PED FRAMEWORK 3.0

A policy guide to advance Positive Energy Districts in Europe

DUT Driving Urban Transitions

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Driving Urban Transitions (DUT) Partnership for SET Plan IWG 3.2
Website: https://dutpartnership.eu/

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October 2025

Executive summary

Urban areas are significant contributors to climate change, generating over 70% of global CO_2 emissions. Positive Energy Districts (PEDs) offer a strategic response to these urban energy challenges by enhancing energy efficiency, increasing renewable energy use, and improving the reliability of energy supply. PEDs support key climate initiatives in Europe, especially the European Green Deal, which aims to make Europe the first climate neutral continent by 2050. They also contribute to the EU's "Fit for 55" targets (55% emissions reduction by 2030), the Renovation Wave initiative for improving building efficiency, and the EU Mission on Climate-Neutral and Smart Cities*, which seeks 100 climate neutral cities by 2030.

To help integrate the PED concept into European, national, regional and local strategies, a unified PED Framework has been developed. This framework serves as a policy and planning guide for European, national, and regional policymakers to align PEDs with broader climate and energy policies, as well as for city authorities and practitioners to adapt and implement PED concepts tailored to local environmental, economic, and social conditions.

Instead of offering rigid criteria, the framework provides an adaptive structure, recognising that cities vary widely in terms of geography, infrastructure, and community needs. It balances uniformity with local adaptability, promoting inclusive and practical implementation.

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. Core aspects are renewable energy production, affordability, and financial sustainability, enabling PEDs to unlock their full potential as drivers of systemic transformation. By integrating diverse systems and infrastructures – such as energy, mobility, and ICT – and fostering interactions between buildings, users, and regional networks, PEDs align with a clear mission toward sustainability. Through engagement at all levels of governance, the empowerment of local energy communities, and alignment of initiatives, PEDs secure energy supply and a good life for all in line with social, economic, and environmental sustainability.

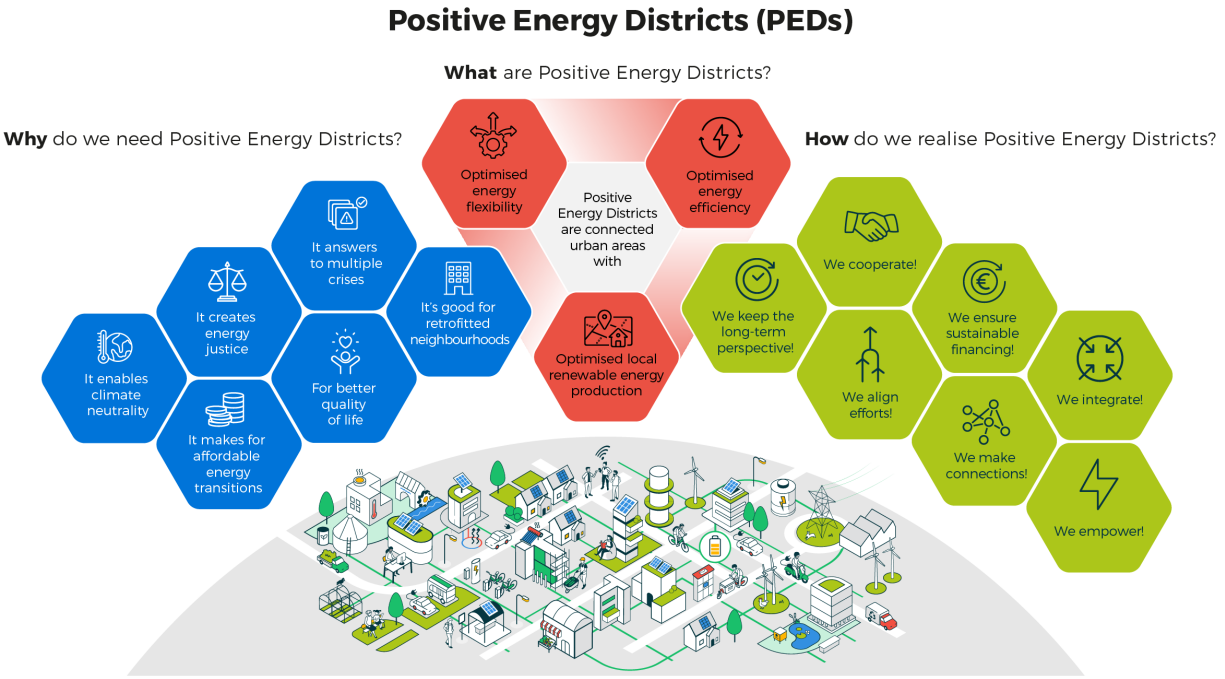

Figure 1: Overview PED Framework 3.0

* in further text titled as EU Cities Mission


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1 Aim and motivation

Cities account for more than 70% of global CO2 emissions, largely due to reliance on fossil fuels for heating, transportation, and electricity. Additionally, buildings are responsible for around 36% of global energy use, while retrofitting and transitioning to renewable energy sources is slow and resource intensive. Positive Energy Districts (PEDs) address the issues of urban energy consumption, energy efficiency, and energy supply reliability.

PEDs directly contribute to the objectives of the EU Green Deal by supporting climate neutral cities and reducing reliance on fossil fuels, which aligns with the overarching goal of making Europe the first climate neutral continent by 2050. PEDs enhance energy efficiency and promote renewable energy in urban areas, which is key to meeting the EU Fit for 55 targets of reducing greenhouse gas emissions by 55% by 2030 and increasing the share of renewable energy while also supporting the EU Cities Mission, which aims for 100 climate neutral cities by 2030. PEDs align with the Energy Performance of Buildings Directive (EPBD) and the "Renovation Wave", improving energy efficiency in buildings and driving sustainable development across European cities.

Bridging the technological and systemic challenges of transforming the energy system with the need for a comprehensive transformation of urban structures towards a climate neutral future – encompassing social, economic, and environmental dimensions – the definition of PEDs remains a subject of ongoing discussion. This background paper aims to **establish a joint European policy-relevant PED Framework** as a guiding tool for:

- **Policymakers on European, national and regional levels** for integrating the concept in respective strategic plans and policies,
- **Policymakers and practitioners on municipal and urban district levels** for integrating and further detailing the concept in strategic plans and policies, as well as concrete projects, according to the local context in terms of geographic, environmental, economic, political, cultural and social dimensions.

The PED Framework is designed to provide guidance for diverse urban areas in their pursuit of sustainable energy goals, acknowledging the complexity and multifunctionality of urban districts and their integration with surrounding environments. Rather than imposing rigid, uniform

criteria, the framework offers a flexible, yet consistent approach that regional and local authorities can adapt to their specific contexts, ensuring that PED goals remain both relevant and attainable.

While the framework touches on various energy components in a multi-building setting, it delegates in-depth discussions of the mobility sector and embedded energy to national or local concretisation, allowing for tailored approaches to these aspects. Recognising the diversity of urban settings, the framework definition reconsiders the emphasis on achieving a positive energy balance as a universal objective, proposing a more nuanced approach that accounts for local conditions and priorities.

By integrating context-specific criteria, the PED framework strives to be inclusive and accessible, enabling a wide range of urban districts – each with its own unique characteristics and challenges – to engage with and achieve sustainability targets. This balanced and adaptable approach ensures that the framework can support realistic and meaningful mission-orientated progress toward climate neutral cities and regions across Europe.

The need for an updated PED Framework

The Positive Energy Districts (PED) Programme was launched in 2018 as an Implementation Working Group 3.2 (IWG 3.2) of the European SET Plan[1] and implemented via JPI Urban Europe[2]. Since 2022, IWG 3.2 is also part of the Driving Urban Transitions (DUT) Partnership as the PED Transition Pathway. The PED Mission aims at supporting urban energy transitions through innovative solutions for the planning, large-scale implementation and replication of PEDs by bringing forward at least 100 PEDs by 2025. Furthermore, it will contribute to the Mission on Climate-Neutral and Smart Cities (EU Cities Mission) by building a portfolio of PED-related solutions towards climate neutrality[3].

The first PED Framework was published in 2019. In the following years, European policy frameworks have significantly changed, not least through the adoption of the European Green Deal and the EU Cities Mission. First PED projects provided additional evidence. Besides the need for integrating the PED concept into the renewed policy frameworks, updating the Framework for PEDs became necessary due to several key reasons such as technological advancements (rapid advancements in renewable energy technologies and smart grid solutions necessitate a framework that reflects the latest capabilities and integrates these innovations effectively), evolving standards and regulations, lessons learned from pilot projects. Another motivation for the update was to enhance acceptance and uptake among the target groups. The previous definition was reported to be not very user friendly for local authorities. To improve usability and raise acceptance, it was decided to involve a broader range of stakeholders throughout the entire update process and to incorporate their feedback to ensure it meets diverse needs and expectations.

By updating the framework, **we ensure that Positive Energy Districts remain at the forefront of sustainable urban development**, capable of leveraging new technologies and insights to addressing climate change and achieving sustainability targets that requires a robust, updated framework driving significant energy efficiency and integrated renewable energy production in urban areas.

The update of the existing Framework for PEDs was conducted in a modular manner, involving relevant stakeholders and actors. In close collaboration with the PED Steering Group (SG) and the SG Subgroup

1 https://energy.ec.europa.eu/topics/research-and-technology/strategic-energy-technology-plan_en

2 Joint Programming Initiative Urban Europe

3 The programme has launched three calls so far: JPI UE PED Pilot Call in 2020, JPI UE PED Call II in 2021, PED topics in DUT Call 2022, DUT Call 2023 and DUT Call 2024.

for PED Update, several discussion formats have been conducted to collect input for the update of the Framework (e.g. PED Agora Dialogue, online public consultation, workshops and discussion rounds). It was crucial to bring the diverse group of stakeholders with different perspectives to a common viewpoint, also utilising fresh insights from a range of initiatives such as the Clean Energy Transition Partnership community (CET-P), IEA EBC Annex 83[4], Cost Action[5] etc. as well as city representatives. Additionally, the limitations and associations of the term itself were taken into account. Involvement of the policy level in the process was essential to ensure that final framework of PED definition is in line with European policy framework.

Thus, the updated Framework represents a widely supported, European initiative that harmonises diverse perspectives, inputs, and needs from various stakeholders and experts. By complementing rather than competing with other R&I efforts or local definitions from specific projects and case studies, this inclusive approach strengthens coherence and collaboration. It ensures the framework is both relevant and practical for different target groups, fostering unified efforts in the successful implementation of PEDs across Europe. It follows a three-level approach:

1. Development and update of a PED Framework by the PED Programme

2. Refinement and application of the PED Framework in the local, regional and national context

3. Development of certifications and labels for PEDs by regional, national and European Standardisation and Certification Bodies

4 https://annex83.iea-ebc.org/

5 https://pedeu.net/

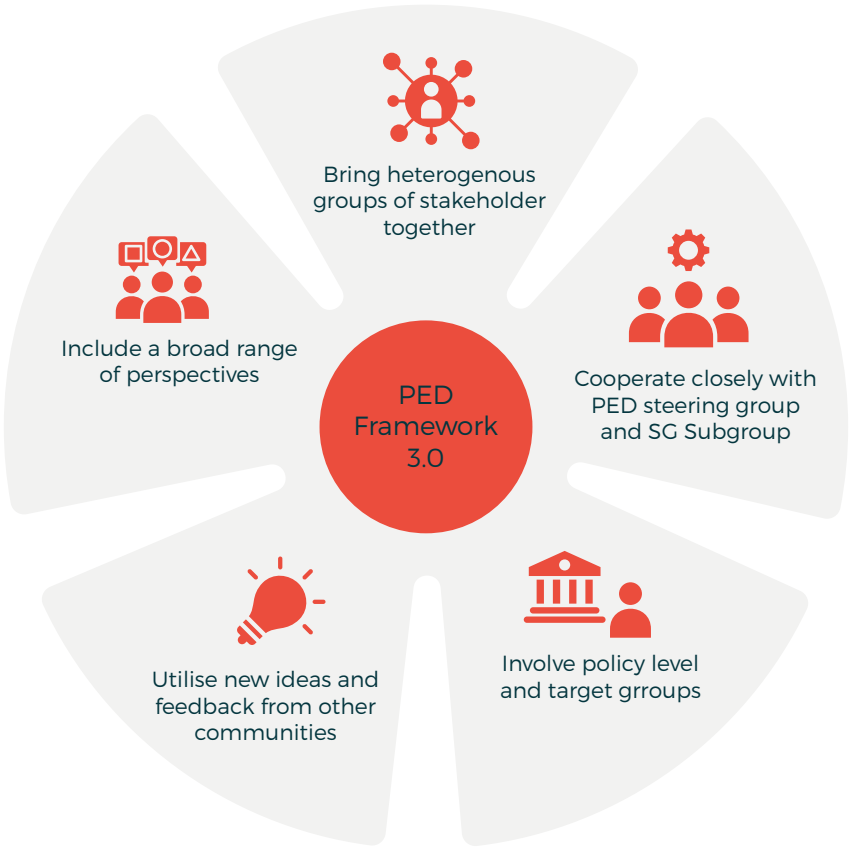


Figure 2: Motivation and background of the update of the PED Framework

2 PED Framework 3.0

2.1 What is a Positive Energy District (PED)?

PEDs are energy-efficient and energy-flexible urban areas that produce local renewable energy, achieve net zero greenhouse gas emissions and play an active role in the energy system for achieving overall climate neutrality.

The Positive Energy District (PED) concept centres around **three key functions: energy efficiency, energy flexibility and local renewable energy production**. Based on these functions, PEDs are highly interconnected with their surroundings and play an active part in the overall energy system. PEDs are not meant to be self-sufficient 'energy islands' by solely relying on local resources, especially in areas with limited renewable potential or high energy demand. Sharing energy between a PED and surrounding areas enhances flexibility, resilience, and cost-effectiveness in both electricity and heating/cooling. The role of a PED extends beyond maximising local energy production; it aims to optimise the entire energy system. This includes integrating flexible loads, energy storage, sector coupling, and providing services to the national or European grid.

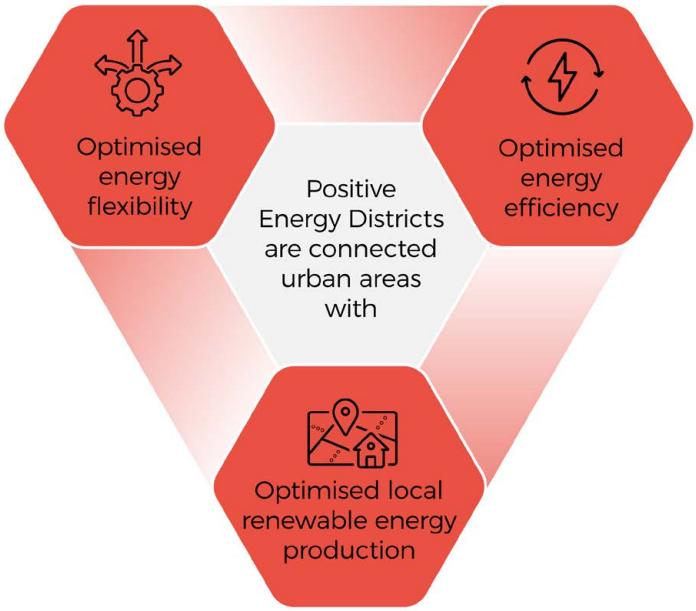


Figure 3: Key functions of PEDs

In general, the concept of PED is understood to include energy needs related to living, working and recreating in and around buildings, covering such as heating and cooling, hot water, lighting and home appliances. Mobility is typically not included, although there is a clear connection with grid system. Embedded energy in building materials is typically not included, although future PED concepts may do so.

In addition, more efficient spatial planning is tightly connected to energy efficiency, ensuring the optimal arrangement of energy resources and infrastructure. It aligns PEDs with the broader mission of climate neutral cities by enhancing efficiency and promoting sustainable urban growth. By actively engaging the different stakeholders in this way, they become new market actors (prosumers) and could play a crucial role in driving the transition towards a more sustainable, efficient, and resilient energy system.

2.1.1 Energy efficiency function

Among the functions of a Positive Energy District (PED), energy efficiency should be a priority ("energy efficiency first"), as the space needed for renewable energy generation is often limited in urban environments. Maximising energy efficiency reduces overall energy demand, making it easier to meet the remaining needs with locally generated renewable energy. The technologies and solutions employed can vary widely depending on local specificities and should not be restricted to specific approaches. This flexibility allows PEDs to adopt the most effective measures for reducing energy consumption, improving system performance, and contributing to the broader goal of sustainable urban development. With respect to their energy efficiency function, PEDs call for a well-thought-out spatial policy with energy-efficient building design and retrofitting of existing stock in order to reduce heat and cooling demand. Smart city design introducing nature-based solutions can also reduce the energy needs for cooling by reducing the Urban Heat Island Effect, while promoting mixed land use and densification will enable more sustainable mobility (e.g., walking, cycling and public transport) thus reducing transportation energy needs.

2.1.2 Energy flexibility function

Energy flexibility refers to the ability of an energy system to adjust its electricity and heating/cooling consumption or production in response to changes in energy supply and demand. This function should balance the supply and demand of energy (both electricity and heating/cooling[6]), improve grid stability, and integrate renewable energy sources as much as possible.

In this context, the main roles and functions of PEDs regarding energy flexibility are

- to actively contribute to the resilience and balancing of the regional and national energy system with the optimal benefit for the regional energy system in mind. With urban districts/ neighbourhoods being among the main consumers of energy in the energy system, demand side management, sector coupling and storage are among the main instruments to achieve this goal.

- to manage any interactions between the urban district/neighbourhood and the regional and national energy system such as to enable carbon neutrality and 100% renewable energy in the local consumption and an additional surplus of renewable energy over the year.

6 The same applies for cooling.

Energy flexibility can be achieved through various technologies and strategies, such as energy storage systems, sector coupling, demand response programmes and other smart grid technologies.

The closer we get to future scenarios of energy systems with 100% renewables, the more important the energy flexibility function will become in respect to the volatility of renewable energy (since the majority of dispatchable energy is currently fossil-based).

The energy flexibility function is closely linked to the flexibility concept defined in the implementation plan of SET Plan Action 4 ("*Increase the resilience and security of the energy system*"). This concept refers to the important role which urban areas have as the largest consumers and, to a certain extent, prosumers of energy (apart from industrial production sites) in the future renewable energy system. Therefore, we refrain from a more detailed definition and concretisation of the term "flexibility" and instead refer to the discussion and work in connection with the CET Partnership[7].

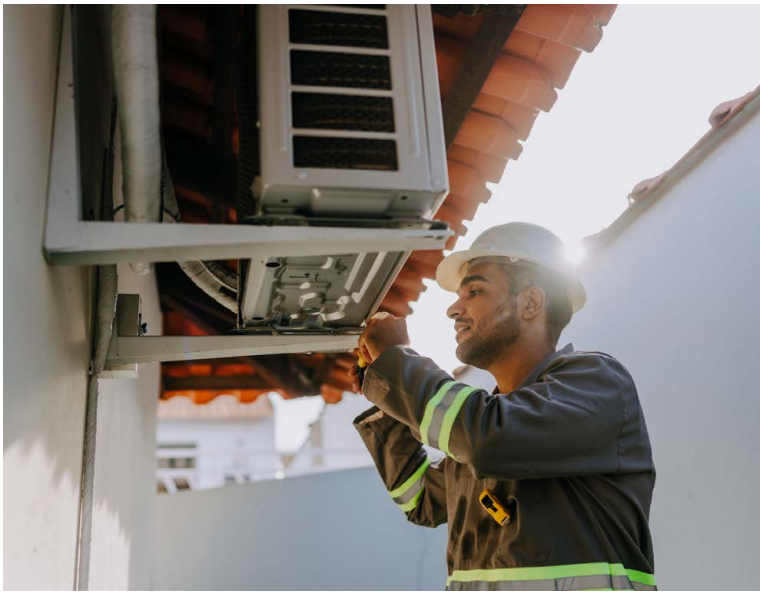
2.1.3 Local renewable energy production function

Locally and regionally produced renewable energy can enable a substantial reduction in greenhouse gas emissions if they replace fossil-fuel based technologies. However, the local production of renewable energies depends to a large extent on local and regional conditions and also on the chosen transformation paths for the transition of the local, regional, national and European energy system.

As an example, photovoltaic systems can substantially increase the share of renewables in the local electricity mix, using existing building surfaces such as rooftops and walls. By integrating solar panels into buildings, it avoids the need for additional land that would be required for traditional ground-mounted solar farms. More advanced technologies like photovoltaic-thermal (PV-T) hybrid solar systems increase electricity production further by cooling the PV panel and using the removed thermal energy for space heating. These systems have the same footprint as a standard PV system but have an even much higher energy efficiency.

In most cases, the transformation of heating and cooling systems towards 100% renewable sources is even more challenging than the local electricity production. PEDs could play a crucial role in this transition, since renewable heating and cooling is dependent on very local sources (heat cannot be transported over very large distances). Moreover, the interplay between retrofitting and thus reducing the heat demand, the type of heat needed, the heat demand density and the type of heat available is a delicate and complex puzzle. In this context, the use of waste heat or geothermal energy could play an important role in many locations.

It is about designing the system of a PED in such a way that the highest contributions for achieving the main objective (climate neutrality of the whole energy system) are possible. However, it is not a primary goal to maximise the amount of locally generated energy or to achieve a positive energy balance.



7 Clean Energy Transition Partnership (cetpartnership.eu)

2.2 Why do we need PEDs?

This section details the main objectives and desired impact of PEDs. This mission-oriented approach aims to provide elements for a consistent narrative of PED implementation and therefore is an integrated part of the PED Framework.

2.2.1 It enables climate neutrality

PEDs work towards climate neutrality by inspiring sustainability and driving innovation for optimising the overall energy system.

Climate neutrality is an integral goal of PEDs, to both limit and adapt to climate change, enhance its resilience and protect the environment. By taking ambitious and coordinated actions, PEDs have to contribute to global efforts to create a more sustainable and resilient future for all.

Thus, the overarching objective is not the optimisation of the local sub-system, but to make appropriate contributions for optimising the overall energy system. Rather, it is about system design for enabling the highest contributions for achieving climate neutrality in an integrated approach, taking into account the respective national and regional transition pathways.

Besides the reduction of all greenhouse gas emissions associated with city operations and activities, there are a lot of co-benefits when transforming an area towards climate neutrality. Examples for environmental co-benefits are improved air quality, reduced pollution, and preservation of natural resources. By committing to climate neutrality, local stakeholders can demonstrate leadership in sustainability and inspire other communities to take action. PEDs can serve as hubs of innovation, testing new technologies and practices that can be scaled up and replicated in other urban areas.

However, there is no generally applicable definition for the term "*climate neutrality*" in connection with urban districts or cities. Definitions of climate neutrality can vary depending on the context, region, and specific frameworks used by different organisations or initiatives[8]. Consequently, PEDs could be understood as going beyond the pure technical concept of climate neutrality, but on the other hand, if the concept of climate neutrality is defined more broadly, the respective terms "*positive energy district*" and "*climate neutral neighbourhoods*" can be used as synonyms.

Figure 4: Why do we need PEDs?

2.2.2 It answers to multiple crisis

By addressing environmental, social and economic impact, PEDs provide answers to the current energy crisis, the climate

8 Examples for such organisations or initiatives are the European Commission, the UNDP, C40, ICLEI and the Word Resources Institute (WRI).

crisis and cost of living crisis in the urban context.

The war in Ukraine has revealed the vulnerability of our energy system, which is still heavily dependent on fossil energy sources like oil or natural gas from outside Europe. Furthermore, the combination of the increasing urbanisation, and the expected effects of climate change increase the vulnerability of urban areas. The associated risks need to be studied systemically, taking into account cities' physical, functional and socio-economic vulnerability and the interactions and feedback loops at different spatial and temporal scales. Moreover, when it comes to risks, reducing dependence on energy imports helps to increase the security of energy supply. Key strategies to achieve this in a PED are energy efficiency, diversification of renewable energy sources, energy storage and engaging with communities and stakeholders. The localised energy production within PEDs makes urban areas less vulnerable to multiple crises.

In this context, appropriate energy security policies, regulations and frameworks that promote diversity, reliability, and resilience of energy supply are of crucial importance. By implementing such strategies and measures, local stakeholders can work towards achieving resilience and security of energy supply, ensuring a stable, reliable, and sustainable energy future.

However, resilience in a PED goes far beyond the security of energy supply. PEDs have to be developed to be better equipped to adapt to the impacts of climate change, such as extreme weather events, sea-level rise, and urban heat islands. By investing in climate-resilient infrastructure and sustainable urban planning, stakeholders can enhance their resilience and reduce vulnerability to climate-related risks. This includes in particular urban mobility strategies, the addition of green and blue infrastructure and sustainable and rational land use.

2.2.3 It's good for retrofitted neighbourhoods

PEDs promote reuse, retrofitting and repurposing of existing districts and neighbourhoods.

The EU building stock is relatively old and not adapted to the future of a carbon free environment and actions are needed to reduce energy needs. Taking into account the existing building stock is crucial for achieving climate neutrality in PEDs for several reasons. Buildings account for a significant portion of overall energy consumption and greenhouse gas emissions. Existing buildings are often older and less energy-efficient, leading to higher energy consumption and carbon emissions. Retrofitting existing buildings to improve energy efficiency can significantly reduce their negative environmental impact and emissions.

Demolishing and replacing existing buildings are usually not the best solution. Existing buildings have a significant carbon footprint (embodied carbon) due to the energy and materials required for construction. Preserving and retrofitting those buildings helps reduce embodied carbon emissions associated with new construction.

Furthermore, retrofitting existing buildings helps preserve natural resources by reducing the need for new materials and minimising waste. Reusing and repurposing existing buildings can also help to protect historic and cultural resources. It has to be taken into account that existing buildings are often integral parts of communities, contributing to local identity and character. While preserving these buildings the social and cultural fabric of neighbourhoods can be maintained.

However, besides the transformation of existing buildings PEDs also foster the transformation of new buildings for climate neutrality. Overall, more efficient spatial planning is tightly connected to energy efficiency and thus an influential lever in transforming new and existing buildings towards climate neutrality: for example, a well-thought-out spatial planning policy, in which urban areas are mixed-use and have a certain degree of density, will limit the need for transportation and thus reduce energy demand.

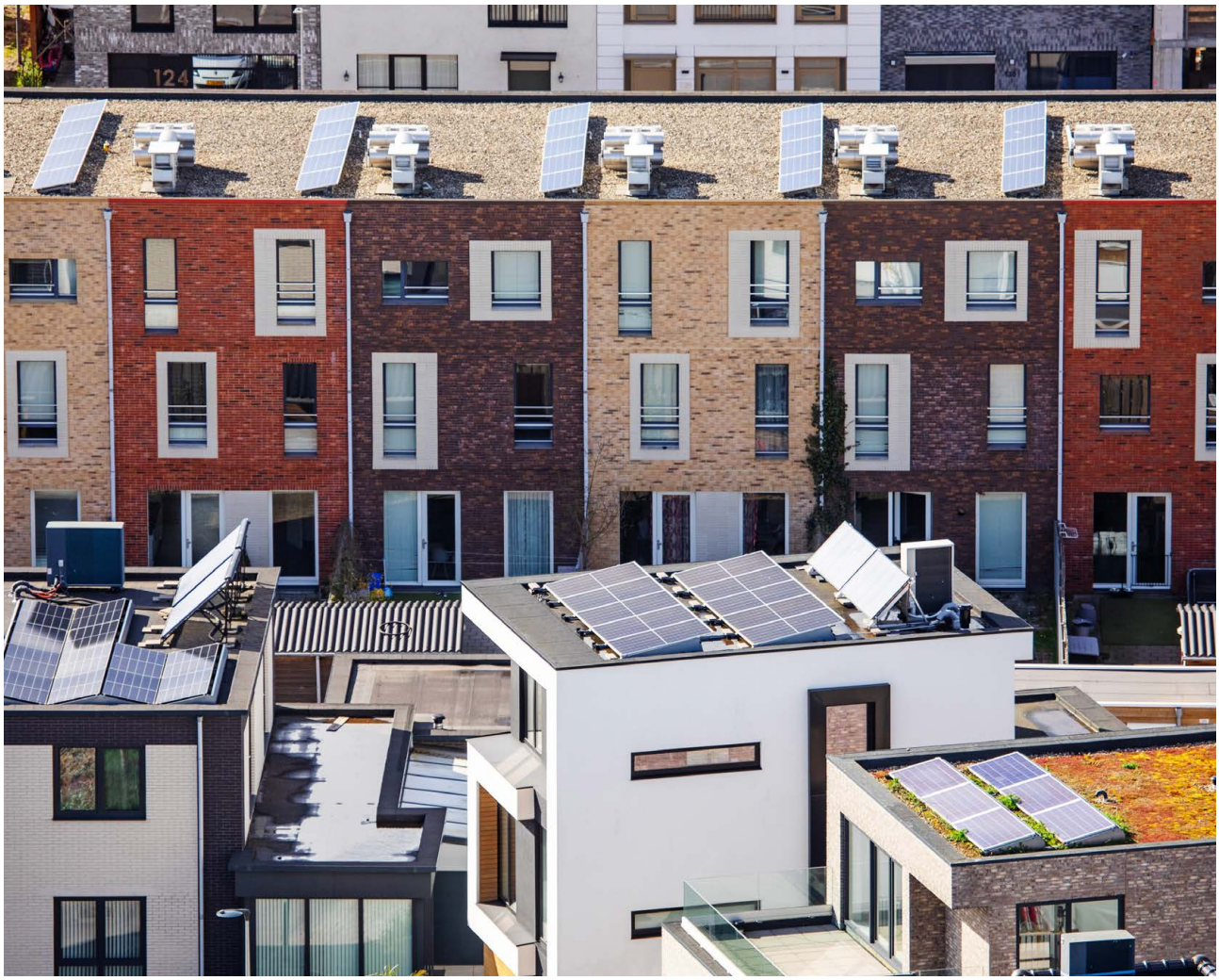
2.2.4 For better high quality of life

PEDs improve quality of life and prioritise inclusive approaches for present and future generations.

PEDs are a powerful instrument in the transition from a centralised and fossil fuel-based energy production system to a decentralised, renewable energy produc-

tion-use system. This transforming ability touches the three axes: social, economic, and environmental sustainability as three interconnected concepts, each of them equally important for the development of PEDs. Each dimension plays a critical role in ensuring the well-being of current and future inhabitants in a PED and promoting a balance between economic stability, social equity, and environmental protection. Thereby, economic sustainability focuses on achieving long-term economic stability and prosperity while minimising negative impacts on society and the environment. Environmental sustainability refers to the responsible stewardship of natural resources and ecosystems to meet the needs of current and future generations without compromising the health of the planet. Achieving social, economic, and environmental sustainability requires a holistic approach that balances the needs and aspirations of society, the economy, and the environment.

In the context of PEDs, the concept of a high quality of life encompasses the idea of creating conditions and opportunities that enable all individuals, communities, and societies to live fulfilling, satisfying, and meaningful lives. In particular, it goes beyond measures of material wealth or economic prosperity rather taking into account the interconnectedness of economic, social, environmental sustainability and cultural factors in shaping the quality of life for individuals and communities. In essence, a "good life for all" reflects a vision of an urban neighbourhood that prioritises human well-being, social harmony, environmental stewardship, and sustainable development. It emphasises the impor-



tance of holistic and inclusive approaches to societal progress including a focus on healthcare, education, social welfare, gender equality, and social cohesion, and thus promoting social sustainability. By working towards a "good life for all," we can strive to create just, prosperous, and sustainable communities for present and future generations also fostering a sense of community and cultural diversity.

By integrating the three dimensions of sustainability into policies, practices, and decision-making processes, more equitable, resilient, and sustainable neighbourhoods can be created.

2.2.5 It creates energy justice

PEDs address energy justice for fair and equitable distribution of renewable energy resources.

Energy justice is a concept that encompasses the fair and equitable distribution of energy resources among individuals and communities within a certain area (in this case, within a PED). It addresses the social, economic, and environmental dimensions of energy production, distribution, and consumption, with a focus on promoting that all people within the geographical area of the PED have access to affordable, reliable, and clean energy sources. Key principles of energy justice in a PED include:

- Equity: Energy justice seeks to ensure that energy resources and services are distributed fairly among all individuals and communities, regardless of income, race, ethnicity, or location. It aims to reduce disparities in energy access and affordability, particularly for marginalised and low-income populations.

- Environmental justice: Energy justice recognises the disproportionate environmental impacts of energy production on disadvantaged communities. It advocates for clean and renewable energy sources that promote environmental sustainability and minimise harm to affected populations.

- Participation and empowerment: Energy justice emphasises the importance of community engagement, empowerment, and decision-making in energy-related policies and projects. It calls for greater transparency, accountability, and inclusivity in energy governance to ensure that the voices of all stakeholders are heard and respected.

- Health and well-being: Energy justice considers the health and well-being implications of energy systems on individuals and communities. It advocates for access to safe and reliable energy sources that support public health, improve living conditions, and enhance quality of life.

Overall, energy justice aims to transform the energy system into one that is socially equitable, environmentally sustainable, and economically viable for all. It seeks to address energy poverty, environmental injustices, and social inequalities by promoting policies and practices that prioritise fairness, inclusivity, and human rights in energy decision-making and planning.

2.2.6 It makes for affordable energy transitions

PEDs create new market opportunities and contribute to making sustainable energy accessible to all.

Ensuring the affordability of the energy transition is vital to its success and central to justifying transformative concepts like PEDs. With their decentralisation and community-based approach, PEDs have the potential to significantly reduce energy costs for end-users. By shifting value from a centralised energy economy to a decentralised model, PEDs empower prosumers, SMEs, and citizens, offering direct savings through energy efficiency and self-generated energy, or local revenues from energy-sharing models.

PEDs also promote local economic development by supporting job creation throughout the PED lifecycle, including installation, maintenance, and advanced service models such as financing and energy flexibility markets. This decentralised ownership of energy assets can generate value for communities through both non-profit and for-profit models, fostering equitable and sustainable growth. At the same time, by strengthening regional and local value chains and supporting innovation, PEDs contribute to the EU's competitiveness objectives, ensuring that the transition to clean energy also enhances Europe's economic resilience and leadership in sustainable technologies.

Affordable energy options provided by PEDs can lower costs for households, alleviate energy poverty, and make sustainable energy accessible to all. Indirect benefits, such as influencing other costs like rent, also need consideration. Financially accessible solutions can increase public support and ensure the broad participation of individuals and organisations in the transition.

In addition to supporting local green economies, PEDs attract businesses and investors committed to sustainability, driving innovation and job creation in the clean energy sector. For public entities, financial sustainability ensures the delivery of essential services, responsible resource management, and long-term fiscal health, all of which are crucial for PED success.

Ultimately, the availability of appropriate financing is a critical enabler for developing PEDs, allowing them to drive the energy transition while ensuring economic and social inclusion.

Photo by: Newpowa on Unsplash

2.3 How do we realise PEDs?

For an impact-driven PED Framework, innovative processes are key. This section elaborates on the crucial elements of how to make transition happen.

2.3.1 We keep the long-term perspective!

Realisation of a PED is a (long-lasting) process.

Achieving climate neutrality is a long-lasting transformation process, to be achieved in the context of future regional or national 100%-Renewable Energy Sources (RES) scenarios. There are no pre-defined or guaranteed recipes for success. However, it is obviously recommendable to build on already existing demonstration projects and elements of PEDs.

Furthermore, PEDs need to be well embedded in stakeholder development and negotiation processes. The transformation process will (hopefully) start with a shared vision of the future. But new challenges will emerge, and the common goals will need to be adapted. Urban neighbourhoods are in constant change, physically, economically, demographically and culturally. PED development as a process is subject to collaboration between many different and changing types of stakeholders.

Many cities have already set up a multitude of local initiatives which touch upon important aspects of the PED concept, although they do not cover all dimensions of the holistic (PED) approach. Those initiatives can be considered important steps towards PED realisation, in spite of being at different levels of maturity.

2.3.2 We align efforts!

The PED development relies on multi-level governance and alignment of initiatives.

Figure 5: How do we realise PEDs?

The PED concept is not about merely putting together different technologies. Rather, it is a holistic concept and takes the systems perspectives into focus. Thus, there is a need for adequate policy frameworks and financial instruments. These frameworks have to be created at different political levels (nationally, regionally, locally).

In this context, multi-level governance refers to the distribution of authority and decision-making power across different levels of government as well as non-state actors such as businesses, civil society and organisations. In such a system, multiple actors at different levels of government and society have to work together to

address complex policy issues and challenges. Such an approach recognises both the interdependence of actors at different levels of governance and the need for coordinated efforts and shared responsibilities to address complex, cross-cutting issues such as developing a PEDs.

By embracing a multi-level governance approach, the relevant problem owners and stakeholders can better address complex policy issues, promote democratic participation, and enhance the effectiveness and legitimacy of public policies and decisions. Ideally, efforts on the local level are aligned with policies and initiatives on the local, regional and national level, incl. EU mission efforts towards sustainability (100 Climate neutral and Smart Cities Mission)

It is worth mentioning that capital and larger cities that do not only have the legal status as municipality, but also as a region, province or federal state, have more legislative powers themselves and therefore more options to shape the policy frameworks to their needs than might be available for other cities.

2.3.3 We cooperate!

PEDs require the cooperation among all main problem owners and key stakeholders.

The implementation of PEDs requires the cooperation of many stakeholders. As an example, local authorities have to make relevant political decisions. Equally important, however, are stakeholders that have to implement the necessary measures and are responsible for investment decisions like e.g. for refurbishment of residential buildings or setting up the necessary technical infrastructures such as heating or cooling networks.

These key stakeholders (city administrations, real estate industry, energy suppliers/grid operators) are also referred to as main problem owners. Without their commitment to take political or investment decisions, the realisation of PEDs is not feasible.

The involvement of these stakeholder groups varies from country to country, depending on the national legal and regula-

tory context. As an example, very different ownership structures regarding heating (or cooling) networks can be observed in Europe. In some countries (e.g. Germany, Austria, Denmark, Switzerland) district heating is mostly supplied by public utilities. In other countries (like e.g. France) district heating networks are typically operated by private companies through a concession.

Thus, depending on ownership structures and legal frameworks, different approaches for cooperation between public and private stakeholders are needed. The viability of innovative energy concepts depends on the right mix of strategies, know-how and on the ambition of decision makers in city administrations and local politics.

Photo by: Dmitrii E. on Unsplash

2.3.4 We empower!

PEDs need to empower local initiatives and energy communities.

Citizen participation and empowering local communities are important success factors for the realisation of PEDs. By actively engaging citizens and civil society, they could play a crucial role in driving the transition towards a more sustainable, efficient, and resilient energy system.

In particular, participating in energy communities can empower citizens to shape their energy production and consumption. This could stimulate economic development, job creation, and investment opportunities within a community.

Local initiatives promote greater community engagement, participation, and ownership in decision-making processes. By involving residents, businesses, and stakeholders in the design, implementation, and management of energy projects, local initiatives can enhance social cohesion, trust, and collaboration within the community. It is further a way to promote energy inclusion.

In this way, such initiatives serve as hubs for innovation, experimentation, and knowledge-sharing, driving progress and fostering learning within and across communities. By testing new technologies, business models, and strategies, energy communities can inspire others and contribute to the scaling up of sustainable solutions.

Furthermore, empowered local initiatives can advocate for policy changes, regulations, and incentives that support renewable energy, energy conservation, and community empowerment. By amplifying their voices and collaborating with other stakeholders, local initiatives can also influence decision-making at higher levels of government and drive systemic change.

2.3.5 We integrate!

Integrate different systems and infrastructures - sector coupling and cross-sectorial integration.

To date, energy infrastructures like e. g. electricity or heating systems and networks, have mostly been operated and

optimised separately. However, there is a lot of technical and economic potential in taking advantage of synergy effects between the different sectors and networks. Due to the high density of infrastructure in comparison to rural areas, this is especially true in the urban context.

Sector coupling will become increasingly important in the near future. It involves linking different energy sectors (electricity, heating, cooling, transportation) to create synergies, maximising the efficiency of energy use and enabling greater utilisation of local renewable energy sources, thereby reducing overall carbon emissions. One example of technologies which enable sector coupling are heat pumps that convert energy between power and heat and are used e.g. also in district heating networks. On the neighbourhood level, for instance, waste heat from industrial processes can be used for district heating, or excess renewable electricity can be stored as thermal energy, etc.

2.3.6 We make connections!

Connect various urban elements and improve spatial planning: Interactions between buildings, the users and the regional energy, mobility and ICT systems.

Interactions between the different building blocks and systems of a PED are crucial for creating intelligent and connected environments that enhance efficiency, comfort, safety, resilience and sustainability. Special attention needs to be paid to the existing building stock, with energy efficiency strategies to be integrated into ambitious refurbishment strategies for urban neighbourhoods. PEDs are an important part of neighbourhood planning or renovation because they promote energy efficiency both inside buildings (more efficient architecture) and in public and private spaces outside. PEDs call for a well thought through spatial policy where mixed functions and density foster walking, biking and public transport, thus reducing energy needs. A place-based

Photo by: Justin Min on Unsplash

approach, taking local specificities into account, is crucial to fully develop the local potential.

By connecting various urban elements, such as buildings, transportation networks, and information systems, city administrations can improve urban planning, resource management, and overall quality of life for residents. Furthermore, by deploying smart sensors, buildings can monitor and optimise energy usage, reduce carbon emissions, and contribute to a greener environment. By integrating ICT systems into buildings, users can benefit from increased efficiency in terms of energy usage, space utilisation, and overall building operations. For example, smart building technologies can optimise lighting, heating, and cooling systems based on occupancy patterns and user preferences.

2.3.7 We ensure sustainable financing!

Unlock responsible investments and lowest cost of green energy for districts and communities.

Sustainable financing for PEDs means embedding environmental, social, and governance (ESG) factors in investment decisions to support long-term projects that prioritise climate neutral infrastructure and social inclusion. Local energy systems within PEDs can reduce energy costs by generating green energy near demand, decreasing reliance on costly grid upgrades, and supporting equitable access to clean energy for everyone. By integrating community-level energy production, PEDs ensure stable, affordable energy prices, particularly in urban settings. Business models are designed to make the energy transition affordable for end-users by distributing the benefits of renewable energy equitably and reducing upfront costs through innovative financing mechanisms, offering flexible payment options tailored to different income levels, establish shared ownership models, peer-to-peer trading or energy-as-a-service models.

To make PEDs investable, innovative policy and governance models are key. Collective Self-Consumption (CSC) and Renewable Energy Communities (RECs) allow communities to share and own energy assets, benefiting from incentives like reduced grid tariffs and tax adjustments. However, challenges in storage, grid interaction, and equitable distribution remain, requiring technical solutions and supportive policies. Building local expertise through tools and education empowers stakeholders – from policymakers to households – to make informed decisions and contribute to PED success.

Access to finance is critical, and frameworks like the European Green Deal support sustainability investments in PEDs. For long-term viability, PEDs need clear standards, certifications, and multi-level governance structures, similar to those seen in the European Building Performance Directive, which raised efficiency standards and drove market innovation. Local authorities play a crucial role in setting PED-aligned urban development standards and creating resources like one-stop-shops to guide communities in this transformative shift toward green, decentralised energy. By emphasising affordability and accessibility, PEDs can serve as a blueprint for a just energy transition. This initiative not only supports Europe's climate goals but also strengthens competitiveness, creates future-oriented markets, and generates jobs across local communities. In collaboration with the European Commission, DUT's efforts will inform policies at the macroeconomic level, fostering institutional frameworks that enable market creation and lay the foundation for a multiplicity of future PEDs. This approach exemplifies mission-driven innovation, turning ambitious climate goals into tangible, community-centred action.

3 Summary conclusions

3.1 PEDs as building blocks for climate neutrality and sustainability

PEDs are crucial in the transition towards climate neutrality and sustainable urban development. They drive innovation and inspire sustainability by not only focusing on reducing greenhouse gas emissions but also optimising the overall energy system. PEDs enhance resilience against energy supply vulnerabilities and climate change impacts by promoting energy efficiency, diversification of renewable sources, and local renewable energy production. They also prioritise the retrofitting and repurposing of existing buildings as well as the transformation of new buildings, which helps to support climate neutrality and preserve cultural heritage. Moreover, PEDs aim to create inclusive, high-quality living environments that balance social, economic, and environmental sustainability. By addressing energy justice, PEDs support fair and equitable access to clean energy for all community members. Financial sustainability is also a key focus, ensuring that the transition to cleaner energy is affordable and accessible, fostering public support and long-term economic viability as well as job creation and access to future markets. In this context, PEDs need to be positioned as integral parts for achieving the European Green deal for overall climate neutrality by 2050 and specifically be integrated into pathways towards the Mission of 100 Climate-neutral and Smart Cities by 2030.

The PED Framework is an impact-driven approach where processes are key. Consequently, realising PEDs is a complex and ongoing process that requires long-term commitment and collaboration across multiple levels of governance and stakeholder groups. The journey towards climate neutrality in PEDs involves leveraging existing projects, engaging diverse stakeholders, and aligning local initiatives with broader regional and national policies. Effective PED development relies on multi-level governance to create the necessary policy frameworks and financial instruments, ensuring that efforts are coordinated across all levels of government and society. Key to success is the cooperation among main problem owners, such as city administrations, real estate industries, and energy suppliers, who must make crucial political and investment decisions. Empowering local communities and fostering energy communities are also vital, as they drive innovation, promote energy inclusion, and stimulate local economic development. Sector coupling and cross-sectoral integration further enhance the efficiency and sustainability of PEDs by linking different energy systems and maximising the use of local renewable energy. Additionally, improved spatial planning and the integration of various urban elements are essential for creating connected, efficient, and resilient neighbourhoods. Finally, ensuring sustainable financing and leveraging new financial frameworks like the EU Taxonomy are critical to supporting the long-term viability of PED initiatives.

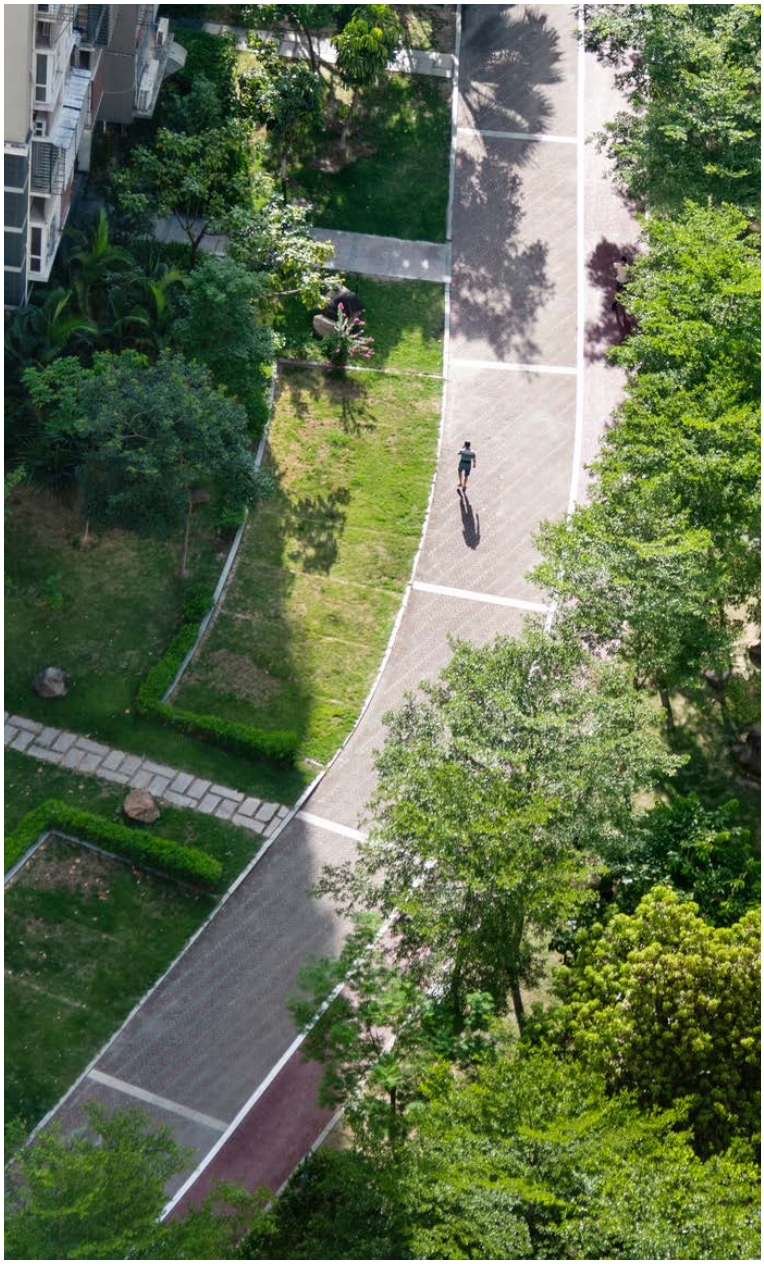
3.2 Implementation on national and regional level

In this Framework, no minimum or maximum size of a district or neighbourhood is determined, due to different conditions in EU-Member States. Nevertheless, it can be stated that a PED comprises a group of connected buildings and utilities within a specific area. In terms of urban functions, the mix of different uses in a specific area (housing, industry, business, etc.) is an important parameter for the definition of case-specific boundaries.

Furthermore, the definition of the terms 'regional' and 'local' has been intentionally left open. In fact, the complexity of energy systems and networks might require system boundaries of various subsystems to be defined differently sector by sector. Various functional boundaries must be taken into account, depending on existing networks and infrastructures and their underlying physics. Thus, there will be differences in the definition of system boundaries between regions and countries, also depending on interconnections with neighbouring regions or countries. Due to different planning cultures and ownership structures, **there is no one-fits-all strategy** regarding the implementation and replication of the PED concept. In particular, strikingly different legal frameworks require different approaches and strategies.

Quantification is a (very) important aspect of the process towards climate neutral neighbourhoods. Nevertheless, detailed quantification rules are not part of this Framework. Instead, this (European) definition only sets out the main features and objectives of PEDs in general. Concrete quantitative specifications or minimum criteria should be defined at national or regional level.

This approach leaves room for the specific framework conditions of neighbourhoods, cities and countries, like e.g., climate zone, population density, type of buildings, access to renewable and waste energy.



4 Annex

Relation to other existing PED definitions

An Energies article published in 2022[9] summarises the different efforts, approaches and struggles in defining PEDs and providing a PED framework on European level. It highlights the delicate balance between a "narrow" framing and a "holistic" framing of the concept. While acknowledging and building on the SET Plan / JPI Urban Europe PED Framework, additional detailing and modifications were included in the work of several R&I networks and initiatives:

EERA Joint Programme Smart Cities: together with the Horizon 2020 Lighthouse project +CityxChange and in cooperation with the SET Plan/JPI UE PED Programme and with the ambition to include more technical and governance challenges based on experiences from the H2020 Lighthouse projects, the initiative elaborated a more detailed framework, including **3 system boundary modes** (geographical / functional / virtual system boundaries) and 4 ambition levels: PEDautonomous, PEDdynamic, PEDvirtual and prePED[10].

9 Vandevyvere, H., Ahlers, D., & Wyckmans, A. (2022). The Sense and Non-Sense of PEDs—Feeding Back Practical Experiences of Positive Energy District Demonstrators into the European PED Framework Definition Development Process. Energies, 15(12), 4491. https://doi.org/10.3390/en15124491

10 PEDautonomous: 'plus-autarkic', net positive yearly energy balance within the geographical boundaries of the PED and internal energy balance at any moment in time (no imports from the hinterland) or even helping to balance the wider grid outside, not expected as a common case;
PEDdynamic: net positive yearly energy balance within the geographical boundaries of the PED but dynamic exchanges with the hinterland to compensate for momentary surpluses and shortages;
PEDvirtual: net positive yearly energy balance within the virtual boundaries of the PED but dynamic exchanges with the hinterland to compensate for momentary surpluses and shortages;
PrePED: candidate PED, no net positive yearly energy balance within the geographical boundaries of the PED but energy difference acquired on the market by importing certified green energy (i.e., realising a zero carbon district).
(Vandevyvere et al. 2022: 8)

IEA EBC Annex 83[11]: Annex 83 defines Positive Energy Districts as "an urban area that annually produces more energy from renewable sources than it consumes. The goal is to create energy-positive urban districts by maximising energy efficiency, integrating renewable energy production, and enabling energy exchange and flexibility at the district level. Key characteristics include the use of local renewable energy sources, energy storage, and smart energy management systems to balance production and consumption."

→ The IEA EBC Annex 83 PED definition focuses on the technical core of PEDs (efficiency, local production, flexibility) and stresses the positive annual energy balance.

11 International Energy Agency Energy in Buildings and Communities Programme (n.d.). Annex 83 – Positive Energy Districts. IEA EBC. Retrieved August 27, 2025, from https://annex83.iea-ebc.org/

dutpartnership.eu