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NEW CHALLENGES FOR XXI CENTURY CITIES

Multilevel scientific approach to impacts of global warming on urban areas, energy transition, optimisation of land use and emergency scenario

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REVIEW NOTES – International Regulation and Legislation for the Energy Transition

Positive Energy Districts for urban energy transition: regulatory challenges and implementation strategies

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Abstract
Starting from the relationship between urban planning and mobility management, TeMA has gradually expanded the view of the covered topics, always remaining in the groove of rigorous scientific in-depth analysis. This section of the Journal, Review Notes, is the expression of continuously updating emerging topics concerning relationships between urban planning, mobility and environment, through a collection of short scientific papers written by young researchers. The Review Notes are made of four parts. Each section examines a specific aspect of the broader information storage within the main interests of TeMA Journal. This section, International Regulations and Legislation for the Energy Transition, explores the challenges and opportunities in the urban context to understand the evolving landscape of the global energy transition. This contribution analyzes the role of Positive Energy Districts (PEDs) in the urban energy transition, highlighting key regulatory barriers and the potential of Renewable Energy Communities (RECs) as an enabling tool. Through an examination of the European legislative framework, the text emphasizes the importance of integrated urban planning and proposes policy recommendations to facilitate the widespread implementation of PEDs in European cities.

Keywords
Energy transition; Urban Planning; Positive Energy Districts; Renewable Energy Communities.

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1. Introduction

The growing urgency of addressing climate change and promoting the energy transition imposes radical transformations on European cities, which are now the main critical nodes in terms of energy consumption and climate-changing emissions, concentrating about 70 percent of global CO_2 emissions and more than two-thirds of energy demand (Sassenou et al., 2023). In such a scenario, the concept of Positive Energy District (PED), or urban district that can produce more energy from renewable sources than it consumes annually, emerges as one of the most promising strategies for urban decarbonization (Sgambati, 2023). PEDs are not limited to mere energy efficiency at the building scale, but introduce a systemic and multilevel approach, integrating energy production, storage, management and exchange between buildings, networks and users through innovative organizational models and advanced spatial planning tools (Tuerk et al., 2021). The European Union has recognized the strategic role of PEDs in achieving climate neutrality, promoting their deployment through the Strategic Energy Technology (SET) Plan, which sets the goal of implementing at least 100 PEDs by 2025 as a pilot project for cities of the future (EC, 2018). The focus on PEDs was further consolidated with the adoption of the Clean Energy for All Europeans (CEP) legislative package, which introduced regulatory tools such as Renewable Energy Communities (RECs), making it possible to share energy produced within neighborhoods through the public grid, overcoming the limitations imposed on energy cooperation between buildings (Kozlowska, 2024). In this new regulatory context, PEDs take shape not only as technical aggregates but also as social entities capable of activating new local supply chains, generating shared value, and contributing to energy equity (Angiello, 2020). The integration between PEDs and energy communities is a crucial node for urban planning, which becomes the place where these innovations are designed, regulated and implemented. However, the effective localization of PEDs in urban settings depends on the ability to identify suitable areas according to multidimensional criteria-environmental, regulatory, socioeconomic, and morphological-and to implement coherent, flexible, and enabling land-use governance tools (Casamassima et al., 2022). In this context, urban planning assumes a central role in the design of PEDs, providing an integrated framework for spatial energy governance and fostering the emergence of sustainable, resilient and participatory urban development models. This paper aims to critically analyze the concept of PEDs, with particular reference to the role of spatial planning, the link with RECs, and the identification of the constraints, particularly regulatory ones, that limit their implementation in urban settings.

2. Definition of Positive Energy Districts

A Positive Energy District (PED) is defined as a defined urban area that, on an annual basis, generates more energy than it consumes, achieving a positive energy balance and aiming for net CO_2 emissions close to zero (Albert-Seifried et al., 2021). This concept emerges as an advanced operational tool of the urban energy transition and represents an evolution of previous energy configurations promoted by European directives, such as near-zero energy buildings (nZEBs). In this perspective, PED expands the energy approach from the individual building to the neighborhood, promoting systemic integration between distributed generation (e.g., photovoltaics, wind), storage, high-performance buildings, electric mobility, and smart grids (Chen et al., 2024). The European Union has recognized the strategic role of PEDs in achieving climate neutrality, promoting their deployment through the Strategic Energy Technology (SET) Plan, which sets a goal of implementing at least 100 PEDs by 2025 (EC, 2018). The focus on PEDs was further consolidated with the adoption of the Clean Energy for All Europeans (CEP) legislative package, which introduced regulatory tools such as RECs, making it possible to share energy produced within neighborhoods via the public grid, overcoming the limitations imposed on energy cooperation between buildings (Kozlowska et al., 2024). The Clean Energy Package enshrined the right of citizens to produce, consume, store, and share energy from renewable sources (RED II, 2018/2001/EU), paving the way for the creation of RECs, while RED III, part of the "Fit for 55" package, raised the binding renewable energy target to 42.5 % by 2030. This further reinforces the need for

integrated instruments such as RECs in PEDs for collective energy production and management at the local level. According to the JPI Urban Europe program, PEDs must be efficient and flexible, capable of actively managing a renewable energy surplus, integrating buildings, heat and power grids, sustainable mobility and digital systems, while ensuring well-being, quality of life and social inclusion (JPI Urban Europe, 2020). In this sense, PEDs stand at the crossroads of technological innovation, European energy regulation and urban spatial planning, with the potential to catalyze sustainable urban regeneration practices. In this vein, PEDs are configured not only as energy projects, but as complex spatial devices for sustainable urban transformation and the realization of climate neutrality goals to 2050 (Volpatti et al., 2024; Molinaro, 2020).

3. Spatial planning and enabling tools for PEDs

The design and location of a PED in an urban setting requires an integrated approach that connects urban and energy planning. At the design stage, it is crucial to assess the characteristics of the urban site and the built environment: an effective PED tends to combine buildings of different types (new interventions and redevelopment of existing) and mixed uses (residential, commercial, services), so as to exploit synergies in energy demand profiles and maximize self-consumption from local renewables (Alpagut et al., 2021). European studies show that many pilot PEDs are in urban expansion or regeneration districts where it is easier to integrate clean technologies and advanced building standards from the outset, or in existing districts with large-scale deep energy retrofits. Urban planning tools can guide this localization: administrative units can identify areas suited to become energy-positive districts, while through building codes requirements such as the widespread installation of photovoltaic panels, connection to renewable-source district heating networks, or nZEB standards for PED buildings can be imposed (Autonomous Province of Trento, 2021). In parallel, municipal energy planning can complement PED goals by coordinating local energy supply and demand interventions (Municipality of Bologna, 2021). In this context, a key role is played by RECs: introduced by recent European legislation to encourage local production and sharing of renewable energy, they are complementary to PEDs in that they allow citizens, businesses, and institutions to come together to collectively manage neighborhood energy facilities, sharing economic and environmental benefits (Maranesi & Santangelo, 2024). Although PEDs are not explicitly mentioned in European directives, RECs are the key legal-organizational tool for their implementation. Indeed, energy communities, as defined by RED II, enable the exchange of energy between different users and the sharing of energy infrastructure, which are essential conditions for the technical and economic functionality of a PED. The integration between PEDs and RECs thus becomes a normative synergy: PEDs define the technical and urban perimeter, while RECs enable its participatory and decentralized management (Mihailova et al., 2021).

Moreover, several demonstration projects in Europe show the effectiveness of these integrations. For example, the Horizon 2020 projects Making city, Atelier, and Pocityf are implementing PEDs in various cities (such as Groningen, Amsterdam, Bilbao, Évora) by combining innovative technological solutions (smart grid, storage, electric mobility) with participatory energy community approaches, all supported by ad hoc urban planning tools (Making city consortium, 2018; Atelier consortium, 2020; Pocityf consortium, 2019). These case studies highlight how urban planning, when properly directed, can act as a catalyst for positive energy neighborhoods, integrating energy goals into urban plans and mobilizing local actors through multilevel and collaborative governance models.

4. Conclusions

Positive Energy Districts today represent one of the most advanced paradigms for urban energy transition, synthesizing energy efficiency, climate neutrality, social inclusion and technological innovation goals into a single spatial device. However, their systemic deployment within European cities is still hampered by a multifaceted set of regulatory, normative and operational barriers that slow their implementation. In particular,

the lack of coherent and enabling legal frameworks at the European and national levels, coupled with the fragmented transposition rules of the RED II and RED III directives, limits the possibility of configuring energy-positive urban districts on a large and replicable scale. Rigid regulations, complex permitting processes, stringent spatial constraints on energy sharing, the absence of one-stop shops, and misalignments between urban and energy regulations are among the most frequently cited obstacles in the literature (Krangsås et al., 2021). These critical issues are compounded by economic-financial challenges-due to the high initial investment required by PEDs and the absence of established business models-and technical-design challenges related to the integration of generation, storage, and dynamic energy management at the neighborhood scale (Jradi et al., 2023). In this context, the integration of PED and RECs represents a key opportunity to overcome many of the obstacles mentioned above. RECs, formally recognized by European legislation as entities empowered to produce, self-consume, store and share renewable energy (RED II, RED III), provide the legal-organizational basis for the collective management of energy flows in PEDs. They enable participatory, flexible and resilient models, facilitating direct citizen involvement and redistribution of economic benefits from the transition. However, the full functionality of RECs in PED depends on consistent and enabling regulation: indeed, many European experiences show that without procedural simplifications, stable incentives, and equitable access to the grid, even the most advanced projects risk being confined to an experimental phase. To unlock the potential of PEDs, it is therefore crucial to move forward on several regulatory fronts: first, by harmonizing the criteria for defining and operating RECs in different member states, overcoming limits to energy sharing perimeters and reducing tax and tariff burdens on shared energy; second, by updating urban and land-use planning tools so that they explicitly provide for the promotion of PEDs and the structural integration of RECs into urban regeneration strategies. In addition, synergies between energy and urban policies should be strengthened through multilevel governance, local co-design processes, and experimentation with regulatory sandboxes capable of testing legislative innovations before their generalization (Mazzeo, 2023). Support from European programs such as Horizon Europe, the SET Plan, and the "100 Climate Neutral Cities Mission" remains essential to create the framework conditions conducive to the scalability of PEDs, but it must be accompanied by national and local political will to update and coordinate regulations governing energy, land, and buildings. Only through a convergence of regulatory innovation, enabling planning, and active participation will it be possible to transform PEDs from exceptions to a structural component of the European cities of the future. In this perspective, RECs are not simply complementary actors, but true regulatory and institutional catalysts of the urban energy transition.

References

Alpagut, B., Lopez Romo, A., Hernández, P., Tabanoğlu, O., & Hermoso Martinez, N. (2021). A GIS-based multicriteria assessment for identification of Positive Energy Districts boundary in cities. *Energies, 14* (22), 7517.

Albert-Seifried, V., Murauskaite, L., Massa, G., Aelenei, L., Baer, D., Krangsås, S. G., Alpagut, B., Mutule, A., Pokorny, N., & Vandevyvere, H. (2021). Definitions of Positive Energy Districts: A Review of the status quo and challenges. Smart Innovation, Systems and Technologies, 493–506. https://doi.org/10.1007/978-981-16-6269-0_41

Angiello, G. (2020). Toward greener and pandemic-proof cities: Italian cities policy responses to Covid-19 pandemic. *TeMA - Journal of Land Use, Mobility and Environment, 13* (2), 271–280. https://doi.org/10.6092/1970-9870/7047

ATELIER Consortium. (2020). PED Innovation Atelier. Retrieved from: https://smartcity-atelier.eu/about/work-packages/ped-innovation-atelier/

Autonomous Province of Trento. (2021). Piano Energetico Ambientale Provinciale 2021–2030. Retrieved from: https://www.provincia.tn.it/Amministrazione/Documenti/Piano-Energetico-Ambientale-Provinciale-2021-2030

Casamassima, L., Bottecchia, L., Bruck, A., Kranzl, L., & Haas, R. (2022). Economic, social, and environmental aspects of Positive Energy Districts—A review. *Wiley Interdisciplinary Reviews Energy and Environment, 11* (6). https://doi.org/10.1002/wene.452

Chen, X., Vand, B., & Baldi, S. (2024). Challenges and Strategies for achieving High energy Efficiency in building Districts. *Buildings, 14* (6), 1839. https://doi.org/10.3390/buildings14061839

European Commission: Directorate-General for Research and Innovation, The strategic energy technology (SET) plan, Publications Office, 2018, https://data.europa.eu/doi/10.2777/04888

JPI Urban Europe. (2020). Europe towards Positive Energy Districts – First update: A compilation of projects towards sustainable urbanization and the energy transition. Retrieved from: https://jpi-urbaneurope.eu/wp-content/uploads/2020/06/PED-Booklet-Update-Feb-2020_2.pdf

Jradi, M., Nielsen, E. W., & Lund, M. (2023). A Comprehensive Technical Analysis of Retrofitting a Danish Residential Area into a Positive Energy District. *Future Cities and Environment, 9* (1), Article 18. https://doi.org/10.5334/fce.200

Kozlowska, A.; Guarino, F.; Volpe, R.; Bisello, A.; Gabaldòn, A.; Rezaei, A.; Albert-Seifried, V.; Alpagut, B.; Vandevyvere, H.; Reda, F.; et al. (2024). Positive Energy Districts: Fundamentals, Assessment Methodologies, Modeling andResearch Gaps. *Energies, 17*, 4425. https://doi.org/10.3390/ en17174425

Krangsås, S. G., Steemers, K., Konstantinou, T., Soutullo, S., Liu, M., Giancola, E., ... & Maas, N. (2021). Positive energy districts: identifying challenges and interdependencies. Sustainability, 13(19), 10551.

MAKING-CITY Consortium. (2018). MAKING-CITY: A Positive Energy Districts (PED) demonstration project. Retrieved from: https://makingcity.eu/the-project/

Manaresi, S., & Santangelo, A. (2024). Investigating the spatial distribution of energy poverty. An application to the city of Bologna. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 81–96. https://doi.org/10.6093/1970-9870/10344

Mazzeo, G. (2023). Analysis of strategic natural resources: the FEW Nexus model applied to Irpinia (Italy) and implications for regional planning. *TeMA - Journal of Land Use, Mobility and Environment*, (2), 123–142. https://doi.org/10.6093/1970-9870/10257

Mihailova, D., Schubert, I., Burger, P., & Fritz, M. M. (2021). Exploring modes of sustainable value co-creation in renewable energy communities. *Journal of Cleaner Production, 330*, 129917. https://doi.org/10.1016/j.jclepro.2021.129917

Molinaro, W. (2020). How Italian metropolitan cities are dealing with the issue of climate change? The study cases of metropolitan cities of Bologna, Milan and Venice. *TeMA - Journal of Land Use, Mobility and Environment*, *13* (1), 55–80. https://doi.org/10.6092/1970-9870/6606

Municipality of Bologna. (2021). Piano d'azione per l'energia sostenibile e il clima (PAESC). Retrieved from: https://www.comune.bologna.it/servizi-informazioni/piano-azione-energia-sostenibile-clima-paesc

POCITYF Consortium. (2019). POCITYF: A Positive Energy City Transformation Framework. Retrieved from: https://pocityf.eu/about/

Sassenou, L., Olivieri, L., & Olivieri, F. (2023). Challenges for positive energy districts deployment: A systematic review. *Renewable and Sustainable Energy Reviews, 191*, 114152. https://doi.org/10.1016/j.rser.2023.114152

Sgambati, S. (2023). The interventions of the Italian Recovery and Resilience Plan: sustainable development. *TeMA - Journal of Land Use, Mobility and Environment, 16* (2), 461–468. https://doi.org/10.6093/1970-9870/10038

Tuerk, A., Frieden, D., Neumann, C., Latanis, K., Tsitsanis, A., Kousouris, S., Llorente, J., Heimonen, I., Reda, F., Ala-Juusela, M., Allaerts, K., Caerts, C., Schwarzl, T., Ulbrich, M., Stosch, A., & Ramschak, T. (2021). Integrating Plus Energy Buildings and Districts with the EU Energy Community Framework: Regulatory Opportunities, Barriers and Technological Solutions. *Buildings, 11* (10), 468. https://doi.org/10.3390/buildings11100468

Volpatti, M., Mazzola, E., Bottero, M., & Bisello, A. (2024). Toward a certification protocol for Positive Energy Districts (PED). A methodological proposal. *TeMA - Journal of Land Use, Mobility and Environment*, (1), 137-153. https://doi.org/ 10.6093/1970-9870/10301

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