districts into efficient and low-impact energy ecosystems.

Finally, the PED model requires a synergy between the management of social, economic, and technological aspects related to urban planning and building design.

Accordingly, among the next steps of the PED-EU-NET research, will be defining PED specific KPIs to develop effective integrated frameworks and guidelines for European Public Administrations, with the aim of implementing and realizing 100 PEDs in different European geographical and social contexts by 2025.

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