

EXECUTIVE SUMMARY

This Implementation Plan of the Temporary Working Group of the European Strategic Energy Technology (SET)-Plan on Action 3.2 “Smart Cities and Communities” aims to **support the planning, deployment and replication of 100 ‘Positive Energy Districts’ by 2025 for sustainable urbanisation.**

Positive Energy Districts will raise the quality of life in European cities, contribute to reaching the COP21 targets and enhancing European capacities and knowledge to become a global role model.

The Temporary Working Group (TWG) 3.2 has developed an integrative approach to **Positive Energy Districts (PED)** including technological, spatial, regulatory, financial, legal, environmental, social and economic perspectives. PEDs will be developed in an open innovation framework, driven by cities in cooperation with industry and investors, research and citizen organisations. In this context, a PED is seen as a district with annual net zero energy import and net zero CO₂ emissions, working towards an annual local surplus production of renewable energy. The building blocks of PEDs are defined in Section 2.3.

The TWG 3.2 involved delegates from 17 countries (Figure 1) and stakeholders from R&I funding networks, cities, industry, research organisations and citizen organisations (e.g. Joint Programming Initiative Urban Europe, European Regions Research and Innovation Network, Eurocities, European Energy Research Alliance Joint Programme on Smart Cities, European University Association - European Platform of Universities in Energy Research & Education, European Construction Technology Platform).



Figure 1: Countries involved in the TWG 3.2. Smart Cities and Communities

The TWG 3.2 has:

- (1) developed a pathway towards PED in Europe,
- (2) generated commitment for research and innovation, as well as planning and implementation actions (Activity Fiches) to follow the iterative processes along the pathway towards PEDs and
- (3) generated a concept for continuous PED Programme Management ensuring coordination of activities along the pathway towards PEDs.

What has become clear through the work of the TWG is that cities take a unique role on the pathway towards PEDs as host, facilitator and incubator. They are drivers of the process towards PEDs. However, cities cannot succeed without industry as solution provider, they depend on each other. The roles, mandates and decision making authorities of cities and industry vary across Europe, depending on governance structures, planning systems and public private partnership regulations, and cannot be generalised.

Therefore, the process of working with cities as main drivers and industries in implementing PEDs will be an integral part of the Implementation Plan and implemented on several levels, i.e., in the establishment of national networks towards PEDs that mobilise city actors, industry, academia and citizen organisations.

Pathway towards Positive Energy Districts

PEDs require an open innovation model for their planning, deployment and replication. In the TWG 3.2, cities have been identified as the stakeholders who need to take a leading role in the integrated and holistic planning of PEDs, aligning it with their long-term urban strategies. Industries such as real estate developers, construction companies, network operators, utility companies and many others, will play a vital role as solution providers. Energy providers, mobility providers and real estate developers are in need of new business models when energy efficiency and RES become standard in society. Investors will need to develop new models for risk sharing, cooperative innovation and participatory funding pipelines. Citizens will take on a new role as prosumers with active participation in energy trading. Academia will provide robust documentation, monitoring and evaluation, will develop planning tools and technology solutions for the medium-to-long term, and will secure capacity building and education of the next-generation positive energy professionals and citizens.

Consequently, a pathway towards PED has been developed including six modules (**Fehler! Verweisquelle konnte nicht gefunden werden.**), which will be addressed in parallel and inform one another (via an iterative, not linear approach). European cities are invited to become **European Positive Energy Cities**. Cities with the ambition to develop PEDs will be welcome to join a networking activity to identify common dimensions of PEDs across Europe as the basis for national PED certifications and mutually learn from PED pilot activities, e.g., funding models, digital planning and capacity building. The European Positive Energy Cities will be part of and share their knowledge within national networks dedicated to PEDs. **PED Labs**, as seeding ground for new ideas, solutions and services, will be developed according to place-based needs and local context baselines. PED Labs will follow an integrative approach including technology, spatial, regulatory, financial, legal, social and economic perspectives. Based on experiences in the Labs, **PED Guides and Tools** will be developed to support replication and mainstreaming. This includes, e.g. PED definition, national PED certification, a process towards one standard in digital planning, construction, and building information management of PEDs, guides on funding and business models, guides for capacity building and PED planning tools. **PED Replication and Mainstreaming** will be driven by cities, including PED development in their city strategies, providing the necessary pre-conditions for PED deployment and the actual deployment and maintenance of PEDs.

100 Positive Energy Districts in Europe are expected to be in concrete planning, construction, or operation, synergistically connected to the energy system in Europe, by 2025. The ambition of positioning European industry in the global competition for solutions towards PED will be addressed via pilots for more international collaboration efforts of the future. **PED Monitoring and Evaluation** on each point of the pathway will help to constantly make improvements and adaptations along the circle. PED Labs and PED Replication and Mainstreaming are by nature driven by individual cities, whereas the development of PED

Guides and Tools take place at national and European level and the PED Monitoring and Evaluation activities will be carried out locally, but will be linked and synthesised at national and European level as a support action to speed up the process of PED replication and mainstreaming. Each module along the pathway needs dedicated activities, therefore, **Innovation Actions** supported by national and transnational R&I funding ensure knowledge creation, transfer and translation of experience between the modules and stakeholders (e.g., support for PED Labs, support for a common guide on capacity building for PED, development of a common PED monitoring framework).

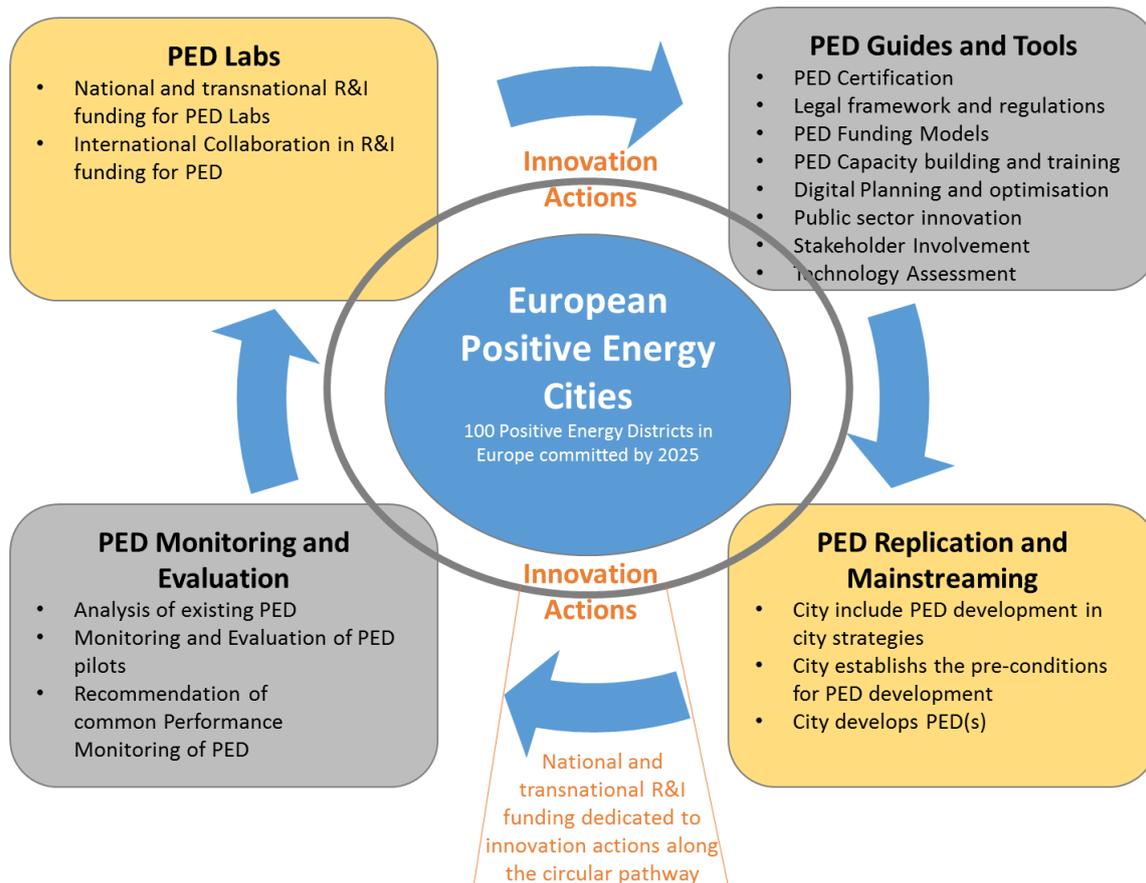


Figure 2: Pathways to Positive Energy Districts in Europe

Commitment for research and innovation as well as planning and implementation actions (Activity Fiches) to follow the pathway towards PED

All members of the TWG 3.2 were asked to propose activities contributing to the targets and the developed pathway towards PEDs. A total number of 12 Activity Fiches were proposed, most of them covering and integrating several topics:

- 4 Activity Fiches support the coordination of the European Positive Energy Cities
- 8 Activity Fiches support the PED Labs
- 9 Activity Fiches support the development of PED Guides and Tools
- 8 Activity Fiches support the PED Replication and Mainstreaming
- 2 Activity Fiches support the PED Monitoring and Evaluation
- 1 Activity Fiche supports Innovation Actions along the pathway

PED Programme Management

There is a need for PED Programme Management to ensure (1) coordination of actors and activities along the pathway, (2) synergies between activities making sure they build on previously achieved results and (3) a speeding up of the process.



Figure 3 Structure needed for Implementation of the Programme/Pathway

For the implementation of the programme it is proposed to create a governance structure in the soon-to-be Implementation Working Group 3.2 (Figure 3), which will evolve out of the current TWG 3.2. It would be headed by an IP Steering Group composed of delegates of the countries involved in the Programme. It would work in close connection with all other stakeholder involved in the Implementation Working Group. The Steering Group would be supported by a Funding Agencies Group, which will work in variable geometry, based on the financial involvement of the respective countries. All of this would be underpinned by a well-established Programme Management Structure, which can be provided by the JPI Urban Europe. Most of the countries engaged in the SET-Plan TWG 3.2 are also members of the JPI Urban Europe. However, joining the JPI Urban Europe as a full member would not be a pre-requisite for participating in the IP Steering Group, or the Programme Management of this Implementation Plan. In addition to the funding budgets for transnational joint calls (as indicated in the Activity Fiches), the Programme Management would rely on cash or in-kind support from the involved SET-Plan countries as the Implementation Plan progresses along its way.

Budget

In order to give a budget estimation, the focus is set on public R&I funding of the participating countries dedicated towards PED development. Based on a recent assessment of national R&I programmes dedicated to urban sustainability, ERA-NETs and the annual joint calls organised by the JPI Urban Europe heading towards a similar direction, the following budgetary indications can be given for the next 8 years (2018-2025):

- PED Labs: **20 M€** of transnational R&I funding through JPI Urban Europe (and EC) and **100 M€** through alignment of national R&I funding
- Innovation Actions: **80 M€** of transnational R&I funding and **300 M€** through alignment of national R&I funding
- PED Knowledge Diffusion and experiences: **7 M€** through alignment of national R&I funding/programmes

Together with the private funding required by law to co-fund any innovation-related public funding, the total envisaged budget involved is of a magnitude of **0.74 Billion €** in R&I funding over the period of **2018-2025**. Obviously the final budget allocation will depend on national decisions of R&I funders and programmes. The investments on the ground which will be needed in terms of infrastructure, construction and refurbishment can be estimated at a **minimum of 100 Billion €** and will typically be carried by cities, real estate developers and housing companies.

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1. INTRODUCTION AND POLICY CONTEXT

1.1. Integrated SET-Plan and Key Priority Actions

The Strategic Energy Technology (SET) Plan has been recognised as one of the major tools to deliver the Energy Union Strategy¹, by contributing to the cost reduction and improvement of the performance of low carbon energy technologies through impactful synergetic innovation actions.

As part of the deliverables of the Energy Union Strategy, the European Commission adopted a Communication for an Integrated Strategic Energy Technology Plan² in 2015. The Communication identifies ten priority actions to accelerate the energy system transformation through coordinated or joint investments between European countries, private stakeholders (including research and industry) and the European Commission. SET-Plan Action Number 3 (out of the ten priority actions), namely, 'Create technologies and services for smart homes that provide smart solutions to energy consumers' was divided up into two Sub-Actions: 3.1 "Smart Solutions for Energy Consumers", and 3.2 "Smart Cities and Communities". For each Sub-Action an Implementation Plan has been developed. The Implementation Plan described in this document is dedicated to Sub-Action 3.2.

1.2. Scope and Participation of SET-Plan Action 3.2 "Smart Cities and Communities"

The strategic target of the Implementation Plan was inspired by discussions in the European Innovation Partnership on Smart Cities and Communities, especially by the Initiative on Positive Energy Blocks (at least three connected buildings) and the "Zero Energy/Emission Districts" mentioned in the TWG 3.2 Declaration of Intent³. The ambition was raised towards having 100 Positive Energy Districts by 2025 in Europe as a strategic target of this Implementation Plan, in order to address the ambitious climate targets of the COP21 agreement, and to align with the increasingly progressive goals foreseen by the Energy Efficiency and Buildings Directives (EED)⁴, under which EU countries must set up an energy efficiency obligation scheme, and recently adopted new Energy Efficiency in Buildings Directive (EPBD)⁵, which foresees the development of a smart readiness indicator to measure the capacity of buildings to use information and communication technologies and electronic systems to adapt the operation of buildings to the needs of the occupants. The package of measures proposed by the European Commission on November 2016, the so-called Clean Energy Package (CEP)⁶, sets out a new approach that aims at enabling the consumers to become active and central players of the future. The development of smart cities and communities is a key element for a successful clean energy transition, the growth sector of the future. A Temporary

¹ Energy Union Package, COM (2015)80 final

² (C(2015) 6317 final)

³ SET Plan – Declaration of Intent on Strategic Targets in the context of an Initiative for Smart Cities and Communities, https://setis.ec.europa.eu/system/files/integrated_set-plan/action3_2_scc_declaration_of_intent.pdf

⁴ Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on Energy Efficiency.COM (2016) 761 final

⁵ [Proposal for the Directive of the European Parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings.COM \(2016\) 765 final](https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition)

⁶ <https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition>

Working Group (TWG) 3.2 “Smart Cities and Communities” was set-up in April 2017 to propose the actions and commitments needed for the planning, deployment and replication of Positive Energy Districts (PEDs) as foreseen in this Implementation Plan.

The TWG is chaired by national representatives from Austria and co-chaired by representatives from the European Regions Research and Innovation Network (ERRIN) and the European Construction Technology Platform (ECTP). Delegates from 17 countries are involved in the TWG 3.2 (see Figure 4). They work in close cooperation with stakeholders from cities, industry, research organisations and citizen organisations (e.g. Joint Programming Initiative Urban Europe, Eurocities, European Energy Research Alliance Joint Programme on Smart Cities, European University Association - European Platform of Universities in Energy Research & Education). All members of this TWG 3.2 are listed in Annex 1. The Implementation Plan is expected to be endorsed by the Steering Group members in June 2018.



Figure 4: Countries involved in the TWG 3.2 Smart Cities and Communities

1.3. Learning experiences and outcomes from the work of the TWG 3.2

What has become clear through the work of the TWG, is that cities take a unique role on the pathway towards PEDs as host, facilitator and incubator. They are drivers of the process towards PEDs. However, cities cannot succeed without industry as solution provider, they depend on each other. Among the industries active in the urban context of PEDs are real estate developers, housing providers, energy and mobility providers, technology providers, and planning, engineering and construction companies. The roles, mandates and decision making authorities of cities and industry vary across Europe, depending on governance structures, planning systems and public private partnership regulations, and cannot be generalised. The process of working with industries when implementing PEDs will therefore be an integral part of the Implementation Plan and will take place in dialogue between national PED city networks

and the respective investors and providers, as main actors in the respective national planning and implementation culture (see Section 4 and Module 1).

We have to acknowledge that almost all existing PED examples in Europe could only be delivered through a partnership of certain technology providers with cities, and which allowed ample opportunities for learning, both on a technological and process level (see Section 3.1 and Annex 2 for details).

2. VISION, STRATEGIC TARGET AND UNDERSTANDING OF POSITIVE ENERGY DISTRICTS

2.1. Vision

Positive Energy Districts raise the quality of life in European cities, contribute to achieving the COP21 targets and enhancing European capacities and knowledge to become a global role model. The TWG 3.2 “Smart Cities and Communities” has developed an integrative approach including technology, spatial, regulatory, legal, financial, environmental, social and economic perspectives, to support the planning, deployment and replication of PEDs for sustainable urbanisation.

2.2. Strategic Target

Europe to become a global role model in integrated, innovative solutions for the planning, deployment and replication of Positive Energy Districts with the aim to have at least 100 Positive Energy Districts by 2025, that are synergistically connected to the energy system in Europe.

2.3. Definition and scope of Positive Energy Districts

PEDs require interaction and integration between buildings, the users and the regional energy, mobility and ICT system, as well as an integrative approach including technology, spatial, regulatory, financial, legal, social and economic perspectives (Figure 5). Ideally, PEDs will be developed in an open innovation framework, driven by cities in cooperation with industry and investors, research and citizen organisations.

In this context, a PED is seen as a district with annual net zero energy import⁷, and net zero CO₂ emission working towards an annual local surplus production of renewable energy. The defining aspects, or “building blocks” of PEDs are:

- A PED is embedded in an urban and regional energy system, preferably driven by renewable energy, in order to provide optimised security and flexibility of supply.

⁷ Electricity generated by dedicated renewable energy systems in the region as well as biomass which is supplied to the PED is not necessarily regarded as import into the PED.

- A PED is based on a high level of energy efficiency, in order to keep annual local energy consumption lower than the amount of locally produced renewable energy.
- Within the regional energy system, a PED enables the use of renewable energy by offering optimised flexibility and in managing consumption and storage capacities on demand. Active management will allow for balancing and optimisation, peak shaving, load shifting, demand response and reduced curtailment of RES, and district-level self-consumption of electricity and thermal energy
- A PED couples built environment, sustainable production and consumption, and mobility to reduce energy use and greenhouse gas emissions and to create added value and incentives for the consumer. E.g., PEDs facilitate increased EV charging capability within the district and ensure that the impact of EVs on the distribution will be minimised by using local generation where possible.
- A PED makes optimal use of elements such as advanced materials, local RES and other low carbon energy sources (e.g. waste heat from industry and service sector, such as data centres), local storage, smart energy grids, demand-response, cutting edge energy management (electricity, heating and cooling), user interaction/involvement and ICT.
- PED should offer affordable living for the inhabitants.

PEDs will be implemented in newly built and retrofitted districts or districts with a mix of both.

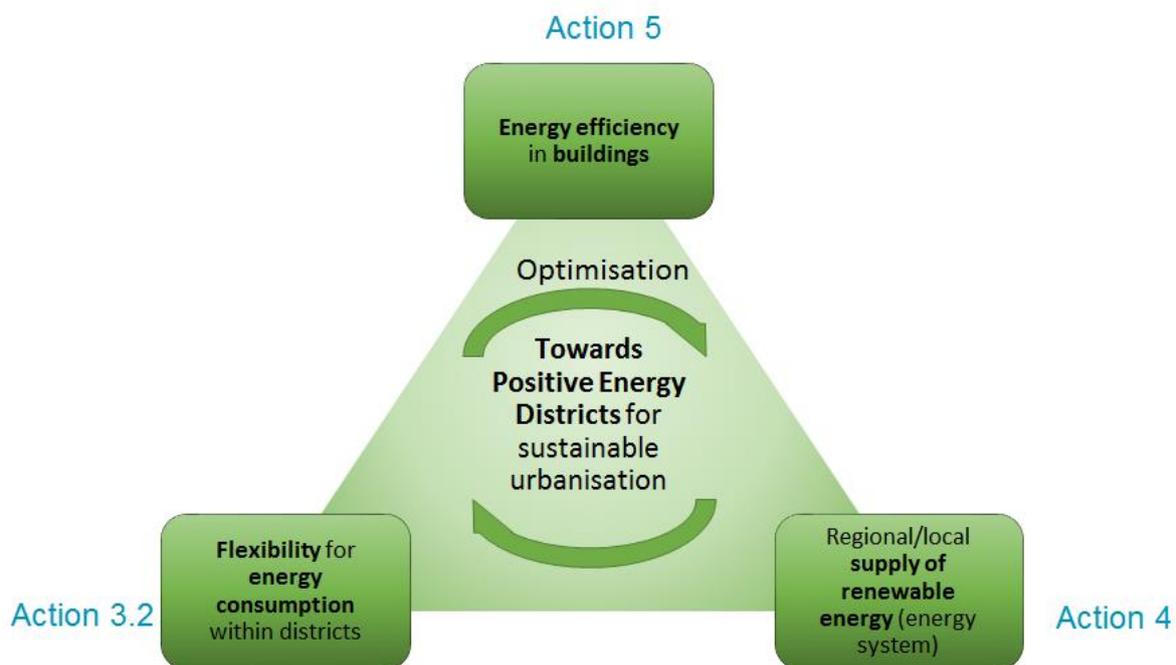


Figure 5: Definition of Positive Energy Districts

3. STATE OF PLAY AND CHALLENGES TO DEPLOY POSITIVE ENERGY DISTRICTS

3.1. State of Play

The European society should take steps from Zero and Plus Energy Buildings, Positive Energy Blocks and Green Districts to Positive Energy Districts and Cities over time to reach the

European energy and climate targets. A review of existing Zero and Positive Energy Buildings (Annex 2) shows encouraging examples that provide lessons learned and valuable sources for adaptation for the envisaged PEDs. The main features of such Zero and Plus Energy Buildings are their reliance on on-site renewable energy supply, advanced energy saving measures in terms of efficient construction (building insulation and orientation), efficient appliances and optimized operation and maintenance. These features can be transferred from individual buildings to district solutions, e.g. combining onsite PV and nearby (i.e. district level) heat provision via a DH network.

3.2. Challenges and Requirements for Deploying PEDs

The deployment of PEDs within European cities will face a set of diverse challenges embedded predominantly in technological, social, economic, financial, environmental and legal/regulatory areas. Tackling such challenges calls for integrated and innovative solutions to spur the deployment of PED in respect to the sustainable urban transformation process. Main challenges and their solution approach can be summarized by the following requirements and needs for (Figure 6):

1. **Integrated and innovative technologies for PEDs:** to tackle the innovation need across building, energy, mobility and ICT sectors, including integrated urban energy system operation and planning and digital planning of cities (see Annex 3 and Annex 5). Guidelines and tools for planning and designing PED are necessary to support the PED developers and managers to calculate optimized PED solutions adapted to the local conditions, including the identification of optimized PED systems and the development of implementation roadmaps from the starting point until the finalization of the PED.
2. **Societal innovation, social entrepreneurship and citizen participation:** aiming to integrate societal innovation, social entrepreneurship and citizen participation to spur the deployment of PED within an integrated urban transformation process;
3. **New energy markets and sustainable funding models for implementation of PEDs:** the deployment of PEDs is expected to impact the whole energy market and its related technological, financial and regulatory aspects. Key aspects correspond to new innovative energy solutions and corresponding new roles such as prosumers, the complex regulatory framework and the resulting investment risks that require credible and robust investment concepts and access to new financing schemes.
4. **Regulatory framework, certification and standardisation:** to formulate and approve policy, regulation and standards for issuing legislation on PED and its impact on the actual construction and management process, impose standards, test and attest novel solutions on PED and issue certification for realised solutions. For PEDs it is essential that the overall optimal result is envisaged and not limited by a focus on individual buildings and solutions. KPIs and minimum requirements must be further developed or newly defined also at the district level. Improved international standards are needed in order to define the PED by using the KPI provided by the certification schemes.

5. **Capacity-building, education and training:** Building the knowledge base for and supporting the whole process of developing and deploying PEDs, including the steering of the PED implementation process. This requires technical process expertise, public administration and regulatory authorities to handle and oversee the implementation process of PED.
6. **Co-creation, open innovation, public sector innovation and procurement:** the transformation pathway towards PEDs requires a structured, integrated and innovative approach embedded within the city's overall vision and based on a co-creation process involving all relevant stakeholders. In this regard, open innovation pipelines from research to market and society, with living labs, innovation playgrounds and urban prototyping will be useful instruments for developing integrated innovative solution for PEDs. Furthermore, strong leadership of public sector is essential to lead the transformation process and respond to the emergence of PEDs besides stimulating innovative public procurement and its ability to push innovation to lead market strategy through appropriate instruments (e.g. green public procurement, e-procurement, pre-commercial procurement (PCP) or research oriented public procurements) targeting the development of investible PED projects.
7. **Replication, upscaling and mainstreaming** to replicate the PED pilot in other districts of the city as well as in other cities: cooperative innovation shall be enabled, including replication profiles, feasibility studies, intellectual property rights, market access, and STI cooperation.
8. **Business models for implementation and operation of PEDs:** the large-scale deployment of PEDs requires the development of sustainable business models that consider the whole process of building, operating and maintaining PEDs and engage all actors among owners, city authorities, real estate developers and operators of the energy infrastructure.



Figure 6: Key challenges and needs for deploying PEDs

4. PATHWAY TOWARDS POSITIVE ENERGY DISTRICTS

PEDs require an open innovation model for their planning, deployment and replication. As energy efficiency and RES, onsite and on the district level, are becoming standard practice in society, energy providers, mobility providers and real estate developers are in need of new business models.

Investors will need to develop new models for risk sharing, cooperative innovation and participatory funding pipelines.

Citizens will take on a new role as prosumers with active participation in energy trading. Academia will need to provide robust documentation, monitoring and evaluation, development of solutions for the medium-to-long term, and secure capacity building and education of the next-generation positive energy professionals and citizens.

Cities have been identified in the TWG 3.2 as the stakeholders who need to take a leading role in the integrated and holistic planning of PEDs in line with their long-term urban strategies.

In order to pave the way for 100 PEDs by 2025, this Implementation Plan introduces six interlinked modules along a circular pathway towards PEDs (Figure 7), namely 1) European

positive energy cities, 2) PED labs, 3) PED guides and tools, 4) Replication and Mainstreaming, 5) PED Monitoring and Evaluation and 6) Innovation Actions for PEDs.

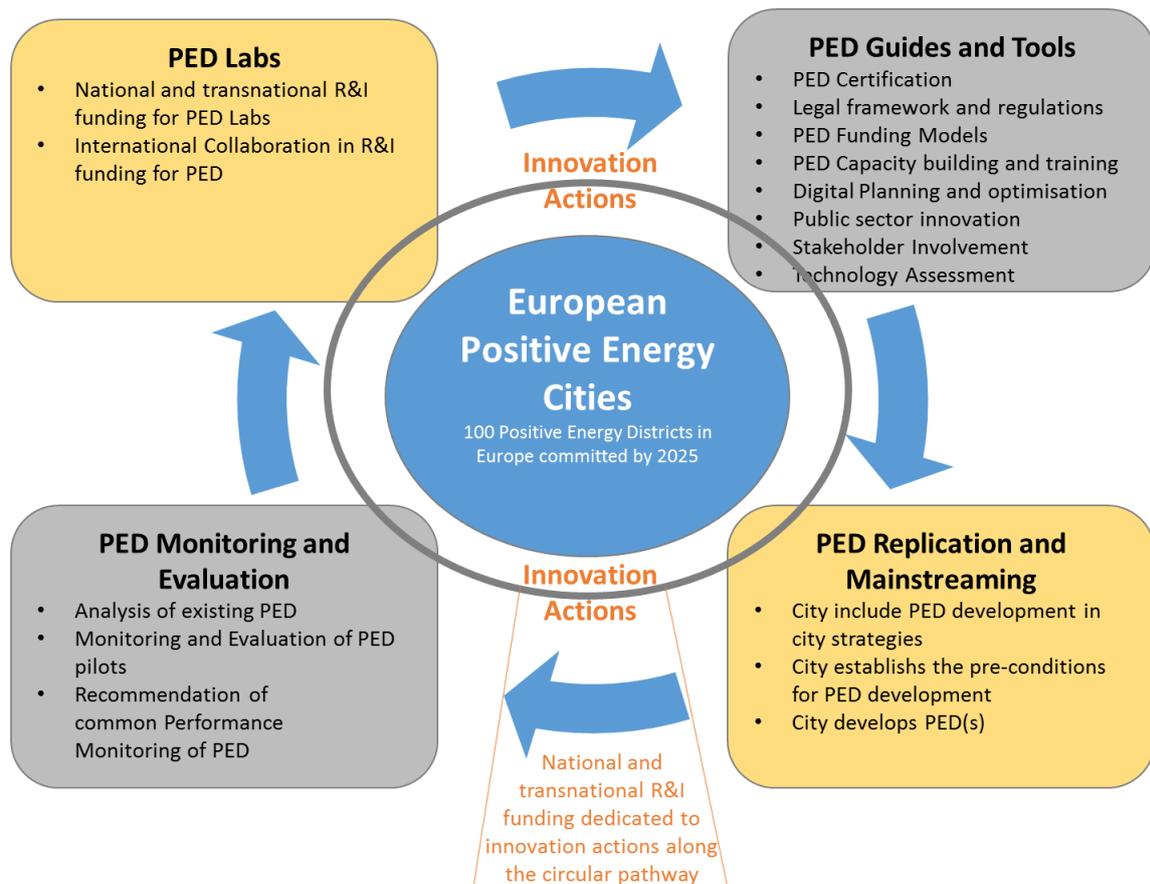


Figure 7: Pathways to Positive Energy Districts in Europe

In order to involve a broad range of relevant stakeholders and ensure successful implementation of PEDs, cities need to take a leading role. Therefore, cities will be invited to become **European Positive Energy Cities** (Module 1). Cities with the ambition to develop PEDs will be invited to join a networking activity to (1) identify common dimensions of PEDs across Europe as basis for national PED certifications and (2) mutually learn from PED Labs, e.g. on funding models, digital planning and capacity building. Although the network of European Positive Energy Cities will be city-driven, energy and mobility providers, real estate developers, energy utilities, investors, citizen organisations and academia will be engaged in the network, depending on steps that need to be taken (e.g. PED certification needs a strong role of national policy makers; new business models need a strong role of real estate developers and construction industry).

The European Positive Energy Cities will be part of and share their knowledge within national networks dedicated to PEDs.

PED Labs (Module 2) will be developed according to place-based needs and local context baselines. PED Labs will be pilot actions that provide opportunities to experiment with planning and deployment of PEDs, as well as provide seeding ground for new ideas, solutions and services to develop. PED Labs will follow an integrative approach including technology, spatial, regulatory, financial, legal, social and economic perspectives.

Based on experiences in the Labs, **PED Guides and Tools** (Module 3) will be developed to support planning and designing, implementation and monitoring, as well as replication and mainstreaming of PEDs. Experiences on local level will be synthesised and interlinked on national and European level to develop PED Guides and Tools. This will include, e.g. development of planning tools, national PED certification, a process towards one standard in digital planning of PEDs, construction, and building information management of PEDs, guides on funding and business models and guides for capacity building.

PED Replication and Mainstreaming (Module 4) will call for cities to include PED development in their city strategies, take care of the necessary pre-conditions for PED deployment and the actual deployment and maintenance of PEDs. **100 Positive Energy Districts in Europe are expected to be in concrete planning, construction, or operation, synergistically connected to the energy system in Europe by 2025.** The ambition of positioning European industry in the global competition for solutions towards PEDs will be addressed via international cooperation in the framework of COP21 and Mission Innovation.

PED Monitoring and Evaluation (Module 5) on each point of the pathway will help to constantly make improvements and adaptations along the cycle. Monitoring and Evaluation of PEDs will take place on local level, but findings will be linked on national and European level to develop recommendations for common monitoring and evaluation activities across Europe.

Each module along the pathway will need dedicated activities, therefore **Innovation Actions** (Module 6) will be supported by national and transnational R&I funding to ensure knowledge creation, transfer and translation of experience between the modules and stakeholders (e.g. support for PED Labs, support for a common guide on capacity building for PED, development of a common PED monitoring framework).

The six modules of the circular pathway towards PEDs will be addressed in parallel and will inform one another (via an iterative, not linear approach). The modules will be described in more detail in the following paragraphs.

4.1. Module 1: European Positive Energy Cities

Objective: Set-up a dialogue among cities or national city networks on the planning, financing, deployment and replication of PEDs; ensure an integrated open innovation process in PED development

Process:

- Mobilise cities with an ambition to develop “Positive Energy Districts for sustainable urbanization” (e.g. shown in Sustainable Energy Action Plans) for a **European city-driven network towards PEDs** in cooperation with public utilities, infrastructure operators, construction industry, real estate developers, research organisations and citizen organisations.
- European Positive Energy Cities will be involved in all activities/modules on the pathway to PEDs, therefore the network provides them with the opportunity to contribute to the development of:

- **Joint understanding and definition of PED:** Identifying the common building blocks of PED across cities and countries as a basis for shared tools and services and common PED Monitoring and Evaluation
- **PED Labs:** Preparing and setting up PED Labs using a place-based perspective and experience with new digital planning, permit giving, construction, and building management standards, regulatory innovation zones, new technologies, sector coupling, stakeholder involvement, etc.
- **PED Guides and tools:** Contribution and assessment of drivers and enabling conditions for PEDs, e.g.:
 - Common aspects for national PED certification
 - Legal frameworks, regulations and standardisation for PEDs
 - Funding model and investments for PED
 - PED capacity building and training
 - Digital Planning and optimization for PED
 - Identification of local potentials for RES, efficiency, storage
 - Public sector innovation
 - Stakeholder Involvement
 - Technology Assessment and Integration
 - Policy support for PED on national level
- **PED Replication and Mainstreaming:** Share good practices on replication and mainstreaming and establish strong links between the European Positive Energy Cities and their national networks to support replication.
- **PED Monitoring and Evaluation:** Contribute and commit to a common Performance Monitoring of PED, respecting place-based differences.
- Grow the number of European Energy Cities, especially in the dialogue on learning and replication.
- The European Positive Energy Cities will be a mobiliser of **national networks towards PEDs** and translate dialogues on European level to national level and the other way around. Additionally they will coordinate and engage:
 - with national ministries or agencies (e.g., on national PED certification)
 - with local public utility providers, real estate developers, planners and construction industry (e.g., on business models for PEDs and certification)
 - with local citizen organisations (e.g., on stakeholder involvement in PED planning and development)
 - with research organisations or networks of research organisations to adapt research and technology to local needs and identify training and skills needed for PED planning, deployment and use

Triggering implementation of Module 1

Activity leader	Fiche No	Tasks to be performed
JPI Urban Europe	1	➤ Offer to host, coordinate and grow the network of European Positive Energy Cities in their AGORA
JPI Urban Europe, ERRIN, Eurocities	1, 5, 6	➤ Inform and mobilise cities for the engagement activity, also in cooperation with other networks, i.g. E5, Covenant of Mayors, ICLEI, Alliance for Sustainable Urbanisation, EERA JPSC City Advisory Committee, SCC Lighthouse and Follower Cities, Celsius Cities, cities active in the EIP SCC Initiative on Positive Energy Blocks, National cities/stakeholder networking platform (e.g. AT, NO, FR, etc.)
EERA Joint Programme Smart Cities	4	<ul style="list-style-type: none"> ➤ Develop and scientifically validate PED definition and boundary conditions ➤ Define, plan and execute the RDI needed to move from PED to Positive Energy Cities and Societies, in line with new knowledge and ambitions on an international, EU and national scale

4.2. Module 2: PED Labs

Objective: Develop city-driven PED Labs according to individual cities' needs and approaches towards PED, in Europe and globally.

Process:

- PED Labs will be pilot actions of cities towards PEDs. **PED Labs are designed for cities' needs** and support concrete next steps in the planning and deployment phase, which includes a range of activities and steps towards PEDs (e.g. test new technologies, test new forms of stakeholder engagement, test new regulations, test new funding mechanisms)
- PED Labs should support cities in the development of innovative solutions (that can then be used and replicated in all PEDs)
- A systematic analysis of experiences and lessons learnt from already existing PEBs and PEDs should inform the set-up and specificities of PED Labs. The goal is to create, collect, qualify, compare and analyze data from the 100 European PEDs, which then contribute to the PED Lab. The identification of how each system innovation evolves in specific settings helps to plan and manage the spatial diffusion of such PED innovations and to strategically feed into the value chains
- Mobilise cities to develop PED Labs in Europe **funded through national and transnational R&I funding**, which can alleviate the first-mover risk of creating new solutions
- Identify and monitor PED Labs in participating networks of cities, industry partners, universities and research institutes, support development of existing and new PED Labs to function as open innovation playgrounds

- **International cooperation** in R&I funding for PEDs will be considered to meet the ambition of positioning European industry in the global competition for solutions towards PEDs. Identify potential international/global PED Lab development and initiate cooperation

Triggering implementation of Module 2

Activity leader	Fiche No	Tasks to be performed
EERA Joint Programme Smart Cities	3, 4	<ul style="list-style-type: none"> ➤ Identify and monitor PED labs in our networks of cities, industry partners, universities and research institutes. Use own facilities as living labs (our own campuses, research and work facilities, cities). Support development of existing and new PED Labs to function as open innovation playgrounds; ➤ Develop a virtual PED lab that shows how these solutions can be integrated and deployed in a specific urban context, with a database and a system for sharing data (BIM, smart meters, GIS, satellite, cell phones, sensors etc), in cooperation with the EERA Secretariat and other EERA JPs; ➤ Create, collect, qualify, compare and analyse data from the 100 European PEDs, contributing to the virtual PED lab ➤ Identify potential international/global PED Lab development and initiate cooperation (e.g., scoping workshops coordinated by the URBAN-EU-CHINA Innovation Platform on Sustainable Urbanisation, in cooperation with JPI UE in China) ➤ Use the Technology Roadmap towards PED of EERA JP SC to inform the design of PED Labs
JPI Urban Europe	2	<ul style="list-style-type: none"> ➤ Establishment of a decision process for Innovation Actions to fund PED Labs by transnational R&I funding, however pilot actions towards PED are not limited to JPI Urban Europe funded PED Labs
ERRIN, Eurocities	5,6	<ul style="list-style-type: none"> ➤ Mobilise cities to initiate PED Labs
EUA Energy and Environment Platform	7	<ul style="list-style-type: none"> ➤ Will engage with PED Labs to learn about the needs for capacity building and training
European Construction Technology Platform	10	<ul style="list-style-type: none"> ➤ Develop digital modelling of cities for energy management including built and natural environments

4.3. Module 3: PED Guides and Tools

Objective: Develop guides and tools based on the needs of the PED stakeholders and the learning experience from PED Labs as a basis for successful planning and designing, implementation and operation, as well as replication and mainstreaming of PEDs

Process:

- **Development of common criteria for national PED certification:** The development of common criteria for PED certification based on ongoing activities in several countries (e.g. Switzerland, Austria) could be the starting point for national or European level PED certificates. PED certificates are enablers and serve as quality assurance and

marketing tools which attract cities as well as investors. Thus, they may accelerate PED replication

- **Guidance on regulations and legal frameworks for PEDs** reveal differences in national level regulations and legal frameworks towards PED and provide good practice considering place-based differences
- **Guidance on funding models for PEDs:** Analysis and recommendations for different funding models for PEDs for all relevant actors and all phases of PED development
 - City authorities (planning)
 - Real estate developers/planning and construction industry (deployment)
 - Infrastructure Operators (energy, mobility, maintenance)
- **Guide on capacity building in institutions and training**
 - Provide recommendations to city authorities on institutional resources (e.g. additional skills and funding) and policy coordination (horizontally and vertically)
 - Development of a training and skills catalogue necessary for the development of PEDs, i.e. for staff at city authorities, university graduates, construction industry
- **Guide on stakeholder participation for PED development** shares approaches of stakeholder participation in PED Labs as a basis for replication and mainstreaming
- **Public sector innovation:** Initiate a discussion on how public sector innovation and the development of PEDs can be connected and how synergies can be created.
- **Technology Assessment and Integration for PEDs:** Assessment of technologies in PED Labs and other pilot actions and dissemination of technology assessments to cities and industry actors to enable learning. Later on, their optimized integration should be addressed according to local boundary conditions, while also taking into account innovative concepts. Finally, future technology scenarios should be developed considering uncertainties (e.g. energy prices), assess technological alternatives and include risk management/ sharing.
- **Digital planning and optimisation for PED:** Develop processes, tools and standards for digital planning of PEDs in city authorities using the same standards and common tools, but at the same time considering the local characteristics and needs. Develop those standards and tools in a way that they can be integrated with other digital tools in permitting, construction, and the operation of buildings (BIM) and, consequently, provide optimized holistic system solutions, taking into account interdependencies between the sectors, as well as transformation and implementation plans.

All guides and tools will be made public on the EIP SCC Marketplace to reach a broader audience.

Triggering implementation of Module 3

Activity leader	Fiche No	Tasks to be performed
JPI Urban Europe	2	<ul style="list-style-type: none"> ➤ Support the development of guides and tools for PEDs through Innovation Actions; Innovation Actions are an instrument of JPI Urban Europe, aligning national R&I funding programmes in order to take up cities' needs and address them via dedicated R&I activities funded by participating countries (for more information see Annex 4)
EUA Energy and Environment Platform	7	<ul style="list-style-type: none"> ➤ Contribution to the training catalogue for university graduates
ERRIN, Eurocities	5,6	<ul style="list-style-type: none"> ➤ Support for the development of guides and tools with knowledge, coordination competences and funding ➤ Support the dissemination and exploitation of guides and tools
European Construction Technology Platform	9, 10	<ul style="list-style-type: none"> ➤ Develop a TOOLBOX for Positive Energy Blocks upgradable to Districts ➤ Develop digital modelling of cities for energy management including built and natural environments
EERA Joint Programme Smart Cities	4	<ul style="list-style-type: none"> ➤ Develop a toolbox of planning instruments for PEDs, including data and metrics, planning and design, and investment and business models; ➤ Identify and analyse policy mixes and initiatives for PED transitions. Enable and encourage transfer from research into practice, as well as co-creation with industry and city partners; ➤ Suggest how to revise the regulatory framework; ➤ Build capacity (training, education, knowledge exchange), exchange researchers, organize mobility to promote knowledge exchange (young and experienced researchers, industry and city networks)
European Technology & Innovation Platform on Renewable Heating and Cooling	11	<ul style="list-style-type: none"> ➤ Development of guidelines which describe step by step how the energy system of the PED can be designed and optimized ➤ Develop a web-based planning tool, which allows to calculate an cost-optimized energy system for a PED taking into account sector coupling and the dynamic of the energy system.
Euroheat & Power	12	<ul style="list-style-type: none"> ➤ Development of toolbox of solutions and technologies regarding DHC of PEDs

4.4. Module 4: Replication and Mainstreaming of PED

Objective: Support European cities in replication and mainstreaming to have 100 Positive Energy Districts in Europe committed by 2025

Process: Individual cities and their cooperation partners from industry, infrastructure operators, research organisations and citizen organisations lead replication and mainstreaming of PED demo experiments, PED labs and knowledge derived from testing and implementing PED building blocks. The following activities of cities will be supported by the guides and tools of

Module 3 and can be taken as an indicator showing that PEDs are in concrete planning, construction, or operation:

- City includes PED development in its city strategies by:
 - Creating a vision and intention in city's strategies
 - Assessing replicability and scalability
 - Preparing a PED plan
- City establishes appropriate pre-conditions for PEDs through:
 - Preparing the necessary local legal framework
 - Coordinating within city authority and on national level
 - Building or facilitating commitment of several stakeholders
 - Realigning and mobilising the necessary resources (e.g. funding, capacity building, etc.)
 - Modifying institutional structures in cities when necessary
 - Preparing PED performance monitoring
- City develops PED(s) via:
 - Coordination of PED deployment
 - Quality assurance of PED deployment
 - Conducting and maintaining performance monitoring

Triggering implementation of Module 4

Activity leader	Fiche No	Tasks to be performed
JPI Urban Europe, ERRIN and Eurocities	1, 5, 6	➤ Grow the platform for the network of European Positive Energy Cities to enable replication and mainstreaming in cooperation with other networks, especially the EIP SCC Initiative on Scaling up & Replication of Smart City Plans
JPI Urban Europe	2	➤ Launch of Innovation Actions according to the R&I-needs indicated by cities in the phase of replication and mainstreaming
EERA Joint Programme Smart Cities	4	<ul style="list-style-type: none"> ➤ Activate national EERA networks to engage with cities for PED planning, deployment and use; ➤ Identify and document barriers, challenges and opportunities in existing PED projects. What are the main causal mechanisms that either enable or inhibit successful diffusion of PED innovation, systems, or policies, and how can PED innovations be scaled up both within the EU and beyond
European Construction Technology Platform	9	➤ Development of a TOOLBOX for Positive Energy Blocks upgradable to Districts

European Technology & Innovation Platform on Renewable Heating and Cooling	11	➤ Compilation and description of a list of demonstration examples of existing technologies and solutions for PEDs in new construction and retrofitting
Euroheat & Power	12	➤ Demonstration examples of existing technologies and solutions for PEDs in new construction and retrofitting

4.5. Module 5: PED Monitoring and Evaluation

Objective: Monitor, evaluate and assess PED performance to support each module with relevant information for learning

Process:

- Develop and recommend a common monitoring and evaluation framework for PED planning, deployment and use/maintenance respecting place-based differences which can then be used and implemented on national and individual city level
- PED monitoring and evaluation is not limited to technology aspects, but takes spatial, regulatory, legal, financial, social and economic perspectives into account
- Development of guidelines for systemic and standardized PED monitoring and evaluation including key performance targets as well as process oriented targets to ensure high quality monitoring including data measurement, collection, processing, assessment and storage.
- Analysis and assessment of existing Zero and Positive Energy Buildings and Districts to inform the specifications of PED Labs
- Monitoring and evaluation of PED pilots (e.g. PED Labs, H2020 SCC Lighthouse Projects with a focus towards PED, etc.) to provide learnings for the guides and tools to be developed in Module 3

Triggering implementation of Module 5

Activity leader	Fiche No	Tasks to be performed
JPI Urban Europe	2	➤ Launch of Innovation Actions supporting the necessary activities to develop a common framework for monitoring and evaluation, which can be used for the cities' own purposes

EERA Joint Programme Smart Cities	4	<ul style="list-style-type: none"> ➤ Support in defining core KPIs for PEDs, systematically screen existing and new PEDs using these KPIs, and report them into the Smart Cities Information System ➤ Provide inputs to the PED Labs, as a basis for knowledge exchange and learning, and as a basis for designing strategies for replication and mainstreaming
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4.6. Module 6: Innovation Actions

Objective: Innovation Actions funded by national and transnational R&I funding aim to support innovation activities along the circular implementation pathway to avoid or alleviate potential risks and ensure knowledge flows through the different modules.

Process:

- National and transnational R&I funding will be dedicated to Innovation Actions along the circular pathway (see Annex 4 for more information on the Innovation Actions of the JPI Urban Europe)
- Participation by national R&I programmes in the funding of Innovation Action calls is not limited to JPI Urban Europe members, but is open to all European and international countries
- Innovation Actions will be used to drive the pathway forward, e.g. to support
 - cities and their cooperation partners to set-up PED Labs (Module 2)
 - the development of guides and tools (Module 3)
 - innovative activities in cities in the replication and mainstreaming process (Module 4)
 - the analysis and monitoring of PED and the development of a common framework (Module 5)

Triggering implementation of Module 6

Activity leader	Fiche No	Tasks to be performed
JPI Urban Europe	2	<ul style="list-style-type: none"> ➤ Provide the instrument of Innovation Actions (transnational R&I funding for a joint call) as a flexible mechanism to support the pathway to PEDs ➤ JPI Urban Europe has established and tested the Innovation Action as a new call instrument in 2017. It picks up and focuses on the specific innovation needs of problem owners (cities, industry), and was first used and tested in the transnational call “Making Cities Work” resulting in very positive feedback from stakeholders.

4.7. Timeline for the circular Pathway towards PEDs

The following Figure 8 presents the timeline for the circular pathway towards PEDs.

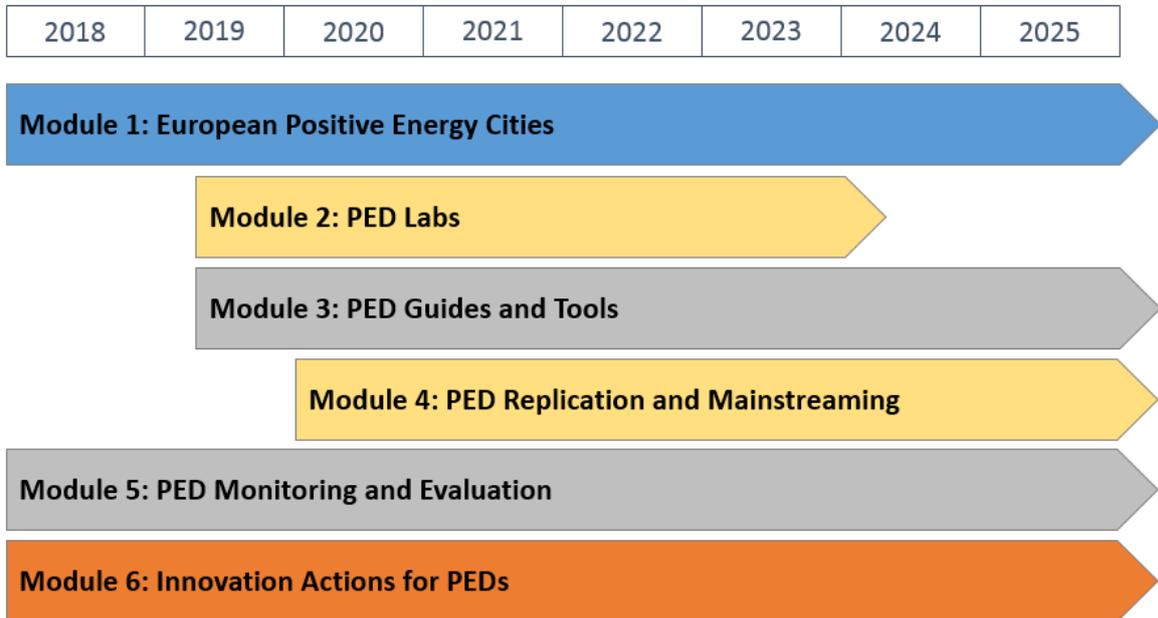


Figure 8: Timeline for the circular pathway towards PEDs

5. ACTIVITY FICHES

5.1. Activity Fiches supporting the circular pathway towards PEDs

For the implementation of the circular pathway towards PEDs Activity Fiches have been formulated by stakeholders as a way to indicate their commitment to research and innovation, as well as planning and implementation actions. A total number of 12 Activity Fiches were proposed by stakeholders (Table 1).

Considering learning from the TWG 3.2. (Section 1.3), cities take a unique role on the pathway towards PEDs as host, facilitators and incubator. They are drivers of the process towards PEDs. However, cities cannot succeed without industry as solution provider. At this stage, the European Construction Technology Platform gathers commitment from industry, while nationally active real estate developers, housing providers, energy and mobility providers, technology providers, and planning, engineering and construction companies will be mobilised via national networks. This activity is an integral part of the Implementation Plan.

Table 1 Overview of Activity Fiches for the Pathway towards PEDs

Fiche No	Activity leader	Target
1	JPI Urban Europe	a) Coordinate and promote the network of European Positive Energy Cities in the JPI UE AGORA stakeholder platform b) Adjust JPI UE Programme Management Structure to support the SET-Plan Implementation Working Group 3.2 on Smart Cities and Communities
2	JPI Urban Europe	c) Provide R&I funding for PED Labs, Innovation Actions, and international R&I funding collaborations d) Facilitate the alignment of national programmes and calls towards PED across Europe e) Potential ERA-NET or EJP Cofund on PEDs
3	EERA Joint Programme Smart Cities	Presentation, Publication and Dissemination of a Technology Roadmap for PED in the European Union towards 2025
4	EERA Joint Programme Smart Cities	To develop a systematic, robust, evidence-driven approach for PED Labs as open innovation playgrounds – enabling PED lab results to be scaled up, transferred and mainstreamed across European cities as well as global society.
5	European Regions Research and Innovation Network	Mobilisation of cities, support of guidelines and support for cities in replication and mainstreaming
6	Eurocities	Mobilisation of cities, support of guidelines and support for cities in replication and mainstreaming

7	EUA Energy and Environment Platform	Support capacity building and education (trainings and curricula that build future knowledge base) based on PED Labs and pilots
8	JPI Urban Europe	a) Assessment of additional international cooperation actions b) Pilot collaboration with China in joint R&I funding and implementation of PED
9	European Construction Technology Platform	Develop a TOOLBOX for Positive Energy Blocks upgradable to Districts (Industry support to the implementation of PEDs)
10	European Construction Technology Platform	Accessible physical and thermal digital modelling of cities for energy management including built and natural environments (Industry support to the implementation of PEDs)
11	European Technology & Innovation Platform on Renewable Heating and Cooling	Provide a toolbox of solutions and technologies regarding RHC of PEDs (Industry support to the implementation of PEDs)
12	Euroheat & Power	To provide a toolbox of solutions and technologies regarding DHC of PEDs (Industry support to the implementation of PEDs)

Figure 9 illustrates which Activity Fiches (together with their respective stakeholders) support the different actions of the circular pathway towards PEDs:

- 4 Activity Fiches support the coordination of the European Positive Energy Cities
- 8 Activity Fiches support the PED Labs
- 9 Activity Fiches support the development of PED Guides and Tools
- 8 Activity Fiches support the PED Replication and Mainstreaming
- 2 Activity Fiches support the PED Monitoring and Evaluation
- 1 Activity Fiche supports Innovation Actions along the pathway

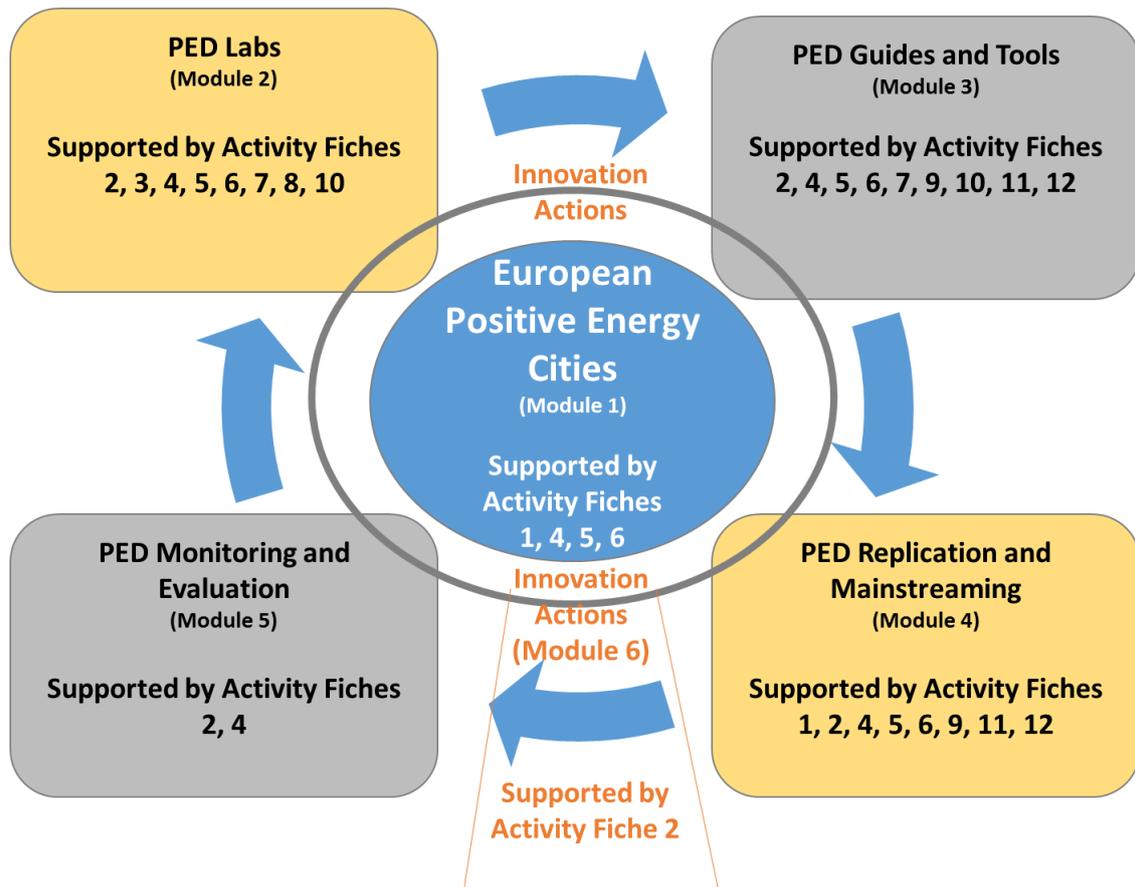


Figure 9: Activity Fiches and their contribution to the implementation of the circular pathway towards PEDs

5.2. Budget

The evaluation of the financing needs and funding sources for the activities included in this IP is complex. Unlike other technological frameworks, the stakeholders driving the pathway towards PEDs are cities. Partners from private companies involved in PED development are public utilities and infrastructure providers, real estate developers and planners, investment firms, technology and service providers and construction sector. Additionally, national authorities (e.g. ministries responsible for regulations or certifications) play a crucial role. RTOs and civil society organisations will also be involved in the development of PEDs. The different stakeholders will support the pathway towards PEDs with different means: public R&I funding for projects, in-kind funding of R&I research organisations, in-kind contributions of cities that engage in the process; communication and promotion channels by city networks; mandatory cash contributions from industry for R&I projects funded through national funding agencies.

In order to give a budget estimation, the focus is put on the public R&I funding of the participating countries dedicated towards PED development. Based on a recent assessment of national R&I programmes dedicated to urban sustainability, ERA-NETs and the annual joint calls organised by the JPI Urban Europe Calls heading towards a similar direction, the following budgetary indications can be given for next 8 years (2018-2025):

The total envisaged budget is **0.74 Billion €** in public and private R&I funding for the period **2018-2025** given in the Activity Fiches, but obviously final budget allocation will depend on national decisions of R&I funders and programmes and strategic decisions in companies.

Among the total envisaged budget the following activities can be highlighted:

- PED Labs: **20 M€** of transnational R&I funding through JPI Urban Europe (and EC) and **100 M€** through alignment of national R&I funding
- Innovation Actions: **80 M€** of transnational R&I funding and **300 M€** through alignment of national R&I funding
- PED Knowledge Diffusion and Experiences: **7 M€** through alignment of national R&I funding/programmes

In the majority of participating countries national public research funding, especially innovation funds, need to be matched by contributions of the beneficiaries. On average, approximately **at least 30% (150M€ out of 500M€)** of **public funding** will be contributed by the beneficiaries (depending on the national funding rules). Additionally, **public R&I funding is expected to have a leverage effect**, leading to investments for the deployment and operation of PEDs, infrastructure, construction and refurbishment by cities, public housing organisations, real estate developers etc. The investments on the ground can be estimated at a **minimum of 100°Billion°€**.

5.3. Activity Fiche 1: JPI Urban Europe –European Positive Energy Cities

R&I Activity Fiche 1:
<p>Target:</p> <ol style="list-style-type: none"> a) Coordinate and promote the network of European Positive Energy Cities in the JPI UE AGORA stakeholder platform b) Adjust JPI UE Programme Management Structure to support the SET-Plan Implementation Working Group 3.2 on Smart Cities and Communities
<p>Activity supports the pathway towards Positive Energy Districts: Modules 1, 4</p>
<p>Activity leader: JPI Urban Europe</p>
<p>Description of activity:</p> <ol style="list-style-type: none"> 1. Adjust the existing Programme Management structure of JPI Urban Europe, so that it can serve as a support to the SET-Plan Implementation Working Group 3.2 <ol style="list-style-type: none"> a. Set up a Strategic R&I plan with all participating countries b. Establish a monitoring plan and instrument c. Prepare joint calls d. Assess disseminate results e. Evaluate progress and success 2. Mobilise cities with an ambition to develop “Positive Energy Districts for sustainable urbanization” for a <i>European city-driven networking activity</i> in cooperation with public utilities, infrastructure operators, construction industry, real estate developers, research organisations and citizen organisations 3. Facilitate dialogue on <ul style="list-style-type: none"> ● Joint understanding and definition of PED ● PED Labs: Preparing and setting up PED Labs using a placed-based perspective and experience with new digital planning, permit giving, construction, and building management standards, regulatory innovation zones, new technologies, sector coupling, stakeholder involvement, etc. ● PED Guides and tools: Contribution and assessment of drivers and enabling conditions for PEDs, e.g. <ul style="list-style-type: none"> ▪ Common aspects for national PED certification ▪ Legal frameworks, regulations and standardisation for PEDs ▪ Funding model and investments for PED ▪ PED capacity building and training ▪ Digital Planning for PED ▪ Public sector innovation ▪ Stakeholder Involvement ▪ Technology Assessment ▪ Policy support for PED on national level ● PED Replication and Mainstreaming: Share good practices on replication and mainstreaming and establish strong links between the European Positive Energy Cities and their national networks to support replication ● PED Monitoring and Evaluation: Contribute and commit to a common Performance Monitoring of PED with respected to placed based differences
<p>TRL: 8-9</p>

Total budget required: 2 M€
Expected deliverables: Platform established; dialogue process ongoing
Timeline: continuously
Partners and stakeholders involved: National PED cities networks of participating countries; partner networks on European level, e.g. ERRIN, Eurocities, Covenant of Mayors, E5 Network, etc.
Implementation financing / funding instruments: cash and in-kind personnel contributions for management efforts by participating countries
Indicative financing contribution: 2 M€ from participating countries over 8 years
Ongoing R&I Activities relevant to this new activity proposal: Modules 2, 3, 5; JPI Urban Europe Activities

5.4. Activity Fiche 2: JPI Urban Europe – PED Labs and Innovation Actions

R&I Activity Fiche 2:
Target: <ol style="list-style-type: none"> Provide R&I funding for PED Labs, Innovation Actions, and international R&I funding collaborations Facilitate the alignment of national programmes and calls towards PED across Europe Potential ERA-NET or EJP Cofund on PEDs
Activity supports the pathway towards Positive Energy Districts: Module 2, 3, 4, 5
Activity leader: JPI Urban Europe
Description of activity: <ol style="list-style-type: none"> Preparation of the implementation of Strategic R&I Plan (Activity Fiche 1) into series of transnational calls Planning and execution of calls towards PED Labs and Innovation Actions for PEDs Facilitation of transnational collaboration regarding alignment of national programmes and R&I funding calls towards PEDs Application for ERA-NET or EJP Cofund and subsequent implementation of call activities with focus on digital planning
TRL: 2-7
Total budget required: 635 M€
Expected deliverables: Calls prepared and launched for PED Labs and Innovation Actions
Timeline: Annual
Partners and stakeholders involved: Approx. 20 participating European countries in variable geometry;
Implementation financing / funding instruments: national R&I funding programmes of participating countries; H2020 cofund for potential digitalisation call
Indicative financing contribution: <u>PED Labs:</u> 20 M€ of transnational R&I funding through JPI Urban Europe contributed by participating countries in variable geometry 10 M€ as Cofund potentially provided by European Commission 100 M€ through alignment of national R&I funding over 8 years approx. 30 M€ in mandatory contribution from project participants (cities & industry) <u>Innovation Actions:</u> 80 M€ of transnational R&I funding contributed by participating countries in variable geometry 300 M€ through alignment of national R&I funding over 8 years approx. 95 M€ in mandatory contribution from project participants (cities & industry)
Ongoing R&I Activities relevant to this new activity proposal: Module 1, JPI Urban Europe Activities

5.5. Activity Fiche 3: EERA JP SC - Technology Roadmap for PEDs

R&I Activity Fiche 3:
Target: Presentation, Publication and Dissemination of a Technology Roadmap for PED in the European Union towards 2025
Activity supports the pathway towards Positive Energy Districts: 2
Activity leader: EERA Joint Programme Smart Cities (EERA JPSC) / AIT
<p>Description of activity:</p> <p>The EERA Joint Programme Smart Cities has developed a Technology Roadmap for PEDs toward 2025 as a contribution to the Implementation Plan in its preparation phase. The Technology Roadmap is presented in Annex 5.</p> <p>EERA Joint Programme Smart Cities will contribute with a concerted effort of its expert partners from research, industry and cities to:</p> <ul style="list-style-type: none"> ➤ Present, promote and disseminate the Technology Roadmap for PEDs ➤ Inform national and transnational calls for PEDs with the research needs identified in the Technology Roadmap for PEDs ➤ Mobilise EERA JP SC Members and the its national networks to support cities in the set-up of PED Labs
TRL: 4-6
Total budget required: 1 M€
Expected deliverables: Technology Roadmap for PED in the European Union towards 2025
Timeline: continuously: 2018
Partners and stakeholder involved: all partners in EERA JPSC: research organisations, cities, industry in EERA JP SC
Implementation financing / funding instruments: national R&I Programmes and FP9
Indicative financing contribution: 200.000 € in kind EERA and 800.000 national and FP9 R&I funding
Ongoing R&I Activities relevant to this new activity proposal: Module 1, 3, 4, 5, EERA JPI SC Activities

5.6. Activity Fiche 4: EERA JPSC - Diffusion of knowledge and experiences

R&I Activity Fiche 4:
<p>Target: To develop a systematic, robust, evidence-driven approach for PED Labs as open innovation playgrounds – enabling PED lab results to be scaled up, transferred and mainstreamed across European cities as well as global society.</p>
<p>Activity supports the pathway towards Positive Energy Districts: 1, 2, 3, 4, 5</p>
<p>Activity leader: EERA JPSC / NTNU</p>
<p>Description of activity: The EERA Joint Programme Smart Cities will contribute with a concerted effort of its expert partners from research, industry and cities to:</p> <p>Contribute to Module 1 “Towards European Positive Energy Cities”:</p> <ul style="list-style-type: none"> • Develop and scientifically validate PED definition and boundary conditions; • Define, plan and execute the RDI needed to move from PED to Positive Energy Cities and Societies, in line with new knowledge and ambitions on an international, EU and national scale <p>Contribute to Module 2 “PED Labs”:</p> <ul style="list-style-type: none"> • Identify and monitor PED labs in our networks of cities, industry partners, universities and research institutes. Use our own facilities as living labs (our own campuses, research and work facilities, cities). Support development of existing and new PED Labs to function as open innovation playgrounds; • Develop a virtual PED lab that shows how these solutions can be integrated and deployed in a specific urban context, with a database and a system for sharing data (BIM, smart meters, GIS, satellite, cell phones, sensors etc), in cooperation with the EERA Secretariat and other EERA JPs; • Create, collect, qualify, compare and analyse data from the 100 European PEDs, contributing to the virtual PED lab • Identify potential international/global PED Lab development and initiate cooperation (e.g., scoping workshops coordinated by the URBAN-EU-CHINA Innovation Platform on Sustainable Urbanisation, in cooperation with JPI UE in China) <p>Contribute to Module 3 “PED Guides & Tools”:</p> <ul style="list-style-type: none"> • Develop a toolbox of planning instruments for PEDs, including data and metrics, planning and design, and investment and business models; • Identify and analyse policy mixes and initiatives for PED transitions. Enable and encourage transfer from research into practice, as well as co-creation with industry and city partners; • Suggest how to revise the regulatory framework; • Build capacity (training, education, knowledge exchange), exchange researchers, organize mobility to promote knowledge exchange (young and experienced researchers, industry and city networks) <p>Contribute to Module 4 “PED Replication & Mainstreaming”:</p> <ul style="list-style-type: none"> • Activate national EERA networks to engage with cities for PED planning, deployment and use;

<ul style="list-style-type: none"> Identify and document barriers, challenges and opportunities in existing PED projects. What are the main causal mechanisms that either enable or inhibit successful diffusion of PED innovation, systems, or policies, and how can PED innovations be scaled up both within the EU and beyond <p>Contribute to Module 5 “PED Monitoring & Evaluation”:</p> <ul style="list-style-type: none"> Define core KPIs for PEDs; Systematically screen existing and new PEDs, using these KPIs, and report them into the Smart Cities Information System
<p>TRL: Mainly TRL 5-7 for the PED Labs (validation and demonstration in relevant environment, prototyping of systemic solutions for PEDs rather than individual technologies).</p>
<p>Total budget required: 18 M€ (4 years) Equipment: € 250,000 (Y1); € 750,000 (Y2); € 500,000 (Y3); € 500,000 (Y4) Consumables: € 250,000 (Y1); € 250,000 (Y2); € 250,000 (Y3); € 250,000 (Y4) Personnel: € 3.0 million (Y1); € 3.5 million (Y2); € 3.5 million (Y3); € 4.0 million (Y4) Other cost; € 250,000 (Y1); € 250,000 (Y2); € 250,000 (Y3); € 250,000 (Y4) Total: € 3.75 million (Y1); € 4.75 million (Y2); € 4.5 million (Y3); € 5.0 million (Y4)</p>
<p>Expected deliverables: D1: Systematic, evidence-driven approach for PED Labs (Month 6) D2: Database of PED Labs in Europe + associated global PED Labs (Month 12 + updates) D3: Virtual platform for Positive Energy Districts, Cities and Societies (Month 12 + updates)</p>
<p>Timeline: 4 years (can be extended)</p>
<p>Partners and stakeholder involved: Full and Associated Partners of EERA JP Smart Cities EERA JPSC City Advisory Committee National networks of industry, cities and research of the EERA JPSC partners</p>
<p>Implementation financing / funding instruments: Clustering / Alignment of already funded PED Labs H2020 SCC-01 projects and related calls JPI UE Joint Calls Climate-KIC / KIC InnoEnergy National funding mechanisms Digital Innovation Hubs</p>
<p>Indicative financing contribution: 7 M€ (50% of personnel costs) of EERA JPSC, 11 M€ national and FP9 R&I funding</p>
<p>Ongoing R&I Activities relevant to this new activity proposal: See all suggested contributions to the other modules</p>

5.7. Activity Fiche 5: ERRIN - Mobilising cities

R&I Activity Fiche 5:
Target: Mobilisation of cities, support of guidelines and support for cities in replication and mainstreaming by dedicated knowledge and resources of ERRIN
Activity supports the pathway towards Positive Energy Districts in Modules: 1, 2, 3, 4
Activity leader: ERRIN
Description of activity: <ul style="list-style-type: none"> - Inform and mobilise interested cities in ERRIN to become part of the network on European Positive Energy Cities and promote the set-up of PED Labs (support for Module 1 and Module 2) - Mobilise in cooperation with other cities (e.g. Eurocities, ICLEI) additional cities for the pathway towards PED and invite them to join the process (support for Module 1) - Support the development of guides and tools (in Module 3) with knowledge, coordination competences and funding (support for Module 3) - Support cities in the replication and mainstreaming phase (Module 4)
TRL: 8-9
Total budget required: in-kind 0,2 M€
Expected deliverables: European Positive Energy Platform
Timeline: 2018-2025
Partners and stakeholder involved: cities and other city networks
Implementation financing / funding instruments:
Indicative financing contribution: in-kind 0,2 M€ (meeting facilities, person months, materials, travel)
Ongoing R&I Activities relevant to this new activity proposal:

5.8. Activity Fiche 6: Eurocities - Mobilising cities

R&I Activity Fiche 6:
Target: Mobilisation of cities, support of guidelines and support for cities in replication and mainstreaming by dedicated knowledge and resources of Eurocities
Activity supports the pathway towards Positive Energy Districts in Modules: 1, 2, 3, 4
Activity leader: Eurocities
Description of activity: <ul style="list-style-type: none"> - Inform and mobilise interested cities in Eurocities to become part of the network on European Positive Energy Cities and promote the set-up of PED Labs (support for Module 1 and Module 2) - Mobilise in cooperation with other cities (e.g. ERRIN, ICLEI) additional cities for the pathway towards PED and invite them to join the process (support for Module 1) - Support the development of guides and tools (in Module 3) with knowledge, coordination competences and funding (support for Module 3) - Support cities in the replication and mainstreaming phase (Module 4)
TRL: 8-9
Total budget required: in-kind 0,2 M€
Expected deliverables: European Positive Energy Platform
Timeline: 2018-2015
Partners and stakeholder involved: cities and other city networks
Implementation financing / funding instruments:
Indicative financing contribution: in-kind 0,2 M€ (meeting facilities, person months, materials, travel)
Ongoing R&I Activities relevant to this new activity proposal:

5.9. Activity Fiche 7: EUA-EPUE – Capacity Building

R&I Activity Fiche 7:
Target: Support capacity building and education (trainings and curricula that build future knowledge base) based on PED Labs and pilots
Activity supports the pathway towards Plus Energy Districts in Module(s): 2, 3
Activity leader: EUA Energy and Environment Platform (EUA-EPUE)
<p>Description of activity:</p> <p>EUA-EPUE has, based on the input of its university experts, have identified the activities that support learning from existing PED demonstrators and pilots to plan and initiate the replication and mainstreaming of PED (as described in Module 3 of the Implementation Plan).</p> <ul style="list-style-type: none"> • Build effective PED bottom-up community-level actions that are resilient and adaptive to social, economic, and technological change. • Bridge technological and social innovation aspects: incorporating the social and technological dimension not only helps to foster smart and sustainable neighbourhoods, but also builds and/or reconstructs mixed and multifunctional, liveable spatial patterns and public spaces • Capacity building and engagement with civil society: Capacity building should care for a comparison of the Universities’ curricula to agree upon a common workflow (e.g. concept of Collaborative Innovation Networks). Furthermore, engaging with civil society requires research on their expectations which are often unknown or heterogeneous <p>Activities:</p> <p>This section intends to identify concrete actions to achieve the objective of PED translation and learning from PED innovation labs for follower cities (as mentioned in Module 3).</p> <p>1) Maps on methods and business models of “Smart cities and communities”</p> <ul style="list-style-type: none"> • Mapping of methods: a key important factor for the study of smart cities and communities is human behaviour and interaction, alongside institutional development and technological adaptation. The use of simulation modelling can for instance support this multi-dimensional study. • Mapping of business models: new business models that deeply engage citizens and various forms of local governance and energy regulators are required to support these new developments. Analysis of existing and new business and contracting models, taking into account organisational, financial, legislative, social and technological barriers. <p>2) Training courses and dissemination activities on smart cities</p> <ul style="list-style-type: none"> • Development of skill needs and training catalogue for university graduates (incl. competences in technologies, but also social sciences) based in experiences in PED labs. • Serious games and roles plays to enable cooperation between researchers and practitioners and support collective decision making. • Host workshops and discussions on the topic of capacity building for PEDs:

<ul style="list-style-type: none"> ✓ Learn from success stories and from mapping exercise and share best practices. ✓ Engage with citizens, professional training associations, long-life learning institutions, industry clusters in smart cities, municipalities, technology transfers (e.g. accelerator, incubators), associations of secondary school representatives. <p>3) Development of guidelines</p> <ul style="list-style-type: none"> • ‘Guidelines of capacity building and training needs for PED deployment’ with knowledge, coordination competences and funding • Guidelines take into account multidisciplinary approaches in higher education and research programmes (particularly in Master, Doctorate and Research Programmes)
TRL: 6-8
Total budget required: 5 M€
<p>Expected deliverables:</p> <ol style="list-style-type: none"> 1) Maps on methods and business models of “Smart cities and communities” 2) Training courses and dissemination activities on smart cities 3) Development of guidelines
Timeline: continuously
Partners and stakeholder involved: academia, industry, research institutions, financial institutions, local and national authorities, communities
<p>Implementation financing / funding instruments:</p> <p>A mixture of national, European and private funding</p>
Indicative financing contribution: in-kind of universities to develop training curricular and align them among universities, 5 M€ public (e.g. cities, national and FP9 R&I funding programmes) and private sources (e.g. public utilities, industry)
Ongoing R&I Activities relevant to this new activity proposal: Module 1, 4, 5

5.10. Activity Fiche 8: JPI Urban Europe – International Cooperation

R&I Activity Fiche 8:
Target: a) Assessment of additional international cooperation actions b) Pilot collaboration with China in joint R&I funding and implementation of PED
Activity supports the pathway towards Positive Energy Districts: Module 2, 5
Activity leader: JPI Urban Europe
Description of activity: <ol style="list-style-type: none"> 1. Assessment of additional international cooperation actions in the topic of PED 2. Preparation of R&I funding and implementation strategy with China as a pilot for international collaboration 3. Series of 2-3 scoping workshops with Chinese and European stakeholders, in cooperation with EERA JP Smart Cities / URBAN-EU-CHINA 4. Implementation of one joint R&I call with China 5. Subsequent opening of ongoing PED calls for Chinese stakeholders (funded by China) 6. Implementation collaboration via Chinese dissemination partners (CCUD, CAUPD) in close partnership with European Commission; facilitation of city partnerships for solution sharing; cooperation with URBAN-EU-CHINA / EERA JP Smart Cities 7. Evaluation of results and conclusions for other actions of international collaboration
TRL: 2-8
Total budget required: 35 M€
Expected deliverables: Call prepared and launched; potential Chinese involvement in subsequent calls negotiated and established; implementation collaboration agreed;
Timeline: 2022 and later
Partners and stakeholders involved: Approx. 20 participating European countries in variable geometry; China;
Implementation financing / funding instruments: national programmes of participating countries; potential contribution from FP9
Indicative financing contribution: 15 M€ in public R&I funding contributed by participating European countries in variable geometry for the first joint call; approx. 15 M€ from Chinese side for their national participants; 5 M€ potential contribution for implementation collaboration from European Commission
Ongoing R&I Activities relevant to this new activity proposal: see Module 1, 3, 4, 6, Activities within JPI Urban Europe

5.11. Activity Fiche 9: ECTP – From Positive Energy Blocks to Districts

R&I Activity Fiche 9:
Target: to develop a TOOLBOX for Positive Energy Blocks upgradable to Districts
Activity supports the pathway towards Positive Energy Districts: Module 3, 4
Activity leaders: ECTP – European Construction Technology Platform & EIP SCC -European Innovation Partnership on Smart Cities and Communities – Action Cluster for Sustainable Districts and Built Environment (AC SDBE)
<p>Description of activity:</p> <p>In order to successfully develop PEDs, it is vital to first model its smallest component, the Positive Energy Block. This will allow to clearly identify the implemented energy technologies and concentrate innovation to boost them into higher efficiency and easier and wider application. ECTP commits the development of a TOOLBOX for Positive Energy Blocks upgradable to Districts.</p> <p>The following activities are foreseen:</p> <ol style="list-style-type: none"> 1) Identification of operating Positive Energy Block in Europe for evaluation One reference source to launch this initiative is the thorough study of The Positive Energy Block (PEB) of HIKARI, located in Lyon Confluence District, France (see Annex 2). As HIKARI is a block of connected NEW buildings, it will be essential to identify sites with either a mix of new and existing buildings, as well as sites of existing renovated (or to be) buildings. This will require at first a close collaboration with SCC projects and also identify more sites through the cities and regions associations. 2) Development of a TOOLBOX for Positive Energy Blocks upgradable to Districts Assessment of operating technologies and innovation in operating Positive Energy Blocks in Europe and identify measures to boost them into higher efficiency and easier and wider application. This activity will also consider ECTP work in FP7 and H2020 has on “geoclustering Europe”, trying to adapt solutions to the different geo-climatic conditions. The TOOLBOX will conclude the findings of the assessment and is useable throughout the EU. 3) Alignment of the TOOLBOX with actions proposed in other TWGs ECTP will assure alignment of the TOOLBOX with the actions in the TWGs on Energy Efficiency in Buildings and on PV and solar thermal
TRL: 7-9
Total budget required: 12 M€
<p>Expected deliverables:</p> <p>TOOLBOX for Positive Energy Blocks with geoclustered version and new/retrofitted/mix solutions</p>
<p>Timeline:</p> <p>ONE year for TOOLBOX.1.0. based on existing data. TWO years for TOOLBOX 2.0. with exploitation of latest results of H2020 and triggered innovation from 1.0.</p>

Partners and stakeholders involved: Industry through ECTP and EIP SCC; Cities associations; Regions; Member States; Academia

Implementation financing / funding instruments:

National Smart Cities programs

H2020 Energy efficient Buildings PPP and related calls

H2020 SCC-01 projects and related calls

ERDF

LIFE

Indicative financing contribution:

€ 12 million on three years for toolbox development and innovation on specific technologies related to connecting buildings and blocks for energy flows and energy related data. ECTP and EIP SCC will contribute with HR for compiling the essential data.

6 M€ Industry and 6 M€ FP 9, e.g. Energy Efficient Building

Ongoing R&I Activities relevant to this new activity proposal:

SCC projects and EeB PPP projects

5.12. Activity Fiche 10: ECTP – ESA – Digital Modelling of Cities

R&I Activity Fiche 10:
Target: Accessible physical and thermal digital modelling of cities for energy management including built and natural environments
Activity supports the pathway towards Positive Energy Districts: Modules 2, 3
Activity leaders: ECTP – European Construction Technology Platform, ESA: European Space Agency
<p>Description of activity:</p> <ol style="list-style-type: none"> 1) Stock taking of state of the art space technology Improving energy efficiency and savings at district and city levels must take into consideration that work has to be done both on new urbanized areas but in most cases on existing urban developments. Space imaging technology allows not only to gather physical and thermal data with very high precision but also allows follow up in time thanks to regular iterations on the data collection from satellites. The SET-Plan provides a unique opportunity to take stock of state of the art space technology available from European H2020 projects (like EUGENIUS) and COPERNICUS and boost its capacities of concrete impact at EU level for energy management. 2) Capacity building at EU level for Digital modelling of cities for energy management including built and natural environments To work on a harmonized and financially accessible approach for cities of all sizes will allow a high tech energy audit that will serve as a database for digital urban planning. It will then connect to already existing Building Information Modeling (BIM) which is optimizing energy use at building level. BIM is at the heart of a number of Energy Efficiency H2020 projects. <i>This will create a digital continuum from the satellite to the smart meter in each citizen's living room.</i> Other dimensions of Urban planning related to energy are the role of green spaces and blue spaces. Vegetation and water surfaces can indeed play an important role in shading, air cooling and draft control. These surfaces are also satellite monitored. Research and innovation is proposed to develop and fine tune a ready to use data base could tackle the following issues: <ul style="list-style-type: none"> • Mapping of Urban Heat Islands to identify critical spots with Landsat and Sentinel satellites. • Urban Infrared Thermography from High Altitude Pseudo-Satellites (HAPS) • Audit and projection of green spaces and greening solutions for thermal comfort 3) Development of a portal accessible to cities for physical and thermal mapping A portal will be developed accessible to cities for physical and thermal mapping and follow up (data refreshed up to every five days upon request) <p>With the strong support of all actors involved in the SET Plan and under the piloting of Member States and Cities authorities, this project can turn Europe into a world leader as a digital continent for energy and climate management.</p>
TRL: 8 for access portal for cities; 4 to 6 for new technologies to develop
Total budget required: 27 M€

<p>Expected deliverables: A portal accessible to cities with a reasonably price membership for physical and thermal mapping and follow up (data refreshed up to every five days upon request)</p>
<p>Timeline: 3 years</p>
<p>Partners and stakeholders involved: ECTP ESA Cities and Member States Academia European Commission</p>
<p>Implementation financing / funding instruments: Member States programmes H2020 space related calls LIFE EIB</p>
<p>Indicative financing contribution: 2 M€ for development of database management system and client long term support (cities), 25 M€ for technology related evolutions for finetuning thermal high altitude measurements and green / blue frame solutions. 12 M€ public sources (e.g. national and European R&I Programmes) and 15 M€ industry funding</p>
<p>Ongoing R&I Activities relevant to this new activity proposal: FP7 and H2020 EUGENIUS; COPERNICUS; EeB PPP projects (DIRECTION; EPIC-HUB...)</p>

5.13. Activity Fiche 11: RHC-ETIP – Industry support

R&I Activity Fiche 11:
Target: To provide a toolbox of solutions and technologies regarding RHC of PEDs
Activity supports the pathway towards Positive Energy Districts: Modules 3, 4
Activity leaders: RHC-ETIP
Description of activity: <p>The stakeholders united in the RHC-ETIP represent all aspects of heating and cooling for buildings and districts, which are needed for the implementation of PEDs. They include research institutions, technology planners, as well as technology and infrastructure providers, and can therefore be partners for cities and real estate developers, when it comes to selecting the right elements for an optimal deployment of renewable heating and cooling technologies in PEDs.</p> <p>The following activities are foreseen:</p> <ol style="list-style-type: none">4) Participation in updating the technology roadmap for PEDs<p>RHC-ETIP commits to giving input to the roadmap which has been drafted and will be further developed as part of Activity Fiche 3.</p>5) Demonstration examples of existing technologies and solutions for PEDs in new construction and retrofitting<p>Compilation and description of a list of demonstration examples highlighting the potential of RHC technologies and solutions for the establishment of PEDs in new construction as well as in retrofitting, and how these examples could be extended from individual cases into PEDs.</p>6) Guidelines for the development of energy systems for PEDs<p>Development of guidelines, which describe step by step, how the energy system of the PED can be designed and optimized, how especially the renewable heating and cooling sources can be evaluated and how the designing and planning process can be organized and managed.</p>7) Web-based tool to calculate optimized energy systems for PEDs<p>Develop a web-based planning tool, which allows to calculate an cost-optimized energy system for a PED taking into account sector coupling and the dynamic of the energy system. The tool will be based on 100% renewable energy sources with a specific focus on sustainable heating and cooling systems and will take into account the following elements:</p><ul style="list-style-type: none">• Sector coupling between the electricity, heating, cooling, and transport sector• The temporal dynamic of the system (to consider daily and seasonal variation as well as the influence of batteries and thermal storage)• The expected efficiency improvements of the energy consumer (e.g. by refurbishment of buildings)• The expected overall development of the energy demand (e.g. by population growth and changes in the mobility system)• The local renewable energy potential

<p>8) Support regarding liaison and cooperation with other implementation working groups relevant to the topic of PEDs</p> <p>Being a partner in other implementation working groups of the SET-Plan, such as on Buildings & Materials or Energy Systems, RHC-ETIP will support the ongoing liaison and cooperation with those groups.</p>
<p>TRL: 7-9</p>
<p>Total budget required: 7 M€ over the course of 8 years</p>
<p>Expected deliverables:</p> <p>Contribution to technology roadmap of PEDs; compilation and description of best practice examples, and subsequently a toolbox for PED technologies and solutions; ongoing advice</p>
<p>Timeline:</p> <p>3 years</p>
<p>Partners and stakeholders involved: European Technology and Innovation Platform on Renewable Heating and Cooling (RHC-ETIP) and members of its Horizontal Working Group “100% Renewable Energy Cities” (Research institutes and industry)</p>
<p>Implementation financing / funding instruments:</p> <p>RHC-ETIP members’ own resources; support from H2020/FP9; national and transnational R&I funding;</p>
<p>Indicative financing contribution: 3 M€ industry, 4 M€ public sources</p>
<p>Ongoing R&I Activities relevant to this new activity proposal:</p> <p>Projects on national, H2020, and IEA level; The development of the energy system planning tool is happening on national level in several projects. However, an integrated approach with a European perspective is currently missing.</p>

5.14. Activity Fiche 12: Euroheat & Power – Industry support

R&I Activity Fiche 12:
Target: To provide a toolbox of solutions and technologies regarding DHC of PEDs
Activity supports the pathway towards Positive Energy Districts: Modules 3, 4
Activity leaders: Euroheat & Power
<p>Description of activity:</p> <p>Euroheat & Power represents the European (renewable) district heating and cooling (RDHC) industry, including utilities, planners, manufacturers, researchers and others, which can play an important role for the implementation of PEDs. The DHC+ Technology Platform is the research structure of this sector and is run by the EHP secretariat. The sector is a key partner for cities and real estate developers, when it comes to selecting the right elements for an optimal deployment of renewable heating and cooling and heat/cold recovery technologies in PEDs.</p> <p>The following activities are foreseen:</p> <ol style="list-style-type: none"> 1) Participation in updating the technology roadmap for PEDs DHC+TP commits to giving input to the technology roadmap which has been drafted and will be further developed as part of Activity Fiche 3. 2) Demonstration examples of existing technologies and solutions for PEDs in new construction and retrofitting Compilation and description of a list of demonstration examples highlighting the potential of renewable district heating and cooling technologies and solutions for the establishment of PEDs in new construction as well as in retrofitting, and how these examples could be extended from individual cases into PEDs. 3) TOOLBOX of DHC technologies and solutions for PEDs Drawing from the list of examples, and other evidence, a “toolbox” of technologies and solutions for PEDs will be put together, which can be used by cities, planners, and developers in order to refine the technical configuration of PEDs. 4) Advice on planning of R&I and certification activities DHC+TP will contribute to (public) consultations regarding the configuration of future R&I calls on transnational and national levels and give input to drafts of PED certification schemes. 5) Support in liaison and cooperation with other implementation working groups relevant to the topic of PEDs Being a partner in other implementation working groups of the SET-Plan, such as on Buildings & Materials or Energy Systems, DHC+TP will support the ongoing liaison and cooperation with those groups.
TRL: 7-9
Total budget required: 0,5 M€ over the course of 8 years
Expected deliverables:

Contribution to technology roadmap of PEDs; compilation and description of best practice examples , and subsequently a toolbox for PED technologies and solutions; ongoing advice;
Timeline: 1 year for contribution to technology roadmap, best practice compilation, and toolbox;
Partners and stakeholders involved: RTOs and industrial partners
Implementation financing / funding instruments: Members' own resources; support from H2020/FP9; national and transnational R&I funding;
Indicative financing contribution: 0,3 M€ industry, 0,2 M€ from H2020/FP9; national and transnational R&I funding
Ongoing R&I Activities relevant to this new activity proposal: Projects on national and H2020 level

6. PED PROGRAMME MANAGEMENT

In order to make sure that the circular pathway towards PEDs delivers the targets, there is a need for PED Programme Management to ensure (1) coordination of actors and activities along the pathway, (2) synergies between activities making sure they build on previously achieved results and (3) a speeding up of the process.



Figure 10 Structure needed for Implementation of the Programme/Pathway

For the implementation of the programme it is proposed to create a governance structure in the soon-to-be Implementation Working Group 3.2 (Figure 10), which will evolve out of the current TWG 3.2. It would be headed by an IP Steering Group composed of delegates of the countries involved in the Programme. The IP Steering Group would be responsible for strategic steering, budgets, joint calls, other joint actions, and the funding of projects. It would work in close connection with all other stakeholders involved in the Implementation Working Group, especially those, who come forward with budgets and resources of their own. The Steering Group would be supported by a Funding Agencies Group, which will work in variable geometry, based on the respective financial involvement of the respective countries. It would provide the call texts, call management and funding administration needed to implement the calls, actions, and projects of the programme. All of this would be underpinned by a well-established Programme Management Structure, which can be provided by the JPI Urban Europe, a network of 20 European countries collaborating in the field of sustainable urbanisation since 2008. Most of the countries engaged in the SET-Plan TWG 3.2 are also members of the JPI Urban Europe. However, joining the JPI Urban Europe as a full member would not be a pre-requisite for participating in the IP Steering Group, or the Programme Management of this Implementation Plan. In addition to the funding budgets for transnational joint calls (as indicated in the Activity Fiches), the Programme Management would rely on cash or in-kind support from the involved SET-Plan countries as the Implementation Plan progresses along its way.

ANNEX 1: STAKEHOLDERS AND COUNTRIES INVOLVED IN THE PROCESS

a) Stakeholders consulted for defining the Declaration of Intent

The Declaration of Intent agreement follows consultations with:

- European Innovation Partnership on Smart Cities and Communities
- Covenant of Mayors
- EERA Joint Programme on Smart Cities
- Joint Programming Initiative Urban Europe
- EU Smart Cities Information System
- ERA-NET on Smart Cities and Communities
- Citykeys Support Action
- as well as a public consultation via the SETIS website⁸ on an issues paper prepared by the Commission services⁹.
- and additional comments received from Iceland, Norway, Turkey, and Switzerland.

b) Composition of the Temporary Working Group 3.2

SET Plan Countries

AT (Chair)	ES	NL	TR
BE	FI	NO	UK
CY	FR	PT	
CZ	IT	SE	
DE	LV	SK	

Stakeholders

AER	Assembly of European Regions - https://aer.eu
CARTIF	CARTIF Technology Centre - http://www.cartif.com/en
DHC+TP	District Heating and Cooling Technology Platform - www.euroheat.org
ECTP / Co-Chair	European Construction Technology Platform - http://www.ectp.org
EERA JP on Smart Cities	European Energy Research Alliance - https://www.eera-set.eu/eera-joint-programmes-jps/smart-cities
EIP SCC	European Innovation Platform Smart Cities and Communities - https://eu-smartcities.eu/action-clusters Initiative on Positive Energy Blocks Initiative on Scaling up & Replication of Smart City Plans
EPRA	European Public Real Estate Association - http://www.epra.com
ERRIN / Co-Chair	European Regions Research and Innovation Network - http://www.errin.eu
EUA-EPUE	EUA Energy and Environment Platform - http://energy.eua.eu/ , http://uni-set.eu
EUREC	Association of European Renewable Energy Research Centres
Eurocities	Eurocities - http://www.eurocities.eu
Housing Europe	Housing Europe - http://www.housingeurope.eu

⁸ Strategic Energy Technology Information System website <https://setis.ec.europa.eu>

⁹ https://setis.ec.europa.eu/system/files/issues_paper-action3_smartcities.pdf

IE	Insurance Europe - www.insuranceeurope.eu
JPI Urban Europe	European Joint Programming Initiative Urban Europe
KIC InnoEnergy	KIC InnoEnergy - http://www.innoenergy.com
RHC-ETIP	European Technology and Innovation Platform on Renewable Heating and Cooling - www.rhc-platform.org
SCIS	Smart Cities Information System
STORY/BRIDGE	STORY/BRIDGE - http://horizon2020-story.eu/bridge

European Commission

EC - SET Plan Secretariat
EC - DG ENER
EC- DG RTD
EC - DG JRC
EC - DG CLIMA

ANNEX 2: EXAMPLES OF EXISTING ZERO AND POSITIVE ENERGY BUILDINGS AND BLOCKS

1. One of these examples is the **Zero Bills Home in BRE Innovation Park in Watford (UK)** which presents an inspiring case for innovative PED due to its location in a big innovation park and the ongoing replication. The buildings consist of hybrid construction of timber and steel equipped with top-roof photovoltaic, efficient building envelope and equipment (e.g. air heat pump, standard ventilation, hot water cylinder), passive thermal storage provided by a massive floor and ceiling and the possibility to charge a small EV.
2. Another example is the **Stroomversnelling project in NL (2010-2016)** dealing with the conversion of existing building to Zero Energy Buildings. The project has been implemented with a Government-funded scheme with an extension up to 2020. The project aimed to retrofit social housing to net Zero Energy Buildings and demonstrated new business model and stakeholder's involvement. It offers innovative approaches like 3D building scan model, detailed EE and REE solutions to ensure net Zero Energy Buildings. To reduce the net-zero energy building restoration costs it adopts a joint cooperation scheme of key stakeholders comprising contractors, component suppliers, housing providers, local governments, financiers, TSOs and other parties. Stroomversnelling provides an attractive business model to deploy net-zero energy building which can be considered as a good example for ZEED deployment. It demonstrates a prototype for the refurbished net-zero energy building which -compared to the old type- achieved an average total reduction in energy use of 150 kWh/m² corresponding to an annual consumption of 6000 kWh down from 20,000 kWh. Two thirds of its energy consumption are covered via energy efficiency measures and one third by on-site energy generation. The estimated retrofitting costs of the pilot amounted to approximately EUR 130,000 per unit.
3. Another example is the **Zero Village Bergen (Norway)**, a project currently in planning which will demonstrate a building block of 800 residential homes and service buildings aiming to achieve self-supply using thermal and electric energy. The key innovative elements are photovoltaic generation with excess power used for EV and public facilities, passive houses with full insulation, and underground thermal energy storage. The energy demand for all purposes shall be covered to the greatest possible extent by renewable energy sources without loss of natural diversity.
4. Yet another example is the **Seestadt Aspern (Aspern Lakeside City, Vienna, Austria)**, a smart building and research block, consisting of three residential and service buildings that are equipped with solar photovoltaic and thermal panels and heat pumps along with thermal and electric storage facilities. The energy management is achieved through complex ICT systems. The lessons learned from Zero Energy Buildings are very valuable for the development of PED.
5. A third example is the Plus Energy Village in Wildpoldsried (Germany) which generates about 500% of its own consumption using various renewable options that comprise about 5 MWp of photovoltaics, 11 wind turbines, one hydropower system, several municipal and residential biomass heating systems, supported by five biogas plants, and 2,100 m² of solar thermal systems.

6. The Positive Energy Block (PEB) of **HIKARI** located in **Lyon (France)** Confluence District is a pioneer part of the FP7 project NEXT Buildings. It is composed of three new highly energy efficient and connected buildings for a total surface of 12.000 sqm. They bring together offices, apartments and commercial spaces creating a functional mix that allows optimisation of locally produced renewable energy thanks to complementary consumption curves. It also features bioclimatic architecture principles that allow optimising natural lighting and ventilation. Design is by Japanese architect Kengo Kuma. Renewables produced on site feature, photovoltaic farm on the roofs, one PV integrated façade, geo-thermic and cogeneration from rapeseed oil produced in the Lyon neighbourhood. Energy storage technologies are used for heat, cold and electricity. Energy and data flows are digitally managed in a micro-grid through Building Energy Management System (BEMS) and individual apartments have their own Home Energy Management System (HEMS). The PEB of HIKARI is occupied since September 2015 therefore providing more than two years of data around the fine-tuning of the technologies and training and experience of inhabitants and users. The urban planning of the district of Lyon Confluence foresees the improvement (technical and financial) of the PEB concept through the more recent constructions and then the possibility to connect various PEBs together to create a PED. All data of the NEXT BUILDINGS project is being fed into the Commission's database SCIS (Smart City Information System).

ANNEX 3: CHALLENGES AND REQUIREMENTS FOR DEPLOYING OF PEDS

Annex 3 elaborate on the addressed challenges and requirements for deploying PEDs as stated in Section 3.2. It explains evidences and background to the persisting challenges and provide recommendations for their conceptual treatment based on so far developed concepts and solutions mainly related to ongoing and implemented projects on efficient buildings and PEBs beside additional approaches and solution from other disciplines.

Integrated and Innovative Technologies for PEDs

PEDs rely on integrated innovative technical solutions to ensure the required positive energy balance on annual basis by ensuring highest energy efficiency at buildings and district level and optimal utilization of local renewable energy supply options. In addition, the challenge is to optimise the building integration within the district, local and distant renewable and low carbon energy sources into a resilient energy system. Furthermore, the increased dependence on intermittent RES intensifies the need for flexibility options to ensure reliable power system operation via integrated solutions consisting of energy storage, smart urban energy networks, ICT and e-mobility. In particularly the conceived integrated innovative solutions for realizing and deploying PEDs cover following domains:

- Highest energy saving measures to reducing primary energy demand through a variety of energy conservation measures, highest energy efficiency and cutting-edge energy management systems comprising highly insulated building envelope and windows, integrated PV and solar-thermal façade, passive housing and efficient lighting, and smart metering.
- Maximize the use of renewable energy supply based on local distributed Renewable Energy Systems (RES) within the geographical boundary of the district as well as through **local energy sources** adjacent to the district. This covers PV, solar thermal, heat pumps, geothermal and waste-to-heat-and-power. Complementary to the local renewable energy supplies, the allocation of sites in adjacent urban areas or the surrounding regions should be considered for additional electricity generation from biomass, wind and solar parks, especially to ensure covering the peak demand. The generation of renewable energy sources in the local-regional energy partnership should be taken into account in the calculation of the net zero import definition of the PED.
- Integrated energy system design providing an efficient and flexible energy infrastructure (electrical, heating, cooling, gas grids, all components connected by an ICT platform, etc.), enabling the use of energy sector coupling (electricity, heating, cooling, energy for mobility), the exchange of energy between all consumers and producers in the PED. The energy system shall be designed to be robust and resilient to enable the adaptation to changing surrounding conditions. This includes technical (e.g. grid infrastructure), organizational and regulatory aspects.
- Flexibility options as well as optimized and smart energy management across the different building types within the district and in synchronisation with the wider energy system of the surrounding neighbourhood. This includes developing modular hybrid

microgrids beside the opportunities of DC grids integration, optimizing control algorithms for real-time management of several energy vectors via ICT. In view of increased dependence on intermittent RES, active management will allow for balancing and optimisation of energy demand-supply, load shifting and reduced curtailment impact of RES.

- Energy storage presents one of the biggest gaps to realize PEDs. Finding ways to store energy all year long is not just a challenge when it comes to technology but also in terms of cost effectiveness. Technically feasible solutions for long-time storage of heat and electricity over days and weeks and even seasons must become cheaper in order to make PEDs cost-effective, so they can compete with conventional buildings and districts on the basis of a life-cycle, or total cost assessment.
- EV will be an integrative element of PEDs with an expected increased impact on the district energy system behaviour. Hence, EVs need to be considered already during the planning phase of PEDs. By planning and implementation of an optimized EV charging infrastructure and adequate management of charging as well as considering EV-to-grid, EV can have positive impact on the power load management charging capability within the district and make use of the ensure that the impact of EVs on the distribution will be minimised by using local generation where possible.
- Distributed ledger technology to manage power exchange at the local community level and create added value and incentives for the consumer to generate energy locally, provide flexibility and aggregate power generation in a system-wide cloud solution. Such innovative technologies are vital to maximize the uptake of renewables and manage the emerging local energy systems that couple the different energy demand and supply options in view of the changing role of consumer and producer to the role of prosumer.

Societal Innovation, Social Entrepreneurship and Citizen Participation

A common element affecting the financial and regulatory aspects and consequently the required new policy for deploying PEDs is the societal aspects in term of citizen participation (both tenant and building owners). Depending on the prevailing practices of building ownership relations, cost sharing of building restoration and refurbishment and current costs of energy services new business models need to be applied to ensure that the costs incurred by deploying PEDs will be affordable for the majority of citizens. In fact, the success of the perceived evolution process of PEDs is subject to attracting citizen (also the consumer) and ponder their interest by creating noticeable incentives which are concretely related to significant savings (or acceptable additional cost for those more motivated to address global causes), and a living environment of high quality and liveability within a sustainable urban transformation process. On top of fair cost sharing approaches such as crowd-funding, match-funding and participatory budgeting, stakeholder participation and co-design processes in the planning and implementation of PEDs could help in ensuring public acceptance and send a positive message for the whole deployment process of PEDs.

New Energy Markets and Sustainable Funding Models for Implementation of PEDs

On the building scale, deep retrofitting and new near-zero energy buildings prove to be not cost-effective based on today's energy costs, requiring new financing schemes, including optimized subsidies, particularly for the initial phase, in order to promote and accelerate the replication process and enable the construction industry to generate economies of scale among the whole value and supply chains. For residential housing the costs of cooling and heating are relatively high, compared to office, or industrial buildings, and in many residential buildings, cooling systems are not integrated. The expensive part of a change in this regard, does not lie with the production of sustainable energy, but rather with the necessary change of the energy system. "Small" projects with an investment in the area of one- or two-digit M€ are facing the obstacle of mobilising financial resources. Big investors are not interested in small or single housing projects due to the low profit margin.

PEDs represent an even higher challenge than individual buildings, when it comes to regulations and financing. In some countries, zoning regulations and building regulations contradict one another. Therefore, local and regional administrations as well as national regulatory authorities will need to be part of a holistic plan that goes beyond the normal measures, both for individual buildings, and whole districts. Moreover, one needs to take into account the resulting technological implications of such a switch from the consumers to the prosumers role. This will require close cooperation between innovative PED projects and regulatory authorities to provide dispensation for small-scale experiments where needed, and to oversee the systematic deployment of district-scale living labs, innovation playgrounds and urban prototyping to co-create, test and improve PED solutions until they are ready for the market.

Such emerging development sectors like PEDs imply high investment risks for investors due to hidden costs, technical and licensing challenges and the lack of established certification and standards. Hence, investors are very reluctant to move into such new areas without incentives and financial security mechanisms at least in the short-term, until the standard market mechanisms begin to work. Therefore, credible and robust investment concepts are needed to enable long-term investment decisions by building confidence for business players as well access to financing like citizen-enabling funding chains such as microtransactions, participatory funding, crowd-funding and match-funding.

New energy markets and business models for PEDs can be created based on consumer-driven innovation, developed in close working cooperation with national regulators, DSOs/CSOs, property developers, and local energy communities in alignment with the emerging EU energy markets supporting the clean energy transition (EU Winter Package). In effect, such solutions will drive the convergence of digital and energy single markets through the deployment of Distributed Ledger Technology, smart integrated building/energy control systems, Distributed Energy Resource Management Systems, and trading platforms. Profits can be created based on flexibility at the core of a new distributed energy system for PEDs by creating new micro-grid optimisation model/control systems, new prosumer-driven community system operators, and new markets for peak shaving/RES trading that reduce both overall grid investment needs and system curtailment (Clean Energy for All Europeans). In addition, investment and replication

can be stimulated with decentralised platforms, blended finance, and risk shaving through dedicated crowdfunding and participatory budgeting mechanisms, innovative public procurement (preliminary market consultations, pre-commercial innovation, and innovation partnerships) and project pipeline development using city-focused EIB services such as URBIS and JASPERS. These financial mechanisms can be connected to new forms of holistic spatial, social, political, economic, regulatory, legal, and technological innovation combining citizen observatories, innovation playgrounds and regulatory sandboxes to engage civil society, local authorities, industry, and RTOs.

Regulatory Framework, Certification and Standardisation

Regulatory aspects are vital to accelerate the development of PEDs and ensure their long-term deployment. Hence, the successful implementation of PEDs needs to be accompanied by a well-developed regulatory framework to ensure formulating and approving policy, regulation and standards for issuing legislation on PEB/PED and its impact on the actual building process, impose standards, test and attest novel solutions and issue related certification. In particular, this implies scaling up from Energy Performance of Buildings, transforming regulations from a building-scale to a district-scale to respond to the increased technological complexity of PEDs and the need for licensing of new technologies, regulating the interests of various stakeholders and new cooperative innovation mechanisms, clearly specifying their responsibility and conditions for exchange of energy flows.

In this regard, one hard legal barrier will be to regulate the energy exchange between users that will change to become more energy prosumers¹⁰. Especially for the electric energy the future PEDs (as well as smart cities) will be pronounced by the transition from passive consumers to active prosumers. The consequence is that each prosumer will become an economic actor equipped with a set of technical components to control various innovative elements like smart grid devices, renewable energy generation and storage units as well ICT and smart meters for load control and management¹¹ as well as distributed ledger technologies that enable microtransactions between and among organisations and individual citizens - enabling any individual citizen to profit from energy trading. As stated in the Winter Package¹² of the EU “Local energy communities can be an efficient way of managing energy at a local community level – with or without a connection to distribution systems”. In view of such transition the EU-directive requires from the member states to adopt a legal framework to regulate the new role of local communities to own, build, lease and manage community network.

Finally, as many hidden aspects cannot be captured adequately at the initial stage, the full legal framework will evolve successively along the development path of PEDs.

¹⁰ Prosumers are users who produce energy for their own use beside sending it to other users.

¹¹ Massimo La Scala, Sergio Bruno, Carlo Alberto Nucci, S. Lamonaca, Ugo Stecchi, 2017. From Smart Grids to Smart Cities: New Challenges in Optimizing Energy Grids, John Wiley & Sons.

¹² Hanche, L., Winter, B.M., 2017. The EU Winter Package: <http://fsr.eui.eu/wp-content/uploads/The-EU-Winter-Package.pdf>

Capacity Building, Education and Trainings

Building capacity and establishing education and training curricula are key elements building sustainable knowledge base for and support the whole process of developing and deploying PEDs. Such multidisciplinary learn-process targets technical expertise, public administration and regulatory authorities to handle and oversight the development and implementation process of PED. Training and capacity building programme can be developed via a joint undertaking between national governments and the European Commission. Due to specific local and regional conditions like language and culture, it is important to implement those programmes at a national level. In this sense establishing partnership among EU cities allows the creation of wider benefits when implementing PED projects at a regional level, as capacity, knowhow and financial/legal instruments can be shared between connected cities and thus help in improving and expanding national capacities and training materials. This also supports professionalising governance systems and ensures increased impacts.

Capacity building goes hand in hand with research and innovation actions, in order to ensure that training curricula are up to date with the actual requirements for innovation for PEDs. Thus, different actions are recommended to ensure process sustainability and continuity comprising bottom-up community-level actions, linking technological and social innovation aspects, capacity building and engagement with civil society, dissemination activities and training courses on smart cities, analysis of existing business and contracting models and proposals for new business, guidelines on multidisciplinary approaches.

Co-creation, Open Innovation, Public Sector Innovation and Procurement

Transformation pathways towards PEDs require a structured approach of navigation, leadership, ownership and enablement as well as the establishment of organizational structures to manage the PED development and implementation in an interdisciplinary way in cooperation between public, industry and research sector as well as the citizens. In order to develop their roadmaps towards PEDs and eventually Positive Energy Cities, **urban authorities** need to review their existing city, regional and national strategies, securing support from all political and operational levels, Councillors, Council Management and Strategic Policy Committees for this innovative work to become part of their formal city development plans.

For this transformation to take place, strong leadership is core to the approach. Constant engagement and co-creation of the vision and roadmap will enable **community leaders** to emerge and ensure that citizens and businesses in the PEDs as well as the wider community know, understand and participate in the development of the PEDs. The transformation process needs to have the appropriate human, technological and financial resources. This transformation is not a one-off process but rather a constant cycle of supply and demand of information both at macro level “visionary” and also “operational”, grounded in the daily reality.

Furthermore, the transformation towards PEDs requires an **open innovation** framework in order to secure involvement and **co-creation of the key stakeholders** in different sectors. This can be obtained by organising regular meetings, workshops and brainstorming sessions between the cities, industry partners, local stakeholders and other interested parties. During these activities, participatory design methods, forecasting, mock-ups, storyboards, future workshops,

brainstorming and experience prototyping methods can be used to identify and address the needs of the stakeholders in an effective manner. This co-creation process aims to align goals and priorities, to promote cross-cultural communication, understanding and collaboration, and to speed up the learning process and iteration of results across the stakeholders and value chain and.

The focus on public sector innovation and scaling up Smart City type actions should not be limited to the dissemination of PED projects. It is important to have a broader perspective in mind to elaborate the potentials of rolling out Smart City plans in Europe. One crucial element in rolling out these kinds of initiatives is to empower the role of cities, especially the smaller and mid-size cities. Therefore, the local conditions of cities need to be understood as well as a focus being placed on non-technological barriers, such as:

- Political and cultural context,
- Financial requirements and sustainable business models,
- Local conditions on capacity and knowhow / skills,
- National requirements on public procurement,
- Social and organisational opportunities and constraints,
- Local stakeholders.

The integration of the above issues in appropriate way in order to ensure the desired results of public sector innovation. In this regard innovative public procurement has the ability to push innovation to lead market strategy by encouraging the application of innovative energy technologies at the tender level which represents an enormous boost to deploy innovative solutions of PEDs. For this purpose, different instruments can be applied targeting the development of investible PEDs projects like green public procurement, e-procurement, pre-commercial procurement (PCP) or research oriented public procurements. Nevertheless, innovative procurement should not remain a prerogative of the public sector. It must act also as a paradigm to encourage private projects to follow this trend. Both public and private actors can also act as “role models” or “pioneers” in energy efficiency issues.

Replication, upscaling and mainstreaming

Replication, upscaling and mainstreaming enabling cooperative innovation, including replication profiles, feasibility studies, intellectual property rights, market access, and STI cooperation.

Partnership among cities allows the creation of wider benefits when implementing PED projects at a regional level, as capacity, knowhow and financial instruments can be shared between connected cities as it is considered in the recently started H2020 projects for SCCs. Such projects consider the replication of the implemented PED lighthouse projects in the follower cities by ensuring further exchange and upscaling of the different solutions within the regions where the pilot actions have taken place. In this regard, adequate need to be taken to roll out and tailor the solutions to fit specific local and regional conditions.

Business models for implementation and operation of PEDs Within the development of PEDs concept, the construction of interconnected new buildings and deep and networked retrofitting of existing buildings, are extremely expensive. To reach the expected high impact,

the first step will certainly be to optimize subsidies, adapted to demonstrators or specific local priorities like social housing. Ongoing discussions for future programmes like FP9 or Structural Funds for 2021-2027 should ideally consider dedicated envelopes or guaranteed percentages of regional programmes. Once they are secured, specific strategic loan plans like the Juncker Plan should be optimized for these issues. Besides, to ensure large scale transition, there is a strong need to develop and apply sustainable business models that consider the whole process of building, operation and maintenance of PEDs and engage all actors among owners, city authorities, national regulators, real estate developer and operator of the energy infrastructure and local energy communities.

The development process of such models consists of mapping and evaluating of the existing successful models in the building and contracting branches to identify further modifications and enhancements needed for application on PEDs. The models should fit to the prevailing national circumstances related to social, economic, financial and legally aspects (e.g. disbursing the cost of transforming existing building stock to PEDS) and support the upscaling and the future replication of PEDs.

ANNEX 4: JPI URBAN EUROPE INNOVATION ACTIONS

A substantial knowledge base has already been created within JPI Urban Europe research projects. Other national and international (incl. EU framework) research initiatives are also generating knowledge about the development of urban environments including both technological and socioeconomic aspects.

However, much of this knowledge is not accessible to potential users and is not easily implemented. Implementation of new solutions can be hindered by institutional barriers (e.g. standards and regulations for construction, installations, procurement), social barriers (e.g. resistance of organisations and individuals to accept new ways of doing things) and financial barriers (business models to implement social innovations are unclear or not viable, or there are insufficient possibilities for scaling up innovations).

JPI Urban Europe thus calls for **Innovation Actions that tackle these barriers and address implementation issues**. Innovation Actions will work on concrete urban challenges and focus on developing a proof of concept and learning on a European scale using transdisciplinary consortia with active participation of both municipalities and companies.

To ensure that such Innovation Actions supported by JPI Urban Europe have a lasting value, the participating cities must express its support and intention to develop follow-up activities by implementation in a real-life situation. Sharing innovation experiences amongst European cities is the key to effectively tackle city innovation problems.

Innovation Actions of the JPI Urban Europe invite municipalities, businesses, researchers, civil society and other stakeholders to build project consortia to create challenge-driven innovations for European urban areas that have the potential to result in commercially successful services and products. To this end Innovation Actions are expected to:

- Have a challenge-driven approach with the problem owners in an active role and relevant stakeholders to address this problem in the consortium;
- Have transdisciplinary and trans-sectoral collaboration with active cooperation between all stakeholders throughout the project;
- Be focused on innovative solutions, getting to a proof of concept, demonstration, or test replicability and scalability;
- Show the added value of European collaboration.
- Describe the way in which gender and diversity aspects are relevant

ANNEX 5: TECHNOLOGY ROADMAP FOR THE DEPLOYMENT OF PEDS



Cities must move from green districts to plus energy districts (PEDs) over time to reach the European energy and climate targets. Zero/Plus Energy Buildings (ZEBs/PEBs) represent the pioneers for the future PEDs. The main features of PEBs are their reliance on on-site renewable energy supply, advanced energy saving measures in terms of efficient construction (building insulation and orientation), efficient appliances and optimized operation and maintenance. Compared to PEBs, PEDs have specific advantages and opportunities in achieving higher energy performance due to the positive synergy of interaction and integration of various building types, the larger energy system and the diverse users and consumption behaviours.

A5.1. The Imperatives of Technology Roadmap for Deploying PEDs

The proposed technology roadmap offers a development pathway to support the planning process of deploying PEDs within an integrated sustainable urban transformation process. It focuses on identifying innovative technologies to tackle the persisting challenges and enable the implementation of integrated solutions needed for deploying PEDs.

Within the interdisciplinary process implementing, upscaling and finally large-scale deployment of PED the establishment of a technology roadmap is essential considering that this process is mainly driven by technological innovation that still faces a lot of challenges and gaps as elaborated in Annex 3. Moreover, even if the innovative technologies are developed, their transfer to and implementation in the real-world remain strongly dependent on the development of regulatory framework and financial schemes needed to convert such technologies into reliable and feasible solutions. However, the three dimensions are mutually interacting within a development process where innovative technologies can be an important driver and enabler for establishing new regulation and financial schemes (Figure 1). Thus, the selection of appropriate business models to implement the new technologies is essential for PEDs deployment. As elaborated in Annex 3, the deployment of PEDs faces a set of persisting challenges and gaps that need to be tackled to enable the integration of PEDs within the city future development vision and support its further upscaling and deployment in respect to the prevailing socio-economic and urban development status.

A5.2. Urban Transformation and Integrated Energy System Planning

The deployment of PEDs is an integrative process imbedded within a long-term urban transformation strategy including a bold energy transition plan of the considered city reflected usually in a sustainable energy action plan (SEAP). Such future vision projects the future urban energy system development under the condition of increased deployment of PEDs based on consistent spatio-temporal scenarios reflecting the future socio-economic and technological development of the considered city. This approach allows for reflecting future socio-economic trends and attitudes on the energy demand side and incorporating technological innovations of

energy efficiency improvement, increased electrification in covering energy services and considering the interaction and integration between the buildings. Within the conceived energy transition the supply side account for the successively increased dependence on local renewables that will intensify with the scaling up and replication of PEDs within the city. Besides, the penetration of innovative flexibility options (like energy storage, DSM and ICT, EV) will build the corn stone for achieving the perceived positive energy balance of the deployed PEDs which will gradually penetrate the city energy system and interact with it.

PEDs development and deployment will be realized within such integrative urban transformation process with focus on achieving a sustainable energy transition. Accordingly, PEDs has a central role to play in this interdisciplinary process where various **technical, financial, social and legal driving aspects** are experiencing a deep transformation with allot of innovative needs to tackle the persisting gaps and enable the perceived development trajectory. adopt to such an emergence.

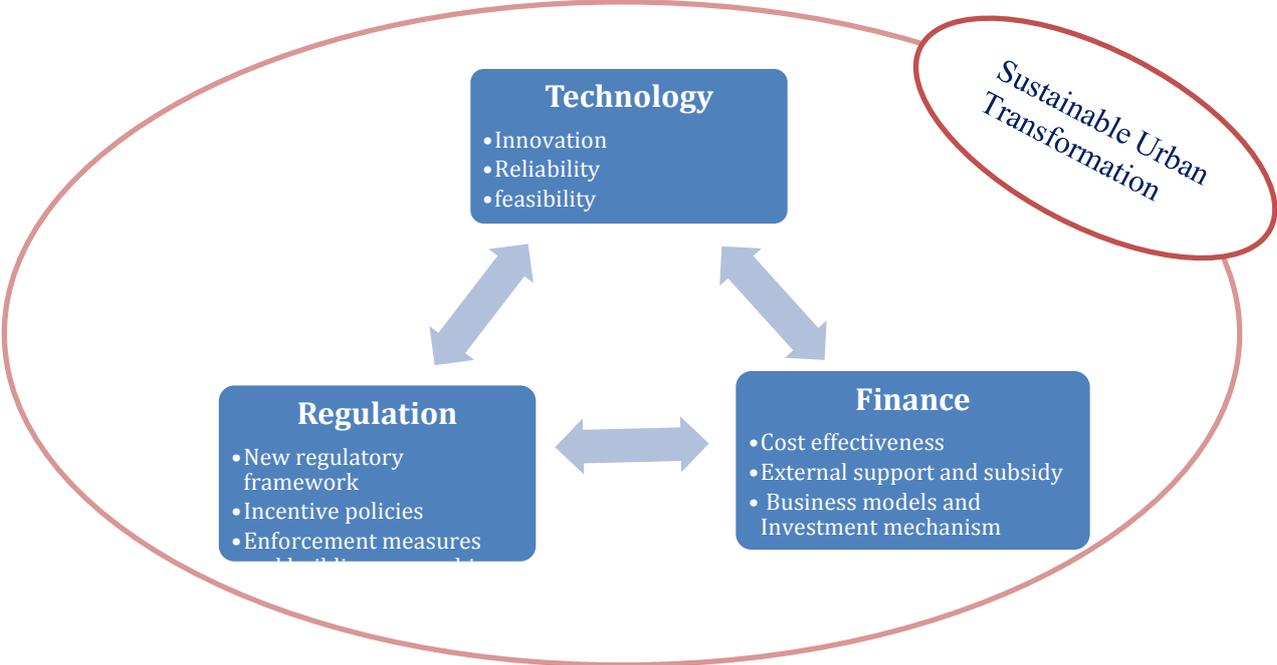


Figure 1: Interaction and synergies of technological, financial and legal aspects affecting the deployment of PEDs within a sustainable urban transformation process

A5.3. Lessons-learned from implemented PEBs/PEDs

The review of selected ZEBs/PEBs shows a variety of technologies and smart solutions at building levels that provide an important basis for the future development of PEDs (Annex 2).

Zero Bills Home in BRE Innovation Park in Watford (UK) presents an inspiring case for innovative PED due to its location in a big innovation park and the ongoing replication.

Stroomversnelling project in NL deals with the conversion of exiting building to ZEB and shows that effective energy saving measures of ZEB can save about two thirds of the energy consumption of traditional buildings. It applies innovative planning approach, adopts a co-creation process among key stakeholders during the implementation and operation process and offers also an attractive business model based on Government-funded scheme to finance the retrofitting costs.

Zero Village Bergen is a district of different building types aiming to achieve energy self-supply by relying on renewables and applying passive houses with full insulation, underground thermal energy storage and EV charging.

The Plus Energy Village in Wildpoldsried is a special multi PEDs achieving 500% energy excess by employing several RES (PV, solar thermal, wind, small hydropower, biomass and biogas).

The Seestadt Aspern demonstrate a smart research object with different building types to achieve nearly PEDs using PV, solar thermal, heat pumps, thermal and electric storage and ICT-based energy management system.

The above elaborated examples beside many others internationally implemented or planned PEBs/PEDs projects show the main energy system characteristics of PEBs/PEDs of on-site renewable energy supply (like roof-top PV and air source heat pumps) beside advanced energy saving measures in terms of efficient construction (building shell insulation and orientation), efficient appliances and optimized operation and maintenance, local storage of power and heat, EV-charging and the ICT-based energy management system. The evaluation allows for the following conclusions:

- The realized ZEBs/PEBs show a variety of technical, financial and regulatory concepts depending on the local conditions and the set of building types.
- Currently available energy storage technologies are still lacking behind the needed capacities to manage the short- and long-term power and heat availability. EV as part of PEDs solutions is still in its infancy and needs a lot of R&I for further synchronisation with the overall concept of electric load management.
- The current fragmented knowledge and experiences on PEDs illustrate the need to establish database for PEDs or use an already existing one like SCIS to document new advancements and thus enable a systematic exploitation of the accumulated experiences. The database should offer an open source on different technologies, services, construction and retrofitting solutions, financial and legal aspects as well business model and current best practices.
- The retrofitting process to qualify traditional buildings to PEBs/PEDs requires case-dependent solutions in respect to the prevailing local socio-economic, legal and climate conditions. In case of historic urban areas special architectural aspects are crucial.
- Even though the promised high quality and liveability of PED's living environment is of high importance, public acceptance and citizen engagement is strongly linked to the affordability of the costs incurred by the building conversion to PEBs/PEDs. Hence, cost sharing approach and new business models need to be applied to ensure that the transition to PEDs will be affordable for the majority of citizens.

A5.4. Integrated innovative solutions for deploying PEDs

The currently persisting technological challenges, hindering the deployment of PEDs, call for innovative solutions at the integrated scale of the urban energy system considering the internal interaction of different building types within the PED beside its intersection with the larger energy system of the surrounding urban neighbourhood. Broad literature review and expert interviews reveal the following conceptual solutions to tackle the key challenges:

- Provision of sufficient areas for onsite PV generation beside the optimal utilization of other local renewable energy sources,

- Ensuring highest energy efficiency at buildings and district level, e.g. highly insulated building envelope and windows, integrated PV and solar-thermal façade with architecture oriented and adapted to passive use of sun and efficient lighting, DSM and smart metering,
- Providing technically feasible solutions for long-time storage of heat and electricity over days and weeks and even seasons,
- Need for flexibility options to manage the intermittent behaviour of renewable energy sources and optimize the real-time management of several energy vectors including power, heat and EV,
- Developing modular hybrid microgrids and considering the opportunities of DC grids integration,
- Applying modular concept with interoperability features for the different district components,
- Developing appropriate technological, administrative, and business solutions tailored to integrate PEDs with the surrounding neighbourhood and the city energy system.
- Another innovative contribution to overcome technological gaps comes through the industrialisation of the processes, like fabricating modular and standardized elements to speed up work and reduce costs, and production models planned on groups of buildings rather than single ones, have also contributed to overcome obstacles and drastically reduce costs.

Among all the challenges, one outstanding bottleneck is to find suitable administrative solutions and business models to enable the deep retrofitting and converting existing buildings to PEDs and thus accelerate the deployment towards PEDs. This challenge is proven by the fact that about 75% of existing buildings in OECD will still be in use by 2050 (Dulac and LaFrance, 2014)¹³.

A5.5. R&I Needs and Innovation Fields for Implementing and Deploying PEDs

Intensive R&I is needed to provide, develop and deploy integrated solutions, in order to enable the deployment of PED across EU countries. The main research activities with their expected technological leaps are embedded within four fields related to local renewable energy generation, advanced energy efficiency measures at building level, heat and power storage and load control (Figure 2). Furthermore, PED requires the adaptation of integrated solutions in term of optimized infrastructure, smart energy network, building interlinkage, ICT, and other elements related to demand side management. In terms of any technological leap, further innovation can be stimulated by adopting new approaches, like biomimicry (inspired by nature).

¹³ Dulac, J. and LaFrance M. 2013. Transition to sustainable buildings: Strategies and roadmaps to 2050. IEA,

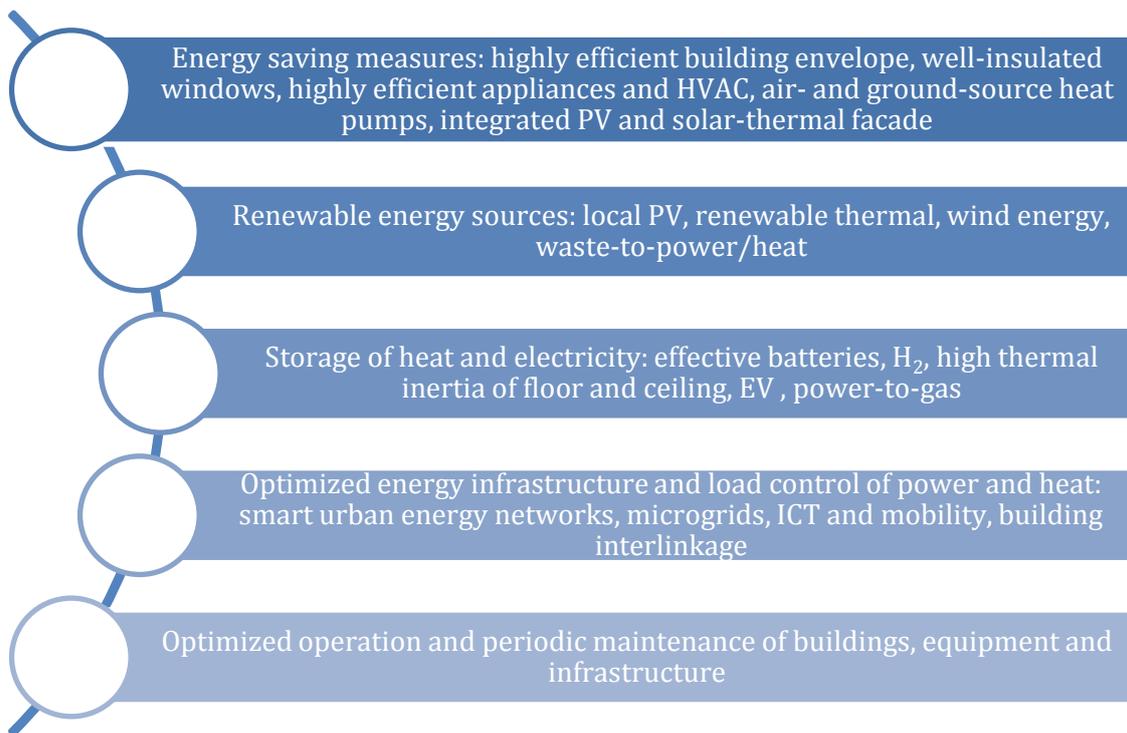


Figure 2: Key research fields of technological innovations needed for deploying PED

To prepare the deployment of PEDs at large scale, research on the following technologies needs to be prioritized:

- ❑ Highly efficient buildings:
 - Highly efficient building envelope using thin insulation technology
 - Super-insulated windows (triple layers with $U < 0.6 \text{ W/m}^2 \text{ K}$) and dynamic solar control
 - efficient lighting: LED and CFL standard
 - Integrated façade: optimized designs and orientations for better harvesting of daylight and passive heating, reduction of cooling loads and electric peak demand; integrated PV and/or solar-thermal collectors
 - Efficiency standards need to exceed the standards of passive housing, efficiency should not suffer because of the Net-Zero objective
- ❑ Renewable and clean energies
 - Solar energy in term of On- and off-grid PV, and solar thermal,
 - Wind (allocate remote sites around the urban areas),
 - waste-to-power/heat
 - Ground source heat pumps, water to air heat pumps, air heat pumps
 - Move from centralized district heating to decentralized networks and low-temperature
- ❑ Heat and electricity Storage:
 - New types of batteries without lithium
 - Phase change materials,
 - Power-to-gas (H₂, methane), small pumped storage
 - Make use of thermal storage capability of each building (e.g. thermal inertia of floor and ceiling)
 - Long-term storage for electricity and heat
 - Phase-change materials as promising material for heat storage

- Exploring the potential of alternative of new electrochemical storages.
- Smart urban energy networks, ICT and mobility,
 - Smart management systems and related business models
 - Vehicle-to-grid integration
 - Interoperability of ICT for urban services (integrated ICT architecture, based on common formats, standards and protocols)
 - Controller-algorithms in grid balancing
 - Reactive power compensation
 - Smart electric grid+ ICT: functioning as aggregator to enable sustainable and efficient energy use
 - Cloud platforms related to the building sector for the purpose of combination of aggregated and open data to support energy efficiency measures, incl. investments and real-time control.

The expert interviews revealed that one of the most urgent action items is to find technically feasible solutions for long-term storage for electricity and heat over days and even weeks and seasons. Currently, pumped storage presents the most feasible option of large scale electricity storage. This option should be expanded and optimized for small scale applications. However, pumped storage is just one option for e-storage which is not necessarily applicable in all countries and locations. Moreover, smart management systems and new business models present additional challenges.

A5.6. Technology Roadmap for PEDs in EU

A bundle of integrated joint actions is needed to accelerate the conversion of existing building stocks to PEDs and stimulate the transition to PED for new building. At a quick glance, the following main steps for a proposed technology roadmap for deploying PED in EU within the time horizon of 2025 can be addressed, as presented in Figure 2.

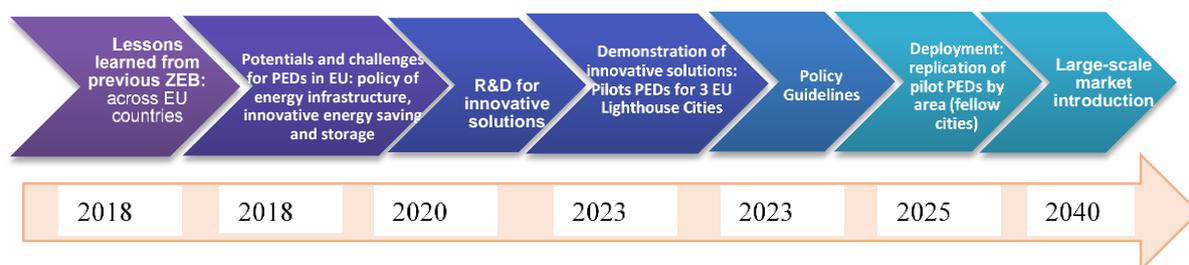


Figure 3: main steps for a technology roadmap to deploy PED in EU

The main steps of the technology roadmap are summarized as follow:

1. Lessons learned: comprehensive evaluation of existing PEBs/PEDs demo cases across EU countries and beyond to specify challenges, barriers and opportunities identified in various socio-economic, technological, financial and legal fields related to the planning and implementation of the projects.
2. Identification of opportunities and challenges for PEDs deployment in EU in technical, financial and regulatory dimensions based on lessons-learned, emerging technologies and needs for innovative solutions for application on PEDs;

3. Preparing a strategic plan on R&I to coordinate the effort among research organization and industry to realize the desired innovative technologies for realizing PEDs (see above section on R&I needs).
4. Demonstration of case studies for PEDs: establishment of pilot PEDs projects within the Smart Cities and Communities Initiatives for different climate situations in the EU, e.g. Northern, Central and Southern Europe, in order to implement and test innovative solutions and explore suitable business models, and addressing techno-economic and regulatory concerns. This implies an intensive **monitoring** scheme for improvement and optimization of the new adopted technologies and the applied integrated solutions. In this regard the applicability of existing urban energy modelling tools can be tested and further improved, to establish integrated energy modelling concepts for local energy systems for future application;
5. Policy guidelines: conduct comparative assessment among the case studies addressing the demonstrated pilot projects to extract recommendations and policy guidelines regarding the potential of technology deployment and appropriate business models for future replications;
6. Deployment plan: setting up a medium to long range **Replication Plan** of the implemented pilot PEDs within the lighthouse cities and the fellow cities;
7. large scale market introduction: based on the successful implementation of pilots in the lighthouse cities and the further deployment in the fellow cities, a large-scale introduction of PEDs in the global market will be initiated and supported until reaching the market maturity

In line with above steps it is worthwhile to mention that the investment necessary for large demonstration projects like the Smart City Light House projects can only be made by large and comparatively wealthy cities. As many European cities do not fall into this category, initial replication solutions could start with medium-size demonstration projects. Some kind of multi-criteria assessment is necessary for moving to the next stage in demonstration and replication. Furthermore, developing a systematic toolbox can help projects to avoid common mistakes and learn from existing examples.

A5.6.1. Messages and Recommendations Along the implementation of the TRM

The developed TRM come with a set of key recommendations targeting the key stakeholders responsible for developing, implementing and deploying the innovative integrated concept of PEDs within the EU cities. Those stakeholders consist of R&I institutions, industry, construction companies, energy suppliers, municipalities, city governors, regulatory authorities, financing institutions, national government, citizens and consumer.

The majority of the recommendations addresses jointly different stakeholders calling to take appropriate actions. The main recommendations are summarized as follow.

Recommendation	Targeted Stakeholders
Treat the deployment of PEDs as integrative part of city’s long-term urban transformation strategy and integrated within a bold energy transition plan (like sustainable energy action plan: SEAP).	<i>Municipality, city governors, energy suppliers</i>
Promote the use of renewable energy via decentralized energy production systems	<i>Municipality, city governors, energy suppliers</i>
Accelerate the development of innovative technologies and integrated solutions on different renewable energies and energy efficiency, and power and heat storage forming that form the key elements for implementing PEDs	<i>R&I institutions, industry, energy suppliers, national governments and EC</i>
Support the applied research for developing innovative and cost-effective solutions to handle the bottleneck challenge of power flexibilization and power and heat storage	<i>R&I institutions, industry, energy suppliers</i>
Ensure coordination between national and regional governments, local policy makers and local communities	<i>EC, national governments, city governors,</i>
Stimulate the cooperation among municipalities, housing businesses, R&I institutions, industry, construction companies, financial institution and private investors to enable cost-effective technological innovations for PEDs	<i>Municipality, city governors, national governments</i>
Support the rollout and market uptake of urban data platforms and smart cities management systems	<i>Municipality, city governors,</i>
Establish medium-sized demonstration projects as pilot PEDs by EU-area for learning and adaptation and subsequent upscale	<i>EC, national governments,</i>
Develop a systematic toolbox to help PED implementation projects avoid common mistakes and learn from existing examples	<i>R&I institutions, industry, construction companies</i>
Adopt advanced business models to deal with the technical, economic and regulatory challenges for deploying PEDs and in particularly disbursing the cost of transforming existing building stock to PED	<i>Financing institutions, city governors, national governments</i>
Translate the technologies into attractive “transactions” with the customer	<i>Industry, consumers, citizens</i>
Propose innovative policy incentives on EU-level (new regulation, financial incentives, etc.) to stimulate the market, encourage investors and support consumers on the way to introduction and deployment of PED across EU countries	<i>EC, national governments,</i>
Establish a new energy policy framework to enforce/encourage the deployment of PEDs	<i>EC, national governments, Municipality, city governors,</i>

Develop Life Cycle Assessment (LCA), and Total Cost Assessment (TCA) methods for GHG emissions and other environmental impacts related to PEBs/PEDs	<i>R&I institutions, Municipality, city governors,</i>
Consider remote sites in adjacent urban areas, or the surrounding regions, for additional bioenergy, or electricity supply through wind and solar parks during the peak demand period.	<i>energy suppliers, municipalities, construction companies,</i>
List enablers and barriers based on previous experiences (departmental silos; budgets and financial flows, lack of dedicated budgets, teams and processes; targets and performance management processes; attitude to risk and failure limits experimentation; etc.)	<i>Municipality, city governors,</i>
Launch a PED Support Service, with an easy to use service for cities to assess their capability to create PEDs, including clear benefits for cities and stakeholders to encourage participation.	<i>EERA smart cities members, interested Municipality, city governors,</i>
Consider -by each new PED project- to embrace the challenge of discovering, analysing, understanding and exploiting their own unique local potentials (e.g. geothermal, wind, open water for cooling or waste materials)	<i>Municipality, city governors, energy suppliers</i>
Take into consideration that neighbourhood-scale projects are effective in term of bringing social and economic benefits for the community on top of energy and emissions savings	<i>Municipality, city governors, energy suppliers, citizens and consumers</i>
Setting up platforms to bring stakeholders together and facilitating difficult stakeholder constellations e.g. in multi-ownership settings.	<i>Municipality, city governors,</i>
Consider having an interdisciplinary team in place right from the start of the planning process of a PEDs.	<i>R&I institutions, municipality, construction companies, energy suppliers</i>
Consider that converting existing building to PEDs is a big challenge calling for developing and rolling-out know-how, affordable and replicable solutions and business models	<i>Municipality, construction companies, financial institutions</i>
Ensure effective citizen involvement and engagement as it is a key for success	<i>Municipality, citizen</i>
Adopt evidence-based national strategies for the renovation of the building stock bringing together supply and demand for renovation, regulation and finance, with the view to achieve affordability for both tenants and owners (EPBD)¹⁴	<i>National government, Municipality, construction companies</i>
Develop the relevant skills in the field of demand (building owners) and supply (renovation companies) of renovation as	<i>National government, Municipality,</i>

¹⁴ Energy Performance of Buildings Directive

well as finance (loans and subsidies) and regulation (related to split incentives)

construction companies, financing institutions