







URBAN TRANSITIONS MISSION &
DRIVING URBAN TRANSITION PARTNERSHIP

POSITIVE ENERGY DISTRICTS AND NEIGHBOURHOODS

A global perspective on district-scale urban transitions

URBAN TRANSITIONS MISSION
DUT
EUROPEAN PARTNERSHIP
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EXECUTIVE SUMMARY

While cities globally account for over 70% of energy-related greenhouse gas emissions, the building sector is responsible for around half of it and almost 50% of global material extraction. To achieve climate neutrality, urban decarbonization must scale beyond individual zero-energy buildings to connected neighbourhood systems. Positive Energy Districts (PEDs) and Positive Energy Neighbourhoods (PENs) offer a holistic framework to accomplish this by integrating energy efficiency, local renewable energy production, and demand-side flexibility across the built environment, mobility, and local utility grids. They represent a transformative approach: energy-efficient, energy-flexible urban areas that generate a net surplus of local renewable energy while actively balancing and supporting the broader urban energy system.

Extensively piloted and promoted across Europe through the Driving Urban Transitions (DUT) Partnership's PED Framework 3.0, the PED concept offers immense potential for global climate mitigation.[1] Furthermore, PEDs can also serve as testbeds for integrated spatial planning, local energy markets, and social innovation. However, translating a European PED framework and piloting successes into worldwide urban practice both require broadening the perspective. Global urban environments face fundamentally different challenges: cooling-dominated tropical climates, rapid urban expansion, high-density high-rise clusters, informal settlement infrastructure deficits, and reliance on private or commercial capital rather than public research grants.

This publication bridges the European PED experience with global urban realities, thanks to the role of the Urban Transitions Mission and its cohort of cities. Drawing upon empirical findings from over 115 European case studies and integrating best practices from Latin America, Asia Pacific, and Sub-Saharan Africa, this document re-frames PEDs as flexible, context-adaptable building blocks for net-zero, resilient, and inclusive cities.

Key insights highlight that while technological solutions (such as photovoltaics, heat pumps, energy management systems) are mature, the global scaling of PEDs hinges on four operational pillars:

1. **Systemic technical integration balancing heating, cooling, local microgrids, and energy storage.**

2. **Market viability utilizing innovative financing such as Public-Private Partnerships (PPPs), Energy-as-a-Service (EaaS), Energy Service Companies (ESCOs), and Green Bonds.**

3. **Inclusive urban regeneration guarding against green gentrification while still delivering social equity, energy justice, and affordable service delivery in diverse urban settings.**

4. **Mainstreaming energy priorities into mission-oriented urban planning and local policy frameworks.**

To support city leaders and practitioners worldwide, this publication provides actionable policy recommendations, real-world case studies, and a practical 10-step self-assessment tool designed to guide municipal decision-making from initial concept to district-wide execution.

[1] The DUT PED activities build on and are inter-connected with the work of IEA EBC Annex 83, ISO/IEC JTC 4, IEA TBC Cities, COST Action PED-EU-NET and others.



1. THE CHALLENGE AND THE UTM CONTEXT

To achieve climate neutrality, urban decarbonization must scale beyond individual zero-energy buildings to connected neighbourhood systems. While single-building efficiency improvements and utility-scale renewable deployments are essential, they are no longer sufficient on their own to meet net-zero climate trajectories. The district scale — encompassing connected blocks of buildings, public spaces, and localised infrastructure — represents the critical operational bridge between individual buildings and city-wide systems.

Acting at the district level allows cities to aggregate diverse energy loads, combine complementary demand profiles (such as mixing residential, commercial, and industrial usage), and achieve economies of scale for decentralised infrastructure that single buildings cannot sustain. District-scale interventions unlock key systemic opportunities:

- **Infrastructure Optimisation**: Implementing shared thermal networks (heating and cooling), local microgrids, and community-scale energy storage.
- **Circular Resource Flows**: Utilising urban excess heat recovery, wastewater thermal energy, and local organic waste-to-energy systems.
- **Systemic Resilience**: Reducing strain on broader urban transmission grids by balancing local generation, self-consumption, and load flexibility.
- **Neighbourhood-scale refurbishment processes**: Synergetic process regarding building retrofits, public spaces and local mobility support energy efficiency and CO_2 emission reduction.

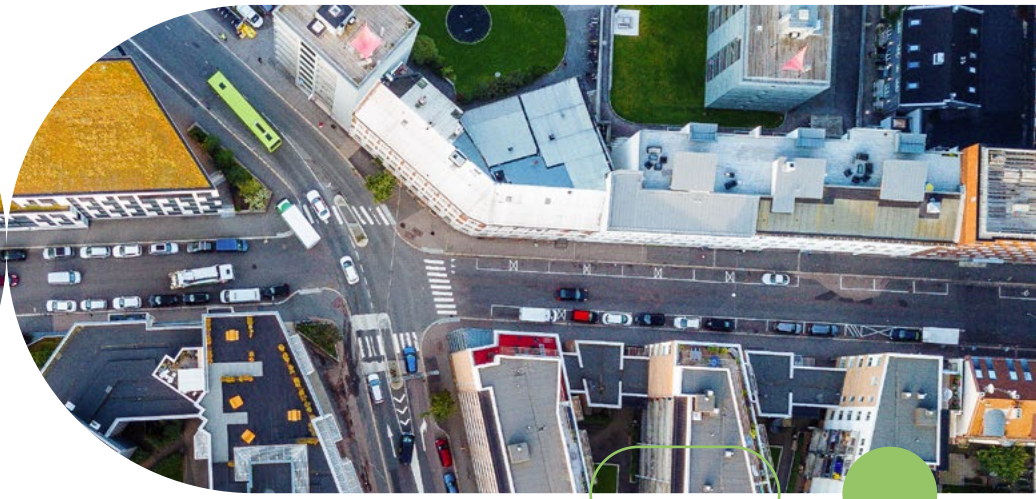
Urban energy transitions face structural challenges, including fragmented infrastructure networks, aging grid capacity, regulatory barriers to energy sharing, and split-incentive dilemmas between property owners and tenants. Under the Urban Transitions Mission (UTM), cities addressing these systemic bottlenecks require shifting from siloed municipal governance toward mission-oriented, cross-sectoral management frameworks.

The Driving Urban Transitions (DUT) Partnership has defined the PED Framework 3.0, offering a policy-relevant, guiding approach for European cities. However, scaling the PED concept globally under the UTM requires adapting this European framework to diverse geographical, climatic, and socio-economic realities:

- **Heating vs. Cooling Priorities**: While European PED initiatives heavily focus on space heating, thermal retrofits of legacy housing, and district heating networks, cities across the Global South, Latin America, Southern Asia, and the Middle East operate in cooling-dominated climates. In these regions, urban energy transitions must aggressively tackle the exponential growth in space cooling and refrigeration, particularly across tropical and rapidly urbanizing regions. District-scale strategies should integrate Nature-based Solutions (NbS) —such as cool roofs, urban greening, and bioclimatic design—with high-efficiency cooling technology to combat the urban heat island effect. Some options are for example space cooling, thermal energy storage (TES), district cooling systems, and optimizing solar photovoltaics (PV) for peak air-conditioning loads. Furthermore, district energy planning should expand to encompass sustainable cold chains for food and pharmaceutical logistics, ensuring broader urban resilience and food security.
- **Infrastructure Context and Informal Settlements**: In rapidly urbanizing regions across Sub-Saharan Africa and South America, district-scale action must address fundamental service access gaps in informal settlements and low-income areas. Here, decentralised microgrids, Pay-As-You-Go (PAYGO) solar models, and local community energy hubs form the foundation of sustainable urban transitions.

This publication serves as a practical, mission-oriented guide for local policymakers, municipal technical staff, urban planners, and district energy developers globally. By bridging the mature technical frameworks developed across European PED pilots with actionable global approaches, this document provides city leaders with the strategic tools, governance insights, and financial frameworks required to initiate, design, and scale district-level energy transitions.





2. PEDs & INTEGRATED URBAN ENERGY SYSTEMS: CONCEPTS, TECHNOLOGIES & DRIVERS

According to the PED Framework 3.0 definition: *"Positive Energy Districts (PEDs) are energy-efficient and energy-flexible urban neighbourhoods or areas of connected buildings and facilities, that produce local renewable energy, achieve net zero greenhouse gas emissions, and actively contribute to overall climate neutrality."*

PEDs are not isolated, self-sufficient energy islands; rather, they are dynamically interconnected with the surrounding urban infrastructure, exchanging energy with regional networks to optimise overall energy system resilience, affordability, and performance. They operate at the intersection of four core transition vectors: Decarbonization, Decentralization, Electrification, and Digitalization.

The PED concept relies on three core interconnected functions:

- **Energy Efficiency**: Reducing baseline energy demand through passive building design, high-performance building envelopes, deep retrofits, efficient lighting, and optimised Heating, Ventilation and Air Conditioning (HVAC) systems.
- **Local Renewable Energy Production**: Harnessing clean energy on-site or nearby (rooftop and building integrated solar photovoltaic (PV), solar thermal, geothermal heat pumps, wind, waste heat recovery, or bioenergy) to generate an annual surplus of net-clean energy.
- **Energy Flexibility**: Adjusting energy consumption, generation, and storage dynamically in response to grid conditions, market price signals, or user requirements. This can be done by utilizing thermal storage, battery energy storage systems (BESS), demand-response management, and Vehicle-to-Grid (V2G) interfaces to manage peak loads and prevent distribution grid overload.

The primary technological building blocks and value chain elements include:

- Generation: Solar PV arrays (rooftop and building-integrated), heat pumps, geothermal energy systems, solar thermal collectors, and waste heat recovery.
- Smart Sustainable Buildings (SSBs): Buildings within a PED transition from passive consumers to active "prosumers" equipped with IoT-driven Building Energy Management Systems (BEMS) compliant with standards like ISO 37173 and ISO 50001.
- Sector Coupling & Storage: Seamless integration of low-temperature district heating/cooling (4GD/5GDHC) networks, heat pumps, localised electrical storage electrochemical batteries, thermal energy storage (water tanks, underground seasonal storage), and dynamic EV battery integration (Vehicle-to-Grid/V2G) to link electric, thermal, and transport sectors.
- Management & ICT: Digital Energy Management Systems (EMS), Virtual Power Plants (VPPs), smart meters, and open-source data protocols for peer-to-peer (P2P) trading and automated demand response.

- Digital Infrastructure & Local Digital Twins (LDTs): Implementation of standardised data architectures (referencing ISO/IEC JTC 1 and JTC 4) to monitor real-time energy flows, simulate flexibility assets, and execute smart contracts for local energy trading.

- District Cooling Systems (DCS): In cooling-dominated environments, District Cooling Systems (DCS) serve as a foundational technology block. By centralizing chilled water production, DCS leverages local renewable and secondary sources—such as seawater, surface water, wastewater thermal energy, and solar thermal absorption chillers—to deliver dramatic efficiency gains over individual, decentralised air conditioning. Combined with Thermal Energy Storage (TES) and microgrid integration, DCS provides significant electrical load-shifting capability during peak summer periods.

Figure 1 below shows a visual representation of PEDs which highlights the interplay of the three core functions—Optimised Energy Efficiency, Optimised Local Renewable Energy Production, and Optimised Energy Flexibility—supported by the guiding principles: Keep the long-term perspective, Align efforts, Cooperate, Empower communities, Integrate systems, Make connections, and Make PEDs investable and affordable.

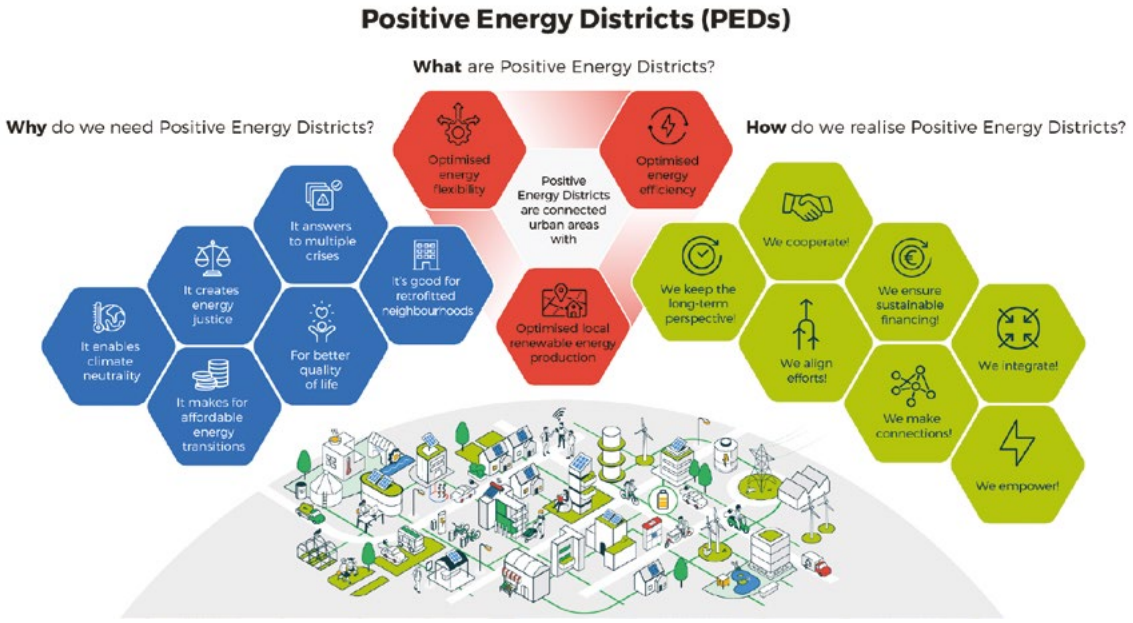
A central operational challenge in designing a PED is balancing its three key functions:

1. **Priority of Energy Sufficiency and Energy Efficiency**: Minimizing baseline demand must always precede sizing energy generation systems. Oversizing renewable assets to compensate for inefficient, poorly insulated, or unshaded buildings increases upfront capital expenditure (CAPEX) unnecessarily.

2. **Maximizing Self-Consumption**: Local energy sharing among buildings with complementary demand profiles (e.g., combining commercial daytime office loads with residential evening loads) maximises self-consumption and reduces energy losses.

3. **Deploying System Flexibility**: Uncontrolled renewable feed-in or sudden load spikes (from e.g. EV charging or heat pumps/air conditioning) can stress the distribution grid. By integrating demand-side management, thermal/electrical storage, and smart EMS control, PEDs buffer grid fluctuations, provide valuable ancillary grid services, and enhance overall regional grid stability.

Figure 1: Overview PED Framework 3.0, 2025



4. **Local Energy Generation in Dense Urban Areas**: High-density, high-rise urban clusters (prevalent in East Asia and North America), as well as historical city centres in Europe face severe spatial constraints to achieve a 100% on-site annual net-energy surplus where rooftop areas are insufficient relative to floor space. Achieving positive energy balances in these contexts requires integrating vertical building-integrated photovoltaics (BIPV), transit-oriented development (TOD) hubs, and off-site community renewable assets.

Achieving positive energy status requires more than annual net-positive generation; it demands dynamic energy flexibility to balance intermittent renewable production with urban demand profiles.

Short-term Thermal Energy Storage (TES), such as utilizing chilled water tanks, phase-change materials, or building thermal mass, are a key mechanism for daily peak shaving and demand response. By pre-cooling buildings during off-peak hours or shifting thermal loads away from peak electrical demand periods, integrated district cooling networks reduce stress on power grids, optimise capacity sizing, and avoid the dispatch of emissions-heavy peaking generators.





3. GLOBAL LANDSCAPE & KEY FINDINGS

While Europe has formalised the "Positive Energy District" label through dedicated research programmes and database tracking, equivalent district-scale net-zero frameworks are being actively deployed worldwide under different designations. Over 35 different terms (e.g., Net Zero Energy Districts, Plus Energy Blocks) exist globally, but standardizing around PED under ISO/IEC JTC 4 and IEC SyC Smart Cities is creating a unified global consensus. The global adoption of PEDs reflects diverse regional policy frameworks, climate conditions, and market architectures:

- **European Union (PEDs & PENs)**: Europe leads global PED deployment, driven by SET Plan Action 3.2, the DUT Partnership, and the EU Mission for 100 Climate-Neutral and Smart Cities. Characterised by a strong focus on high thermal efficiency, heritage building retrofits, district heating systems, and citizen-led energy communities. Strongly supported by public R&D grants and municipal climate mandates.

- **North America (Grid-Interactive Efficient Buildings & Eco-Districts)**: Focuses heavily on demand-side flexibility, automated demand response, Virtual Power Plants (VPPs), and building-to-grid integration driven by utility market signals and private capital performance contracting.

- **East Asia & High-Density Hubs (Smart Energy Communities & TODs)**: Focuses on spatially constrained, high-density environments, smart microgrids, high-capacity battery storage and advance disaster resilience. Priorities centre on integrated district cooling, digital twin monitoring platforms, transit-oriented development (TOD) energy integration, and waste-to-energy systems.

- **Emerging Economies & Global South (Low-Emission Districts & Microgrid Precincts)**: Priorities emphasise urban regeneration, expanding energy and utility service access, informal settlement upgrading, and deploying decentralised solar microgrids paired with mobile Pay-As-You-Go financing models. In the Middle East and hot climates, for example, the tendency is to prioritise passive solar design, high-reflectance urban surfaces, light-shading structures, wastewater recycling, and rooftop PV integration to handle extreme cooling demands.

Scaling district energy transitions globally requires leveraging international multi-stakeholder networks and open-access decision-support tools. Initiatives such as the UNEP District Energy in Cities Initiative, Mission Innovation's Innovation Community on Affordable Heating and Cooling of Buildings (IC7) and the Cool Coalition play a crucial role in closing technical capacity gaps. They provide cities with standardised policy handbooks, precious resources such as e.g., thermal mapping tools, and peer-to-peer knowledge exchange platforms that de-risk early-stage project development and accelerate the replication of district heating and cooling networks.

An empirical analysis of 115 European case studies documented in the PED Database[2] (PED-DB) provides critical baseline insights into how district transitions unfold:

- **Development Stages**: Over 88% of European case studies remain in the planning, living lab, or early implementation phases, with only a small minority fully completed or operational. This indicates that district-scale energy models still need to leap from experimental pilot concepts to mature market deployment. In order to establish these models as a common urban practice in the energy transition, viable business models and organisational innovation need to be in focus.

- **Technology Trends**: Energy efficiency is dominated by deep building retrofits (38.3%) and HVAC/lighting service upgrades (32.2%). Renewable generation is heavily anchored by solar PV (73%) and heat pumps (52%). Flexibility mechanisms are primarily enabled through Energy Management Systems (EMS) (50.4%) and district thermal networks (49.6%).

[2] https://peddatabase.dutpartnership.eu/

However, system-level flexibility mechanisms—such as electric storage (33.9%), thermal storage (29.6%), and P2P trading (11.3%)—remain underutilised.

- **Financial Models & Funding Patterns**: European cases demonstrate a heavy reliance on public funding and research grants (EU/national), with comparatively low private sector equity involvement. To achieve global scaling, financial models must shift toward commercial structures, including Public-Private Partnerships (PPPs), Energy-as-a-Service (EaaS), Energy Service Companies (ESCOs), Land Value Capture (LVC), and Green Bonds. This might be achieved in the near future, with more PEDs transitioning from experimental pilot concepts to mature market deployment.

- **Core Drivers**: Climate change mitigation, specifically the reduction of CO_2 emissions, is universally rated as the primary driving factor, followed by climate adaptation and urban regeneration. Energy security and independence have also emerged as urgent drivers in response to recent global energy crises.

- **Systemic Barriers**: While perceived unlocking factors for district-scale developments highlight the viability of local energy generation and the importance of up-to-date local and national regulatory frameworks, community awareness and mobilisation, as well as supportive financial mechanisms, the main barriers are perceived in the following areas:

  - Administrative: Complex authorization procedures, fragmented land ownership, and municipal departmental silos.

  - Regulatory: Outdated energy market regulations that restrict private microgrids, impede peer-to-peer electricity trading across property lines, or lack frameworks for local energy communities.

  - Financial: High initial upfront capital costs, long payback periods, split incentives between property owners and tenants, and an absence of standardised, bankable business models.

  - Technical & Social: Shortages of skilled technical personnel, grid capacity constraints, and limited public awareness or stakeholder engagement



4. KEY SUCCESS FACTORS FOR DISTRICT-SCALE ENERGY TRANSITIONS

Successfully establishing fertile ground for district-scale energy transitions requires aligning governance, institutional, community structures, policy, and finance enablers. Empirical research across European and international PED implementations demonstrates that non-technical factors, such as governance structures, legal frameworks, and market alignment, frequently present greater hurdles than technical deployment. The multi-actor nature of district energy projects requires cross-departmental city task forces and public-private partnerships capable of navigating regulatory restrictions, complex land-use rights, and split-incentive dilemmas between property developers and long-term utility operators. Standardizing concession models and creating clear municipal regulatory sandboxes are vital prerequisites to de-risking private capital investment in district thermal infrastructure.

Following, some key success factors to foster PED implementation.

LOCAL GOVERNANCE AND CROSS-DEPARTMENTAL ALIGNMENT

- **Breaking Municipal Silos**: Establishing cross-departmental task forces that integrate urban planning, energy, housing, transport, and finance departments from project inception.
- **Utility and Operator Engagement**: Involving distribution system operators (DSOs), local utilities, and private developers early to align grid integration and civil works.
- **Clear Spatial and Functional Mandates**: Defining geographic or functional district boundaries and establishing clear performance targets (net-zero carbon, annual energy surplus, or grid flexibility thresholds).
- **Integrated Spatial & Energy Planning**: Aligning municipal master plans early with district energy modelling and utility expansion timelines

COMMUNITY ENGAGEMENT, OWNERSHIP, AND SOCIAL EQUITY

- **Citizen Empowerment & Co-Design**: Utilizing participatory planning processes, living labs, establishing "One-Stop Shops" for urban retrofits, and local workshops to build public trust, ownership, and behavioural alignment.
- **Community Energy Ownership**: Supporting energy co-operatives and community-owned generation assets that allow residents to directly share financial dividends and lowered energy costs.
- **Energy Justice & Social Safeguards**: Incorporating protections against "green gentrification," ensuring affordable housing quotas, and designing targeted tariff structures to alleviate energy poverty among vulnerable households.

POLICY INCENTIVES AND REGULATORY FRAMEWORKS

- **Adaptive Zoning and Building Codes**: Implementing positive energy building standards, green roof/wall requirements, and density bonuses for developments that achieve high performance or connect to local thermal networks.
- **Regulatory Sandboxes**: Establishing temporary regulatory exemptions that allow cities to test peer-to-peer energy trading, dynamic local tariffs, and private microgrid management within designated district living labs.
- **Standardised Technical Frameworks**: Adopting international consensus standards (IEC/ISO) to ensure interoperability between IoT devices, microgrids, BESS, and central distribution grids.

CROSS-SECTOR FINANCING MODELS

- **De-Risking Upfront Capital**: Utilizing public seed capital, green guarantees, or multilateral climate funds to de-risk private sector investments in district infrastructure.

- **Innovative Business & Financing Models**: Leveraging Energy-as-a-Service (EaaS), Energy Service Company (ESCo)'s Energy performance contracting (EPC), Land Value Capture (LVC), Power Purchase Agreements (PPAs), citizen-led Renewable Energy Communities (RECs), and Municipal Green Bonds to fund initial capital expenditure through long-term energy savings and land value appreciation help to further de-risk upfront capital investments.

To accelerate investment in low-carbon district energy systems, municipalities must move beyond voluntary guidelines to statutory urban thermal zoning. City authorities should establish designated "District Energy Zones" where new commercial and high-density residential developments are mandated or strongly incentivised to connect to local district heating or cooling networks. Combining these mandates with passive cooling incentives—such as real estate tax credits or building density bonuses for reflective roofs and green facades—creates a predictable market environment for private and concession-based infrastructure investments.



5. SELECTED CASE STUDIES & INNOVATIVE PRACTICES

This section presents a global portfolio of innovative practices and case studies, showcasing diverse district-scale approaches across different climate zones and urban contexts.

1. INTEGRATED ENERGY SYSTEMS & INFRASTRUCTURE

E2X Energy Management System Platform (oPEN Lab Project)

Location: Pamplona (Spain)

Developed by CENER in Spain, the E2X platform represents a modular, interoperable Energy Management System (EMS) designed for neighbourhood-level optimization. It integrates weather forecasting, energy production, price signals, and building control assets (PV, heat pumps, batteries, EV chargers) into a unified platform. Using open protocols and blockchain for data security, it optimises local energy flows, supports grid balancing, and provides the technical architecture for local energy communities.

Off-Site Community Solar Farm for Heritage Districts (POCITYF Project, Évora, Portugal)

Location: Évora (Portugal)

In Évora, Portugal, regulatory restrictions prevented on-site solar PV installations on protected historical buildings. The POCITYF project resolved this by establishing a 7.81 MW district-level Community Solar Farm (CSF) split between the city periphery and an industrial area. The centralised solar generation is shared among historical residential and commercial prosumers via a Community Manager entity, reducing installation costs per capacity, maximizing self-consumption across varied load profiles, and cutting grid consumption by up to 7% without altering historic building facades

High-Density Integrated Cooling and Smart District

Location: Tengah Eco-Town (Singapore)

Focus: High-density, tropical climate district energy system.

Key Features: Tengah Eco-Town features a centralised District Cooling System (DCS) for high-rise public housing, integrated with pervasive rooftop solar PV, smart microgrids, and digital twin management platforms. By centralizing thermal cooling infrastructure, the district reduces electricity consumption for cooling by up to 30%, mitigates the urban heat island effect, and demonstrates an optimised tropical district model.

2. ENERGY MARKETS, COMMERCIAL VIABILITY & FINANCE

ASTER – Grid-Competitive Clean Energy for Social Housing

Location: Flanders (Belgium)

ASTER is an energy services company established by 40 social housing corporations in Flanders, supported by the EIB ELENA programme. Fully funded through private capital without government subsidies (€155 million investment), ASTER installs, owns, and maintains solar PV systems across social housing stocks. Social housing tenants consume the electricity generated at rates up to 40% below market prices (guaranteeing a minimum 20% savings on annual bills), while excess generation is sold to the grid to fund future sustainability initiatives.

HeatCOOP – Cooperative Ownership for Shared Thermal Systems (DUT Partnership)

Location: Vienna (Austria), Prague(Czech Republic), Vipava and Lovrenc (Slovenia)

Tested across Austria, the Czech Republic, and Slovenia, the HeatCOOP project demonstrates cooperative ownership models for shared neighbourhood heating and cooling. A legal cooperative collectively owns shared geothermal borehole fields and seasonal thermal storage, while individual homeowners own their in-house heat pumps. This shared model lowers upfront individual investment costs, enables seasonal thermal storage (heating in winter, passive cooling in summer), and protects residents from volatile fossil fuel markets.

Public-Private Partnerships & Innovative District Financing

Mechanisms: Green Bonds, Energy-as-a-Service (EaaS), and Land Value Capture (LVC).

Overview: Cities worldwide are leveraging non-grant financial mechanisms to bridge the capital gap. Public-Private Partnerships (PPPs) allow private operators to build and operate district energy utilities under long-term concession agreements. Municipalities issue Green Bonds backed by property taxes or utility fees to fund civil works, while Land Value Capture (LVC) allows cities to fund green infrastructure by capturing land value.

3. URBAN REGENERATION & COMMUNITY BUILDING

Hammarby Sjöstad 2.0 Citizen-Led Energy Community

Location: Stockholm (Sweden)

Founded by residents, Hammarby Sjöstad 2.0 evolved into a professionalised economic association linking 64 housing associations, 80,000 residents, and industry partners. The community operates an open-source data protocol connecting building assets (PV, heat pumps, batteries) to perform energy sharing and participate in local flexibility markets. By focusing on bankable investments with short payback periods (e.g., batteries with 3-year paybacks), the association has achieved 70-80% energy cost reductions for participating members while building strong local community governance.

PED-ID – Holistic Assessment and Stakeholder Process (JPI Urban Europe)

The PED-ID project developed a standardised methodology to accelerate early-stage decision-making for district energy developments. Combining quantitative Multi-Criteria Decision Analysis (MCDA) with structured stakeholder participation tools (such as Letters of Intent and stakeholder mapping), the framework helps decision-makers evaluate spatial, social, economic, and technical data simultaneously, significantly reducing early project risk and decision-making delays.

Low-Emission District & Reviver Centro

Location: City Center (Rio de Janeiro, Brazil)

Focus: Urban regeneration, clean mobility, environmental monitoring, green infrastructure, historic preservation and building retrofits

Key Features: Established in 2021 as Brazil's first Low-Emission District (DBE), covering 3.5 km² in central Rio de Janeiro, this initiative designates an area for the prioritized implementation of measures such as promoting clean transport and active mobility, the sustainable urban redevelopment of public spaces, improving air quality, and carrying out complementary compensatory actions—including those related to buildings and waste management. The DBE is part of a broader initiative called "Reviver Centro" (Revive the Center)—a plan for the urban, cultural, social, and economic recovery of Rio's central district. The primary goal of the plan is to attract new residents by making use of existing buildings and plots of land that have sat vacant for decades in an area of the city already rich in infrastructure and cultural heritage.



Low-Emission District & Reviver Centro, Rio de Janeiro, Brazil (Photocredits: Ecomimesis)

Comprehensive Retrofitting and Vulnerable Neighbourhood Integration

Location: Buenos Aires (Argentina)

Focus: Large-scale building stock retrofitting and informal settlement integration.

Key Features: Buenos Aires established a target to retrofit 80% of its residential building stock by 2050 and required energy plans across public buildings (converting all public lighting to LED). The city developed an interactive "map of sustainable roofs" to geolocate rooftop solar potential and green roof opportunities. Crucially, the city links energy retrofits with informal settlement ("barrios populares") integration programs, installing solar water heating, insulation, and improved utility connections to address energy poverty increases resulting from re-zoning and public utility upgrades.

4. ENERGY WITHIN MISSION-ORIENTED URBAN PLANNING

Digital Twin Urban Planning Platform (MAKING PEDs, DUT)

Location: Linz (Austria), Civitavecchia (Italy), Sant Esteve de Palautordera (Spain), Baerum (Norway)

The MAKING PEDs project developed a digital twin platform tested across four pilot cities (including Linz and Sant Esteve de Palautordera). The tool provides interactive 3D visualizations of district energy, economic, and environmental metrics, allowing urban planners, municipal staff, and citizens to simulate different energy scenarios, evaluate policy interventions, and participate in data-driven co-design processes.

Municipal Incentives and Green Building Standards

Location: Baguio City (Philippines)

Focus: Mid-sized city climate action, green building incentives, and energy tracking.

Key Features: Committed to cutting carbon emissions by 2030 and reaching net-zero by 2050, Baguio City passed ordinances providing local property tax credits and discounts for real estate developers adopting green building standards, green roofs, and green walls. These passive design measures lower internal building temperatures, reducing cooling demand. The city also tracks electricity/water usage across public buildings and deploys pilot solar projects on municipal infrastructure.



Photo: Public Information Office, LGU Baguio

Positive Energy Standards for New Developments (EXCESS Project, Espoo, Finland)

Location: Espoo (Finland)

As part of the EXCESS project, Espoo developed positive energy building standards, policy guidelines, and design protocols tailored for residential and mixed-use developments in Nordic climates. By integrating high-performance building envelopes, smart EMS, local PV, and grid-interactive heat pumps directly into municipal urban development policies, Espoo ensures that new developments achieve a net-positive energy balance, directly contributing to its municipal goal of climate neutrality by 2030.

Extreme Cold Climate District Heating Transition

Location: Darkhan City (Mongolia)

Focus: Deep retrofits and district heating modernization in severe climates.

Key Features: Located in an extreme continental climate zone, Darkhan City is implementing low-energy, net-zero-ready, positive energy district concepts by combining deep envelope insulation with substation and control modernisation and energy supply diversification within its centralised district heating network.



Photo: Darkhan Redevelopment Authority

Municipal Building Energy Retrofit and Solar Initiative

Location: Accra (Ghana)

Focus: Auditing and retrofitting municipal public buildings (such as offices and healthcare facilities) with energy efficiency measures and rooftop solar PV to slash grid electricity demand.

Key Features: Through urban smart energy partnerships (such as agreements with the Covenant of Mayors in Sub-Saharan Africa), Accra is actively auditing public buildings and deploying municipal energy efficiency retrofits. Energy audits across municipal offices and polyclinics demonstrate that combining basic efficiency measures (LED lighting, smart AC thermostats) with rooftop solar PV can cut building electricity demand by 41% to 76% with rapid capital payback periods, serving as a blueprint for positive energy municipal nodes in developing urban contexts.

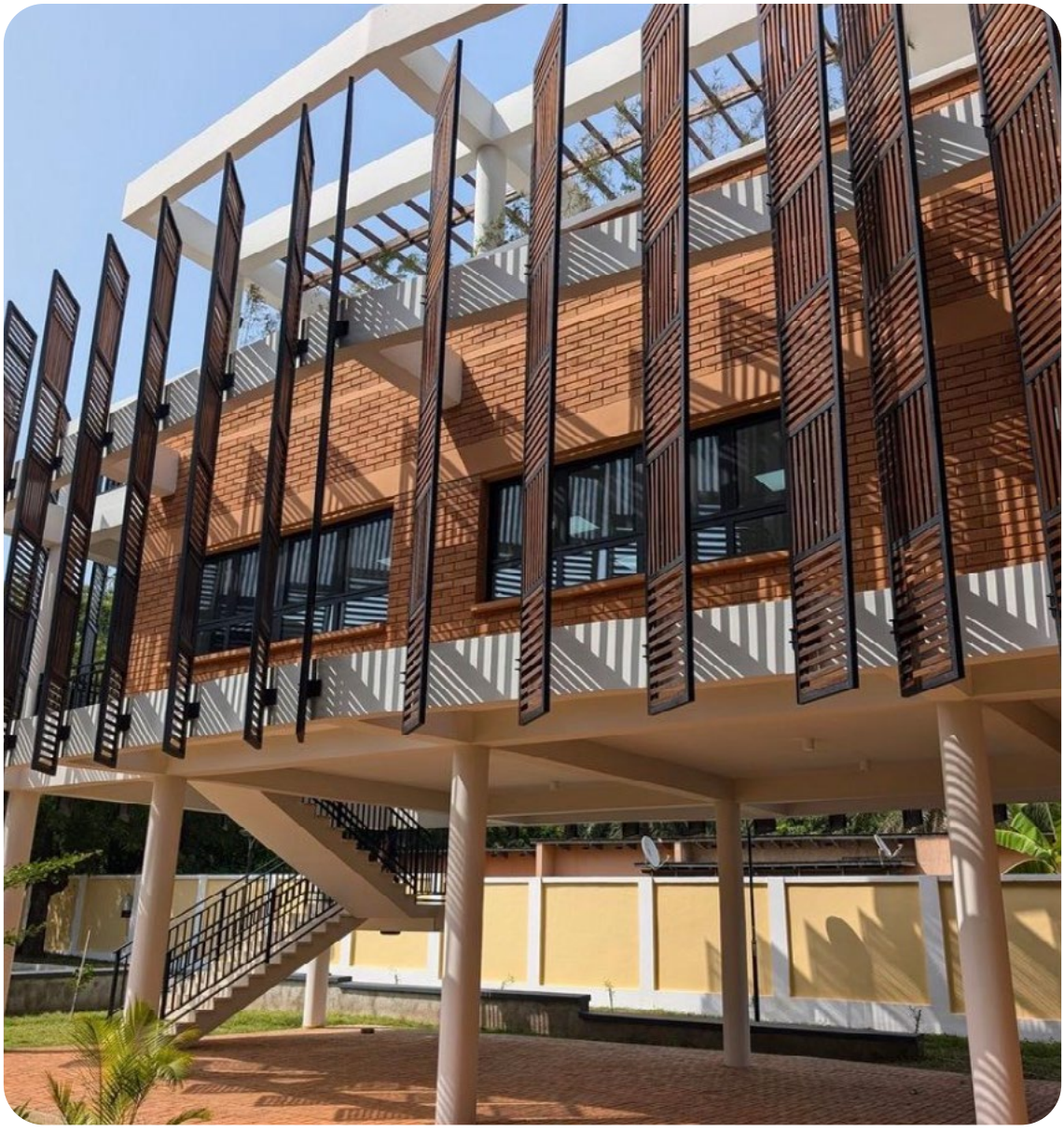


Photo: Energy Commission of Ghana

District cooling & multi-stakeholder city transitions (UNEP District Energy in Cities Initiative)

Context & Implementation: Across pilot and replication countries globally, local governments are partnering with UNEP's District Energy in Cities Initiative to double the rate of urban energy efficiency improvements by replacing fragmented, power-intensive air conditioning with modern District Cooling Networks.

Key Innovations:

- **Resource Synergy:** Utilizing natural free-cooling sources (such as deep seawater or lake water cooling) paired with industrial waste heat/cool recovery.
- **Peak Load Reduction:** Shifting up to 50% of peak electrical cooling demand through integrated Thermal Energy Storage (TES) ice/chilled water banks.
- **Replication Frameworks:** Demonstrating how municipal anchor loads (public buildings, hospitals, transport hubs) can de-risk initial capital investments for private concessionaires.



6. MISSION-ORIENTED POLICY RECOMMENDATIONS

To accelerate the global adoption of Positive Energy Districts and transform them into standard urban practice, coordinated policy action is required across all levels of governance.

1. RECOMMENDATIONS FOR NATIONAL AND REGIONAL GOVERNMENTS

- **Establish regulatory Sandboxes**: Modernise energy market regulations by legally enabling neighbourhood peer-to-peer (P2P) energy trading, private and localised microgrid management, dynamic network tariffs and local community energy ownership outside conventional utility restrictions. Establish flexible grid connection regulations that reward district-level demand response and flexibility services.

- **Mandate Interoperability & Align with Global Standards**: Adopt ISO/IEC JTC 4, ISO 37101, and IEC SyC Smart Cities standards into national building codes and municipal urban planning frameworks to prevent vendor lock-in and secure grid stability.

- **Include PED financing provisions in existing Climate Facilities**: include provisions to financially support the development of PEDs by public investment banks. Those include utilizing ESG-related metrics for infrastructural investment decisions covered by PEDs, such as high energy efficiency standards, renewable energy sources, or re-use of construction material. National Governments should also support private investments in PEDs via establishing de-risking mechanisms, blended finance structures and dedicated provisions to support PEDs via sustainability-linked and green bonds. Additional recommendations on the topic can be found in the UTM Publication "Blending Finance for Net-Zero Resilient and Inclusive Cities", released in 2025.

- **Update Building Codes and Master Planning Frameworks**: Transition national building performance codes from single-building metrics to district-scale, grid-interactive performance standards.

- **Empower Municipalities through Capacity Building**: Fund municipal "Urban Transition Offices" and One-Stop Shops to coordinate cross-departmental initiatives, manage Local Digital Twins, and facilitate public-private-people partnerships (4P models).

- **Promote Passive Cooling Standards**: Integrate passive cooling requirements, district cooling feasibility assessments, and urban thermal comfort metrics directly into national building performance codes and climate adaptation plans.

2. RECOMMENDATIONS FOR LOCAL GOVERNMENTS AND CITY LEADERS

- **Embed Energy Targets into Spatial Planning**: Integrate mandatory or incentive-backed positive energy performance targets, district heating/cooling connection requirements, and renewable generation zones into statutory urban master plans and zoning regulations.

- **Establish Institutional Governance Task Forces**: Create cross-departmental working groups linking urban planning, housing, transport, environment, and finance departments to eliminate internal municipal silos.

- **Promote Passive Cooling Standards and Multi-Stakeholder Capacity Building**: Establish local heat mitigation task forces and utilise robust technical handbooks to guide climate-responsive urban master planning and workforce capacity building.

- **Leverage Public Assets and Procurement**: Use municipal property portfolios, public housing stock, and public infrastructure retrofits as anchor projects to demonstrate commercial viability and aggregate local demand.

- **Ensure Social Equity & Guard Against Displacement**: Incorporate mandatory affordable housing requirements, anti-displacement covenants, and targeted energy subsidies into low-emission district plans to ensure energy transitions benefit all residents.

- **Guarantee Socially Inclusive Funding Mechanisms**: Ensure public subsidies for PED retrofits prioritise low-income and vulnerable neighbourhoods, funding community-owned energy infrastructure to deliver a just transition.

- **Implement Mission-Oriented Urban Procurement**: Transition public procurement from lowest-cost initial bids to full Life Cycle Assessment (LCA) and long-term carbon balancing performance criteria.

To maintain public trust and avoid spatial inequalities, district-scale decarbonization frameworks must explicitly incorporate energy justice indicators. Without targeted structural policy interventions, ambitious urban retrofits and district cooling/heating investments risk exacerbating climate gentrification or leaving low-income households unable to absorb connection fees. Municipalities should align PED initiatives with structural energy poverty alleviation by directing public subsidies toward vulnerable building stocks, establishing community energy sharing mechanisms, and integrating social equity goals directly into project Key Performance Indicators (KPIs).

3. STRATEGIES FOR SCALING: UP, OUT, AND DEEP

- **Scaling Deep (Capacity & Culture)**: Invest in local technical capacity building, municipal staff training, and community-led energy education to foster a culture of local energy stewardship.

- **Scaling Out (Replication)**: Adapt proven technical, financial, and organizational district models across different neighbourhoods, cities, and climate zones through peer-to-peer exchanges such as the Urban Transitions Mission City2City programme.

- **Scaling Up (Institutional Mainstreaming)**: Institutionalise successful pilot practices into permanent national legislation, utility market structures, and commercial real estate finance standards.

4. TARGETED MESSAGING FRAMEWORK

To build broad political, commercial, and public support, cities can build upon messaging that addresses specific stakeholder priorities, tailoring the communication activities accordingly. Here is an overview of the priority narrative & key message for different target audience.

- **National Policy Makers**: PEDs strengthen national strategic energy autonomy, reduce grid peak loads, enhance macroeconomic resilience, and lower national carbon emissions.

- **Peer Local Governments**: PEDs provide the core infrastructure for local green economies, revitalise aging urban neighbourhoods, lower municipal operating costs, and improve public health.

- **Private Investors & Developers**: PEDs offer de-risked, bankable real estate investments with lower operating costs, higher asset values, stable long-term yields, and strong ESG compliance.

- **Local Businesses**: PEDs create local commercial opportunities, green jobs, lower operational energy bills, and enhance local supply chain resilience.

- **Local Communities**: PEDs deliver affordable, reliable, locally produced clean energy, lower household energy bills, protect against energy poverty, and foster healthier, high-quality living environments.

7. GETTING STARTED: 10 QUESTIONS TO ASK YOURSELF

10 essential questions for local decision-makers to assess district energy readiness. Transforming an urban district into a Positive Energy District requires aligning municipal policy, technical systems, community engagement, and financing. Before launching a PED or similar initiative, local decision-makers can use these ten questions to assess readiness, define scope, and identify critical pathways forward.

1. SPATIAL BOUNDARIES AND DISTRICT TARGET

Has a clear spatial boundary been defined for the district, and is there a baseline assessment of its current or projected energy balance? Is the project a greenfield development, an infill project, or a complex brownfield/heritage retrofit, and what is the overarching target (e.g., net-annual positive energy surplus, net-zero carbon, or grid-interactive self-sufficiency)?

2. EXISTING POLICIES AND REGULATORY FRAMEWORK

Does your national, regional, or local government have existing policy frameworks, building codes, or urban plans supporting district-scale energy decarbonization? Does the current legal and market framework permit private microgrids, peer-to-peer (P2P) energy trading, or local community energy ownership?

3. INSTITUTIONAL ALIGNMENT AND CROSS-DEPARTMENTAL CO-OWNERSHIP

Is there a dedicated task force or co-ownership structure across relevant municipal departments (urban planning, energy, housing, transport, climate)? Are you already collaborating with local energy utilities, distribution system operators (DSOs), and municipal services to ensure alignment from the outset?

4. REGIONAL ENERGY DEMAND AND THERMAL PROFILE

Has an assessment of the dominant local energy demand profile been conducted (e.g., space heating, cooling, hot water, or peak electricity)? Which local renewable and secondary energy sources (such as rooftop solar, geothermal, waste heat recovery, or wastewater thermal energy) can be harnessed within or adjacent to the district boundary?

5. ENERGY EFFICIENCY AND DEMAND REDUCTION PRIORITY

Have stringent energy performance standards and passive design principles been integrated into the district plan prior to sizing energy supply systems? Are there mechanisms or smart building management systems required to minimise baseline energy demand before deploying local generation assets?

6. GRID INTERACTION AND SYSTEM FLEXIBILITY

Has the impact of local generation and load spikes (e.g., solar PV feed-in, heat pumps, EV charging) on the wider urban power grid been evaluated? Does the district design incorporate energy storage systems (thermal or battery), demand-response mechanisms, or Virtual Power Plant (VPP) integration to support broader grid stability?

7. BUSINESS MODEL AND LONG-TERM FINANCING

Has a bankable financing strategy been developed that goes beyond temporary public R&D grants? Are you exploring private capital, Green Bonds, Land Value Capture (LVC), or Energy Service Company (ESCo) models that leverage energy cost savings to fund upfront infrastructure?

8. COMMUNITY ENGAGEMENT AND LOCAL OWNERSHIP

Is there a structured public engagement strategy to involve local residents, property owners, and businesses in the design and decision-making process? Are there mechanisms in place to foster local energy co-operatives, shared asset ownership, or behavioural change programs?

9. SOCIAL EQUITY AND ENERGY AFFORDABILITY

Does the district plan include safeguards against "green gentrification" and rising living costs for vulnerable populations? Are there targeted tariff structures, affordable housing quotas, or shared community energy benefits designed to address energy poverty in the area?

10. SKILLED WORKFORCE AND INTERNAL CAPACITY

Does your local authority have staff with experience in managing complex, multi-stakeholder urban energy projects, or do you need external technical assistance? Is there a strategy to capture standardised performance data (e.g., via digital twin platforms) to evaluate results and replicate the model across other districts in the city?

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About the Urban Transitions Mission (UTM)

Launched at COP26 under the framework of Mission Innovation (MI), the Urban Transitions Mission (UTM) is a joint effort by GCoM, the European Commission, and Joint Programming Initiative (JPI) Urban Europe. It offers an urban net-zero transition framework that builds on the knowledge and expertise of a Global Innovation Alliance of supporting partners and organizations together with the first-hand experience of cities. Through the Urban Transitions Mission, cities will strengthen their net-zero visions, scale action, and accelerate implementation.

The Mission works with a cohort of 150 ambitious cities across 54 countries to demonstrate integrated pathways towards holistic, people-centred urban transitions built around clean energy and innovative net-zero carbon solutions. By 2030, these pathways will be validated by a group of 300 cities and inspire cities across all world regions on their journey toward decarbonisation.

About the Driving Urban Transitions (DUT) Partnership

The Driving Urban Transitions (DUT) Partnership is an intergovernmental research and innovation programme addressing key challenges of urban transitions towards a climate neutral and resilient future for all. It funds transformative research and innovation projects to facilitate an innovation ecosystem for urban transition processes. The DUT Partnership is co-funded within the European Research and Innovation (R&I) Framework Programme, Horizon Europe. The partnership started in 2022, building upon and stepping up the ambition and efforts of the Joint Programming Initiative (JPI) Urban Europe.To reach its vision and mission, DUT operates through three interconnected Transition Pathways - 15-minute City, Circular Urban Economies and Positive Energy Districts. DUT's calls and activities aim at creating a critical mass of knowledge and action for urban transitions.