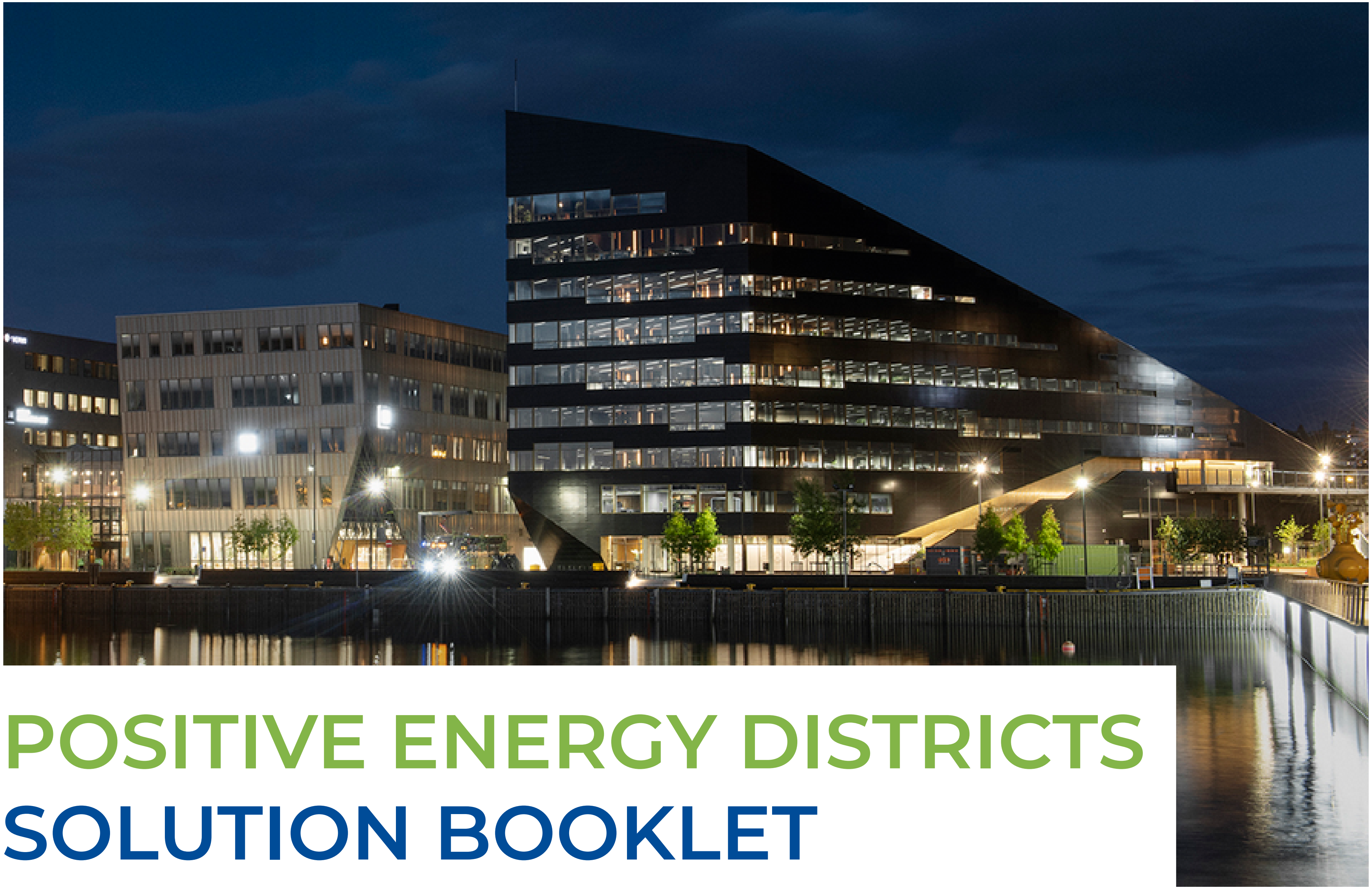

# POSITIVE ENERGY DISTRICTS SOLUTION BOOKLET

EU Smart Cities Information System

SCIS Smart Cities Information System | November 2020


# TABLE OF CONTENTS

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## WHAT IS THE SMART CITIES INFORMATION SYSTEM?

The Smart Cities Information System (SCIS) brings together project developers, cities, institutions, industry and experts from across Europe to exchange data, experience, know-how and to collaborate on the creation of smart cities and an energy-efficient urban environment.

## WHAT IS A SOLUTION BOOKLET?

A summary of the management framework, primarily written for cities. It seeks to reduce the effort, speed up the process, strengthen quality and confidence in outputs, align across disciplines, and generally prepare a city to engage the market to acquire a solution.

Solar Settlement. Copyright: Rolf Disch Solar Architecture, Freiburg, Germany

# WHAT & WHY


Powerhouse Brattørkaia Project (powerhouse.no). Copyright: Ivar Kvaal

# WHAT & WHY

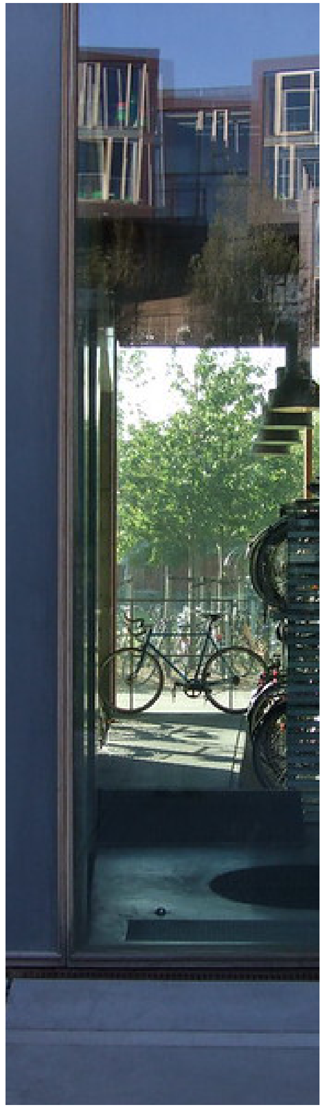
**Positive Energy Districts (PEDs) are gaining importance, both as urban innovation labs and as concrete, on-the-ground projects for creating future proof, energy-positive and climate-neutral urban living environments. Where do they come from and why should one have one or more PEDs developed in one's own city?**

The need to transition to sustainable and climate neutral cities and districts is a major driver for developing PEDs. They provide a net positive energy balance over the year by producing more renewable energy than needed to fulfil the district's demand.

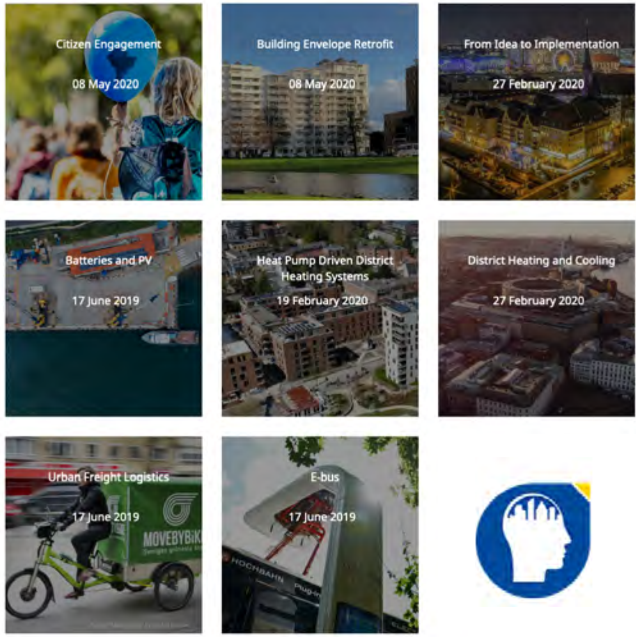
**More importantly, they answer to multiple sustainability needs. They are envisaged as affordable, inclusive and future proof urban living environments where people wish to reside or work and see a safe and healthy future taking shape.**

PEDs are not exclusive (energy) islands within a city. They are strongly embedded in their urban and regional context, as much from the energy perspective as from a more holistic point of view. They are a part of sustainable urban development. PEDs will often come in the form of urban renewal projects rather than through newly built districts, which adds to the challenges and the complexity of their implementation. **Today, based on a yearly basis, only 1,3 % of the EU's residential building stock is undergoing a medium to deep energy retrofit.** With the EU's climate goals in mind, such retrofit needs to become more prevalent. PEDs can have an instrumental role in this effort, and this way, contribute to realising the Green Deal's Renovation Wave targets.

At the same time, buildings should evolve from being unresponsive and highly-energy-demanding assets to becoming highly-efficient micro-energy-hubs embedded in PEDs: **consuming, producing, managing, storing and supplying energy in an intelligent way, making the system more flexible and efficient. PEDs will also supply their surplus energy to neighbouring areas where deep retrofitting remains a bottleneck, for example in an area with heritage buildings.**

This solution booklet cannot summarise everything related to a PED. Therefore, the booklet is conceived as an umbrella, referring to other solution booklets and relevant sources where appropriate. The themes addressed will vary from citizen engagement and urban planning to the technical matters of district heating and cooling networks, refurbishment, local energy generation or home and district batteries. Innovative business models and financial schemes are considered.




Hereby, the present booklet focuses on the following questions: **how can a PED be set up? Which factors are important? Who should be involved, and when? What are the main issues to consider for its energy system? How can costs and benefits be fairly shared through business models that are fit for this purpose? How to secure qualitative aspects like social inclusion and spatial quality?**

**The origins: the EU's energy and climate targets, smart city and community projects and the SET Plan Action 3.2**

The concepts of Positive Energy Blocks (PEBs) and Positive Energy Districts (PEDs) have initially emerged from the EU Horizon 2020 Smart Cities and Communities project calls and from the Strategic Energy Technology Plan, of which an action is dedicated to realising 100 PEDs throughout the EU by 2025.

All these initiatives are underpinned by the EU's long term climate and energy strategies and derived policies like the Clean energy for all Europeans package. The EU Green Deal is the latest policy roadmap complementing and regrouping such objectives, and an EU climate law is in the making. This sets the scene for increasing ambitions and a tighter agenda for all involved actors.

Meanwhile, the PED concept is picked up by other initiatives and organisations as well. Like this, the Smart Cities Marketplace has a working initiative on PEDs, a European COST Action on PEDs with partners from public and private sector has been set up, and at the international level, the International Energy Agency has started a new annex to work on PED definition and development: IEA Annex 83 Positive Energy Districts.

These initiatives help to mature the concept for mainstreaming PEDs both within and outside the EU.

## A working definition for PEDs

**In the framework of the already mentioned SET Plan Action 3.2, JPI Urban Europe and the EERA Joint Programme on Smart Cities have set out to detail an operational definition of PEDs. This initial definition is used as the working basis for the present booklet. It states:**

**"Positive Energy Districts are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability[1]."**


1 www.jpi-urbaneurope.eu/ped

## Beyond energy: sustainable districts and cities – setting the targets towards a carbon-free 2050

PEDs are a powerful concept, but at the same time, they are only one piece of the urban low carbon puzzle. PEDs are moreover **not exclusively about energy and climate**. According to the concept, it is important to adopt a whole systems approach and aim at realising **integrated sustainability**, a principle which is already reflected in the definition above. Given this broad set of conditions, other solutions and strategies than a PED may exist, depending on the specific urban context at stake. Nevertheless, PEDs may be instrumental for progressing beyond the current urban planning practices: they **connect the visionary with the practical**.

## PEDs and the post-COVID era

In the **post-COVID era**, certain aspects of sustainable urban life may come under pressure. Is living in a green suburb better while being under lockdown? How to implement everyday travel through urban areas in a **sustainable yet safe manner**, using (e-)bikes, walking, public transportation, or perhaps e-shuttles?

While there seems to be no evidence that cities pose a higher risk of infection, urban environments do come with the challenge of providing a safe and attractive life under all conditions. This has implications on **location strategies, the design of soft transport modes, the provision of green areas and of sufficient individual outdoor spaces**. PEDs might, in one way, supply interesting answers, both to the requirements of the low carbon transition and to pandemic-proof operations, including social aspects that have been revealed to be of primary importance for the wellbeing of citizens.

# CITY CONTEXT

# CITY CONTEXT

**From NZEBs over PEDs to Positive Energy Regions and back: combining bottom-up and top-down approaches.**

One could try to make a city energy positive and climate neutral by bringing every single building separately to the near-zero energy building (NZEB) standard. Yet, such a city with separate NZEBs would miss many opportunities for technical and financial optimisation, for scale advantages, the use of district energy systems, energy flexibility services and collective energy production and storage. In a similar vein and from the non-technical point of view, a city is neither a mere accumulation of buildings. The goal of integrated urban functioning is of utmost importance, regardless of the chosen perspective.

PEDs are thus the next logical evolutionary step following NZEBs. Once a city has buildings that start to generate surplus energy part time or all the time, a step change occurs and these buildings can be integrated in a different way into the energy system - in the case of plus-energy buildings, the surplus energy has to be shared with others. They can then not only be treated as local generation but lead the path towards upgrades of larger neighbourhoods. Buildings with different energy use profiles over the day can moreover exchange energy, and new plus-buildings can support older buildings with limited energy retrofit potential. Local connections can also reduce stress on the grid and lead to larger urban rejuvenation projects.

**The scale of integration can be progressively extended, but an overall strategy working in the opposite direction is also necessary.**

Solving the urban clean energy puzzle is indeed best done in a combined bottom-up and top-down approach. In fact, the regional sustainable and renewable energy potentials (within the urban texture as well as in the surrounding hinterland) define the overall envelope of possibilities to realise a fully decarbonised system. Hereby heat can be sourced from up to some tens of kilometres away, while electricity can – if needed - be brought in from hundreds or thousands of kilometres away. But the closer the energy sources can be located, the better.


Figure: Energy from district to regional integration and beyond. Scheme adapted from the Whitepaper Transformation Swiss Energy System – Swiss Competence Centre of Energy Research, Future Energy Efficient Buildings & Districts

Therefore a natural hierarchy emerges where NZEBs are complemented by Positive Energy Blocks (PEBs), PEDs and eventually Positive Energy Cities and Positive Energy Regions. Hereby the use of renewable energy sources changes the energy production and consumption paradigm fundamentally from a centralised, hierarchical system with off-site power plants to a connected, decentralised system with a myriad of on-site prosumers complementing the larger off-site production units. From the business model point of view, citizens are empowered to occupy a central role in Local Energy Communities (LECs). LECs thus fully support PEDs as a new energy market model.


**Local Energy Communities**

Local Energy Communities (LECs) are an overall concept. The EU regulatory frameworks provide two definitions embodying the same principle, yet with slight differences: Renewable Energy Communities (RECs – under the Renewable Energy Directive) and Citizen Energy Communities (CECs – under the Electricity Directive). See the RESCOOP platform.

The need to integrate these new energy infrastructures into the urban design and planning processes sharply increases: renewable energy sources need space. Their substantial functional and visual impact within the (urban) public space and landscape is at best turned into a quality of its own.

A multitude of actors including the **local authorities, energy utilities, grid operators, private property developers, building owners and occupants, civil society organisations and other relevant stakeholders will need to be involved in the development of PEDs.**

## From energy and carbon to integrated sustainability

Transforming the urban energy system cannot go without **engaging all concerned stakeholders in the process** and having a shared vision of where to go.

The role of a city (energy) vision is to define and settle the long-term energy planning that will be implemented in the city to achieve its 2050 climate goals. Such planning will come in the form of a set of actions identified after a thorough analysis of the city's situation, its renewable energy potentials, strategies, plans (short term and mid-term plans, SEAPs or SECAPs, SUMPs, Digital Agendas, etc.) and after technical and financial viability assessments have been done, to ultimately foster the required energy transition by 2050.

Urban stakeholders like citizens, enterprises, knowledge institutes and, of course, local authorities themselves, shall be **involved in this envisioning and planning process** so that all concerned parties can **take ownership of the identified actions**. This implies that a proper governance structure is put in place, assuring the legitimacy of the actions and securing the long term engagement of all relevant stakeholders.

The city's energy vision will most preferably be integrated in a wider narrative, including a **captivating Leitbild, envisioning the city's future as the vibrant and future proof place where people want to live and work**.

Resulting commitments need then to trickle back down into concrete actions in different activity sectors (residential and tertiary buildings, transport, services and food, etc.), all of them focused on **reaching the 2050 goals** and, equally important, **realising the high quality urban life that its citizens aspire. These actions underpin the Positive Energy District (PED) concept.**


In Belgium a consortium of industrial and academic partners teamed up to create ROLECS, a collaborative research project that intends to clarify the potential and practicalities of LEC implementation in Flanders.

## City (Energy) Visions and Roadmaps: setting the beacons towards the future

**In Amsterdam,** Lighthouse City of the **ATELIER SCC Lighthouse project**, the city connects to New Amsterdam Climate, the city's roadmap towards climate neutrality in 2050.

**The Leuven** 2030 roadmap illustrates how one can integrate concrete urban projects into the urban roadmap as part of its climate action plan.

**Groningen, Lighthouse City of SCC Lighthouse project MAKING-CITY**, has set its environmental and energy vision 2050 – "The Next City" that is being developed within the project from the experiences of testing and implementing PEDs.

LEUVEN 2030

ROADMAP
2025 · 2035 · 2050

13 programma's naar een klimaatneutraal Leuven

The time is now. Nú moet de stap gezet worden van 'doen wat kan' naar 'doen wat moet'. Dat impliceert een systemische verandering van de stad en de samenleving. Leuven heeft de ambitie en de verantwoordelijkheid om hierin een voortrekkersrol te spelen. De Roadmap 2025 - 2035 - 2050, opgesteld door Leuven 2030 en tal van experten, dient als leidraad om tegen 2050 het doel van een klimaatneutrale stad te realiseren. Dat deze uitdaging op véle schouders dient te worden gelegd, is meer dan ooit duidelijk. Daarom startte in september 2019 een professioneel team van programmaverantwoordelijken, die dit unieke plan zullen omzetten naar verdere concrete actie en impact op het terrein.


# THE ENERGY SYSTEM OF A PED

Powerhouse Brattørkaia Project (powerhouse.no). Copyright: Ivar Kvaal

# THE ENERGY SYSTEM OF A PED

**At the core of a PED is the physical energy system. The main objectives of a PED are energetic: a high level of local urban renewable energy and of energy efficiency. This section highlights the main aspects of the PED energy system but does not attempt to be complete. The large number of energy technologies that can be applied in the PED, in combination with a wide variety of required energy services, leads to a large number of energy system designs, which require a specific assessment.**

## What is an energy system?

**An energy system is a physical system designed to supply energy services to end-users. It includes all interconnected components related to production, conversion, storage, delivery, and use of energy. A PED is an energy system in itself, and, at the same time, a component of a wider energy system (urban and regional).**

The overlaying control and management systems can be considered as a part of the energy system as well. These systems are used by the system operator to control the way the services are delivered, such as ICT-based smart grid management systems and building energy management systems, and by the end-user to control the demand for energy services, such as the manual radiator controls.

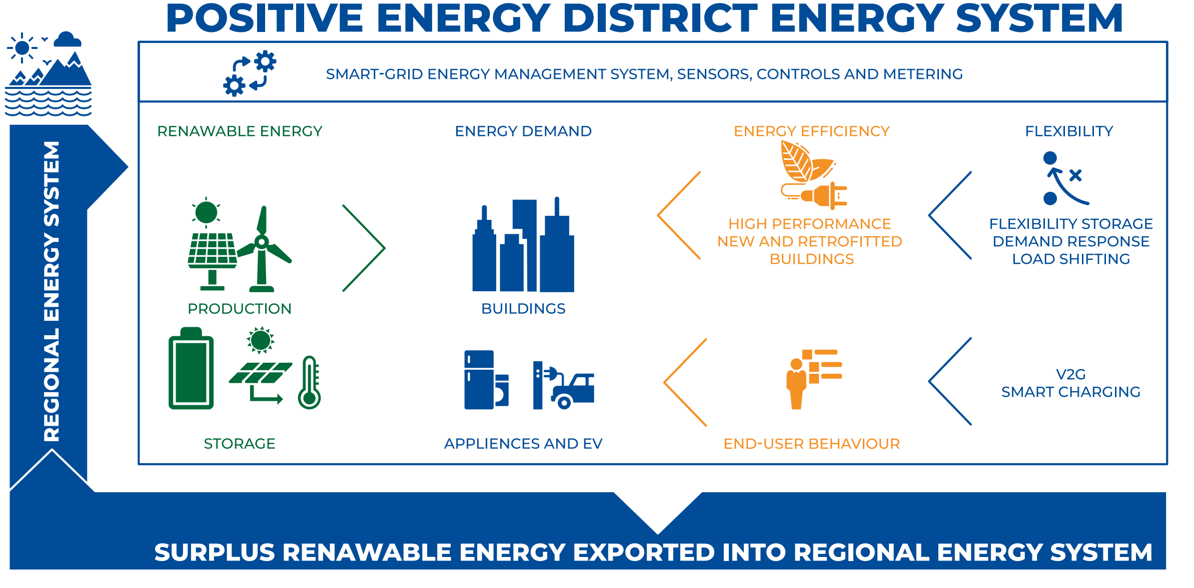



Figure: Simple graph energy system PED in wider context | Adapted from Amsterdam University of Applied Sciences

## Boundaries to PED energy systems

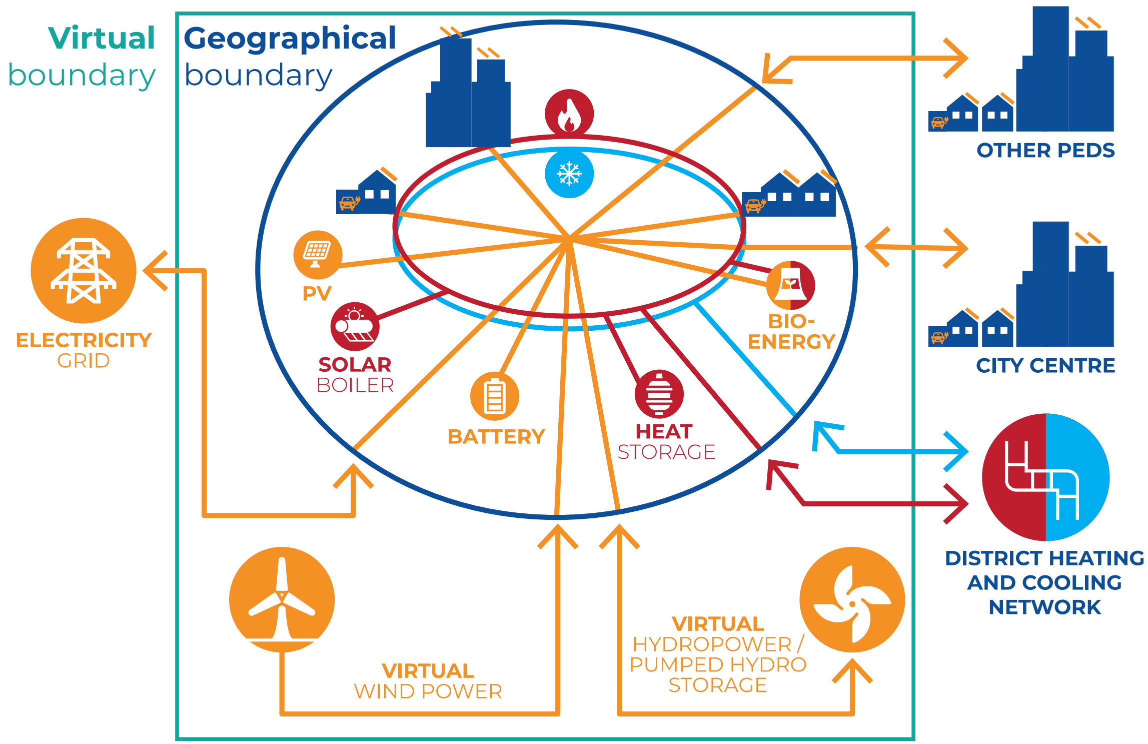
**A PED is characterised by achieving a positive energy balance within a given boundary. Defining the boundaries to the PED energy system is not straightforward. Such a boundary can be geographical or virtual. In all cases, the energy system boundary will include a virtual component through connection to a smart grid.**

**Geographical boundary.** The energy system is constrained within a geographical area that does not include other independent energy systems. The PED achieves a net positive yearly energy balance within the geographical boundaries of the PED and allows/requires dynamic exchanges with the wider energy systems to compensate for momentary surpluses and shortages.

**Virtual boundary.** Disaggregated energy systems are connected by a smart grid and managed by a common energy management system. For example, renewable energy generation sources dedicated to the PED can be located outside the geographical boundaries of the district. The PED achieves a net positive yearly energy balance within the virtual boundaries of the PED and allows/requires dynamic exchanges with the hinterland to compensate for momentary surpluses and shortages.

The optimal design of a PED and the corresponding level of surplus energy can only be determined with a wider energy system context and within an upscaling strategy. Boundaries need to be set for the design of the smart grid and interconnections, as well as for evaluation of impact and performance. However, it should be considered that these boundaries are temporary and, to some extent, ambiguous. A strict focus on setting specific boundaries, within which the PED pilot must be energy positive at all costs, could even hinder upscaling.

Figure: PED boundaries. | Adapted from VTT, SPARCS




Limerick Weir location. Source: Google Street View

Figure: Aerial view of the +CityxChange Limerick PED with the Gardens International anchor building and the historic Georgian Innovation district.

Photo: Limerick2030 / Limerick City and County Council. Copyright: Eugene Hogan

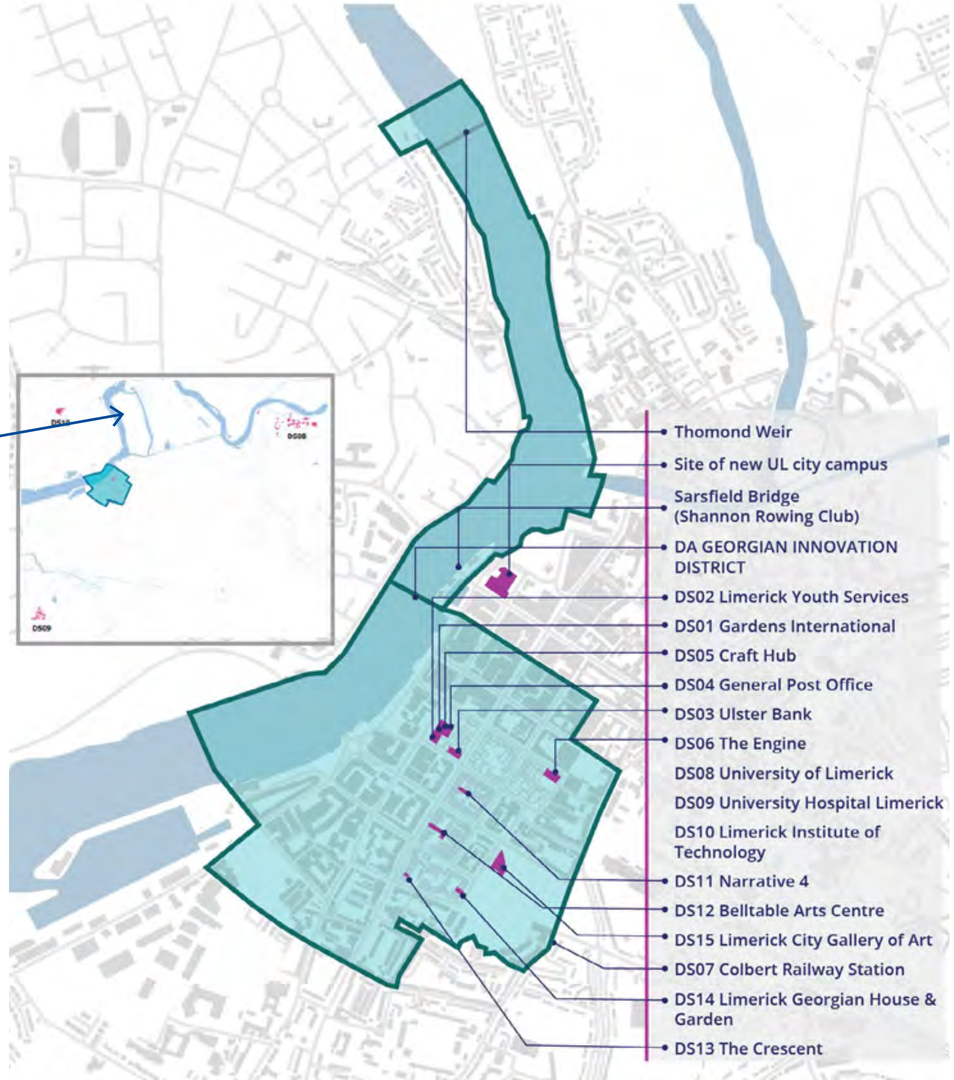
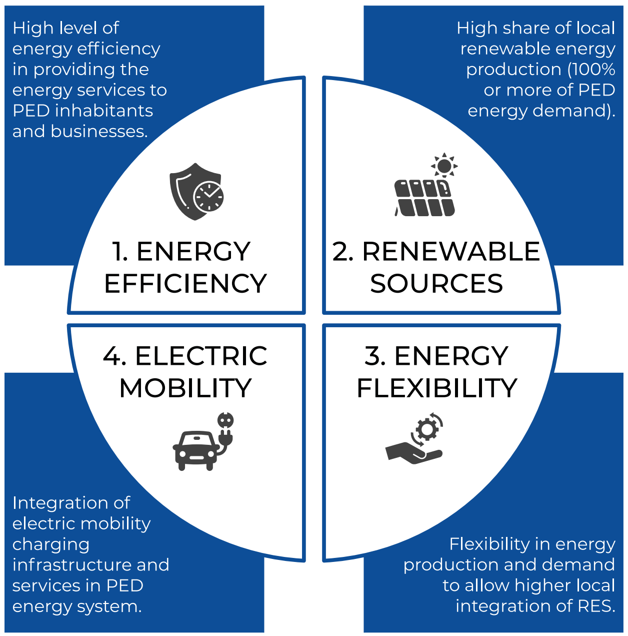



Figure: A virtual PED in Limerick (+CityxChange) where some electricity for the historic city centre blocks will be sourced from a turbine in the Shannon river, about one kilometre away. The turbine will be part of the PED energy management system and smart grid. More: [cityxchange.eu/our-cities/limerick](cityxchange.eu/our-cities/limerick)

## The four components of PED energy systems

**A high level of energy efficiency and renewable energy production are the obvious components in PED design.** As a complementary component, energy flexibility aims to allow a **higher level of integration of renewables in urban areas**. In those cities with plans to expand e-mobility, the charging infrastructure and charging demand as well as e-mobility services could also be integrated in the energy systems. As this will be the case in most cities that are considering PEDs, e-mobility is emerging as the fourth component of a PED.




### Component 1: Energy efficiency

**A district's or building's energy performance can be improved in several ways. This includes:**

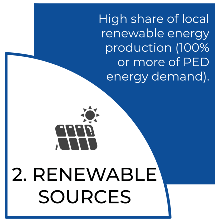
- choosing a suitable building design (compact structure, optimum orientation and daylight, using passive climate control measures like solar shading devices),
- improving the thermal insulation (high-performance windows and insulation systems to protect the building envelope),
- optimised construction (thermal bridge free, airtight constructions and connections) and
- ensuring energy-conscious user behaviour (visualising consumption, smart metering, adaptive controls, energy-awareness etc.).

**Energy efficiency may be further improved by:**

- low heating system temperatures (and hence low heat losses),
- short pipe lengths in heating, warm-water and ventilation systems (and hence lower heat losses and less energy for driving pumps and fans),
- avoiding hot water circulation,
- including heat recovery systems in ventilation and wastewater systems,
- hydraulic balancing of all systems (and hence less energy for driving pumps and fans),
- using demand-controlled heating and ventilation systems (due to avoiding the oversupply of spaces with fresh air and heat),
- using high efficiency domestic appliances and space lighting (LED or energy-saving lamps in conjunction with demand-responsive control systems).

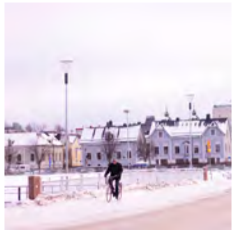
Increasing energy efficiency in the existing building stock is one of the biggest challenges in the energy transition and is, therefore, a high priority in city energy and climate plans. In new buildings, a higher level of efficiency can be achieved with less effort and lower costs. In addition, it is easier to integrate RES and storage into new construction during the design stage. Addressing the existing building stock's energy performance is without doubt the bigger challenge, and PEDs will have to address this.

## Component 2: Renewable energy production




Energy systems for PEDs will require a higher share of renewable energy sources for heating, cooling and electricity, compared to current regulation and business-as-usual practices. This is achieved by: 1) integration of renewable energy sources into buildings and their immediate surroundings, such as PV roofs and 2) adding stand-alone RES production facilities to the PED, such as PV-plants. The latter production units can possibly be located outside the group of buildings or districts composing the PED, as long as they are part of the PED within its virtual energy system boundary.

Sources of renewable energy can be integrated into buildings actively and passively. For instance, passive solar gains through windows will reduce the heating energy demand and reduce the energy demand for lighting by using daylight. Actively, **renewable energy may be used via thermal solar collectors, biogenic fuels, small-scale hydropower, wind, geothermal energy or environmental heat and waste heat recovery.** Within this system, energy storage units are of high importance. The energy surplus in buildings supplied by electricity-generating systems, like photovoltaic systems or wind turbines, can be stored for flexible use or fed back into the energy providers' grids. Apart from the classical hot water storage tanks, buildings and underground energy storage (geothermal) could also serve as low temperature heat buffers.



### Renewable energy in PEDs

**In Amsterdam**, as part of the ATELIER project, a PED is developed with a high share of **photovoltaic power** production. Part of this is achieved through the integration of PV into the buildings; part through a separate PV plant located in the district and connected to the PED smart grid. smartcity-atelier.eu/about/lighthouse-cities/amsterdam

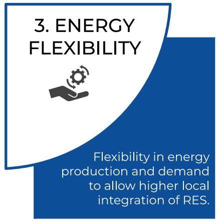
**In Bilbao**, also as part of the ATELIER project, a geothermal ring supplies low temperature space heating to the buildings within the PED. smartcity-atelier.eu/about/lighthouse-cities/bilbao

**In Groningen**, as part of the MAKING-CITY project, the heat demand of Mediacentrale building will be balanced by **solar thermal panels** connected with geothermal heat pumps that will use the temperature of the ground. makingcity.eu/groningen

**In Oulu**, as part of the MAKING-CITY project as well, heat for hot water is recovered from sewage water from apartments in the PED. makingcity.eu/oulu

**In Trondheim**, as part of the +CityXChange project, the fjord is used as a source of heating, while other heat pumps will extract waste heat from commercial warehouses. cityxchange.eu/our-cities/trondheim

## Component 3: Energy flexibility




**Energy flexibility in PEDs aims to contribute to the resilience and balancing of the regional energy system, with the optimal benefit for the regional energy system in mind. Also, PEDs manage any interactions between the urban district and the regional energy system such as to enable carbon neutrality and 100% renewable energy in the local consumption, and an additional surplus of renewable energy over the year.**

An energy system is flexible if it can cost-effectively, reliably, and across all time scales meet peak load demand, net loads from increased use of renewable energy and reduce energy losses. For this purpose, the system maintains the balance of supply and demand and has sufficient storage capacity (both electricity storage and, through sector coupling, renewable heat and gas) to [balance periods of high variable renewable energy generation and periods of high demand but low generation](#).

Within a PED energy system, energy storage is indeed of high importance. Energy storage provides the basis for flexibility within the energy system. Storage supports the integration and optimisation of intermittent renewable energy into the system by storing excess renewable energy during periods of peak production to align with periods of peak demand. Storage has the potential to reduce energy consumption, emissions and costs, while increasing overall system efficiency.

Energy can be stored in many ways. Electrical storage options include pumped hydro-electric storage and batteries including large grid systems through to building level systems and more recently the inclusion of vehicle batteries (vehicle-to-grid, V2G). Thermal storage systems including water tanks, underground systems, phase change materials and different types of gas storage including hydrogen and compressed gas systems. However, also the district heating network itself, as well as the thermal masses of buildings, can be seen as energy storage and utilised in thermal energy balancing.

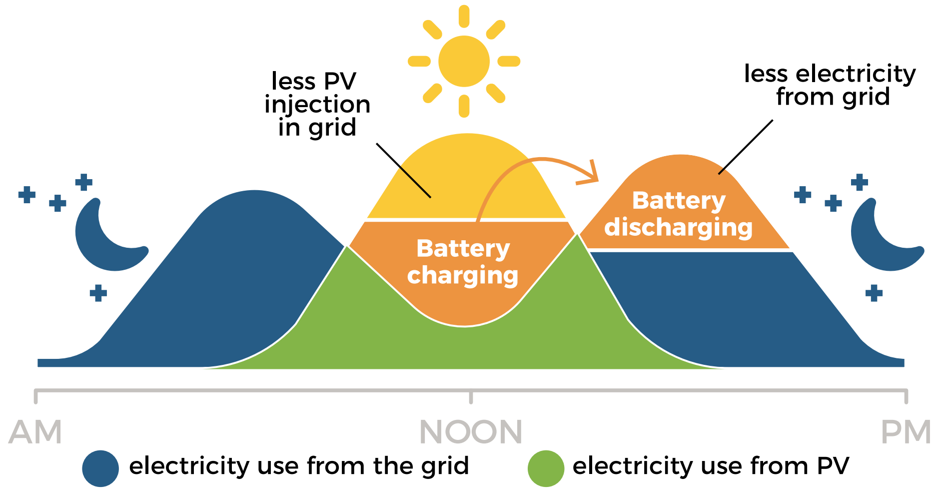
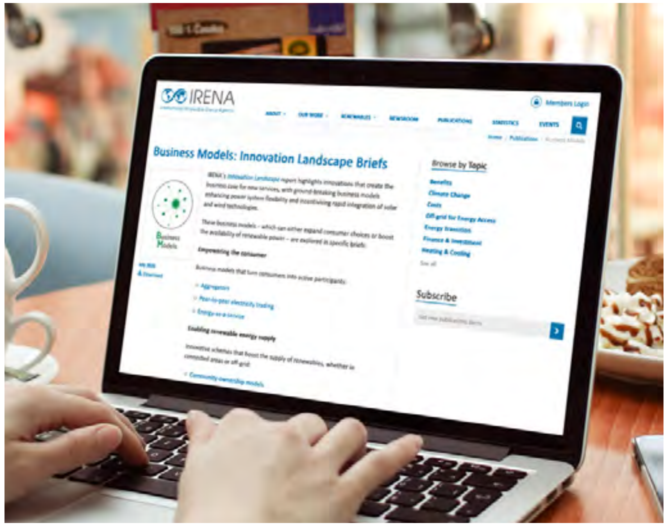



Figure: Peak load shifting by the use of a battery. (Source: [SCIS Solution Booklet PV and Batteries](#))

Until now, energy infrastructures, such as electricity or heating and cooling systems and networks, have mostly been operated and optimised separately. However, there is much technical and economic potential in taking advantage of synergy effects between the different sectors and networks. Due to the high density of infrastructures in comparison to rural areas, this is especially true in the urban context. Sector coupling will become increasingly important in the near future. One example for technologies that enable sector coupling are heat pumps. They can convert energy between power and heat and are used frequently in urban areas and at larger scale in district heating networks.




**Energy storage and flexibility in PEDs**

**Battery systems** are used in many PEDs. In **Amsterdam**, as part of the ATELIER project, a combination of central (for each apartment building) and decentralised (for each dwelling) systems is used. smartcity-atelier.eu/about/lighthouse-cities/amsterdam/

In **Oulu**, as part of the MAKING-CITY project, for increasing the energy content of the conventional water based thermal storage, **phase change materials** are utilised to increase the energy content of the tank. These phase change materials are commercial and they are made of either salt-based material or organic materials. As the temperature rises, material changes its form from solid to liquid. makingcity.eu/oulu/

In **Groningen**, as part of the MAKING-CITY project, **HeatMatcher** is a real-time matching solution for heating and cooling systems. It determines the optimal balance between producers (supply) and consumers (demand) of heat and cold. It is able to handle many energy consumers and producers at the same time, which is expected to be a prerequisite for heating and cooling networks in the near future. makingcity.eu/groningen/

**Further reading on energy system flexibility and local trading:**

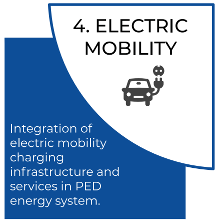
SCIS Solution Booklet on batteries and PV;

Introduction to power system flexibility by IRENA;

Introduction to the flexibility market by the project +CityxChange;

An introduction to peer-to-peer energy trading by IRENA.

## Component 4: E-mobility charging infrastructure and PEDs




**Many cities have adopted local objectives on climate, including energy, as well as the expansion of electric mobility in the city. This will create a new significant electricity demand to be served by a local charging infrastructure for e-vehicles. Therefore, the design of PEDs and their roll-out in cities should consider this increased demand for electricity and integrate charging infrastructure into the PED energy system.**

**Smart charging (SC)** can facilitate the integration of e-mobility into the PED. This implies that the charging load is matched with the capacity of the grid. Electric vehicles can also provide energy storage and grid support during periods of grid failure or spikes in demand. Although most EVs today are not designed to supply energy back into the grid, vehicle-to-grid (V2G) cars can store electricity in car batteries and then transfer that energy back into the grid later. This concept is being piloted throughout Europe, including in some PED demonstration projects.

While local energy needs for mobility in any form should be considered in a PED, this can become difficult to track, as most vehicles/means of transportation will cross districts. No clear guideline has emerged yet, but the inclusion of, for example, all charging stations, can be a sufficient approximation, unless there are specific circumstances. Since some chargers will be within buildings, this also is easier to track as overall energy demand. In case energy demand from charging is high in the PED area, it will become very difficult for a PED to remain energy positive. However, in this case, this becomes irrelevant as a benchmark because a wider scope (city) needs to be addressed.

Beyond serving the energy demand from e-mobility, the PED should also aim at reducing mobility demand through urban planning and promoting efficient transport solutions such as car-sharing and well-designed public transport. Soft transport modes (walking, biking) can greatly enhance the PED's mobility solutions and **local quality of life**.

Smart, clean Energy and Electric Vehicles in Amsterdam. Copyright: Flexpower Amsterdam project (SEEV4-City)

**Integration of e-mobility in PEDs**

**In Trondheim**, as part of the +CityXChange project, **e-buses** are charging within the harbour area PED and smart car chargers are connected to buildings.

cityxchange.eu/our-cities/trondheim

**In Espoo and Leipzig**, the SPARCS project demonstrates how to integrate e-mobility hubs into PEDs by developing large-scale EV charging systems. The Sello block in Espoo will be developed into a e-mobility hub connecting local and long-distance trains, city e-buses, and a new fast tramline. The EV-charging and its power management is optimised with the energy demand and the virtual power plant of the Sello block by utilising load prediction, demand response services as well as control and charging strategies based on business models.

sparcs.info/about/actions

**Further reading on mobility and PEDs**

A global outlook on e-mobility by the International Energy Agency.

An overview of smart mobility solutions in smart city projects.

Solution Booklet link tiles:


## Targets and calculating the energy performance of a PED

**The optimal design of a PED and the corresponding level of surplus energy can only be determined within a wider energy system context. Generic targets on the level of energy positivity cannot be set. For example, in some cities with potential for large central renewable production in the urban area or in the region around the city, near-zero energy districts may be enough in reaching the city's targets. In other cities, without complementary RES potential, achieving energy positivity is more important.**

Nevertheless, it is necessary to measure the energy performance of a PED in comparison to a reference case or baseline. This supports PED design and evaluation, through the annual energy balances. To this purpose, standardised calculation methods, such as the EC's Building Energy Specification Table (BEST), can be applied. This methodology is currently being further developed to better match the characteristics of PEDs. In the ex-ante evaluation or ex-post monitoring of PED energy performance, however, the scope and limitations of the calculation methodology used need to be considered in relation to the local and city-level impact and objectives of the PED.

Calculation of the energy balance in PEDs is complex since it includes several parameters regarding RES on-site, primary energy factors, deciding if a resource is an input or not for calculation and so on. In order to reach an annual positive energy balance, buildings involved in the district have to manage their energy consumption and the energy flow between them and the wider energy system.

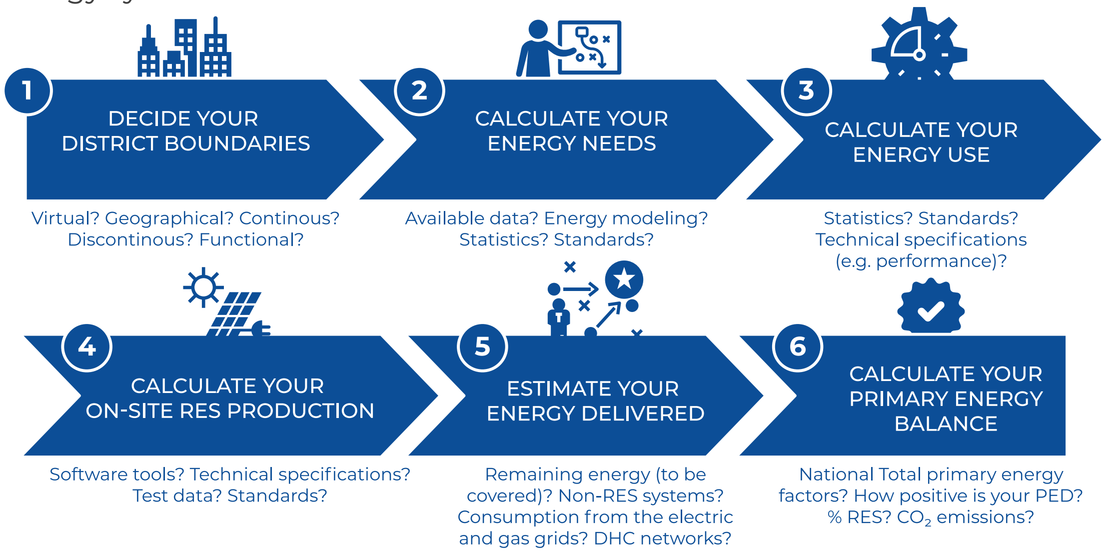



Figure: The steps in calculating the energy performance of a PED. Adapted from MAKING-CITY guidelines.

**Further reading on calculating PED energy performance**

The **EC's Building Energy Specification Table** template used for assessing the performance of the Horizon 2020 Lighthouse PED demonstrators; ec.europa.eu

**Improved and extended guidelines for calculating energy performance;** MAKING-CITY: Guidelines to calculate the annual energy balance of a PED.

# ICT APPLICATIONS IN PEDS

# ICT APPLICATIONS IN PEDS

**Information and Communication Technologies (ICT) are instrumental to the functions and smart solutions in PEDs.**

They benefit from the rapid developments in ICT, such as in artificial intelligence (AI), visualisation, GIS use, blockchain, and big data processing. Optimal operation of PEDs requires high interoperability among various stakeholder's systems and equipment, including systematic data exchange through application programming interfaces (APIs), with defined ontologies.

First of all, ICT supports the planning, design, construction and operation of buildings, infrastructure, and urban components, regardless of PED or not. Nevertheless, **ICT plays a crucial role in enabling the following PED innovations:**

**Energy system management.** Operating a highly interactive and flexible multi-commodity energy system cannot be done by hand. Smart energy management systems will control and optimise the flows of energy, connecting and balancing the local demand and supply of RES, including EV charging infrastructure for load shifting and energy storage.

**Local market operation.** Many PED pilots experiment with setting up local energy communities, local (peer-to-peer) energy trading platforms and local trading in flexibility services. Blockchain is often explored for these local transactions.

**Citizen engagement.** Smart user interfaces can be used to raise awareness with the inhabitants and to actively engage and empower them as energy citizens.

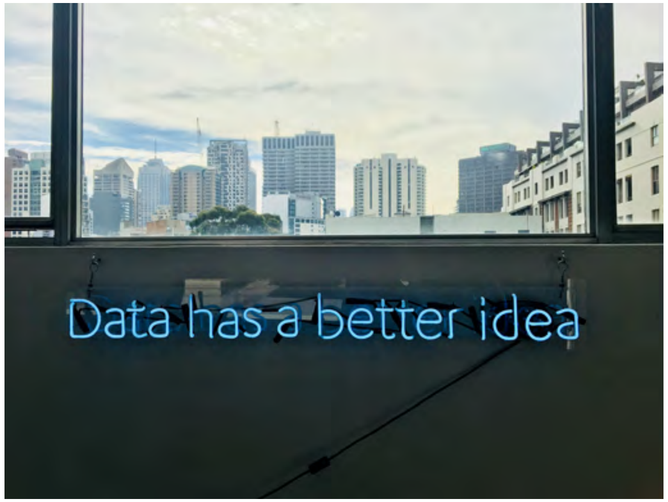
**City data management.** Many cities are developing urban data platforms to support fact-based policy making and increase the transparency for the citizens.

**Digital twinning and visual 3D models.** The latest developments move from visualising buildings to turning the 3D models into a rich source of information related to the urban landscape and built environment.[2]

**Interoperability and integration** are important in any complex smart city project. In the case of PEBs, the complexity from control systems from multiple vendors in multiple buildings with various owners, up to energy companies and cities means that systems need to work together and partners need to agree on the use of suitable standards. Cities and operators can foster this by demanding interoperability and open data access in tenders.

2 Smart City Platform Enabling Digital Twin. Available from: mysmartlife.eu/fileadmin/user_upload/publications/FVH_HEL_IEEE-IS2018_Smart_City_Platform_Enabling_Digital_Twin.pdf

While ICT is an enabler for these innovations, the actual impact of the flexibility and trading measures on energy and environment performances remain to be validated as we are in the early days. These products and services are mainly technology and commercially driven at the moment. Given the complexity of these ICT products, lock-in of suppliers is a serious risk for cities, to be addressed when piloting these products. The use of open standards and open ecosystems can partially mitigate this issue. Ideally such requirements are also part of tendering offers. Finally, **data and system security and privacy requirements need to be complied with as well.**





Read more about the major barriers to the implementation and replication of a smart energy project as well as citizen engagement here.

**ICT for PEDs.**

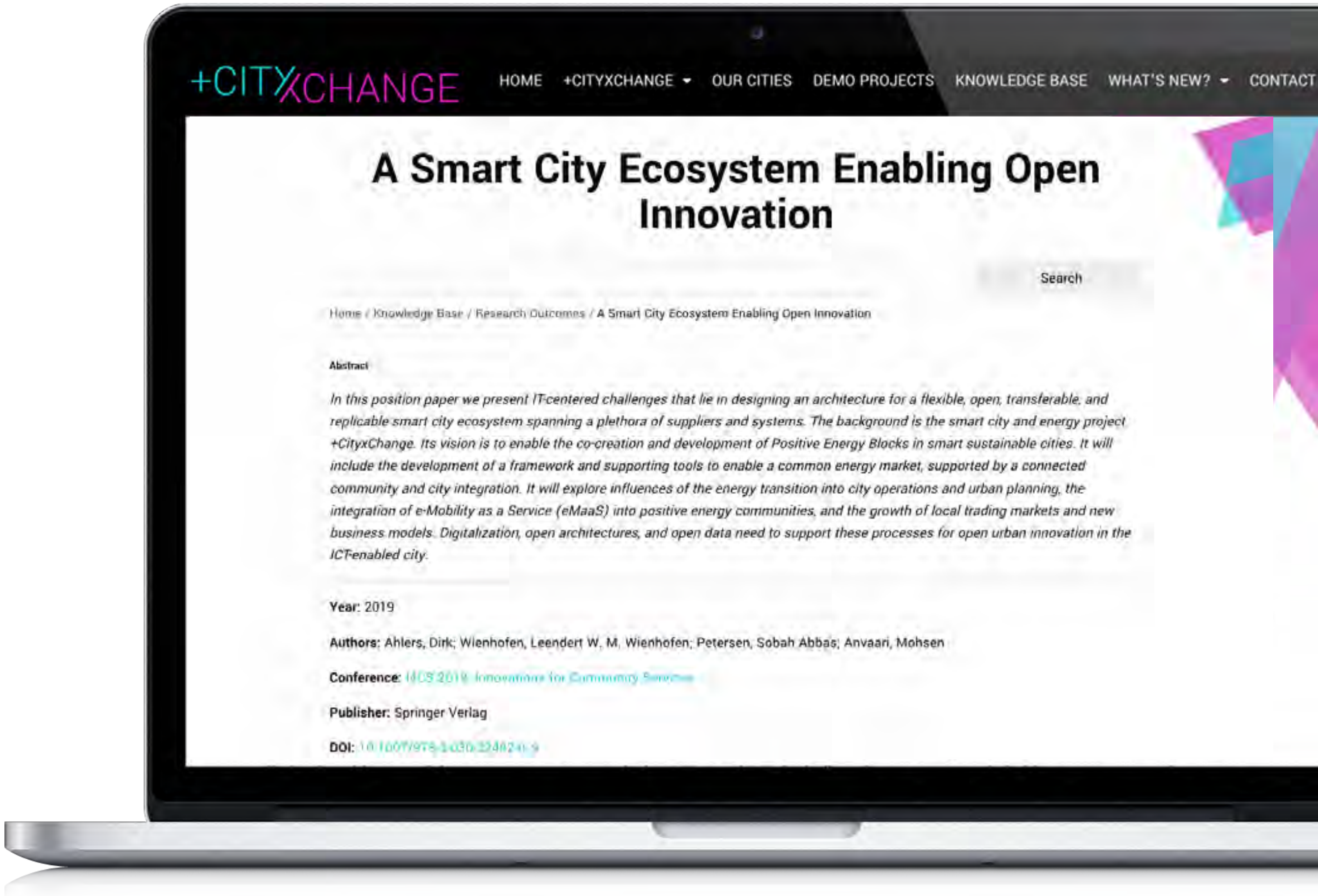
**Oulu**, as part of the MAKING-CITY project, has developed an interface as “Visualisation Units” to study human behaviour regarding the energy consumption in which participants can access their energy consumption, water consumption, evaluate their comfort and provide feedbacks on it, as well as information on their environmental impacts. [D4.1 Methodology and guidelines for PED design].

+CityxChange follows an open architecture and open ICT ecosystem approach, with a strong focus on open standards and open APIs used between partners, up to the inclusion of [Open Data repositories from the cities for KPI data].

**Further reading on ICT and PEDs**

Ready4SmartCities’s innovation and research roadmap for [ICT in energy systems of smart cities];

+CityxChange’s [Smart City Ecosystem Enabling Open Innovation].



# SOCIETAL AND CONSUMER ASPECTS

# SOCIETAL AND CONSUMER ASPECTS

## Stakeholder support and citizen engagement

**The success of implementing PEDs will not only depend on the availability of technical solutions but also on social, political and business commitment. The energy transition is a multi-level phenomenon, involving cultural and societal aspects next to planning and finance, for example. In order to achieve a truly sustainable and 'smart' energy system, that is secure and affordable for all citizens, the social dimension needs to be addressed upfront and throughout.**

Citizen and stakeholder engagement is an important means through which to achieve this. Putting the goals and aims of the engagements first, different methods, tools and forms of participation can be suitable and effective. From activating awareness through events, to co-creation interventions and citizen science projects. The SCIS solution booklet on Citizen Engagement and the CE Guidebook of the +CityxChange project give an elaborate overview of means, methods and best practices.

**Considering a citizen and stakeholder engagement approach in PED projects, the following considerations are especially relevant:**

**Working in a setting of new and existing buildings** over large parts of neighbourhoods makes it important to build good connections to citizens and stakeholders, to include their ideas, concerns, and contributions, and to make them **partners in the transition**;

To improve **energy-conscious inclusive citizen services**, it is required to **take measures such as shifting their energy consumption to periods with surplus renewables or using shared e-mobility** instead of private cars. This calls for extensive and innovative citizen engagement and co-creation methods, resulting in citizens who understand, trust, use and feel ownership of the integrated energy and mobility solutions offered in their district;

**Citizens in a PED may even become energy prosumers.** What does that mean for them? What do they need to live and work in a PED? What does it mean to have a form of ownership of your energy consumption and market?

Can we, also beyond the individual PED demonstrators, engage more citizens in the energy transition: **increasing citizens' knowledge level and motivation** and growing support for, and informed appreciation of, energy transition measures?

## Setting up urban living labs

To generate more long-lasting impact and to be able to innovate with and in PEDs, it is crucial to tap into or to build new sustainable innovation ecosystems. Creating such innovation ecosystems helps to structurally work on challenges with the stakeholders in the energy transition. Urban labs, field labs or living labs are interesting forms for creating such innovation ecosystems, on the ground, within neighbourhoods. The Urban living lab approach offers a way to foster new collaborative, trans-disciplinary ways of thinking in urban planning and development and provides a real-world testing ground for urban innovation and transformation. Such living labs bring inventiveness and audacity: going beyond the traditional comfort zones and discovering new potentials, collaborations, business models, governance and legitimacy.

Th!nk E Battery Lab in Oud-Heverlee, Belgium

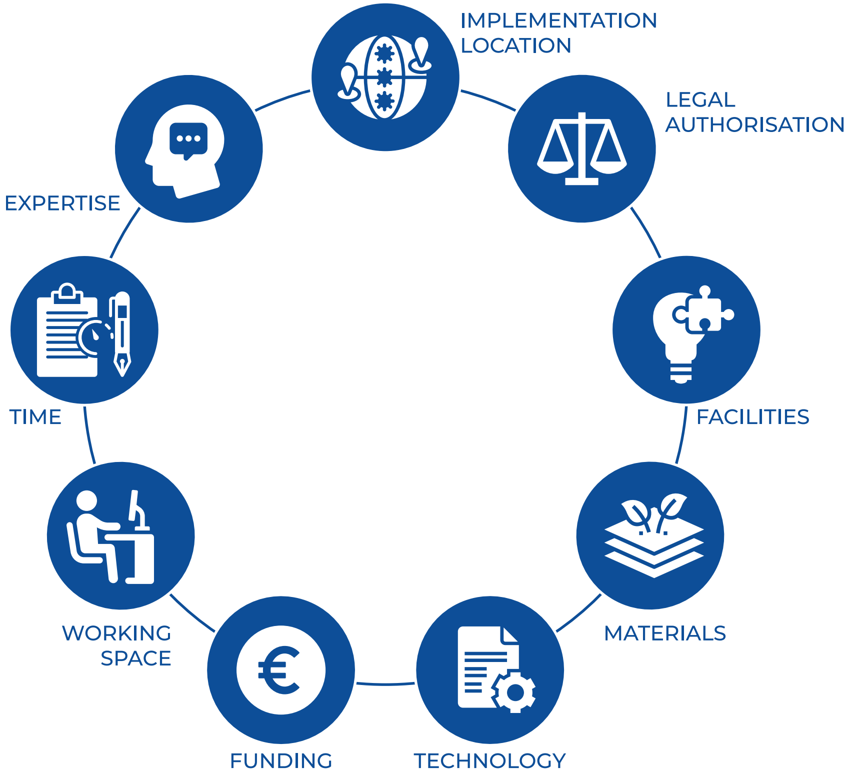



Figure: Map of recurring conditions for the development, implementation, and replication of innovations to be supported by urban living labs. Adapted from Amsterdam Institute for Advanced Metropolitan Solutions

Th!nk E Living Lab in Oud-Heverlee, Belgium

A PED can be seen as a typical urban living lab, being a real life setting for co-creating and developing innovations leading to a positive energy district. The Amsterdam Institute for Advanced Metropolitan Solutions states:

**'The goal within our urban Living Labs is to make impact by developing new products on a small scale – be it an object, a service, a technology, an application, or a system – and to find solutions that can be implemented on a larger scale. This is done in a real-life and co-creating setting in which different stakeholders give shape to the innovation process. The actors are users, private and public actors, as well as knowledge institutes. In the process, the feedback gathered from use and evaluation of the product is used to accelerate further development. As the product is implemented in a real-life setting and validated by the involved actors, it is more likely to be adopted smoothly and swiftly by all involved, and subsequently have a large impact in the city quickly.'**

**Further reading on urban living labs.**

Examples and guidance for urban living labs

Urban Living Labs: A Living Lab Way of Working
AMS Research report 2016-2017.


Th!nk E Living Lab in Oud-Heverlee, Belgium

## Impact: primary and secondary benefits for society

**Talking about the impact of PEDs, it is relevant to keep in mind primary benefits, but also more indirect or secondary benefits. Starting with the primary benefits:**

**Energy and carbon emission savings; financial savings in the operational phase.** Moreover, energy-efficient technologies are made available for the PED stakeholders/residents and thanks to the process of engagement, information is provided, increasing the social acceptance of new technologies. New skills (how to use the new technologies) are learned and new habits are initiated - if they settle, they might lead to a behavioural change.

A PED can be seen as an experiment where it is possible to try out new ideas and solutions. In order to implement innovative solutions, most times, exceptions in policy, legal, and planning regulations need to be made to allow for these innovations. This idea of PED as a **catalyser**, as a “safe ground”, where innovation can take place can be seen as a primary benefit.

Stakeholders and inhabitants can reap **additional economic benefits**, including increased value of real estate or additional revenue from delivering specific energy services.

At the root of a successful PED there are **innovative governance structures** that, at the same time, enable and are made possible by a thick and overlapping network of stakeholders in the PED and in its wider context. One of the primary benefits of a PED is to make this set-up available. A successful PED will be the one able to maintain and develop this governance structure in time, especially after the pilot phase has ended.


**But also the following secondary benefits could be achieved in PEDs:**

**Activated community**, feeling of ownership of energy use and energy system, leading to active energy communities inside and outside the PED.

**Less energy poverty and fossil fuel dependency, more comfortable homes and more well-being, a healthier urban environment, more greenery and less urban heat island effects, less traffic congestion.**

Understanding of "what is normal" for the **new urban life** of the future, i.e. social norms are shaped in these PEDs and it is up to the successful scaling-up of PEDs that these lessons spread to other areas of the city or to other cities.

New challenges and **solutions in areas such as policy, regulation, market organisation and business models.**

Increased **awareness** of the importance of reducing energy consumption and development of more sustainable lifestyles and behaviours within the PED, but also in the surrounding areas.

**These secondary impacts can only be established building on existing social structures, innovation ecosystems and interventions that are embedded in the context of the PED.**

**Paddepoel citizen engagement – "Real people, not personas in Paddepoel"**

In the PED-district Paddepoel in **Groningen**, a typical post-war district, three homes were selected to become 'sustainable demo houses'. These demo houses and their owners bring the fairly abstract PED-concept to a local scale and make it thus more tangible. A Facebook page has been set up as a platform to show the progress and setbacks the three families face in implementing the innovative measures for their homes. Updates on the demo houses are mixed with news on local sustainable activities. Having people from a local energy community in the team brings on a close connection to residents and stakeholders in the district.

(Source: groningenco2neutraal.nl/nieuws/2-2/ | facebook.com/MakingCityDemohuizenPaddepoel/)

**Further reading on citizen engagement**

Citizen engagement is ideally part of a more extensive quadruple helix open innovation model, meaning there is intensive **cooperation between stakeholders from research, industry, government, and society**. How this can be done is illustrated in the SCIS Citizen Engagement Solution Booklet;

The **+CityxChange Citizen Participation Playbook** helps local authorities to enable local communities on how they could become a Positive Energy Block (PEB) and lead the transformation towards Positive Energy Districts (PEDs) and Cities;


# BUSINESS MODELS & FINANCE

# BUSINESS MODELS AND FINANCE

**Setting up a PED is a complex process. It involves many stakeholders, each with their own interests, constraints and agendas. Managing this requires a high degree of coordination.**

This is why the large-scale deployment of PEDs requires the inclusion of sustainable business models that consider the whole process of building, operating and maintaining PEDs.

There is no predefined single business model for the successful development of a PED. Instead, a combination of different business models has to be found for each stakeholder involved. This applies to each of the pillars of the PED energy system (energy efficiency, renewable energy production, energy system flexibility and electric mobility). For each stakeholder involved (cities, real estate developers, building owners, providers of innovative technologies, energy infrastructure operators, inhabitants...), the PED has to bring a value proposition that meets the stakeholders' needs and wishes.

Therefore, an important step in the development of business models for PEDs is the identification and mapping of stakeholders involved in PEDs, their individual interests and their interactions, representing the PEDs' complex ecosystem.

This may turn out to be a difficult process. As an example, in ATELIER's Lighthouse City Bilbao, difficulties have arisen for finding a party, public or private, interested in acting as the smart grid operator (local DSO or Community System Operator - CSO) because of an insufficiently attractive business case.

MAKING-CITY Ecosystem analysis for Positive Energy District
+CityxChange Report on bankability of the demonstrated innovations

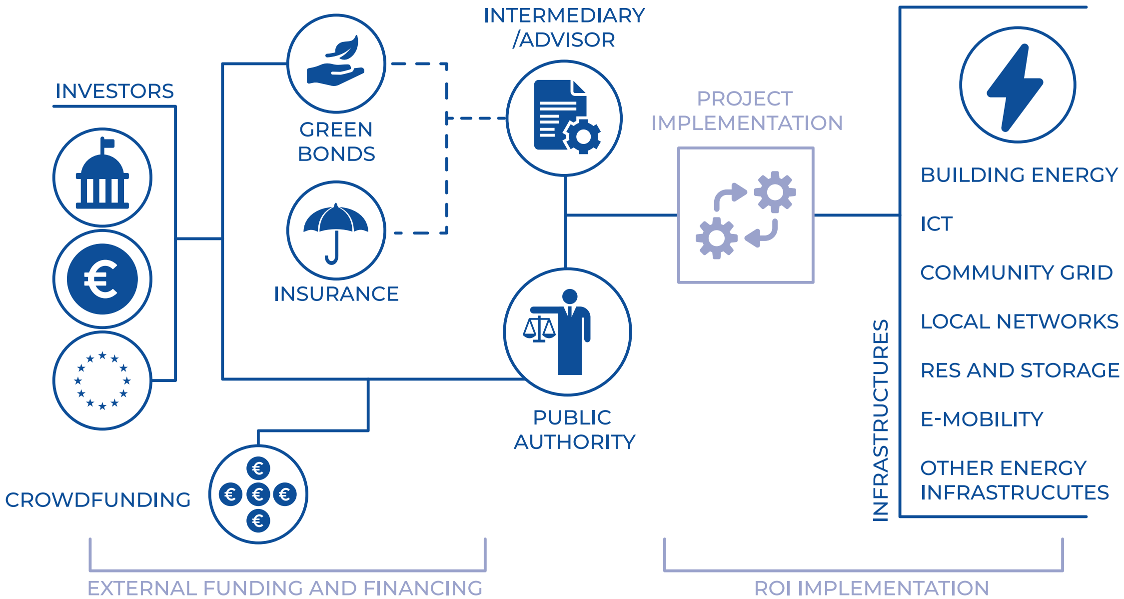



Figure: PEB Implementation and Operation through Business and Investment Models Innovation. Adapted from: +CityxChange D2.4: Report on bankability of the demonstrated innovations; cityxchange.eu/knowledge-base/report-on-bankability-of-the-demonstrated-innovations

**Suitable business models have to be identified for each involved actor. Typical business models that are relevant for the four pillars of PED energy systems are listed below. Most of these business models already exist in practice: the challenge and the innovation for PEDs is to combine several of them.**

**For energy efficiency:** The energy renovation of buildings can benefit from several business models, adapted to different types of buildings and the needs of their owners.

Within **a one-stop-shop business model**, a single service provider is responsible for holistic renovation of the building as per the wishes of the building owners, including implementation of energy efficiency measures, or building internal renovation. Thus, the one-stop-shop model foresees that a single actor offers full-service holistic renovation packages including consulting, independent energy audit, renovation work, follow-up (independent quality control and commissioning) and financing. This model is particularly well suited for social housing and individual houses.

Within the **Energy Performance Contracting (EPC) model**, an Energy Service Company (ESCO) enters into arrangements with property owners to improve energy efficiency of their property by implementing various energy efficiency measures (lighting, HVAC, energy management and control, envelope insulation…). The ESCO guarantees energy cost savings in comparison to a historical (or calculated) energy cost baseline. For its services and the savings guarantee, the ESCO receives a performance-based remuneration in relation to the savings it achieves. The model is particularly suited to public buildings and industrial facilities. Some countries in Europe already have a well-developed ESCO market.

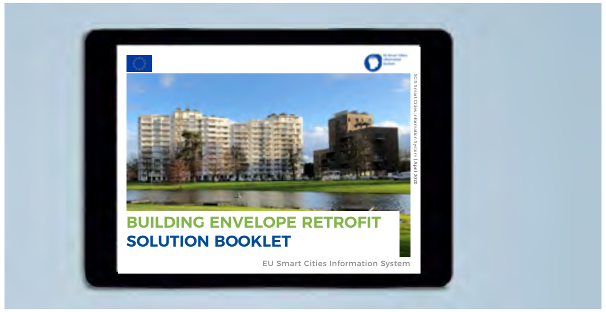
There are many more ways urban (energy) renovation projects can be financed. Local authorities can hereby take a leading role in **setting up innovative investment schemes**. A summary overview of concrete financing solutions can be found in SCIS's policy paper on urban energy retrofit, see the "further reading" box.

**Further reading on urban retrofit:**

SCIS Building Envelope Retrofit Solution Booklet;

SCIS Policy Paper on Urban Energy Retrofit;

Renovation hub 'Stunning' overview of business models.



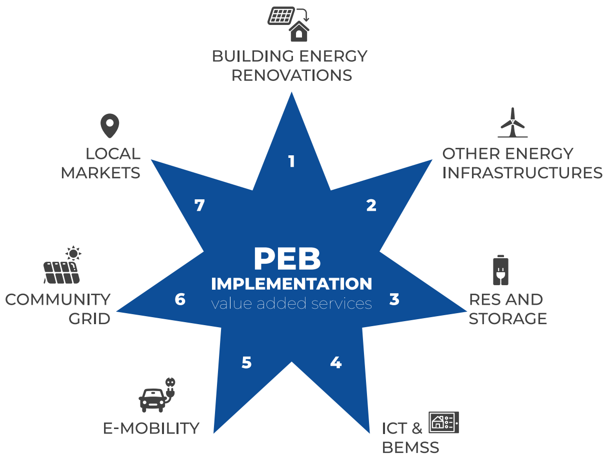




Figure: Business and Investment Model Innovations. Adapted from +CityxChange D2.4: Report on bankability of the demonstrated innovations; cityxchange.eu/knowledge-base/report-on-bankability-of-the-demonstrated-innovations/

**For renewable energy production:** The development of local, renewable energy production within a PED can equally be based on different business models. Some are exemplified in the following.

Within a **roof or land renting model**, the contractor offers to lease the roof or plot for up to 20-25 years and, in exchange, installs and maintains renewable energy devices, typically solar panels. Building owners do not have to do upfront investments and they benefit from the free electricity produced by the system. The contractor benefits from financial incentives like feed-in tariffs. Many commercial, industrial, and retail buildings can provide the real estate needed for these systems and are therefore viewed as excellent candidates for roof rental.

With the **leasing of renewable energy equipment**, building owners are enabled to use a renewable energy installation without having to buy it. The installation is owned or financed by another party, usually a financial institution. The building owner pays a periodic lease payment to that party. Leasing energy-related improvements is a common and cost-effective way for state and local governments to finance upgrades and then use the energy savings to pay the investments. Leases often have slightly higher rates than bond financing.

An **energy cooperative** is a non-profit entity for green energy production and consumption, which performs the same activities as any other retailer or energy producer company. The cooperative is committed to drive a change on the current energy model in order to promote a 100% renewable model. The cooperative only supplies energy to its members, who can participate in financing collective renewable energy projects to produce their own energy. Consumers are thus both members and co-owners, integrating various stages of the value chain. On the production side, the cooperative promotes collective financing for renewable energy installations. Thanks to this contribution, members benefit from a yearly discount on their bills. In Groningen (Lighthouse City in MAKING-CITY), Grunneger Power is an energy cooperative involved in the development of two PEDs in the city.


Our Power is a non-profit energy supply company established in Austria. It is owned by social housing providers, community organisations and local authorities, whose aim is to make energy fairer for all energy customers.

The deployment of a **district energy system**, which can be combined with local heat and cold production (based on heat pumps, biomass, geothermal, solar or waste energy), is a way to facilitate the access to renewable heating or cooling for inhabitants and the creation of a PED. The business model for a district energy system needs to ensure that all of the involved players– including investors, owners, operators, utilities/suppliers, end-consumers and municipalities – can achieve financial returns, in addition to any wider economic benefits. The majority of business models for district energy involve the public sector to some degree, whether as a local policymaker, planner, regulator or consumer, or more directly through partial or full ownership of projects. Where citizens or local enterprises can become shareholders of the local district energy system, acceptance and uptake may be higher. Within Groningen and Oulu (Lighthouse Cities in MAKING-CITY), the district heating systems are the backbones of the development of the PEDs. Within the Netherlands, the City of Groningen has a special role in relation to heat grids. Some years ago, the city and the local water company founded the company WarmteStad, from which both parties have a 50 % share. WarmteStad is the local heat grid operator and owns the system that is connected to many buildings in the PEDs. The district heating system is a key asset to realise the energy transition in a city historically linked with gas production. The current gas grid in the Netherlands is a very effective energy system; therefore, moving away from gas needs to be based on another very effective and efficient energy system. This can be done thanks to **efficient and smart heat grids.**

**Further reading on district heating and cooling systems**

SCIS District Heating and Cooling Solution Booklet;

SCIS Heat Pump Driven District Heating Systems Solution Booklet.


**For energy system flexibility:** Energy flexibility, consisting in adjusting energy consumption (and possibly production), to the needs of the energy system, can be combined with other pillars of PED energy systems, in particular energy production and electric mobility. The following business models illustrate the concept of energy flexibility.

**Demand response** consists in reducing or increasing the load level of consumers for some time when the price of electricity reaches a high/low enough level. Demand response is nowadays perceived as a major flexibility source in the decades to come in order to successfully integrate high shares of RES electricity while controlling the overall cost of the power system. Some countries in Europe have well developed demand response markets. Big energy consumers have been the first consumers involved in such mechanisms, which have progressively spread, thanks to aggregating technologies and actors, among medium-size consumers (for instance commercial buildings) and possibly even small consumers (households). Today, the profit that individual households can reap from offering flexibility services remains, however, limited.

Tariff structures also play a role. As far as capacity is going to be charged rather than the quantity of electricity purchased, the viability of offering flexibility may increase (e.g. BE, CZ).

Also, thermal flexibility services in district heating are bringing new advantages (among others, better indoor environment for residents, and peak demand curving for producers, e.g. in SPARCS).

With increased feed-in of dynamic renewables, the ability to flexibly use assets is also of strong value to a DSO for grid balancing and for system services, such as frequency adaptation.

Under the **Electricity Directive, Citizen Energy Communities (CEC)** are defined by the EC as a legal entity which is based on voluntary and open participation, effectively controlled by shareholders or members that are natural persons, cooperatives, local authorities, including municipalities, or small- and microenterprises. This is a new concept promoted at European level which may revolutionise and decentralise energy systems and favour the creation of PEDs. IoT and blockchain technologies which are currently experimented with in several pilot projects will be key enablers of CECs. Close to this concept are Renewable Energy Communities (REC), a legal concept from the EC's Renewables Directive - see also the box on Local Energy Communities (read more in chapter "City context" on page 9).

Note that an energy cooperative may be a format that serves well to set up a CEC or a REC, in this case eventually extending its services to offering flexibility as well.

Community grids and Community System Operators may be instrumental in setting up a CEC or REC.

**For electric mobility:** Electric mobility can nicely complement the other pillars of the PED energy system.

**Mobility as a Service (MaaS)** aims at providing an innovative and environmentally friendly transportation service in order to complement available transportation alternatives. This mobility alternative corresponds to on-demand short-term e-car / e-bike / e-scooter rentals with the vehicle owned and managed either by a private fleet operator or a public entity, typically a municipality. The business model offers two different rental possibilities: the classic modality, in which customers must deliver the e-car / e-bike / e-scooter in the same parking area where they started the rental, and the one-way rental, in which the customer can deliver the vehicle in another area.

When electric vehicles are well spread and technology allows for it, **smart charging (SC)** or **vehicle-to-grid (V2G)** can complement demand response from buildings by adjusting the charging load or even discharging the car battery depending on the energy system needs. This can create a revenue stream for car owners. In this way, electric mobility and flexibility services can thus be combined.

Business models for **urban freight logistics (UFL)** are discussed in the SCIS UFL Solution Booklet.

**Further reading on smart city business models**

Smarter Together handbook on Smart City Business Model innovation;

SmartEnCity Regeneration Strategy: New business models, procurement schemes and financing mechanisms for smart city projects;

IRIS Smart City Business Model Canvas;

Replicate City Model Canvas;

# URBAN PLANNING AND DESIGN

# URBAN PLANNING AND DESIGN

**PEDs require interaction and integration between buildings, building users, local and regional energy systems, mobility and ICT systems, as well as an integrated approach including technology, spatial, regulatory, financial, legal, social and economic perspectives. PED energy systems should consider the wider context of regional and local energy systems to avoid the creation of tailor-made energy systems that limit opportunities for integration, scale-up and replication.**

A novel, integrated approach to planning and implementation is needed, which considers not only the full lifecycle of planned investments in the built environment, but also the entire community influenced by them.

One challenge is that planning aspects like renewable energy production and decentralisation and digitalisation of the energy sector have previously not been a focus of urban planning. Until now, energy planning and urban planning have remained separate, even though the need for their integration has been identified. Hence, **integrated spatial and energy planning** – supporting climate protection and the energy transition with means of spatial planning – dealing with challenges, barriers and opportunities in different spatial contexts, has become more important. In this sense, PEDs can offer an opportunity for a highly efficient and sustainable route to progress beyond the current urban planning traditions. In the context of integrated spatial and energy planning, **urban planning** is the process of envisioning alternative futures for an urban area, setting goals and objectives, and formulating implementation strategies to reach an alternative future. A step towards this integration is city-level energy modelling.

Image from the conference 'The Smart City Guidance Package: The way forward', April 2019
Copyright: European Union / Giedre Daugelaite

**Land use planning** is one element of urban planning. Land use planning operates at a municipal level in order to regulate the conversion of land and property uses, with an aim of integrating social, economic and environmental issues, and reconciling competing interests and different spatial claims. As the integration of various interests is the central aim of urban planning and land use planning, cities can utilise them to foster and enable energy actions. On the level of strategic master planning, municipalities may use land use plans to guide the development of the urban structure in the long-term, and search locations for integrated urban functions, such as PEDs. Regional and local energy systems and networks are composed of locally and regionally available energy sources, built infrastructure, specific production and consumption characteristics as well as user and consumer structures from different sectors, including industry and the transportation system.

SOCIAL

ECONOMIC

ENVIRONMENTAL

Moreover, surveys and impact assessments produced during land use planning can be utilised to generate knowledge about energy opportunities. Land use planning can also be utilised to reach energy targets with implementation: local detailed plans juridically enable implementation of building projects with energy actions, and the participatory land use planning processes can be utilised for energy-related participation.

**Renewable energy production needs much more space** than installations based on the classical fossil fuel sources, and this **production must often be located on or next to its user's premises.** Urban design addresses this scale between architecture and urban planning and focuses on the physical and spatial features of the built environment. Urban design seeks to design a coherent whole starting from the place-specific resources and qualities, within the wider regulatory systems and market conditions[3].

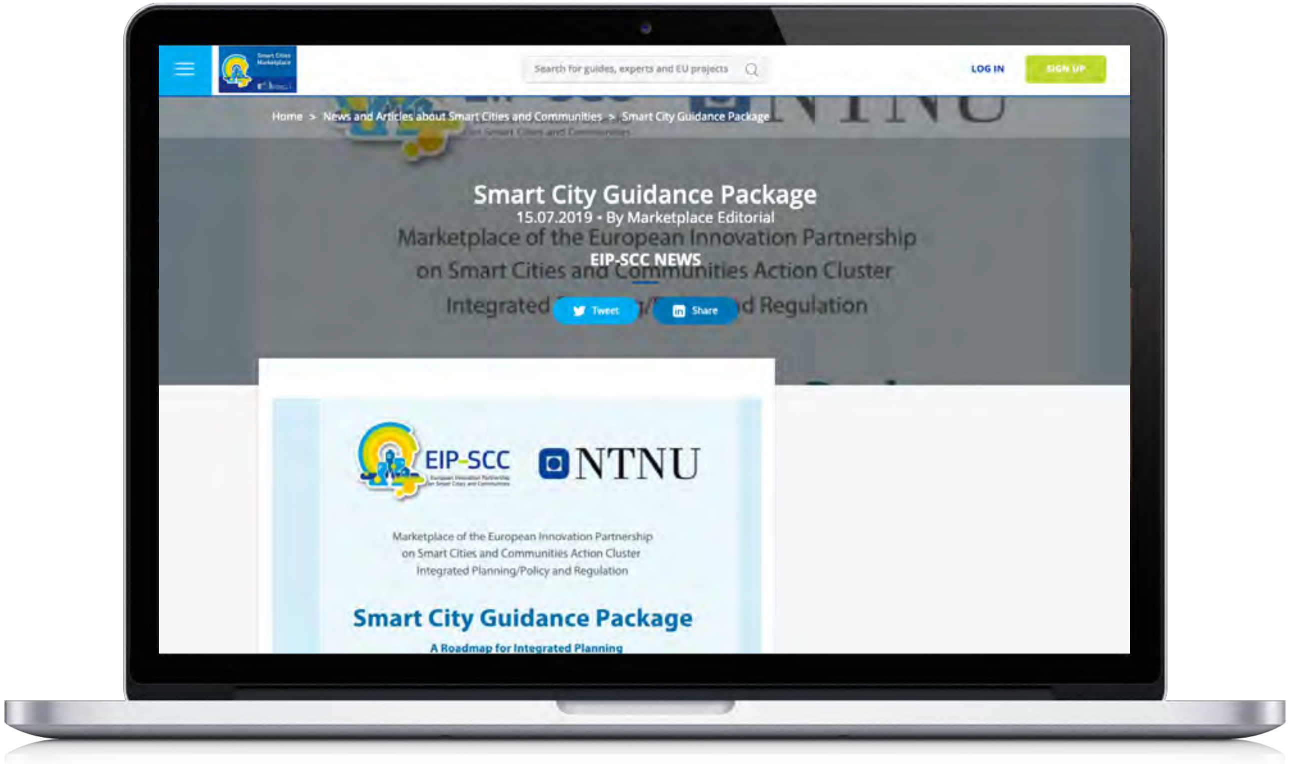
3 Carmona, M., Heath, T., Oc, T., & Tiesdell, S. (2012). Public places — Urban spaces. London: Routledge.

One limitation for utilising land use planning in fostering new PEDs is that the prerequisites of municipalities to practice land use planning **vary depending on the spatial planning system in each country or region.** Another limitation is that land use planning can be best utilised in contexts where new buildings are being built, that is, in PEDs based on new urban development or infill buildings (densification). **In PEDs that consist of existing buildings, other planning and policy tools, such as citizen engagement strategies, might be more applicable.**

**Further reading on urban planning and design**

The Smart City Guidance Package helps to plan and implement smart city and low energy district projects in an integrated way by describing common situations and giving real-life examples. [eu-smartcities.eu/news/smart-city-guidance-package](eu-smartcities.eu/news/smart-city-guidance-package).

Image from the conference 'The Smart City Guidance Package: The way forward', April 2019 Copyright: European Union / Giedre Daugelaite



# LEGAL AND REGULATORY ASPECTS

# LEGAL AND REGULATORY ASPECTS

**Traditionally, the energy generation and distribution systems as well as the legislation and regulation framework around it, assume a centralised, hierarchical system. This is an obstacle for the energy transition. Decentralisation efforts and the necessary feed-in of renewables cause a paradigm shift. Large installations are treated as power plants, but small installations on or close to buildings need a local distribution grid capable of two-way power flow. At the EU level, this is handled by directives like the Electricity Directive , and within the EU member states, through grid regulation and general or specific renewable energy feed-in rules and tariffs.**

PEDs go one step further and strongly include local and decentralised energy generation, distribution, and storage; within a local part of the grid, but at the same time in connection to the wider grid.

Even if the EU's Clean Energy for all Europeans Package is now coming into application through 'recast' directives, most of the current energy regulation in Europe is still geared towards the traditional centralised generation and distribution system. Decentralisation is an ongoing topic and many grids are already partially enabled for two-way energy flow, at least for the feed-in of larger scale renewables, and also in many cases for the local production of electricity, for example through PV on houses. Such feed-in produces disturbances and imbalances that need to be handled. However, this only means feed-in back into the general grid to be managed there. This leaves options of local management and optimisation untouched, as well as options to exchange energy directly with one's neighbour through better planning, further reducing stress on the grid.

Images from the conference 'The Smart City Guidance Package: The way forward', April 2019.

One characteristic of a PED is the use of local active grid management. Examples include the local balancing of energy flows in community grids or microgrids, the (automatic) peer-2-peer local trade of energy and flexibility between energy assets and optimisation, integration of e-mobility needs, the use of local storage, the link of market operation and system operation, the type and character of feed-in tariffs, and the use of other incentive schemes (for households and industry consumers/prosumers). District heating and cooling systems are less regulated and require less control structures, since they are less demanding than the electrical grid in terms of stability.

Local planning or zoning regulations can further play a role, as already described in the section on urban planning and design.


Image from the conference ‘The Smart City Guidance Package: The way forward’, April 2019. Copyright: European Union / Giedre Daugelaite

## The energy markets: a shift in regulation happening now

This flow between buildings and local assets, either directly between neighbours, or through a local community grid operator role, is not yet part of current regulations. New regulatory principles on this topic have been formulated in the so-called EU Clean Energy for all Europeans Package. Subsequently, the EU’s recast directives in the field of energy are now expected to gradually mainstream such new regulations suitable for PEDs, including price incentive schemes for the green shift. EU Member States have one to two years to transpose the new directives into national law.

Market mechanisms for PED trading will be part of the electricity market transition. To enable prototypes, different concepts are explored.

Current solutions include specific processes to request individual permissions and dispensations, or larger processes for so-called Regulatory Sandboxes or Pilots as processes towards regulators to set up testing areas with the aim to adapt local, national, or European regulations by demonstrating proofs-of-concept. Such legal sandboxes and special dispensation also allow specific demonstrations to be tested in negotiations with the local or national regulators.

Solar Settlement. Copyright: Rolf Disch Solar Architecture, Freiburg, Germany

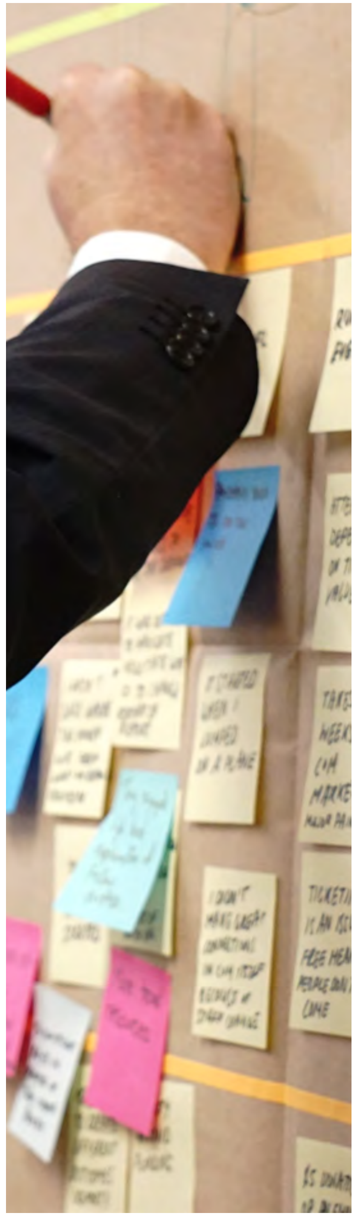
Apart from **energy trading, the trading of flexibility and its management** is going to be a major success factor for PEDs, as it allows the operator to manage capacity and reduce peaks.

One should note that trading markets are used as one option for incentive schemes and the control of energy assets. For a single campus with one owner, there can be sufficiently clear individual interest, but in a complex city situation with many stakeholders, trading is expected to better share responsibilities and benefits. The local market designs for PEDs are still under a lot of development, and results are slowly coming out of the prototype stages.

The way grid management and pricing is set up is a major operational aspect. One possible legal option is to set up new entities of Local Energy Communities, see also the box on LECs, RECs and CECs (read more in chapter "City context" on page 9). Another aspect is to accept the shifting roles in the European energy system and enable a role below the DSO (Distribution Network Operator): the Community Network Operator, see +CityxChange report on regulatory mechanisms. This will also address the changing role of DSOs and provide incentives for DSOs to be active partners in the transition and support a fair share of responsibility in its developments.

For further city-driven development of this topic, a new Smart City Marketplace Initiative on Regulatory Frameworks launches in October 2020. It will support the transition towards climate-neutral cities of the European Green Deal and help cities with regulatory framework conditions and best practices.

This section mostly covered electricity grids. A wider discussion also includes further details on the e**lectricity grid, heating/cooling grids, e-mobility, building performance and building codes**. Further regulations to consider are similar to other building projects and would include **permitting processes, participatory processes, data exchange, contracting, finance regulations** etc. Some of these aspects have also been included in the **Clean Energy for all Europeans Package**, e.g. through the recast **Energy Performance of Buildings Directive**.

# GOVERNANCE

# GOVERNANCE

## “A PED is a process, not a product”

PEDs are still novel systems but will always involve multiple building blocks and a large number of stakeholders and contributors, which will each have their own ambitions, agendas, interests and constraints. The PED process and projects are therefore complex and require a high degree of coordination. The stakeholders in the projects discussed within this booklet usually include municipalities, real estate developers, building owners, tenants, energy providers for electricity and heating, research institutes and universities, mobility providers, energy system providers, ICT companies, industry, SMEs, non-profits or NGOs, politicians, and last not least citizens and citizen organisations.

## PEDs are evolving

Changing the - historically grown - energy infrastructure at the district or urban scale is more disruptive than transforming individual building installations. Most PEDs will moreover involve urban renewal and retrofit to complement the energy system upgrades and to achieve the necessary demand reduction. Given this complex context, it will therefore not be possible to realise a PED overnight. Managing the corresponding urban transformation process will require a well-conceived governance structure.

## Role of municipalities and decision-making/ collaboration processes

Based on the complexity, the scale, and the character of PEDs as urban transformation projects, there is an obvious lead role for local authorities in facilitating the PED process as a pilot project and integrating it into wider city strategies. In this respect, PEDs can be understood as urban renewal or Smart City projects with their specific governance structures. In special cases, it may also be taken up by large real estate developers or owners of campus-like structures. For the future, when PEDs are more mainstreamed, other actors may start more bottom-up approaches (see also the section ”Business models and finance” on page 34).

Stakeholder integration and a commitment for collaboration from local actors is important, especially from building owners and energy providers, as is the need for citizen engagement, to ensure activities are in line with their needs and that their concerns and contributions can be heard and included. Furthermore, fair incentives and distribution of responsibilities and benefits should be achieved with all relevant partners. These processes can otherwise become a failure point for projects.

Project initiators are a vital part of the PED process as they have to facilitate and coordinate with other actors, and ensure high-level buy-in from the stakeholders, including strong political anchoring from the city. In line with the city as an important stakeholder, PEDs should also be strategically aligned with city visions , urban development plans, and sustainable energy and mobility plans such as SEAP, SECAP or SUMP - see also ”City context” on page 9.

To develop the necessary partnerships and to ensure higher success rates of projects, two concepts are recommended. Open innovation opens up internal innovation processes and invites external contributions and collaborations. Quadruple helix approaches mean the inclusion of wide innovation ecosystems comprising at least local authorities, enterprises, citizens and knowledge institutes. As an example, the non-for-profit organisation Leuven 2030, a governance structure for realising the city's climate goals, was conceived as a quadruple helix structure from its very outset.

## EU context factors

As described in the introduction, PEDs can be understood as a highly local and city-focused mechanism for the EU's Energy Transition. They fit within both the EU energy and climate versus Smart City ambitions. Overall EU emission reduction and energy efficiency targets are translated to national legislation and will have to be implemented where energy use is taking place, which is predominantly the European cities. Like this, PEDs may provide a tangible contribution to implementing the mandatory Member States' National Energy and Climate Plans (NECPs).

Furthermore, European and city transitions are founded on the UN Sustainable Development Goals. Apart from SDG 11 on sustainable cities, the aims and mechanisms described in SDG 17 "Partnership for the Goals" can be a valuable structure for local processes.

United Nations | Department of Economic and Social Affairs Sustainable Development

**Governance**

**ATELIER** addresses the local public sector together with other contributors. The governance structures include the instruments available to the city, such as public administration, policy, strategy, public finance, regulation, urban planning, and citizen engagement. Governance should ensure that these domains consistently and coherently promote PEDs.

In **+CityxChange**, the two Lighthouse Cities and their demonstrations are coordinated by the respective municipalities together with the local ecosystem of partners and associated stakeholders. Both city teams have strong political support and are situated high in the municipal structure, to enable them to work easier across different departments. Regular alignment and learning sessions organised by the project enable the cities to exchange experiences across cities. The cities are aligning their local strategies and activities through the Bold City Vision transition framework.

**Trondheim municipality** is expanding and applying the strategic frameworks in a new UN centre for sustainability together with UNECE.

**Further reading on governance**

SCIS From Idea to Implementation Solution Booklet;

+CityxChange Bold City Vision framework (SDG City Transition Framework);

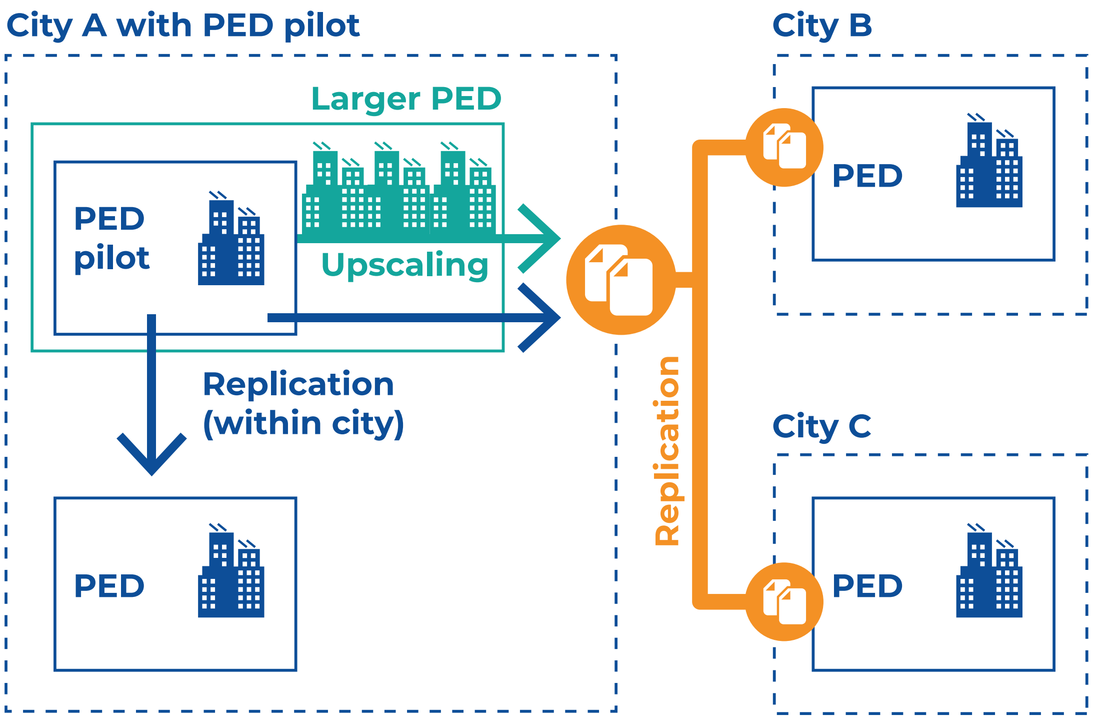
The Smart City Guidance Package;


# UPSCALING AND REPLICATION OF PEDS

# UPSCALING AND REPLICATION OF PEDS

**The PEDs that are being piloted currently throughout Europe only have value if they can be upscaled and replicated. PEDs should therefore be inherently growable and scalable. They are an intermediate step in the energy transition, so the core concept is the growing integration of local renewables and the fulfilment of all local energy needs. For a demonstration pilot, a certain area needs to be chosen, but the growth path should ideally already be present as part of the plan.**

(Up)Scaling refers to extending the initial PED by adding buildings, energy production facilities and other components. It is not the initial PED that is most important; it is the upscaling that will prove the viability of the PED concept to have a significant impact on the city. The upscaling of PEDs is important to enable the integration of renewable energy sources and the expansion of smart energy solutions. The initial design of a PED can influence success factors for upscaling, e.g. the unthoughtful selection of off-site renewable energy production for one virtual PED may limit the options for the next PED, respectively the possibilities of realising the overarching Positive Energy City or Region.




Therefore, in all PED pilots, and in parallel to the design, the upscaling strategy and approach for the specific PED should be established and embedded in the city's or region's overall clean energy strategy. The scaling aspect will thus also interfere with urban planning principles and procedures. The risk here is that, because realising the initial pilot PED is already difficult in itself, little attention is paid to the further upscaling potential.

**Replication** refers to implementing a proven PED design elsewhere in the city or in another city without a direct connection to the initial PED. PED solutions can be replicated by adapting the original idea to a new context, thus creating a comparable project in another location. Assessing the feasibility of replicability includes determining parts of the PED that can be transferred directly, and parts which need to be adapted. How to take into account the diversity of cities in terms of size, geography, demographics, culture, climate, infrastructure, economic context etc.? What is required in terms of urban design and planning, investments and risk mitigation models, citizen empowerment, collaborative governance and impact assessments? Replication of PED designs is difficult, as both design and performance are strongly context dependent. Also, the design of the initial pilot tends to be based on the most suitable location in the city and/or cherry-picking the optimal components. Within a city, the implementation of a first PED pilot should therefore go hand in hand with the exploration and assessment of other locations and designs of subsequent PEDs, similar to the upscaling principle.

### MAKING-CITY replication approach

In the **MAKING-CITY project**, a methodology for PED design aims to empower replicability, scalability, and sustainability of PEDs, taking into account the city's needs and priorities, on-site resource availability, relevant solutions, and the related business models through a decision-making journey emphasising citizen engagement. City needs are central to the approach. The main goal is the creation of a specific plan/design/guideline for each city that may reach, understand and try to follow the phases of the methodology and find out its needs, vision and objectives. More: D4.1 Methodology and Guidelines for PED Design.

### Further reading on upscaling and replication

An analysis of the drivers and barriers for upscaling smart solutions can be found in Smart City Pilot Projects: exploring the dimensions and conditions of scaling up;

An overview of the barriers and opportunities for replication is equally presented in the SCIS policy paper Why may replication (not) be happening – Recommendations on EU R&I and regulatory policies?

# MONITORING AND EVALUATION OF PEDS

# MONITORING AND EVALUATION OF PEDS

**PEDs are a new concept. Although they build on ongoing urban transitions and on proven energy efficiency and renewable energy measures, key innovations in PEDs are still being piloted and the actual benefits are not yet fully validated. Monitoring and evaluation of PED pilots and projects, therefore, is essential. The potential impacts of PEDs cover a range of different domains, from the greenhouse gas emission reduction achieved to the positive social impacts realised in the area. This implies that the monitoring and evaluation approach will encompass a range of different methodologies from different disciplines.**

Monitoring uses data collected before implementation of the PED and after completion (operational phase). The data range from the energy produced from renewable energy sources to the engagement of the stakeholders. The main question to be answered on the basis of evaluation is whether PEDs could have a significant positive contribution to a city's environmental, economic and social goals, and how they can be upscaled and replicated.

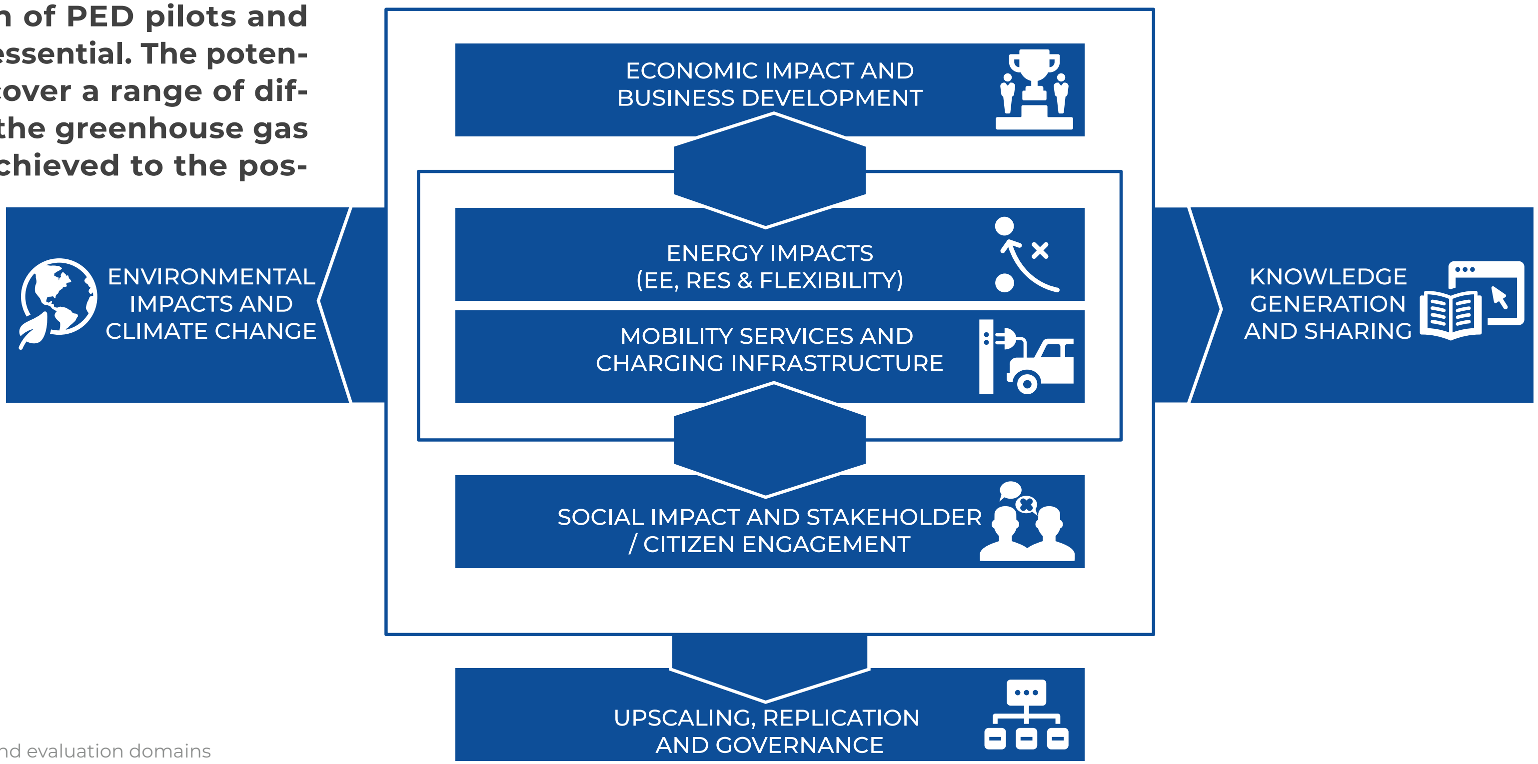



Figure: Overview of the monitoring and evaluation domains for a PED project. Adapted from smartcity-atelier.eu

LESSONS LEARNED

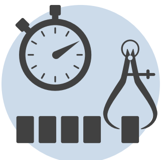
**Key performance indicators (KPIs) are a proven approach to monitoring and performance-based evaluation. They measure the effectiveness of a project towards the achievement of specific key objectives. The process of selecting KPIs also assists in clarifying the project's measures of success. However, it is important to remain aware of the limitations and risks associated with the use of KPIs:**

1. **Limitation.** A balance needs to be made between the number of KPIs used and the level of detail and comprehensiveness of the monitoring. It is inevitable that a typical number of 30 to 60 KPIs for complex and broadly scoped projects cannot cover all impacts in full detail.
2. **Bias in monitoring.** In some evaluation areas (e.g energy), it is easier to clearly define quantitative impacts, based on metering. Other areas are more difficult (e.g. citizen engagement). The risk is that in evaluation, more attention is paid to the "easy" impacts, which are not necessarily the most important ones.
3. **False sense of accuracy and precision.** For example, an outcome that a PED pilot achieves in terms of a certain surplus in annual energy can only be interpreted with insight on the level of accuracy (range of uncertainty) and precision (systematic errors), for example, if the energy surplus appears to be 2% but the error and/or uncertainty range is 5%, claiming the PED status cannot be done for sure.
4. **Uncertainty in the baseline.** A critical starting point in any monitoring and impact assessment is the assumed baseline: what would happen with the district without the PED project? Often, the baseline is based on the current situation and business-as-usual.

For these reasons, it is necessary to complement performance-based evaluation, using KPIs with other evaluation methodologies, such as those based on repeated reflection of progress involving key stakeholders.

Finally, harmonisation of monitoring and evaluation across projects and PED pilots is crucial for allowing cross-project evaluation and a portfolio approach to PEDs. The **diversity of both PED designs and district and city contexts** is moreover large, so that only limited broader conclusions can be drawn on the basis of a few cities and PED pilots.

PED DESIGN DIVERSITY



PED DISTRICT DIVERSITY

CITY CONTEXT

**References for monitoring and evaluation of PEDs**

**Smart City projects that focus on PEDs have published their monitoring and evaluation approaches, including the selection of KPIs, for example:**

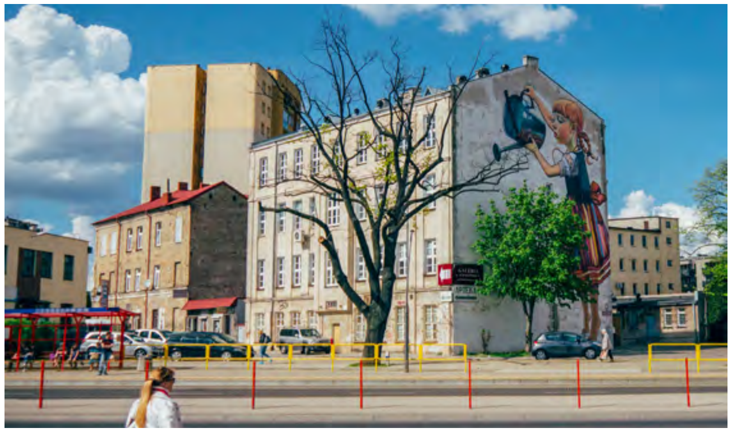
+CityxChange Approach and Methodology for Monitoring and Evaluation;

City-level indicators from MAKING-CITY;

Simulating the energy behaviour with the **Oulu digital twin Target energy behaviour** can be monitored only partly under the right circumstances. There can be various reasons for the partial monitoring. One reason is that intelligent control is used, and the control is made possible only for limited time instead of the whole two years monitoring period.

In Oulu, for the case of partial monitoring the final monitoring outcome is simulated using the digital twin of the target building or the target district. In this case, the real monitoring time shall be used for training and validating the digital twin.

SPARCS' holistic impact assessment methodology,
SCIS guidance on the monitoring of smart city projects and PEDs.



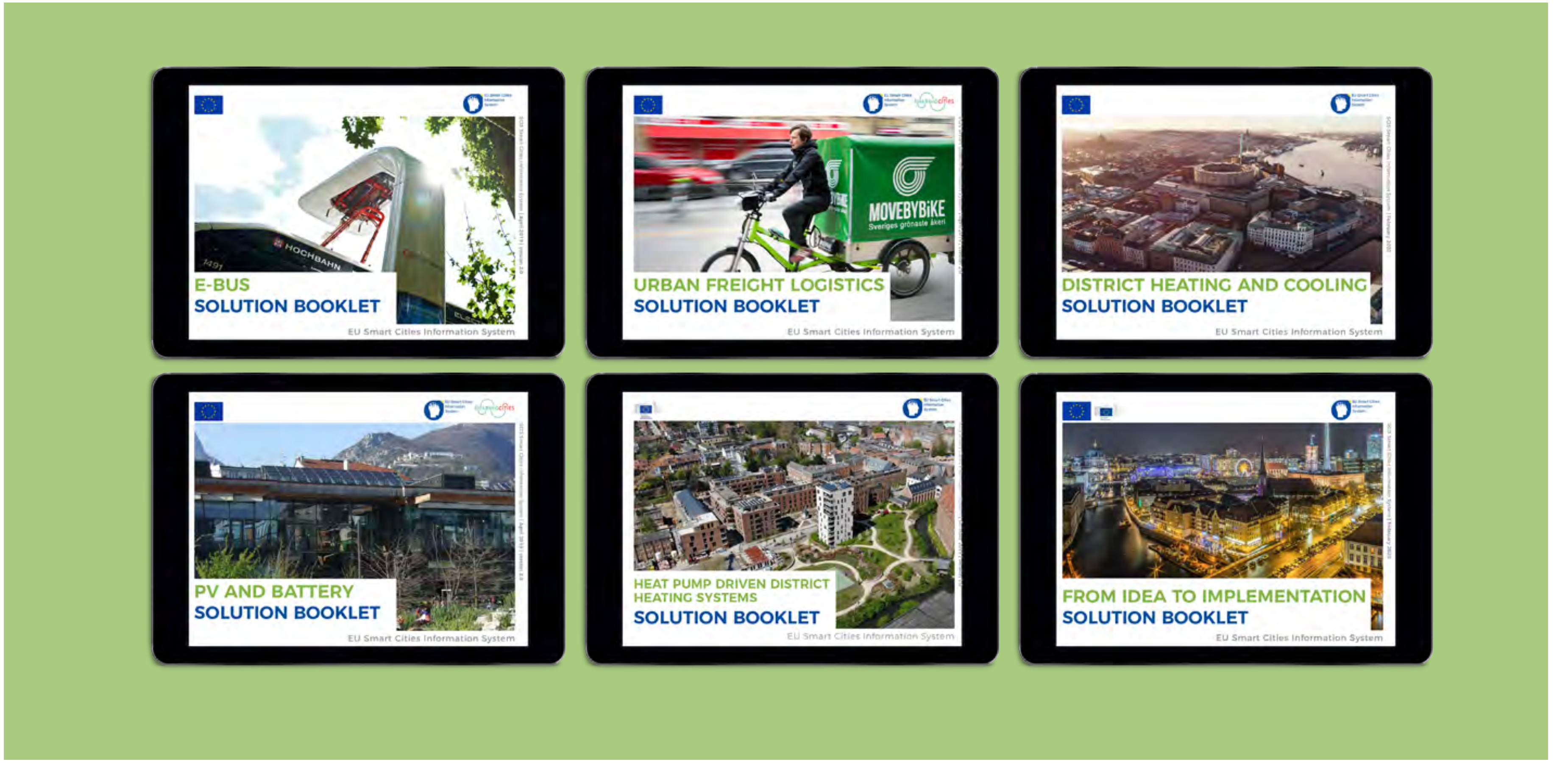
# HOW TO GET STARTED IN MY CITY?

LESSONS LEARNED

# HOW TO GET STARTED IN MY CITY?

**If you are a city planner or another stakeholder and interested in PEDs, these are some recommended steps to take:**

- **Get informed,** using the information shared by SCC Lighthouse Projects, SCIS and other initiatives - for example through the suggestions for further reading in this booklet. Also, engage with knowledge institutes in your city.
- **Assess the added value of PEDs** in comparison to the ongoing activities and policies in your city.
- **Assess the current planning and governance practises** in your city, and how PEDs could fit in.
- **Map the local stakeholders and bring them together.** Involve citizens at an early stage. Make a common assessment of the potential of PEDs in your city.
- **Verify how PEDs can contribute to the overall clean energy strategy** of your city or region and make sure that the corresponding bottom-up and top-down approaches synergise.
- **Start by testing** the approach in one or a few cases (pilots), while addressing upscaling and replication in your city at the same time.
- **Join a national or European project** on PEDs to ensure financing for your pilot and assuring access to best practices.
- **Create a PED vision and roadmap** for your city.
- **... and do not forget to share** what you have learned.




# EU SMART CITIES INFOSYSTEM
# SOLUTION BOOKLETS

smartcities-infosystem.eu

# CONTRIBUTIONS

smartcities-infosystem.eu

smartcity-atelier.eu

makingcity.eu

sparcs.info

cityxchange.eu

## SCIS

The Smart Cities Information System (SCIS) is a knowledge platform to exchange data, experience and know-how and to collaborate on the creation of Smart Cities, providing a high quality of life for its citizens in a clean, energy efficient and climate friendly urban environment. SCIS brings together project developers, cities, research institutions, industry, experts and citizens from across Europe.

SCIS focuses on people and their stories – bringing to life best practices and lessons learned from smart projects. Through storytelling, SCIS portrays the "human element" of changing cities. It restores qualitative depth to inspire replication and, of course, to spread the knowledge of smart ideas and technologies – not only to a scientific community, but also to the broad public!

### ATELIER

ATELIER is an AmsTErdam and BiLbao cItizen drivEn smaRt cities project funded by the European Commission under the H2020-LC-SC3-2018-2019-2020 Smart Cities and Communities call. Coordinated by the City of Amsterdam, the project combines the expertise and the commitment of 30 partners from 11 countries.

ATELIER focuses on developing citizen-driven Positive Energy Districts (PEDs) in the two Lighthouse Cities Amsterdam (Netherlands) and Bilbao (Spain).

### MAKING-CITY

Launched in December 2018 and coordinated by the CARTIF Technology Centre, MAKING-CITY will address and demonstrate advanced procedures and methodologies based on the Positive Energy District (PED) during 60 months.

A PED is defined as "a district with annual net zero energy import and net zero carbon emissions, working towards an annual local surplus production of renewable energy" in the European Strategic Energy Technology Plan (SET Plan).

### SPARCS

SPARCS is working to create a network of Sustainable energy Positive & zero cARbon CommunitieS in two lighthouse and five fellow cities.

The project supports these cities as they deal with the multifaceted challenges they face on their path to sustainability. By setting up inclusive management and planning models and processes, SPARCS aims to demonstrate and validate innovative solutions for smart and integrated energy systems that will transform these cities into sustainable, zero carbon ecosystems with improved quality of life for their citizens.

### +CityxChange

In the +CityxChange project, seven cities (Trondheim, Limerick, Alba Iulia, Písek, Sestao, Smolyan and Võru), 23 solution providers within energy, ICT, mobility and citizen engagement, and two universities have set out on a journey to co-create positive energy blocks, districts, and cities. The project, led by NTNU, is built on three main pillars (1) deliver integrated planning and design by better data and better use of data, (2) create a local energy flexibility market through public-private partnerships and regulatory sandboxes, and (3) community exchange with local citizen and professional stakeholders.

SCIS is funded by the European Union