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# Climate-Neutral Districts and Positive Energy Districts as Governance and Investment Environments: A Conceptual Stakeholder–Pathway Framework

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**Abstract**

Climate-Neutral Districts (CNDs) and Positive Energy Districts (PEDs) have become central concepts in European strategies for climate-neutral cities. Existing research, however, has predominantly interpreted these models from technological and energy-system perspectives, while their governance implications and effects on real-estate investment remain comparatively underexplored. This paper develops a conceptual and interpretative framework that also considers CNDs and PEDs as governance and investment environments shaped by different stakeholder configurations. Methodologically, the study combines an evidence-informed stakeholder and governance framework developed within CapaCITIES 2.0 with an interdisciplinary conceptual interpretation. The framework derives from comparative analysis of Countries' Self-Assessments and National Action Plans involving 33 consortium participants representing 14 Member States, complemented by interviews, focus-group exchanges, collegial reconciliation, and participant validation. The unit of analysis is the stakeholder configuration associated with a dominant district-transition logic. The analysis positions PEDs as an energy-system-led, rather than energy-system-exclusive, configuration characterised by high infrastructural integration and comparatively strong dependence on specialised technical and regulatory actors. This perspective also highlights the structurally central, yet often under-leveraged, role of real estate actors. The paper concludes that recognising the plurality of district-transition logics provides a more differentiated basis for examining governance arrangements and the conditions under which real-estate stakeholders may move from reactive implementation roles towards greater strategic agency in urban climate transitions.

**Keywords:** Climate-Neutral Districts; Positive Energy Districts; governance; real estate investment; stakeholder ecosystems; urban transitions; urban governance



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## 1. Introduction

Climate change and rapid urbanisation are two major challenges shaping contemporary European sustainability policies. According to the European Commission, nearly 85% of Europeans are expected to live in urban areas by 2050. This trend will reinforce the strategic role of cities both as centres of energy consumption and greenhouse gas emissions and as key arenas for implementing the climate transition [1,2].

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Within this context, the building sector plays a pivotal role, as evidence shows that residential buildings are responsible for a substantial share of energy use and related greenhouse gas (GHG) emissions [3,4].

The urgency of climate transition has progressively reshaped European regulatory frameworks and urban planning instruments. Over the past decade, European strategies such as the European Green Deal, the "Fit for 55" package, the Renovation Wave Strategy, and the REPower EU Plan have established increasingly ambitious targets for the decarbonisation of the building stock, energy efficiency improvements, and the integration of renewable energy systems [5,6]. In parallel, the revision of the Energy Performance of Buildings Directive (EPBD) and the development of the EU Taxonomy framework are reshaping the real estate sector towards climate-neutral development models [7]. This transformation is particularly relevant given that buildings in the European Union are responsible for around 40% of total energy consumption and 36% of $CO_2$ emissions, while also contributing significantly to global resource depletion, waste generation, and water consumption [8–11].

Alongside regulatory developments, real estate actors have increasingly integrated sustainability considerations into their corporate strategies and investment decisions [8,9]. This evolution has been accompanied by the expansion of sustainability assessment and certification systems, such as BREEAM, LEED, and DGNB, which initially focused mainly on new developments but are now increasingly applied to the renovation and long-term management of existing real estate portfolios.

Nevertheless, despite the growing prominence of sustainability within the real estate sector, current approaches often remain largely confined to resource efficiency measures implemented at the individual building or portfolio scale. The broader systemic and urban dimensions of climate transition are still insufficiently addressed. At the same time, urban governments are increasingly relying on indirect forms of meta-governance to steer private investments towards collective goals related to sustainability, resilience, and social inclusion [12].

Within this broader policy and governance landscape, Positive Energy Districts (PEDs) and Climate-Neutral Districts (CNDs) have emerged as influential frameworks for structuring urban decarbonisation at the district scale. PEDs have been developed through initiatives such as the SET Plan IWG 3.2 and the Driving Urban Transitions Partnership, while CNDs are increasingly associated with the implementation of the EU Mission for 100 Climate-Neutral and Smart Cities. Both concepts promote the integration of buildings, energy systems, infrastructures, and user practices, positioning urban districts as active components of the climate transition rather than merely as aggregates of individual buildings.

Existing research has predominantly examined CNDs [13] and PEDs [14,15] from technological and energy-system perspectives, with particular attention to infrastructure performance, optimisation processes, and energy balances. Comparatively less attention has been devoted to how district-based transition strategies reshape governance arrangements, redistribute decision-making authority, and influence real estate investment and asset management [16,17].

Climate-Neutral Districts, and more broadly Climate-Neutral Cities, cannot be understood solely through their technical dimensions [18]. Their implementation depends on complex ecosystems of actors operating across energy, buildings, mobility, digital infrastructure, and social services. Different transition logics may therefore generate distinct governance arrangements, investment logics, and stakeholder configurations. Against this background [19], this paper argues that although PEDs have become increasingly emblematic of district-scale decarbonisation strategies in the European policy debate, the

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conditions under which they are implemented remain highly specific and are difficult to replicate across different urban and governance contexts [13,16,20].

Rather than representing a universally replicable model, PEDs can be interpreted as a specific configuration within a broader family of energy-system-driven approaches, characterised by high levels of infrastructure integration, system optimisation, and dependence on specialised actors such as utilities, grid operators, system integrators, and regulators.

This configuration has important implications for governance and for the role of real estate stakeholders. In an energy-system-led configuration, property owners, housing providers, and investors often operate within frameworks shaped by external infrastructural and regulatory conditions, limiting their strategic agency relative to other transition logics.

This article theoretically elaborates and applies an evidence-informed stakeholder–pathway framework originally developed through the CapaCITIES 2.0 stakeholder-mapping exercise [21]. Its original contribution does not lie in the initial construction of the stakeholder matrix itself but in its theoretical interpretation at the district scale and in the analytical relationship established between dominant transition logic, stakeholder functional relevance, infrastructural dependence, and real-estate agency. Within this framework, PEDs are examined as an energy-system-led configuration and used to investigate the conditions under which the structural centrality of real-estate assets [22,23] may, or may not, translate into strategic agency for real-estate actors. Accordingly, the paper addresses the following research question:

**RQ.** *How do alternative dominant district-transition logics shape stakeholder configurations and real-estate agency, and under what conditions may real-estate actors move from a reactive towards a more strategic role within energy-system-led configurations, including Positive Energy Districts?*

## 2. Materials and Methods

Generative AI was used as a writing support tool during manuscript preparation to assist with improving the clarity, organisation, and readability of the text, including reducing redundancies, refining the structure of arguments, and enhancing linguistic coherence. The conceptual framework, research questions, interpretation of the literature, analytical arguments, and conclusions were entirely developed and critically reviewed by the authors. All AI-assisted outputs were carefully verified, substantially revised where necessary, and approved by the authors, who assume full responsibility for the content of the manuscript.

### *2.1. Materials*

The literature component of the study was used as a structured and purposive conceptual synthesis rather than as a systematic literature review. Its purpose was to provide a theoretical interpretation of the analytical dimensions emerging from the project-derived framework, rather than to achieve exhaustive bibliographic coverage or estimate the prevalence of particular findings. Accordingly, systematic-review procedures such as database-based screening or PRISMA-type selection were not applied.

#### Theoretical Foundations and Their Translation into the Analytical Framework

Climate-Neutral Cities (CNCs) are understood here as processes of systemic transformation. Climate neutrality is not the linear outcome of individual technological solutions but emerges from interactions between infrastructures, regulatory frameworks, economic models, behavioural patterns, and institutional capacities. Consequently, urban climate transitions depend not only on the performance of individual interventions but also on the capacity to coordinate actors, resources, infrastructures, and decisions across sectors and governance levels.

Climate-Neutral Districts (CNDs) translate the city-wide ambition of climate neutrality into a district-scale implementation context. From this perspective, a city may comprise multiple districts pursuing climate neutrality through different configurations adapted to their spatial, infrastructural, institutional, and socio-economic conditions, while jointly contributing to the broader climate-neutral transition of the city. In this paper, Positive Energy Districts (PEDs) are interpreted as an energy-system-led configuration within this broader landscape. This positioning does not imply that PEDs are exclusively energy-system constructs; rather, it recognises that their defining operational logic requires a particularly high degree of integration between energy production, demand, flexibility, storage, infrastructures, and system operation.

Key decisions shaping climate-neutral urban transitions are distributed across governance levels and among public, private, technical, financial, and community actors. This distribution of authority, resources, and implementation capacity is structural rather than incidental. No single actor controls all the relevant transition levers. District transitions are consequently shaped by the interaction between public steering and resources allocated or controlled through market and non-public actors. The framework does not treat public planning and market coordination as alternative systems: public authorities establish collective objectives and enabling conditions, while substantial assets, capital, infrastructures, and implementation capabilities remain distributed among public and private actors. Governance therefore concerns not only stakeholder participation, but also the way responsibilities, resources, dependencies, and decision-making capacities are distributed and coordinated. The district scale provides a particularly relevant level at which these relationships can be observed, since infrastructures, buildings, investments, users, and public-policy decisions interact within a relatively identifiable implementation environment.

District-scale transitions cannot consequently be interpreted through a single disciplinary perspective. The theoretical foundations adopted in this study (Table 1) are organised into three complementary analytical levels, rather than treated as independent or equivalent theoretical strands.

The first level concerns the transition logic. Socio-technical transition studies provide the basis for understanding climate neutrality as an objective that may be pursued through different implementation configurations rather than through a single predetermined model [18,20]. This perspective supports the distinction, developed later in the paper, between different dominant district-transition logics.

The second level concerns governance, actor configuration, and control of critical resources. Multi-level and meta-governance perspectives help explain how municipalities and other public authorities coordinate actors, policies, and infrastructures that frequently remain outside their direct control. Infrastructure-governance approaches draw attention to the influence associated with the control of networks, operational data, technical capabilities, and regulatory interfaces. Stakeholder-power, resource-dependence, and actor-configuration perspectives complement these approaches by distinguishing the formal presence of an actor from its effective capacity to influence implementation and by highlighting how different transition configurations mobilise different actor constellations.

The third analytical level concerns investment and asset agency. Research on sustainable real-estate investment, fragmented ownership, split incentives, and district-scale business models highlights how investment cycles, risk allocation, transaction costs, access to finance, and asset-level objectives may enable or constrain coordinated district transformation. This perspective is particularly important because buildings and real-estate assets constitute both a physical component of district transition and an investment environment governed by actors whose objectives and decision horizons do not necessarily coincide with those of infrastructure operators or public authorities.

**Table 1.** Summary of how the selected theoretical perspectives contribute to these analytical levels and how they are translated into the stakeholder–pathway framework developed in the following sections.

| Theoretical or Empirical Literature Strand | Key Concepts Used in the Paper | Relevance to District Transitions | Translation into the Analytical Framework | Main References |
|---|---|---|---|---|
| Socio-technical transition studies | Transition pathways, socio-technical configurations, path dependence | Explains why climate neutrality can be pursued through different implementation logics | Basis for distinguishing multiple district-transition logics | Loorbach 2010 [16]; Geels, 2011 [20]; relevant transition literature |
| Multi-level and meta-governance | Coordination across institutional levels, indirect steering, institutional capacity | Clarifies the role of municipalities and public authorities in coordinating actors they do not directly control | Governance structures and distribution of decision-making power | Multi-level governance and urban meta-governance studies |
| Infrastructure governance | Infrastructure control, network dependence, interoperability, regulatory conditions | Explains the structural relevance of utilities, grid operators and infrastructure providers | Infrastructural dependencies and stakeholder selectivity | Infrastructure and energy-governance literature |
| Stakeholder power and resource dependence | Control of assets, data, finance, regulatory authority and operational capabilities | Distinguishes formal participation from actual capacity to influence implementation | Classification of dominant, enabling and context-dependent actors | Stakeholder and resource-dependence literature |
| Urban regime and actor-configuration studies | Actor coalitions, institutional arrangements, coordination capacity | Explains why different pathways mobilise different actor constellations | Stakeholder configurations associated with each dominant transition logic | Urban governance and actor-network literature |
| Real Estate investment and asset management | Investment cycles, ownership structures, risk allocation, asset-level returns | Connects district strategies with property investment and management decisions | Real Estate agency and characteristics of the investment environment | Sustainable real estate and property-investment literature |
| Split incentives and fragmented ownership | Divergence between costs and benefits, dispersed decision-making, transaction costs | Explains barriers to coordinated district-scale interventions | Conditions limiting or enabling collective real estate action | Building renovation and energy-efficiency literature |
| District-scale business models | Revenue allocation, aggregation, risk sharing, public–private cooperation | Explains how system-level value can be translated into incentives for individual actors | Alignment between asset-level investments and system-level value | District energy and business-model literature |
| Institutional and regulatory risk | Tariffs, permitting, grid access, data governance, regulatory uncertainty | Explains external constraints affecting feasibility and investment decisions | Regulatory and infrastructural dependencies | Energy regulation and investment-risk literature |
| PED and climate-neutral district frameworks | Energy balance, flexibility, integration, climate-neutrality contribution, stakeholder ecosystems | Provides the specific policy and conceptual context for PEDs and CNDs | Policy and conceptual basis for interpreting the positioning of PEDs within the dominant-logics framework | PED Frameworks 2.0 and 3.0; Mission-related documents |

The integration of these three analytical levels supports the distinction adopted in this paper between stakeholder configuration, governance structure, infrastructural dependence, and real-estate agency. It also requires a careful separation between stakeholder presence, functional relevance, decision-making influence, and strategic agency. Existing PED and climate-neutral-district frameworks acknowledge city authorities, energy providers, property owners, the real-estate sector, users, and other actors as relevant to district transformation [16,17]. Their roles, however, are neither fixed nor equally important across all transition configurations.

This interpretation is consistent with the stakeholder and governance framework developed within the CapaCITIES 2.0 project. That framework treats stakeholder relevance as context-dependent and explicitly links it to governance configuration, institutional maturity, the dominant transition approach, and the phase of the transition process. It also distinguishes a set of dominant transition approaches—including energy-system/infrastructure, building retrofit and real estate, community/social innovation, digital/data, mobility, and nature-based/resilience approaches—while recognising that these may coexist or combine within the same transition process. The empirical and methodological process through which these stakeholder configurations and dominant transition logics were identified is described in Section 2.2.1.

Within this analytical framework, the concept of **operational marginality** does not imply that real-estate actors are intrinsically peripheral to PED or CND development. Rather, it identifies a possible tension between their **structural centrality**—derived from the ownership and management of the physical assets through which many district interventions must be implemented—and their **strategic agency**, understood as their capacity to influence system-level design and implementation decisions. Such a tension may arise where critical infrastructures, operational data, regulatory interfaces, or system-management functions are predominantly controlled by specialised actors operating outside the real-estate sector.

### *2.2. Methods*

#### 2.2.1. Research Approach and Analytical Framework

This study adopts a conceptual and interpretative research approach grounded in an empirical stakeholder and governance analysis developed within the CapaCITIES 2.0 project. The research design combines two complementary components: first, the evidence-based stakeholder and governance framework developed through the project activities and documented in Deliverable 5.1 [21]; second, the theoretical interpretation of that framework through the interdisciplinary literature discussed in the section titled Theoretical Foundations and Their Translation into the Analytical Framework. The purpose of the present study is therefore not to reproduce the project analysis but to use its empirical and methodological results as the basis for examining how different district-transition configurations shape stakeholder relevance, governance dependencies, and real-estate agency.

The empirical foundation of the framework was developed through the comparative analysis of national materials produced within CapaCITIES 2.0, particularly the Countries' Self-Assessments and National Action Plans, complemented by evidence generated through the project Learning Portfolio. The analysis involved 33 participants from the CapaCITIES 2.0 consortium representing 14 Member States. These materials provided structured information on national governance arrangements, stakeholder ecosystems, institutional capacities, transition priorities, barriers, and enabling conditions associated with the implementation of the EU Climate-Neutral and Smart Cities Mission.

The methodological process followed an iterative qualitative sequence. The national Action Plans and related project materials were first reviewed to identify the actors involved in the transition processes described by each participating country and the functions attributed to them. Particular attention was given to actors exercising strategic steering, regulatory authority, infrastructure control, implementation capacity, financial functions, coordination roles, knowledge provision, and societal participation.

On this basis, preliminary stakeholder classifications and role assignments were independently developed by the two authors. The initial classifications were subsequently discussed directly with representatives of the participating Member States through bilateral exchanges, interviews, and focus-group discussions. These interactions were used to verify whether the proposed interpretation of stakeholder roles reflected the governance arrangements and transition processes reported in the national materials and to clarify cases in which roles or levels of relevance were context-dependent.

Following this country-level verification, the classifications were compared and discussed collegially in order to identify recurrent patterns across the participating national contexts and reconcile differences in interpretation. The resulting stakeholder framework and matrix were then re-presented to representatives of the participating Member States for review and validation. The methodological sequence therefore combined documentary analysis, independent author assessment, qualitative elicitation with national representatives, collegial reconciliation, and participant validation.

The analysis was deliberately evidence-based and conservative in its treatment of stakeholder configurations. Actors and roles were derived from those documented in the project evidence and discussed with the relevant national representatives rather than inferred solely from an idealised model of a climate-neutral-city ecosystem. This principle is consistent with the methodology adopted in Deliverable 5.1, which distinguishes evidence-based stakeholder identification from subsequent assessments of stakeholder relevance and activation and avoids filling undocumented gaps through extrapolation [21].

The comparative analysis also showed that stakeholder relevance cannot be interpreted independently of the transition configuration in which actors operate. Across the national Action Plans, recurrent implementation patterns were identified in which different combinations of infrastructures, assets, governance mechanisms, and societal objectives placed different stakeholder groups in more or less central positions. These recurring configurations provided the basis for the six dominant transition logics described in the section titled Dominant Transition Logics.

The six approaches should therefore be understood as dominant transition logics, rather than as mutually exclusive or exhaustive categories. A national, urban, or district transition may combine several approaches or evolve between them over time. The CapaCITIES 2.0 case-based applications confirmed this interpretation, showing hybrid configurations in which one dominant approach coexists with complementary transition dimensions and in which stakeholder relevance varies according to both the dominant approach and the lifecycle phase.

Within the present paper, this project-derived framework is transferred from the national and city-enabling scale to the district scale as an analytical lens. The unit of analysis is therefore not the individual stakeholder in isolation but the stakeholder configuration associated with a dominant district-transition logic. The framework is used to compare how different configurations redistribute functional relevance among stakeholder categories and to investigate the implications of these differences for governance, infrastructural dependence, and the strategic agency of real-estate actors.

Accordingly, the stakeholder–pathway matrix presented later in is not a quantitative measure of participation or power. It is an evidence-informed qualitative representation of recurrent patterns of stakeholder relevance identified through the CapaCITIES 2.0 analytical process and subsequently interpreted through the theoretical framework developed in this article. Decision-making power, resource control, stakeholder activation, and real-estate agency are treated as related but analytically distinct dimensions.

The overall methodological workflow, from the empirical evidence base developed within CapaCITIES 2.0 to the interpretative application adopted in this paper, is summarised in Figure 1.

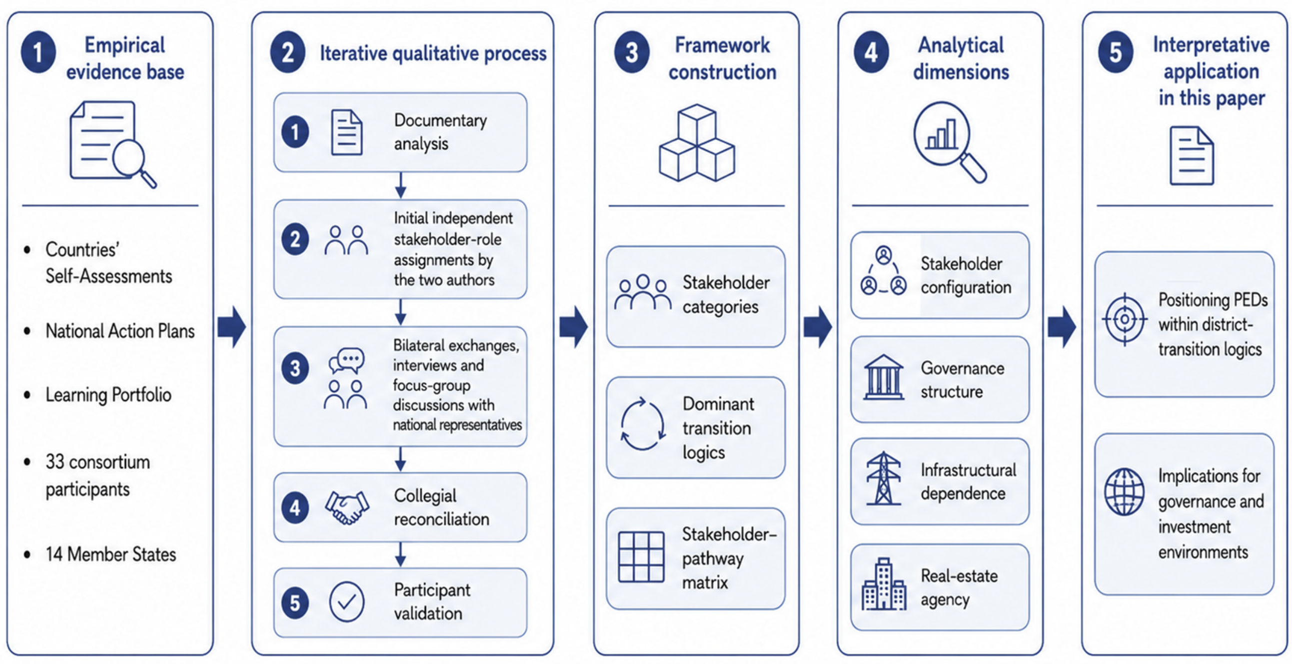


**Figure 1.** Methodological workflow for the stakeholder–pathway analytical framework. Source: Authors' elaboration based on CapaCITIES 2.0 Deliverable 5.1 [21].

Stakeholder Categories

The stakeholder categories (Table 2) used in this study derive from the comparative stakeholder-mapping exercise developed within CapaCITIES 2.0 and documented in Deliverable 5.1 [21]. The analysis of the Countries' Self-Assessments, National Action Plans, and related project evidence showed that climate-neutral urban transitions involve recurrent groups of actors performing distinct regulatory, infrastructural, investment, implementation, societal, and data-related functions.

Rather than attempting to provide an exhaustive list of every actor potentially involved in a Climate-Neutral District or Positive Energy District, the framework adopts a functional classification. Stakeholders are grouped according to the principal resources, responsibilities, and implementation capacities that they may contribute to the transition process. This approach makes it possible to compare stakeholder configurations across different institutional and transition contexts while retaining sufficient detail to identify the actors controlling critical assets, infrastructures, finance, data, regulatory authority, or implementation capabilities.

On this basis, the stakeholder ecosystem is organised into seven broad functional categories:

- Public governance and regulation;
- Property, real estate and building use;
- Energy and infrastructure;
- Mobility and logistics;
- Local economy and society;
- Finance, insurance and procurement;
- Data, digital systems and interoperability.

**Table 2.** Functional stakeholder categories considered in the analytical framework.

| Stakeholder Category | Description |
|---|---|
| Public governance and regulation | Municipality/City (planning, permitting, procurement, incentives, monitoring); Region/State (regulation, funding, energy-climate programmes); Regulatory authorities (energy, transport, data—where applicable); Energy agencies, climate offices, city labs (technical support and facilitation). |
| Property, real estate and building use | Public and private property owners; condominiums and housing associations; social housing providers; facility and property managers; tenants and end users (households, students, elderly people, vulnerable groups). |
| Energy and infrastructure (technical value chain) | DSOs/TSOs (electricity distribution and transmission); utilities and energy retailers; district heating and district cooling operators (where present); ESCOs, EPC contractors, system integrators; installers, O&M providers, technology manufacturers (PV, heat pumps, storage, BEMS); actors involved in local energy sources (geothermal, waste heat recovery, sustainable biomass). |
| Mobility and logistics | Public transport operators; MaaS providers; shared mobility services (bike, scooter, car); EV charging operators; parking operators; last-mile logistics actors (micro-hubs, couriers). |
| Local economy and society | SMEs and district-based companies; business associations and retailers; third sector organisations and NGOs; neighbourhood committees and informal communities; schools, universities and research centres; health and social services (where objectives include resilience and equity). |
| Finance, insurance and procurement | Banks, funds, impact and infrastructure investors; philanthropic foundations and blended finance instruments; insurance companies (climate, performance and construction risks); central purchasing bodies and procurement authorities. |
| Data, digital systems and interoperability | ICT providers; urban data platforms; IoT and telecom operators; data stewards and data governance bodies; cybersecurity and compliance actors (privacy, GDPR, data access). |

These categories define the analytical universe of potentially relevant actors, but they do not imply that all stakeholder groups are equally important in every transition configuration. Their relative relevance varies according to the dominant transition logic, governance arrangements, local institutional conditions, and lifecycle phase. This differentiation is examined in the Dominant Transition Logics and Construction and Interpretation of the Stakeholder–Pathway Matrix through the transition-logic framework and the stakeholder–pathway matrix.

Dominant Transition Logics

The comparative analysis undertaken within CapaCITIES 2.0 also highlighted that climate-neutral urban transitions are not organised around a single implementation model. The Countries' Self-Assessments, National Action Plans, and related project activities revealed recurrent configurations in which different combinations of infrastructures, assets, governance mechanisms, investment processes, and societal objectives placed different groups of stakeholders in central or supporting positions.

Through the comparative reading of these national transition processes, six recurring dominant transition logics were identified:

- Energy-system and infrastructure-led;
- Building retrofit and real-estate-led;
- Energy communities and social-innovation-led;
- Digital and data-led;
- Mobility-led;
- Nature-based and climate-resilience-led.

These categories are used as ideal-typical analytical configurations. They are intended to identify the principal organising logic through which a transition process is structured, rather than to classify all measures implemented within a city or district. They are therefore neither mutually exclusive nor exhaustive. Several transition logics may coexist within the same urban context, and their relative importance may change over time as implementation progresses.

This distinction is important for interpreting cross-cutting dimensions. Digital technologies, for example, may constitute the dominant organising logic of a data-driven transition but may also support energy-system, retrofit, or mobility configurations. Similarly, resilience, social inclusion, and circular-economy principles may be embedded across several transition logics without necessarily constituting the primary organising mechanism through which stakeholder roles and implementation responsibilities are structured. The absence of a separate category should therefore not be interpreted as the exclusion of these dimensions from climate-neutral urban transitions. For example, circular-economy principles may inform retrofit-led configurations through the reuse of building components and circular procurement, while also supporting energy-system-led configurations through waste-heat recovery and the valorisation of local secondary energy resources.

The analytical purpose of the six-logics framework is to compare how the dominant implementation logic changes the relative functional relevance of stakeholder categories. An energy-system-led transition, for example, structurally depends on actors controlling energy infrastructures, networks, and regulatory interfaces, whereas a retrofit-led configuration places greater emphasis on property ownership, asset investment, construction value chains, and financing. Community-led, digital, mobility-led, and nature-based configurations similarly generate different patterns of functional dependence and stakeholder centrality.

Table 3 summarises the core focus of each dominant transition logic, the stakeholder categories with the highest functional relevance, and the main governance and implementation characteristics associated with each configuration.

**Table 3.** Dominant district-transition logics and associated stakeholder configurations.

| Approach | Core Focus | Stakeholders with Highest Functional Relevance | Key Aspects/Evidence |
|---|---|---|---|
| (A) Energy-system and infrastructure-led | Energy grids, heat networks, electricity systems, flexibility and optimisation | Utilities, DSOs and network operators (including district heating), ESCOs, system integrators, regulators | Communities and third-sector actors usually enter later unless inclusivity is designed upfront. Strong dependency on permitting, tariff models, access to grid data, and technical constraints. The literature on climate-neutral district heating and heat planning highlights the dominant role of value-chain actors and system limits. |
| (B) Building retrofit and real estate-led | Large-scale renovation, EPC schemes, building performance and investment | Property owners, condominium managers, social housing providers, ESCOs/EPCs, construction companies, building value chains, financial institutions | Ownership structure is a key differentiator: many small owners increase complexity compared to few large ones. The literature on climate-neutral districts shows growing multi-actor complexity linked to retrofit processes, governance arrangements, and business models. |

**Table 3.** *Cont.*

| Approach | Core Focus | Stakeholders with Highest Functional Relevance | Key Aspects/Evidence |
|---|---|---|---|
| (C) Energy communities and social innovation-led | Co-ownership, co-decision, social equity and inclusion | Citizens, cooperatives and energy communities, NGOs, social services, community mediators, municipality as enabler | Users shift from passive targets to active co-implementers (investing, deciding, managing). Evidence from CNC, vulnerability and energy justice studies shows that social objectives require different actors and metrics beyond $CO_2$ reduction. |
| (D) Digital and data-led | Digital twins, data platforms, system optimisation and monitoring | ICT providers, data platforms, cybersecurity actors, DSOs/utilities (data holders), municipalities as data governance authorities, regulatory and compliance bodies | Data governance is the critical issue: data ownership, access rights, and conditions of use. Mission-oriented reports on urban data governance explicitly map stakeholder roles and responsibility nodes. |
| (E) Mobility-led | Low-emission zones, MaaS, urban logistics, EV charging | Public transport operators, sharing and MaaS providers, logistics operators, parking operators, EV charging operators, local police and traffic authorities | Compared to energy-first approaches, many levers are behavioural and regulatory rather than purely technological CAPEX-driven, making governance and enforcement central. |
| (F) Nature-based and climate resilience-led | Urban cooling, soil and water management, climate adaptation | Green space managers, water consortia and operators, schools, local communities, public health authorities | Co-benefits such as health, comfort, and well-being become primary drivers. As a result, sponsors, priorities, and performance metrics shift beyond energy and carbon indicators. |

Construction and Interpretation of the Stakeholder–Pathway Matrix

The stakeholder–pathway matrix presented in Table 4 originates from the stakeholder-by-dominant-approach analysis developed within CapaCITIES 2.0 and documented in Deliverable 5.1 [21]. Its purpose is to synthesise how the relative relevance of stakeholder categories changes according to the dominant transition logic, rather than to provide a universal or static stakeholder hierarchy.

The construction of the matrix followed the comparative qualitative process described in Section 2.2.1. Drawing on the evidence base generated by 33 CapaCITIES 2.0 consortium participants representing 14 Member States, the two authors first examined the actors and roles documented in the Countries' Self-Assessments, National Action Plans, and related project materials. Preliminary assignments of stakeholder relevance were made independently by the two authors, based on the roles attributed to actors in the transition processes reported by the participating countries.

These preliminary classifications were subsequently discussed with representatives of the participating Member States through bilateral exchanges, interviews, and focus-group discussions. This step was used to verify the interpretation of stakeholder roles against the institutional and governance contexts from which the evidence originated and to clarify cases in which stakeholder relevance depended on national arrangements, transition maturity, or implementation phase. Differences in the initial classifications were then discussed and reconciled collegially by the authors.

The resulting matrix was subsequently re-presented to the participating Member-State representatives for review and participant validation. The final classification therefore results from an iterative process combining documentary analysis, independent initial assessment by the authors, qualitative elicitation with national representatives, collegial reconciliation, and participant validation. No statistical inter-rater coefficient was calculated, since the purpose of the exercise was qualitative framework construction and consensus-based interpretation rather than quantitative coding reliability.

The assignment of symbols reflects recurring patterns in the functional relevance of stakeholder categories within each dominant transition logic. In the original CapaCITIES 2.0 framework, actors were distinguished as core, enabling, involved, or marginal. For the purposes of the present analysis, these categories are specified as follows:

- **● Core functional relevance:** The stakeholder performs a function that is recurrently central to the dominant transition logic and is directly involved in shaping or enabling its implementation.
- **○ Enabling functional relevance:** The stakeholder provides a significant enabling, coordination, financing, technical, or implementation function but does not normally constitute the leading actor within that transition logic.
- **△ Context-dependent relevance:** The stakeholder is involved in particular configurations or phases, but its relevance depends more strongly on local governance arrangements, ownership structures, institutional conditions, or project design.
- **— Marginal or non-structural relevance:** The stakeholder may be present in individual cases but does not emerge as a recurrent structural component of the dominant transition logic.

Accordingly, these four categories do not correspond to numerical thresholds or empirically validated cut-off values. Their assignment represents an interpretative qualitative judgement based on the documented stakeholder roles, recurrent patterns, and validation process described above.

These classifications should not be interpreted as quantitative scores or as direct measures of stakeholder power. In particular, functional relevance, observed involvement, decision-making authority, resource control, and strategic agency are treated as analytically distinct concepts. A stakeholder may control an asset that is essential for implementation while having limited influence over system-level decisions; conversely, an actor may hold significant regulatory or coordination authority without being directly involved in operational delivery. This distinction is particularly important for the interpretation of real-estate actors developed in Sections 3 and 4.

The matrix should also be read as an ideal-typical comparative representation rather than as a fixed prescription for individual projects. Stakeholder relevance may vary with the lifecycle phase and with the specific institutional configuration of a city or district. The CapaCITIES 2.0 framework explicitly incorporates this phase-sensitive logic, and its subsequent case-based applications showed that the same stakeholder categories assume different levels of relevance across early structuring, implementation, and scaling contexts.

Finally, the broader stakeholder and governance framework was subjected within CapaCITIES 2.0 to case-based validation across three contrasting national and regional enabling ecosystems. The exercise tested whether the framework could consistently interpret differences in dominant transition logic, stakeholder relevance, governance structure, and lifecycle maturity. The cases populated the framework differently, including hybrid transition configurations, supporting its use as a context-sensitive analytical framework rather than a one-size-fits-all classification. This validation was intended to assess internal coherence, adaptability, and interpretative capacity, not to evaluate the performance or effectiveness of the individual initiatives.

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**Table 4.** Stakeholder–pathway matrix. Relative functional relevance of stakeholder categories across dominant district-transition logics. Derived from the stakeholder-by-dominant-approach framework developed in CapaCITIES 2.0 Deliverable 5.1 [21] and adapted to the district-scale analytical framework used in this study. Note: ● = core functional relevance; ○ = enabling functional relevance; △ = context-dependent relevance; – = marginal or non-structural relevance. The symbols represent qualitative functional relevance and should not be interpreted as quantitative measures of participation, power, or decision-making authority.

| Stakeholder Categories | (A) Energy System | (B) Retrofit & Real Estate | (C) Energy Communities | (D) Digital & Data | (E) Mobility-First | (F) Nature-Based & Resilience |
|---|---|---|---|---|---|---|
| Municipality/City | ● | ● | ● | ● | ● | ● |
| Region/State/Regulators | ● | ○ | ○ | ● | ● | ○ |
| Energy agencies/city labs | ○ | ○ | ○ | ○ | △ | △ |
| Property owners/housing providers | △ | ● | ○ | △ | – | ○ |
| Facility & property managers | △ | ● | △ | △ | – | △ |
| Tenants/end users | △ | ○ | ● | △ | ○ | ● |
| DSOs/TSOs/utilities | ● | ○ | △ | ● | △ | – |
| District heating/cooling operators | ● | ○ | – | △ | – | – |
| ESCOs/EPCs/system integrators | ● | ● | ○ | ○ | △ | – |
| Installers/O&M/manufacturers | ○ | ● | △ | △ | △ | △ |
| Local energy source actors | ● | △ | ○ | – | – | ○ |
| Public transport operators/MaaS | – | – | △ | △ | ● | – |
| EV charging/parking operators | △ | – | △ | △ | ● | – |
| Logistics/last-mile operators | – | – | – | △ | ● | – |
| SMEs/local businesses | △ | △ | ○ | △ | ○ | ○ |
| NGOs/community groups | △ | △ | ● | △ | ○ | ● |
| Schools/universities/R&I | △ | △ | ○ | ○ | △ | ● |
| Health & social services | – | △ | ● | – | △ | ● |
| Banks/funds/investors | ○ | ● | △ | ○ | △ | ○ |
| Insurance companies | ○ | ○ | – | – | – | ○ |
| Procurement authorities | ○ | ● | △ | ○ | ● | ○ |
| ICT/data platforms/IoT | △ | △ | △ | ● | ○ | – |
| Data governance/cybersecurity | – | – | – | ● | ○ | – |
| District governance entity (meta-stakeholder) | ● | ● | ● | ● | ● | ● |

The functional logic underlying the classification can be illustrated through several entries in Table 4. Property owners are classified as context-dependent (△) in the energy-system-led configuration because their relevance varies with the ownership and asset configuration, whereas they are core actors (●) in retrofit-led transitions, where renovation and investment decisions directly depend on asset owners. Conversely, DSOs, TSOs, and utilities are core actors (●) in energy-system-led configurations because network access, operation, and system integration constitute intrinsic implementation requirements. Municipalities remain core across the six configurations because planning, permitting, regulation, coordination, procurement, or data-governance functions recur across district transitions, although the form of their authority differs between configurations. Banks, funds, and investors are core actors in retrofit-led configurations, where capital mobilisation is directly linked to asset transformation, while their role is more enabling or context-dependent in configurations where finance does not constitute the dominant organising mechanism. The matrix is therefore interpretative in nature and should not be read as an empirically validated ranking of stakeholder power.

## 3. Results

### *3.1. The Energy-System-Led Transition Logic: Stakeholder Structure and Dependencies*

Among the six dominant transition logics identified in the framework, the energy-system-led configuration is characterised by a comparatively high degree of dependence on energy infrastructures, system operation, and regulatory interfaces. Its implementation typically involves electricity networks, district heating and cooling systems, distributed generation, storage, flexibility mechanisms, and the technical and institutional arrangements required to coordinate them.

The stakeholder–pathway matrix reflects this configuration through the high functional relevance attributed to a relatively specialised group of actors. Municipalities and regulatory authorities, DSOs/TSOs and utilities, district heating and cooling operators, ESCOs and system integrators, local energy-source actors, and the district governance entity occupy core or enabling positions. By contrast, property owners, housing providers, facility and property managers, tenants, and community actors are predominantly classified as context-dependent or enabling actors rather than as core actors of the dominant energy-system logic.

This classification does not imply that these latter stakeholders are absent or unimportant. Rather, it indicates that the defining implementation requirements of the energy-system-led configuration are associated primarily with functions such as network operation, system integration, regulatory coordination, infrastructure access, and technical interoperability. The relative relevance of other stakeholder groups depends more strongly on the ownership structure, project design, local governance arrangements, and lifecycle phase.

The framework also identifies a set of implementation conditions that are particularly salient for this transition logic, including grid access and network capacity, tariff and regulatory arrangements, permitting and planning procedures, access to operational and performance data, and compatibility with existing infrastructures. Because several of these conditions are controlled or mediated by infrastructure operators and regulatory authorities, energy-system-led configurations display a comparatively high degree of dependence on actors operating outside the individual building or asset level.

For real-estate actors, the resulting configuration reveals an important distinction between asset ownership and functional relevance within the dominant transition logic. Buildings and property assets remain necessary physical components of district transformation, while property owners and managers do not necessarily control the infrastructures, operational data, or regulatory interfaces through which system-level integration is organised. The matrix therefore identifies a configuration in which the structural importance of real-estate assets may coexist with a more context-dependent role for real-estate actors in system-level decision processes.

Compared with the other dominant transition logics, the principal result is therefore one of stakeholder selectivity rather than stakeholder exclusion. The energy-system-led configuration assigns particularly high functional relevance to actors controlling or coordinating energy infrastructures and regulatory interfaces, whereas retrofit-led and community-led configurations redistribute functional centrality towards different actor groups.

### *3.2. PEDs as an Energy-System-Led Configuration with Cross-Pathway Components*

PEDs have gained increasing prominence in European policy and research as district-scale models combining energy efficiency, local renewable-energy production, storage, flexibility, and interaction with the wider energy system. While earlier PED definitions placed particular emphasis on the achievement of a positive annual energy balance, the PED Framework 3.0 adopts a broader interpretation that also considers greenhouse gas emissions, flexibility, system interaction, and the contribution of PEDs to wider climate-neutrality objectives. Within the analytical framework developed in this paper, PEDs are positioned as an energy-system-led configuration. This classification refers to their dominant organising logic and should not be interpreted as an exclusive classification of their constituent dimensions. PEDs may simultaneously incorporate building renovation, community participation, mobility solutions, digital technologies, and resilience measures. These elements can complement the PED configuration, while the achievement and operation of a positive-energy condition nevertheless require coordination of energy production, demand, storage, flexibility, infrastructures, and system operation.

This distinction between a dominant organising logic and complementary transition components is consistent with the broader framework adopted in this study, in which transition logics are neither mutually exclusive nor exhaustive. A PED may therefore combine energy-system, retrofit, digital, mobility, or community-related components without ceasing to be interpreted as energy-system-led when integrated energy-system operation remains the defining implementation requirement.

Applying the stakeholder framework to this configuration highlights the relevance of actors responsible for energy infrastructures and system operation. Utilities and energy retailers, DSOs/TSOs, district heating and cooling operators where applicable, ESCOs and system integrators, ICT and data actors, municipalities, and relevant regulatory authorities may perform core or enabling functions because PED implementation requires coordination across energy flows, infrastructures, data, and regulatory interfaces. The precise combination of actors nevertheless remains dependent on the technical and institutional characteristics of the individual PED.

The position of real-estate actors is more differentiated. Property owners, housing providers, facility managers, and investors control assets through which energy demand, efficiency measures, distributed generation, and flexibility can be implemented, but their functional relevance to system-level integration varies according to ownership structures and governance arrangements. The framework therefore does not classify real-estate actors as intrinsically marginal to PEDs; rather, it highlights that ownership of essential physical assets does not automatically imply equivalent influence over energy-system design and operation.

Comparison with the other dominant transition logics helps clarify this distinction. In retrofit-led configurations, property ownership, renovation decisions, construction value chains, and finance constitute the principal organising mechanisms, placing real-estate actors closer to the core of the transition process. In community-led configurations, collective ownership and participatory governance increase the functional relevance of citizens, communities, and social actors. PEDs differ insofar as their defining energy objective requires a particularly explicit coordination of infrastructures and operational energy-system functions.

The comparison therefore suggests a potential trade-off rather than a deterministic relationship. Higher levels of energy-system integration may be associated with greater dependence on specialised infrastructure and regulatory actors, but this does not imply that every PED necessarily exhibits restricted governance flexibility or marginalised real-estate stakeholders. The actual distribution of influence depends on the governance configuration, ownership structure, lifecycle phase, and institutional context of the specific initiative.

PEDs are consequently treated in this paper as one energy-system-led configuration within the wider landscape of Climate-Neutral District transitions, rather than as either a universal CND model or an exclusively energy-sector construct. This positioning provides the basis for examining, in the Discussion, the conditions under which structurally important real-estate actors may acquire greater strategic agency within highly integrated district-energy configurations.

### *3.3. Illustrative Application: The Kaukovainio PED in Oulu*

The Kaukovainio Positive Energy District in Oulu, Finland, provides an illustrative example of how the stakeholder configuration identified above can materialise in an implemented European PED. The vignette is not intended as an empirical validation of the stakeholder–pathway framework but as an application showing how its analytical distinctions can be interpreted in a documented PED context.

Kaukovainio was developed as one of the Lighthouse PEDs of the MAKING-CITY project. The district combines residential and commercial buildings with building retrofit, renewable-energy production, heat recovery, heat pumps, thermal storage, and interaction with the district-heating system. Rueda Castellanos and Oregi [24], in their comparative assessment of early European PED projects, identify Kaukovainio as a particularly integrated configuration in which building-level interventions are combined with district-heating infrastructure, recovered heat, photovoltaic generation, and energy-storage solutions. From a stakeholder perspective, its implementation involved the City of Oulu, the city-owned energy company, the housing company, research and technical partners, construction actors, and commercial actors [25].

The allocation of responsibilities illustrates the energy-system-led stakeholder configuration identified in Table 4. The City of Oulu performed enabling, planning and local coordination functions, while Oulun Energia owned and operated the district-heating network and was responsible for planning, investing in, implementing and maintaining key energy-system components. Technical partners contributed to energy-system design and monitoring. At the same time, Sivakka played a structurally important role by constructing new residential buildings, renovating an existing building and integrating building-level energy solutions into the PED. The housing company and the energy company jointly planned the energy solutions and associated investments [25].

The case therefore illustrates why structural centrality and strategic agency should not be treated as equivalent concepts. Real-estate assets and investment decisions were indispensable to PED implementation, but district-level energy integration depended simultaneously on infrastructure and operational functions controlled by the energy company and other specialised actors. Importantly, however, the housing provider was not merely a downstream implementer: its direct collaboration with the energy company illustrates that real-estate agency can increase where asset owners are involved in the design and investment process. The Oulu case thus supports the interpretation of PEDs as energy-system-led rather than energy-system-exclusive configurations and illustrates how the actual position of real-estate actors depends on governance arrangements and the distribution of critical implementation resources.

## 4. Discussion

*Real Estate Agency Across District-Transition Logics: Constraints, Heterogeneity and Enabling Conditions*

The comparison across dominant transition logics provides a differentiated answer to the Research Question. Real-estate agency depends not simply on whether property actors participate in a district-transition process but on the extent to which they control, or have access to, the resources and decision-making arenas through which the dominant transition logic is implemented. Where building ownership, renovation decisions, and asset investment constitute the principal implementation mechanism, as in retrofit-led configurations, real-estate actors occupy a more directly strategic position. Where transition processes depend more strongly on networks, system operation, regulatory interfaces, and infrastructure integration, as in energy-system-led configurations, the structural importance of real-estate assets does not necessarily translate into equivalent influence over system-level design.

This distinction clarifies the relationship between structural centrality and operational marginality introduced in the section titled Theoretical Foundations and Their Translation into the Analytical Framework. Structural centrality refers to the fact that buildings, land, investment cycles, and property-management decisions constitute essential components of district transformation. Strategic agency refers instead to the capacity of actors controlling those assets to formulate and pursue their own transition strategies and to influence decisions concerning system design, investment priorities, infrastructure interfaces, and value allocation. Operational marginality therefore does not indicate low economic importance, limited investment capacity, or absence from implementation. It refers more narrowly to situations in which control of critical real-estate assets is not accompanied by comparable influence over the wider governance and infrastructure configuration.

Real-estate actors should not, however, be treated as a homogeneous stakeholder category. Institutional investors and large developers, public and social-housing providers, fragmented private owners and condominiums, and facility or property managers differ substantially in their access to capital, investment horizons, risk tolerance, ownership structures, decision-making autonomy, and capacity to aggregate assets. Large institutional owners may be able to coordinate portfolio-level investment and negotiate directly with infrastructure operators, whereas fragmented residential ownership may face high transaction costs and collective-decision barriers. Public or social-housing providers may operate under different investment mandates and public-policy constraints, while property and facility managers may influence operational performance without controlling major capital-allocation decisions. The scope for strategic agency therefore varies not only across transition logics but also within the real-estate sector itself.

From an investment perspective, energy-system-led configurations may introduce forms of dependency that are less pronounced when asset transformation itself constitutes the dominant transition mechanism. Real-estate investment decisions may need to interact with grid availability, tariff structures, data-access conditions, flexibility requirements, infrastructure-development schedules, and regulatory interfaces. These dependencies do not necessarily reduce investment attractiveness or asset autonomy in every case, but they may alter risk allocation, timing, transaction costs, and the capacity of individual owners to define transition strategies independently. The concept of the district as an investment environment therefore refers here to the institutional and infrastructural conditions within which asset-level investment decisions are made, rather than to a uniform financial effect attributable to PED or CND status.

Comparison with retrofit-led and community-led configurations further illustrates this point. In retrofit-led transitions, property owners, housing providers, construction actors, and financial institutions are closer to the core of the implementation logic because transformation depends directly on decisions concerning buildings and capital expenditure. In community-led configurations, ownership, participation, and co-decision mechanisms can redistribute agency towards citizens and collective organisations. Energy-system-led configurations instead assign greater functional relevance to infrastructure and regulatory actors. The comparison therefore suggests that real-estate agency is configuration-dependent rather than intrinsically limited and that the same property actor may occupy a different strategic position under different transition arrangements.

On this basis, the framework identifies several conditions that may expand the scope for strategic real-estate agency within energy-system-led configurations. These include early involvement in planning and system-design discussions; access to relevant operational and performance data; participation in district coordination or governance structures; incentive and business-model arrangements capable of connecting asset-level investment with system-level value; and aggregation mechanisms that enable fragmented owners to participate collectively. These conditions should be interpreted as analytically derived enabling propositions rather than as empirically validated policy prescriptions. Their effectiveness will depend on the specific governance, regulatory, ownership, and market context and will require further empirical assessment.

Such enabling conditions may support different forms of real-estate participation. Depending on actor type and context, property stakeholders may aggregate demand or flexibility across portfolios, participate as co-investors in selected energy infrastructures, contribute data needed for system optimisation, or mediate between technical systems and building users. The framework does not imply that all real-estate actors should perform these functions, nor that increasing their influence necessarily improves PED or CND performance. Rather, it identifies possible mechanisms through which the asymmetry between control of physical assets and influence over system-level decisions may be reduced where greater integration is considered desirable.

The resulting interpretation also moderates the notion of a simple shift from "passive" to "strategic" actors. Real-estate agency should be understood as a continuum rather than a binary condition. At one end, actors mainly adapt asset-level decisions to transition requirements defined elsewhere; at the other, they participate in shaping governance arrangements, investment structures, and system interfaces. Their actual position along this continuum depends on transition logic, actor type, ownership structure, lifecycle phase, and access to critical resources.

The main implication is therefore not that PEDs or energy-system-led transitions necessarily marginalise real-estate actors but that high infrastructural integration can create governance configurations in which asset ownership and system-level influence are distributed among different actors. Recognising this distinction helps explain why real-estate stakeholders may be structurally indispensable while remaining less influential in some implementation settings and why governance arrangements capable of connecting asset-level and system-level decision processes deserve further empirical investigation.

## 5. Conclusions

This paper examines CNDs and PEDs from a governance and real-estate perspective, moving beyond interpretations that reduce them to primarily technical or energy-system constructs. Adopting a multiple-transition-logics perspective, it argues that district-based climate transitions operate through different implementation logics associated with distinct governance arrangements, actor constellations, and investment dynamics. This positioning refers to the dominant organising logic of PEDs and does not exclude the simultaneous presence of retrofit, digital, mobility, community, or resilience-related components. This reframing highlights that PEDs are linked to system integration and, consequently, to a selective and highly specialised stakeholder configuration. Their implementation requires the involvement of specialised actors—such as utilities, system operators, and regulators—because access to infrastructures, operational data, and regulatory interfaces forms part of the implementation environment. The paper also identifies stakeholder selectivity as a critical dimension of transition logics. While energy-system-led configurations assign comparatively high functional relevance to a specialised group of infrastructure and regulatory actors, alternative logics—such as retrofit-led or community-based approaches—place other stakeholder groups in more central positions. This demonstrates that climate neutrality can be pursued through different institutional and investment arrangements, without necessarily requiring the same level of technical integration and dependency that characterises PEDs. Within this framework, the paper has also critically examined the role of real estate actors. The analysis suggests that, in energy-system-led configurations, real estate stakeholders may occupy a comparatively constrained strategic position when system-level decisions depend primarily on infrastructures and regulatory interfaces controlled by other actors. This condition, however, is neither inevitable nor technologically predetermined. The paper instead argues that real-estate actors remain structurally central yet under-leveraged actors in district-based transitions. Structural centrality, however, should not be confused with strategic agency: ownership of essential physical assets does not automatically translate into equivalent influence over system-level decisions.

Buildings are simultaneously sites of energy consumption, generation, storage, and operational management. Real estate actors control assets, investment cycles, and user interfaces that are essential for the effective functioning of district-level systems. As such, their marginalisation within certain transition logics reflects governance and system-design choices rather than intrinsic limitations.

This leads to a further analytical insight: the conditions under which real-estate actors may move from a predominantly reactive towards a more strategic role deserve explicit consideration, particularly within energy-system-led configurations. The framework suggests several potentially enabling conditions, including early stakeholder involvement, access to relevant data, participation in coordination structures, and business models that better align building-level investments with system-level value creation.

From a policy and implementation perspective, these findings suggest moving beyond one-size-fits-all models toward more differentiated and context-sensitive transition strategies. Recognising the plurality of transition logics allows cities and stakeholders to combine strategies more closely aligned with local institutional capacities, governance conditions, and investment environments. Greater attention should therefore be paid to the interaction between stakeholder configurations and governance arrangements, as this intersection helps shape who drives the transition, how risks are distributed, and how value is created and captured over time.

The findings should nevertheless be interpreted within the scope of the study. The stakeholder framework is evidence-informed and draws on the CapaCITIES 2.0 comparative exercise across 14 Member States, but its district-scale interpretation and the propositions concerning real-estate agency have not been systematically tested across a comparative sample of PED and CND cases. The relationships identified in this paper should therefore be understood as analytical propositions that require further empirical testing across different governance, ownership, and market contexts.

The paper also opens several directions for further research. Future studies could use comparative case studies to test how different transition-logic configurations affect real estate value and investment behaviour or examine hybrid models that combine elements of energy-system-driven and real estate-driven approaches. Further research is also needed to better understand how regulatory frameworks and market mechanisms can be adapted to support a more active role for real estate actors in district-based energy systems.

Although PEDs represent a powerful configuration for achieving deep energy-system integration, they should be understood as one option among multiple transition logics, each with distinct implications for stakeholders, governance, and investment. Recognising this plurality and examining more explicitly the conditions affecting real-estate agency may support the design of climate-neutral urban transitions that better integrate technical, economic, and institutional considerations.

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