Innovation Action

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# D4.1 - Methodology and Guidelines for PED design

**WP4, Task 4.1**

Date [M24]

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# Abbreviations and acronyms

| ACRONYM | DESCRIPTION |
|---|---|
| DER | Distributed Energy Resources |
| FWC | Follower City |
| GHG | Greenhouse gas |
| LHC | Lighthouse City |
| MC | MAKING-CITY |
| PEB | Positive Energy Block |
| PED | Positive Energy District |
| PEN | Positive Energy Neighbourhood |
| RES | Renewable energy sources |
| SEC | Smart Energy Cities |
| SET | Strategic Energy Technology |

# Executive Summary

This deliverable is consisting of an extensive description of a recently developed Positive Energy District planning and design methodology within WP4 "*POSITIVE ENERGY DISTRICTS CONCEPT EARLY REPLICATION*" of the MAKING-CITY Project. More specifically, it focuses on the activities carried out in Task 4.1 "*Methodology / guidelines for PED design*" which aims a comprehensive definition of PED including the definition of a rigorous procedure to evaluate the annual positive energy balance, according to technical, financial, social, legal and spatial constrains.

The main objective of MAKING-CITY is the development of new integrated strategies to address the urban energy system transformation towards low carbon cities, with the PED approach as the core of the urban energy transition pathway. Aligned with this aim, a harmonized energy and urban planning methodology is developed for PED design in cities. PED Methodology will be early adopted by FWCs (Task 4.2 Analysis of FWC candidate areas to become a PED) in the second year of the project to identify PED boundaries and select proper technologies collectively and co-design PED in their cities in the following year. This document will later be a basis for replication and upscaling plans of LHCs and FWCs in MAKING-CITY.

As indicated before, cities must have a holistic approach on harmonizing energy and urban planning for energy transitions. Urban developments must evolve from single, unintegrated, simple "building" based interventions into Positive Energy Districts and Neighbourhoods concepts in order to reach energy and climate targets which will lead to an integrated energy planning. Proposed PED Methodology in this report provides cities considerations and guidelines to plan and design PEDs not only technically but also socially, economically, politically and spatially aligned with sustainable urbanization domains. Phases of the proposed methodology analyses main characteristics and priorities of cities by evaluating city indicators, a deep research on existing national/regional/local level city plans and implementation areas of these plans, analysing city components (e.g. resources, urban macro-form, energy infrastructure and services, social aspects), and energy demand. Once PED concept boundary is defined by these analyses, cities start social, economic and technical processes for selection of solutions to achieve PEDs. The outcome of the PED methodology is the detail cards (SPECs) of all technical and non-technical solutions collected in solution catalogue (PEDBoard) The following figure describes in a schematic way the phases of the Methodology for PED Design.

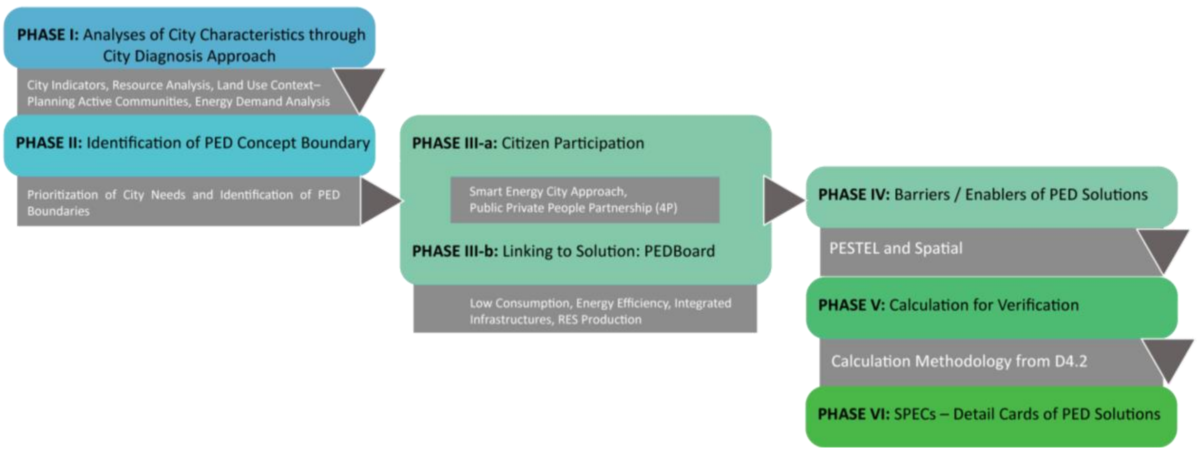


**Figure 1 Phases of the PED Methodology**

Thanks to proposed PED Methodology, aspects related with the specificities of the cities, regions and even countries, is considered, in order to have a standardized concept valid to be the core of specific urban energy transitions planning processes. As this incipient PED concept is a valid pathway towards an Energy transition, this must be aligned with the long-term and mid-term vision of the city plans (WP1). For the specific design of PED, technical and social barriers, and regulatory framework conditions will be identified for ensuring that technical and non-technical solutions are properly accompanied by a solid transferability perspective. In addition, in the demonstrations tested in Oulu (WP2) and Groningen (WP3), a set of solutions (can be considered as a 'catalogue') and their associated benefits to reach PEDs is carried out, establishing the basis to document any other suitable solution.

Furthermore, a set of guidelines according to the different application scenarios will be carried out to facilitate designers the identification and combination of the solutions to transform a district in positive energy in the final version of this deliverable.

# Keywords

Positive Energy Blocks, Positive Energy Districts, Positive Energy Neighbourhoods, Energy Transition, Harmonization of urban and energy planning, Participatory design, Public-private-people participation, local RES production, energy flexibility, energy efficiency, energy markets, replication

# 1 Introduction

This report constitutes Deliverable *"D4.1 Methodology and Guidelines for PED design (Final Version)"* which is the based on the outcome of the *"Task 4.1: Methodology / guidelines for PED design*".

The objectives of the deliverable are:

- Definition of the PED methodology
- Establishing guidelines according to the different application of scenarios to facilitate designers the identification and combination of the solutions to transform a district in PED

The present deliverable is structured as follows:

Chapter 1 gives general information about the report and relation with MAKING-CITY.

Chapter 2 provides literature review on PED concept and different PED definitions and framework according to different initiatives, projects and network and reference PED projects. A study describing challenges for PED implementation in cities is also held for defining state of play in cities.

Chapter 3 identifies the definition of PED for MAKING-CITY and objectives of the proposed PED Methodology. A brief explanation for calculation methodology is presented and experience mapping of two LHCs is evaluated for introducing the phases LHCs went through during PED area selection.

Chapter 4 describes in detail the proposed PED Methodology by its phases to be pursued to implement Methodology for PED Planning and design

Chapter 5 discusses a reference method for citizen involvement strategies applied in Netherlands

Chapter 6 is focused on identification of stakeholders of each LHC and FWC.

Chapter 7 cites the activities performed during 1$^{st}$ year of MAKING-CITY, specifically GamePED Workshop that was held in project meetings, a section of brief lessons learnt from LHCs and how citizens will be involved in future cities for describing how to proceed with PEDs.

Finally, Annex I includes a barrier/enabler matrix that is contributed by all FWCs and their support partners which is mentioned in Phase IV of PED Methodology.

Annex II presents SPEC (Detail) Cards of technical and non-technical solutions of MAKING-CITY and other projects. The cards will be finalized in the final version of this deliverable.

## 1.1 Purpose and target group

The main purpose of Methodology and Guidelines for PED design is to provide an approach for planning and designing PEBs/PEDs in cities. Since PEDs play a key role on energy transition in cities, the aim of this report highlights the importance of citizen participation, economic, technical, political, regulatory and spatial issues for a sustainable urbanization. In line with this, definition of the methodology and establishing guidelines according to the different application of scenarios to facilitate designers the identification and combination of the solutions to transform a district into a PED, is pointed out. In this deliverable, the analyses and conceptions for defining PED boundaries in cities and selection of technologies in parallel with participative processes are intensely examined and presented.

The target group of the proposed PED method is mainly the municipalities, nonetheless the process defined in this report covers citizens, designers, planners, technology providers, energy utilities, grid operators, researches, energy real estate investors, energy generators, energy service providers and public transport operators and mobility planners.

## 1.2 Contribution partners

The following Table 1 depicts the main contributions from participant partners in the development of this deliverable.

**Table 1 Contribution of Partners**

| Partner nº and short name | Contribution |
|---|---|
| 25-DEM | Main contributor for developing PED method, literature review and generator of PED Methodology Phases |
| 01-CAR | PED concept definition according to MAKING-CITY, identification of city level indicators and analyses of existing city plans, calculation of PEDs |
| 02-TEC | Energy demand analyses, summary of calculation of PEDs |
| 03-GRO | Discussions on PEDBoard and SPEC cards generation |
| 04-TNO | Citizen participation approach development, smart energy city methodology integration and citizen engagement strategies in Netherlands, SPEC cards |
| 11-RUG | Contribution to integrated energy planning approach |
| 13-OUK | Discussions on PEDBoard and SPEC cards generation |
| 14-UOU | Harmonization of urban and energy planning and design, contribution to phases and Public-Private-People Partnerships, SPEC cards generation |
| 20-VTT | SPEC cards generation, definition of city level indicators |
| 21-BAS | Contribution to Barriers and enablers of solutions, solution Index |
| 22-UNI | Contribution to Barriers and enablers of solutions, solution Index |
| 23-LEO | Contribution to Barriers and enablers of solutions, solution Index |
| 24-KM | Contribution to Barriers and enablers of solutions, solution Index |
| 28-VID | Contribution to Barriers and enablers of solutions, solution Index |
| 29-GSC | Contribution to Barriers and enablers of solutions, solution Index |
| 30-LUB | Contribution to Barriers and enablers of solutions, solution Index |
| 32-R2M | Identification of stakeholders, economic challenges against implementation of PEDs |
| 33-GBCE | Reference PED projects, SPEC Cards generation, contribution to phases of the methodology |

## 1.3 Relation to other activities in the project

The following table depicts the main relationship of this deliverable to other activities (mainly deliverables) developed within the MAKING-CITY Project and that should be considered along with this document for further understanding of its contents.

**Table 2 Relation of the report to other deliverables and activities**

| Deliverable / Task nº | Relation |
|---|---|
| T4.1/D4.15, D4.2 | PED Methodology Phase V adopts Guidelines to calculate the annual energy balance PED (demand, consumption, Energy flows, storage, RES) to verify if the selected boundary and solutions already provide surplus in energy balance. |
| T4.2/D4.16, D4.3 | This report will be a basis document for the analysis of districts in the FWC and selection of candidate areas to become a PED. |
| T2.1/D2.13 | Action Cards of Oulu PED (Kaukovaino) interventions detailed design report provide basis data for SPEC cards |
| T3.1/D3.13 | Action cards of Groningen PEDs (North, Southeast) interventions detailed design report provide basis data for SPEC cards |
| T1.2/ D1.2 | *City diagnosis: analysis of existing city plans* mentioned in Phase I of the PED Methodology for identification of city needs and priorities |
| T1.3/ D1.22, D1.3 | *Tools for modelling energy demand, supply side, simulation of scenarios and estimation of impacts* mentioned in Phase I of the PED Methodology for identification of city needs and priorities |

# 2 Positive Energy Districts Concept

This section provides literature review on PED concept and different PED definitions and framework according to different initiatives, projects and network and reference PED projects for displaying the state of the art on complex structure of PEDs. A study describing challenges for PED implementation in cities is also held for defining state of play in cities.

One of the most important global trends is the dynamic growth of cities and the concentration of socio-economic functions in metropolitan areas. According to UN projections, world population will increase to 8.9 billion by the year 2050, two thirds of which will live in cities. The average population of the thirty most populous cities of the world will have tripled between 1965 and 2025.[1] The 2015 Paris Agreement has supported international efforts to reduce CO2 emissions, where urban areas with 70% share of emissions have a key role. UN Sustainable Development Goal 11 is the goal of sustainable cities and communities with the aim of supporting the transition towards low-carbon cities. Thus, the development of cities in the following years, will determine progress on addressing the key

[1] Wołek, M., & Wyszomirski, O. (2013). The trolleybus as an urban means of transport in the light of the Trolley project. Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego.

environmental, economic and social challenges. Until now, **smart cities** have been evaluated within **energy, mobility and ICT domains**, while integrated ***sustainable urban planning, land use planning and urban design*** is also highly relevant for designing and implementing smart cities. Sustainable urbanisation is planned in a way that commuter towns are avoided, and the created districts provide as much services as possible with an integrated approach considering the environmental, social, economic, and spatial impacts. The challenge is that smart city aspects, such as **decentralization and digitalization of the energy sector**, have not previously been a part of integrated urban planning, land use planning and urban design. In this line, **Positive Energy Districts (PEDs)** can be seen as foundation of a highly efficient and sustainable route to progress beyond the current urban transformation roadmaps as PEDs **are integrated mixed-used districts** that have a positive impact within and beyond the limits of the district.

The Strategic Energy Technology (SET) Plan short definition is "Positive Energy Districts (PED) are energy efficient districts that have net zero carbon dioxide ($CO_2$) emissions and work towards an annual local surplus production of renewable energy (RES)." PED or Positive Energy Blocks[2] (PEB) are seen as "seeds" for an urban regeneration of all sizes, in fact, PEDs can raise the quality of life in European cities, contribute to achieving the COP21 targets and enhancing European capacities and knowledge to become a global role model. The TWG 3.2 "Smart Cities and Communities" has developed an integrative approach including technology, spatial, regulatory, legal, financial, environmental, social and economic perspectives, to support the planning, deployment and replication of PEDs for sustainable urbanisation[3].

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

The strategic target of the Implementation Plan was inspired by discussions in the European Innovation Partnership on Smart Cities and Communities, especially by the Initiative on PEBs and the "Zero Energy/Emission Districts" mentioned in the TWG 3.2 Declaration of Intent. The Programme on PEDs and Neighbourhoods (PED Programme) that was established in 2018 by the Action 3.2 on Smart Cities and Communities of the European SET Plan, has the ambition to support the planning, deployment and replication of 100 'Positive Energy Districts' across Europe by 2025 for urban transition and sustainable urbanisation. PEDs will raise the quality of life in European cities, contribute to reaching the COP21 targets and enhancing European capacities and knowledge to become a global role model.

*PEB / PED = Circular Economy*

When considering the PEB/PED concept, a series of elements naturally come into place: the need for a smart grid; local renewable energy production; optimal use of elements such as advanced materials, or local storage; Information and Communication technologies (ICT); digital design; active management (demand-response, load shifting, peak shaving, optimisation, user interaction involvement and connection to electromobility solutions.[4]

The +CityxChange project considers that *Positive Energy Districts should also enable the trade of energy within the block and its surroundings utilising advanced Distributed Ledger Technology to create added value and incentives for the consumer to generate energy locally, provide flexibility and aggregate power generation in a system-wide cloud solution. The aggregation of these local energy, flexibility, power*

[2] A Positive Energy Block (PEB) is a group of at least three connected neighbouring buildings producing on a yearly basis more primary energy than what they use. These buildings must serve different purposes (housing, offices, commercial spaces...) to take advantage of complementary energy consumption curves and optimise local renewable energy production, consumption and storage. Another key advantage of the concept is that by creating a **functional and social mix**, they will contribute to **urban regeneration**. PEBs, mainly focussed on energy, can also help with taking-up bioclimatic architecture, advanced materials, Information and communication Technologies (ICT) with on-site renewable energy production. https://eu-smartcities.eu/initiatives/71/description

[3] Twg Action plan 3.2 Set Plan

[4] EIP-SCC Webinar on Positive Energy Blocks for Small & Medium Sized Cities, 3rd November 2016.

*quality and balancing markets will lead the way towards maximum uptake of renewables and a near zero energy economy in the future.*

## 2.1 From smart cities towards Positive Energy Districts

PEDs are evolving from sustainable neighbourhoods, energy efficient districts and nearly zero energy districts concepts. Earlier concepts are with reference to Trias Energetica model that is developed by the Delft University of Technology and acts as a guide when pursuing energy sustainability in urban design. The Trias Energetica makes clear that energy savings have to come first on the path to environmental protection.[5] The method consists of three steps:

1. **Reduce the demand for energy through the rational use of energy:** There is substantial possibility for reducing energy demand in cities by an integrated approach to the design of buildings, building clusters, the transport system and district or micro- power generation, with novel technologies. Their effectiveness can be evaluated by and assist governments in writing their strict energy policies.
2. **Use sustainable sources of energy like renewable energy** to fulfil demands: Using natural resources wherever possible at any level, combined with reliable energy design choices. Using for instance the building facade and parking lots as solar collectors and use that energy for heating and/or cooling also applying wind power, hydropower, geothermal power, biomass where possible.
3. **Use fossil fuels, if necessary, as efficiently and cleanly as possible**: (compensate) After having applied the first two steps to the maximum possible, the remaining energy need, if any, will be met by applying fossil fuels as efficiently as possible, by applying state-of-the-art techniques, such as: CHCP: combined heating, cooling, and power generation , use waste fuelled biogas generators.

Traditionally, energy has been centrally produced by big power plants, transmitted into cities and then distributed among the several consumers, such as: households, companies, or service providers. This corresponds to a linear progression from a centralized production (Figure 2) to a decentralized distribution. However, this landscape is quickly changing in all the steps of its supply chain. In the production process, we see a shift from centralized to decentralized generation.[6]

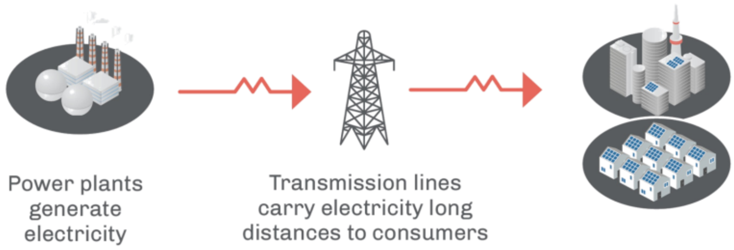


**Figure 2 Centralized Generation - One-way power**

According to +CityxChange project, "recent technological developments have changed and reshaped the functioning scheme of different service sectors, including the energy markets. The consumption-production model is becoming more complex in terms of design, operation and maintenance. This is accompanied by the introduction of new key elements to the system, such as **renewable source, energy storage, smart grids, data management and prosumers.**"

5 Critical review of sustainable energy schemes of trias energetica
6 Smart cities MOOC prepared by IGLUS (innovative governance of large urban systems), EPFL – École polytechnique fédérale de Lausanne

This relatively new, reshaped and derived concept emphasizes the so-called **energy flexibility**[7]**/complexity** which enables communication and trade between peers, all the while striving for a localized, flexible heat/power supply market, is defined as the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide **a service** within the energy system. Regarding this transformation in energy supply chain, the pricing of electricity has changed. Instead of fixed prices, consumers now find price signals, which change according to supply and demand. Individual electricity generators can choose to sell back to the grid when prices are high and buy from the grid when prices are low, for instance. This provides new generation of technologies that can automatically react to this shifting. The new concept towards PEDs for sustainable urbanization is schematized in Figure 3 From Trias Energetica Model to PED Concept.

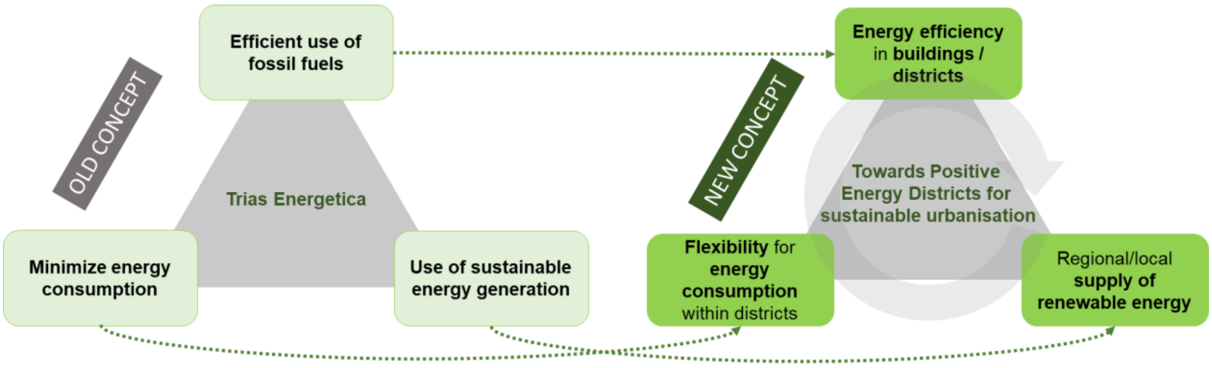


**Figure 3 From Trias Energetica Model to PED Concept**

Power demands are continuing to rise, and energy availability and reliability are becoming primary concerns for utilities, independent power producers, industrial manufacturers, and commercial campuses—all of which need solutions to help provide a reliable and cost-efficient electricity supply. At the same time, Distributed Energy Resources (DERs) such as renewable generation sources and energy storage are being added to the grid (Figure 4) , creating new operational challenges, while also bringing new business opportunities and revenue streams, resulting in decentralized systems also mentioned above.

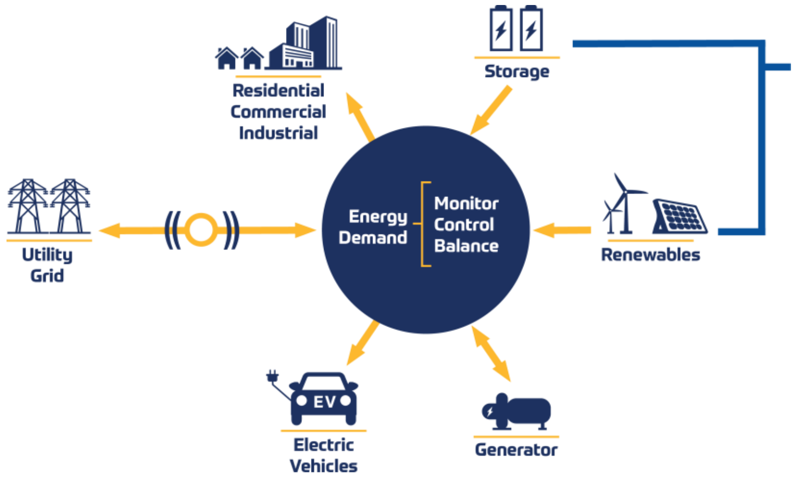


**Figure 4 Distributed Energy Resources in decentralized micro-grid systems**

There are several key factors driving the DER trend such as:

[7] By flexiblity, we intend here the ability of a system to provide supply and demand balance over different time scales in an economic and reliable way, including response to unforseen events (N.Good, E.A. Martinez Cesena, P. Mancarella, 2017).

- Going Green (Many countries have made policy and regulatory changes, setting targets for the increase of green energy and reduction of GHGs),
- Security of Supply (As traditional fossil-fuelled generation plants are reaching end of life or being retired, new generation sources are needed to cover primary energy needs),
- New Revenue Streams (Power producers are starting to take advantage of new commercial models, including peer-to-peer energy transactions),
- DER Availability and affordability (As DERs become more cost effective, the rise of the "prosumer", the traditional energy consumer who is now also a producer.)

Prosumers are active energy users who both produce and consume energy from renewable sources (RES). Along with new PED concept, the framework of prosumers is developing into end users in energy flexibility approach. The development of micro-generation and storage in addition to consumption, empowers individual households and perhaps even more, those organized in cooperatives, neighbourhoods etc, to become pro-active actors and stakeholders that It is not just a matter of producing and consuming RES anymore, but also becoming actors who contribute to the resilience and balancing of the regional/local energy system by just-in-time communicating and trading between each other. If some amount of predictability can be imparted to micro-generation/storage in PED or even PEN districts via forecasts, end users and/or end user groups provide sufficient in energy flexibility in the local energy system architecture that could ease reinforce the shift from centralized to decentralized generation explained above to advantage from the service of pricing for optimal benefit. Demand side management, sector coupling (power-to-heat, heat-to-power) and storage are among the main instruments to achieve this goal. PED/PEN's as the nucleus of the urban energy transition require wholesale changes in the present energy supply and demand architectures. New market structures and players, local and/or independent multi-carrier micro grids, energy generation/storage at community level as mentioned above, drastically different end-user involvement and probably new technologies. Smart control of energy consumption inside (nanoGrid) and around buildings or group of buildings (microgrid) can provide a major contribution to address the imminent energy stability problems of the total energy infrastructure.

## 2.2 Definition and scope of PED

The Positive Energy Block concept is already integrated in the Action 3.2 Smart Cities and communities of the Energy Union and Set Plan that aims at net–zero-energy/emission districts (ZEED) that will strongly contribute to COP21 targets. A further step to this ZEED concept is the consideration of "positive energy districts (PED) or positive energy blocks (PEB)[8]".

There is not a standard definition for the PED concept. In fact, there are small differences between the definitions from the EIP-SCC[5], the EU definition[9], JPI Urban Europe[10] or within the the SET-Plan Implementation Working Group 3.2. They specially differ in qualitative characteristics of the PEDs such as "integrated buildings" within the city or that PED need to have a "positive impact" on the district/city energy system. All of the definitions agree that PEDs are consisting of delimited areas[11] of buildings and public spaces where the total annual energy balance (considering heating, cooling, air conditioning, lighting and domestic hot water) is positive, therefore the area will deliver, in average, an energy surplus

[8] According to EIP-SCC, Positive Energy Block (PEB) is a group of at least three connected neighbouring buildings producing on a yearly basis more primary energy than what they use. https://eu-smartcities.eu/initiatives/71/description

[9] In the last tender of Smart Cities and Communities, LC-SC3-SCC-1-2018-2019-2020, the PED concept is defined https://cordis.europa.eu/programme/rcn/703271/en

[10] https://jpi-urbaneurope.eu/ped/

[11] The delimited area (the boundaries) has been discussed that can be functional boundaries (e.g. buildings connected through a district heating), geographical or even virtual boundaries (district contractually connected to an energy system outside the geographical limits).

to be shared with other urban or peri-urban zones. To that aim, these districts need to be designed with local RES generation systems in order to not only be able to cover its own needs but the needs of their surrounding limits.

Furthermore, several projects and cities are adopting the concept, with different particularities. The project *Hunziker Areal*, from Zürich (Switzerland) defined their newly built neighbourhoods as PEDs, integrating concepts such as affordable housing, jobs on-site, citizen participation, energy efficiency, RES production and sustainable materials. *+CityxChange* H2020 project defines a positive energy district in a similar way as the SET-Plan Implementation Working Group 3.2 on Smart Cities and Communities (IWG 3.2) emphasizing energy retrofitting, RES on-site, active management, mobility, social aspects, and energy flexibility, among others. *SPARCS* project defines a positive energy district with virtual boundaries, where the energy management, storage, e-mobility, RES production, NZEBs and retrofitted buildings concepts are integrated (among other characteristics). Even *COOPERaTE* project has developed an open, scalable neighbourhood service and management platform that provides services and energy management towards energy positive neighbourhoods and it was tested in two demo-sites. As a summary, the quantitative and qualitative characteristics of a PED observed in the state of the art are included in Table 3: Quantitative and Qualitative Characteristics of a PED.

**Table 3: Quantitative and Qualitative Characteristics of a PED**

| QUANTITATIVE CHARACTERISTICS | QUALITATIVE CHARACTERISTICS |
|---|---|
| Several buildings (New, retrofitted, combination of both, mixed-use)<br>Positive Energy Balance<br>Scalable<br>Optimal use of systems<br>Active management<br>Energy Efficiency<br>Net CO2 emissions<br>Surplus of RES | Integrated buildings<br>Positive impact<br>Interaction between buildings/users/systems<br>Synergically connected<br>Role model<br>Innovative<br>Sustainable urbanization<br>User added value<br>Affordable, high standard living<br>Sustainable Mobility, consumption and production |

The definition within MAKING-CITY project is explained in more detail in section 3.1.

On the other hand, discussions and studies on PED definitions and framework according to other projects, initiatives and organizations such as Strategic Energy Technology Plan of EC, European Energy Research Alliance – Joint Programme Smart Cities (EERA-JPSC), European Innovation Partnership on Smart Cities and Communities (EIP-SCC) and JPI Urban Europe, are still on-going. These discussions are summarized in following sections:

### 2.2.1 Strategic Energy Technology (SET) Plan - ACTION n°3.2 Implementation Plan

The Positive Energy Districts in this work consists of several buildings (new, retro-fitted or a combination of both) that actively manage their energy consumption and the energy flow between them and the wider energy system. Positive Energy Blocks/Districts make optimal use of advanced materials, local RES, local storage, smart energy grids, demand-response, cutting edge energy management (electricity, heating and cooling), user interaction/involvement and ICT. Positive Energy Districts are designed to be integral part of the district/city energy system and have a positive impact on it. Their design is intrinsically scalable and they are well embedded in the spatial, economic, technical, environmental and social context of the project site. PEDs require interaction and integration between buildings, the users and the regional energy, mobility and ICT system, as well as an integrative approach including technology, spatial, regulatory, financial, legal, social and economic perspectives. Ideally, PEDs will be developed in an open innovation framework, driven by cities in cooperation with industry and investors, research and citizen organisations.

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

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

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

Cities must have clear commitment to **sustainability, liveability and going beyond carbon neutrality** by becoming energy positive. Such "Positive Energy Districts/Neighbourhoods "(PED/PENs) could be new developments but should also implement ambitious solutions for urban district renewal.

**PED Guides and Tools** will be developed to support replication and mainstreaming. This includes, e.g. PED definition, national PED certification, a process towards one standard in digital planning, construction, and building information management of PEDs, guides on funding and business models, guides for capacity building and PED planning tools. **PED Replication and Mainstreaming** will be driven by cities, including PED development in their city strategies, providing the necessary pre-conditions for PED deployment and the actual deployment and maintenance of PEDs.[12]

### 2.2.2 Energy Research Alliance-Joint Programme Smart Cities (EERA-JPSC)

SET-Plan Action 3.2 has the ambition to create a city driven network of municipalities and their stakeholders with ambition to develop PEDs. This PED City Panel will identify common dimensions of PEDs across Europe as a basis for national PED certifications, and aims to mutually learn from PED Labs.

To define the required RDI to move towards Positive Energy Districts, and from there to Positive Energy Cities, we have identified 4 lines of actions or conditions: Think big (system innovation), Start small (co create with citizens), Learn fast (and collaborate), Scale up (including design of strategy).

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

From a technical point of view, a PED is characterized by achieving a positive energy balance within a given boundary. Such boundary can be a

- **Geographical boundary:** Spatial-physical limits of the PED in terms of **delineated buildings, sites and infrastructures –** these may be contiguous or in a configuration of detached patches.
- **Functional boundary:** Limits of the PED in terms of **energy grids**, e.g. the electricity grid behind a substation that can be considered as an independent functional entity serving the PED; a district heating system that can be considered as a functional part of the PED even if the former's service area is substantially larger than the heating sector of the PED in question; or a gas network in the same sense;
- **Virtual boundary:** Limits of the PED in terms of **contractual boundaries**, e.g. including an energy production infrastructure owned by the PED occupants but situated outside the normal geographical PED boundaries (for example an offshore wind turbine owned through shares by the PED occupant community).

### 2.2.3 European Innovation Partnership on Smart Cities and Communities (EIP-SCC)

A Positive Energy Block (PEB) is a group of at least three connected neighboring buildings producing on a yearly basis more primary energy than what they use. These buildings must serve different purposes (housing, offices, commercial spaces...) to take advantage of complementary energy consumption curves and optimize local renewable energy production, consumption and storage. Another key advantage of the concept is that by creating a **functional and social mix**, they will contribute to **urban regeneration**. PEBs, mainly focused on energy, can also help with taking-up bioclimatic architecture, advanced materials, Information and communication Technologies (ICT) with on-site renewable energy production. The initiative links-in directly with the EU Strategic Implementation Plan's ambition to improve the energy efficiency of Europe's buildings and districts. 2016-PEB Initiative

First definition of Positive Energy Blocks, according to EIP-SCC was *"At least three connected neighbouring buildings producing on a yearly basis more primary energy than what they use (in terms of lighting, heating, cooling and ventilation)."*

The target was to launch by 2020 the construction of 100 PEBs throughout EU and neighbouring countries, with at least 1 PEB per EU Member State. Of this figure, 50% of the PEBs should be in cities with <100,000 inhabitants. These buildings must serve different purposes (housing, offices, commercial spaces...) to take advantage of complementary energy consumption curves and optimise local renewable energy production, consumption and storage.

**Financing:** exploring Smart Specialisation Strategy (S3) (The Smart Specialisation Platform (S3 Platform) provides information, methodologies, expertise and advice to national and regional policy makers, as well as promoting mutual learning and trans-national cooperation, and contributing to academic debates around the concept of smart specialisation.) at regional level, EIB, Private investors…

**Location:** Identification specific to each city with preference given to central area for demonstration purposes

### 2.2.4 JPI Urban Europe and Positive Energy Neighbourhoods

According to PED Framework report prepared by JPI Urban Europe: *In honoring the economic, cultural and climate-related diversity of European countries and cities, a definition for such PED/PENs should not be just an algorithm for calculating the input and output of energy, but rather a framework, which outlines the three most important* ***functions of urban areas in the context of their urban and regional energy system****. The first obvious requirement is that PEDs should ultimately* ***rely on renewable energy***

***only (energy production function)**, which is one of the main contributions towards climate neutrality. Secondly, they should make energy efficiency as one of their priorities in order to best **utilize the renewable energies available (energy efficiency function)**. Thirdly, the awareness that urban areas are bound to be among the largest consumers of energy, and therefore need to make sure that they act in a way which is **optimally beneficial for the energy system (energy flexibility function)**.*

There shall be enablers such as political vision and governance framework, active involvement of problem owners and citizens, integration of energy and urban planning, ICT and data management to reach PED/PENs target. These enablers pursue guides on their way towards climate neutrality and energy surplus taking into account the guiding principles such as quality of life, inclusiveness and sustainability. [13]

## 2.3 State of Play in Cities and Challenges for PED concept and implementation of PED

### 2.3.1 Legal and Institutional Challenges

Regulations are the most important instrument that serves for the improvement of technology ecosystems. During the transformation towards smarter cities, legal advisors play an important role as public authorities and investors. Smart city approach reveals a deep transformation of the relevant cities' infrastructure. Technological changes especially those that involve new information and communication technology (The Internet of Things (IoT) etc.) enable to infrastructure meets more efficiently the needs to which it responds. As another major transformation, the infrastructure's components are increasingly interconnected; they operate less and less in isolation. Finally, conventional urban infrastructure sits a digital meta-infrastructure made up of various public and private communication channels in which flow of data enabling smart cities to function.

From the legal perspective, smart city concept brings a variety of regulation areas in its wake as follows:

- Innovation and communication technologies (personal data and profiling, smart buildings, cyber security, cloud services etc.)
- Energy regulation (internal market liberalisation rules, renewable energy support schemes, unbundling requirements, smart grids, energy efficiency, energy storage etc.)
- Environmental legislation (EIA, emission allowances, waste management)
- Procurement rules (public procurement rules, concessions and PPP projects)
- Banking/Finance (e.g., banking and public funding, capital markets (MIFID a MIFID II) regulation and project financing)
- IP regulation (Right of intellectual, industrial property and copyright)[14]

When preparing smart city strategies, public authorities may face conflict of competence with one another as well as legal restrictions in more strictly regulated areas, such as energy market, procurement, competition and state aid rules. Due to nature of smart city strategy in which runs the risk of amendments or even dismissal like any other such project, it passes through the standard and long-lasting bureaucratic process. During the process of strategy development, the basic plan to finance

13 Norman Akhtar and Kevin Hasley, Smart cities face challenges and opportunities

14 https://www.citiesdigest.com/2017/03/16/legal-aspects-smart-city-development-kamil-blazek-interview/

the respective projects has to be found in which includes a review of the possibilities for financing (i.e., private (e.g. bank financing, capital markets, PPP projects) and/or public (local/EU funds or cross-border financing)). Finding workable policies to regulate stakeholders, unleashing economic development, maintaining benefits for the citizens and permitting growth in research-and-development investment become important challenges for legislators. Public-private partnerships are one of the more popular investment types used to manage these financial challenges. Since interoperability and funding challenges faced by smart cities in every region of the world, lawmakers are trying to formulate common interest among project partners. Legislation can help local governments implement smart city technologies and overcome the various challenges. For example, the Smart Cities and Communities Act was introduced in the US Congress in February 2017. Although it has not received final Senate approval, the bill focuses on coordinating activities and funding from federal agencies among various smart cities-related municipal departments, by establishing an inter-agency council.

Aligning multiple city departments and stakeholders on common ground, and allowing interoperability and the sharing of data among them and with the potential regional and national platforms, helps in the allocation of the initial financial investment because, before implementing smart city initiatives, government departments and private partners have been working in their own silos. This silo mindset is one of the main problems governments and system integrators must overcome. A change in management style, which introduces open collaboration and data sharing among municipal bodies can help reduce the financial blockade, allowing smart cities to achieve their goals.

Getting participants to share their personal data, and balancing trade-offs, is also a challenge for many policymakers. Due to the fact that Smart Cities are investing more money and resources into security, while tech companies are creating solutions with new built-in mechanisms to protect against hacking and cyber-crimes. On the other hand, IP and ownership rights to the outcomes of smart solutions call for equal attention. Real estate issues, EU internal market regulation limitations, including security and reliability of the smart solutions and responsibility issues must also be taken into consideration.

Educating and engaging the community is another challenge area for smart cities. Smart city needs "smart" citizens who are engaged and actively taking advantage of new technologies. With any new city-wide tech project, part of the implementation process must involve educating the community on its benefits. City governments can communicate the intrinsic benefits of smart city projects more easily by making technology education programmes available. For instance, cities such as Singapore, Dubai, London and New York are among those that have moved forward with supporting policies, stronger digital and cyber security, improved connectivity and better education.

These partnerships demonstrate the growing readiness of city authorities and the project partners to work together to develop smart city projects. There are currently more than 450 cities that have adopted at least one smart city project, and project partners such as IBM, Cisco, Nokia and Huawei have introduced their platforms and are providing end-to-end solutions for the mentioned challenges. Also public, integrated open source platforms are being developed.

REMOURBAN project states that institutional challenges are often linked to tensions between top-down managerial approaches and bottom-up needs. It is widely accepted that democratic societies should adopt governance approaches that involve multiple stakeholders including residents and other civil communities-of-interest. However, there are often conflicts between what local communities want for their neighbourhoods and the plans coming from the city administrations. Additionally, financing schemes are often difficult to identify, also involving the right stakeholders and commercial developers.

The SCIS technology replication study already mentions a number of barriers city authorities, planners and developers face in the project preparation and implementations phases. Shifting cities to a low carbon future presents major technological, economic and social challenges, this includes reforming and adjusting policies at all levels. The framework conditions need to be created to facilitate the adoption of new solutions and promote innovation. This requires a flexible, but also a stable positive policy environment.[15]

At the local level the following aspects are key difficulties that can be addressed by policy actions:

- Insufficient level of local competences;
- Inappropriate level of local administrative capacity;
- High administrative burdens;
- Inappropriate procurement rules;
- Inappropriate Stakeholder involvement;
- Access to capital;
- Public Private Partnerships;
- Inappropriate Regulatory environment at national level.
- Urban planning regulations, energy market rules, DSO prescriptions, fiscal & financial regulations, public budget & tendering regulations (in particular the risk of 'prior knowledge') > need for sandboxes / regulation free zones and/or regulatory changes at the regional, MS or EU level – according to EIP-SCC.
- **Cross-sectoral & cross-silo collaboration** in order to acquire integrated solutions and maximizing secondary benefits. Effective guidance by proper urban strategies & governance. Cooperation with higher scale policy levels and between PED projects (peer-to-peer exchange).
- **Need for competent planners** (knowhow, tools, communication, talent, creativity) & proper capacity at all levels (local authorities, solutions providers, developers), 'planning for change', need for integrated planning (capacity)

## 2.3.2 Economic Challenges

### 2.3.2.1 Economic challenges anticipated by the SET Plan

Key challenges and needs for planning, designing and deploying PEDs have been identified in the TWG 3.2 Implementation Plan (Figure 5). Most of these challenges are non-technological, business-related ones. They include for instance:

- The large-scale deployment of PEDs requires the development of **sustainable business models** that consider the whole process of building, operating and maintaining PEDs and engage all actors among **owners**, **city authorities**, **real estate developers** and **operators of the energy infrastructure**.
- **Strong leadership of public sector** is essential to lead the transformation process and respond to the emergence of PEDs besides stimulating innovative public procurement and its ability to push innovation to lead market strategy targeting the development of **investible PED projects**.
- The deployment of PEDs is expected to impact the whole energy market and its related technological, financial and regulatory aspects. Key aspects correspond to new innovative energy solutions and corresponding new roles such as **prosumers**, the complex regulatory

[15] The making of a smart city: policy recommendations for decision makers at local regional, national and EU levels https://smartcities-infosystem.eu/

framework and the resulting investment risks that require **credible and robust investment concepts** and **access to new financing schemes**.


**Figure 5. Key challenges and needs for planning, designing and deploying PEDs as identified by SET-Plan TWG 3.2**

### 2.3.2.2 Economic challenges concretely encountered by existing projects

Even though the PED concept is quite recent and only a few projects are implemented or under implementation, experience sharing with regards PED implementation has already been carried out:

- The PED Programme Management of JPI Urban Europe published in March 2019 its "Booklet of Positive energy Districts in Europe – Preview: A compilation of projects towards sustainable urbanization and the energy transition".[16] Concrete economic challenges encountered by the PED projects listed in this booklet are explained.

- Economic challenges have also been discussed with MAKING-CITY partners active in Oulu and Groningen through interviews carried out in summer 2019 by R2M Solution (see chapter 6.1 of the present report).

The following economic challenges have been mentioned by projects:

- The main economic challenge is related to the **high investment costs for the transition from the previous (fossil-based) system to the new (carbon-neutral) system**. This is the case for instance

[16] https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-Positive-Energy-Districts.pdf

in Groningen where all buildings are currently connected to the gas network, which is well-functioning and efficient, and where the project consists in (inter alia) switching from the gas to the heat network (heat being generated by renewable sources). Even though in the long run this should be financially efficient, there are high investment costs at the beginning.

- When applied to citizens, the challenge related to high investment costs is even harder. **The most energy-inefficient dwellings are often owned by families with modest revenues**, who cannot afford investing in energy-efficient technologies. They may also be owned by housing cooperatives with complex decision-making processes related to finance. That's why regulations pushing for energy-efficient refurbishments have to be accompanied by proper financial schemes.
- There is often a **lack of appropriate business models**, like for instance energy performance contracts (EPCs). Such contracts are widely spread for big energy consumers (like industrial or large commercial assets), but they are not tailored to smaller consumers. This is an issue since PEDs necessarily include residential buildings and other small energy consumers (for instance small shops). The situation might evolve positively thanks to the roll-out of smart meters and digital technologies which should facilitate the generalisation of EPCs to small energy consumers.
- The creation of a PED requires **optimising energy flows between different generation, storage and consumption assets**. This relies on optimisation algorithms and real-time data gathering, which represent a certain cost. It must be demonstrated that this cost does not exceed the savings and benefits brought by optimisation. Doing such demonstration might be challenging because of a lack of reliable historical data.
- The creation of PEDs generates **multiple benefits to multiple stakeholders**. Such benefits include for instance reduced costs for new energy infrastructures thanks to peak shaving, decreased health costs due to improved air quality, increased real-estate value thanks to PED branding, etc. The **identification and quantification of these benefits** is a difficult task. Therefore, it is challenging to make beneficiaries pay for the benefit they are receiving. For this, it's necessary to collect experience feedback in order to prove the benefits and facilitate the acceptance of (for instance) increased rents for tenants.
- The financial viability of PEDs will be ensured when the main PED building blocks (such as renovation packages for existing buildings and construction of passive or positive energy buildings) will be **mature enough to be scaled up** and become cheaper and less risky.
- Mixed funding models, role of public investment for realizing long-term infrastructures, identifying suitable business models. Ownership structures and financing beyond the common short & midterm horizons, sharing models for costs & benefits across actors/investors – According to EIP-SCC

### 2.3.3 Social Challenges

Sustainability is not just about solar panels, heat pumps and being energy neutral. Not the first user is important, but the second and the third, which means that the change should also become an inherited daily custom. That is why sustainable solutions should be economically cost-effective and have a long lifespan.[17]

Sustainability is about users' behavior and about users who make sustainable choices. How users make choices depends on many factors. To give a clear overview of these factors we use the Consumer Decisions Comprehended (CODEC) model (Brunsting, 2018) that has been developed by ECN part of TNO. This model has been developed to model, quantify and thereby calculate the market share of a specific innovation. Here we will use only the theoretical framework of the model. The model balances determinants stemming from several psychological models and theories, including habits, factual barriers, social processes, and irrationalities in the consumer decision processes.

This model has already been used to define the factors that play a role in the choice behavior of people towards fossil free living (see Figure 6) (Tigchelaar et al., 2019). The model consists of three elements:

1. attention, which is about whether people are engaging in decision making, or is there no trigger to provide attention? Do users consider buying/investing in sustainable alternatives?
2. enablers, which is about whether people are practically enabled to buy the sustainable alternative? Is it possible for them to take sustainable measurements?
3. intention, which is about whether consumers would like to buy the sustainable alternative? Does this provide them personal benefits, status and are there many other people who already have the sustainable alternative? Do sustainable alternatives offer people advantages?

Each of the underlying factors of the three elements – attention, enablers and intention - will be briefly explained at the same time indicating social challenges or barriers for the adoption of sustainable energy means by users/citizens:

#### Attention

- Presence of a trigger: at this moment there will be few natural moments when users consider fossil free alternatives, unless they are intrinsically motivated or there is a specific trigger (e.g., a central heating boiler that does not work anymore or a frontrunner neighbour).
- Breakthrough habits: when users have to make a choice there is a high chance of habitual behaviour if users have made the specific choice before. If for example the central heating boiler does not work anymore and the user is satisfied, the chance is high that s/he will buy a central heating boiler again.

#### Enablers

- Practically feasible: the solutions that are offered to users should be practically feasible.
- Acceptable investment: the investment for a fossil renovation should be feasible. What is an acceptable investment differing per user, the house s/he is living in and the fossil free alternative?
- Sufficient knowledge: many users have limited knowledge about the technical options of their houses. They do not know either what the fossil free alternatives are and whether these solutions are suitable for their houses.

[17] Ecovat.eu

- Certainty about regulation and policy: users are uncertain about policies for fossil free homes. They want to be sure that the rules do not change when they have just made investments in their houses.
- Option available on the market: options have to be available that are of high quality and that are affordable. Also, a qualified workforce has to be available to install the fossil free solutions.
- Intention
- Attractive investment costs and variable costs: users will have to make investment costs for fossil free solutions. Many users expect that they will get a compensation for the costs that they make.
- Personal benefits: for many user's sustainability is not their first priority. More important topics are for example family, work and health. People will come into action for topics that are related to their values. Some examples of values are autonomy, competence and relatedness (Sheldon, 2001).
- Attractive fossil free alternatives without hassle: many users are reluctant to the amount of work and all the choice they will have to make.
- Social comparison: the decision to invest in fossil free alternatives will be influenced by the (direct) context of the user. The more people will buy fossil free products and services, the higher the chance that others will also make these investments. Users are especially influenced by people that are like them.
- Social status: some users will be motivated to buy fossil free products if this improves their status.

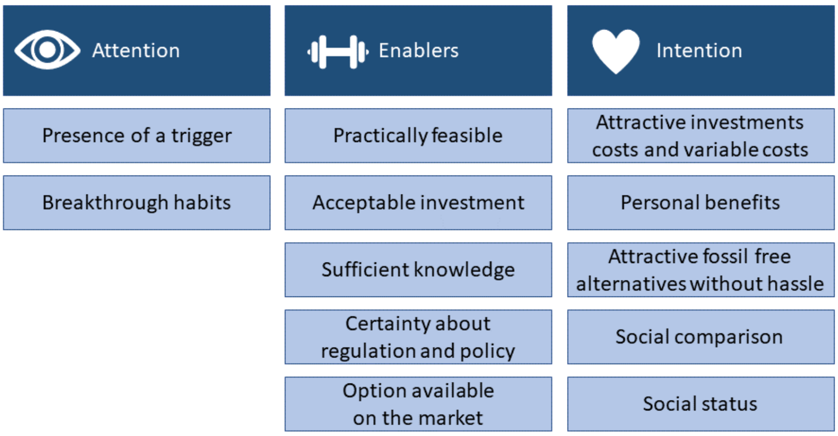


**Figure 6: Overview of the factors that play a role in choice behaviour towards fossil free living (based on the CODEC model)**

## 2.3.4 Technical Challenges

From a technical point of view, the main challenge in PED concept is to optimize the building integration within the district and renewable energy sources (on/out site the district). Due to the variability in the RES generation, the needs for having flexibility options are higher. In order to decrease that reliability, Integrated and innovative technologies for PEDs could be a smart mix consisting of smart urban energy networks, energy storage, ICT's and e-mobility, among others.

According to Set Plan Working group, innovative solutions for realizing and deploying PEDs cover following domains[18]:

- Highest energy saving measures to reducing primary energy demand through a variety of energy conservation measures, highest energy efficiency and cutting-edge energy management systems comprising highly insulated building envelope and windows, integrated PV and solar-thermal façade, passive housing and efficient lighting, and smart metering.

- Maximize the use of renewable energy supply based on local distributed Renewable Energy Systems (RES) within the geographical boundary of the district as well as through local energy sources adjacent to the district. This covers PV, solar thermal, heat pumps, geothermal and waste-to-heat-and-power. Complementary to the local renewable energy supplies, the allocation of sites in adjacent urban areas or the surrounding regions should be considered for additional electricity generation from biomass, wind and solar parks, especially to ensure covering the peak demand. The generation of renewable energy sources in the local-regional energy partnership should be taken into account in the calculation of the net zero import definition of the PED.

- Integrated energy system design providing an efficient and flexible energy infrastructure (electrical, heating, cooling, gas grids, all components connected by an ICT platform, etc.), enabling the use of energy sector coupling (electricity, heating, cooling, energy for mobility), the exchange of energy between all consumers and producers in the PED. The energy system shall be designed to be robust and resilient to enable the adaptation to changing surrounding conditions. This includes technical (e.g. grid infrastructure), organizational and regulatory aspects.

- Flexibility options as well as optimized and smart energy management across the different building types within the district and in synchronisation with the wider energy system of the surrounding neighbourhood. This includes developing modular hybrid microgrids beside the opportunities of DC grids integration, optimizing control algorithms for real-time management of several energy vectors via ICT. In view of increased dependence on intermittent RES, active management will allow for balancing and optimisation of energy demand-supply, load shifting and reduced curtailment impact of RES.

- Energy storage presents one of the biggest gaps to realize PEDs. Finding ways to store energy all year long is not just a challenge when it comes to technology but also in terms of cost effectiveness. Technically feasible solutions for long-time storage of heat and electricity over days and weeks and even seasons must become cheaper in order to make PEDs cost-effective, so they can compete with conventional buildings and districts on the basis of a life-cycle, or total cost assessment.

- EV will be an integrative element of PEDs with an expected increased impact on the district energy system behaviour. Hence, EVs need to be considered already during the planning phase of PEDs. By planning and implementation of an optimized EV charging infrastructure and adequate management of charging as well as considering EV-to-grid, EV can have positive impact on the power load management charging capability within the district and make use of the ensure that the impact of EVs on the distribution will be minimised by using local generation where possible.

[18] Set Plan Action Nº 3.2 Implementation plan, Annex 3, June 2018.

- Distributed ledger technology to manage power exchange at the local community level and create added value and incentives for the consumer to generate energy locally, provide flexibility and aggregate power generation in a system-wide cloud solution. Such innovative technologies are vital to maximize the uptake of renewables and manage the emerging local energy systems that couple the different energy demand and supply options in view of the changing role of consumer and producer to the role of prosumer.

## 2.3.5 Requirements for implementation of PED

### 2.3.5.1 Urban Planning, Land Use Planning and Urban Design

**Urban planning** can be defined as "the process of envisioning alternative futures for an urban area, setting goals and objectives, and formulating implementing strategies to reach the alternative future".19 **Land use planning** is one element of urban planning. 20 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.21 **Urban design** addresses the scale between architecture and urban planning22 and focuses on the physical and spatial features of the built environment. Urban design seeks to design a coherent whole out of the place-specific resources and qualities, within the wider regulatory systems and market conditions.23

As the integration of various interests is the central aim of urban planning and land use planning, cities can utilize 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 urban structure in the long-term, and search locations for integrated urban functions, such as PEDs. Moreover, surveys and impact assessments produced during land use planning can be utilized to generate knowledge about energy opportunities. Land use planning can also be utilized to bridge 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 utilized for energy-related participation.

Urban planning is in its very essence an attempt at promoting cross-sectoral working and the development of integrated local policies. In taking a confined area such as a region as its basis, spatial planning tries to guide and stimulate positive regional developments while directly touching upon many sectoral policy agendas. Hence, spatial planning might well be the main instrument to also promote energy policies to be integrated and linked to these other sectoral agendas. Consequently, a key urban planning can be a useful steppingstone to also pursue more integrated and holistic working on pursuing energy transition. There is various important example of how urban planning might be used to do so:

- The promotion of mixed-use areas, where alternative land use functions and activities are combined, e.g. using residual heat of companies to heat houses, promote low carbon transport in dense multi-use areas, using roofs of logistic centers for solar panels, etc.

19 Caves, R. W. (2005). *Encyclopedia of the City*. London: Routledge.

20 Caves, R. W. (2005). *Encyclopedia of the City*. London: Routledge.

21 Commission of The European Communities. (1997). *The EU Compendium of Spatial Planning Systems and Policies*. Luxembourg: Regional Development Studies, Office for Official Publications of the European Communities.

22 Caves, R. W. (2005). *Encyclopedia of the City*. London: Routledge.

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

- Using land use plans to guide the development of urban structure in the long-term, and search locations for integrated urban functions, such as PEDs.
- Using surveys and impact assessments produced during land use planning can be utilized to generate knowledge about energy opportunities. Land use planning can also be utilized to bridge 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 utilized for energy-related participation.
- Strategic use of land and real estate owned by the municipality can be an important instrument to pursue energy efficiency and renewable energy generation. Notably, it allows municipalities to urge developers to comply with their demand and thus, proactively contribute to energy transition.
- Combining policy actions aiming for investments; e.g. sewage renewal with constructing heat networks, improved energy efficiency with targeting energy poverty, climate change adaptation measures to improve isolation of housing (and urban heat island effect), investments in infrastructure to allow for more low carbon mobility or solar panels on the side of roads, etc.

A central ingredient for urban planning is its focus on integrating various land uses and thus, related sectoral policy interests and stakeholder interests. For doing so, urban planning relies and urges for a holistic approach towards sustainable, livable neighborhoods / Integrative perspective e.g. integrating technological, spatial, regulatory, financial, legal, economic, social, cultural and governance aspects. Synergetically connected to the wider energy/mobility/digital infrastructure. Sometimes the circular economy/sustainable urban metabolism is put forward.

- **Context-sensitive,** urban structure – *'location, location, location'*

In the case of the City of Oulu PED, the existing central district heating network forms the framework for PED scale-up in the urban structure. This is because Kaukovainio PED uses excess heat from the district heating network as a heat source, which is possible only in selected locations within the city.

- **Mixed use & functions,** strong public spaces, integrating green and blue networks

implementation areas of PEDs are grouped as New Area Development, Infill Area and Retrofitting areas, to describe the nature of interaction processes with the stakeholders in PED development. Within this, according to the PED definition in MAKING-CITY project, a Positive Energy District (PED) is "an urban area with clear boundaries, consisting on buildings of different typologies that actively manage the energy flow between them and the larger energy system to reach an annual positive energy balance". We can estimate that diverse PED solutions match with different groups of buildings including different types of functions. In the case of City of Oulu PED, big public and private buildings in the neighbourhood are key factors in energy supply. Therefore, big public and private buildings' capacities are of interest. We may also expect that buildings fostering a diversity of energy actions in a PED, is capable of contributing to the energy system more flexibly.

### 2.3.5.2 Investment and Risk Models

There is no predefined single business mod¬el for the successful development of a PED. Instead, a combination of different business models must be found for each stakehold¬er involved. This applies to each of the pillars of the PED energy system (energy efficiency, renewable energy production, energy sys¬tem flexibility and electric mobility). For each stakeholder involved (cities, real estate devel-opers, 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.

#### 2.3.5.3 Citizen Empowerment

Citizen empowerment in most EU countries starts with statutory regulations with common planning procedures. Such participation can, however, be quite limited and tends to reach only a modest amount of people. Public hearings, announcements in local media or having plans open for consultation are important starting points for participation but are not yet sufficient as true open planning processes. An open planning process allows for all affected stakeholders – including citizens – to be directly involved in processes such as defining the scope of the problem or plan, its ambitions, the approach taken, actual interventions and implementation. As such, it thrives on communicative planning ideals (e.g. Nilsson, 2007[24]) and co-creation (Sanders & Stappers, 2008[25]).

Open planning processes are not self-evident, as there are key challenges regarding democratic legitimacy, how to engage people and differences between stakeholders. To begin with, democratic legitimacy can be contested, as a key question becomes if decisions made between stakeholders are politically accepted; i.e. should formal political decisions allows follow the outcomes of such processes or, if not, what does this mean for the commitment of stakeholders to the process? As such, it can be useful to also consider opportunities to sign agreements or covenants between those involved, including governmental agencies represented by the municipal council.

Secondly, engaging people can be challenging as they are not always able to allocate time, are little interested or simply have not been reached through information. Examples to improve involvement exists, but often require expertise from governmental organisations. These examples include social media, games, campaigns, design workshops and involving children in school.

Approaching citizen engagement might be supported by relying on working with citizen groups, which can be professional communities. Nevertheless, individual citizen engagement tends to demand a different approach. For one, this is because of practical reasons, as they can hardly be considered able to have the time and resources to be fully engaged all the time. Secondly, they might also not be sufficiently interested, until actual decisions affect their own homes to direct neighbourhoods. Finally, for citizens the issue of energy is usually not a standalone issue, but connected to the overall improvement of well-being, both on the level of individual homes as on the level of neighbourhoods or districts.

Hence, a key challenge for PED development is to understand how citizens consider the topic of energy as related to their own lives and other local challenges such as public green, climate adaptation, mobility, quality of their houses, parking, etc. A citizen engagement strategy should ideally allow for the creation of efforts that allow citizens to identify with the ambitions of a plan, including of developing a PED. A key challenge thus is to create a shared story of the future of a neighbourhood or district that people recognize and value.

An important challenge for citizen empowerment is to move beyond mere interest representation and towards value representation; i.e. decision making moves beyond negotiating interests or about implementing a 'product' or 'solution', but is contextualized by a shared story for the future of a neighbourhood or town that the PED represents and fits into. Doing so can be a mechanism to evolve from self-interest to working on common values and hence, allow for a more efficient form of citizen participation. A key ingredient to support citizen empowerment by working on common values is also to financially enable citizens to be part of PED development. The challenge is thus to develop financial arrangement that allow and stimulate individual companies or individual households to (co)invest and financially participate. While much tends to depend on national legislation, also on a local level key opportunity exist, ranging from cheap loans, subsidies, or facilitating easy access to financial institutions.

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24 Nilsson, K.L (2007) Managing Complex Spatial Planning Processes, Planning Theory & Practice, 8 (4), pp. 431-447.
25 Sanders EB-N, Stappers PJ (2008) Co-creation and the new landscapes of design. CoDesign 4: 5–18.

Various EU countries currently see a thriving network of community energy groups, which can be a basis for community building (e.g. Seyfang & Haxeltine, 2012; Walker & Devine-Wright, 200826). Similarly, in many cities' communities have formed networks targeting alternative ambitions, ranging from public green, mobility to social activities. These can also be helpful starting points for the community building in the face of PED development. Finally, community building might to a degree also occur on the level of the city, where energy transition might be utilized as one of the underlying storylines for urban development.

#### 2.3.5.4 Collaborative Governance

Collaborative governance goes beyond direct citizen engagement and moves towards the creation of networks or coalitions where discussions and negotiations can take place with a wide range of stakeholders (e.g. Healey, 199727). Collaboration can start with allowing for true open planning processes where affected stakeholders, now also including companies and NGOs. Therefore, this also thrives on communicative planning ideals (e.g. Nilsson, 2007[28]) and co-creation (Sanders & Stappers, 2008[29]).

Collaborative governance goes beyond open planning processes, but also sees the creation of coalitions, platforms or networks for sharing and discussing policy outcomes as an ambition. Larger energy companies, energy network operators, housing assertions, project developers or big companies are all examples of more professional organisations with significant financial capabilities that need to be explicitly included in PED development. These stakeholders might be engaged through establishing economic and social networks together with governmental organisations and departments. The development of agreements, covenants and public private partnerships can be the result and ambitions of such networks, addressing wider urban energy challenges such as large solar fields, heat networks, neighbourhood revitalisation, etc. The result is a professional community of practice able to coordinate its work in pursuing PED development.

#### 2.3.5.5 Impact Assessment

In order to verify the coherence of PEDs with the needs and demand of the citizens of the city, region neighbourhood or area where the project is intended to be implemented, the interrelation among the urban challenges has to be highlighted. These challenges need to be identified with the different PED implementations in the city. A standardized matrix could be created to assess the impact of PEDs in terms of political, economic, social, technical, spatial or legal aspects. The matrix should summarize all elements and allow to identify how each city challenge is addressed by the project elements. Since PEDs support minimizing the impact on the connected centralized energy networks, the impact assessment on the innovative integration of technologies (such as sustainable energy services solutions, storages, smart control – demand response, e-mobility, DERs ...etc.) gains importance for encouraging decentralized systems.

26 G. Seyfang, A. Haxeltine, Growing grassroots innovations: Exploring the role of community-based initiatives in governing sustainable energy transitions, Environ. Plan. C Gov. Policy. (2012). doi:10.1068/c10222.
G. Walker, P. Devine-Wright, Community renewable energy: What should it mean?, Energy Policy. 36 (2008) 497–500. doi:10.1016/j.enpol.2007.10.019.
27 Healey, P. (1997) Collaborative Planning; Shaping Places in Fragmented Societies, MacMillan Press Ltd., Londen.
28 Nilsson, K.L (2007) Managing Complex Spatial Planning Processes, Planning Theory & Practice, 8 (4), pp. 431-447.
29 Sanders EB-N, Stappers PJ (2008) Co-creation and the new landscapes of design. CoDesign 4: 5–18.

## 2.4 Reference PED Projects

The following table provides a list of projects and implementations of Positive Energy District (PED), Positive Energy Blocks (PEB) and with similar approaches throughout the Europe. Links to projects and further information are also presented under the table.

| PE - Positive Energy District (PED), Block (PEB), Zero Emission, Energy Neutral, Energy Efficient, Carbon-free, Climate Neutral | | | | | |
|---|---|---|---|---|---|
| Code | Project Name | City (Country) | Links and further information | Type | Phase |
| PE-1 | Åland Island | Åland Island (Finland) | •Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>•https://sustainabledevelopment.un.org/content/documents/1523development_and_sustainability_agenda_for_aland.pdf<br>•https://www.barkraft.ax/english<br>•https://flexens.com/the-demo/<br>•https://smartenergy.ax/om-smart-energy-aland/<br>•Smart Islands Projects and Strategies (page39): https://library.fes.de/pdf-files/bueros/athen/12860.pdf<br>•https://www.euislands.eu/clean-energy-islands<br>•https://flexens.com/flexens-and-smart-energy-aland-joins-forces-with-kokar-island-in-the-clean-energy-for-eu-islands-project/D13 | PED -<br>Energy efficient<br>Carbon-free<br>Climate neutral | In operation: implemented |
| PE-2 | +CityxChange | Trondheim (Norway) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://cityxchange.eu/our-cities/trondheim/<br>• https://smartcities-infosystem.eu/scis-projects/demo-sites/eco-city-site-trondheim | PED –<br>Energy efficient | In implementation stage |
| PE-3 | +CityxChange | Limerick (Ireland) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://cityxchange.eu/our-cities/limerick/<br>• http://smartcitiesireland.org/wp-content/uploads/2018/10/1-2_M.Bilauca_LimerickLighthouseCity.pdf<br>• http://www.collaborativehousinglimerick.ie/wp-content/uploads/2019/01/6Webb_-Georgian-Neighborhood-Programmes-.pdf | PED | In implementation stage |
| PE-4 | +CityxChange | Võru (Estonia) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://cityxchange.eu/our-cities/voru-estonian/ | PED<br>Zero-emission<br>Energy neutral<br>Energy efficient<br>Carbon-free<br>Climate neutral | In implementation stage |
| PE-5 | Laser Valley | Land of Lights, Măgurele (Romania) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://ec.europa.eu/jrc/sites/jrcsh/files/20190618-bucharestconference-ss3_tt-curaj_en.pdf | PED<br>Energy efficient | In implementation stage |

| Code | Project Name | City (Country) | Links and further information | Type | Phase |
|---|---|---|---|---|---|
| | | | •http://www.laservalley.ro/Home_files/BrosuraLV_EN_tipografie_compressed.pdf | Carbon-free | |
| PE-6 | Edificio LUCÍA | Valladolid (Spain) | •https://www.construible.es/comunicaciones/edificio-energia-casi-nula-integracion-energias-renovables-generacion-energetica-autosuficiente-sector-terciario-edificio-lucia<br>•https://www.construction21.org/espana/data/sources/users/882/docs/b03-03-simulacion-equest-lucia.pdf<br>• http://aulagreencities.coamalaga.es/edificio-lucia-arquitectura-sostenible-y-consumo-nulo-de-energia/ | PEB<br><br>Energy efficient<br><br>Zero-emission | In operation: implemented |
| PE-7 | HIKARI | Lyon-Confluence (France) | • Positive Energy Blocks for Small and Medium Sized Cities: https://eu-smartcities.eu/sites/default/files/2017-09/1.%20Positive%20Energy%20Blocks%20for%20Small%20%26%20Medium%20Sized%20Cities_0.pdf<br>• HIKARI, a mix-use positive energy block: https://eu-smartcities.eu/sites/default/files/2017-09/3.%20HIKARI%2C%20a%20mix%E2%80%90use%20positive%20energy%20block.pdf<br>• Ichinomiya, Hiroki (Mitsubishi Research Institute, Inc.). Case Study: Smart Community Demonstration Project in Lyon, France. https://www.nedo.go.jp/content/100871965.pdf<br>• Lyon Smart Community: http://www.lyon-confluence.fr/ressources/flipbooks/LyonSmartCommunity/en/files/assets/common/downloads/publication.pdf<br>• Gaiddon, Bruno; Valentin, Maxime; Alfonsi, Laetitia; Laquerriere, Marie-Lyne; Gouranton, Germain; & Corgier, David. (2016). HIKARI: A POSITIVE ENERGY BUILDING WITH AN ARCHITECTURALLY INTEGRATED PV FACADE and a PV ROOFTOP SYSTEM (190 KWP). Zenodo. http://doi.org/10.5281/zenodo.834534<br>• https://www.construction21.org/espana/city/fr/hikari-1st-positive-energy-urban-islet.html | PEB - Positive Energy Block<br><br>Energy efficient | In operation: implemented |
| PE-8 | Hunziker Areal | Zurich (Switzerland) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>•ttps://www.mehralswohnen.ch/fileadmin/downloads/Publikationen/Broschuere_maw_engl_inhalt_def_181004.pdf<br>• https://tdlab.usys.ethz.ch/livlabs/hunziker.html<br>• https://issuu.com/ethel.baraona/docs/zurich_low<br>• Case Study 2019 - Sustain. practices: mobility: https://tdlab.usys.ethz.ch/teaching/tdcs/current.html<br>• Case Study 2017 - Suff. nutrition sector: https://tdlab.usys.ethz.ch/teaching/tdcs/former/cs2017.html | Climate neutral<br><br>Energy efficient | In operation: implemented |
| PE-9 | Fleuraye | Carquefou/Nantes (France) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://www.construction21.org/france/city/fr/quartier-de-la-fleuriaye-a-carquefou.html<br>• https://www.nantesmetropole.fr/actualite/l-actualite-thematique/3-solutions-vertes-qui-font-de-la-fleuriaye-un-quartier-exemplaire-urbanisme-100458.kjsp<br>• http://www.quartierlafleuriaye.fr/ | | In operation: implemented |

| | | | | | |
|---|---|---|---|---|---|
| PE-10 | Hammarby Sjöstad 2.0 | Stockholm (Sweden) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://hammarbysjostad20.se/?lang=en<br>•https://energiforskmedia.blob.core.windows.net/media/23661/14-pilotprojekt-hammarby-sjostad-sten-bergman.pdf<br>• https://www.nordregio.org/sustainable_cities/hammarby-sjostad/ | Carbon-free<br><br>Climate neutral | In operation: implemented |
| **Code** | **Project Name** | **City (Country)** | **Links and further information** | **Type** | **Phase** |
| PE-11 | Sharing Cities | Milano (Italy) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• http://www.sharingcities.eu/sharingcities/city-profiles/milan<br>• https://sharingcities.wixsite.com/milano<br>• https://smartsustainablecities.uk/milan-sharing-cities/<br>• http://anyflip.com/zerr/kusu/basic | Energy efficient | In operation: implemented |
| PE-12 | Smart Otaniemi | Espoo (Finland) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://smartotaniemi.fi/<br>• https://urbanmillblog.files.wordpress.com/2019/01/smart-otaniemi.pdf<br>• https://clicinnovation.fi/wp-content/uploads/2019/04/Smart-Otaniemi.pdf | Climate neutral | In operation: implemented |
| PE-13 | EnStadt:Pfaff | Kaiserslautern (Germany) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://pfaff-reallabor.de/<br>• https://www.pfaff-quartier.de/ | Climate neutral | In implementation stage |
| PE-14 | mySMARTlife | Helsinki (Finland) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• https://www.mysmartlife.eu/cities/helsinki/ | Climate neutral | In implementation stage |
| PE-15 | Sinfonia | Bolzano (Italy) | • Booklet of PED - UrbanEurope: https://jpi-urbaneurope.eu/app/uploads/2019/04/Booklet-of-PEDs_JPI-UE_v6_NO-ADD.pdf<br>• http://www.sinfonia-smartcities.eu/en/project | | In implementation stage |
| **EN - Eco-Neighborhood, Sustainable cities National Programs** | | | | | |
| **Code** | **Project Name** | **City (Country)** | **Links and further information** | **Type** | **Field of interest** |
| EN-1 | Écoquartier GINKO | Bordeaux (France) | • http://www.nouvelle-aquitaine.developpement-durable.gouv.fr/visite-de-l-ecoquartier-ginko-a-bordeaux-le-7-a479.html<br>• http://www.nouvelle-aquitaine.developpement-durable.gouv.fr/IMG/pdf/FP-Ginko-BordeauxV4_cle0f1996.pdf<br>• https://fr.calameo.com/read/00180283644f52af56df8 | Eco-neighbourhood | Sustainable neighbourhood<br>Transport |
| EN-2 | Écoquartier ARAGO | Pessac (France) | • http://www.revelarchi.com/nos-projets/ecoquartier-arago-pessac/<br>• https://urbanisme-bati-biodiversite.fr/IMG/pdf/6-ecoquartier-arago-pessac.pdf<br>• https://www.construction21.org/france/case-studies/fr/eco-quartier-arago.html | Eco-neighbourhood | Sustainable neighbourhood |

| | | | | | |
|---|---|---|---|---|---|
| | | | • https://palmares.archi/2016/projets-candidats/smlxl/eco-quartier-arago/ | | |
| EN-3 | Killesberghöhe | Stuttgart, Germany | • https://www.db-bauzeitung.de/db-themen/db-archiv/insel-in-weiss/<br>• https://www.world-architects.com/en/kcap-architectsandplanners-zurich/project/killesberghohe<br>• https://www.dbz.de/download/92553/2207-killesberg.pdf<br>• Park: http://www.landezine.com/index.php/2015/11/park-killesberg-development-towards-an-urban-environment/<br>• https://www.kcap.eu/en/projects/v/killesbergh_he/ | Eco-neighbourhood | Sustainable neighbourhood |
| Code | Project Name | City (Country) | Links and further information | Type | Phase |
| EN-4 | Oberbillwerder | Hamburg, Germany | • https://www.oberbillwerder-hamburg.de/<br>• https://transsolar.com/projects/hamburg-oberbillwerder-masterplan<br>• https://www.karresenbrands.com/project/the-connected-city<br>• https://www.pinarbalat.com/oberbillwerder-masterplan | Eco-neighbourhood | Sustainable neighbourhood |
| EN-5 | 2000 Watt Sites | (Switzerland) | • https://www.2000watt.swiss/ | Sustainable cities national program | Sustainable neighbourhood |
| EN-6 | ÉcoQuartier | (France) | • http://www.ecoquartiers.logement.gouv.fr/ | Sustainable cities national program | Sustainable neighbourhood |
| EN-7 | Viable Cities | (Sweden) | • http://viablecities.com/en/home/ | Sustainable cities national program | Sustainable neighbourhood |

# 3 MAKING-CITY PED Methodology

This chapter identifies the definition of PED for MAKING-CITY and objectives of the proposed PED Methodology. A brief explanation for calculation methodology is presented and experience mapping of two LHCs is evaluated for introducing the conditions that LHCs went through during PED area selection.

As the research for PED definitions was explained previously, a background of PED concept will be shown in this section. A homogenous definition about what we understand as a PED and the procedure to define Ped concept boundary and select proper technologies in cities and to measure how positive a district is, will be described below.

Different definitions and approaches can be found in the bibliography (See section 2.1), nevertheless we need a common starting point, in one hand, to be able to compare the results of each of the three demonstration PEDs that will be implemented in the MAKING-CITY project, and in the other, help other cities to replicate what we will do in lighthouse cities. Definition of MAKING-CITY is explained in section 3.1 of the present document and the calculation methodology (boundaries, energy balance calculation, etc.) is explained in D4.2.

For the demonstration that a district is positive and the evaluation of its energy surplus, the **annual energy balance** is a key aspect and for this calculation, the **primary energy factors** should be used to consider all possible energy carriers in the balance. This annual energy balance can be calculated assuming different rules, but in MAKING-CITY project, the standard that guides the calculations in terms of positive energy balance will be the "*Guidelines 2012/C 115/01 accompanying Commission Delegated Regulation (EU) 244/2012 supplementing Directive 2010/31/EU on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements"*[30] *and ISO 52000*. D4.2 provides the guidelines for the calculation of a positive energy district, following the process that was performed during the initial state of MAKING-CITY project, and it completes the design of the PED by setting a robust methodology for replication of the PED concept.

## 3.1 What we understand as a PED

According to MAKING-CITY project, a **Positive Energy District (PED)** is **"an urban area with clear boundaries, consisting on buildings of different typologies that actively manage the energy flow between them and the larger energy system to reach an annual positive energy balance"**

PED is a relatively new concept, derived from the **Positive Energy Block (PEB)** concept. MAKING-CITY assumes that a single energy transition process can be accelerated if PEDs can be achieved and scaled up, due to the special features and ambitious of the approach. Reaching positive balance means a step forward regarding net zero energy districts but can obtain better impacts, since intensive use of RES and high efficiency can achieve very high reduction of $CO_2$ emissions. PEB is a group of at least three connected neighbouring buildings producing on a yearly basis more primary energy than what they use[31].

Speaking of neighbouring, **Positive Energy Neighbourhood (PEN)** is a system-level concept where the neighbourhood generates more energy than it consumes, with surplus energy being either stored locally or exported[32].

Before positive vision, Nearly Zero Energy Buildings (NZEB) and therefore Nearly Zero Energy Districts (NZED) were the tractors for helping the energy transition the cities. NZEB as a building that has a very high energy performance with the nearly zero or very low amount of energy required covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby[33] forms the NZED.

In fact, other definitions of PED, quite similar and not contradictory to the MAKING-CITY one, is defined by the SET-Plan as a district with annual net zero energy and net zero $CO_2$ emission working towards an annual local surplus production of renewable energy (the comparative. **PED Labs** has appeared also as a pilot action that provide opportunities to experiment with planning and deployment of PEDs, as well as provide seeding ground for new ideas, solutions and services to develop[34].

Nevertheless, in terms of SET-Plan definitions, it is necessary to take into account that although the PED concept is complementary to the MAKING-CITY one, the assumptions for the annual energy balance are less restrictive in terms of the electricity generated from Renewable Energy Sources (RES) than the MAKING-CITY procedures is. The EU Guidelines[35] considers that the primary energy factor should be

[30] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012XC0419%2802%29
[31] https://eu-smartcities.eu/initiatives/71/description
[32] Antonello Monti Dirk Pesch Keith Ellis Pierluigi Mancarella. Energy Positive Neighborhoods and Smart Energy Districts. Methods, Tools, and Experiences from the Field. 1st Edition. Academic Press, September 2016
[33] D'Agostino et al., Synthesis Report on the National Plans for NZEBs; EUR 27804 EN; doi 10.2790/659611
[34] SET-Plan ACTION n°3.2 Implementation Plan. Europe to become a global role model in integrated, innovative solutions for the planning, deployment, and replication of Positive Energy Districts. June 2018.
[35] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012XC0419%2802%29

applied to all energy (RES or non-RES) imported to the PED; the SET-Plan assumes that the electricity generated by dedicated renewable energy systems in the region outside the PED and supplied to it, is not necessarily regarded as import into the PED[34]. Therefore, bioenergy production outside the PED would affect in different way depending on the procedure followed to calculate the annual energy balance.

## 3.2 Objective of the PED Methodology

The objective of the MAKING-CITY PED Methodology is to empower replicability, scalability, and sustainability of PEDs, taking into account the city needs and priorities, on-site resource availability, urban planning, land use planning and urban design situation, MAKING-CITY PED solutions (demand side solutions as low consumption in buildings, improving energy efficiency by energy management in buildings and districts, supply side solutions as alternative energy resources and integrated infrastructures as large storage, heat pumps, district heating, ICT platforms, etc..) and their business models through a decision-making journey emphasizing citizen engagement. Since scaling up heavily depends on city size, geography, demographics, climate, infrastructures and economic and planning context, MAKING-CITY project works on identifying a method that firmly pursues this ambition.

PED Methodology focuses on the procedure considering the identification process of the PED concept boundary and selection of proper PED solutions peculiar to the cities. It is composed of the phases encompassing a decision-making route that underlines citizen engagement throughout this process. The procedure aims to understand what the city is looking for, described as state of play in cities (city characterization) for figuring out the priorities, objectives and needs of the cities. Therefore, 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.

Aligned with JPI Urban Ped framework studies, PED Methodology strongly builds upon wide stakeholder consultations and dialogues; connects to ongoing policy and strategy debates, in particular the implementation of Agenda 2030 SDGs, the Urban Agenda for the EU or the National / Regional and Local Energy and Climate and Urban Plans and strategies. In addition to citizen empowerment, urban planning, land use planning, urban design, investments and business models, collaborative governance and impact assessment have fundamental requirements to implement PED in any other places.

## 3.3 Calculation of PEDs

The basis for the energy calculation in MAKING-CITY PEDs is the Primary Energy Balance (annual base). If this average value is positive our district will be a PED, if not our district will only be nearly zero, not positive. The basis for the energy calculation in MAKING-CITY PEDs is the Total Primary Energy Balance (annual base – following ISO 52000). It is also important to calculate the Non-Renewable Primary Energy Balance, as it is another important indicator when aiming to PEDs. Indeed, many districts could have a difficulty achieving a zero-energy balance in terms of Total Primary Energy if there are not enough renewable resources within the district boundaries, and in these cases a zero-energy balance in terms of Non-Renewable Primary Energy could be a compromise, accepting renewable energies coming from outside the district boundaries.

A very detailed procedure for PEDs calculation is included in the deliverable D4.2 "Guidelines to calculate the annual energy balance PED", nevertheless the main aspects will be here summarized for helping the understanding of this guidelines.

The methodology explained in D4.2, goes step by step from explaining the district boundaries to the primary energy balance calculation (Figure 7). The first step of the procedure will be to define the boundaries of the PED, in order to set the limits of the calculation (what is the energy produce within the district, what is the energy exported and imported, etc.). PEDs can be delimited by spatial-physical limits including delineated buildings, sites and infrastructures (Geographical boundaries). Furthermore, it might be possible that the district has several buildings within a district or city interconnected with each other in terms of energy grids (functional boundary). Besides that, the case of a community that has the resources to own a windmill which are not usually located close to the city, could be considered a PED with "virtual boundaries" as the district is managing this energy facility.

Secondly, the standards and different calculation methodologies to calculate the energy needs are described. Later by identifying the on-site systems (as reported in the deliverable D4.2.), the next step is to calculate the on-site production. Once the energy outputs and inputs of each system have been identified, the different connections between the systems and the energy flows need to be linked. By doing an energy balance, the energy that should be imported into the district can be estimated. Finally, primary energy factors to be used are explained and the primary energy (total and non-renewable) associated with the delivered and exported energy of the district is calculated. The difference between them is the "Primary Energy Balance" of a PED.

Calculation goes from net energy needs to primary energy use and different steps have been identified for making easier the following of the energy calculations.

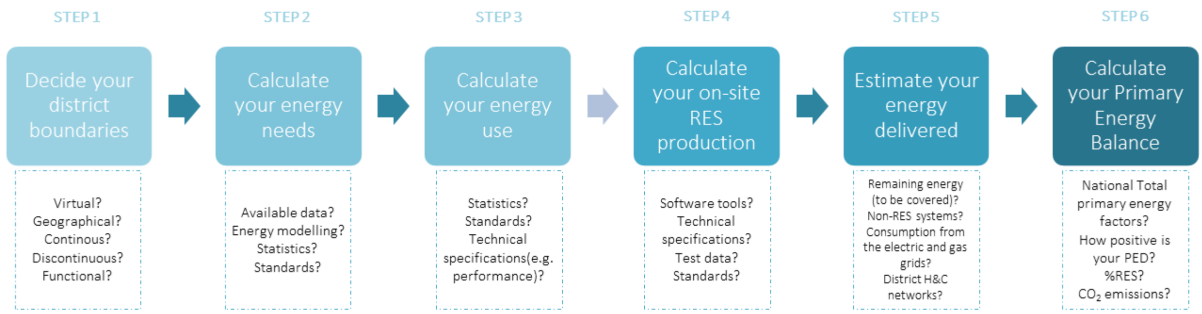



**Figure 7: Steps of the calculation procedure**

At the end, the overall Sankey diagram can be performed. For the energy flows (Figure 8), energy is separated by energy use (heating, cooling, DHW, appliances, etc.) and energy carriers (delivered energy: fuel energy, electric energy coming from RES, electric energy coming from grid, etc.). The difference between energy needs and energy use is the efficiency in the distribution system (if there is any).

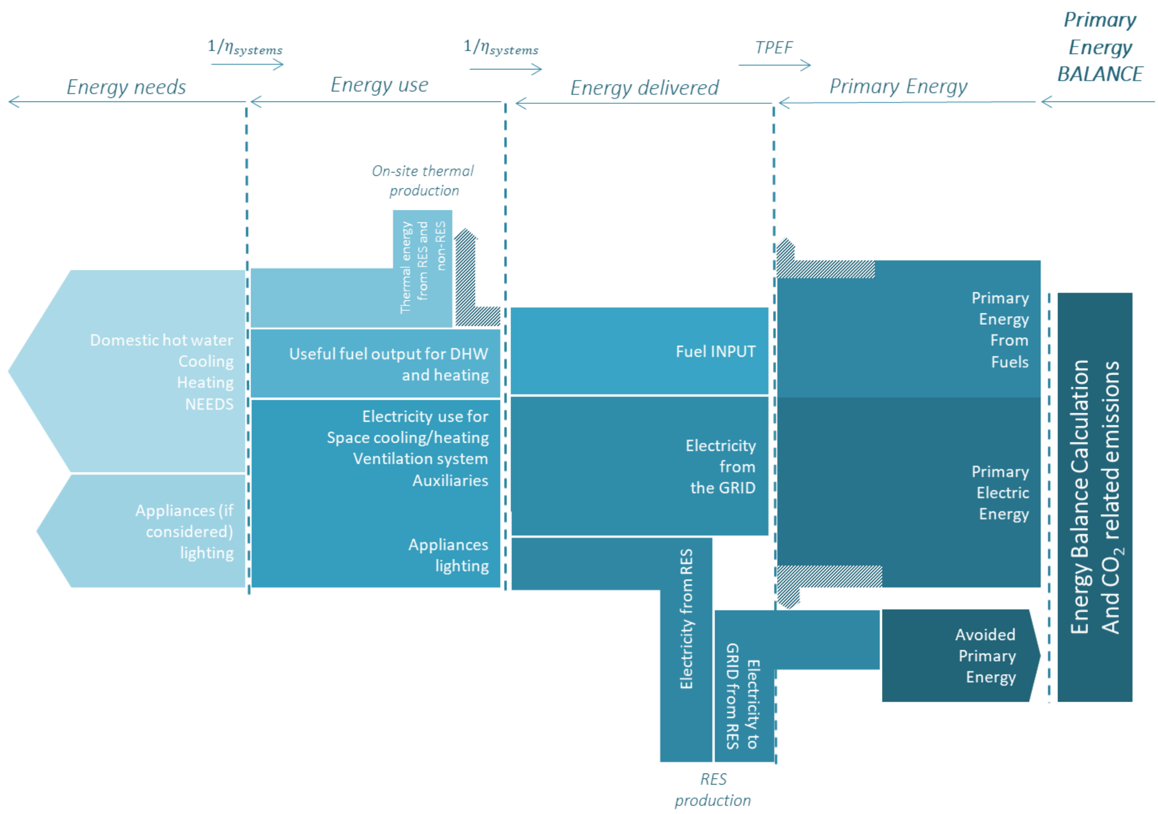
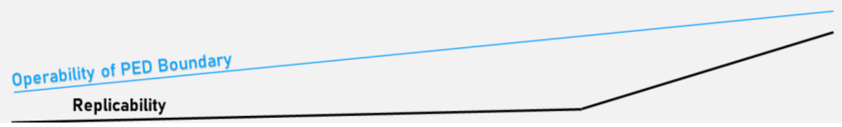



**Figure 8: Sankey Diagram of the energy flows in a PED**

## 3.4 PED Experiences in Lighthouse Cities: Oulu & Groningen

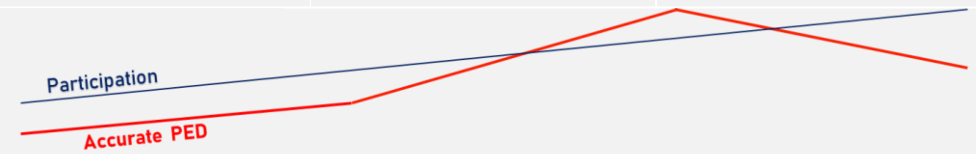
Methodology for PED design aims to find solutions for identifying PED concept boundary and proper technical and non-technical actions for cities in their pathway to energy transition. Oulu, Finland and Groningen, Netherlands which are two Lighthouse Cities of MAKING-CITY, already identified PED concept boundaries and designed solutions at the proposal stage of the project. Interviews have been held with city representatives in April 2019 before Project Meeting in May (in Groningen) in order to figure out the experienced cities' approach on PED planning and design. Main conditions on the process for selecting PED area and defining PED boundary and priorities of these cities while selecting PED areas are discussed within these interviews and knowledge share from LHCs to FWCs is expected as a result of this study. The conditions and priorities are summarized in Experience Mapping Tables of Oulu and Groningen (Table 4 and Table 5).

**Table 4 Experience Mapping of Oulu**

| PED Area Selection | PHASE 1<br>1st Condition | PHASE 2<br>2nd Condition | PHASE 3<br>3rd Condition |
|---|---|---|---|
| ACTIONS | City Planning / Development Area | Maintaining network stability | Buildings / RES |
| Questions / Thoughts | How can we place PED on the urban development plans of the city? | How can we identify the stakeholders in the area? | Which solutions can we use? How do we improve technologies to go for (+)? |
| Happy Moments | Urban Development Area / including Arina Shopping Mall<br>Urban Planning Department Approval | They are willing to collaborate and willing to implement PED in this time schedule | High COP Heat pumps integrated to return pipelines of district heating<br>Waste heat from AC systems<br>Geothermal Heat Well for SM |
| Pain Points | | Part of the buildings are being held up until certain percentage of apartments are preserved. Development company asks the city of Oulu to be marketed for future residence. | Too long pay-back times for some investors.<br>Technological uncertainties, especially concerning the most ambitious solutions. |
| OPPORTUNITY |   | | |

<u>Experience Mapping of Oulu:</u> Oulu City together with technical partners considered potential PED areas in relation to the urban development plans of the city. They specified KAUKOVAINIO district after a set of analyses since this is an urban development area with a shopping mall and regeneration plans. Secondly, the team analysed the stakeholders in the area in terms of their land use agreements and investment plans for the near future. And finally, they considered which energy solutions could be implemented in the area. The PED boundary was identified by addressing both technical and non-technical solutions. All of the happy and pain points of the conditions are summarized in Table 4. The opportunities are illustrated in the same table regarding the conditions in Oulu's process.

**Table 5 Experience Mapping of Groningen**

| PED Area Selection | PHASE 1<br>1st Condition | PHASE 2<br>2nd Condition | PHASE 3<br>3rd Condition |
|---|---|---|---|
| ACTIONS | Heat Grid | Active Community | Buildings / RES |
| Questions / Thoughts | Most of the city is upon gas grid, since resource has to be within boundaries, what chances do I have? | How can we foster the transition process from citizen perspective? | Which buildings already have plans & processes? |
| Happy Moments | Resource Availability within city | Paddepoel Energiek (PE) is the local foundation that has the goal to foster the transition in Paddepoel (part of the North district). Grunneger Power has hired two people that are active in PE to represent the local community | Apts belong to housing association. Tenants willing to collaborate<br>TNO worked on probable tech & calculations |
| Pain Points | Gasgrid is socialised, heatgrids are not | Everyone needs to be connected in order to remove gas grid | To get enough buildings connected to make a business case work |
| OPPORTUNITY |   | | |

<u>Experience Mapping of Groningen:</u> Groningen City together with technical partners first considered the resources and heat grids in the city boundaries. Since most of the city is upon gas network, they searched for geothermal based district heating area in order to benefit from renewable energy production. The infrastructure of heat grid is being built and therefore, second consideration was to involve active communities in the area to arrange a full commitment on investment and implementation of PED in this area. Finally, city plans were analysed in order to define buildings listed for retrofitting targets. All of the happy and pain points of the conditions are summarized in Table 5. The opportunities are illustrated in the same table regarding the conditions in Groningen's process.

# 4 The Phases of the MAKING-CITY PED Methodology

The next sections explain the general context, introduction, identified phases for planning and deployment of PED, stakeholders involved and citizen engagement strategies in the MAKING-CTY Methodology. Regarding planning of PED areas, identification of PED concept boundary and identification of technical and non-technical solutions are considered. On the other hand, for deployment of PED areas, verification of PED calculation, identification urban/land use planning support, stakeholders, financial schemes and citizen engagement are evaluated. PED Methodology also highlights replication view by standardization and workshop activities that will be held in Follower Cities and other potential cities.

MAKING-CITY Methodology pursues six phases of which the first is related to analyses of city characteristics through city diagnosis approach. Phase II considers all of the analyses regarding city needs and identifies a prioritization study on defining the PED framework within PED concept boundaries in the city. Phase III and IV focuses on the set of solutions proposed from the experiences of Oulu and Groningen and potential barriers and enablers that the Follower Cities or other cities may face during designing and implementing PED. Phase V offers an annual energy balance calculation relying on the method defined in D4.2 and monitors if the area is absolutely surplus building upon the applied earlier phases. Finally, Phase VI is an outcome of solution catalogue and barriers/enablers study and covers all detailed information regarding PED solutions. The phases are illustrated in Figure 9.

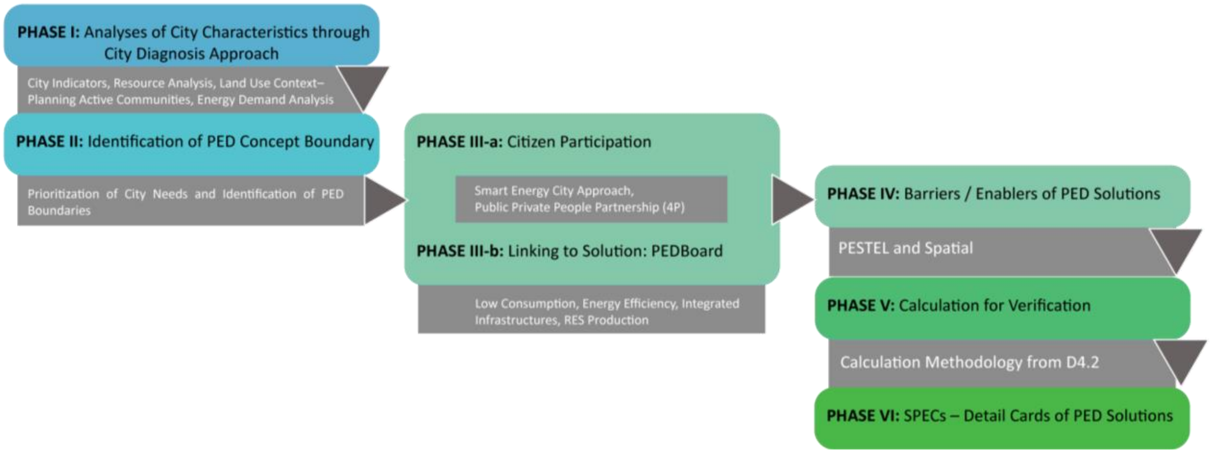



**Figure 9 Phases of MAKING-CITY PED Methodology**

## 4.1 Phase I: Analyses of City Characteristics through City Diagnosis Approach

Phase I addresses main city needs in terms of energy aligned with integrated urban planning, land-use planning and urban design. This phase includes robustly local authorities, citizens, researchers, planners and designers in the process. In doing so, city characteristics and priorities are analysed under four steps (Figure 10):

1. Analysis of the main city characteristics: Calculation of City Level Indicators
2. Analyses of existing City Plans and identification of implementation areas in these plans
3. Analyses of City Components
4. Energy Demand Analyses

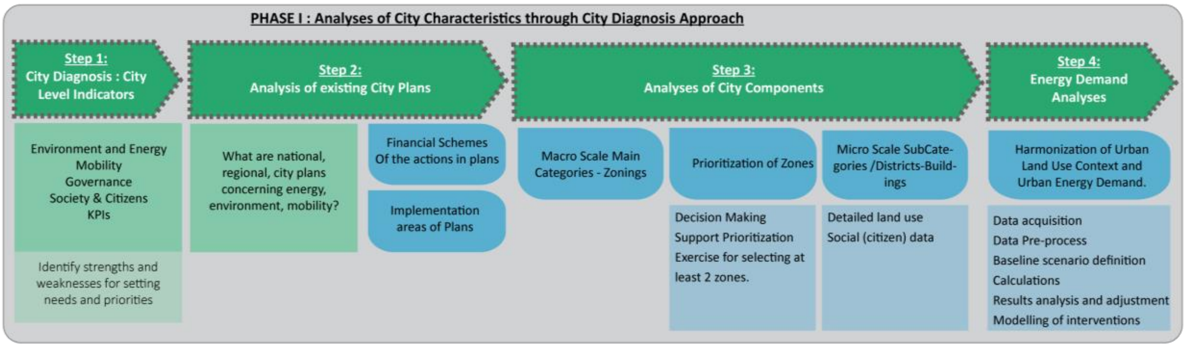



**Figure 10 Four Steps of Phase I**

### 4.1.1 Step 1: City Diagnosis: City Level Indicators

The city level indicators are used to show to what extent overall policy goals have been reached. In the process to become a smart city, establishing a reliable metric is a key point to support cities to identify strengths and weaknesses and consequently set priorities for action. For this reason, a set of city level indicators are established for the city diagnosis and for the identification of their needs and priorities. The indicators are defined within WP5 and used in WP1 in the city diagnosis framework. These indicators are grouped under Energy & Environment, Mobility, Governance and Society & Citizens categories. Within the four categories, application fields are found in which the indicators are included.

Thanks to the calculation of these indicators (D5.1), in D1.2 a process is carried out for the calculation of some city indexes with respect to the four categories. Through this process, the different indicators are scored according to the criteria of a previous normalisation based on a ranking of these indicators across European countries (literature analysis). A prioritisation is also carried out by the cities, in a way that reflects their priorities and needs regarding the different categories, application fields and indicators, since the intention is not to base the diagnosis only on the objective values, but also in the concerns and interests of the cities. This is done using an Excel Tool for pair-wise comparisons of the elements (Analytic Hierarchy Process, AHP).

Through the prioritisation, weights are obtained for the indicators of each city, which are aggregated with their scored to reach the city indexes (4 indexes, one per category). The method of aggregation of these two elements varies according to the city and its results, so that the parts in which the city have a good score are differentiated (either because it is very important for the city and many measures have been taken in this regard, or because there have never been any problems regarding that issue), from the parties in those the city is not well punctuated (and that score is attenuated because the city is aware of its problems and is on the way to improve it, or the low score is marked to highlight a problem that the city was not aware of).

This whole process and its results are reported in D1.2.

### 4.1.2 Step 2: Analyses of existing City Plans and identification of implementation areas in these plans

After city diagnosis research for defining the state of play in cities, a comprehensive study on analysis of existing city plans and the targets defined in these plans is carried out. The relationship between Step 1 and Step 2 is illustrated in Figure 11.

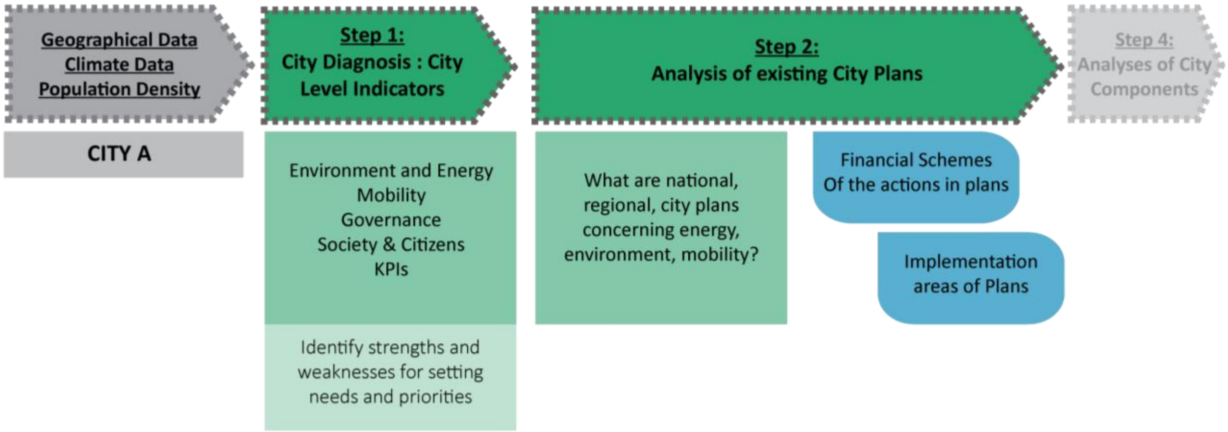



**Figure 11 Step 1 and Step 2 of Phase I**

To analyse the plans of the cities (explained and reported in D1.2) a table template of information gathering was made, so that all the plans were comparable to each other, both those of the city itself and those of some cities with others. Within this template, it is collected in a first approach the description of the plan, the implementation period, the scope of the plan, and the topics covered (energy, mobility, ICT, social). With this key information, it can already be made analysis about the plans of the city, the issues addressed in them, their scope or term of implementation. It also allows classifying the plans according these characteristics: their short, medium- or long-term planning, and their local, regional or national scope. At this phase, cities can also utilize their strategic land use plans to explore opportunities for PED implementation, by taking into account the aims of the city, the energy network operators, private sector and citizens. For instance, areas with both strategic importance for the city and energy network operators, and on-going or anticipated development activities by private sector or citizen initiatives could be prioritized.

Then, cities can profile areas suitable for implementing PEDs. At this phase, more specific information is collected on the main targets of the plans, and within these targets, the actions defined to achieve this goal, if there are actuation areas identified to implement the previous actions, the current status of the implementation of the actions (finalised, just getting started, on-going, cancelled due to lack of budget, cancelled due to technical issues), the execution period of the action, and the financial scheme that is or will be applied for the deployment of the actions. Once, the implementation area is selected, financial schemes or innovative business models for the deployment of the actions are analysed. To enhance implementation, cities may utilize detailed land use planning and land policy tools, as well as citizen and stakeholder engagement strategies. For instance, in some spatial planning systems, local detailed plans juridically enable implementation of building projects, and their participatory planning processes can be utilized for energy planning-related participation.

For the regional and national plans, the second approach of information collection has been simplified so that the actions are not repeated and taking into account that the measures or targets defined in these broader plans serve as the basis for the drafting of the local plans, in which the specific measures and areas of the city are already defined. Therefore, these plans only collect information about the targets and their related actions (or measures).

### 4.1.3 Step 3: Analyses of City Components

Analyses of City components play a key role for identification of peculiar and efficient PED concept boundary in cities. Until today, smart cities were particularly evaluated with energy, mobility and ICT (rarely with waste, water, too) domains. In fact, the challenge is that **local energy production and distribution, connected with digitalization**, have not previously been a part of the integrated urban planning and design approaches, while they have included many other environmental and social topics.

MAKING-CITY PED Methodology underlines **energy sustainability in urban planning, land use planning and urban design** and therefore repeats deep analysis in macro/micro scale in the city/neighbourhood/district/building level. A harmonization of these diverse modes of spatial planning with energy planning is the main aspect of PED Methodology for pointing out city characterization.

Likewise, MAKING-CITY PED Methodology indicates that inclusiveness, co-creation and participatory planning shall rule the energy transition since an inclusive city is a city in which the processes of development include a wide variety of citizens and activities. These cities maintain their wealth and creative power by avoiding marginalization, which compromises the richness of interaction upon which cities depend.[36]

The main analyses of integrated energy planning, spatial planning and data is divided into two categories, comparatively **macro and micro scale** main categories. Macro scale main categories involve GIS based spatial data as zonings. Cities start to assess zones of efficiency for PED areas peculiar to their characteristics, climate, demography, geography in different macro scale categories listed below (Figure 12)

1. Resource Analysis
2. Urban Macro-form Analysis
3. Land-use Context
4. Energy Infrastructure Analysis
5. Social Aspects

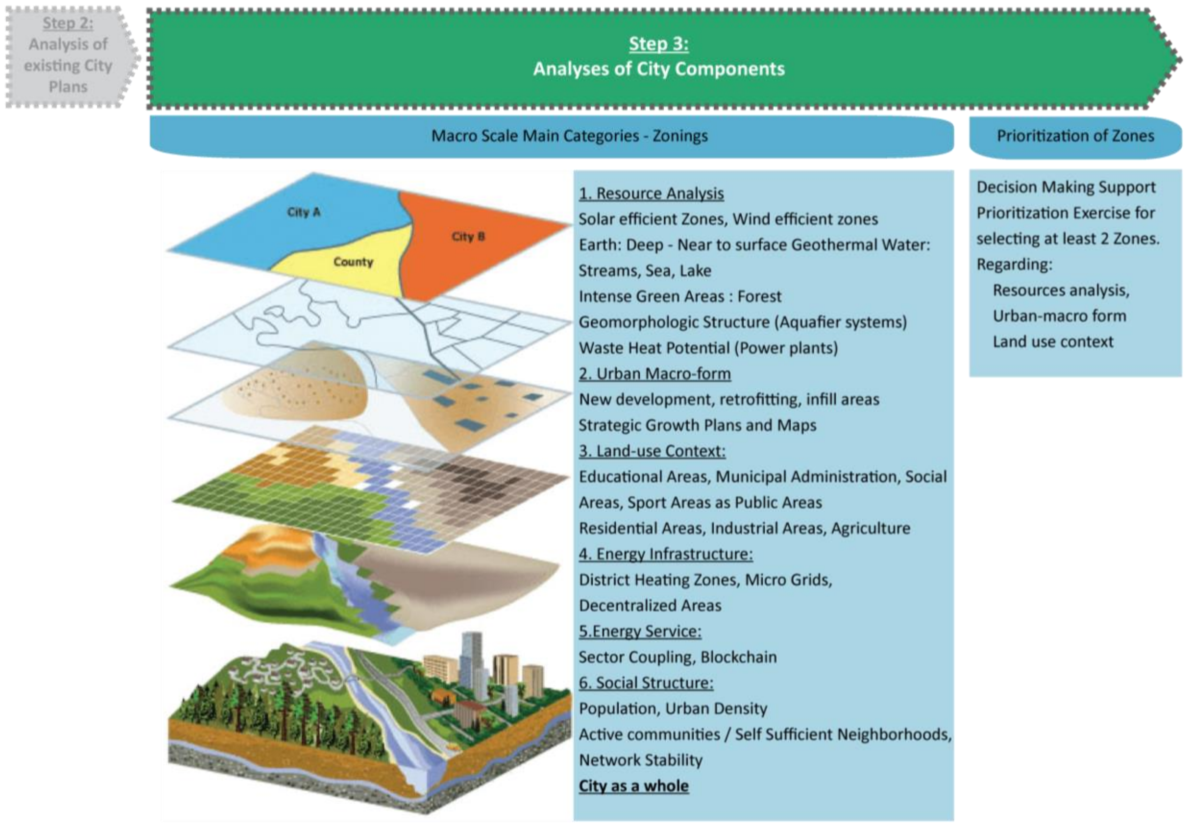



**Figure 12 Step 3 of Phase I**

[36] http://www.inclusiveurbanism.org/

Macro scale main categories are explained in detail as follow:

Resource Analysis: This category comprises recognition of solar efficient zones, wind efficient zones, earth resources (e.g. deep-near to surface geothermal), water resources (e.g. streams, sea, lake) or intense green areas (reduce urban heat island effect) and other available resources in the city boundaries. Existing power plants, RES plants & facilities may also be evaluated for waste heat potential, thus their locations shall be identified for potential renewable energy sources. Municipalities specify the relevant zones for aforementioned resources as in spatial data.

Urban Macro-form Analysis: The macro-morphological zones of the city are drawn for this analysis depending specifically on the implementation areas of strategic plans that are already examined in Phase I Step 2. Suggested implementation areas are grouped as New Area Development, Infill Area and Retrofitting areas. In these areas, the form of property ownership and participation needs in urban planning, land use planning and urban design processes are different, which also affects PED implementation. New development areas are new urban areas where there are no existing buildings. There, land use planning has good prerequisites to steer PED implementation, because PED can be planned to integrate with the other development interests of the area, prior to the implementation of the buildings and infrastructure. This is especially the case when the local spatial planning system allows public officials to have regulatory powers over private developers' investments, or when PED is developed on publicly owned land. Whereas, Infill Areas are redevelopment or land recycling that occurs on previously developed land. Infill buildings are constructed on vacant or underused property or between existing buildings. In infill areas, there are certain possibilities for spatial planning to enhance PED replication. As infill projects take place in existing urban environments, there is often a vast number of stakeholders. Thereafter, PED replication depends on the capacity of public officers to cooperate with stakeholders: energy network operators, real estate investors, development companies and citizens. Lastly, Retrofitting Areas are development or upgrading of buildings or technology within existing infrastructure. In retrofitting areas, some spatial planning tools, such as citizen and stakeholder engagement plans, are available to enhance PED implementation. PED implementation is dependent on citizens and property-owners, as well as on the prerequisites of the existing energy network. Municipalities should identify the relevant zones for these strategic areas in spatial data format.

Land-use Context: Since PEDs are consisting of different building typologies or functions, a broad analysis on the macro-scale of land-use is very important for identifying PED concept boundaries. At this stage, zoning of educational, municipal administration, social, sport areas as public areas, residential, industrial, agricultural areas are mapped in spatial data in order to prioritize proper zones for PED boundaries. Municipalities probably have land-use maps and they may be integrated into GIS platform preferably aligned with the INSPIRE model.

Energy Infrastructure Analysis: The analysis of energy infrastructure in the city is a perquisite for defining PED boundary since the existing infrastructure may help demand side management scenarios, energy in and out the district/neighbourhood etc.

Energy Service Analysis: sector coupling applications for energy efficiency for the calculation of surplus. (i.e. district heating/cooling facilities, P2H – Power to heat, H2P – heat to power, P2V – power to vehicle, V2P – vehicle to power…)

Social Structure Aspects: There are **groups or cooperatives** of citizens working on **renewable energy**, energy efficiency and **e-mobility** for integration of citizen involvement for the energy transition and for inspiring others to take action, as well. These active communities are added as a layer (in spatial data) to macro-scale analysis to obtain an image of the city in social characterization. Urban density and population data also affect the Ped boundaries in decision making processes.

After all of macro-scale analysis have been realized and zones have been determined regarding resources, implementation areas of strategic plans, land-use context, energy infrastructures and social aspects (and embedded in GIS based maps as spatial data), cities and relevant stakeholders are encouraged to construct a prioritization study to specify **at least 2 most proper zones** for implementing PED according to the most prioritized zones by **overlay mapping.** Since these zones will cover large areas**,** next step is going through micro-scale analysis and identifying PED areas in the city. Cities will develop micro-scale analysis in the following subcategories (Figure 13):

1. Land-use Detail Maps
2. Social (citizen) Data Maps
3. Energy Demand Analysis

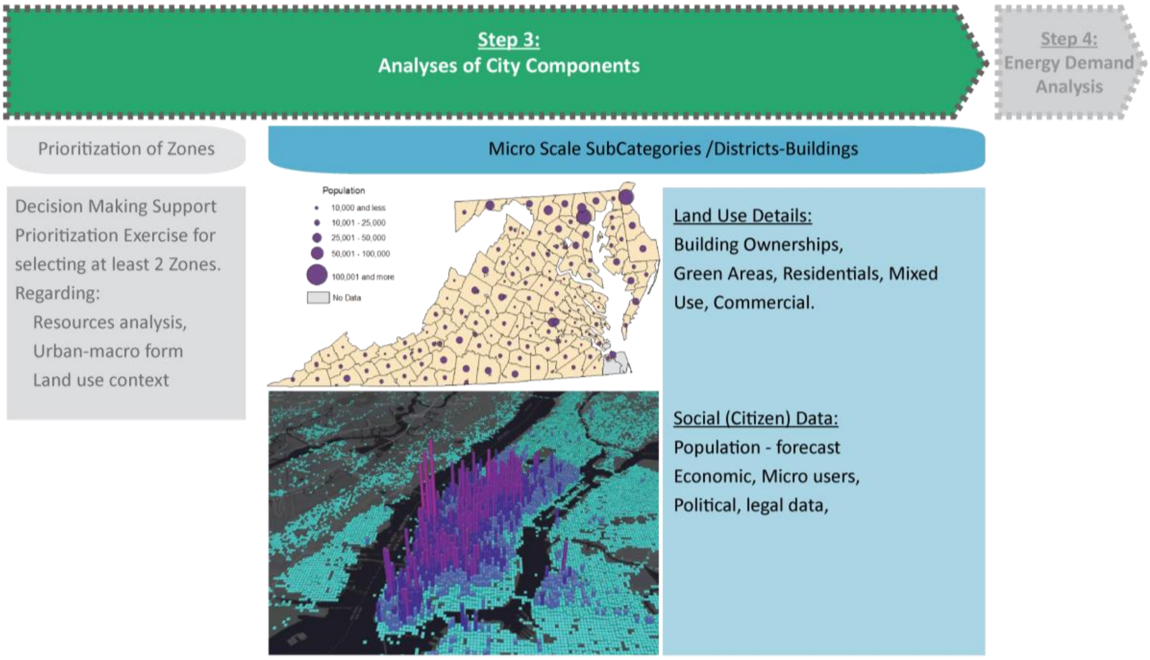



**Figure 13 Step 3 of Phase I**

Micro-scale subcategories for detailed analysis in the prioritized zones are examined as follow:

Detailed Land-use Analysis: Within the selected zones from macro-scale analysis, a detailed micro-scale analysis will be generated. Residential, mixed-use, commercial or all other tertiary buildings are identified in GIS cadastral environment, to find out whether there is a suitable mix of building typologies for PED development. Property ownership (e.g. public, private, semi-public) plays a key role in PED areas as well, and therefore the property ownership data of all the properties in the prioritized zone is defined. The state of existing land use plans in the area is analysed, to find out if the existing local plans already allow for PED development, or whether amendments have to be made for the plan. Based on these analyses and depending on the land use context of the area (new area development/infill development/retrofitting area, relevant stakeholders are then scanned, to find out whether the other property development needs can be integrated to PED development, and whether they are willing to implement PED in the agreed schedule.

Social (Citizen) Data: Citizens must be included from the early stages of PED planning and design in order to raise acceptability and potential for private investment on energy transition. The citizen data, such as, economic welfare level, capacities, legal data on incentives, population forecast etc., (as layer in GIS system) will be integrated in the prioritized zones in order to view the potential of the districts to become PED area.

### 4.1.4 Step 4: Energy Demand Analyses

There are several bottom up methodologies and techniques for making building stock energy models to analyse energy demand, and they can be applied at any level, local (district, municipal) or national level.

This section, presents a bottom up methodology for modelling the building stock of urban districts based on publicly available data and describes the workflow from the collection of the data to the adjustment, calibration and visualization of the simulation results.

The workflow is divided into the following process steps (Figure 14):

1. Data acquisition
2. Data Pre-process
3. Baseline scenario definition
4. Calculations
5. Results analysis and adjustment
6. Modelling of selected interventions.

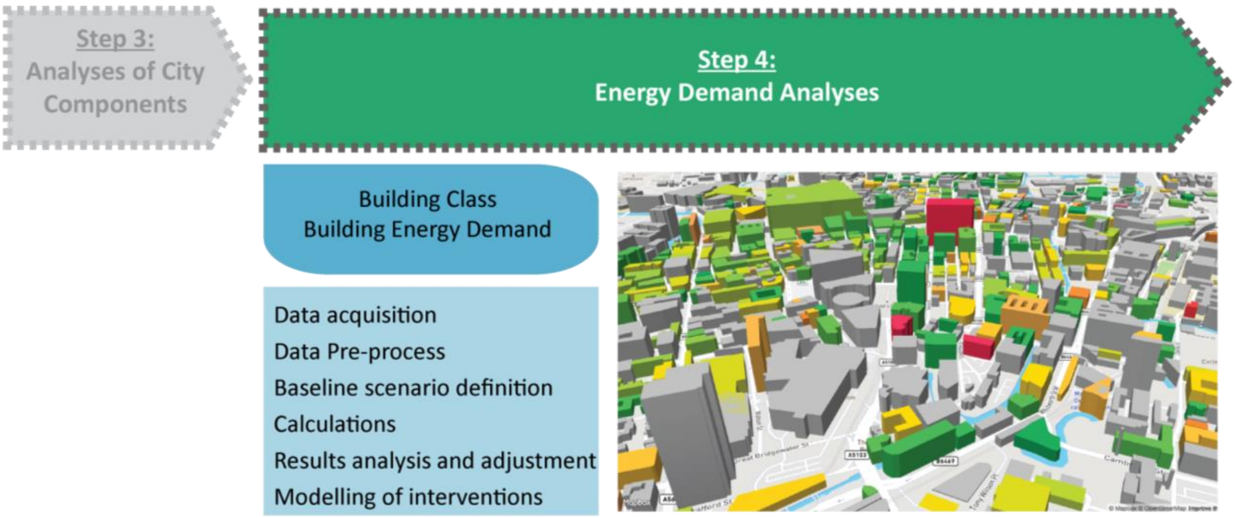



**Figure 14 Step 4 of Phase I**

The data gathering process is necessary to collect buildings' characteristics, regardless of the technique used to generate the model. This information can be obtained from public sources such as the cadastre, municipal datasets, statistical sources or European databases like the EU Building stock or the TABULA Web tool. The type of information and the disaggregation of the data required will depend in each case on the technique used. All this information must be processed and adapted to meet the requirements of the tool used in each case.

In order to obtain a realistic model, the particularities of the study area are defined in the best possible way to represent the current circumstances. These include the representation in a GIS tool of the different buildings with basic information regarding their year of construction, floors, area, use type, etc. With this basic information, the energy demand for heating, cooling, DHW, lighting and appliances can be obtained. If additional information is provided, the energy use for the different services, the emissions and the primary energy demand for each building within the district can also be calculated.

Finally, the results are validated against real data from billing or other sources such as energy performance certificates and the model is adjusted if necessary. The calibration of the energy models with actual consumption data is crucial to quantify current energy consumption correctly and not to overestimate the reduction potential of the measures applied in future scenarios.

These calculations would be a preliminary assessment of the baseline situation, which can also be compared with the analysis of the city indicators in Step 1 of this diagnosis Phase I. In Phase V, more detailed calculations with different solutions for PED design could be modelled, as future scenarios so that the impact on the energy demand, the $CO_2$ emissions and the primary energy demand can be analysed.

For all this process, the use of GIS software facilitates the representation of results, so that it is possible to analyse the actual state of energy demand in the study area in a visual way and identify the areas with the greatest potential for savings or implementation of interventions in the baseline scenario and the comparison with the results of the modelled PED scenarios. For the generation of the energy demand models within the Making City project, the use of ENERKAD® tool is proposed. ENERKAD® is a plugin for QGIS which evaluates urban energy scenarios at building, district and city scale and calculates the energy needs and energy use per hour for each building in a district, departing from generally available cadastral data, basic cartography and climatic information of the study area.

The application of this methodology is detailed in D4.15 section 7.

## 4.2 Phase II: Identification of PED Concept Boundary

Once the city needs and priorities are identified, land use context of the city is clarified and resources are listed, the boundary for the PED concept may be formed. This phase is connected with city and district scale and accommodates the participation of the local authorities, all relevant stakeholders and citizens. In advance of Phase II, what does the city analyse so far?

- City Level KPIs and preliminary outcomes
- Existing city Plans and implementation areas in these plans
- Macro Scale Urban GIS Zone Maps – covering resources, urban macro-form, land-use, energy infrastructure and social structure.
- Micro Scale Neighbourhood GIS Maps - covering land-use in detail, social (citizen data)
- Energy Demand Maps – analysis of heating/cooling demand, building energy properties/class

Phase II is illustrated in Figure 15.

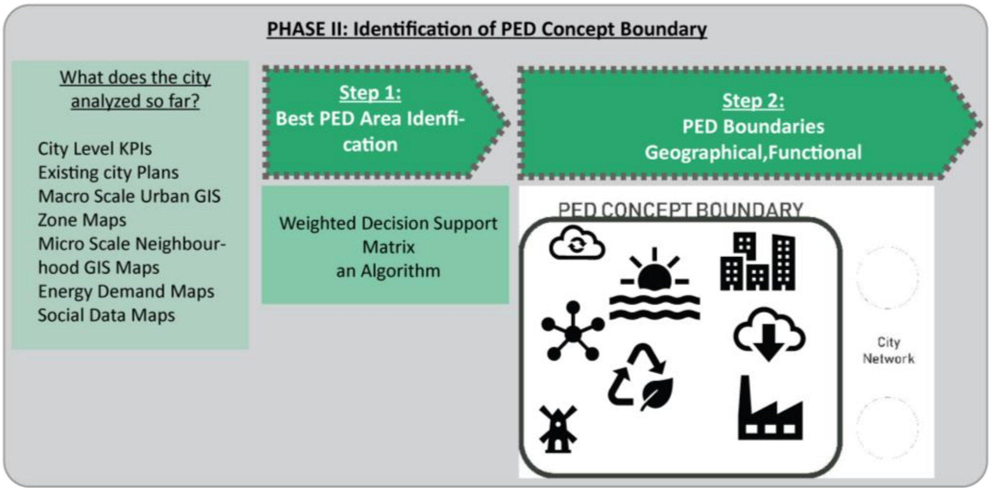



**Figure 15 Phase II Illustration**

### 4.2.1 Step 1: Best PED Area Idenfication

Following the first phase, Step 1 of Phase II focuses on results of the analysis. Within Macro-scale analyses, at least two zones were selected in order to further examine them in detail with micro-scale analyses and energy demand analyses. Phase I deals with city characteristics and needs, introduction to neighbourhood and district scale and prioritization of potential PED zones. In Phase II -Step 1, a decision-making support mechanism / an algorithm is designed to identify PED concept boundary within the prioritized zones. Such a decision-making matrix refers to a harmonization (Synthesis) of Urban Land Use Context and Urban Energy Demand. More detail regarding decision making support matrix will be developed and shared in the final version of this deliverable.

### 4.2.2 Step 2: PED Boundaries

PED framework is still under discussion that PEDs can be delimited by spatial-physical limits including delineated buildings, sites and infrastructures. Therefore, the PED will be characterized by geographical boundaries. Furthermore, it might be possible that the district has several buildings within a district or city interconnected with each other in terms of energy grids. This is the case of a district with a district heating or cooling system. A definition of a PED with a "functional boundary" can be taken from this as the buildings are interconnected by means of the pipes, and buildings are supplied by the same service. A gas network grid or an electric grid will follow the same approach, as an electricity/gas grid behind a substation can be considered as an independent functional entity serving the PED, even if the mentioned service areas are substantially larger than the energy sector of the PED in question. But, what if an energy generation infrastructure own by the community is outside the geographical boundaries of the district? Then, a virtual boundary could be defined, where the momentary energy produced and consumed is compared guaranteeing that, when a district demands, that RES energy is purchased to the grid. This is the case of a community that has the resources to own a windmill which are not usually located close to the city.

More info may be found within D4.15 Guidelines to calculate the annual energy balance of a PED, Section 4.1 decide the boundaries.

## 4.3 Phase III-a: Citizen Participation - Smart Energy City Approach

As explained by the Covenant of Mayors of the EU, "*all members of society have a key role in addressing the energy and climate challenge with their local authorities*". Public participation is useful to determine needs, desires and requirements and to increase transparency. Their implication is also useful to increase citizens' engagement with the environmental challenge.

Essential part in understanding the wider context of an existing urban district, identifying priorities and most urgent needs to address in designing and planning of a sustainable Positive Energy District, is to include the perspective of citizens and end users of the district itself. One of the methods to include the citizens in the process of involvement, being part of planning and prioritizing, is potentially the approach of Smart Energy Cities (Figure 16).

The lessons provided in the five steps to actively involvement citizen in the transitions are discussed in detail below.

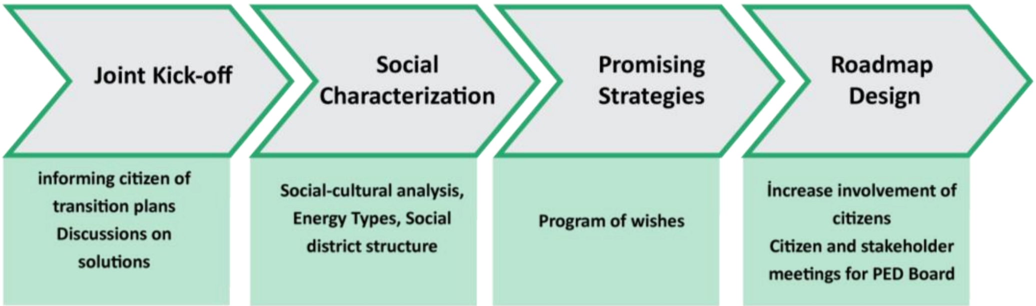



**Figure 16 Smart Energy City Approach Integration**

## 4.3.1 Step 1: Joint Kick-Off

A joint start of the transition process is required in order to create a joint ownership, broad support and participation of all stakeholders relevant to the transition. This should also include citizen.

*"Include the residents as early as possible by informing them and including them in the process"*.

By including citizen, they get the change to organize and join the process as a ***collective***. When residents are not included in the process, they might oppose the eventual outcome of the process. The transition solutions will most likely require investments by the residents. Involving residents includes, first of all, informing citizen of transition plans and second of all, including them in the deliberation process for possible solutions in the district – (a toolbox for participation with suggestions may be developed at this stage).

## 4.3.2 Step 2: Social Characterization

Step two includes the characterization of the district in order to explore the possibilities, challenges and chances of the district, both technical and social. Technically, the buildings, energy infrastructure and heath sources in the district are mapped. In addition, it is vital to map the social character of the district to be able to construct an adequate district transition approach. The social characterization entails different activities:

a) Social-cultural analysis

A social analysis of the district starts with the social data (income, education, age, etc.) which is necessary to create the appropriate approach and communication process for every group of citizens. However, these numbers alone are not enough as these do not tell anything about the level of knowledge, activity or motivation to investment of the citizen in the district. As a policy maker or project manager, it is necessary to really explore and indulge in the district in order to understand social and cultural characteristics of the district.

b) "Explore the wishes, demands and needs of citizen in the district"

Start a conversation in and with the district in order to gain insights in the attitude of citizen towards the energy transition. The SEC recommends to select a diverse group of at least 12 to 15 citizen which represent the citizens in the district. The interaction with the citizens can take place in informal settings such as the supermarket or on the street or during formally organized individual or group meetings. Explore the district as the context in which the citizens are situated. Explore their current attitude towards the district and subsequently their wishes, demands and needs for change. Determine to what extent sustainability is already part of their context and attitude. It is important to capture and secure the outcome of the conversations in order to take it into account in the preparation and implementation phase of the transition not only in energy domain but also in quality of life, spatial quality, liveability etc aspects that affect directly or indirectly energy in cities.

c) Energy Types

Divide the citizens in energy types based on the outcome of the conversations conducted in the district. Not every citizen holds the same motivation or attitude or has equal knowledge or capacities to contribute to the transition. As a result, citizens require an approach to involve them in the transition congruent to their characters. A division in energy types creates a foundation for the development of customized communication, products and services. The energy types can be elaborated into energy personas which are fictional descriptions of fictional citizens. This further increases the understanding of the social characterization of the district and enhances the communication and intervention strategies used. The energy types and energy personas answer the following questions

- What is the knowledge, attitude and behaviour towards sustainability and energy use?
- What is important in sense of housing and residential environment?
- What is the most effective strategy to reach and involve this type in the energy transition?
- What does this type need in order to act and invest in the adaptation of their residence? Knowledge, facilitation, money or something else?

d) Social district structure

It is important to know the social structure of the district in order to understand where and how to entre and start the transition in the district. A **social opportunity map of the district** outlines the social structure of the district. In the social opportunity map marks **the initiatives, pioneering residents and organisations**, **collaborations and communication networks** between the citizen and **promising locations** of the district. The social structure should be used to build on and connect the transition of the district to.

### 4.3.3 Step 3: Weighing Promising Strategies

The third step is to combine the technical and social character discovered in the previous step in order to determine promising strategies. The technical and social possibilities and requirements in the district need to be in harmony. The goal is to formulate the criteria and conditions for the design of a promising strategy to realize a sustainable district. This includes the input provided by the citizen.

e) Program of wishes

A program of wishes is based on the outcome of the social characterization in step two. The program includes the broad wishes, concerns and needs of the citizen. For example, **fundamental living conditions, public spatial planning or personal sustainability challenges.** A program of wishes provides a starting point and guide for the development of promising, efficient and effective transition strategies and approaches to engage citizen in the process. This document contains the above-mentioned information of the locals and the environment and the linkages to energy aspects.

### 4.3.4 Step 4: Design Roadmap

The next step is to design an adaptive roadmap to realize a sustainable district based on the social and technical data collected in the previous steps. According to the SEC, this roadmap includes three aligned approaches: **to increase the involvement of citizens, to realize sustainable heating in the buildings and to invest in the necessary infrastructure** (Technical solutions of PEDBoard – explained in section Phase III-b). In Phase III-b, solution catalogue (PEdBoard and Solution Index) involves all stakeholders for selecting peculiar solutions for the city by Public-Private-People Partnerships framework (detailed between in section 4.3.5). The focus in this section is on the first approach: involvement of citizens. The SEC approach includes several activities to achieve involvement of citizen.

f) Start with promising groups

In an early stage it is not yet efficient or effective to engage everyone in the district. Based on the social characterization of the district in step 2 and 3, select the groups in the district which have the knowledge, opportunity and capacity to contribute to the transition process. These are promising groups which already have plans to develop, reconstruct or renovate or which are already involved in sustainable development.

g) Make residents aware and include them

Besides actively working with the promising groups of the district, the remaining citizens should be kept informed and engaged. Keep all citizens informed of the transition plans in the district and make them aware of their position, role and the possibilities to contribute.

h) Communication and trust

In order to engage citizen and keep them engaged proper communication is required throughout the transition process. This includes communication between the stakeholders in the district and between the stakeholders and the citizen. In order to guarantee proper communication with the citizen the stakeholders in the district should:

- Collectively decide on a message to communication;
- Determine who communicates on the integrated transition process;
- Determine who communicates with whom;
- Create one main information platform for the citizens;
- Use different communication tools to reach all citizens;
- Create formal service points for the citizens;
- Organize informal citizen activities (such as sustainable festivals in the districts);
- Evaluate the response to the communication;

- Communicate on natural moments.

#### i) Ambassador

Collaborate with pioneering citizen, businesses or organizations in the district. Experience shows citizens are more eager to listen to and trust their neighbours then an organization which they believe have more or different interests. The pioneers can act as ambassador for the transition. They can share their experiences and lessons learned and increase awareness and enthusiasm in the district.

### 4.3.5 Public-Private-People Partnerships as a tool for collaboration

Alongside with citizen involvement, the objective of PEDs to integrate smart city objectives with sustainable urban transformation calls for collaborative innovation, which can be obtained in public-private-people partnerships (4P). Here, the 4P denotes collaboration between the city, energy network operators, private property developers and citizens in the context of PEDs. Innovative collaboration that is generated by the 4P can simultaneously improve everyday activities and life conditions in cities, create economic opportunities, and enable experimentation and implementation of new technologies.[37] In the 4P, cities have a crucial role as facilitators and orchestrators of this collaboration.

In the context of PEDs, cities can utilize urban planning, land use planning and urban design to initiate 4Ps. This is the case especially when PED is developed in the context of new urban areas or infill areas, where new buildings are built, and urban planning thus takes place. One potential approach is Integrative Urban Development, which considers urban design and planning as a capacity to establish social relationships that integrate the aims of the city, private actors and citizens.[38] This is remarkably a different perspective focused on the implement ability, from regarding urban planning merely as a regulative framework. The Integrative Urban Development approach takes the development aspirations of all the PED stakeholders as a starting point of development, and proactively and creatively develops them further to discover mutual gains.

In the Integrative Urban Development, the principle is to produce value for all PED stakeholders. Noteworthy is that the concept of value is subjective. For instance, the city might value generation of public good, citizens might value generation of pleasant living environment, and private developers might value economic viability. For the city, the ability to create public value can be ensured by clarifying its strategic priorities in urban development, for example via strategic urban planning. However, the priorities should be set flexibly enough, so that they allow value creation also for other interested parties, such as, citizens and private developers. The value creation can be further facilitated in the negotiations and participatory processes related to urban planning, considered as a learning process where value creation requires continuous interaction between interested parties.[39]

Two parallel phases of social and technical dimensions may be unified and merged at the end of Phase III activities from an economic point of view by involving Public-Private-People partnership (4P) as a tool. PEDs must be planned and designed not only technically but also economically and socially aligned with a participative perspective. Thus, proposed PED Methodology encourages a holistic approach by

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[37] Leminen, S., & Westerlund, M. (2015). Cities as labs. Towards collaborative innovation in cities. In P. Lappalainen, M. Markkula & H. Kune (2015). Orchestrating regional innovation ecosystems – Espoo Innovation Garden (pp. 167-175). Helsinki: Aalto University, Laurea University of Applied Sciences and Built Environment Innovations RYM Ltd.

[38] Ahlava, A., & Edelman, H. (Eds.) (2009). *UDM: Urban Design Management: a guide to good practice*. Abingdon: Taylor and Francis.

[39] Ahlava, A., & Edelman, H. (Eds.) (2009). *UDM: Urban Design Management: a guide to good practice*. Abingdon: Taylor and Francis.

integrating socio-technological dimensions with 4P tools in order to guarantee successful PED designs and implementations in cities. The relation of mentioned cross-sectoral integration is illustrated in Figure 17.

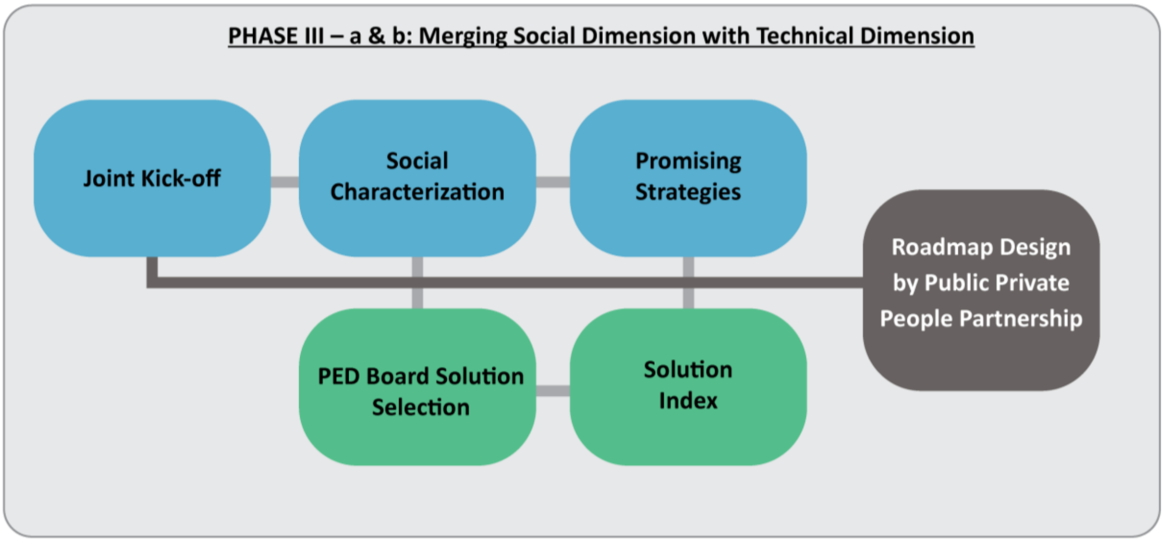


**Figure 17 Phase III-a and Phase III-b merged by 4P tools or shared vision document**

## 4.4 Phase III-b: Linking to Solution: PEDBoard

In parallel with Phase III-a Citizen Involvement, a technical study on PED technologies is realized (Figure 17 – Section 4.4.1). Within this phase, the inputs of Phase I and Phase II are evaluated by a decision-making mechanism and the particular technical and non-technical solutions are linked to the according to the data obtained from Phase I and Phase II. The solutions are classified under main solution categories of demand side, supply side and integrated infrastructures. The concept will enable the delivery of energy services, allow the management and trading of locally generated energy and grid-based energy supplies, and potentially link with other local and cloud-based services such as security/safety and e-mobility in order to progress towards energy positive districts.

Each PED solution is characterized in a solution index table (Figure 17 – Section 4.4.2), including short description, intervention scale, risk factors, benefits and initial budget information. All of the main and subcategories and index of each solution is presented on a panel, named "PEDBoard". While selecting peculiar solutions for a city, the stakeholders may go one step back and feed the PED boundary with the new results / actions. This phase is concerned with district scale and includes municipal departments, researches, technical designers and citizens.

Technical and economic aspects are braced with a social approach in order to implement the required transition innovations in a district. Citizen involvement, collaboration between stakeholders, and selection of technologies are moving on in parallel and learning activities from stakeholders to citizens and citizen to stakeholders in the local are taking place.

### 4.4.1 PEDBoard (PED Solution Catalogue)

**PEDBoard (PED Solutions)**

| | | | |
|---|---|---|---|
| DEMAND SIDE SOLUTIONS | **Category 1: LOW ENERGY DEMAND** Technologies for reducing the energy demand -passive measures or building insulations *Building/District Level* | Solution 0.1 District level strategies according to local environmental conditions | S0.1a Wind strategies |
| | | | S0.1b Solar orientation strategies |
| | | | S0.1c Water resources strategies |
| | | | S0.1d Ground coupling strategies |
| | | Solution 0.2 Climate change adapt. District Strategies | S0.2a Cooling of surfaces |
| | | | S0.2b Evaporative cooling |
| | | Solution 0.3 Mobility (emissions) | S0.3a Foster clean mobility |
| | | Solution 1 Building Envelope Retrofitting in Residential b. | S1a Residential Building (High Rise) retrofitting |
| | | | S1b Residential Building (Private House) retrofitting |
| | | Solution 2 New High-perfor. residential b. | S2a New High-Performance Building (residential) |
| | | Solution 3 Building Envelope Retrofit. Tertiary b. | S3a Retrofitting of the office building |
| | | Solution 4 New high performance tertiary buildings | **S4a New High Performance Building (Shopping Mall)** |
| | | | S4b New High Performance Building (Academy Building) |
| | | | S4c New High Performance Building (Sport Complex) |
| | **Category 2: ENERGY MANAGEMENT** all interventions related to monitoring, control, smart readiness, (Improve Energy Efficiency) *Building/District Level* | Solution 5 Smart Building / Home energy controllers | S5a Smart Control / Advanced Metering / Wireless Advanced Control in Buildings |
| | | | S5b Visualization Units to study human behavior regarding the energy consumption |
| | | | S5c Energy Management Agent for energy optimization and demand response /Smart Grid |
| | | | S5d Heat Matcher |
| | | Solution 6 IoT Monitoring | S6a Smart Lighting, power LED |
| | | | S6b LoRa (Long Range) wireless network and activity sensors to optimize the lighting level |
| | | | S6c Energy data monitoring of PED |
| | | | S6d Integration of new services to the data platform |
| | | | S6e Installation of IoT infra |
| | | Solution 7 ICT Urban Platform | S7a Open Urban Platform adaptation |
| | | Solution 8 High Speed data transfer network | S8a High Speed data transfer network |
| | | Solution 20 e-car Parking & Charging | S20a E-car charging points |
| | | | S20b: Connection of the Stations to the local Demand response system |
| SYSTEM INTEGRATION | **Category 3: INTEGRATED INFRSTRUCTURES** Storage as energy exchange facilitator, pipelines & heat exchangers... etc | Solution 9 Power storage | S9a Neighbourhood electro storage facility (power storage) |
| | | Solution 10 Thermal Storage | S10a Phase transfer Liquid tank |
| | | | S10b Seasonal storage |
| | | | S10c Thermal Storage |
| | | Solution 11 District Heating & Cooling Facilities | S11a Low Temp regional transfer pipeline |
| | | | S11b Adjust geothermal district heating for using low temperature |
| | | | S11c Connection to the low temperature district heat |
| | | Solution 12 Building energy connectivity for energy sharing | S12a Building energy connectivity for energy sharing |
| | | Solution 13 Heat Pumps | S13a CO2 based heat pump |
| | | | S13b Advanced Heat Pump (high COP) |
| | | | S13c Acoustic Air Heat Pump |
| | | | S13d Acoustic Hybrid heat pump |
| | | | S13e Geothermal Heat Pump |
| SUPPLY SIDE SOLUTIONS | **Category 4: RENEWABLE ENERGY SYSTEMS ALTERNATIVE URBAN ENERGY SOURCES** *Building/District Level* | Solution 14 Solar PV Panels | S14a PV in roofs and parking lot |
| | | | S14b Building Integrated PV (on the façade) |
| | | | S14c Floating Solar pontoons |
| | | | S14d Solaroad |
| | | Solution 15 Solar Thermal Panels | S15a Hybrid Heat collector (high preassurised CO2) |
| | | | S15b PVT Panels |
| | | Solution 16 Geothermal energy | S16a Geothermal energy |
| | | Solution 17 Waste Heat Recovery | S17a Heat recovery system from AC and sewage water |
| | | | S17b Heat recovery system from return pipeline to DHW |
| | | Solution 19 Wind turbine | S19a RES from Wind turbines |
| NON-TECHNICAL SOLUTIONS | **Category 5: POLITICAL, SOCIAL, ECONOMICAL INTERVENTIONS** | Solution 18 Policy Innovation | S18a Integrated Sustainable Energy Planning |
| | | | S18b Land use planning fostering energy actions |

## 4.5 Phase IV: Barriers / Enablers of PED Solutions

In this phase, impact-based evaluation is integrated in selection of solutions process and political, economic, social, technical, environmental, legal and spatial barriers, constraints, supporting factors are recognized for each selected solution. A brainstorming on how to overcome the barriers is encouraged and if the results are negative to continue to the next phase, Feedback loop (a system for improving a product, process, etc. by collecting and reacting to users' comments) mechanism starts to find another particular solution for the PED area. The discussion is expected to be developed by an open dialogue and consensus between technical designers, citizens and local authorities. In this report, barriers/enablers analyses are performed and the matrix is filled by FWCs and their support partners to figure out political, economic, social, technical, environmental, legal and spatial aspects in other geographies in EU. Unexperienced cities are encouraged to provide their concerns, thoughts and advantages on solutions of LHC that are being implemented in MAKING-CITY lifetime. Barriers/Enablers matrix may be reviewed in ANNEX I BARRIERS / ENABLERS OF THE SOLUTIONS by FWCs.

## 4.6 Phase V: Calculation

As explained in Section the basis for the energy calculation in MAKING-CITY PEDs is the Primary Energy Balance (annual base). If this average value is positive our district will be a PED, if not our district will only be nearly zero, not positive.

A very detailed procedure for PEDs calculation is included in the deliverable D4.2 "Guidelines to calculate the annual energy balance PED", nevertheless a calculation of the PED will be evaluated in this phase for the verification of surplus in annual energy balance. If the PED calculation is not surplus regarding energy demand, energy use, energy distributed and primary energy balance, new selections from PEDBoard must be assessed in order to provide PED.

## 4.7 Phase VI: SPECs

This Phase presents the detail cards of each solution categorised in PEDBoard. The solution cards, named SPECs, involve general data, technical and graphical details, implementation time, initial investment and financial models, stakeholder mapping, integration with other smart solutions, potential for replication, expected impacts of all of the solutions. This is the main output of proposed PED Methodology, guiding cities with a detailed information on the technical and non-technical issues of solutions presented in PEDBoard (Section 4.4.1)

The cards may be reviewed in ANNEX II SPEC CARDS of SOLUTIONS.

# 5 Citizen Engagement Strategies / Smart Energy City Approach in Netherlands

**Citizen engagement in prioritizing city needs / characteristics**

Essential part in understanding the wider context of an existing urban district, identifying priorities and most urgent needs to address in designing and planning of a sustainable Positive Energy District, is to include the perspective of citizens and end users of the district itself. One of the methods to include the citizens in the process of involvement, being part of planning and prioritizing, is potentially the approach of Smart Energy Cities. The Smart Energy City (SEC) approach Figure 18 is the result of a private-public collaboration between the ministries of economic affairs, interior affairs, the national grid operators, the TKI Urban Energy and the TKI ClickNL.

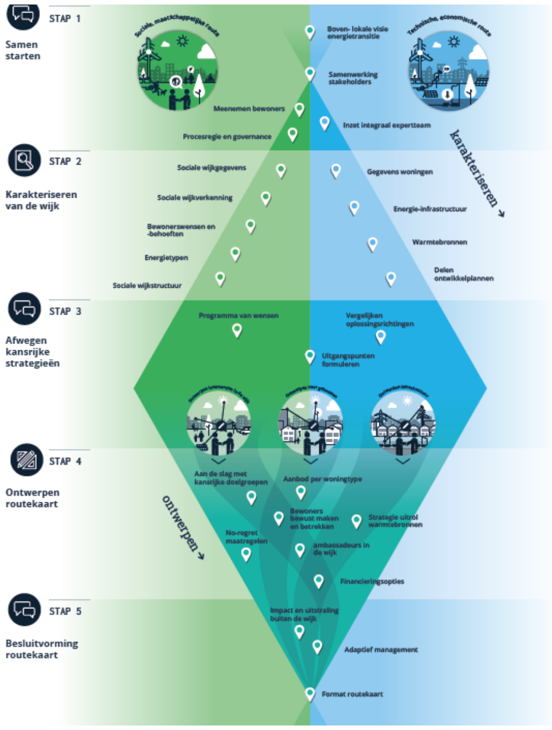


**Figure 18 llustration of SEC Approach in Netherlands**

These parties collaborated in order to develop a national-wide applicable approach to facilitate the energy transition of districts in the Netherlands. The approach is the synthesis of the lessons learned in 16 case studies in which municipalities, grid operators, residents and other local organizations collaborated in a district transition approach. SEC offers an integrative model (Figure 19) with a congruent approach to shape and accelerate the transition process in districts with a sustainability ambition. Technical and economic aspects are braced with a social approach in order to implement the required transition innovations in a district. In the model the converging and diverging blue and green tracks visualize the transition process. The **blue track** outlines the **technical-economic** transition process and the **green track** outlines the accompanying **social transition** process.

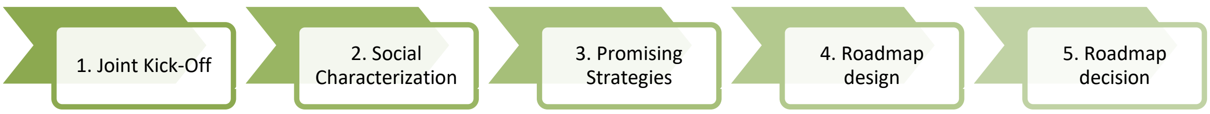


**Figure 19 Smart Energy City Approach**

The two tracks develop individually however simultaneous and aligned. Both the blue and the green track follow the same five process steps:

1. **Step 1:** A joint kick-off
2. **Step 2:** Characterize the district
    - 2.1 Social characterization
    - 2.2 Technical and economic characterization

3. **Step 3:** Weighing promising strategies
4. **Step 4:** Design a roadmap
5. **Step 5:** Decide on a roadmap

These five steps contain multiple technical (blue) and social (green) transition activities which are deemed essential in the transition of a district. As of the last two steps the social and technical tracks converge and are increasingly integrating into the roadmap. After fulfilling the five steps of the SEC approach, a district is able to formulate an adaptive and integrated transition roadmap for the following (depends on the city characteristics) years. In general, a roadmap includes specific technical solutions for the constructions in the district, specific steps for the development of the energy system, an integrated intervention and communication strategy and a concrete investment program for the first period (1 -2 years).

The SEC approach also includes specific guidance on the involvement of citizen. The involvement of citizen is part of the green, social track of the SEC approach. In order to use sustainable energy sources in the district; the houses of the residents, both house-owners and renters, require adaptation. The activities within the five steps of the approach which are relevant for the active involvement of citizens are outlined in the Figure 19.

Though citizen engagement has its place in the SEC approach it is not described in great detail and the means and tools available for citizen engagement are limited. When designing a citizen engagement strategy, it is important to use the perspective of the citizen; what are the steps that the user is going through? And what are his/her experiences? In order to focus on the users' perspective, the customer journey method could be used. The customer journey describes all the steps a user is going through from the perspective of the user. Figure 20 shows the steps a Dutch user is going through in order to make his home fossil free (Tigchelaar et al., 2019). The steps will be briefly described:

**Step 1 –** Awareness of fossil free at a national level: the user has to become aware of the plans of the government to make all homes fossil free by 2050. Users will hear about it from (social) media or other sources.

**Step 2 -** "tam-tam" phase: in this step people will form their opinion about fossil free living via different sources like (social) media and their network. The information that they get can be incomplete or incorrect.

**Step 3 –** awareness of personal situation: at a certain moment it will become clear which solutions will be chosen by the municipality for a certain neighbourhood. This will provide users with somewhat more information about what fossil free living will mean for their own situation.

**Step 4 –** choice for orientating, waiting or resistance: at this point in the journey people will consciously or subconsciously make a decision to start orienting for specific solutions in their house, to wait or to actively resist fossil free living.

**Step 5 –** Orienting: users will look for information to the channels that are at their disposal. They will go to the next phase once they think they are well informed or they have use a specific decision aid (e.g., what choices have others made or what is advised by an expert).

**Step 6 –** choice for a specific solution: users will choose the solution that they find most attractive.

**Step 7 –** living in a house that is being renovated: users might experience disturbance when their house is being renovated.

**Step 8 –** living in a (partly) fossil free house: users live is a house where the renovation operations have been (temporarily) finished. They experience fossil fee living.

**Step 9 –** being an ambassador: users will share their positive or negative experiences about the process they have gone through. This is important information for other people in their social network. The CODEC model, described in 2.3.3. underlies many of these steps in the journey.

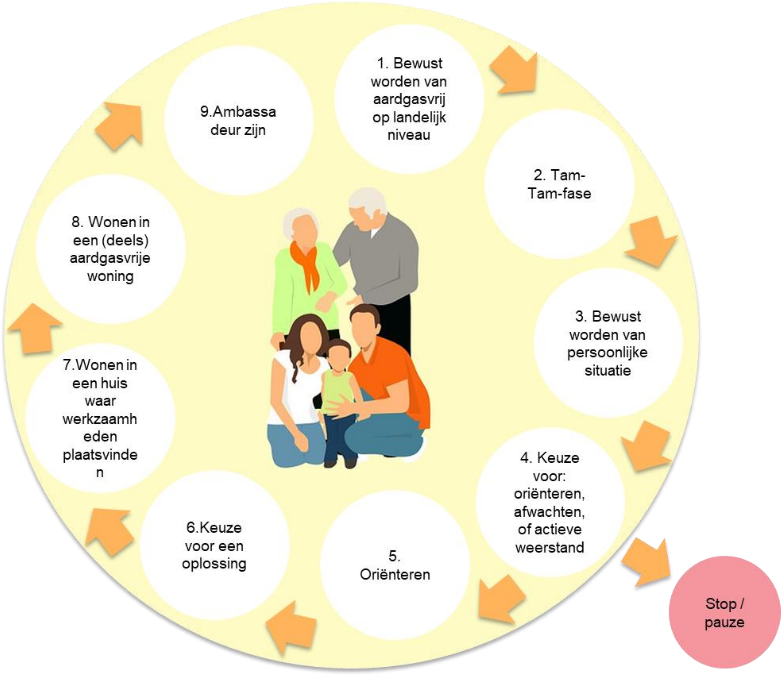


**Figure 20: Fossil free living: customer journey**

Other approaches such as those followed by the municipality of Groningen and Grunnuger Power put (slightly) more emphasis on a more rigorous inventory of the social structure of a neighbourhood and the role of citizen collectives in realizing energy transition means. In short, they put citizens and citizen collectives even more central the vision formulation, decision and implementation/adoption process.

# 6 Innovative Business Models for PEDs / Relevant Stakeholders

## 6.1 Methodology for defining business models for PEDs

The design of a new business model has as its final purpose the creation of business models that:

- satisfy market needs that have not been met yet
- introduce new technologies, new products or new services
- improve / disrupt / transform existing markets
- create new markets (see Blue Ocean Strategy)

To help the MAKING-CITY partners develop their business models, this method provides support on 3 levels: (Chapter 2,3,4,5 are detailed in Annex III - Business model guidelines for PEDs)

- Business model guidance - Business model canvas and its 9 blocks - *chapter 2*
- Listing business model patterns (identified by the inteGRIDy project) - *chapter 3*
- Example of business model for PEDs - *chapter 4*
    - Description of the common business model for PEDs based on literature review
    - Tag each business model for PEDs with the business model patterns
- Tag each MAKING-CITY Spec Card with the common patterns - *chapter 5*

This will allow easy cross analysis while providing exhaustive and open information (figure 1):

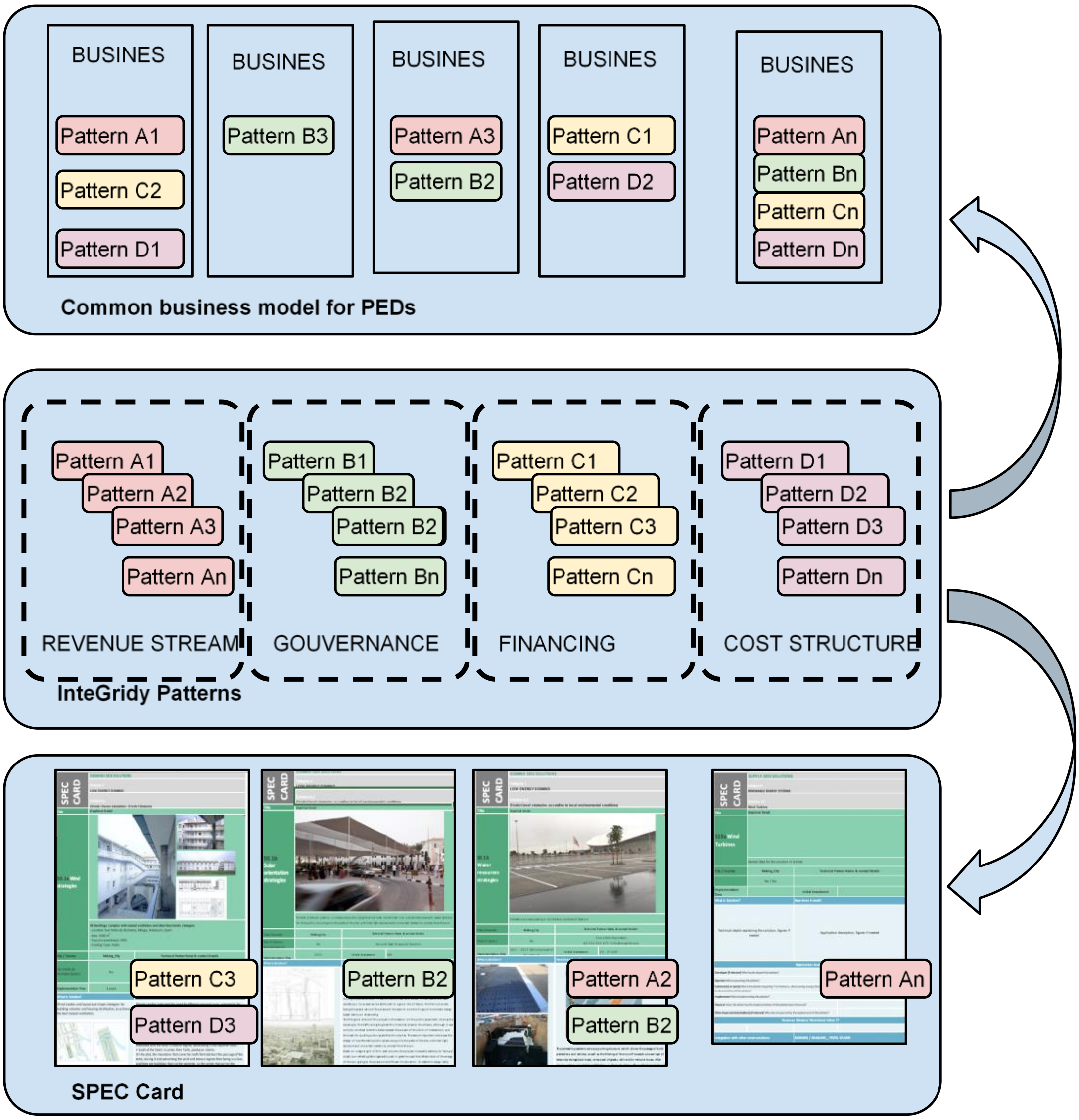


**Figure 21 Scheme for Methodology for defining business models**

## 6.2 Identification of Stakeholders

A specific stakeholder mapping for PEDs has been developed in the project deliverable D6.1 "Ecosystem Analysis for Positive Energy Districts". It is represented on **Figure 22** and further described here after.

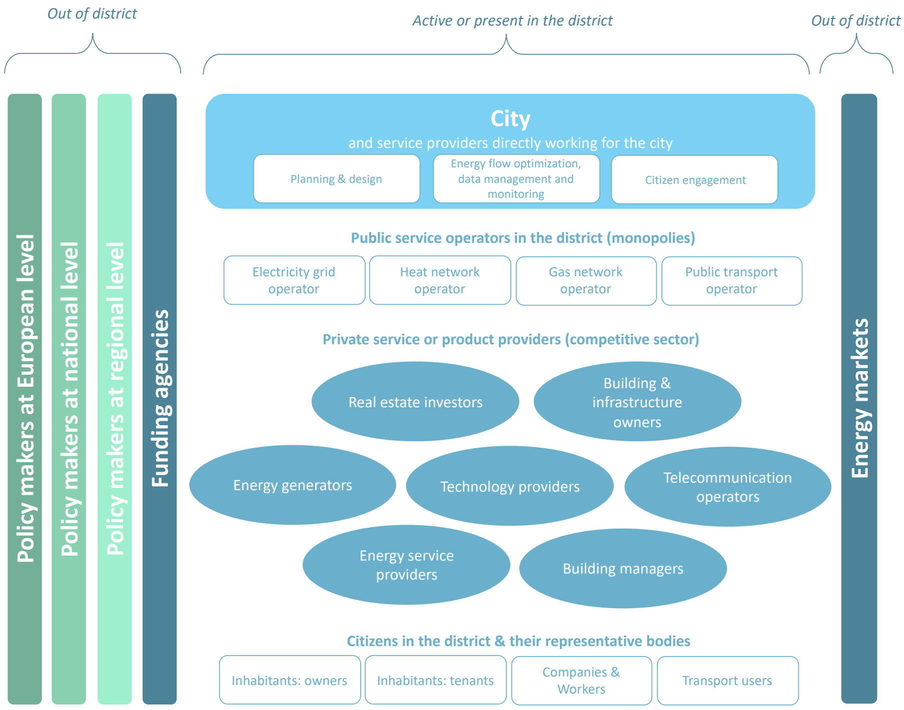


**Figure 22. Stakeholder mapping in PEDs**

This representation is made of four layers regarding the stakeholders active or present in the district, plus some stakeholders not necessarily present or active within the district's boundaries:

- Stakeholders active or present in the district:
  - Layer 1: The City itself is represented at the top of the mapping, as the main body in decision-making and implementation processes of PEDs. The City performs, in general in cooperation with contractors:
    - The planning and the design of PEDs,
    - The optimisation and monitoring of energy flows, and corresponding data management,
    - Citizen and other stakeholder engagement actions.
  - Layer 2: Public service operators are key players in PEDs. Not necessarily all of them are involved: their participation depends on the technological choices and available energy sources within the PED:
    - *Electricity grid operator:* The electrification of many energy usages, the hosting of distributed electricity generation capacities and the growing involvement of consumers in power markets make the electricity grid operator a pivotal player in the design and implementation of PEDs.
    - *Heat network operator:* If heat network exists in the district, or if there is a potential for such network, then the heat network operator is likely to be a central player in the PED design and implementation.

    - *Gas network operator:* If gas network exists in the district, then the gas network operator might be involved in the PED design and implementation. Existing gas networks have more and more available capacity, freed up by the decrease in conventional gas consumption. These networks are likely to take a growing role in energy transition projects by hosting and distributing gas from renewable sources (syngas, biogas or hydrogen).
    - *Public transport operator:* Since the transport sector represents a major share in energy consumption, the public transport operator(s) active in the district is likely to be involved in the PED design and implementation.
- Layer 3: The following service or product providers, in general from the private sector, have a strong role in PEDs:
    - *Real estate investors:* Especially for new districts, but also possibly in existing districts, real estate investors have a crucial role to play in the implementation of a PED. They will often bear extra costs at the development stage of the buildings, in order to implement energy-efficient technologies contributing to the positive energy balance of the district, for which they would be paid back during the exploitation phase of the buildings.
    - *Building and infrastructure owners:* Similarly, with a stronger focus on existing districts in which they would retrofit the buildings or infrastructures they are owners of, they would make energy choices and bear the corresponding costs during the renovation phase.
    - *Building and infrastructure managers:* This role may be played by the same entity owning the building or infrastructure, but it can also be played by a different entity. Building and infrastructure managers are those who are exploiting and operating the energy-efficient technologies implemented at their premises.
    - *Energy service providers:* They are in general providing energy from outside the district's boundaries and have customers inside. Therefore, the implementation of PEDs might have a negative impact on them, since they will be selling less energy to their customers. They have therefore a strong interest to diversify the services they are offering and to find new business models related to the development of PEDs.
    - *Energy generators:* This role may be played by entities playing other roles in the district such as the inhabitants or the building managers, or it may be played by specific entities. Anyway, this role is crucial since the positive energy balance of the district depends on the energy generation which can be done within its boundaries.
    - *Technology providers:* This category includes the providers of different technologies which can be installed at building or district level, such as energy generation, conversion and storage technologies (heat pumps, batteries, BIPV, etc.).

        - *Telecommunication operators:* They might be involved in the concept of Positive Energy Districts especially regarding the IT infrastructure necessary to implement energy data exchanges.

    - Layer 4: Citizens, either individually or through representative bodies, are players in the PED, being them active or passive:

        - *Inhabitants / owners:* Inhabitants are energy consumers, and may be energy producers (for instance, if their house is equipped with solar panels). Especially when they are owning their house or apartment, they are the ones choosing the energy technologies to implement in the case of a renovation for instance. When buying an apartment or a house, they also consider the energy performance of the dwelling. Furthermore, depending on cultural aspects, they are more or less involved in the district-related decisions.

        - *Inhabitants / tenants:* Even though not owning the dwellings they are living in, tenants are concerned by energy technologies since they are in general paying the energy bills. They may be keen paying more for the dwelling if it is energy efficient.

        - *Companies and workers:* A district include in general not only inhabitants but also businesses (like shops or offices) involving workers. Workers might not be interested in energy bills, but certainly appreciate a comfortable working space. Companies are interested in energy bills and are increasingly interested in actions enhancing their reputation regarding climate issues.

        - *Transport users:* They might also be impacted by the development of PEDs. For instance, development of e-mobility might be incentivised in order to use the excess energy generated by the buildings in the district and/or to provide flexibility services when charging.

- Stakeholders not necessarily present in the district:

    - *Policy makers at European, national and regional levels:* Those policy makers, above the level of the city, might be involved in regulatory or economic incentives for PEDs.

    - *Funding agencies:* They might be involved in finance services for the development of PEDs.

    - *Energy market:* By definition, the PED delivers surpluses of energy (in general in the form of electricity, and possibly in the form of gas or heat). These energy surpluses have to be sold to consumers or to resellers, out of the district's boundaries. This can be done through organised markets (for instance power exchanges) or through bilateral contracts with specific stakeholders.

## 6.3 Experience feedback from Lighthouse cities

Detailed stakeholder mapping in Groningen and Oulu has been conducted in the deliverable D6.1 "Ecosystem Analysis for Positive Energy Districts". In this framework, Groningen's and Oulu's stakeholders have been interviewed by phone. The list of interviewees is presented in Table 6.

LIST OF INTERVIEWEES IN LIGHTHOUSE CITIES

| Partners | Role in the project | Persons interviewed | Date of the interview |
|---|---|---|---|
| Partners in Groningen | | | |
| 3-GRO | Municipal regulatory authority | Jasper Tonen | 20/08/2019 |
| 3a-WAR | Heat network operator | Joep de Boer | 13/06/209 |
| 4-TNO | Support to PEDs' planning and design, citizen engagement activities, optimisation of heat consumption and production at building level | Joram Nauta, Marc Hamburg | 20/08/2019 |
| 5-GPO | Community-owned energy cooperative, in charge of citizen engagement actions | Joep Broekhuis | 19/06/2019 |
| 6-SEV | Responsible of the workstream "Business Models and Financing" | Mark de la Vieter | 17/06/2019 |
| 7-WAM | Owner of part of the real estate in the MAKING-CITY project | Bart Jager | 08/07/2019 |
| 8-NIJ | Housing corporation in the city of Groningen | Han Folkerts, Henrik Prosman | 21/08/2019 |
| 9-CGI | Provision of energy platform | Gerard van de Kamp | 26/06/2019 |
| 10-SB | Provision of monitoring technologies and services | Tuan Anh Nguyen | 26/06/2019 |
| 12- HUAS | New approaches and inclusive business models | Rob Roggema, Cyril Tjahja | 21/06/2019 |
| Partners in Oulu | | | |
| 13-OUK | Municipal regulatory authority | Samuli Rinne | 08/07/2019 |
| 14-UOU | Long-term urban planning methodology fostering PED replication and stakeholder salience analysis | Sari Hirvonen-Kantola | 17/06/2019 |
| 15-OEN | Leading energy company, in charge of district heating network in Oulu | Reijo Pantsar, Mikko Ojala | 20/06/2019 |
| 16-SIV | Housing company owned by the municipality of Oulu | Heikki Pohjola, Raimo Hätälä, Kari Puotiniemi | 27/06/2019 |
| 17-YIT | Construction company building two new private houses in Kaukovainio | Kristina Vähäkuopus | 09/08/2019 |

**Table 6: List of Groningen and Oulu partners interviewed**

Some analytics have been calculated based on the mapping (Section 6.2.1); prominent elements from a replication perspective have been identified for Groningen (Section 6.2.2) and Oulu (Section 6.2.3).

### 6.3.1 Analytics about the type of actions conducted

Within the project's Lighthouse cities, Groningen and Oulu, a series of actions are implemented in order to create the PEDs. Those actions range from technical actions (implementation of energy technologies such as photovoltaics, district heating, energy storage, etc.) to non-technical actions (policy innovation, citizen social research, capacity building, etc.).

An analytic study of the distribution of actions among the partners in Groningen and Oulu shows that the proportion of non-technical actions is significant to structure the project, as illustrated by Figure 23

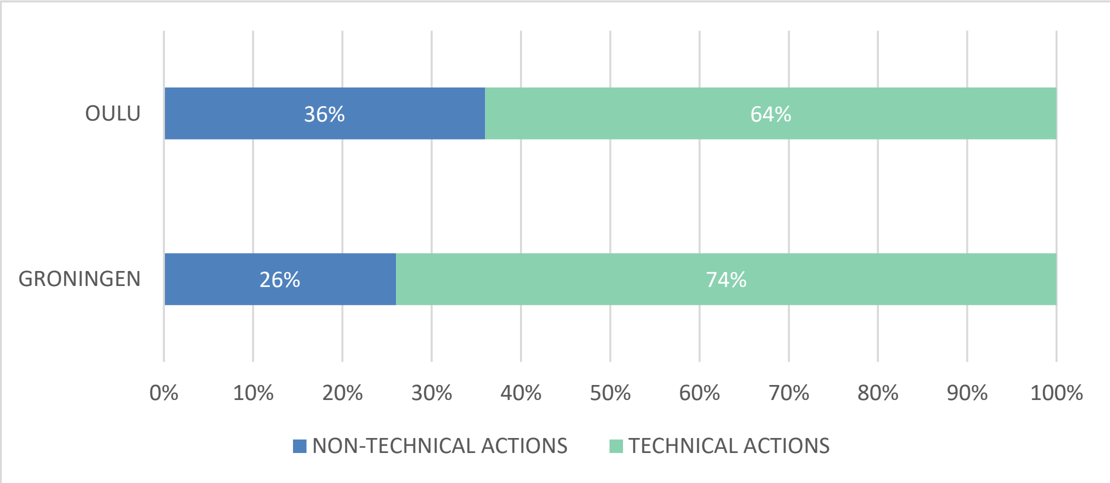


**Figure 23. Distribution of technical and non-technical actions for PED implementation in Oulu and Groningen**

In Groningen, the design and implementation of two PEDs simultaneously result in a lower proportion of non-technical actions than in Oulu (where only one PED is implemented). Furthermore, some savings are made because some actions (including technical actions) are conducted jointly for the PED North (N) and the PED South-East (SE), such as the deployment of smart charging stations for electric vehicles in both PEDs.

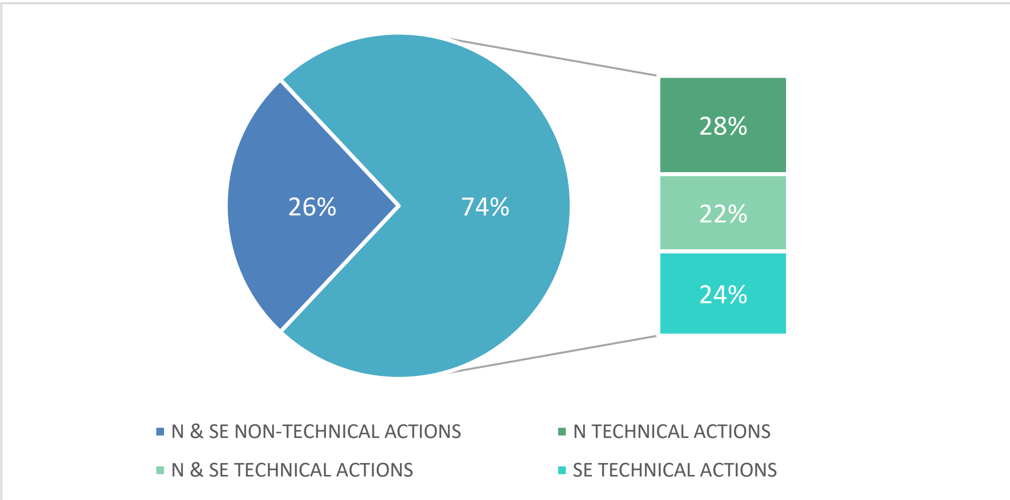


**Figure 24. Distribution of actions by type in GRONINGEN PEDs North and South-East**

A comparison of Groningen and Oulu Municipalities' involvement in the project shows that the City council of Groningen has proportionally more technical actions than the City council of Oulu (see Figure 25 and Figure 26). Indeed, the City council of Groningen owns one of the buildings built in the PED South-East (Sport Complex Europahal), in which several technical actions are conducted. The Municipality of Groningen also leads the implementation of RES technologies in public spaces (SolaRoad, Solar Pontoons, etc.). In terms of technical actions, the Municipality of Oulu focuses mainly on public lighting.

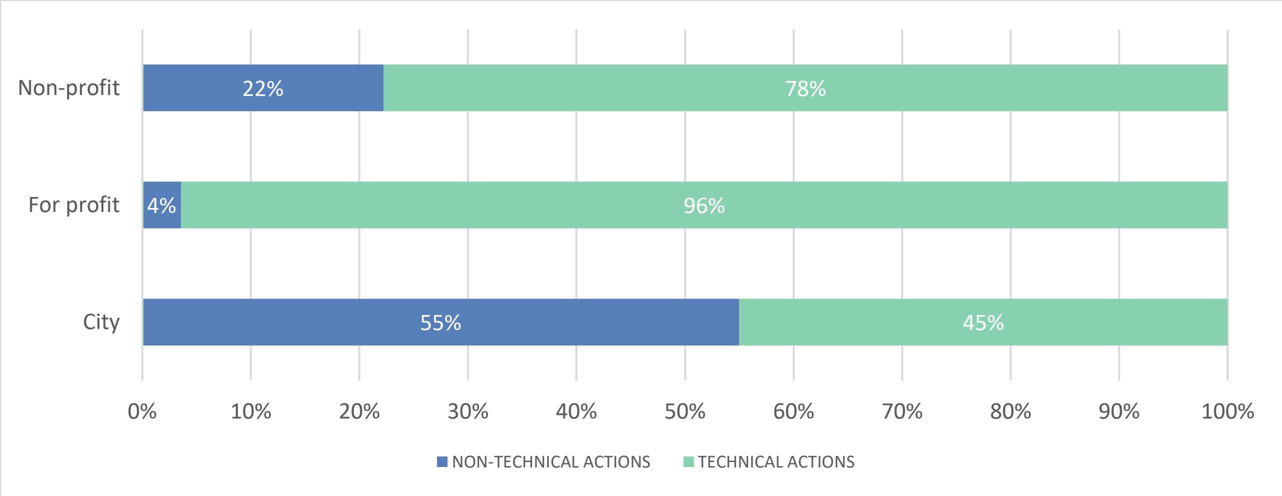


**Figure 25. Distribution of technical and non-technical actions by type of leading stakeholders in Groningen PEDs**

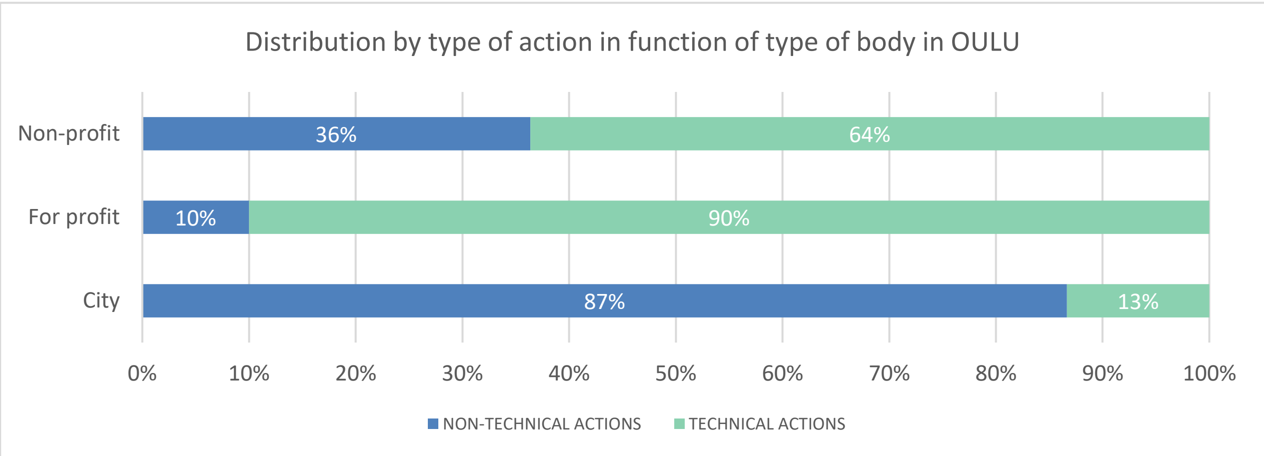


**Figure 26. Distribution of technical and non-technical actions by type of leading stakeholders in Oulu PED**

## 6.3.2 Prominent elements from stakeholder mapping in Groningen

### 6.3.2.1 Context

Groningen was chosen as one of the two Lighthouse cities involved in MAKING-CITY due to its current urban energy transformation strategy. In the Netherlands, natural gas remained for decades the main energy source to respond to the national energy demand. However, reiterated earthquakes caused by the gas exploitation activities seriously damaged houses and revealed a need for sustainable alternatives. In Groningen almost every citizen wants to stop using 'Groningen' gas that is extracted from the nearby gas fields and is causing local earthquakes.

### 6.3.2.2 The City council has set clear goals and KPIs

Targeted goal of Groningen is **clearly identified and quantified**: it is to become $CO_2$-neutral by 2035 and to reduce the use of natural gas. Those goals can be monitored to follow the success of the PED project.

The Municipality of Groningen has already implemented strong policies in favour of the energy transition. For instance, they have set as Energy-Efficiency standards as a strict obligation for obtaining building permits for new buildings. The City council has also decided to build a very ambitious energy performing building, the Sport Complex Europahal, which has involved different departments at City level playing various functional roles, for instance about permits, design requirements, greenery, real estate (since the building is owned by the City), etc.

#### 6.3.2.3 Project team has a dynamic organization

The following features appear to be crucial success factors for the project in Groningen:

- **Scheduled meetings:** On a scheduled basis the Municipality staff meets with the partners to discuss the progress in the project.
- **Flexibility in the actions to reach the objectives**: When it happens that some actions are no longer feasible, the project team talks about suitable alternatives.
- **Market-oriented:** The actions selected have to be profitable. For example, Action 31a consisted in implementing a high-pressure waste-water digester, to collect and digest waste from toilets and canteen. Eventually, it is being redesigned since it would need to change the collection system in the buildings, which is too much efforts and spending and not worth it given the modest contribution of this action to the City objectives. Therefore, only waste from canteens would be collected.
- **Impact on the inhabitants' life:** This PED project enhances the link with the citizens. Citizens are the most important stakeholders targeted by the City. On one hand, the inhabitants are involved in the decision-making, so the City council better understands their needs and wishes. On the other hand, to be able to reach the $CO_2$ neutrality by 2035, the City council has to put more constraints one the citizens' life. In Groningen, the loss of connecting to a heat grid is that customers can no longer choose the energy company for their heating solution whereas in the common situation with natural gas they can.

#### 6.3.2.4 The project is supported by facilitators

In Groningen's PED project, several partners are acting has facilitators.

A facilitator[40] is someone who engages in facilitation—any activity that makes a social process easy or easier. A facilitator often helps a group of people to understand their common objectives and assists them to plan how to achieve these objectives; in doing so, the facilitator remains "neutral", meaning he/she does not take a particular position in the discussion. Some facilitator tools will try to assist the group in achieving a consensus on any disagreements that pre-exist or emerge in the meeting so that it has a strong basis for future action.

Those partners bring their own experience, network and energy needed to reach the City's goals:

- TNO has been supporting the City from the design phase of the project to its implementation. Furthermore, TNO supports **citizen engagement** activities thanks to a participation tool for social innovation. It facilitates citizen engagement, participation and formulation and adoption of sustainable solutions (e.g. by individual citizens and local initiatives) and seeks **alignment with all public and private partners** active in the project to realize community benefits, leading to a sustainable eco-system in collaborations, solutions/value(s), investments and costs. TNO has also developed a Urban Financial Model (UFM) intending to support policy makers and private

[40] Definition of facilitator – source wikipedia

partners in aligning their activities within a neighborhood an seek for **mutual benefits**, thanks to quantitative insight in cash flows.

- Grunneger Power (GPO) is a non-profit organization launched 7 years ago. The cooperation of GPO represents all citizens of Groningen. Currently GPO has more than 2,000 members. GPO started with advising citizens in having rooftop solar panels, who united into a small clean energy company to which people could buy 100% sustainable energy. It then grew based on rewards to members inviting new members to join. Benefits are invested into new local green energy projects for the benefit of the quality of life in the neighbourhoods and of the circular economy. Within MAKING-CITY, GPO is mainly in charge of **citizen engagement** activities, to **empower the people in Groningen** to be in charge of their own energy future. GPO is working hand in hand with the Municipality.

- Stichting Energy Valley (SEV) is supporting the Groningen ecosystem in a transversal manner. Actions in Groningen have been grouped into workstreams; SEV will be responsible of the first workstream, namely "Business Models and Financing". This includes early replication, business concepts, **citizen engagement**, optimizing business models & **acceptability by all stakeholders**, etc.; in short, it is linked with the in-between work needed to come up with replication plans. SEV is also involved in actions involving local dissemination, communication and **capacity building**.

- Hanze University of Applied Sciences (HUAS) is focusing on how innovation is handled in the neighbourhood. HUAS investigates **how people respond to take those measures in their direct environment.** HUAS implements **co-creation & co-ownership** approaches, **social acceptance**, inhabitants' behaviour. HUAS contributes to the "Business Models and Financing' workstream.

#### 6.3.2.5 Data monitoring is conducted

The MAKING-CITY project is developing a procedure for modelling the energy demand side. Data collected from PEDs will be aggregated for monitoring and data analysis. Data monitoring and data management is a very important topic because it allows the project team to be informed to choose the most suitable technical solutions. Three main actors are working on it at different scale:

- Within the project, CGI Nederland **collects the data, process it and enable others to use** it. To be able to do so, they use their Urban Data Platform.

- Sustainable Building (SB) is responsible for collecting the consumption and production data. Based on the data needed, SB will specify the most **suitable hardware solutions (meters, sensors)** and will select hardware providers. SB will ensure the hardware devices installed provide the required data, all in the same way. SB provides the software tool to collect the data, and performs, to some extent, data analysis.

- The municipality of Groningen is connected to the Civity Data platform which is a widely used **open data platform in the Netherlands**. The most important goal of this platform is to share and use the potential of (open) data by governmental, commercial and knowledge institutes.

#### 6.3.2.6 The City council has strong link with energy infrastructures

The City of Groningen has a special role in relation to the heat grids. Some years ago, the City and the local water company founded the company WarmteStad, from which both parties have a 50 percent share. WarmteStad is the local heat grid operator and owns the system that is connected to the Sport Complex and other buildings in the PED South-East. Also, the heat grid in the PED North will be owned by WarmteStad.

#### 6.3.2.7 Technologies are chosen in a flexible way

The choice of technology providers is a key aspect of the project. Some of the technologies were listed at first. But as the City council is flexible some of them might change to reach a better cost and energy efficiency.

### 6.3.3 Mapping in Oulu

#### 6.3.3.1 Context

Oulu was chosen as one of the two Lighthouse cities involved in MAKING-CITY due to its current urban energy transformation strategy. Today, Oulu is one of the fastest growing regions within European high North. The population of Oulu is one of the youngest in Europe with an average age of about 38 years. Every third resident has a university degree. According to a EU's study from 2015, inhabitants of Oulu are the most satisfied with their **quality of life** in the whole Nordic region. It is also considered as one of Europe's "**living labs**", where residents experiment with new technology (such as NFC tags and ubi-screens) at a community-wide scale.

The strong expertise in ICT has created a unique base for innovations and new business in Oulu. During 2014-16 over **500 start-ups started operating**, and the amount of rented offices has over doubled within the last years. In recent years, the business activities of many enterprises have been made difficult by the long global recession. In addition, Oulu has suffered from high unemployment rates, especially among the young. In 2016, however, unemployment levels began to fall.

In the Kaukovainio PED area the housing stock is old and outdated (no lifts in many of the residential buildings for example), so new buildings are needed.

#### 6.3.3.2 The City council has set clear goals and KPIs

The City council of Oulu adopted in 2012 the Sustainable Energy and Climate Action Plan (SECAP) targeting a 20% reduction of Oulu's carbon gas emissions by 2020. Actions such as improving public water management, increasing renewables as energy sources, or developing biogas plants, are expected to achieve this objective. More recently, the 2018 "Light of the North" strategy was adopted, reinforcing the willingness of the city to act for sustainable urban energy transformation.

#### 6.3.3.3 The project is supported by facilitators

To enable the replication and scale-up of the Positive Energy Blocks and Districts, the University of Oulu (UOULU) works on the alignment of the urban plans with the energy strategies and ecosystemic business models, and proposes a Simple Rules toolkit regarding the urban planning activities.

UOULU will also conduct a stakeholder salience analysis, where governmental actors, public organisations, companies and other related associations are surveyed and categorized depending on the **stakeholders' ability and interest in influencing the project**. The end goal is to have a clear understanding of who the stakeholders are, what their stake is, what their influence will be and how likely they are to use their influence.

UOULU has already identified following difficulties that Cities are likely to experience before, during and after the implementation of a PED:

- Before: the integration of all the stakeholders needed to develop and implement the PED,
- Before: finance of the investments on infrastructure,
- During: place branding, to create the prerequisites for the building project to get going,

- After: leadership for the scale up and replication of PEDs.

#### 6.3.3.4 Data monitoring is conducted

VTT has tailored the Oulu ICT Platform infrastructure to high-performance buildings in the PED area, and it will be used for real-time energy monitoring and management services. UOULU will use smart home data-based feedback platform to pilots and assess the impacts of environmental and social awareness on energy consumption.

#### 6.3.3.5 Impact on the value of the district is created

Real estate investors have difficulties to explain new services' gains for future buyers. When they build apartments, it is difficult for them to price new apartments to be sold. Being in PED, it should be easier, thanks to branding of Kaukovainio (the city tries to help the area to have a positive image). They will get new opportunities to brand their premises.

Also, in Kaukovainio PED's case one of the gains can be the knowledge of being a part of the more energy-efficient future. Still, this is not enough to justify higher prices for the apartments. At the moment, quite low prices are proposed in Kaukovainio in order to attract customers to this area in which no new buildings have been built for years. More buildings should be built soon in the area; prices might then go up.

### 6.3.4 Conclusions

Oulu and Groningen develop their PEDs with clear goals and flexible ways to reach them. The selection of technologies is made according to the calculation of annual energy balance. As the Municipalities constantly reassess the relevance of the different technologies, and take into account the various legal, economic or technical constraints arising, the technology portfolio can evolve. This is also why energy data monitoring is an important element of the project. Facilitators are helping City councils to manage all the stakeholders of the project, with the citizens at its heart .

This type of project management is similar to the Agile project management.

Agile[41] is an approach described by a set of principles and practices for delivering projects, which promotes an iterative approach, collaboration of self-organized teams, and process adaptability throughout the lifecycle of the project.

The key characteristics of Agile projects are:

- Focus on delivering value on time and to budget.
- A collaborative approach between all parties, including external suppliers.
- High level plans created based on outline requirements.
- Detailed plans created with the involvement of core project team members.
- Scope management by prioritisation of features.
- Continuous stakeholder involvement at all levels.
- Iterative development with short increments and frequent delivery.

[41] Source : Service@EC: https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?pageId=192092335

- Embracing change, learning and improvement.
- Sufficient but not excessive documentation and control.
- Facilitative leadership and empowerment.

## 6.4 Application in follower cities

Representative of follower cities have been interviewed as presented in Table 7 in order to assess the ecosystem in each follower city.

| Partners | Description | Persons interviewed | Date of the interview |
|---|---|---|---|
| 21-BAS | Municipality of Bassano del Grappa | Giorgio Strappazzon | 12/06/2019 |
| 23-LEO, 01-CAR, 02-TEC | Municipality of Leon and supporting partners (Cartif, Tecnalia) | Monica Prada, Enery Acevedo, Cecilia Sanz Montalvillo, Nora Fernandez | 27/06/2019, 08/07/2019 |
| 24-KM, 25-DEM | Municipality of Kadikoy and supporting partner (Demir Enerji) | Burcu Sari, Beril Alpagut | 08/07/2019 |
| 28-VID, 29-GSC | Municipality of Vidin and supporting partner (Green Synergy Cluster) | Siyana Asenova, Ina Karova, Daniela Kostova | 04/07/2019 |
| 30-LUB | Municipality of Lublin | Dorota Wolinska | 13/08/2019 |

**Table 7: List of follower cities and supporting partners interviewed**

### 6.4.1 Bassano del Grappa

#### 6.4.1.1 Context

Bassano del Grappa (BdG) is located in the North East of Italy in the Veneto region. In the city, very few buildings are owned by the municipality or by other public entities. Most are owned by citizens or private companies.

Bassano has participated in other collaborative EU projects, in particular in the field of smart public lighting. The SUNSHINE project has been started within the context of SMART ENERGY with the objective of supplying intelligent services for the improvement of energy efficiency. Another European-funded project is called ENIGMA. The goal of ENIGMA, involving 5 European cities, is to foster the next generation of public lighting systems developing breakthrough solutions in the field of smart ICT-based lighting through the joint transnational Pre-Commercial Procurement (PCP) procedure.

#### 6.4.1.2 City council's goals

Mid and long-term goals aim at a reduction of non-renewable energy sources in these sectors with a target of a 20% reduction of $CO_2$ emission by 2020. These reductions are the result of careful planning, incentives and monitoring through the implementation of residential energy efficiency, industrial energy efficiency, energy efficiency within the public administration, sustainable mobility, communication, information, education and training.

#### 6.4.1.3 Technology provider first mapping

At the moment, within the project contacts have been established with the local industrial association (which is influential in the city). The full value chain for heating buildings is present in the area and interested in participating in the development of the PED concept: BAXI is one of the main stakeholders. The start-up WindCity which is developing micro wind turbines has also been approached, as well as a company active in energy accumulation (Westrafo). In addition, building developers have been approached.

The grid operator has not been approached so far, but this is planned soon. Furthermore, ENEL-X, subsidiary of ENEL active in the field of EV charging, might be interested to take part in the project.

### 6.4.2 Leon

#### 6.4.2.1 Context

Leon is one of the main provincial capitals in Castilla y León in Spain. Potential districts to become a PED are within the area of Entrevías, in the northern part of the city. This is a group of isolated neighbourhoods without synergies with others next and well-developed areas due to topographic and accessibility constraints. Population amounts to 27,000 inhabitants, representing 21% of the population of León. Population density is high. Population consists mainly of working class with modest revenues and there are problems of physical and social segregation. Most of the housing stock consists in low-quality, energy-inefficient buildings built in the 40s and 50s.

Historically, León has had coal mines. Many people are still using coal for heating their dwellings, which is very cheap. It is forbidden to use coal in new buildings, but the use of old coal boilers is allowed until their end of life.

#### 6.4.2.2 Citizen mindset

Awareness for energy issues is not well developed. There are however some people concerned about energy consumption and generation. They might be the basis for the creation of an energy cooperative and to support involving other citizens.

In general, people are not ready to invest in energy retrofitting. We need to demonstrate that in the long-term retrofitting is beneficial.

#### 6.4.2.3 The project is not yet supported by facilitators

There is a university, but scientists are mainly active in the food sector, not in the energy sector.

There are some IT companies, but they do not form an ecosystem yet.

The levers to create an ecosystem have to be identified.

#### 6.4.2.4 Technology provider first mapping

Public lighting operators are important stakeholders. In Leon, a 10-year contract with a private company to operate public lighting is going to be signed by the municipality. The company will have some targets for the retrofit of energy-inefficient lamps.

Solar potential is high in Leon. Some houses already have solar panels because there is a legal obligation to have a solar panel, but not all of them are working. There are important regulatory changes at the moment, so there might be some opportunities to develop solar further so as to create a PED.

Bike-sharing and car-sharing systems should be considered besides public transport.

### 6.4.3 Kadikoy

#### 6.4.3.1 Context

Kadıköy is one of the central districts of the metropolitan city of Istanbul. Located on the Southwest of Anatolian part of the city, it is surrounded by Marmara Sea on the West and South. Kadıköy Municipality's approach to local public administration has been that of participatory local democracy all the way down to neighbourhood level and a very high degree of citizen empowerment leading to transparent administrative processes and decision-making. Sharing information with citizens is therefore a priority for Kadıköy Municipality which has tried to establish wide open channels of communication, maximizing inclusivity and building on principles of trust and transparency in all functions.

#### 6.4.3.2 The City council has set clear goals

As signatory of Covenant of Mayors since 2012, Kadıköy Municipality, in collaboration with Boğaziçi University, prepared a SEAP aiming at a 20% reduction in carbon emission and energy consumption by 2020. Kadıköy was the fourth city in Turkey signing up to the initiative but was the first metropolis in the country (it is the considered under this term those cities with more than 500,000 inhabitants). The Plan calculated ~ 1.7 million tons of carbon emissions in 2010 for the district, and through energy efficiency and renewable projects in the built environment, lighting sector, transport and via social awareness, targeted 348,000 tCO2eq reduction in total by 2020. Kadıköy Municipality has recently signed a grant contract with Central Finance and Contract Unit with its project of "Integrated and Participatory Climate Action".

#### 6.4.3.3 Stakeholder mapping

Most of the stakeholders on the map haven't been informed yet. Kadikoy Municipality is a local municipality under Istanbul Metropolitan Municipality (IBB). The public service operators are public for Gas and transport network but is private for electricity. The elections in IBB were in a problematic situation for a few months, but now solved and the Mayor of Istanbul or the related departments should be contacted for MAKING-CITY in order to define the PED area.

### 6.4.4 Vidin

#### 6.4.4.1 Context

Vidin is a port town on the southern bank of the Danube in North-Western Bulgaria. It is the 20$^{th}$ town by population in Bulgaria. It has serious demographic problems (decrease of population).

#### 6.4.4.2 City council sets clear goals and KPI

The city has an EE and RES Strategy and Action Plan. In 2016, the total energy consumption of the city was 297 GWh of which 75% were due to residential sector, 17% to industry and 8% to the public buildings and facilities.

Major target for the city is to reduce the energy demand in the public buildings through energy renovation and RES integration – most buildings need in-depth renovation, self-sufficient production capacities or prosuming capacities, intelligent energy monitoring and management.

#### 6.4.4.3 The project is not yet supported by facilitators

The city is open to suggestions about how to implement smart energy management solutions.

The city has strong expectations about what the lighthouse cities are doing, and about what can be replicated and what can't.

#### 6.4.4.4 Technology provider first mapping

The heat network of the city is non-operational, but its revitalisation is under consideration in order to connect several municipal buildings (schools, kindergartens, etc.) to a single heat source. Time horizon is approx. 5 years.

Solar panels represent the main potential for local energy production. Biomass-based boilers have potential for local heating and domestic hot water production.

Energy cooperatives are not very popular in Bulgaria. By law, they have to feed all energy generated into the grid. They can't use the energy (being from any source: PV, biogas, etc.) for the community. An energy community would need to be part of a balancing group or stand-alone provider and to satisfy a production schedule, with important financial penalties in case of deviation.

### 6.4.5 Lublin

#### 6.4.5.1 Context

Lublin is the biggest city in Eastern Poland with a population of 340,466 (2016). Lublin benefits from high standards of living, good economic situation, ambitious sustainability objectives and has 9 universities.

#### 6.4.5.2 Citizen mindset

Citizens have to be involved to push for energy transition. At the moment they are quite passive. This is also related to the cost of new technologies (for instance to change boilers). The city is supporting citizens in changing supplier to switch from coal to PV (50% of cost is subsidized), but this is not enough.

Energy cost has just raised at national level; therefore, citizens are complaining about that.

There are also complains because of bad air quality.

No local energy communities have been active so far.

#### 6.4.5.3 Technology provider first mapping

Regarding solar photovoltaic, an analysis has been done and there is a big potential in Lublin. At the moment, few buildings in the city have PV panels. Development of PV in Poland should be a political decision at national level. At the moment the energy system is mainly based on coal.

Heat network exists in the city; it actually covers the whole city. Heat is generated from coal. Lublin owns the heat network operator LPEC which is Lublin's linked third party in the MAKING-CITY project.

Up to 50-60% of citizens in Lublin are connected to the gas network. Around Lublin there are agriculture areas so there might be some potential for biogas – but this is not a priority now.

With regards to energy-efficiency retrofits, a renovation plan covering 2013-2023 exists; it will be updated soon for 2024. There is an ongoing renovation in one building owned by the city.

There is a strong focus on urban mobility. There are ambitious objectives at national level in terms of development of electric vehicles. Lublin is applying these objectives by developing EV charging stations and developing EVs within its own fleet. Unfortunately, electricity is based on coal at national level and there is no plan to move away from coal in the short term.

Lublin University of Technology is working on energy technologies and is developing a new energy measurement method, which might be used in future PEDs.

## 6.5 Conclusion and next steps

As observed in Lighthouse cities and anticipated in Follower cities, each district has its own constraints and barriers, leading to different priorities regarding the stakeholders to be involved in the design and implementation of a PED. Though, some structural point of the stakeholders mapping can be considered as essential:

- The PED project should include non-technical actors who will act as facilitators to manage the team, , stakeholders and the citizen involvement,
- The PED project should include data monitoring,
- The PED project should be based on sustainable, tailor-made business models adapted to the local financial situation.

The MAKING-CITY project will help the Lighthouse and Follower cities to simulate their annual energy balance. The data monitoring is a key element to establish those energy simulations. The annual energy balance is the starting point of the reflection to establish the technology-mix and the interaction in-between the technologic actors.

# 7 How to proceed with PED Design

In previous chapters all the analyses that should be taken into account, have been described. Regarding the process to be a guideline, this chapter could have an organigram of the different steps, identifying each of them and describing in detail linking with the previous chapters. This section will be a base for replication potential of PED concept and how knowledge transfer could be performed via innovative tools or learning methods. Since citizens are in the "core" of this transition process towards PED/PEN and more ambitiously towards Positive Energy Cities, citizens gain innovative roles and undertake different interactions regarding power/heat energy markets, Public Private People Partnerships models, participatory design approaches for participative decision-making. This study is summarized in section 7.1.3 to support the replication and upscaling potential of PEDs.

### 7.1.1 A new Workshop "GamePED"

After studies have been started on Methodology for PED design (in the first year of MAKING-CITY), Fellow cities are introduced to be on board for early adoption of methodology for PED design for selection of areas to be PED in their cities. In order to involve fellow cities intensely in this methodology development procedure, first project meeting in Groningen (May 2019) was selected to be the first interaction space for Lighthouse and Fellow cities to work collaboratively. As being WP4 (Positive Energy District Methodology and Early Replication) Leader, Demir Energy designed and developed a workshop structure, namely GamePED, in order to share knowledge and experience from LHCs to FWCs. GamePED layout is illustrated in Figure 27. It presents the phases of the proposed PED Methodology for identifying city needs of each FWC, then defining the PED Concept boundary depending on resource availability, selection of technical solutions (that are being implemented in LHCs) and finally, a section to be considered for analysing barriers and enablers of these solutions. There are six tables (six different layouts) regarding six fellow cities and partners of LHCs are divided into these six tables in order to help FWCs for determining the above explained phases.

GamePED will be flourished and refined for the second project meeting, for instance PED methodology has been analysed and advanced in the first year. Probably, tools like GIS based layouts in relation with Phase I – section 4.1.3-Step 3: Analyses of City Components of proposed methodology. This advanced version will also support interaction of FWCs and LHCs in a more digitalized way. GamePED design and description will be updated in the final version of this deliverable.

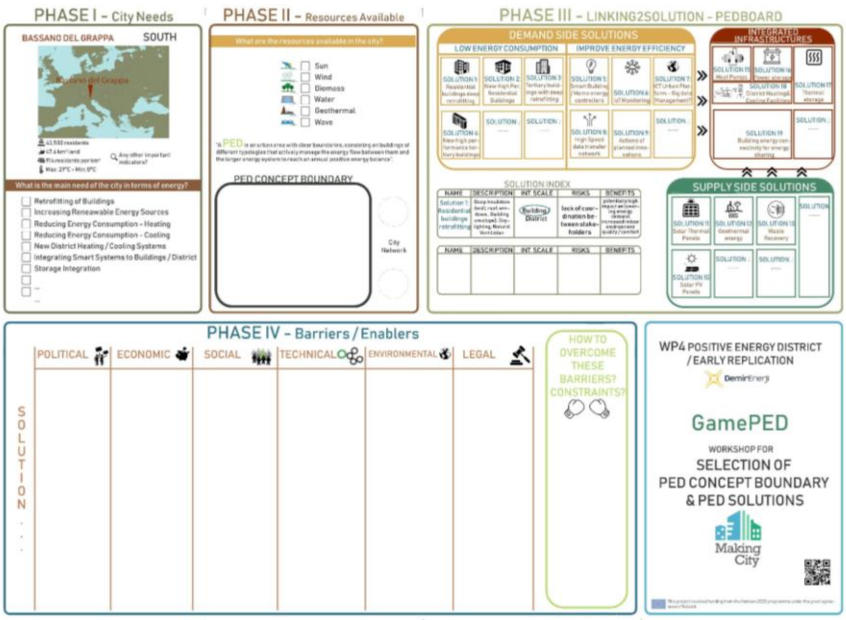


**Figure 27 GamePED Layout**

### 7.1.2 Lessons Learnt from the methodology development perspective

The PED development in Oulu illustrates the central role of the city in PED selection. Aligned with the PED selection actions in Oulu, described in Table 2 in section 3.4, the first condition is the examination of the potential PED area in relation to the strategic urban plans and land use plans of the city, to fit in the planned overall future and infrastructure development in the city area. Another condition for the existence of a new PED is the identification of the investors in the potential PED area, and their planned schedules for infrastructure and building implementation. In some spatial planning systems' contexts, cities can use urban planning, land use planning and urban design tools and approaches, such as Public-Private-People-Partnerships, to enhance these two prerequisites for PED implementation, scale up and replication.

PED experience of the first year in Groningen will be mentioned in the final version of this deliverable in M24.

### 7.1.3 Citizens in Future of PEDs / PENs/ Positive Energy Cities

Due to environmental and resiliency benefits, distributed energy resources (DER) are a potential solution for meeting future electricity demand, but their integration into centralized power markets on the large scale is challenging. Many practitioners argue that blockchain technology can create new market structures for DER like peer-to-peer (P2P) markets, community-based market, hybrid P2P market, and aggregators which foster renewable generation. As explained in Chapter 2.2 From smart cities to Positive Energy Districts, DERs have become key levers for transforming the electricity market from a vertical structure into a decentralized, bottom-up landscape and for providing a reliable and sustainable energy supply despite shrinking natural resources[42].

Incorporating DER in the market thus increases the complexity of the optimization problem for utility providers and challenges their distribution networks that are not built for bi-directional electricity and information flow. These developments have led to a paradigm shift toward a more decentralized market and spurred ambitions to build peer-to-peer markets (P2P) in which owners of solar panels can sell their production to other consumers on the local low-voltage distribution system. This puts small generation system operators in the focus and creates a competitive environment for distributed generation.

[42] Green J, Newman P (2017) Citizen utilities: The emerging power paradigm. Energy Policy 105:283–293

Mengelkamp[43] also states that on a blockchain-based market, transactions can be settled without the mediation of a utility company or a financial institution.

Local electricity markets are defined as the exchange between prosumers and consumers to balance locally and to trade energy surplus (e.g. excess wind or solar), manage load peaks, optimize the use of RES, and maximize the use of flexibility asset.[44] In such a system, citizens gain new and innovative roles than just being consumers. Within the traditional system, citizens were trying to be involved in energy production without sharing mechanisms, therefore investing in for their own benefit. **(Citizen as an Investor)**. Intense participation and collaborative innovation by the new flexible mechanisms provides new roles, such as **Citizen as a Trader, Citizen as a Prosumer** and citizens begin to share with neighbours (P2P) and provide congestion management for the local grid, facilitate Local RES integration, preserve power quality, energy savings because of short distances in distribution and citizen participation.

Meanwhile, citizen as an individual may participate to this new and innovative market, whereas **Citizen as an Organization Member** would have more power and pressure on decision policies and mechanisms. Citizen becomes one of the main stakeholders (apart from city authorities, energy utilities, research institutes, NGOs etc.) and Public-Private-People Partnership model can simultaneously improve everyday activities and life conditions in cities, create economic opportunities, and enable experimentation and implementation of new technologies. The main objective of PEDs/PENs/Positive Energy Cities is to integrate smart city objectives with sustainable urban transformation calls for collaborative innovation.

Besides, citizen knowledge (living knowledge) develops effective citizenship and democracy building through participation. Today, necessities and priorities of smart citizens should be considered in inclusive cities. Citizens uses know-how, saves knowledge and saves time with regards to participative science by their own platforms for planning and designing the cities. As a result of this, new roles are identified as: **Citizen as a Scientist, Citizen as a Participatory Designer** and they demand more information social and economic benefits and technological assets as they participate actively to management and the living of their cities.

# Conclusions

Conclusion section will be detailed and finalized in the final version of this deliverable in M24 when impacts of the methodology is clearer after early adoption by FWCs to select their areas to be PED.

As mentioned, and extensively described in this deliverable, PEDs are complex structures regarding unclear definitions, framework and boundary issues and lacking of real integration between urban and land-use planning to energy planning in cities. Since the main objective of MAKING-CITY is the development of new integrated strategies to address the urban energy system transformation towards low carbon cities, (with the PED approach as the core of the urban energy transition pathway) this methodology will serve as a basis document for cities for identifying their PED boundaries, selection of technologies, managing a citizen -community led participative governance and co-creation activities for energy transition. Innovative and social business schemes will be indicated and referred in this deliverable later in the final version.

The impact of this methodology is expected to be high and may be replicated in different geographies / demographies / urban economies / socio-cultural structures since it considers parameters through smart and sustainable urbanization.

[43] Designing microgrid energy markets: https://ideas.repec.org/a/eee/appene/v210y2018icp870-880.html

[44] Backe, S., del Granado, P. C., Kara, G., & Tomasgard, A. (2019, August). Local Flexibility Markets in Smart Cities: Interactions Between Positive Energy Blocks. In Energy Challenges for the Next Decade, 16th IAEE European Conference, August 25-28, 2019. International Association for Energy Economics.

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Yonas, A. Critical review of sustainable energy schemes of trias energetica

# ANNEX I BARRIERS / ENABLERS OF THE SOLUTIONS by FWCs

| Name of the Solution | City Cont | POLITICAL | ECONOMIC | SOCIAL | TECHNICAL | ENVIRONMENTAL | LEGAL | SPATIAL |
|---|---|---|---|---|---|---|---|---|
| S1a Residential (High Rise) retrofitting | Kadikoy | (-) inadequacy of promotional campaign<br>(-) inadequacy of sustainable and integrated policies<br>(+) Commitments/ agreements | (-) High costs<br>(+) incentives and funds<br>(+) financial savings of customers in mid or long-term (from bills, invoice of heating-cooling) | (+) raising of ecological trends<br>(+) prestige for companies<br>(+) raising of wondering new and smart technologies | (-) difficulties of implementations<br>(-) Time and labor constraint<br>(-) Inadequacy of Turkish Standards on building materials | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incents<br>(-) Lack of inspections | (+) Set an example for neighborhood<br>(-) Rebuilding is more popular |
| | Vidin | (+) Existing and updated Residential buildings strategy at national level<br>(+) Existing financial mechanism for renovation: National program for renovation of Bulgarian homes<br>(+) Increasing responsibility from the institutions related to the building renovation<br>(+) Decentralized management - local responsibilities from the municipalities<br>(-) Slowly and hard administrative procedures<br>(-) Lack of trust in the authorities | (+) Existing financial mechanism for 100% funding of the residential buildings renovation<br>(+) Financial savings realized by energy costs reduction - reduction of household heating costs<br>(+) profits both in the construction sector and in building materials<br>(-) Relatively high price of the EE services | (+) Improved living environment<br>(+) Energy poverty decreasing<br>(+)Improving healthy living conditions - thermal and hygienic comfort in buildings is greatly increased<br>(+) More aesthetic appearance of the renovated residential buildings is achieved<br>(+) Increased market value of the property<br>(-) Lack of trust in the energy service providers<br>(-) Lack of interest in issuing energy and technical audits | (+) Energy costs reduction<br>(+) Better thermal conditions<br>(+) Extending the life of buildings<br>(-) Some restrictions for renovation of buildings culture heritage<br>(-) Low skilled staff, short deadlines and low procurement prices lead to poor performance<br>(-) Lack of regulatory penalties and fines for poor quality of the renovation processes, before and after their implementation | (+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change | (+) Restrictions in the Ownership Act (CA) and in the Regulations for the Management, Order and Supervision of Households cooperation regarding the Insulation and windows replacement by individuals | (+) More aesthetic appearance of the renovated residential buildings compared to the rest, resulting in a change in the appearance of entire neighborhoods |
| | Bassano Del Grappa | (+) the Municipality has the RES Regolamento Edilizo Sustainable (Sustainable building Roles)<br>(+) the residential retrofitting is depending from the national policies and strategies | (+) since many years in Italy there is the possibility to have fiscal earning in 10 years of the 65% of the final bill<br>(+)opportunities for ESCO solution especially for big building or financial models designed specifically for retrofitting and energy efficiency improvement projects | | (+) Most of companies are able to install the retrofitting solution. The technology is well known.<br>(-) a lot of building are historical or the Heritage list: So, the retrofitting solutions are more complicate and/or expensive | (+) there are many advantages for having less consumption of fossil fuel | (+) Recent modification of Regional building law allow to increase the volume of 10% in order to reduction the global consumption of energy<br>(-) Projects that affect common parts of residential buildings needs high percentage of agreement | (+) in many small properties is possible to retrofit the building<br>(-) in heritage building is not possible to modify the existing situation and the spatial characteristics<br>(-) in the historical area the building attached and is difficult to retrofit |

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| | Leon | (+) Residential retrofitting is part of State and Regional policies and strategies | (+) ESCO solution or financial models designed specifically for retrofitting and energy efficiency improvement projects<br>(-) Difficult economical context. Low incomes or lack of economical sources to afford the costs of retrofitting<br>(-) E-S-T many owners change their windows through individual retrofitting thus it is sometimes difficult to implement more efficient global projects | (+) Property managers (real state managers) are useful stakeholders.<br>(+) Existing examples can be used to increase social interest and awareness<br>(-) Aged citizens, more reluctant to changes<br>(-) Difficulties to reach agreements between community of owners<br>(+) Fast and easy to feel comfort improvements after retrofitting | (+) SATE systems are quite known<br>(-) Façade or roof structures sometimes are incompatible with retrofitting<br>(-) In protected areas/buildings retrofitting solutions are more complicate and/or expensive<br>(+) free technical tools (e.g. SG-Save)<br>(-) scarce use of energy modelling or advanced tools | (-) Econ-Envir_Retrofitting of some roofs includes the management of asbestos materials (complicate and expensive protocols) | (+) Recent modification of building bylaw to allow volume increase<br>(-) Projects that affect common parts of residential buildings needs high percentage of agreement<br>(-)(+) IEE, ITE and CE*<br>The IEE is only compulsory for some kind of interventions (usually public funding ones)<br>The ITE is mandatory for buildings older than 40 years<br>CE is mandatory for public buildings, for new buildings, and in commercial transactions<br>* IEE: (Informe de Evaluación de los Edificios_Evaluation Report of Buildings), ITE: (Informe Técnico de Edificación Technical Report of Building), CE: (Certificación Energética (Enegy Certification or Label) | (-) Floor retrofitting is not always viable due to spatial characteristics<br>(-) Party walls or elements adjacent to different properties are difficult to profit |
| | Lublin | (+) consistent with government policy<br>(-) no | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) Solution widely accepted and known to residents. | (+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations<br>(+) improving the quality of space |
| | Trencin | (+) Existing residential buildings strategy at national level<br>(+) Existing financial mechanism for renovation an d retrofitting | (+) Financial savings realized by energy costs reduction - reduction of energy costs<br>(+) Financial support for local, national bussines sector - stabilitation of labour in construction sector<br>(+) Increased market value of the property<br>(-) Long term economic return period<br>(-) High investments costs | (+) raising of awarness about ecological trends through best practice<br>(+) increasing of quality of live for end-users<br>(+) increasing of aestetic value of the property | (+) Extending the life of buildings and solving of technological and technical fails in buildings<br>(-) Regulation for renovation of buildings culture heritage | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(-) Retrofitting includes the management of risks materials (asbestos) (complicate and expensive protocols) | (-) Retroffiting projects tneeds high percentage of agreements<br>- bureaucracy | (+) the renovated residential buildings increasing quality of the envirnment (aesthetic) |
| S1b Residential (Private House) retrofitting | Kadikoy | (-) inadequacy of promotional campaign<br>(-) inadequacy of sustainable and integrated policies.<br>(+) Commitments/ agreements | (-) High housing costs<br>(+) incentives and grants<br>(+) financial savings of customers in long-term (from bills, invoice of heating-cooling) | (+) raising of ecological trends<br>(-) difficulties of changing of daily routine<br>(+) raising of wondering to new and smart technologies | (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) difficulties of changing of routine implementations | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials | (-) difficulties in individual act<br>(-) Lack of incentives<br>(-) Lack of inspections | (-) Rebuilding is more popular |
| | Vidin | (+) Existing and updated Residential buildings strategy at national level<br>(+) Existing financial mechanism for renovation: National program for renovation of Bulgarian homes<br>(+) Increasing responsibility from the institutions related to the building renovation<br>(+) Decentralized management - local responsibilities from the municipalities | (+) Existing financial mechanism for 100% funding of the residential buildings renovation<br>(+) Financial savings realized by energy costs reduction - reduction of household heating costs<br>(+) profits both in the | (+) Improved living environment<br>(+) Energy poverty decreasing<br>(+)Improving healthy living conditions - thermal and hygienic comfort in buildings is greatly increased<br>(+) More aesthetic appearance of the renovated residential | (+) Energy costs reduction<br>(+) Better thermal conditions<br>(+) Extending the life of buildings<br>(-) Some restrictions for renovation ob buildings culture heritage<br>(-) Low skilled staff, short deadlines and low procurement | (+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change | (+) Restrictions in the Ownership Act (CA) and in the Regulations for the Management, Order and Supervision of Households cooperation regarding the Insulation and windows replacement by individuals | (+) More aesthetic appearance of the renovated residential buildings compared to the rest, resulting in a change in the appearance of entire neighborhoods |

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|---|---|---|---|---|---|---|---|---|
| | | (-) Slowly and hard administrative procedures<br>(-) Lack of trust in the authorities | construction sector and in building materials manufacturers, engineers, architectural and design companies<br>(-) Relatively high price of the EE services<br>(-) Lack of trust in the energy service providers | buildings is achieved<br>(+) Increased market value of the property<br>(-) Lack of trust in the energy service providers<br>(-) Lack of interest in issuing energy and technical audits | prices lead to poor performance<br>(-) Lack of regulatory penalties and fines for poor quality of the renovation processes, before and after their implementation | | | |
| | Leon | Most of the (+) and (-) are same ones of High-Rise Residential Buildings. The difference may be the degree of the (-) and (+). Share of cost of retrofitting are usually higher in private houses than in high rise residential buildings. On the other hand, improvements in comfort and energy bills are usually better in this kind of retrofitting. | | | | | | |
| | Lublin | (+) consistent with government policy<br>(-) no | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) Solution widely accepted and known to residents. | (+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations<br>(+) improving the quality of space |
| | Trencin | (+) Existing residential buildings strategy at national level<br>(+) Existing financial mechanism for renovation an d retrofitting | (+) Financial savings realized by energy costs reduction - reduction of energy costs<br>(+) Financial support for local, national bussines sector - stabilitation of labour in construction sector<br>(+) Increased market value of the property<br>(-) Long term economic return period<br>(-) High investments costs | (+) raising of awarness about ecological trends through best practice<br>(+) increasing of quality of live for end-users<br>(+) increasing of aestetic value of the property<br>(-)Long way/difficulties in agreements between community of owners | (+) Extending the life of buildings and solving of technological and technical fails in buildings<br>(-) Regulation for renovation of buildings culture heritage<br>(-) Lack of using energy modeling tools/advenced tools in phase of planning retrofittin projects in sector of private houses | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(-) Retrofitting includes the management of risks materials (asbestos) (complicate and expensive protocols) | (-) Retroffiting projects tneeds high percentage of agreements - bureaucracy | (+) the renovated residential buildings increasing quality of the envirnment (aesthetic) |
| S2a New High-Performance Building (residential) | Kadikoy | (-) Inadequacy of sustainable and integrated policies. | (-) High investment costs<br>(+) financial savings of customers in long-term (from bills, invoice of heating-cooling)<br>(-) High housing costs<br>(+) incentives and grants | (+) prestige for companies<br>(+) raising of ecological trends<br>(+) promoting eco and healthy life | (-) difficulties of implementations<br>(-) time and labor constraint | (+) negative effects of climate change on life | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections | (+) Set an Example for neighborhood<br>(-) Limited areas |
| | Vidin | (+) Existing National NZEB action plan which states that until 21.12.2020 all new buildings have to be NZEB<br>(+) Existing National EE action plan<br>(+) Comprehensive and well-structured EPC scheme<br>(+) Strict regulations regarding the implementation of the EPCs<br>(-)Lack of targeted actions for implementation of the NZEB action plan<br>(-)lack of trained experts | (-) EU structural funds are a major source of funding for energy efficiency measures in public and municipal buildings, as well as in the housing sector | (+) Buildings that have a certificate of energy performance rated A or B may be exempted from Building tax<br>(-) Lack of expertise regarding the NZEB directive among the construction sector<br>(-) Lack of creatively integrated approach by teams of architects, engineers, builders, consultants to match contemporary energy efficient forms of buildings with modern building materials, products and technologies | (+) Energy costs reduction<br>(+) Better thermal conditions<br>(-) lack of expertise for EE in architects to design High performance buildings<br>(-) Lack of interest in investors to implement ambitious EE solutions in residential buildings | (+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change<br>(-) | (+) Existing National NZEB action plan which states that until 21.12.2020 all new buildings have to be NZEB | |
| | Bassano Del Grappa | (+) the Municipality has the RES Regolamento Edilizio Sustainable (Sustainable building Roles) that give economic advantages to the owners (+) the residential retrofitting is depending from the national policies and strategies | (+) High performance building have much more value in market | (+) for young owners the high Energy Class or energy is a priority | (-) New solutions for energy efficiency enter slowly into the market | (+) there are many advantages for having less consumption of fossil fuel | (+) the national law number 10 give the imposition to calculate the energy consumption and certificate new buildings and also the ancient one. | (+) in many small properties is possible to retrofit the building<br>(-) in heritage building is not possible to modify the existing situation and the |

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| | | | | | | | | spatial characteristics<br>(-) in the historical area the building attached and is difficult to retrofit |
| | Leon | (+) Part of national and regional policies and strategies | (-) High performance building are more expensive but | (-) Low demand. Energy Class or energy behaviour of housings is not a priority for new owners. | (-) New solutions for energy efficiency enter slowly into the market | (-) Climate conditions (cold winter + hot summer and high daily temperature swing) | (+) Legal imposition to certificate new buildings in two phases<br>(-) CTE (Technical Building Code), reviewed every 5 years and updated to European directives. It regulates energy savings requirements. Strict compliance to the CTE means an Energy Class lower than B. | (-) High performance buildings need thicker envelopes |
| | Lublin | (+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) Solution widely accepted and known to residents. | (+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations<br>(+) improving the quality of space |
| | Trencin | (+) Existing residential buildings strategy at national level<br>(+) Existing financial mechanism high performance residential building | (+) Financial savings realized by energy costs reduction - reduction of energy costs<br>(+) Financial support for local, national bussines sector - stabilitation of labour in construction sector<br><br>(-) Long term economic return period<br>(-) High investments costs | (+) raising of awarness about ecological trends through best practice<br>(+) increasing of quality of live for end-users | (-) Regulation for investments in areas of culture heritage | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Improving environmental quality, mitigating the effects of climate change | (+)Legal obligation for new buildings to reach high performance energy class<br>(-) Building projects needs high percentage of agreements - bureaucracy | |
| S3a Retrofitting of tertiary buildings | Kadikoy | (-) Inadequacy of sustainable and integrated policies. | (-) technology transfer and implementation costs<br>(-) high investment costs<br>(+) incentives and grants | (+) prestige for companies<br>(+) raising of ecological trends<br>(+) raising of wondering to new and smart technologies | (-) difficulties in applying standards | (+) negative effects of climate change in life | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections | (-) Rebuilding is more popular |
| | Vidin | (+) Existing National NZEB action plan which states that until 31.12.2018 all public buildings have to be NZEB<br>(+) Existing National EE action plan<br>(+) Comprehensive and well-structured EPC scheme<br>(+) Strict regulations regarding the implementation of the EPCs<br>(-)Lack of targeted actions for implementation of the NZEB action plan<br>(-)lack of trained experts | (-) EU structural funds are the major source of funding for energy efficiency measures in public and municipal buildings, as well as in the housing sector<br>(-) Lack of interest in ESCO approach | (+) Improved environment<br>(+) Improving healthy working conditions<br>(+) More aesthetic appearance of the renovated public buildings is achieved<br>(-) Lack of trust in the energy service providers<br>(-) Lack of expertise regarding the NZEB directive among the construction sector<br>(-) Lack of creatively integrated approach | (+) Energy costs reduction<br>(+) Better thermal conditions<br>(-) Some restrictions for renovation of buildings culture heritage<br>(-) Low skilled staff, short deadlines and low procurement prices lead to poor performance<br>(-) Lack of regulatory penalties and fines for poor quality of the renovation processes, before and after their implementation | (+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change | (+) Existing National NZEB action plan which states that until 31.12.2018 all public buildings have to be NZEB | |
| | Bassano | | (+) High performance building have much more value in market | | (-) New solutions for energy efficiency enter slowly into the market | (+) there are many advantages for having less consumption of fossil fuel | there is new N-ZEB building | |

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|---|---|---|---|---|---|---|---|---|
| | Leon | | (-) Incompatibility of retrofitting works with normal activity | | | | | |
| | Lublin | (+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) Solution widely accepted and known to residents. | (+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations<br>(+) improving the quality of space |
| | Trencin | (+) Existing residential buildings strategy at national level<br>(+) Existing financial mechanism for renovation an d retrofitting | (+) Financial savings realized by energy costs reduction - reduction of energy costs<br>(+) Financial support for local, national bussines sector - stabilitation of labour in construction sector<br>(+) Increased market value of the property<br>(-) Long term economic return period<br>(-) High investments costs | (+) raising of awarness about ecological trends through best practice<br>(+) increasing of quality of live for end-users<br>(+) increasing of aestetic value of the property | (+) Extending the life of buildings and solving of technological and technical fails in buildings<br>(-) Regulation for renovation of buildings culture heritage | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(-) Retrofitting includes the management of risks materials (asbestos) (complicate and expensive protocols) | (-) Retroffiting projects tneeds high percentage of agreements - bureaucracy | (+) the renovated residential buildings increasing quality of the envirnment (aesthetic) |
| S4a New High-Performance Building (Shopping Mall)<br><br>S4b (Academy Building)<br><br>S4c (Sport Complex) | | (+) Part of national and regional policies and strategies<br>(-) Inadequacy of sustainable and integrated policies.<br>(+) Part of national and regional policies and strategies<br>(+) Existing strategy at national level<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) technology transfer and implementation costs<br>(-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(+) Financial savings realized by energy costs reduction - reduction of energy costs<br>(+) Financial support for local, national bussines sector - stabilitation of labour in construction sector<br>(+) Increased market value of the property<br>(-) Long term economic return period<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation cost | (+) prestige for companies<br>(+) raising of ecological trends<br>(+) raising of wondering to new and smart technologies<br>(+) raising of awarness about ecological trends through best practice<br>(+) increasing of quality of live for end-users<br>(+) Solution widely accepted and known to residents. | (-) inadequacy of knowledge of new implements and technologies<br>(-) time constraint<br>(-) difficulties of transferring technology<br>(-) New solutions for energy efficiency enter slowly into the market<br>(-) Regulation for investments in areas of culture heritage<br>(+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(-) Climate conditions (cold winter + hot summer and high daily temperature swing)<br>(-) New solutions for energy efficiency enter slowly into the market<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(+) only benefits | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections<br>(+) Current CTE regulates that new buildings (except residential ones) must be Class B or A. A review will be soon approved and it will be even more strict introducing NZEB concept.<br>(+)Legal obligation for new buildings to reach high performance energy class<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (-) Limited areas<br>(-) politic risks<br>(+/-) the need to take into account local and building regulations<br>(+) improving the quality of space |
| S5a Smart Control / Advanced Metering / Wireless Advanced Control in Buildings | | (-) Inadequacy of sustainable and integrated policies.<br>(+) Promotion of ISO 50001 for Energy management<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) technology transfer and implementation costs<br>(-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(+) financial savings of customers in long-term<br>(-) Still relatively high price of BEMS devices | (-) Loss of manual control over the system can be seen as something undesirable<br>(-) Aged people has difficulties to understand new technologies<br>(+) raising of wondering to new and smart technologies<br>(+) promoting healthy life | (-) Need of expert management<br>(-) Security<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) difficulties of changing of routine implementations<br>(+) Energy savings increased | (+) Set an example for public<br>(+) reduction of CO2 emissions<br>(+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change<br>(+) only benefits<br>(+) raising of use of eco and recyclable materials | (-) depends on individual initiatives<br>(-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a | (+) No direct interference in space. |

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| | (-) Lack of sustainable and integrated policies dealing with management of the data receiving from monitoring. | (+) Fast return of investment for installation of smart metering system at city level due to the high level of energy savings<br>(+) Better decision making in an open energy market with variable prices<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation cost | (-) Loss of manual control over the system<br>(+) Energy monitoring encourages behavior change<br>(+) Misuse of unscrupulous neighbors<br>(+) Increase of the customer's awareness about energy efficiency and smart metering system<br>(+) Setting and achievement of individual targets for energy efficiency savings<br>(+) Attracting of clients towards the smart metering and related services<br>(+) Evaluation of expenses/ benefits for clients from the use of smart metering system at customer level.<br>(+) Solution widely accepted and known to residents.<br>(-) Group of ends users have difficulties to understand new technologies - non user friendly approach (to much technical data for undestanding for user to ensure proper functions of the system) | (+) Easier operation and maintenance of energy systems in buildings<br>(+) lack of transparency in the calculation and approval of regulated electricity prices will be eliminated<br>(+) Possibility for energy production and consumption forecasts<br>(-) The only technical possibility for accounting for the heat consumed in the homes and its distribution is by installing individual distributors of each heating unit.<br>(-) Inefficient and old heating systems - barrier for energy management implementation<br>(-) Lack of experts for implementing BEMS in buildings<br>(-)the need to use highly qualified service<br>(+) Avalibility of data for expert decision making and optimalisation of the system<br>(-) Need of expert management<br>(-)Data security problems | (+) Improving environmental quality, mitigating the effects of climate change | common problem, which makes it impossible to undertake investment activities. | |
| S5b Visulation Units to study human behaviour regarding the energy consumption | (-) Inadequacy of sustainable and integrated policies.<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(+) financial savings of customers in mid or long-term<br>+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) raising of ecological trends<br>(+) raising of wondering to new and smart technologies<br>(+) promoting eco and healthy life<br>(+) Solution widely accepted and known to residents.<br>(+) Increasing of awarness about energy efficiency matters<br>(+) Support for socila innovations in behaviour of end users | (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) difficulties of changing of routine implementations<br>(-) incompatibility of infrastructure<br>(-)the need to use highly qualified service | (+) negative effects of climate change in life<br>(+) increased awareness and people's desire to learn consumption data<br>(+) only benefits | (-) depends on individual preference<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+) No direct interference in space. |
| S5c Demand Response Smart Grid | (-) PED concept is quite unknown<br>(-) Difficulties involving institutional and different levels of administration and/or stakeholders to co-design, co-build and co-manage the Smart Grid<br>(-) PED concept is quite unknown<br>(-) Difficulties involving institutional and different levels of administration and/or stakeholders to co-design, co-build and co-manage the Smart Grid<br>(+) city-level decision support to authorities and energy service providers | (-) is not clear what is the real advantage of smart grid.<br>(-) lack of financial resources<br>(-) high investment costs<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (+) young people are more sensible about this matter<br>(-) There is a general social preference towards individual energy systems<br>(+) decision making in an open energy market with variable prices<br>(+) Social engagement<br>(+) Engagement consumers and prosumers by capturing near real-time data related to their energy consumption | (-) There is no site experience implementing and managing energy districts<br>(+) optimal integration of all resources such as connections between elec., gas and water<br>(+) Planning of new energy producers for the future needs of the city<br>(+) Flexibility of the production to the change of demand | (+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change<br>(+) raising of use of eco and recyclable materials<br>(+) only benefits | (-) There are some legal gaps in district energy infrastructures and some barriers.<br>(-) existing limited energy laws and regulations (for storage-transfer etc.)<br>(-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives, inspection<br>(-) There are some legal gaps in district energy infrastructures and some barriers. However, a | (-) Some areas of the city are quite dense, with little spare space<br>(-) Some areas of the city are quite dense, with little spare space<br>(+) No direct interference in space. |

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| | (-) legal environment is not proper suitable for implementation this kind of spproach<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | | (+) city-level decision support to authorities and energy service providers<br>(+) high flexibility of GRID system<br>(-) social preference towards individual energy systems<br>(+) Solution widely accepted and known to residents. | (+) Reduce of energy costs through participation in Demand Response pro-grams<br>(+) Reduce of peak demand<br>(-)the need to use highly qualified service | | new regulation of electricity sector was recently approved, some administrative proceedings are long and complicate.<br>(-) legal environment is not proper suitable for implementation this kind of approach<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | |
| S5d Heat Matcher | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions<br>(-) Lack of sustainable and integrated policies<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(+) financial savings of customers in long-term<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies | (-) Loss of manual control over the system by end user<br>(+) Solution widely accepted and known to residents. | (-) unexperienced in thermal grids (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) Need of expert management<br>(-)the need to use highly qualified service | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set an example for public<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+) No direct interference in space. |
| S6a Smart Lighting, power LED | (-) Inadequacy of sustainable and integrated policies.<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses<br>(+) financial savings of customers in long-term<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies | (+) raising of wondering to new and smart technologies<br>(+) increasing of quality of live for end-users<br>(+) Solution widely accepted and known to residents. | (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) difficulties of changing of routine implementations<br>(-)the need to use highly qualified service | (+) Mostly available<br>(+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set An example for public<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(+) only benefits | (+) Legal obligation in new buildings<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+) No direct interference in space. |
| S6b LoRa (Long Range) wireless network and activity sensors | (-) Inadequacy of sustainable and integrated policies.<br>(-) Poor awareness about Lora Network among policy makers<br>(-) Lack of sustainable and integrated policies<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses<br>(-) Few or none possibilities to introduce additional improvements in lighting system<br>(+) The cost of small LoRa cellular base stations (gateways) is very low<br>(+) LoRa stations are very cost effective<br>(+) Low costs for info transfer<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies | (+) raising of wondering to new and smart technologies<br>(+) numerous city and business process management solutions<br>(+) it will contribute to the automation, simplification and improvement of living quality<br>(+) it will make life in urban areas smarter, safer and more sustainable<br>(+) public security solutions<br>(+) increasing of urban safety<br>(+) Solution widely accepted and known to residents. | (-) difficulties of integration current systems<br>(+) easy to implement technology<br>(+) In addition to its large range, it also has extremely low power consumption<br>(+) possibility of integrate smart monitoring solutions for energy, environment, air quality, traffic, process optimization, etc.<br>(-) network management algorithms and implementation process are complex and require a lot of radio expertise<br>(-) Need of expert management<br>(-)the need to use highly qualified service | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set an example for public<br>(+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change<br>(+) only benefits | (+) No legal restrictions<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+) No direct interference in space. |

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| S6c Energy data monitoring of PED | (+) help you make more accurate decision - policy implication<br>(-) Lack of sustainable and integrated policies<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (+) help you make more accurate decision<br>(-) Cost to maintain monitoring and management of the system in a long time period<br>(-) high investment costs<br>(-) lack of financial resources<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (-) Private residents could reject to allow systems that monitor their equipment<br>(+) help you make more accurate decision - policy implication<br>(+) Solution widely accepted and known to residents. | (+) help you make more accurate decision<br>(-) Smart City Platform is a project of the city, but it is still in design phase<br>(-) Need of expert management<br>(-) Problems with integration to current systems | (+) help you make more accurate decision<br>(+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+) No direct interference in space. |
| S6d Integration of new services to the data platform | (+) help you make more accurate decision - policy implication<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(-) lack of financial resources<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (-) Mismatch of city characterization<br>(+) support (data based) social innovations<br>(+) Solution widely accepted and known to residents. | (-) Mismatch of city characterization<br>(-) Smart City Platform is a project of the city, but it is still in design phase<br>(-) Need of expert management<br>(-) Problems with integration to current systems<br>(-)the need to use highly qualified service<br>(-)the need to use highly qualified service | (-) Mismatch of city characterization<br>(+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(+) only benefits | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+) No direct interference in space. |
| S6e Installation of IoT infra | (-) Inadequacy of sustainable and integrated policies.<br>(+) good awareness about IoT technologies among policy makers and local authorities<br>(+) already implemented projects | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(+) relatively low costs for implementing IoT technologies | (+) possibility for air quality control, waste management, smart lighting and smart parking | (-) failure to share data of institutions or individuals<br>(-) difficulties of collect and follow the data<br>(+) made easier data collecting data and following the process<br>(+) Low energy consumption<br>(+) possibility to optimize the processes<br>(-)the need to use highly qualified service | (+) Improving environmental quality through reduced greenhouse gas emissions, and mitigating the effects of climate change | (+) No legal restrictions<br>(-) Legal regulations regarding data protection always raise legal problems. | (+) No direct interference in space. |
| S7a Open Urban Platform adaptation | (+) The Municipality is collecting all the data about energy of the public buildings<br>(-) There is no platform to manage, monitor and show the set of municipal buildings energy data.<br>(+) Better estimate future local needs through access to local data<br>(+) Empowering consumers and providing accurate and frequent billing<br>(+) Possible win-win data exchange collaboration scenario between energy data providers and public authorities<br>(+) help you make more accurate decision - policy implication<br>(+) The city is in the process of implementing an "open data" project. The awareness of local authorities in implementing such solutions is growing | (-) High cost to stablish, manage and control data management and protection of privacy<br>(+) Insufficient resources in terms of time, costs or tools to undertake energy planning and systematically monitor and implement actions.<br>(-) high investment costs<br>(-) lack of financial resources<br>(+) Data monitoring can generate savings | (+) transparent services at any occasion will increase public trust and confidence in local authorities<br>(+) new jobs created, impact on fuel poverty<br>(+) allowing evaluation city plans implementation<br>(+) availability of local and accurate energy data<br>(+) driving forces for engaging energy data providers<br>(+) support (data based) social innovations<br>(+) The solution could be approved by the residents | (-) Smart City Platform is a project of the city, but it is still in design phase.<br>(-) Low experience in open data management. Inexistence open data platform<br>(-) failure to share data of institutions or individuals<br>(+) Processing (aggregating or disaggregating) and modelling of raw data provided by data providers at national, regional and local levels<br>(+) Possibility to correlate data and estimate local energy consumptions and GHG emissions<br>(+) Energy planning facilitator improves access to energy data for energy planning purposes.<br>(-) Need of expert management | (+) Joint participation of local authorities and experts and joint efforts against climate change<br>(+) only benefits | (-) until 2 years ago there was a monopoly of energy of ENEL. Now the market has been liberalized and data collection is much more difficult.<br>(-) Complicate privacy procedures in data management<br>(-) restriction for the sharing of individual private data with third parties<br>(-) no obligations for TSO and DSO to provide local energy data to public authorities at sub-national level<br>(+) Sustainable energy legislation needs to have provisions that facilitate easy access to energy data by all Public Authorities | (+) P-T-S National center for ciber-security (INCIBE) is settled in Leon city; with a wide experience and skills on ciber-security that can act as lever to solve some barriers; In addition, there is considerable number of SMES from IoT and ICT sector.<br>(+) No direct interference in space. |

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| | | | | (-) Problems with integration to current systems<br>(-) There may be potential problems with the integration of various IT systems. | | (-) Legal regulations regarding data protection always raise legal problems. | |
| S8a High Speed data transfer network | (+) help you make more accurate decision<br>(+) Existing strategy at national level<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (+) Public funds to develop that kind of projects<br>(-) The economical context of the city in general it is not a good one. There is a lack of financial resources (private and/or public)<br>(+) As European, national and regional policies are in favor of energy efficiency it is a good momentum to get public funds to develop that kind of projects<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) many stakeholder like Confindustria, Confartigianato, private companies and others have agreed to Making City project and well understood the potential<br>(-) security and resillience of the system<br>(+) The solution could be approved by the residents | (-) failure to share data of institutions or individuals<br>(-) difficulties of collect and follow the data<br>(+) possibility to use the existing government high speed transfer network implemented to connect the public institutions<br>(-) There may be potential problems with the integration of various IT systems. | (+) help you make more accurate decision<br>(+) only benefits | (-) Legal regulations regarding data protection always raise legal problems. | (+) P-T-S National center for ciber-security (INCIBE) is settled in Leon city; with a wide experience and skills on ciber-security that can act as lever to solve some barriers; In addition, there is considerable number of SMES from IoT and ICT sector.<br>(+) No direct interference in space. |

| Name of the Solution | POLITICAL | ECONOMIC | SOCIAL | TECHNICAL | ENVIRONMENTAL | LEGAL | SPATIAL |
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| S9a Neighbourhood electro storage facility | (+) regional advertising campaign about this opportunity<br>(-) inadequacy of promotional campaign<br>(-) inadequacy of sustainable and integrated policies<br>(-) The Energy Storage Systems have not been set in any way in any official policy document<br>(-) Energy storage and energy storage systems are a new innovative technology, not yet proven among policy makers, design engineers, construction and engineering companies and also to individual households<br>(-) Energy storage infrastructure remains in a conflict with the FiT<br>(-) lack of a clear and specific regulatory approach to energy storage<br>(+) consistent with government policy | (+) Regional fiscal advantages for this kind of technology<br>(-) investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(+) financial savings of customers in mid or long-term<br>(-) Storage is economically not attractive option for households<br>(-) high investment costs required for deployment of PVs coupled with energy storage and also due to the low electricity costs currently marketed<br>(-) Currently there is also lack of appropriate compensation for the beneficial services that a storage system can provide to the grid.<br>(+)supported by subsidies<br>+) raising of ecological trends<br>(+) raising of wondering to new and smart technologies | (-) Not in my backyard<br>(+) raising of ecological trends<br>(+) raising of wondering to new and smart technologies<br>(-) difficulties of changing of daily routine<br>(-) Low level of awareness among the community about benefits of electricity storage<br>(-) There are no incentives for stimulating energy storage or increased RES self-production<br>(-)fear of costs, ignorance of technology<br>(-) difficulties of changing of daily routine | (-) technical failures for solar power storage installation<br>(-) Permission process for establishment of any rooftop PV installation in a building already connected to the grid can be obtained only as a backup source.<br>(+) The distribution grid system will require more flexibility if higher shares of renewable energy are integrated and energy storage is one of the available flexibility options<br>(+) Energy storage enables the optimization of production and consumption 'behind-the-meter'<br>(+) Energy storage is an alternative to provide more stability, reliability and resilience to transmission and distribution gridsp0<br>(-) effeciency of current technologies | (+) reduction of CO2 emissions<br>(-) ¿Noise?<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) legal barriers or legal limits for energy production and storage<br>(-) The current Law on Energy from Renewable Sources doesn't recognize energy storage, respectively energy storage systems<br>(-) no law prohibiting Electric energy storage in buildings with PVs, however there is also no clear signal whether is permitted. | (-) Difficulties to find free space in existing buildings or urban space<br>(-) lack of suitable area for installation<br>(+/-) the need to take into account local and building regulations |

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| S10a Phase transfer Liquid tank | | (-) investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(+) financial savings of customers in long-term (from bills, invoice of heating-cooling<br>(-) Not profitable as an investment | (+) increasing demand for individual energy production<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure | (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) Not applicable as it requires large volumes for a small amount of energy<br>(-) Requires a change in concentration to increase energy absorption | (+) reduction of CO2 emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | | (+/-) the need to take into account local and building regulations |
| S10b Seasonal storage | (-) Geothermal energy is not a priority in energy policies<br>(+) consistent with government policy | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs<br>(-) lack of financial resources | (+) Solution widely accepted and known to residents. | (-) Lack of detailed information about soil of the urban area and its behavior<br>(-) Some areas of the city are not very efficient for geothermal well<br>(+) Capability of high accumulative potential kW/m3<br>(-) High price of the dwelling process<br>(-) Not very applicable for this case as the efficiency is depending by the soil type and Vidin is near to big river<br>(+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set An example for public<br>(+) only benefits<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) Long and complicate administrative process to get permits, especially open transfer wells<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations |
| S10c Thermal Storage | (+) consistent with government policy | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (+) Solution widely accepted and known to residents. | (+) known technology, with a wide range of solution in currently market<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(+) Low energy transfer costs<br>(+) Technically, the solution is simple, common and proven. It is easy to apply.<br>(+) low energy transfer costs<br>(+) availability to proper technologies | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set An example for public<br>(+) only benefits<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (-) Difficulties to find free space in existing buildings<br>(+/-) the need to take into account local and building regulations |
| S11a Low Temp regional transfer pipeline | (+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs | | (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(+) very applicable for new buildings with new heating installations designed for low temperature mode<br>(-) not applicable to old buildings with high-temperature heating installations<br>(-) the need to change technology<br>(-) heating units should be radiant heating or fan coils (convective heating)<br>(+) low energy transfer costs | (+) only benefits<br>(+) reduction of CO2 emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections<br>(-) (+) pipelines are in a legal gap, they are not specifically considered in public services regulations<br>(-) Regulation on heat supply that states the supply and return temperature of the district heating providers | (-) Compatibility with other existing services that use shame soil under road space<br>(+/-) the need to take into account local and building regulations |

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| S11b Adjust geothermal district heating for using low temperature | (-)lack of geothermal potential | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs | (+) raising awareness and demand technological applications<br>(-) reluctancy about a new and unknown system | (-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(+) very applicable for new buildings with new heating installations designed for low temperature mode<br>(-) not applicable to old buildings with high-temperature heating installations installed<br>(-) heating units should be radiant heating or fan coils | (-) Some areas of the district are not very suitable for the geothermal applications.<br>(+) reduction of CO2 emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections | (-) Some areas of the district are not very suitable for the geothermal applications.<br>(+/-) the need to take into account local and building regulations |
| S11c Connection to the low temperature district heat | (+) consistent with government policy<br>(-)Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | | (-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) existing thermal emitters of houses (mainly radiators) are high temperature ones<br>(-) the need to change technology | (+) reduction of CO2 emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections | (+/-) the need to take into account local and building regulations |
| S12a Building energy connectivity for energy sharing | (+) consistent with government policy<br>(-)Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | | (-) difficulties at integration of current systems<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(+) new buildings with new heating installations designed for low temperature mode<br>(-) not applicable to old buildings with high-temperature heating installations installed<br>(-) heating units should be radiant heating or fan coils | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set An example for public<br>(+) Improving environmental quality, mitigating the effects of climate change | | (-) Difficulties to find free space in existing buildings<br>(+/-) the need to take into account local and building regulations |
| S13a CO2 based heat pump | (+) consistent with government policy<br>(-)Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) technology transfer and implementation costs<br>(-) maintenance expenses<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (+) Solution widely accepted and known to residents.<br>(-) lack of experience and information | (-) lack of experience and information<br>(+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) reduction of CO2 emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations |
| S13b Advanced Heat Pump (high COP) | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies | (+) raising of ecological, innovative and economic trends<br>(+) aerothermal pumps are helping to introduce heat pump technology into housing energy systems, us there are currently a viable and quite common market solution<br>(+) Solution widely accepted and known to residents. | (-) difficulties at integration of current systems<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) lack of information and experiences<br>(+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) reduction of CO2 emissions<br>(+) raising of use of eco and recyclable materials<br>(-) Heat pumps generally has a remarkable reduction of their COP under very low temperature, and climate in Leon has many frosty days, that coincides with energy demand peak | (-) En-L Acoustic emissions<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations |

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| | opportunity to scale market and product innovations | (+) lower energy consumption (costs) in the future | | | (+) Improving environmental quality, mitigating the effects of climate change | | |
| S13c Acoustic Air Heat Pump | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions<br>(+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (+) complaints about on noise pollutions<br>(+) Solution widely accepted and known to residents. | (-) difficulties at integration of current systems<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(+) Technically, the solution is simple, common and proven. It is easy to apply. | | (-) lack of noise audit<br>(-) lack of legal obligation<br>(-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations |
| S13d Acoustic Hybrid heat pump | (+) consistent with government policy<br>(-) Supporting only the simplest technologically solutions - lost opportunity to scale market and product innovations | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses<br>(+) financial savings of customers in mid or long-term<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (+) raising of ecological, innovative and economic trends<br>(+) raising of wondering to new and smart technologies<br>(+) Solution widely accepted and known to residents.<br>(-) lack of experience and information | (-) difficulties at integration of existing systems<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) lack of experiences and information<br>(+) Technically, the solution is simple, common and proven. It is easy to apply. | (+) Reduced negative effects of climate change in life<br>(+) only benefits<br>(+) reduction of $CO_2$ emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) In the case of old buildings (tenements), the unregulated legal status of ownership is a common problem, which makes it impossible to undertake investment activities. | (+/-) the need to take into account local and building regulations |
| S13e Geothermal Heat Pump | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions<br>(-)lack of geothermal potential | (-) high investment costs<br>(+) incentives and grants<br>(-) lack of financial resources<br>(-) technology transfer and implementation costs<br>(-) maintenance and repair expenses | (+) raising of ecological, innovative and economic trends<br>(+) raising of wondering to new and smart technologies | (-) difficulties at integration of existing systems<br>(-) difficulties of implementations<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) Lack of detailed information about soil of the urban area and its behavior<br>(-) Some areas of the city are not very efficient for geothermal wells | (+) Reduced negative effects of climate change in life<br>(+) increasing awareness<br>(+) reduction of $CO_2$ emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) depends on individual initiatives<br>(-) Inadequacy of law and regulations<br>(+) Gaps in law and regulations<br>(-) Lack of incentives<br>(-) Lack of inspections<br>(-) Long and complicate administrative process to get permits, specially open transfer wells | |

| Name of the Solution | POLITICAL | ECONOMIC | SOCIAL | TECHNICAL | ENVIRONMENTAL | LEGAL | SPATIAL |
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| S14a Solar PV on roofs and parking lot | (+) the national government is lancing a green new deal that should increase the investment in solar PV<br>(+) Existing strategy at national and regional level<br>(+) Existing financial mechanisms<br>(+) In recent years, a lot of projects have been implemented, which aimed to co-finance the installation of solar installations in private households.<br>(-) Much less emphasis on using the solution in public space. | (-) Lack of economic resources (public and private). There is a need of an initial investment that owners could not be able to afford<br>(-) Lack of economic resources (public and private). There is a need of an initial investment that owners could not be able to afford<br>(-) long term investment return<br>(+) Relatively cheap solution for single households. | (+) increasing awareness about environmental issues<br>(-) Complex legal framework<br>(-) Old-aged people with low inco.<br>(-) Vandalism (in parking lot)<br>(+) raising of ecological trends | (+) in the area of proposed PED there are several flat roofs where to collocate the PV panels<br>(-) In existing buildings, roofs and building structures may be not prepared to support additional loads.<br>(+) high solar potential of the region<br>(-) demand and offer of the power is not in accurate in time<br>(+) Technically, the solution is simple, common and proven. It is easy to use in individual households and public spaces. | (-) In protected areas material of roof must be ceramic curved tiles<br>(-) In protected areas material of roof must be ceramic curved tiles<br>(+) new bylaws (beyond national building laws) facilitating or compelling solar pv in new buildings could be an enabler<br>(-) Complicate legal system for prosumers<br>(+) The Lublin region is well sunny. | (+) new bylaws (beyond national building laws) facilitating or compelling solar pv in new buildings could be an enabler<br>(-) Complicate legal system for prosumers<br>(-) legal barriers or legal limits for energy production and storage<br>(+) No major difficulties in legal regulations. Property owner approval needed. | (+) Climate in Bassano is very appropriate for solar, hydro and wind energy<br>(+) Climate in Leon is very appropriate for solar energy<br>(+) Several open-air public parking lots available<br>(-) Few buildings have flat roofs. That are covered with tiles<br>(+) available space/roofs for installation<br>(-) Solutions of this type are practically not reflected in spatial plans. |
| S14b Building Integrated PV (on the façade) | (-) Long legal process<br>(-) The RES Low doesn't recognize energy storage<br>(-) No any net-metering or net net-billing scheme have been established in the country<br>(-) There is general uncertainty, due to the innovative aspect of the scheme, which renewable technologies will be facilitated in order a building to meet the 55 % renewable goal set in the nZEB definition.<br>(+) Existing strategy at national and regional level<br>(+) Existing financial mechanisms<br>(+) The solution should not raise objections on the part of local authorities. | (+) financial savings of customers in long-term (from bills, invoice of heating-cooling)<br>(-) High investment costs<br>(+) incentives and funds<br>(-) residential PV systems can be financially supported only through one scheme - the FiT scheme. However, the scheme is introduced in a way that doesn't stimulate investment.<br>(-) Low electricity prices compared to the high investments currently required for implementation of PVs are making them still unattractive solution<br>(+) Lower electricity costs for households<br>(-) long term investment return<br>(+) The solution is already relatively cheap but is rather not dedicated to individual households. | (+) raising of eco-friendly implementations trends<br>(+) raising of wondering to new and smart technologies<br>(-) The PV technologies still sound in abstract way to the community<br>(-) low level of awareness among end users<br>(+) increasing awareness about environmental issues<br>(+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) Lack of experience in practice<br>(-) Sun blockage of existing building heights<br>(-) In existing buildings, building façades or structures may be not prepared to support additional loads.<br>(-) Permission process for establishment of any rooftop PV installation in a building already connected to the grid can be obtained only as a backup source.<br>(-) Households PV implementation is accompanied with autocratic and time-consuming procedure<br>(+) high solar potential of the region<br>(+) already a lot of technology suppliers at the local market<br>(-) demand and offer of the power is not in accurate in time<br>(-) Lack of experience in the use of such a solution in Lublin. | (+) Set an Example for people<br>(+) The Lublin region is well sunny. | (-) legal barriers or legal limits for energy production and storage<br>(-) There is only one compensation policy for small-scale residential PV installations put on practice in the country, namely the Feed in Tariff (FiT) scheme. It is a policy mechanism designed to accelerate investment in renewable energy, where small-scale residential and non-residential PV installations are distinguished according to their capacity<br>(-) In order a household to implement a residential rooftop PV system it should meet a number of national requirements and also clear a number of procedures before actual pilot implementation takes place<br>(+) No major difficulties in legal regulations. Property owner approval needed. | (+) available space/roofs for instalation<br>(-) potencial eastetical negative effects to living environment<br>(-) Solutions of this type are practically not reflected in spatial plans. |
| S14c Floating Solar pontoons | (-) The water reservoir located in Lublin is to play a recreational and sport role and various activities of local authorities are heading in this direction. | (-) Limited Municipal budget<br>(-) Lining comes expensive from face<br>(-) risk infestation<br>(-) high investment costs<br>(-) long term investment return<br>(-) The water reservoir located in Lublin requires other, necessary outlays (cleaning from sediments). | (+) raising of eco-friendly implementations trends<br>(+) raising of wondering to new and smart technologies | (+) wide sea coastline<br>(+) higher efficiency due to the fact that the modules are cooled by the evaporating water below the<br>(-) many risks due to the potential for destruction in natural disasters<br>(-) Variable river level<br>(-) Difficulty in transporting the energy received<br>(-) risk of freezing of the water surface | (+) The Lublin region is well sunny. | (-) River space is competence of a public regional administration (Confederación Hidrográfica del Duero) and use permits are under its jurisdiction | (-) Few water surface within the city<br>(-) availability of water surface<br>(-) Solutions of this type are practically not reflected in spatial plans. |

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| | | | | (-) There is a large water reservoir in Lublin, but it is not in the close vicinity of buildings. | | | |
| S14d Solaroad | (+) The solution should not raise objections on the part of local authorities. | (+) incentives and funds<br>(-) limited municipal budget<br>(-) High investment costs<br>(-) new investment and employment field<br>(-) High infestation in risky technologies<br>(-) long term investment return<br>(-) The solution probably increases the costs of road investments. | (+) raising of eco-friendly implementations trends<br>(+) raising of wondering to new and smart technologies<br>(+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) difficulties at integration of existing infrastructure or road surface<br>(-) time and labor constraint<br>(-) incompatibility of infrastructure<br>(-) Poor performance because there is no optimal angle of inclination, this results in less power and more often shades<br>(-) The panels are also covered with dirt and dust and require much thicker glass than ordinary panels to withstand the traffic burden, further limiting light absorption.<br>(-) air circulation is impeded, panels will inevitably heat up more than photovoltaic panels placed on roofs<br>(-) demand and offer of the power is not in accurate in time<br>(-) Lack of experience in the use of such a solution in Lublin. | (+) negative effects of climate change in life<br>(+) increasing awareness<br>(+) The Lublin region is well sunny. | (+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |
| S15a Hybrid Heat collector | (+) The solution should not raise objections on the part of local authorities. | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) Mismatch of energy management systems | (+) reduction of $CO_2$ emissions<br>(+) raising of use of eco and recyclable materials<br>(+) Set An example for public<br>(+) Improving environmental quality, mitigating the effects of climate change | (+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |
| S15b PVT Panels* | (+) The solution should not raise objections on the part of local authorities. | (+) financial savings of customers in long-term<br>(-) High investment costs<br>(+) incentives and funds<br>(-) maintenance and repair expenses<br>(+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future | (+) raising of eco-friendly implementations trends<br>(+) raising of wondering to new and smart technologies<br>(+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) difficulties at integration of existing systems<br>(-) inadequacy of knowledge of new implements and technologies<br>(-) time constraint<br>(-) difficulties of transferring technology | (+) reduction of $CO_2$ emissions<br>(+) Improving environmental quality, mitigating the effects of climate change<br>(+) The Lublin region is well sunny. | (-) legal barriers or legal limits for energy production and storage<br>(+) CTE requirements about ACS production in residential buildings<br>(+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |
| S15c Ridge Boiler | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions<br>(+) The solution should not raise objections on the part of local authorities. | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) Mismatch of energy management systems<br>(-) Lack of experience in the use of such a solution in Lublin. | | (-) legal barriers or legal limits for energy production and storage<br>(+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |

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| S16a Near to surface Geothermal energy | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions | (+) financial savings of customers in long-term (from bills, invoice of heating-cooling)<br>(-) High investment costs<br>(+) incentives and funds<br>(+) Surface-mounted soil collectors are a cost-effective alternative to a geothermal heat pump. | (+) raising of eco-friendly implementations trends<br>(+) raising of wondering to new and smart technologies | (+) very efficient during operation.<br>(-) horizontal collectors require a large area | (-) environmental pollutions<br>(+) reduction of CO2 emissions<br>(+) Improving environmental quality, mitigating the effects of climate change | (-) lack of legal regulations | |
| S16b Deep Geothermal District Heating | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and collaboration among the public-public or public-private sector institutions | (-) investment costs | | (-) difficult access to geothermal energy in our region (Very Deep)<br>(-)lower geothermal pootential in the area | | | |
| S17a Heat recovery system from AC and sewage water | (+) The solution should not raise objections on the part of local authorities. | (+) financial savings of customers in long-term (from bills, invoice of heating-cooling)<br>(-) High costs<br>(+) incentives and funds<br>(+) The solution is already relatively cheap but is rather not dedicated to individual households. | (+) raising of eco-friendly implementations trends<br>(+) raising of wondering to new and smart technologies<br>(+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) sewage water heat recovery system is carried out in an off-site facility<br>(-) Lack of experience in the use of such a solution in Lublin. | | (+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |
| S17b Heat recovery system from return pipeline to DHW | (+) The solution should not raise objections on the part of local authorities. | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-) Mismatch of energy management systems<br>(-) Lack of experience in the use of such a solution in Lublin. | (+) regulation for district suppliers states that it is obligatory (a scheme when DHW load exceeds the heating load energy recovery from return pipeline to DHW is obligatory) | (+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |
| S17c High pressure waste water digester | (-) Inadequacy of sustainable and integrated policies.<br>(-) lack of communication and colalboration among the public-public or public-private sector institutions<br>(+) The solution should not raise objections on the part of local authorities. | (+) Acquiring funds for implementation from EU funds, grants, subsidies<br>(+) lower energy consumption (costs) in the future<br>(-) High implementation costs | (+) The solution would be approved by the residents as long as the aesthetic values are preserved. | (-)Mismatch of energy management systems<br>(-) Lack of experience in the use of such a solution in Lublin. | | (-) lack of authorization for district municipality<br>(+) No major difficulties in legal regulations. Property owner approval needed. | (-) Solutions of this type are practically not reflected in spatial plans. |

| Name of the Solution | POLITICAL | ECONOMIC | SOCIAL | TECHNICAL | ENVIRONMENTAL | LEGAL | SPATIAL |
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| S18a Integrated Sustainable Energy Planning | (+) positive view towards energy saving and sustainability of new way of living<br>(-) needs of different political levels can be confronted<br>(-) there is lack of collaboration between different administrations<br>(-) Lack of technical skills and energy data collection in municipalities | (+) two different hydroelectric power plants are already present in the municipal territory<br>(-) local resources can be more expensive than others<br>(-) there are not many economical resources (nor public neither private)<br>(-) Insufficient resources in terms of time, costs or tools to undertake energy planning and | (+) there is a general positive feeling of Bassano citizens about using local products and resources<br>(-) integrated solutions can be studied for implementing collaboration between stakeholder<br>(+) the use of local resources can be an enabler us there is a general positive feeling of Leon citizens about using local products and resources<br>(-) integrated solutions can face social confrontation between different | (-) Mismatch of energy management systems<br>(-) lack of monitoring of energy system at local and urban level<br>(-) Availability of data: Often, there are insufficient data available for energy planning purposes or for improving the energy efficiency of public and domestic sector buildings<br>(-) The challenge of using energy data and statistics is complex; | (+)Bassano del Grappa is located at the end of a valley: wind and water flow constantly<br>(-) image and landscape preservation can be confronted with exploitation of some resources (solar or wind infrastructures)<br>(+) rational use of some resources can help to environmental preservation | (+) heritage law that create problem for using the natural energy<br>(-) next year the energy market will be totally free in Italy<br>(-) Energy regulation is a national competence, but urban planning is regional<br>(-) Lack of obligations for data providers in energy data sharing with public authorities | (+) the extension of the town is large and give the possibility of different site for collecting energy<br>(-) Leon municipality has a small surface and the city is quite dense<br>(-) Insufficient consideration of energy issues and sustainable development in the spatial planning process. |

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| | (-) Poor information at local level on thermal renewable sources, difficulties to get information<br>(-) Lack of coordination structures<br>(+) Local and Regional Energy Observatories established to support Sustainable energy plans<br>(+) awareness about necessity of sustainable planning in municipality<br>(+) The growing perception of energy issues as priority problems at various levels (global, national, regional).<br>(-) Basing the Polish energy economy on hard coal and the reluctance of central authorities to move away from this model, which also translates into solutions at the regional and municipal level. | systematically monitor and implement actions.<br>(-) lack of resources for implementation operations resulted from planning<br>(+) Quite a lot of support for the replacement of individual (in households) heat sources, e.g. boilers, heat pumps, solar and photovoltaic installations.<br>(-) Due to the average wealth of the population, decisions in households are often based on the economic calculation. | neighborhoods, urban areas or regions (not in my backyard, not by my property, not my resources, etc.)<br>(-) Commercial sensitivity and data privacy can hinder the collection and use of data.<br>(+) raising of awareness about ecological trends through presenting of best practice<br>(+) increasing of participation different stakeholders on implementation of plans<br>(+) increasing of quality of live for end-users<br>(+) Social pressure to implement solutions to reduce smog and emissions of harmful substances. | continuously engaging with a range of stakeholders is important for raising awareness and understanding data, but also for identifying stakeholder needs and priorities in order to develop tailored and durable solutions.<br>(+) some undertaken and recognizable projects related to sustainable energy planning<br>(-) Limited possibilities to dedicate sufficient human and time resources necessary to develop the plan. | (e.g. use of forest biomass can help to forest maintenance)<br>(+) Regularly inventory of the GHG | (-) Strict data protection regulations in Bulgaria<br>(+) No major difficulties at the level of legal regulations in Lublin. | |
| Solution 19 Business Model | (+) Possibility to development of innovative business solutions<br>(-) no business model in Lublin | (+) lower investment cost | (-) fear of public-private partnership | (+) greater possibilities in Lublin | (+) only chances in Lublin | (+) No major difficulties at the level of legal regulations in Lublin. | |
| Solution 20 Social Awareness | (+) Implemented project for effective stakeholders' involvement in the process of amending, improving and implementing the municipality's policies<br>(+) Possibility to generate successful, innovative business ideas and community projects<br>(+) Social awareness is considered in all municipality's strategic plans<br>(-) No socially just strategy decarbonisation in Poland and a restructuring plan<br>Silesia mining areas | (+) High social awareness for energy efficiency will decrease the energy costs<br>(+) Social awareness campaigns don't require high budget<br>(-) emission reduction solutions are more expensive than standard ones<br>(+) funding | (+) there is a program of meeting with the population for creating a positive feeling about MC<br>(-) Energy efficiency is not recognized as a major issue for consumers, as energy costs are often low compared to the cost of many other factors.<br>(-) lack of user friendly tool for presentation of energy effeciency matters for public (visualization, interpretation of detailed data in proper form for public)<br>(-) emission reduction solutions are more expensive than standard ones<br>(+) funding | (-) the need to involve an external company | (+) Social pressure to implement solutions to reduce smog and emissions of harmful substances. | (-) Practice shows that problems most often arise from the diversity of owners, with different social, financial, age and psychological profile, which leads to a poorly functioning mechanism for managing condominium buildings.<br>(+) No major difficulties at the level of legal regulations in Lublin. | (-) Insufficient consideration of energy issues and sustainable development in the spatial planning process. |

# ANNEX II SPEC CARDS of SOLUTIONS

## S01a Wind strategies

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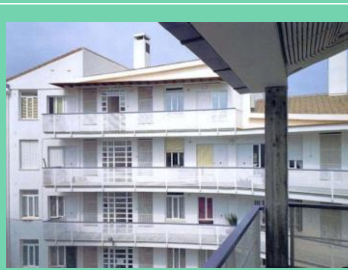
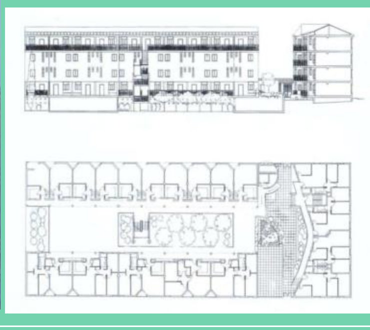
| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
| | Category 1<br>LOW ENERGY DEMAND | | |
| | Solution 0.1<br>Climate change adaptation - District Strategies | | |
| Title | Graphical Detail | | |
| S0.1a<br>Wind strategies |     | | |
| | 49 dwellings complex with natural ventilation and other bioclimatic strategies<br>- Location: San Pedro de Alcántara, Málaga, Andalusia, Spain<br>- Area: 2500 m2<br>- Year of commitment: 1993<br>- Funding Type: Public | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| San Pedro de Alcántara (Spain) | No | Margarita de Luxán (ETSAM, Universidad Politécnica de Madrid)<br>Subsequent studies of energy monitoring and analysis of the building in use:<br>CIEMAT (Center for Energy, Environmental and Technological Research) www.ciemat.es | |
| **Implementation Time** | 3 years | **Initial Investment** | 1,653,600 € |
| What is Solution? | | How does it work? | |
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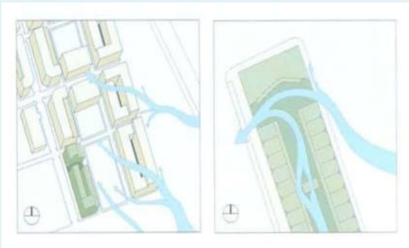
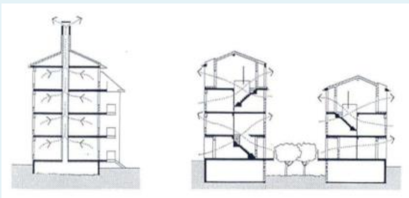
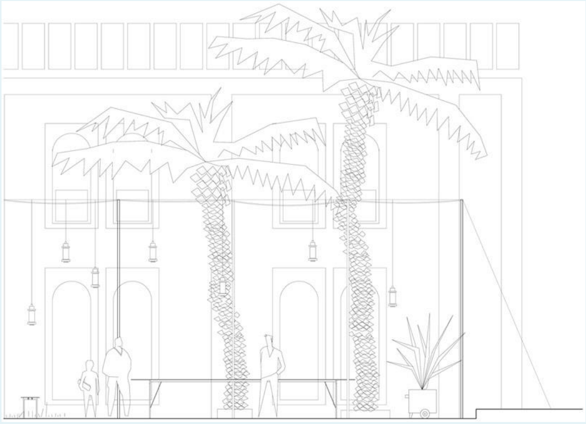
| Wind studies and layout and shape strategies for building volumes and housing distribution, to achieve the best natural ventilation.<br><br> | Climate studies indicated the need for different seasonal uses, and mainly for cooling in summer. The overall volumetry of the set has been designed, therefore, to take advantage of the seasonal wind and breeze regime. The dominant ones in the area are the following:<br>• Terral: it comes from the Northwest, from the interior, of a dry and gusty character, it alternates with the levante in a breeze and wind regime.<br>• Poniente (west): it comes from the Atlantic, with a humid and temperate character.<br>• Levante: comes from the Southeast; Of humid and fresh character it is alternated with the terral in breeze regime, dominating in the daytime hours.<br>• South of the Strait: it comes from Tarifa, produces storms. On the plot, the mountains that cover the north front obstruct the passage of the terral, raising it and preventing the wind and breeze regime from being so clear, and there are buildings that cut the poniente, so the winds that act on the building are the south in summer and the levante throughout the year. It is the action of this last wind, dominant in summer, that has been sought for cooling, adapting the volumetry of the building for its use. All dwellings are developed with at least two opposite orientations on the facades, facilitating cross ventilation due to temperature differences between them. In duplex dwellings, the effect is increased with the ventilation established between the two levels. Specific, new elements have been designed for this project, such as solar cooling chimneys, which suck up the hot air accumulated in the upper part of the rooms and which are statically self-regulated by their shape and orientation, for a suction action in the hottest months. |
| **Stakeholder Analysis** | |
| **Developer** (if relevant) Who has developed this solution? | Regional Government of Andalusia |
| **Operator** Who is operating this solution? | Office of Public Works and Transportation of the Regional Government of Andalusia |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | Architects: Margarita de Luxán G. de Diego, Flavio de Celis D'Amico, Ernesto Echevarría Valiente |
| **Business Model Patterns** | |
| Public investment (Resilient strategy) | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |

| | |
|---|---|
| The houses are designed trying to make the best use of the capacities of the environment in the aspects of solar collection, natural cooling, seasonal variations, as well as the specificity in the choice of materials and construction details, and in the creation and plant treatment of outdoor use spaces. | Political:<br>Economic:<br>Social:<br>Technical:<br>Environmental:<br>Legal: |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The research has been conducted so that it could be carried out with extremely economic and simple means, so that the solutions that it provides can be incorporated into the promotions of publicly promoted housing without higher costs than usual. | The premise to carry out this project has been the consideration that bioclimatic or energy conscious buildings are not so much the result of an application of specific techniques, as of the maintenance of a logic, directed towards the adaptation and use of environmental conditions, maintained during the planning and design process of the architectural form; without losing the rest of the implications: constructive, functional, aesthetic, economic, etc. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| **(1)** Luxán García de Diego, M. de, Celis D'Amico, F., Casa Martín, F. da, Echeverría Valiente, E., Villota Rocha, I. de. (1997). 49 viviendas en San Pedro de Alcántara, Málaga. In Dirección General de Arquitectura y Vivienda (Junta de Andalucía) (Ed.), Arquitectura y clima en Andalucía. Manual de diseño (pp. 213-220). Sevilla: Consejería de Obras Públicas y Transportes de la Junta de Andalucía. (ISBN 84-8095-095-1) | |
| **(2)** Article about the project in the book 'Arquitectura y clima en Andalucía. Manual de diseño' (Spanish) | |
| **(3)** The project was presented at the Third European Conference on Architecture "Solar Energy in Architecture and Urban Planning" (Florence, 1993) and published by the Commission of the European Community | |
| **Reference Applications of this Solution** | |
| **(1) Microclimate** is a major part of urban living and is experienced by people in public spaces. The main elements affected by microclimate on a city level are: the temperature, humidity ,wind and solar radiation | http://www.iaacblog.com/programs/urban-microclimate/ |
| **(2)** WINEUR projects EU: | https://ec.europa.eu/energy/intelligent/projects/en/projects/wineur |
| **(3)** WINEUR projects EU - Wind Turbines Guide: | http://www.urban-wind.org/pdf/SMALL_WIND_TURBINES_GUIDE_final.pdf |
| **(4)** WINEUR projects EU - Report: | https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/wineur_publishable_result_oriented_report.pdf |
| **(5)** Rheologic: Basic Urban Wind Effects - Video: | https://rheologic.net/en/urban-wind-assessment |
| **(6)** Wind based urban design in dense urban context. Prefacing wind nuisance and optimizing the human wind comfort for outdoor relaxation. | https://repository.tudelft.nl/islandora/object/uuid:71f03228-175e-40b0-9fd2-5be4480dcfec/datastream/OBJ1/download |
| **(7)** Air flow: | https://salientedge.com/blog/2018cleaning-up-the-big-smoke |

## S01b Solar orientation strategies

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY DEMAND<br>Solution 0.1<br>District level strategies according to local environmental conditions | |
|---|---|---|
| Title | Graphical Detail | |
| S0.1b Solar orientation strategies | <br>The Bab al Bahrain pavilion is a temporary public space that had been transformed into a comfortable area with several activities for the public, by using only the perks of the site, a minimal light structure and a low-tech element to protect from the sun. | |
| City / Country | Making_City | Technical Partner Name & contact Details |
| Bab Al-Bahrain, Manama (Bahrain) | No | Noura Al Sayeh & Leopold Banchini |
| Implementation Time | 2012 | N/A |
| What is Solution? | | How does it work? |



The Bab al Bahrain pavilion is a temporary public space. It had an extraordinary success during its permanence and it was constantly used and visited, it held events and even workshops. Its success can be attributed to a good mix of factors, the first one surely being the special value of the place and the second one the its good bioclimatic design based mainly on shadowing.

The first good virtue of this project is the creation of the public space itself, closing the crossing to the traffic and giving back this historical place to the citizens, although it was only for a limited time this demonstrated the power of this kind of intervention and the need for quality public space that this city has. The second important virtue was the design of a comfortable public space using only the perks of the site, a minimal light structure and a low tech element to protect from the sun.

Based on a regular grid of thin steel columns the project is basically made by its "canopy", a light sun-reflecting fabric (generally used in greenhouses) that reflects most of the energy of the sun giving to the place a nice diffused illumination. To make this design really effective the architects took advantage of a large fountain already existing in the site, the fountain with its fresh water favours evapotranspiration and contributes to lower the temperature of the air, favouring a light breeze that crosses the pavilion.

Lowering the square's temperature with this intervention favours the reduction of energy demand (air conditioning...) of the surrounding buildings.

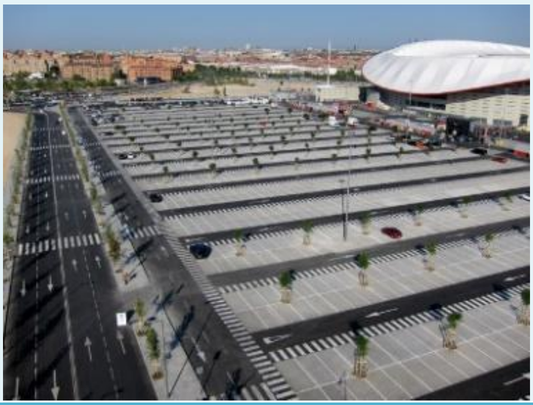
Material Used:
1. Reflective shade mesh for the cover
2. Metallic painted pillars
3. Glass and steel showcases

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Ministry of Culture, Kingdom of Bahrain |
| Operator Who is operating this solution? | Office of Public Works and Transportation of the Regional Government of Andalusia |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| Implementer Who is implementing this solution? | Syed M. Ahmed, Masy Int. Creative wrought iron factory. Bu Hussain aluminium and mirrors. |
| Financer How / By whom has the implementation of this solution been financed? | Manama Capital of Arab Culture 2012, Ministry of Culture, Kingdom of Bahrain |

| | |
|---|---|
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Architects: Noura Al Sayeh & Leopold Banchini |
| **Business Model Patterns** | |
| Space rental<br>Leasing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Shadowing elements combined with vegetation and water bodies (fountains, lakes,...) favor evapotranspiration and contribute to lower the temperature of the air. This favors the reduction of energy demand (air conditioning,...) of the sourrounding buildings. | **Political:**<br>**Economic:**<br>**Social:**<br>**Technical:**<br>**Environmental:**<br>**Legal:** |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The choice of a light structure and easy assembly dry materials allows easy repair and maintenance. Likewise, this is an economic solution. | Lowering the square's temperature with this intervention favors the reduction of energy demand (air conditioning...) of the sourrounding buildings.<br><br>The creation of quality public space, closing the crossing to the traffic and giving back this historical place to the citizens. In addition, a thermally comfortable public space contributes to achieve citizens comfort and allows that several activities take place. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| **(1)** Bar Al Bahrain Pavillion - Archdaily | https://www.archdaily.com/222125/bar-al-bahrain-pavillion-noura-al-sayeh-leopold-banchini |
| **(2)** Bar Al Bahrain Pavillion - Metalocus | https://www.metalocus.es/es/noticias/bab-al-bahrain-pavillion-por-noura-al-sayeh-leopold-banchini |
| **(3)** Bar Al Bahrain Pavillion - Designboom | https://www.designboom.com/architecture/noura-al-sayeh-leopold-banchini-bab-al-bahrain-pavilion/ |
| **(4)** Bar Al Bahrain Pavillion - Archello | https://archello.com/project/bab-al-bahrain-pavillion |
| **(5)** Video | https://vimeo.com/manama |
| **Reference Applications of this Solution** | |
| **(1) Microclimate** is a major part of urban living and is experienced by people in public spaces. The main elements affected by microclimate on a city level are: the temperature, humidity ,wind and solar radiation: | http://www.iaacblog.com/programs/urban-microclimate/ |
| **(2)** Tejiendo la calle: | https://submarina.info/tejiendo-la-calle/ |
| **(3)** Palette 2030 Solar Shading: | http://www.2030palette.org/solar-shading/ |

## S01c Water resources strategies

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY DEMAND<br>Solution 0.1<br>District level strategies according to local environmental conditions | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S0.1b Water resources strategies | <br>Permeable concrete parking in the Atlético de Madrid Stadium | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| Madrid (Spain) | No | Cruz y Ortiz Arquitectos<br>+34 910 052 675 / info@cruzyortiz.com | |
| Implementation Time | 2011 - 2017 (Whole project of the stadium | Initial Investment | 20 - 35 €/m2 |
| What is Solution? | | How does it work? | |



The permeable pavements are a supporting structure, which allows the passage of both pedestrians and vehicles, as well as the filtering of the runoff towards a lower layer of temporary storage (sub-base), composed of gravels, cells and/or reticular boxes. After storage, water is evacuated by infiltration or through drains. The surface layer may be of continuous pavement, such as porous concrete or asphalt, or modular. The latter type includes porous pavers, permeable joint pavers or reinforced grass.

It is not recommended in places with heavy vehicle traffic (e.g. trucks), places with high sediment loads or areas where there are many trees.

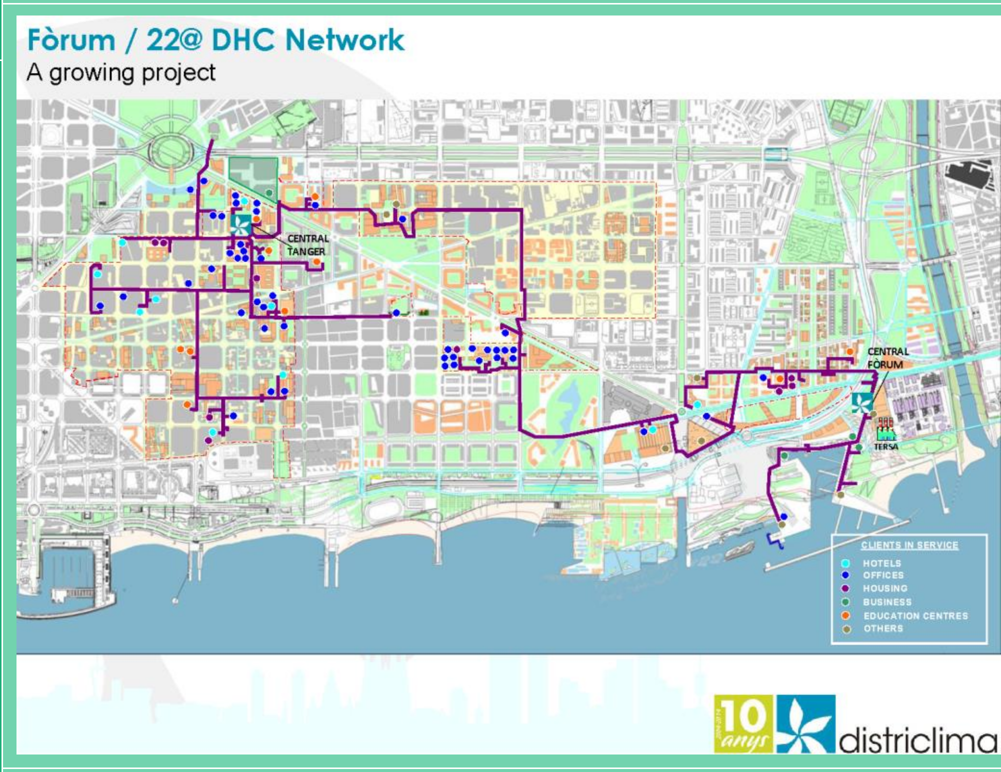
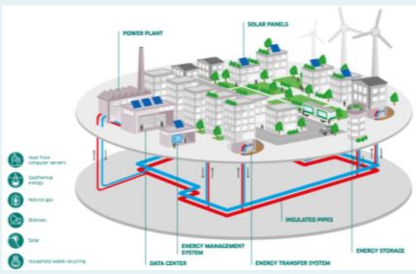
The urbanization project on the Atlético de Madrid Stadium has implemented SUDS techniques using permeable pavements and buried detention tanks. On the parking beaches, the deposit is constituted by the granular sub-base itself on which the permeable concrete of the parking spaces sits. The application of SUDS allowed to reduce, in a global way, approximately the 69% of the peak flows for the design storm (return period 10 years and peak intensity of 60.2 mm / h) compared to a conventional scheme (waterproof pavement + drain to collector).

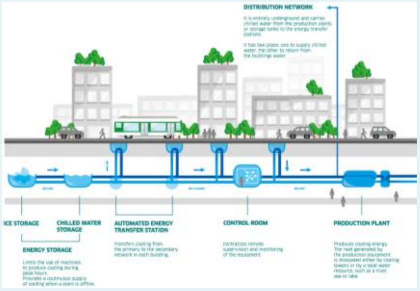
| Stakeholder Analysis | |
|---|---|
| **Developer** (if relevant) Who has developed this solution? | Ministry of Culture, Kingdom of Bahrain |
| **Operator** Who is operating this solution? | FCC |
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | Atlético de Madrid Club |

| | |
|---|---|
| **Implementer** Who is implementing this solution? | Cruz y Ortiz Arquitectos |
| **Financer** How / By whom has the implementation of this solution been financed? | Atlético de Madrid Club |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Service Provider: Ecobloc system - GRAF |
| **Business Model Patterns** | |
| Municipal utility<br>Rising block tariff | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | **Political:**<br>**Economic:**<br>**Social:**<br>**Technical:**<br>**Environmental:**<br>**Legal:** |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | · Reduction of the flow and volume of stormwater runoff.<br>· Improvement of water quality by retaining sediments, oils, fats, heavy metals and some nutrients.<br>· Reduces the area dedicated only to runoff management, as it allows the transit of both pedestrians and vehicles.<br>· Possible aquifer recharge and rainwater use.<br>· Wide variety of designs and flexibility to adapt to different urban environments.<br>· It needs to be integrated into a treatment chain, as it has no inherent capacity to eliminate contaminants. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| (1) Videos | https://www.youtube.com/watch?time_continue=21&v=EPRguq1WC34<br>https://www.motor16.com/videos/alfalto-topmix-permeable-el-suelo-del-futuro/ |
| (2) GRAF - SuDS system | https://www.grafiberica.com/suds-drenaje-sostenible.html |
| **Reference Applications of this Solution** | |
| (1) SuDS: Sustainable drainage systems guide: | https://www.madrid.es/UnidadesDescentralizadas/Agua/TODOSOBREAGUA(Informaci%C3%B3nSobreAgua)/SistemaUrbanosDrenajeSostenible/Gu%C3%ADa%20b%C3%A1sica%20de%20dise%C3%B1o%20sistemas%20de%20gesti%C3%B3n%20sostenible%20de%20aguas%20pluviales.pdf |

| | |
|---|---|
| (2) SuDS: Sustainable drainage systems excel calculation: | https://www.madrid.es/portales/munimadrid/es/Inicio/Medio-ambiente/Agua/SUDS-sistemas-urbanos-de-drenaje-sostenible/?vgnextfmt=default&vgnextoid=05ae02fc13557610VgnVCM2000001f4a900aRCRD&vgnextchannel=63d0e0f6fdc4f510VgnVCM2000001f4a900aRCRD |
| (3) SUD - Atlantis: | https://donosticity.org/la-empresa-suds-del-donostiarra-peio-lasa-entre-los-premios-europeos-de-medio-ambiente/ |
| (4) CONAMA - Water and city SuDS: Sustainable drainage systems: | http://www.conama.org/conama/download/files/conama2018//STs%202018/10_preliminar.pdf |
| (5) Nature-based solutions for local climate adaptation in the Basque Country: | http://growgreenproject.eu/wp-content/uploads/2018/05/NBS-Climate-Adaptation-Basque-Country.pdf |
| (6) Ecopolis - Ecosistema Urbano | https://ecosistemaurbano.com/plaza-ecopolis/ |
| (7) GrowGreen Project - Managing flooding with nature-based solutions in Brest: | |
| (8) Técnicas de Drenaje Urbano Sostenible | |

## S01d Ground coupling strategies

| SPEC CARD | DEMAND SIDE SOLUTIONS | |
|---|---|---|
| | Category 1<br>LOW ENERGY DEMAND | |
| | Solution 0.1<br>District level strategies according to local environmental conditions | |
| Title | Graphical Detail | |
| S0.1d Ground coupling strategies |  | |
| | In Spain, ENGIE operates the country's first heating and cooling network: Districlima in Barcelona, which recover the heat generated by household waste processing for re-use as heat for a heating network and to produce chilled water. The network supplies 94 buildings. | |
| City / Country | Making_City | Technical Partner Name & contact Details |
| San Pedro de Alcántara (Spain) | No | Districlima, S.A.: Engie: 50,8% Tersa: 20% Agbar: 19,2%<br>ICAEN: 5% IDAE: 5%<br>info@districlima.es |
| What is Solution? | | How does it work? |
|  | | Central Forum:<br>Heat and cold are produced taking advantage of the steam generated in the combustion of urban solid waste of the neighbouring TERSA treatment plant.<br><br>The production equipment is cooled by seawater, obtaining high yields, without the use of cooling towers. |

| | |
|---|---|
|   | Energy management is optimized using an accumulator tank of ice water of 5,000 m3. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | Districlima, S.A. |
| Operator Who is operating this solution? | |
| Customer(s) or user(s) Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | Barcelona City Council |
| Implementer Who is implementing this solution? | |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Municipal utility | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| This solution might be complemented with other energy efficiency solutions. | **Political:**<br>**Economic:**<br>**Social:**<br>**Technical:**<br>**Environmental:**<br>**Legal:** |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Similar projects focused on heating and cooling:<br>· In Marseille, three ENGIE subsidiaries (ENGIE Cofely Climespace, ENGIE Ineo and ENGIE Axima) have developed a new solution that uses a very local source of renewable energy: the heat of energy content of the Mediterranean Sea. Located at the Grand Port Maritime de Marseille, the Thassalia marine geothermal plant is the first in France and the wider Europe to use marine thermal | The Districlima solution helps to improve the quality of life of the neighborhoods:<br>· The reduction of CO2 emissions and the reduction of fossil fuels. In 2015, Districlima avoided the emissions into the atmosphere of 17,678 ton of CO2, with a reduction in the use of fossil fuels of 59%.<br>· The lack of machinery for air conditioning in buildings connected to Districlima translates, among others, in the absence of noise and vibration in the buildings and thus improving the acoustic quality of the city.<br>· Improvement in the air temperature of the neighborhood, by drastically reducing the equipment that refreshes the interior of the buildings, at the cost of emitting heat to the outside.<br>· Reduction of the global consumption of water and chemical products: elimination of cooling towers and other equipment that |

| | |
|---|---|
| energy to provide heating and cooling for all the buildings connected to its network - a combined footprint of 500,000 m2 ultimately - at the same time as reducing greenhouse gas emissions by 70 %.<br>· In Lisbon, the heating and cooling network operated by Climaespaço is famous for being the first city-scale centralized thermal energy distribution network. It has reduced the capital's annual CO2 emissions by 40 %, and serves 130 buildings. | consume water and chemical additives (biocides, water treatment, etc.).<br>In addition to these global benefits for the city, users of the buildings connected to the network enjoy the following advantages:<br>· Energy supply guarantee: the heat and cold network has excess supply, both in production plants and in thermal production equipment.<br>· Outsourcing of the thermal production service and associated risks (regulatory, service quality commitment ...).<br>· Elimination of machinery replacement costs, no breakdowns, and reduction of maintenance costs.<br>· Reduction of costs of supply of conventional energy (gas and electricity).<br>· Flexibility and adaptability. Ease to have more power, simply expanding the energy exchangers, with hardly any need for more space. |

**Relevant Publications / Presentations / Services / Products to this Solution**

| | |
|---|---|
| **(1)** Districlima web | https://www.districlima.com |
| **(2)** Districlima downloads | http://www.districlima.com/es/descargas |
| **(3)** Districlima Barcelona | https://www.construction21.org/espana/city/es/la-red-urbana-de-calor-y-frio-de-di en-barcelona-y-sant-adria-de-besos.html |
| **(4)** User Guide | http://www.districlima.com/districlima/uploads/descargas/guias-tecnicas/Gu%C3%ADa%20del%20usuario%20Districlima%20Rev2016.pdf |

**Reference Applications of this Solution**

| | |
|---|---|
| (1) ENGIE's worldwide operating presence - several projects | https://www.engie.com/en/businesses/district-heating-cooling-systems/ |
| (2) Training course on Geothermal District Heating | http://geodh.eu/wp-content/uploads/2014/11/Manual_corrected.pdf |
| (3) Sustainable cities with urban geothermal energy | http://www.conama11.vsf.es/conama10/download/files/conama2014/CT%202014/1896711817.pdf |
| (4) CHEAP-GSHPS PROJECT | https://cheap-gshp.eu/about-cheap-gshps-project/ |
| (5) Canadian Wells | https://www.ecopassivehouses.com/canadian-wells/<br>https://sgarq.com/en/canadian-or-provencal-well/ |

## S02a Cooling of surfaces

| SPEC CARD | DEMAND SIDE SOLUTIONS |
|---|---|
| | Category 1<br>LOW ENERGY DEMAND |
| | Solution 0.2<br>Climate change adaptation - District Strategies |
| Title | Graphical Detail |
| S0.2a Cooling of surfaces |   |
| | · The 'Passeig Sant Joan' (ENABLE project) is a promenade which connects the district of Gràcia with the Ciutadella Park. Part of it was redeveloped into one of the first Green Corridors in Barcelona, aiming at increasing ecological and social connectivity within the city.<br>· The total length of the renovated part is 1.2 km and it was completed in 2015.<br>· This design distributes the use of the space between: wide sidewalks, two car lanes, and a segregated bidirectional lane for bicycles.<br>· Eixample is one the districts with the lowest availability of green space per inhabitant. |
| City / Country | Making_City — Technical Partner Name & contact Details |

| | | | |
|---|---|---|---|
| Barcelona, Spain | No | · Lola Domènech (+34 932 683 277) ld@loladomenech.com<br>· Barcelona City Council<br>· BIMSA | |
| Implementation Time | May 2009 - May 2015 | Initial Investment | 4127161.73 |

**What is Solution?**

**How does it work?**

Objectives

To improve public space functionality and use, to increase access to green spaces for district residents (Eixample), to contribute to higher biodiversity in the city, and to promote more and different retail activity at the ground floor of buildings, so to rejuvenate/boost the local economy.

Actions

Urban regeneration was enabled through the introduction of green infrastructure that: 1) is more welcoming, provides high quality cultural and regulating ecosystem services —thus increases direct use values, attracts more people and more local businesses, 2) through its design favors ground floor service-based retailers (bars and restaurants), which are attractive both to locals and tourists. New green space and amenities promote children's play, relaxation, improved micro-cimate (shading) and less car circulation (pacification, better air quality), hence improving the quality of life in the area. Carbon sequestration is increased via an enlarged area for street trees and other vegetation comparing to traditional sideways in the city. The semi-permeable pavement and irrigation system installed in most part of Passeig Sant Joan allows for water collection and mitigates run-off while also promoting sustainable water use.

**Stakeholder Analysis**

| | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Barcelona City Council |
| Operator Who is operating this solution? | FCC ( fomento de construcciones y contratas) |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Barcelona City Council |
| Implementer Who is implementing this solution? | BIMSA |
| Financer How / By whom has the implementation of this solution been financed? | Proeixample S.A. (Ajuntament de Barcelona) |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Designer: Lola Domènech (+34 932 683 277) ld@loladomenech.com, Cicsa-engineer |

**Business Model Patterns**

Public investment

| (Resilient strategy) | |
|---|---|
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Validate it with other solutions if possible, as a technology package - Grouping of technologies Tech-non-tech. | **Political:**<br>**Economic:**<br>**Social:**<br>**Technical:**<br>**Environmental:**<br>**Legal:** |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Indicate if the system is already in use in other cities, kind of a valuation is also possible | General aspects about the solution. Could be technical, economical, environmental, social more space. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| (1) Article – Archdaily | https://www.plataformaarquitectura.cl/cl/625586/paisaje-y-arquitectura-remodelacion-del-paseo-de-st-joan-un-nuevo-corredor-verde-urbano-por-lola-domenech |
| (2) Article - think nature | https://platform.think-nature.eu/nbs-case-study/18419 |
| **Reference Applications of this Solution** | |
| (1) Green Pavements | https://www.vitoria-gasteiz.org/wb021/was/contenidoAction.do?idioma=es&uid=u3fb0f976_168551e92d9__7f62 |
| (2) Cooling Paint - Coolseal Los Angeles | https://www.youtube.com/watch?v=Y3qc7Hm3D7A<br>https://www.sciencealert.com/la-s-new-grey-streets-are-one-way-to-fight-back-against-climate-change |
| (3) Solar reflectance of materials | https://www.cement.org/docs/default-source/fc_concrete_technology/sn2982-solar-reflectance-of-concretes-for-leed-sustainable-sites-credit-heat-island-effect.pdf |
| (4) Cool Pavements - Reducing Urban Heat Islands: Compendium of Strategies | https://www.epa.gov/sites/production/files/2014-06/documents/coolpavescompendium.pdf |
| (5) Green Pavements - Urban GreenUp Project | https://www.urbangreenup.eu/solutions/green-pavements--green-parking-pavements.kl |
| (6) Palette 2030 Solar Shading | http://www.2030palette.org/solar-shading/ |
| (7) Nature-based solutions for local climate adaptation in the Basque Country | http://growgreenproject.eu/wp-content/uploads/2018/05/NBS-Climate-Adaptation-Basque-Country.pdf |

## S02b Evaporative cooling

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY DEMAND<br>Solution 0.2<br>Climate change adaptation - District Strategies | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S0.2b<br>Evaporative cooling | <br>Smart pavers to refresh from rainwater<br>- Location: Place du Forum, Montaudran, Toulouse<br>- Area: 130 m$^2$<br>- Year of commitment: 2018<br>- Progress Status: Delivered<br>- Funding Type: Public/Private Partnership | | |
| **City / Country** | **Making_City** | **Technical Partner Name & contact Details** | |
| San Pedro de Alcántara (Spain) | No | 2EI Veolia<br>https://www.2ei.veolia.com/en<br>contact@2ei.com | |
| **Implementation Time** | | **Initial Investment** | € 250,000 |
| What is Solution? | | How does it work? | |
| Urban cooling system that uses evaporative pavers fed by depolluting drains.<br><br>This innovative device, tested for the first time in Europe, is a solution to cool pedestrian spaces during periods of high | | This solution allows rainwater to be reused for non-potable use: urban cooling.<br>The innovation also lies in rainwater treatment: runoff water is collected and treated through depolluting drains (developed by Veolia) before being stored.<br><br>Rainwater is collected and stored. Under the paving stones, a system of drip pipes is installed and the mortar to fix the pavers allows the water to rise by capillary action during its evaporation. In case of drought, | |

<table>
<tr><td>temperatures, which reduces the effects of urban heat island.<br><br><br>Rainwater collected on the roadway and pre-treated by depolluting drains is injected together with potable water as a back-up, under a layer of paving stones capable of filtering these waters to the surface, where they evaporate. This evaporation allows to lower the temperature of the pavement locally and thus improve the comfort felt by pedestrians.</td><td>drinking water can take over, but the storage area is sized to cover 80 to 90% of needs, remaining neutral in terms of ecological balance.<br><br>The system is triggered when the weather sensor installed on the surface registers a certain level of heat. In the test phase, in summer, the ground cooling device has allowed a temperature reduction of more than 5°C and an improvement of the comfort index of 5°C.<br><br>It is an autonomous, fully automated solution: the cooling demand is controlled by meteorological sensors. The materials and equipment used are available on the market. The innovation lies in the management and monitoring of the system's performance through these UTCI measures.<br><br>The system can be remotely controlled by the user (to change the setpoints or parameters) and requires very little maintenance.</td></tr>
<tr><td colspan="2">Stakeholder Analysis</td></tr>
<tr><td>Developer (if relevant) Who has developed this solution?</td><td>Toulouse Métropole</td></tr>
<tr><td>Operator Who is operating this solution?</td><td></td></tr>
<tr><td>Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution?</td><td>Toulouse Métropole / Oppidea</td></tr>
<tr><td>Implementer Who is implementing this solution?</td><td></td></tr>
<tr><td>Financer How / By whom has the implementation of this solution been financed?</td><td>Caisse des Dépôts et Consignations</td></tr>
<tr><td>Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution?</td><td>Designer: 2EI Veolia Innove</td></tr>
<tr><td colspan="2">Business Model Patterns</td></tr>
<tr><td colspan="2">Public investment<br>(Resilient strategy)</td></tr>
<tr><td>Integration with other smart solutions</td><td>BARRIERS / ENABLERS _ PESTEL STUDIES</td></tr>
<tr><td>This solution is intended to be combined with other types of cooling solutions (vegetation,...) to create outdoor spaces.</td><td>Political:<br>Economic:<br>Social:<br>Technical:<br>Environmental:<br>Legal:</td></tr>
<tr><td>Potential for Replication</td><td>Expected Impacts - Benefits</td></tr>
<tr><td></td><td></td></tr>
</table>

| | |
|---|---|
| 2EI has developed innovative devices for humidifying pavements from recovered rainwater, raw water, etc. in Lyon, Toulouse and Nice (France).<br>In a similar system of evaporative pavers installed in Nice, the pavers come from the recycling of scallops, while those of Toulouse come from stone from Japan. | Innovation to fight urban heat island, that combines water recovery, decontamination and reuse through evaporation.<br><br>The solution could also be useful in winter to fight against snowfall since the water retained in the paving stones remains at a temperature of 10 to 15°C, which prevents the flakes from settling. |

| Relevant Publications / Presentations / Services / Products to this Solution | |
|---|---|
| (1) Case study description on Construction21 website | https://www.construction21.org/infrastructure/fr/smart-pavers-to-refresh-from-rainwater.html |
| (2) The project on Toulouse Métropole website | https://www.toulouse-metropole.fr/-/quand-la-fraicheur-vient-de-la-terre- |
| (3) 2EI Veolia website | https://www.2ei.veolia.com/en/news/2ei-solution-adapt-heat-waves-and-cool-city |
| (4) The project on the news (20 minutes) | https://www.20minutes.fr/toulouse/2533087-20190606-toulouse-lutter-contre-chaleur-voici-premiers-paves-rafraichissantes-testes-europe |
| (5) The project on the news (La Dépêche) | https://www.ladepeche.fr/amp/2019/05/29/a-toulouse-on-teste-les-premiers-paves-rafraichissants-deurope-en-cas-de-canicule,8228303.php |

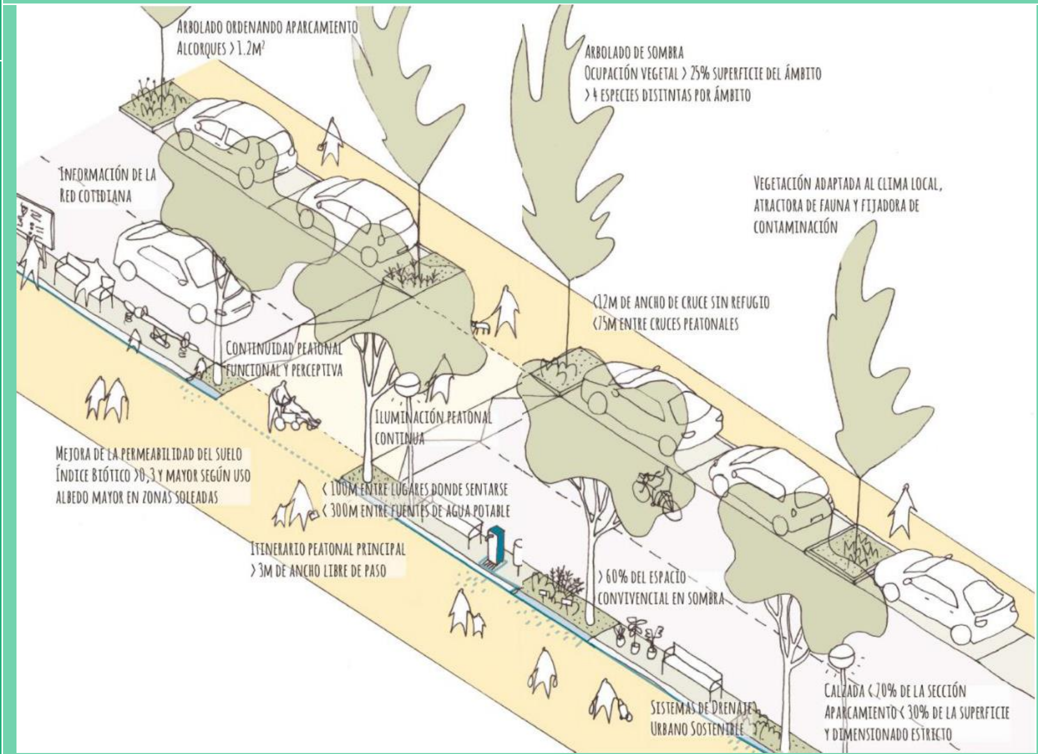
| Reference Applications of this Solution | |
|---|---|
| **(1)** Evaporative towers in Eco-boulevard project, Madrid (Spain) | https://ecosistemaurbano.com/eco-boulevard/ |
| **(2)** Ecoquartier Cœur de ville - La Possession - vegetation for evaporative cooling / climate mitigation | https://www.construction21.org/france/city/fr/ecoquartier-c%C5%93ur-de-ville-la-possession.html<br>https://www.construction21.org/france/data/sources/users/11111/d1315-possession-ref-dd-construction-final.pdf |
| **(3)** Green Roofs | https://www.apabcn.cat/documentacio/areatecnica/PDFS_SHAREPOINT/Presentacions/FA%C3%87ANES-VERDES-07-10-2016/RAMON-MARTINEZ.PDF |
| **(4)** Vertical Gardens - Ecoquartier fluvial de l'île Saint Denis | http://www.philippon-kalt.fr/wp-content/uploads/2017/12/PK_E2R_15-1440x1080.jpg<br>http://www.philippon-kalt.fr/index.php/project/165-logements-bbc-facade-manteau-legere/?lang=fr |
| **(5)** Palette 2030 - Vegetative cooling | http://www.2030palette.org/vegetative-cooling/ |
| **(6)** Palette 2030 - Constructed wetland | http://www.2030palette.org/constructed-wetland/ |
| **(7)** Nature-based solutions for local climate adaptation in the Basque Country | http://growgreenproject.eu/wp-content/uploads/2018/05/NBS-Climate-Adaptation-Basque-Country.pdf |
| **(8)** Madrid Río - urban cooling | https://urbandesignprize.gsd.harvard.edu/madrid-rio/ |
| **(9)** Article: public space for the extreme: evaporation | https://ecosistemaurbano.org/english/public-space-for-the-extreme-evaporation/ |

# S03a Foster clean mobility

| SPEC CARD | |
|---|---|
| | DEMAND SIDE SOLUTIONS |
| | Category 1<br>LOW ENERGY DEMAND |
| | Solution 0.3<br>Mobility (eliminate vehicles emissions) |

**Title:** S0.3a Foster clean mobility

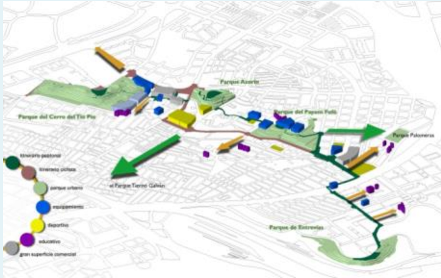
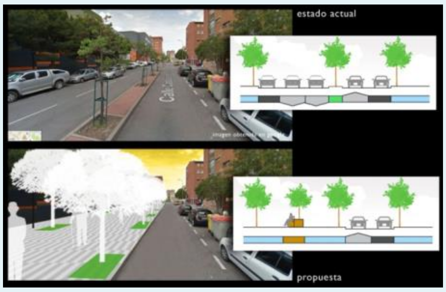
Graphical Detail




Pedestrian strategy for walkable districts:
· At least 1,000 more active travels per day
· High-quality pedestrian corridor improving accessibility

| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| Madrid (Spain) | No | · Carmen Hernanz - Madrid City Council - hernanzcmc@madrid.es<br>· Grupo de Estudios y Alternativas 21 (GEA21) | |
| **Implementation Time** | The measure is expected to be fully operational by October 2019 | **Initial Investment** | The total budget €236,875. This does not include the various construction works required, which will be financed through the Madrid City Council's regular budget |

| What is Solution? | How does it work? |
|---|---|
| | |

| | |
|---|---|
|    | Two pilot actions will be implemented in the living lab. The first one will implement a high-quality pedestrian corridor, connecting the major green areas in Puente de Vallecas, while improving north-south connectivity for pedestrians in the area. As action plan for a walkable district will improve access to key facilities (a hospital, cultural centre and a sports facility), and will connect them through a high-quality pedestrian axis, using physical design measures and new technology tools (e.g. smart signage). In particular, the plan will provide, more convenient access to the hospital to residents, crossing the current barrier created by a motorway. The high-quality pedestrian corridor will address both pedestrians and cyclists (also linking to Madrid's other CIVITAS ECCENTRIC measure 'Enabling cycling outside the city centre'). Several sections of this corridor are expected to be completed during 2018.<br>The second pilot action will transform a disconnected and car-dominated area into a high-quality public space devoted to pedestrian and social life. This will be addressed through the creation of an e-mobility centre (following the experience of similar CIVITAS ECCENTRIC measures in the cities of Munich and Turku, and also linked to Madrid's measure 'Enabling cycling outside the city centre') and will be coupled with a number of improvements in the pedestrian network in the vicinity of the e-mobility centre and in other streets within the city lab.<br>Both actions will be done in cooperation with residents and local stakeholders, following a participatory approach. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | Madrid City Council |
| Operator Who is operating this solution? | |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Madrid City Council |
| Implementer Who is implementing this solution? | |
| Financer How / By whom has the implementation of this solution been financed? | This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 690699. |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Designer: Grupo de Estudios y Alternativas 21 (GEA21) |
| **Business Model Patterns** | |
| | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| Pedestrian strategy for walkable districts is complemented with other 10 strategies (tech and non tech) included in the Booklet: https://civitas.eu/sites/default/files/civitas_eccentric_booklet_madrid_web.pdf | **Political:**<br>**Economic:**<br>**Social:**<br>**Technical:**<br>**Environmental:**<br>**Legal:** |

| Potential for Replication | Expected Impacts - Benefits |
|---|---|
| The project ECCENTRIC (H2020 CIVITAS), focuses on sustainable mobility in suburban districts and innovative urban freight logistics, two important areas that have previously received less attention in urban mobility policies.<br>It is being implemented in 5 cities: Torku, Stockholm, Munich, Ruse and Madrid. For more info visit: https://civitas.eu/eccentric/ | In Madrid, ECCENTRIC will drive the CO2 reduction foreseen in the Air Quality Plan, targeting 51,100 tonnes/year in the laboratory area, with an upscaling potential of 134,500 tonnes in the whole suburban area. Other benefits:<br>· 6% reduction of car travel in Madrid, related to those using the new HOV parking management scheme<br>· Achieve a modal share of 2% for bicycle trips in the lab area<br>· Increasing the modal share for walking by 6% in the lab area<br>· 10-30% decrease of average speed in living lab after safety plans implementation<br>· 50% of reduction in accidents with injuries in the lab area<br>· 10% increase in commercial speed and 9% increase in regularity levels in the new high level bus corridor<br>· 6 new hybrid buses providing 30% energy consumption savings, and noise reduction<br>· 3 pedestrian interventions and 3 traffic safety plans at the neighbourhood level based on a participatory design process<br>· 8% decrease in the number of children travelling to the school by car in the city lab<br>· 20 electric vehicles introduced in Madrid's municipal fleet<br>· 5 urban delivery companies testing e-vehicles in their fleets<br>· 30% reduction of km-goods, thanks to the implementation of a consolidation centre linked to the use of electric vehicles in Madrid<br>· Ultra low emission electric-natural gas distribution vehicle developed and tested in Madrid |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| (1) 2020 CIVITAS: Cleaner and better transport in cities ECCENTRIC Sustainable mobility solutions in Madrid (page 17) | https://civitas.eu/sites/default/files/civitas_eccentric_booklet_madrid_web.pdf |
| (2) Itinerario Miradores (Puente de Vallecas) - Urban regeneration strategies | https://www.arcgis.com/apps/MapJournal/index.html?appid=faaa60fa83364618b7238aafd1d78145 |
| (3) Itinerario Miradores (Puente de Vallecas) - Public Space Strategic Project | http://www-2.munimadrid.es/urbanismo_inter/visualizador/getPDF.do?id=47&nombrePDF=IT.13.02 |
| (4) Street Mix: design making tool to achieve "Complete Streets", ensuring that all streets are accessible to all people | https://streetmix.net/ |
| (5) Living lab area in Madrid | http://civitas.eu/eccentric/madrid |
| **Reference Applications of this Solution** | |
| (1) 2020 CIVITAS: Cleaner and better transport in cities ECCENTRIC | https://civitas.eu/eccentric |
| (2) Lyon Confluence - Mobility project | https://www.construction21.org/france/city/fr/lyon-confluence.html |
| (3) Palette 2030 - Transit Oriented Development | http://www.2030palette.org/transit-oriented-development/ |

## S1a Residential Building (High Rise) retrofitting

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 1<br>LOW ENERGY DEMAND | | |
| | Solution 1<br>Building Envelope Retrofitting in Residential buildings | | |
| Title | Graphical Detail | | |
| S1a<br>Residential Building (High Rise) retrofitting | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| Madrid (Spain) | Yes | · Sivakka (rental housing) | |
| Implementation Time | Autumn 2019 | Initial Investment | Exhaust air heat pump about 2000 e/kW. Sewage water heat recovery about 20 000 e. |

| What is Solution? | How does it work? |
|---|---|
| Improvement of energy efficiency in the block of flats, built in 1972. Solutions are:<br>-exhaust air heat pump, combined with district heating<br>-PV<br>-heat recovery from sewage water<br>-heating system balancing<br>-replacement of room thermostats<br>-ventilation air flow rate adjustment<br>-apartment-wise tap water metering<br>-continuous measurements (temp, humidity and pressure difference)<br>-new windows. | The larger applications here are described in more detail in their specific SPEC-cards. |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Several suppliers: e.g. GST Högfors, Ecowec. |
| Operator Who is operating this solution? | Sivakka |

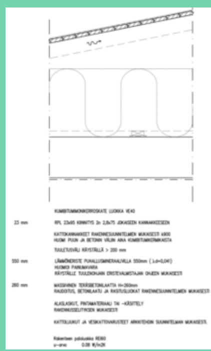
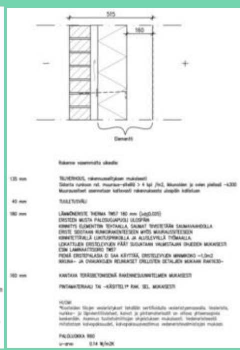
| | |
|---|---|
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | In the first-hand building owner, i.e. Sivakka. Finally the tenants, who pay the rent. |
| Implementer Who is implementing this solution? | Several suppliers |
| Financer How / By whom has the implementation of this solution been financed? | Own funding + EU (by Making-City) |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Oulu Energy |
| **Business Model Patterns** | |
| Shared savings<br>Power purchase agreement<br>White label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Not necessarily dependent on other solutions, but the feasibility is the better the more expensive and "dirty" is the heating energy to be replaced by HP. And vice versa, the cleaner the electricity, the better is HP from environmental point of view. In more detail, HP use timing impacts the effect on the whole system: the more the HP use is weighted towards cheap electricity moments (in Nordic el. market system), the better is also the environmental performance. | Political: Climate targets support this. No major barriers.<br>Economic: HP investment may have pay-back time of e.g. 10 years, sewage heat recovery 20. Window improvements are generally feasible in Finnish context mostly only if the windows must be renewed in every case.<br>Social: If the starting level is weak, then living comfortability is increased (not in this case due to tolerable starting point). However, nearly in every case the change of windows help to decrease the draught from cold window surfaces. HP installation with pre-fabricated modules does not harm the residents.<br>Technical: The building should have hydronic space and DHW heating system. Sewage water collection centralized bottom plumbing is needed.<br>Environmental: In right places and usage patterns HP may decrease the emissions. Adding HP to CHP DH system is however not always environmentally feasible. HP uses electricity and replaces CHP heat and in further CHP power production. Saved energy must also be compared with that of embodied energy in materials and indirect emissions. The renewal generally decreases emissions, but not always.<br>Legal: No significant barriers. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| High. There are a lot of buildings, for which this is applicable. The feasibility of the different solutions depends however on the specific building properties. In general, HPs like these here are the more feasible the larger is the building. E.g. water saving devices in turn are very scalable. | Savings in the energy cost, from the building owner point of view, can be calculated quite easily. They depend on the starting level and on the actions done. The system impact is more complicated and depends on the context. |

## S1b Residential Building (Private House) retrofitting

<table>
<tr><td rowspan="3">SPEC CARD</td><td colspan="3">DEMAND SIDE SOLUTIONS</td></tr>
<tr><td colspan="3">Category 1<br>LOW ENERGY DEMAND</td></tr>
<tr><td colspan="3">Solution 2<br>Building Envelope Retrofitting in Residential buildings</td></tr>
<tr><td>Title</td><td colspan="3">Graphical Detail</td></tr>
<tr><td rowspan="2">S1b Residential Building (Private House) retrofitting</td><td colspan="3"><br>The building is a rental house, currently populated, and includes 56 apartments distributed in 7 floors, with a total area of 2,900 m$^2$</td></tr>
<tr><td colspan="3">Windows change<br>Roof insulation<br>10 kWp PV to the façade (and on the roof will be installed in the end of 2020.</td></tr>
<tr><td>City / Country</td><td>Making_City</td><td colspan="2">Technical Partner Name & contact Details</td></tr>
<tr><td></td><td>Yes</td><td colspan="2">Sivakka (rental housing)</td></tr>
<tr><td>Implementation Time</td><td></td><td>Initial Investment</td><td>-</td></tr>
<tr><td colspan="2">What is Solution?</td><td colspan="2">How does it work?</td></tr>
<tr><td colspan="2">Windows have been changed already earlier. Roof insulation is increased. Heat recovery (HR) from exhaust air, district heating (DH) return water and sewage water have been added to the building. 10 kWp PV to the façade (see the figure) and on the roof will be installed in the end of 2020.</td><td colspan="2">The energy consumption before the renovation is 414 MWh/year (357 MWh for heating and 57 MWh in electricity). The annually estimated energy consumption after this renovation is 241 MWh (heat+electricity), which means 83 kWh/m2yr, below the Finnish goal of 140 kWh/m2yr for renovation buildings.” The impact is due to also other renovation measures than only the window renovation.<br><br>Windows have been changed already earlier. Roof insulation is increased. Heat recovery (HR) from exhaust air, district heating</td></tr>
</table>

| | |
|---|---|
| | (DH) return water and sewage water have been added to the building. COP of exhaust air HR is about 3 and that of DH about 5, according to the experiences this far. HR from sewage water saves DHW heating energy by about 25%. These are in line with the expectations. As a new action concerning the building envelope, the roof insulation is increased. 10 kWp PV to the façade (see the figure) and on the roof will be installed in the end of 2020. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | SIV |
| Operator Who is operating this solution? | SIV |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| Implementer Who is implementing this solution? | OE, OUK |
| Financer How / By whom has the implementation of this solution been financed? | SIV; OE, Making City |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Shared savings<br>Power purchase agreement<br>White label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Validate it with other solutions if possible, as a technology package - Grouping of technologies Tech-non-tech. | Political: Largely supported by politics<br>Economic: Long pay-back time, but low risk<br>Social: Especially in this case the rents must be kept low. Long-sight investments help in this.<br>Technical: No major barriers, partly new technology, however. Components, materials, and solutions have a good availability in general<br>Environmental: At some point the increase in e.g. insulation or building new buildings may override the savings. I.e. embodied energy may be larger than net energy consumed during use.<br>Legal: No remarkable barriers. “The spirit of the laws” concerning building support this. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| After showing the benefits there is a potential for replication by private owners. | The investments would decrease the total cost of living in the apartments. The long-term nature of the investments has been emphasized in public discussions. |

# S2a New High-Performance Building (residential)

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY DEMAND<br>Solution 2<br>New High performance residential buildings |
|---|---|
| Title | Graphical Detail |
| S2a New High Performance Building (residential) |   <br>Apartment block with low space and domestic hot water heating energy consumption |

| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| | Yes | Sivakka & YIT | |
| Implementation Time | Round 1,5 year | Initial Investment | 6,1 Me |

| What is Solution? | How does it work? |
|---|---|
| Ceiling U=0,08 W/m2K<br>Wall U=0,14 W/m2K, insulation 180 mm PU<br>Windows and doors U=0,6 W/m2K<br>Floor U=0,011 W/m2K<br>Exhaust air heat recovery (air-to-air), pre-heating and -cooling from soil layer under the building<br>Heat recovery with heat pump from district heating return line<br>Heat recovery from sewage water with water-to-water heat exchanger<br>Solar panels<br>Metering (temp, moisture, pressure difference in mech. ventilation)<br>Ventilation rate adjustable by inhabitant<br>Moisture-controlled ventilation in bathrooms | Good insulation and windows and heat recoveries from outcoming streams keep the basic heat consumption small. |

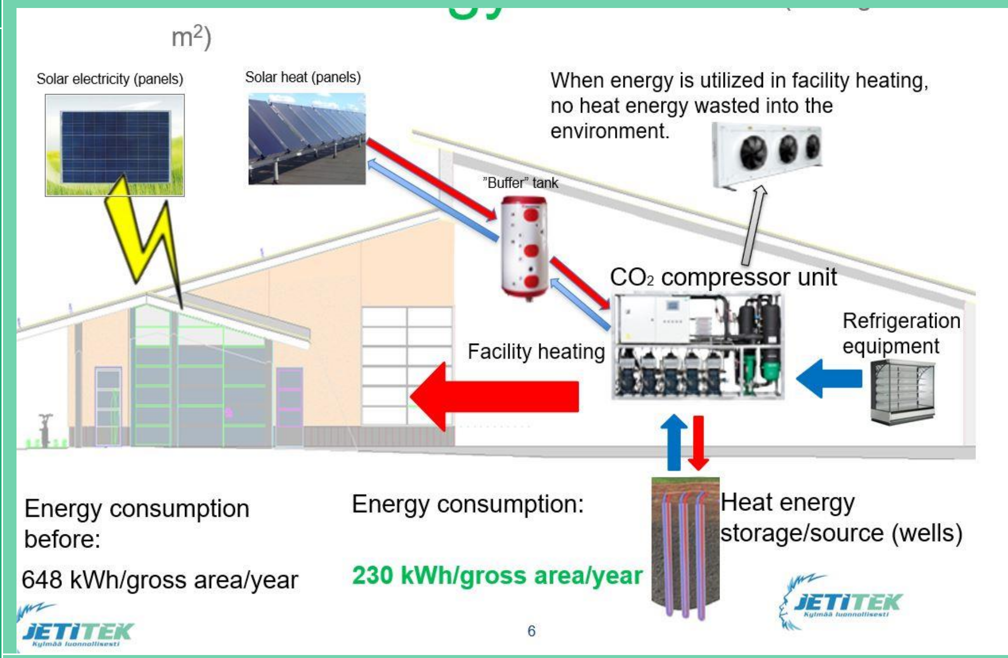
| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Several suppliers |
| Operator Who is operating this solution? | Sivakka |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Finally, the tenant |
| Implementer Who is implementing this solution? | Several suppliers |
| Financer How / By whom has the implementation of this solution been financed? | Own funding |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | All people, who has something to do with the buildings |
| **Business Model Patterns** | |
| Pay-back time varies solution by solution, but in general the improvement over the minimum level set by law (which is quite high already) has a pay-back time of e.g. 20 years. However, the risk is generally low, so the investments are feasible in long term.<br>One time payment<br>Loans | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Not necessarily dependent on other solutions, but the feasibility is the better the more expensive and "dirty" is the heating energy the use of which is decreased or be replaced by HP heat. | Political: Largely supported by politics, even if the populistic parties tend to resist may "green" issues<br>Economic: Long pay-back time, but low risk<br>Social: Especially in this case the rents must be kept low. Long-sight investments help in this.<br>Technical: No major barriers, partly new technology however. Components, materials and solutions have a good availability in general.<br>Environmental: At some point the increase in e.g. insulation or building new buildings in general may override the savings. I.e. embodied energy may be larger than net energy consumed during use.<br>Legal: Good support by Finnish legislation ang gets probably even better. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Very largely replicable | See barriers/enablers. This kind of energy performance is probably at least close to the lowest-cost alternative in long term. |

## S3a Retrofitting of the office building

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY CONSUMPTION<br>Solution 3<br>Building Envelope Retrofitting Tertiary buildings | | |
|---|---|---|---|
| Title | Graphical Detail<br> | | |
| S3a Retrofitting of the office building | Efficient use of multiple energy resources: geothermal heat pump for heating and cooling, solar energy | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | WAM, GRO, ITBB (Geocomfort) | |
| Implementation Time | | Initial Investment | 1.320.000 € (250,000 €EU) |
| What is Solution? | | How does it work? | |
| The retrofitting is a combination of several measures; from implementing thermal energy storage combined with a geothermal heat pump [A26] to installation of smart thermostats for temperature control [A7]. The 'HeatMatcher' concept that optimizes heating and cooling supply and demand and maximize use of renewable energy sources [A10]. Uncertain actions are implementing new HR+++ glass [A4], PV on roofs and parking lot [A11], PVT [A21] and thermal storage in Mediacentrale [A30]. | | | |
| Stakeholder Analysis | | | |
| **Developer (if relevant)** Who has developed this solution? | | | |

| | |
|---|---|
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Tenants |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | EU funding for 250 k €, the rest is self-financed |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Energy and operational cost savings<br>Shared savings<br>Power purchase agreement<br>White label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| It is a combination of different interventions. There are complementary actions like:<br>Advanced energy metering [A7], [A8],<br>HeatMAtcher for Mediacentrale [A10],<br>S14a - PV in roofs and parking lot [A11],<br>S15b - PVT in Mediacentrale [A21],<br>Geothermal heatpumps [A26],<br>S16a-Geothermal District Heating [A27],<br>Thermal Storage in Nijestee [A29],<br>High pressure waste water digester [A31],<br>Smart Charging Stations [A33] | **Political:** The management structure of WAM consists of shareholde have to decide on investments. This sometimes hampers the efficie implementation.<br>**Economic:** Every measure needs to have a solid BC that is supported shareholders.<br>**Social:**<br>**Technical:** Not every technique can be realised considering th construction of the building.<br>**Environmental:** The current environmental impact is rather bad, but improved significantly after the execution of all the measures.<br>**Legal:** Always applies |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The geothermal system is already being used by the city. | The building will be disconnected from the gas network and will not use fosil fuels after the project, PV installations will allow to reduce electricty consumption which will reduce fosil fuel energy demand as well as CO2. The energy bills will be lower and have an economic benefit. |

# S4a New High-Performance Building (Shopping Mall)

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY CONSUMPTION<br>Solution 4<br>New high performance tertiary buildings |
|---|---|
| Title | Graphical Detail |
| S4a New High Performance Building (Shopping Mall) |  Efficient use of multiple energy resources: heat dwells, solar and heat recovery |



| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| OULU | Yes | ARI, JET, OEN, VTT, OUK | |
| Implementation Time | | Initial Investment | Depending of the scale, payback time less than 2 years |

| What is Solution? | How does it work? |
|---|---|
| The system is based on advanced heat pump technology using environmentally friendly CO2 instead of F-gases. When cooling the beverages, the heat pump produces equal amount of heat. This heat is used in the building for heating, for hot domestic water and surplus can be also distributed to other surrounding buildings with reginal heating pipeline. | Efficient use of heat pump technology with advanced scada system, used to optimise the peaks and balance the use of heat and cold.<br>Heat dwells used to get extra energy or to store surplus to the ground (seasonal storage)<br>Solar panels for operating the system (100% self-sustainability on the summer period) for the heat and cold<br>Heat and cold storage by phase change material (improved energy coefficient)<br>Heat recovery from the AC system<br>50% improvement compared to the buildings with the similar size |

| | |
|---|---|
| The heat surplus can also be stored to heat dwells. | |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | Jetitek |
| Operator Who is operating this solution? | Jetititek (since 9/2019 Caverion OY) |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | This solution is being used in 50 shops in the ARINA grocery store chain in Finland |
| **Implementer** Who is implementing this solution? | Arina implements this solution wih the help of Jetitek to every new and refurbished shop |
| **Financer** How / By whom has the implementation of this solution been financed? | The financing is coming from Arina the owner |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Depending the size of implementation, typical reduction in energy bill 50%, payback time less than 2 years<br>One time payment<br>Direct financing<br>Loans<br>Access to cross subsidies | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Best when connected with DH network, since then it is possible to utilize the excess heat. | **Political:** Quite techical and invisible solution that do not require anything special from the society, so no poitical barriers. Climate-friendly, so possible support from political groups supporting these targets.<br>**Economic:** very good, payback and references available<br>**Social:** highly appreciated by consumers<br>**Technical:** a solid tested model<br>**Environmental:** $CO_2$ based, environmentally safe<br>**Legal:** Targets to decrease the use of F-gases makes this even more attractive |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The system can be replicated in Europe. In Finland the estimated potential to feed heat to DH network is about 1 TWh/a, i.e. 1/80 of the total space heating and DHW end-user consumption in Finland. | 50% savings in the energy consumption of the grocery store.<br>One good, easily usable source of heat for DH network, decreasing the electricity use of the heat pumps and thus that of the whole heating system. |
| **Reference Applications of this Solution** | |
| 45 existing systems by ARINA; the most advanced developed for MAKING CITY project with the ability to share the resources with neighboring buildings | |

## S4b New High-Performance Building (Academy Building)

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY CONSUMPTION<br>Solution 4<br>New high performance tertiary buildings | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S4b New High Performance Building (Academy Mall) | <br>'- geothermal heat pump (LTH) for heating and cooling ,<br>- solar energy,<br>- mechanical ventilation with heat recovery, | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | SEV, RUG, SB | |
| Implementation Time | | Initial Investment | |
| What is Solution? | | How does it work? | |
| The Energy Academy Europe is a tertiary building which houses both lecture rooms and offices with a surface of 9,636 m2 and was completed in 2016. It is the most sustainable teaching building in the Netherlands due to a BREEAM Rating Outstanding score of 89.62%.<br>The building is using a heat pump system based upon a district geothermal heat pump. The system is a low temperature heating system which is also used for cooling. -<br>Technical information HP: …. | | This building contains a geothermal heat pump and has 1,600 solar panels on the roof. The panels are arranged in various angles to allow more panels on the roof and thus increase energy performance. | |

| | |
|---|---|
| Expected energy consumption per year for heating is: and for cooling it is:<br>Solar boilers are installed for hot water use.<br>There is mechanical ventilation system with heat recovery.<br>For lighting there is movement detection sensors There are also 1600 panels with a xx MW capacity. Expected electricity generation is xx MWh per year. | |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Academics, students |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Energy savings, maintenance cost savings<br>Onetime payment<br>Loans | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | **Political:** Part of national and regional policies and strategies<br>**Economic:** high investment costs, lack of financial resources<br>Social:<br>**Technical:** time constraints, inadequacy of knowledge of new implements and technologies<br>**Environmental:** reduction of CO2 emissions<br>**Legal:** Lack of incentives |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The system can be replicated in Europe with similar climatic conditions | High. There are a lot of buildings, for which this is applicable. Savings in the energy cost, from the building owner point of view, can be calculated quite easily by comparing consumptions of a similar building with conservative systems. The CO2 reduction can also be calculated for environmental performance. |

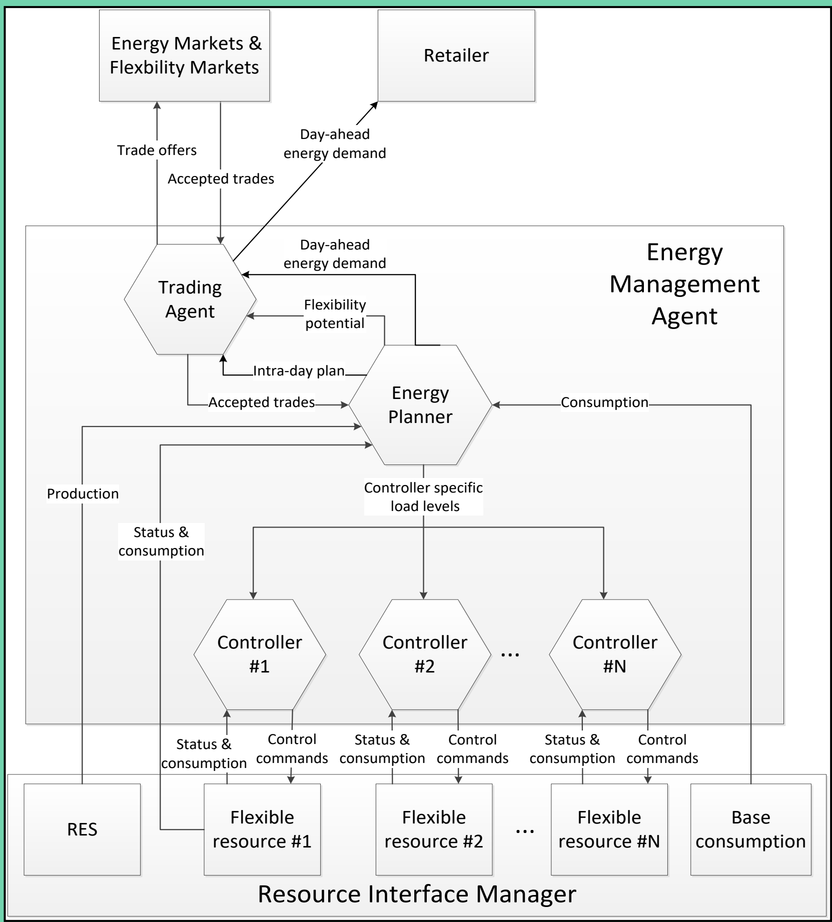
## S4c New High-Performance Building (Sport Complex)

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 1<br>LOW ENERGY CONSUMPTION<br>Solution 4<br>New high performance tertiary buildings | | | |
|---|---|---|---|---|
| Title | Graphical Detail | | | |
| S4c New High Performance Building (Sport Complex) | <br>Efficient use of multiple energy resources: geothermal heat pump (LTH) for heating and cooling, solar energy, flooting solar pontoons, | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | Yes | GRO, WAR | | |
| Implementation Time | | Initial Investment | € 15,500,000 | |

| What is Solution? | How does it work? |
|---|---|
| The sports complex building combines sports-, educational-, office- and meeting room facilities. The sports facilities have a total surface area of 4208 m2, while the remaining occupies 1107 m2 of space. The construction of this energy positive building was finished by the end of 2018.<br>- The building is using a heatpump system based upon a district gothermal heat pump. The system is a low temperature heating system which is also used for cooling. A 800 lt buffer tank will also be installed. The energy consumption is expected to be 61 MWh for heating and 7 MWh for cooliing with 67 tones CO2 avoidance.<br>- Solar boilers are installed for hot water use with an expected energy consumption of 32 MWh and CO2 reduction of 14.4 tons | WarmteStad provided heating and cooling to the building (Action 27). The PVT panels (Action 20) provide hot water for the sportscomplex and are also used for the balance of the hot and cold wells of the geothermal heatpump system. The PV panels on the roof provide enough electricity for the building to become energy positive (Action 11). In the surrounding area Floating solar pontoons are planned (Action 15). Apart from the building 180 Floating Solar pontoons (156.6 kWp) will be installed in the channel behind the building (Action 15) as well as an innovative SolaRoad (Action 16), consisting on a dedicated bike lane with solar panels integrated (70 kWp). For the purpose of energy monitoring and demand/response smart controls will be installed (Actions 7- 8). |

| | |
|---|---|
| - There is mechanical ventilation system with heat recovery.<br>- For lighting there is movement detection sensors<br>- There are also 1040 panels with an expected generation of 247 MWh/y capacity. | |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Academics, sports people, students |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Energy savings, maintenance cost savings<br>One time payment<br>Loans<br>Power purchase agreement<br>White label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| [A7], [A8], [A11], [A16], [A17], [A27], [A31] | **Political:** Such an ambitious building has a strong political support.<br>**Economic:** Because of the political and social benefits it was allowed to invest more than usual.<br>**Social:** The facilities of the building strongly promote sports activities and a healthy life style.<br>**Technical:** The building is energy positive and also has a great deal of extra smart functionalities.<br>**Environmental:** Very positive. Carbon neutral.<br>**Legal:** Very positive. Carbon neutral. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Indicate if the system is already in use in other cities, kind of a valuation is also possible. | Savings in the energy cost, from the building owner point of view, can be calculated quite easily by comparing consumptions of a similar building with conservative systems. The CO2 reduction can also be calculated for environmental performance.<br>Electricity: 265 MWh/y<br>Heat/hot water: 71 MWh/y<br>Expected CO2 reduction: 78 ton<br>Pontoons: 133 MWh/y<br>Solar road: 60 MWh/y<br>Solar parks share: 22 MWh/y |

## S5a Smart Control / Advanced Metering / Wireless Advanced Control in Buildings

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 2<br>IMPROVE ENERGY EFFICIENCY<br>Solution 5<br>Smart Building / Home energy controllers |
|---|---|
| Title | Graphical Detail |
| S5a Energy Management Agent for energy optimization and demand response |  |
| | - Novel solution for energy optimization and bottom-up based demand response,<br>- Energy Management Agent (EMA) automates flexibility management on building-level,<br>- EMA provides a load plan and flexibilities for each site,<br>- Supports peer-to-peer and aggregation-based flexibility management,<br>- Deep learning technologies utilized for learning building dynamics and optimal control policies |



| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| OULU / Finland | Yes | VTT | |
| Implementation Time | | Initial Investment | € 47.500 (€ 43.500 EU) |

| What is Solution? | How does it work? |
|---|---|
| EMA optimizes the energy usage within a site by controlling flexible resources and trading energy via local markets in order to maximize the reward function (i.e., objective) defined by the end-user. Typically, the reward function is money, but it can also include environmental aspects such as $CO_2$ emissions. The money part of the reward function can in turn include various aspects such as the energy price, power tariffs, local power generation and cross-commodity energy trade.<br><br>Energy Management Agent is designed to interact with the outside world (i.e., other Energy Management Agents and/or Aggregators) via local markets. | EMA can be divided into three logical parts as: Trading Agent, Energy Planner and Controller(s). The Trading Agent is the Energy Management Agent's Interface to energy markets. It is responsible for maximizing the flexibility potential of the site in the markets by trading energy with other market participants.<br>The Energy Planner is a central component of the EMA. It is responsible for planning and optimizing the energy usage within the site at all times. The basic functionality of the Energy Planner can be roughly divided into four parts:<br>1. Once a day, before the day-ahead market closes, the Energy Planner provides the Trading Agent with a forecast of the next day's energy demand.<br>2. Continuously during the day, the Energy Planner provides forecasts of the load for a configurable time window. Again, the Energy Planner can utilize information on the generation, demand and flexibility forecast, as well as, various incentives for making the plan.<br>3. The Energy Planner provides the Trading Agent with information about the flexibility potential of the site. This information contains the maximum up and down flexibility as well as the minimum price for adjusting the load in a given direction.<br>4. The Energy Planner monitors and plans the site overall load profile and assigns individual load profiles for each flexible resource. This is done continuously to be able to adapt to trades and other changes in the day-ahead demand plan.<br>Logically there is a Controller component for each flexible resource type within a site. Each Controller component is responsible for controlling a flexible resource according to the plan provided by the Energy Planner. Implementation of the Controller logic depends on the type of the resource. For example, with on/off device the Controller needs to manipulate the on/off pulse ratio so that the average load within the market resolution (i.e., 15 minutes) matches the load plan. With more complex devices such as heat pumps the control is executed by manipulating temperature set points |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | Several organizations. Here VTT as a main technical partner. |
| Operator Who is operating this solution? | Perhaps the best would be the energy company, together with the building owner. However, the will of the residents is the basis of everything. |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Building owner. Finally the residents pay everything, however. |
| Implementer Who is implementing this solution? | See above. |
| Financer How / By whom has the implementation of this solution been financed? | See above. |

| | |
|---|---|
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | All the supplying companies at least in investment phase. |
| **Business Model Patterns** | |
| Depends on the volatility of the energy prices. The higher, the higher streams. This can be studied separately with specific case years and equipment, if needed.<br>Municipal utility<br>Cooperative utility | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political: B: Inadequacy of sustainable and integrated policies, concerning the flexibility issue as a whole. E: Climate targets, emerging discussion about flexibility.<br>Economic: B: high investment costs, lack of incentives, financial savings of customers in long-term is unsure, possibly small savings compared to the required attention. E: Potential savings with certain preconditions.<br>Social: E: Increase of the customer's awareness about energy, B: doubt of self control, does not usually increase social status<br>Technical: B: difficulties of implementations, E: when a suitable model is created, the replication is in principle easy. No difficult technical problems to solve.<br>Environmental: Improving environmental quality through reduced greenhouse gas emission$CO_2$<br>Legal: B: electricity taxes are fixed c/kWh, but they should be %-based for this. E: General "spirit of the law" is in favour of these in many senses. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | -Enables end-users to take more active role in the energy markets<br>-Makes energy systems more predictable by providing incentive for end-users to plan and optimize energy usage<br>-Supports local flexibility management<br>- Supports RES integration<br>- Reduces $CO_2$ footprint |

## S5b Visualization Units to study human behaviour regarding the energy consumption

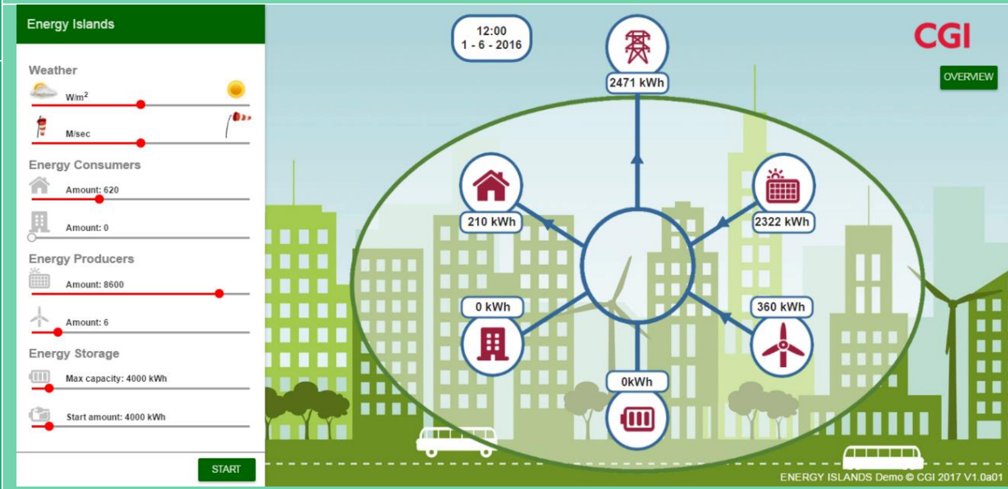
| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 2<br>IMPROVE ENERGY EFFICIENCY<br>Solution 5<br>Smart Building / Home energy controllers | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S5b Visulation Units to study human behaviour regarding the energy consumption | <br>Display units for visualization the energy consumption and comfort levels | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | **UOU**, SIV, OEN, OUK | |
| Implementation Time | | Initial Investment | € 8,480 |

| What is Solution? | How does it work? |
|---|---|
| Making-City project has developed an interface in which participants to the Making-City project can access their energy consumption, water consumption, evaluate their climate comfort and provide feedbacks on it, as well as information on their environmental impacts. The application shall also provide alternative and advice on how to act on the different topics, such as carbon emissions compensations, energy reduction and so on | 56 display modules (PDA) will be installed in building 1 and 50 display modules to building 2 to assess how human behaviour is affected by different information from the system. People living in the SIV buildings will have very comprehensive information of the local resources and energy balance. The assessment of human behaviour in terms of energy usage from both groups of people will be carried out. The digital application is to be available on in-home displays as well as on mobile devices. On top of the web interface accessible publicly, the interface of the digital mobile application allows following the status of the PED even if you are not a participant of the project nor have login information. Furthermore, the solar production, energy and environmental status of the electricity network are made available |

Stakeholder Analysis

| | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | UOU |
| Operator Who is operating this solution? | End-users are the tenants |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Home owners, tenants |
| **Implementer** Who is implementing this solution? | UOU, Sivakka |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | Energy producer |
| **Business Model Patterns** | |
| Bill reduction through energy savings<br>Municipal utility<br>Cooperative utility | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political: Inadequacy of sustainable and integrated policies (part-optimization). This concerns many of PESTEL issues. From political side, in Finland there is quite good consensus that CO2 reductions are to be cut.<br>Economic: Financial savings of customers may occur in mid or long-term, which is a barrier for many<br>Social: raising of wondering to new and smart technologies. Considering the supposed time use of the residents, the energy issues must not take much time per day, but be rather automatic.<br>Technical: In some cases, incompatibility of infrastructure, i.e. the control systems do not have the required properties.<br>Environmental: increased awareness and people's desire to learn consumption data<br>Legal: depends on individual preferences |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Indicate if the system is already in use in other cities, kind of a valuation is also possible. | Increasing awareness of the tenants about their energy consumption is expected to lead to a decrease in consumptions. |

# S5c Demand Response / Smart Grid

| SPEC CARD | |
|---|---|
| | DEMAND SIDE SOLUTIONS |
| | Category 2 |
| | IMPROVE ENERGY EFFICIENCY |
| | Solution 5 |
| | Smart Building / Home energy controllers |
| Title | Graphical Detail |
| S5c Demand Response Smart Grid |  |
| | Providing energy demand supply balance through smart grid |



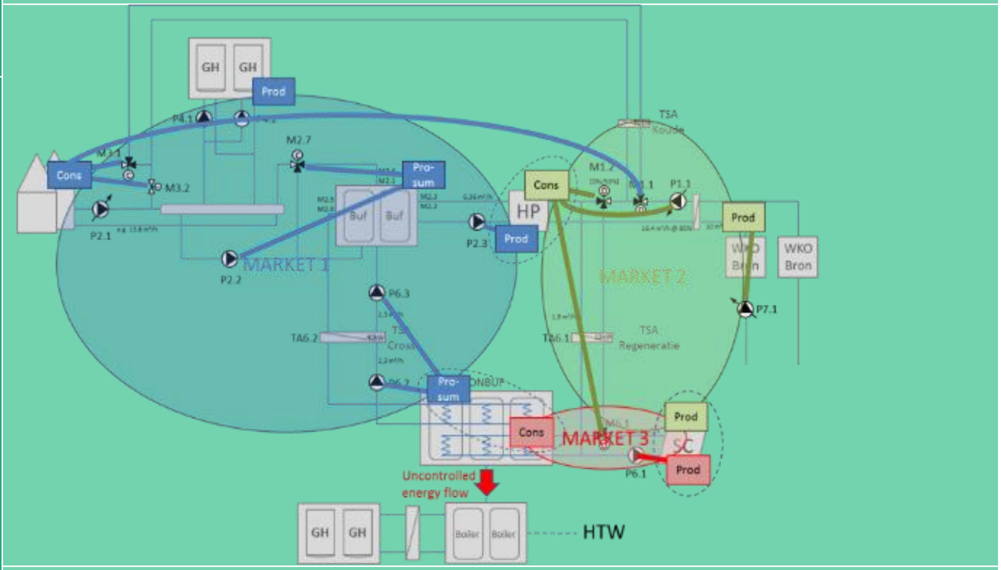
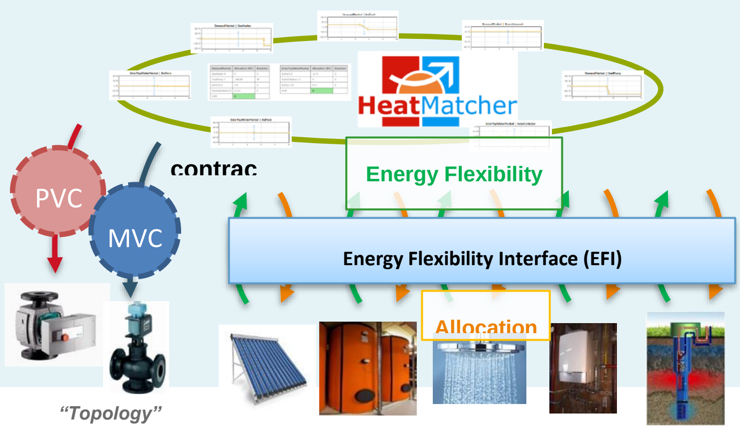
| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| | Yes | **CGI**, RUG, TNO, SB | |
| Implementation Time | | Initial Investment | € 25,000 |

| What is Solution? | How does it work? |
|---|---|
| Using the available energy flexibility within the PEDs (e.g. Storage, time, shifting, etc.) the solution will optimise the energy productions and consumption within the PEDs the flexibility of the buildings and houses is communicated through the advanced energy metering from advanced energy metering. | Energy flexibility information is collected by Sustainable Buildings, TNO and the EV charging operator. The combined monitoring information is analysed in the Energy Islands platform. It includes for example, electricity consumption and production, EV charging information from connected charging poles, heat flexibility information from the TNO Heat Matchers. Instead of controlling the flexibility centrally, the demand/response decisions are taken locally (within the buildings or in charging poles), but with input from the central Urban Data Platform enabling optimization of the available flexibility in the whole district. |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |

| | |
|---|---|
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Bill reduction through energy savings<br>Municipal utility<br>Cooperative utility | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| S5d - The HeatMatcher for the optimisation of heating resources is<br><br>Connection of the charging stations to the local demand response system<br><br>S6c - Energy data monitoring of PED<br><br>S6d - Integration of new services to the data platform | Political: Less energy consumption straightforward to communicate.<br>Economic: More locally produced, renewable energy is used, which is cheaper that “grey” energy.<br>Social: It’s creating greater awareness that renewable energy is cheaper (and cleaner) so citizens will consume energy on in other timeframes.<br>Technical: Integration with several different platforms working together to use the available flexibility.<br>Environmental: Consume or store when it’s produced, so no loss of renewable energy.<br>Legal: GDPR compliance is necessary |
| Potential for Replication | Expected Impacts - Benefits |
| The HeatMatcher algorithm has shown to decrease energy expenses by up to 30%. In an office building like the Mediacentrale with sufficiently large energy requirements this quickly makes the investment profitable. | |

## S5d Heat Matcher

| SPEC CARD | DEMAND SIDE SOLUTIONS | | | |
|---|---|---|---|---|
| | Category 2<br>IMPROVE ENERGY EFFICIENCY | | | |
| | Solution 5<br>Smart Building / Home energy controllers | | | |
| Title | Graphical Detail | | | |
| S5d Heat Mather |  | | | |
| | - Match heating and cooling supply and demand<br>- Maximize use of renewable energy sources<br>- Virtual market mechanism: agents sell and buy their energy on the markets<br>- Exploit the flexibility of all components and uses this flexibility in the optimization algorithm<br>Higher abstraction: Controls the energy flows, instead of temperatures used in traditional systems | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | Yes | TNO<br>Arun Subramanian (arun.subramanian@tno.nl) | | |
| Implementation Time | 3 months | Initial Investment | € 35,000 | |
| What is Solution? | How does it work? | | | |
| HeatMatcher is an innovative real-time matching solution for heating and cooling systems. It determines the optimal balance between producers (supply) and consumers (demand) of heat and cold. One of HeatMatcher's unique features is its ability 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. For |  | | | |

| | |
|---|---|
| instance, by optimising across multiple energy producing components – such as heat pumps with thermal storage, solar collectors and gas heaters – consumers benefit from low costs as the amount of renewable energy in the mix is maximised. With a certain buffer capacity required in the system to enable production of energy when costs are low and consumption occurs later, HeatMatcher is able to exploit the flexibility for each of the components and optimise the match. | In HeatMatcher, each energy producer, consumer and prosumer is represented as an agent capable of expressing its flexibility as a bid curve (as defined in the EFI standard). HeatMatcher combines logically agents into a market and for each discrete time interval requests flexibilities from all participating agents in a market. Upon receiving these flexibility functions, it combines them to determine a market equilibrium, where supply and demand are in balance. Contracts are prepared on the basis of this equilibrium and device constraints and passed down to the agents who translate it to an actuation that the producer/consumer/prosumer device can understand. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | |
| Operator Who is operating this solution? | |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| Implementer Who is implementing this solution? | |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| ~20% financial savings in OPEX per year in energy costs<br>Licensing<br>Pay as you go | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political: N/A<br>Economic: Split between investor and beneficiary of technology<br>Social: N/A<br>Technical: Additional changes to heating installation may be necessary<br>Environmental: N/A<br>Legal: N/A |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Solution was tested across 5 field trials in 4 locations in the Netherlands over multiple years. Definite potential for replication. | Reduction in gas consumption observed to be ~28% less in last field trial. |

## S6a Smart Lighting, power LED

| | | | |
|---|---|---|---|
| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 2<br>IMPROVE ENERGY EFFICIENCY<br>Solution 6<br>IoT Monitoring | | |
| Title | Graphical Detail | | |
| S6a Smart Lighting, power LED | LED lighting with dimming | | |
| City / Country | Making City | Technical Partner Name & contact Details | |
| | Yes | OUK, VTT | |
| Implementation Time | | Initial Investment | The LED lights were installed already earlier. City of Oulu paid the costs, which was estimated to be 260,000 euros. 40,000(Power management, 11,250 EU Funding) |
| What is Solution? | | How does it work? | |
| A new lighting system of the area will be installed in order to reduce the energy consumption. The technology deployed will be high power LED | | The lighting control will be smart, so it will dim the lighting scene when no activity is detected on the area. Power supply may cut down to 50% of the maximum. Ambient lighting sensors are also used to keep track on the daylight so the lighting will adapt to the daylight as well | |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | Lighting suppliers |
| Operator Who is operating this solution? | City of Oulu |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | City of Oulu will save energy |
| **Implementer** Who is implementing this solution? | City of Oulu |

| | |
|---|---|
| **Financer** How / By whom has the implementation of this solution been financed? | City of Oulu |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | The inhabitants, Oulu Energy |
| **Business Model Patterns** | |
| Savings through energy reduction<br>Municipal utility<br>Cooperative utility<br>Virtual power plant<br>Active customers<br>Local aggregator<br>Microgrid<br>Power based tariff | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| S6b Wireless Network and activity sensors | Political: No significant barriers<br>Economic: In some cases, investment budgets may be a short-time barrier, but generally the change for LEDs have been quick. However, for the smart dimming the payback time may be too long and possible technical/social shortcoming may be a question.<br>Social: No major barriers. Generally, it is supposed that people find the colour rendering of LEDs more pleasant than previously used sodium bulbs.<br>Technical: No major barriers.<br>Environmental: CO2 decrease, longer lifetime, less waste.<br>Legal: Energy efficiency requirements guide towards these. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The payback period of such solutions is relatively low compared to other energy efficiency measures and the replication potential is high. | Reduction of energy consumption and thus CO2 |
| **Reference Applications of this Solution** | |
| | |

## S6b LoRa (Long Range) wireless network and activity sensors

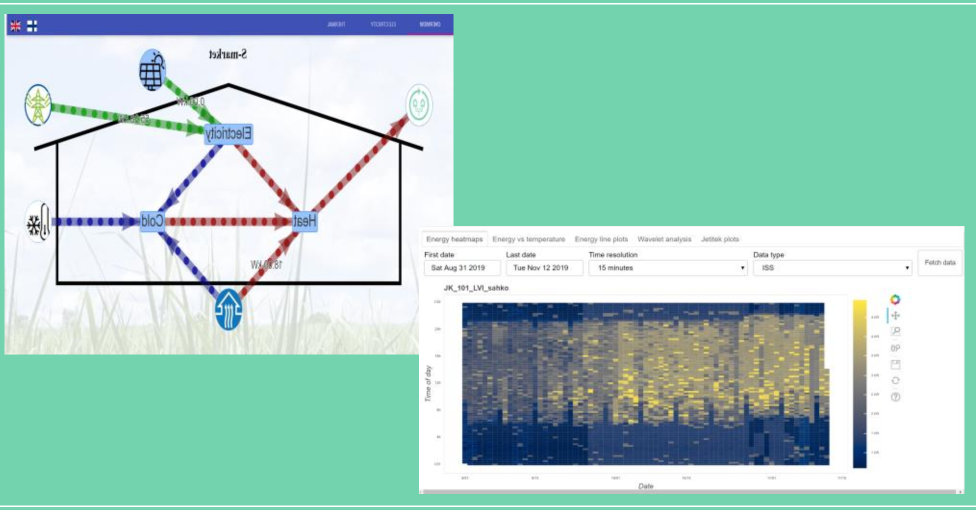
| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 2<br>IMPROVE ENERGY EFFICIENCY | | |
| | Solution 6<br>IoT Monitoring | | |
| Title | Graphical Detail | | |
| S6b LoRa (Long Range) wireless network and activity sensors | Smart lighting controller using wireless network | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | OUK, VTT | |
| Implementation Time | | Initial Investment | € 35,000 |

| What is Solution? | How does it work? |
|---|---|
| Power LED will be combined with smart lighting controller using LoRa (Long Range) wireless network (50 controllers) and activity sensors (50 units) to optimize the lighting level in evening and night time | LoRa based sensor network is used to have seamless control over the "private" and city owned lighting systems. The idea is to send control signals over the area to ensure safe travel and adequate level of lighting in all circumstances. Wireless activity sensors will also be used to provide intelligent control for the lighting |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | City of Oulu |
| **Implementer** Who is implementing this solution? | |

| | |
|---|---|
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Municipal utility<br>Cooperative utility<br>One-time investment<br>Leasing | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| S6a Smart Lighting | Political: Inadequacy of sustainable and integrated policies, low awareness among policy makers<br>Economic: Very cost effective but high initial cost<br>Social: it will make life in urban areas smarter, safer and more sustainable<br>Technical: easy to implement technology<br>Environmental: reduction of CO2 emissions<br>Legal: no restrictions |
| Potential for Replication | Expected Impacts - Benefits |
| | Reduction of energy consumption and thus CO2 |

## S6c Energy data monitoring of PED

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 2<br>IMPROVE ENERGY EFFICIENCY<br>Solution 6<br>IoT Monitoring |
|---|---|
| Title | Graphical Detail |
| S6c Energy data monitoring of PED | <br>- Measures enery data and the state of the environment from the site<br>- Sends the energy data and environment state to the centralized data base<br>- Provides both technical and non-technical visualization user interfaces for monitoring the data<br>- data pipeline for intelligent control |

| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| OULU / Finland | Yes | VTT | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| Energy data monitoring is a key component for enabling intelligent ICT services. It covers the data collection, data storing and data quality monitoring. In addition, the solution provides both technical and non-technical views for both real time and historical data | Data is measured from the sites. Then the data is transmitted to the ICT server who stores the data in database. Automatic data quality checks queries the database and validates that data storing is operating as specified. If the check detects any problems in the data stream it sends alerts to developers to correct the data pipeline. To see the data both technical and non-technical UIs are developed in top of the database to see both the real time data and historical data. |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | VTT, CGI |

| | |
|---|---|
| Operator Who is operating this solution? | VTT, CGI |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Building and apartment owners and tenants |
| Implementer Who is implementing this solution? | VTT, CGI |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Building and apartment owners and tenants, energy companies |
| **Business Model Patterns** | |
| Pay per use<br>Multiu-sided revenue model | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Validate it with other solutions if possible, as a technology package - Grouping of technologies Tech-non-tech. | Political:<br>Economic:<br>Social:<br>Technical:<br>Environmental:<br>Legal: |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | Enables intelligent control and other data intelligent solutions Enables measuring the energy performance of PED |

## S6d Integration of new services to the data platform

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 2<br>IMPROVE ENERGY EFFICIENCY | | |
| | Solution 6<br>IoT Monitoring | | |
| Title | Graphical Detail | | |
| S6d Integration of new services to the data platform | Integration of new data to the data platform | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | CGI, SB, TNO, GRO | |
| Implementation Time | | Initial Investment | € 25,000 |

| What is Solution? | How does it work? |
|---|---|
| The existing ICT platforms in Groningen are adapted and integrated to create an Urban Data Platform. | The purpose of the Urban Data Platform is to collect relevant data about the city and make it available to stakeholders in the city via standardized interfaces. It enables services built on these standards to be used within the city.<br>Expected services would be; Sustainable Buildings data collection and analysis, TNO EDSL and ESSIM simulations, Groningen Open Data Portal and CGI Energy Islands Insights. |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |

| | |
|---|---|
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Multi-sided revenue model<br>Freemium<br>Pay with data | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| S5c Demand response smart grid<br>S6c Energy data monitoring<br>S7a Open Data Platform Adaptation | Political: Enables new services in the city for citizens.<br>Economic: Created services can be monetized.<br>Social: Services generate awareness about PEDs.<br>Technical: Adhering standards ensure the collected data is easily accessible.<br>Environmental:<br>Legal: Data ownership with the municipality |
| Potential for Replication | Expected Impacts - Benefits |
| | |

## S6e Installation of IoT infra

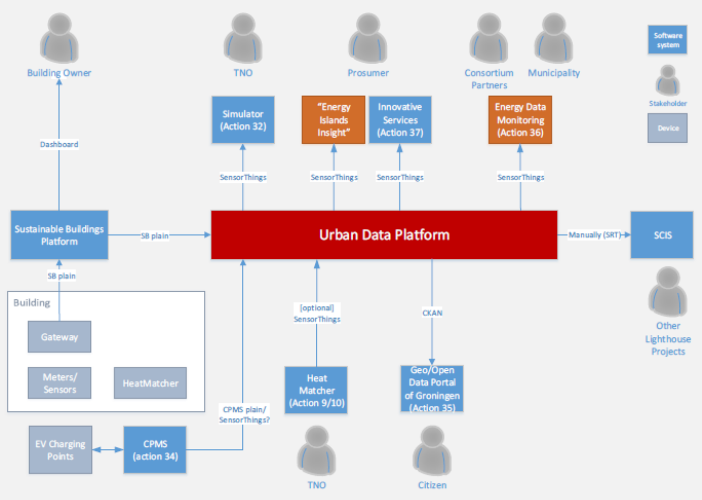
| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 2<br>IMPROVE ENERGY EFFICIENCY<br>Solution 6<br>IoT Monitoring | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S6e Installation of IoT infra | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | | | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| | |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |

| | |
|---|---|
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Multi-sided revenue model<br>Freemium<br>Pay with data | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | |
| Potential for Replication | Expected Impacts - Benefits |
| | |
| Reference Applications of this Solution | |
| | |

## S7a Open Urban Platform adaptation

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 2<br>IMPROVE ENERGY EFFICIENCY | | |
| | Solution 7<br>ICT Urban Platform | | |
| Title | Graphical Detail | | |
| S7a Open Urban Platform adaptation | <br>Figure 16: Schematic overview of Urban data platform.<br>Open Data Platfom | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | | |
| Implementation Time | | Initial Investment | |
| What is Solution? | | How does it work? | |
| The existing data platform will be integrated with other platforms as part of the MAKING-CITY project to create an Urban Data Platform storing and publishing any Open Data created as part of the project | | | |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |

| | |
|---|---|
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Open data | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| Retrofitting of old buildings and energy systems of new buildings (energy actions)<br>S6c - Energy data monitoring of PED<br>S6d - Integration of new services to the data platform<br>Solution XX: Open data Business Models | Political: Municipality owner of data generated in the city.<br>Economic: The urban data platform can be expanded for other data.<br>Social: Increase awareness data available in the city.<br>Technical: Data standardization.<br>Environmental:<br>Legal: GDPR compliance is necessary |
| Potential for Replication | Expected Impacts - Benefits |
| | |
| Reference Applications of this Solution | |
| | |

## S8a High Speed data transfer network

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 2<br>IMPROVE ENERGY EFFICIENCY | | |
| | Solution 8<br>High Speed data transfer network | | |
| Title | Graphical Detail | | |
| S8a High Speed data transfer network | High speed wireless data network | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | VTT | |
| Implementation Time | | Initial Investment | €20,000 (€ 10,000 EU) |

| What is Solution? | How does it work? |
|---|---|
| Wireless data transfer network that will cover the whole area for control and data aggregation. (This is already existing as a standard solution in Finland, using common mobile network, so this is realized as an internal network for practical purposes). | The data network will be used in order to control both electricity and heat management. It also serves the people by delivering online data of the energy balance thus improving the energy awareness of the inhabitants. Third function of this network is to store data for learning, verification and documentation purposes. |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |

| | |
|---|---|
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Pay per use<br>Freemium<br>Multi-sided revenue model | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | |
| Potential for Replication | Expected Impacts - Benefits |
| | |
| Reference Applications of this Solution | |
| | |

## S9a Neighbourhood electro storage facility

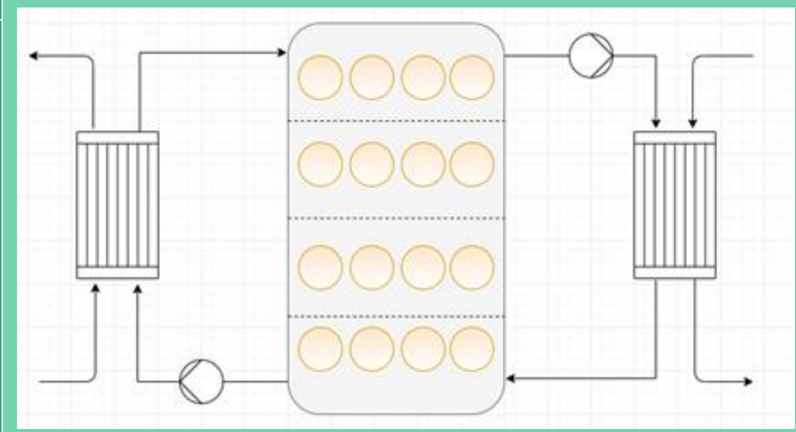
| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 3<br>INTEGRATED INFRSTRUCTURES | | |
| | Solution 9<br>Power storage | | |
| Title | Graphical Detail | | |
| S9a Neighbourhood electro storage facility | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | NIJ, GRO | |
| Implementation Time | | Initial Investment | € 140.000 (€97.000 EU) |

| What is Solution? | How does it work? |
|---|---|
| | |

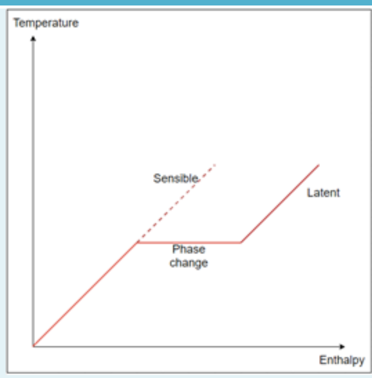
| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | NIJ |
| Operator Who is operating this solution? | |

| | |
|---|---|
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | Enexis (ditribution system operator) |
| **Business Model Patterns** | |
| No direct profits, might not be implemented<br>Pay per use<br>Shared savings<br>Power purchase agreement<br>Cooperative utility<br>Active customer | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political:<br>Economic: There is no business case, funding is challenging<br>Social: Can become an enabler<br>Technical: Location is needed. Solution is very beneficial for net balancing.<br>Environmental:<br>Legal: How to bill and share energy without paying the usual energy taxes |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | |
| **Reference Applications of this Solution** | |
| | |

## S10a Phase transfer Liquid tank

| SPEC CARD | SYSTEM INTEGRATION SOLUTIONS<br>Category 3<br>INTEGRATED INFRSTRUCTURES<br>Solution 10<br>Thermal storage | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S10a Phase transfer Liquid tank | <br>'- Match hot water supply and demand<br>- Prolong the heat pump life time<br>- Increase thermal energy storage intensivity compared to conventional water thermal storage<br>- With increase of energy content, it could be possible to have smaller thermal storage units | | |
| **City / Country** | **Making_City** | **Technical Partner Name & contact Details** | |
| OULU / Finland | Yes | VTT Technical Research Centre of Finland Ltd | |
| **Implementation Time** | | **Initial Investment** | € 70 000 (€ 35 000 EU) |

| What is Solution? | How does it work? |
|---|---|
| To increase the energy content of the conventional water based thermal storage we can utilise phase change materials 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. This transformation absorbs and | Latent heat thermal storage is placed in the heating network with a heat pump for example and it can be charged during the night time or times when heat is not required. Heat is released during the peak hours to increase the life time of the heat pump by reducing it's start times. Latent heat storage can also be placed for storing heat from CO2 cold cycle in markets and release it to DH network. Water acts as a heat transfer fluid between PCM and |



| | | |
|---|---|---|
| releases energy which is called latent heat. This allows for greater energy capacity compared to conventional thermal storage. | heat exchangers. PCM is encapsulated to ensure better heat transfer rate. | |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Several developers, here VTT |
| Operator Who is operating this solution? | VTT for trials, later energy company and building owner |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Energy company and building owner |
| Implementer Who is implementing this solution? | VTT for trials, later energy company and building owner |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |

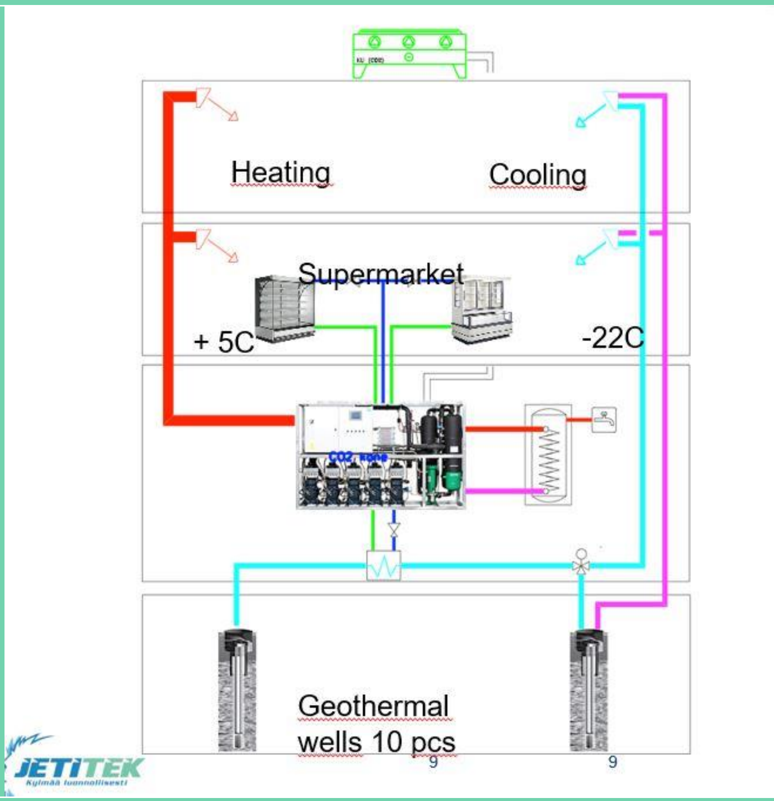
| Business Model Patterns |
|---|
| Depends on the price volatility of electricity and heat. The higher, the better for this.<br>One-time investment<br>Leasing |

| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
|---|---|
| Using heat pumps we increase temperature of District heating low temperature return water and store it in to latent heat thermal storage tank. | Political: No major barriers. As a part of sustainable energy systems may have some positive attraction, which is also probably increased by the novelty of the solution.<br><br>Economic: Price compared to conventional tank is higher. This must be judged against smaller size and better properties for especially HP use.<br><br>Social: Novelty may be an advantage, but also on the contrary<br><br>Technical: Additional changes to heating installation may be necessary, since the output temp from PCM storage is quite constant. The changes are however quite ordinary technical adjustments and thus easy.<br><br>Environmental: Phase change material used is not toxic. Potentially increases HP system COP and thus decreases the electricity consumption.<br><br>Legal: No major barriers, if and when non-toxic PC materials are used. |

| Potential for Replication | Expected Impacts - Benefits |
|---|---|
| | If the size of the thermal storage can be reduced compared to conventional storage tanks, interest towards it will increase. additionally, if the energy capacity of it can be utilised fully it can solve some problems relating to drilling boreholes for energy storage. Since ground is used as a heat dump during the summer this could be possibly replace by using |

| | |
|---|---|
| | proper phase change materials. Problems regarding the thermal storage tanks usually are related to their size. |

## S10b Seasonal storage

| SPEC CARD | SYSTEM INTEGRATION SOLUTIONS<br>Category 3<br>INTEGRATED INFRSTRUCTURES<br>Solution 10<br>Thermal storage | |
|---|---|---|
| Title | Graphical Detail | |
| S10b Seasonal storage | <br>Heat dwells are used to storage heat on summer period<br>10 heat dwells are under the building, total length of the storage is 2,5 km | |
| City / Country | Making_City | Technical Partner Name & contact Details |
| OULU / Finland | Yes | ARI, Jetitek (later Caverion), OEN, VTT |
| Implementation Time | | Initial Investment |
| What is Solution? | How does it work? | |
| | | |

| | |
|---|---|
| Under the summer period the cooling of cold storages in the shop creates lots of heat<br>Normally this heat is evaporated to air with heat exchangers so all the energy is lost<br>In this application the heat is stored to the ground in the winter when extra heat is needed for the building and hot domestic water the heat will be recovered | The cooling of cold storages used temperatures from +10 to -22 C. These temperatures are created worth heat pumps using high pressurised $CO_2$ (100 bars)<br>The hot gas is condensed with compressor and then transferred to the heat dwells into the ground.<br>Each dwell has got a pipe looping down from the surface, these pipes are connected together with a collector pipeline and this pipeline has got heat exchanger. This heat exchanger separated the heat collecting liquid from the highly pressurised $CO_2$ |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | Arina |
| Operator Who is operating this solution? | Arina |
| Customer(s) or user(s) Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | Arina |
| Implementer Who is implementing this solution? | Arina |
| Financer How / By whom has the implementation of this solution been financed? | Arina is the financer |
| **Business Model Patterns** | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| this solution is used together with heat pumps, please refer to SPEC_S4a | Political: Electricity storages have more hype for politics, but substance-wise thermal storages are in most of the cases far more profitable, since they are much cheaper per energy unit.<br>Economic: To have the full advantage, electricity taxation and transmission pricing principle should be changed towards more effective than energy based and in addition to dynamic one, i.e. dependent on the system balance. This kind of development is in fact ongoing.<br>Social: No significant impacts<br>Technical: The technology has been known for decades and there are some well-working examples. The key issue is probably to have the suitable bedrock quality, to prevent the loss of heat with ground water. However, even in this case the system works, but then just as usual ground heat source, without recharging with waste heat.<br>Environmental: Beneficial, since gives timely flexibility and thus helps in integrating variable renewables in the system.<br>Legal: No significant impacts |
| **Potential for Replication** | **Expected Impacts - Benefits** |

| | |
|---|---|
| The system can be applied in Europe if the soils and regulation allow to make heat dwells | |

## S10c Thermal Storage

| | | | |
|---|---|---|---|
| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 3<br>INTEGRATED INFRSTRUCTURES<br>Solution 10<br>Thermal storage | | |
| Title | Graphical Detail | | |
| S10c Thermal Storage | Thermal energy storage in building 1 and 2 | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | **SIV**, JET, VTT, OEN, ARI, OUK | |
| Implementation Time | | Initial Investment | € 66.000 (EU) |

| What is Solution? | How does it work? |
|---|---|
| The heat storage tank will be used to reduce the peak capacity for heat and also serves as a short term storage in 24 hours operating cycle | In building 1 and 2's heat tanks are planned to have a capacity each of 200 kWh (delta T 50ºC). The volume of this kind of heat tank with water is typically 3500 L. Conventional water will be replaced by a fluid with a phase transfer temperature of 60ºC, so the whole capacity of the heat tanks will be available on a narrow temperature range (from 55ºC to 65ºC). This makes the components an ideal solution to be used together with heat pumps and low temperature heat distribution networks.<br><br>Thermal energy storage in Arina, a phase transfer liquid heat tank will have a capacity up to 300 kWh (5000 L). The operating temperature is between 50ºC - 60ºC. This tank is used together with the heat pump and high-pressure heat collector on the roof. It will also reduce the duty cycles of heat pumps in the winter time when they are used for heat generation |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | |

| | |
|---|---|
| Operator Who is operating this solution? | SIV and Arina (for the mall) |
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | SIV, Arina, Customers of the mall |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | EU |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political:<br>Economic: High initial cost, no financial sources<br>Social:<br>Technical: known technology, difficult to find space<br>Environmental:<br>Legal: |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| There is a potential in all EU about thermal storage for buildings who have enough space. | Energy consumption reduction |

## S11a Low Temp regional transfer pipeline

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 3<br>INTEGRATED INFRSTRUCTURES<br>Solution 11<br>District Heating & Cooling Facilities | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S11a Low Temp regional transfer pipeline | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | OEN | |
| Implementation Time | | Initial Investment | € 46,000 (€14,000 EU) |
| What is Solution? | How does it work? | | |
| Low temperature heating pipes allows the heat transferred for heating to be in lower temperatures | The system uses lower temperatures (<60ºC) compared to regional heating (<110ºC) in heating and hot water production. Lower temperature means better economy in production, less losses in distribution and lower cost in building the distribution pipelines (plastic instead of steel piping). Using the lower temperature will also improve the COP of heat pumps. The extra investment in supplies (more powerful heat exchangers – Actions 4, 12 and 14), heating system) is paid back by the savings in energy cost. In the new solution this consists of internal heating water networks in the buildings and their connections via heat exchangers to larger district heating network | | |
| Stakeholder Analysis | | | |
| **Developer (if relevant)** Who has developed this solution? | | | |
| Operator Who is operating this solution? | | | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is | | | |

| | |
|---|---|
| saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Energy cost reduction<br>Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | Political:<br>Economic:<br>Social:<br>Technical:<br>Environmental:<br>Legal: |
| Potential for Replication | Expected Impacts - Benefits |
| | |

## S11b Adjust geothermal district heating for using low temperature

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 3<br>INTEGRATED INFRSTRUCTURES | | |
| | Solution 11<br>District Heating & Cooling Facilities | | |
| Title | Graphical Detail | | |
| S11b Adjust geothermal district heating for using low temperature | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | WAR, NIJ | |
| Implementation Time | | Initial Investment | € 354,000 (€74,000 EU) |

| What is Solution? | How does it work? |
|---|---|
| The geothermal district heating network in Groningen NORTH is initially designed as a high temperature network. However, the heating source has been changed to waste heat of datacentres instead of geothermal energy. The district heating network has been adjusted to a high to medium temperature district heating network. This means that the temperature would be approximately 75 °C in summer and up to 90 °C during cold days in the winter | To connect the retrofitted buildings of Nijestee to a high temperature heating network instead of gas, the existing local heating system has to be adjusted by installing a mix heat transformer. This innovated mix injection will be used to control the supply temperature to the apartments of Nijestee buildings independently from the supply temperature of the heat grid.<br>The connection between the heat grid and the retrofitted buildings of Nijestee has been made last month. The last adjustments on the local heating system are currently made. WarmteStad will provide heat for the retrofitted buildings of Nijestee from the beginning of2021. |

Stakeholder Analysis

| | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| Geothermal District Heating | Political: In this project the local government and the local politics are involved. Social unrest can lead to political questions. In this project questions from politicians are answered adequately. At the moment there is no open question/ barrier.<br>Economic: The energy transition involves high costs. This requires investments from building owners, external financiers and from the heat company itself.<br>Social: The population is increasingly aware of the fact that something needs to change and we need to combat the climate change. A positive trend is gradually emerging. Our customers understand why this project is needed.<br>Technical: In general, there can be more innovative techniques we don't know yet, which are better than the technique we will use.<br>Environmental: With this project we will reduce the CO2 footprint. The switch from geothermal to residual heat has also increased the reduction of $CO_2$.<br>Legal: In the exploitation of our project we have to operate under the national heat law. In general, this law is for protecting consumers for monopoly on heat. The coming years the law will change. The challenge is to be compliant to this law. For now, we do comply |
| Potential for Replication | Expected Impacts - Benefits |
| | |

## S11c Connection to the low temperature district heat

| SPEC CARD | DEMAND SIDE SOLUTIONS | | | |
|---|---|---|---|---|
| | Category 3<br>INTEGRATED INFRSTRUCTURES | | | |
| | Solution 11<br>District Heating & Cooling Facilities | | | |
| Title | Graphical Detail | | | |
| S11c Connection to the low temperature district heat | | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | | | | |
| Implementation Time | | Initial Investment | €548.000 (€23.550 EU) | |
| What is Solution? | How does it work? | | | |
| In the PED South a collective aquifer thermal energy system (ATES) will be connected to a ground source heat pump of the Powerhouse and the Sportscomplex.<br>Technical data Sportscomplex<br>Heat pump central heating<br>Brand: Simaka<br>Type: Simatron WP 201/2 WW-R407C<br>Heating power: 200 kW<br>COP W10/W35: 6,02<br>COP W10/W45: 4,61<br>Heat pump domestic hot water production<br>Brand: Simaka | WarmteStad made for both the Sportscomplex and Powerhouse WarmteStad a connection with the ATES. In order to switch between groundwater for heating and groundwater for cooling a wheatstone bridge is installed. The groundwater is subsequently used as a source for the heat pumps or directly for passive cooling. WarmteStad has installed for both projects a high efficiency high-temperature heat pump. In the Sportscomplex are two heat pumps installed. One heat pump for central heating (weather-dependent controlled temperature between 35 °C and 45 °C) and one for domestic hot water production (65 °C). In the Powerhouse project is one heat pump installed for both central | | | |

| | |
|---|---|
| Type: Simatron WP 50/2 WW- R134a<br>Heating power: 50 kW<br>COP W10/W65: 4,0<br>Central heating:<br>Expected energy consumption using a heat pump: 61.043 kWh<br>Expected energy consumption using a traditional gas boiler: 36.932 m3 natural gas<br>Avoided CO¬¬2 emissions in comparison with a traditional gas boiler: 37.323 kg CO¬2<br>Domestic hot water production:<br>Expected energy consumption using a heat pump: 32.847 kWh<br>Expected energy consumption using a traditional gas boiler: 16.826 m3 natural gas<br>Avoided CO¬¬2 emissions in comparison with a traditional gas boiler: 14.354 kg CO¬2<br>Cooling<br>Expected energy consumption using groundwater: 7.931 kWh<br>Expected energy use with traditional air-conditioning system: 63.444 kWh<br>Avoided CO¬2 emissions in comparison with an air-conditioning system: 29.200 kg CO¬2 | heating and domestic hot water production (65 °C)<br><br> |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |

| | |
|---|---|
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political: In this project the local government and the local politics are involved. Social unrest can lead to political questions. In this project questions from politicians are answered adequately. At the moment there is no open question/ barrier).<br>Economic: The energy transition involves high costs. This requires investments from building owners, external financiers and from the heat company itself.<br>Social: The population is increasingly aware of the fact that something needs to change and we need to combat the climate change. A positive trend is gradually emerging. Our customers understand why this project is needed. That helps us a lot.<br>Technical: In general there can be more innovative techniques we don't know yet, which are better than the technique we will use. But this is for now no issue.<br>Environmental: With this project we will reduce the $CO_2$ footprint.<br>Legal: In the exploitation of our project we have to operate under the national heat law. In general this law is for protecting consumers for monopoly on heat. The coming years the law will change. The challenge is to be compliant to this law. For now we do comply. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | |
| **Reference Applications of this Solution** | |
| | |

## S12a Building energy connectivity for energy sharing

<table>
<tr><td rowspan="3">SPEC CARD</td><td colspan="3">SYSTEM INTEGRATION SOLUTIONS</td></tr>
<tr><td colspan="3">Category 3<br>INTEGRATED INFRSTRUCTURES</td></tr>
<tr><td colspan="3">Solution 12<br>Building energy connectivity for energy sharing</td></tr>
<tr><td>Title</td><td colspan="3">Graphical Detail</td></tr>
<tr><td rowspan="2">S12a Building energy connectivity for energy sharing</td><td colspan="3">   <br>CHP plant, biomass fuel + heat pumps -> DH network -> heat exchanger for consumer</td></tr>
<tr><td colspan="3">- District heating (DH) network<br>- Also feeding heat from buildings to DH network is possible<br>- Both supply and return sides can be utilised for space heating and domestic hot water heating</td></tr>
<tr><td>City / Country</td><td>Making_City</td><td colspan="2">Technical Partner Name & contact Details</td></tr>
<tr><td></td><td>Yes</td><td colspan="2">Oulu Energy</td></tr>
<tr><td>Implementation Time</td><td>Year 2020. DH network building is in place, connecting to it takes one day when the essential other construction works around the DH exchangers are in place.</td><td>Initial Investment</td><td>Ordinary DH exchanger round 3000-10000 euros, DH pipe construction underground > 100 e/m. Heat pump very roughly round 500 euros/heat-kW.</td></tr>
<tr><td colspan="2">What is Solution?</td><td colspan="2">How does it work?</td></tr>
<tr><td colspan="2">Connection to district heating network. Apartment buildings use return pipe as a heat source with heat pump, in addition to the normal connection to the supply side. The grocery store feeds excess heat from refrigeration to supply.</td><td colspan="2">District heating connects is usually used so that the heat only-boiler or combined heat only-boiler feeds heat into the network and consumers are connected by heat exchangers between heating water circuit in the building and primary circuit, i.e. the one which consists of underground DH pipes between heat production and buildings. The heat in common solution is taken from supply side and the cooled flow is fed on the return pipe.<br>In this case also return pipe heat is used, mainly by heat pump that increases the temp so that it is suitable for heating and domestic hot water. In addition, in milder weather excess heat is fed from the building (grocery store) to the DH network. The perquisite is that supply temp is</td></tr>
</table>

| | |
|---|---|
| | below about 85 C, which may take in about 0 degrees outside. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | DH in general many developers e.g. in Finland from 60's on. Return pipe and excess heat supply e.g. Oulu Energy, Jetitek, GST and Arina. |
| Operator Who is operating this solution? | Oulu Energy |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Heat customer, i.e. the owner of the building. Also the energy company and with that all the customers can benefit from the solution. |
| Implementer Who is implementing this solution? | Oulu Energy |
| Financer How / By whom has the implementation of this solution been financed? | Oulu Energy |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Jetitek and GST (heat pump suppliers), Arina (grocet store chain), Sivakka (rental housing company), YIT (construction company), inhabitants. |
| **Business Model Patterns** | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Good with especially those heat production methods, which benefit from economics of scale, like CHP, industrial excess heat, waste combustion, even small nuclear reactors. In more general, always when somebody has excess heat and the other need for it. | Political: May be seen as old-fashioned or vice versa, depending on the country and observer. Requires some central planning.<br>Economic: Expensive to implement. High capital cost and risk of getting customers and keeping them. However, cheap energy sources can be used, i.e. low operating cost.<br>Social: Price setting, its variability, depends on the markets. If the system has different kind of production methods (e.g. CHP and heat pumps with high capacity), the price may be quite stable.<br>Technical: Well-known pratices, but also some new solutions exist.<br>Environmental: Varies a lot. If properly set with a multiple set of energy sources, a flexible and environmentally sound system, potentially the best one. But can be also the opposite, in extreme when burning coal directly to heat (which is however nearly non-existent in Finland currently).<br>Legal: Techno-economically it is of advantage to have obligatory joining to the network, but this of course is a reason for complaints and dissatisfaction. Generally legal issues are well arranged, with a lot of experience, in Nordic countries. |
| **Potential for Replication** | **Expected Impacts - Benefits** |

| | |
|---|---|
| Exists in practically all larger towns and cities in e.g. Finland, Sweden and Denmark. Replicability from scratch may involve quite high economical risk, but is technically generally possible especially when the heating need is large enough (peak load hours e.g. >2000/a) and heat consumption over round 2 MWh/a/pipe-m. | General aspects about the solution. Could be technical, economical, environmental, social |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| | |
| **Reference Applications of this Solution** | |
| | |

## S13a $CO_2$ based heat pump

| SPEC CARD | SYSTEM INTEGRATION SOLUTIONS<br>Category 3<br>INTEGRATED INFRSTRUCTURES<br>Solution 13<br>Heat Pumps |
|---|---|
| Title | Graphical Detail |
| S13a $CO_2$ based heat pump |   |
| | General Data for the solution in bullets |

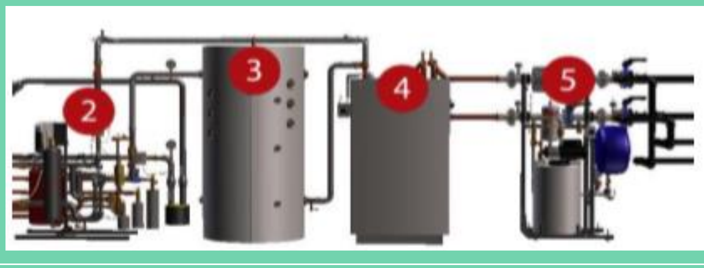
| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| | Yes | Jetitek, Arina | |
| Implementation Time | 2019 | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| Refrigeration machines of the grocery store, which can also supply heat to district heating network. | Carbon dioxide is used as refrigerant, instead of F-gases.<br>The advantage of CO2 as a refrigeant is that it allows high temperature difference between source and sink, with moderate coefficient of performance, i.e. the ratio beween output heat and input electricity. The hot gas coming from compressor is cooled down gradually (due to its transcritical state), which allows different temperatures taken out of the flow.<br>Even if the carbon dioxide is a greenhouse gas, the warming effect of per mass unit is significantly lower than that of F-gases. This has importance, if there are leakages in the cooling system. |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Jetitek, among the others |
| Operator Who is operating this solution? | Arina |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | The store owner, Arina in this case |

| | |
|---|---|
| Implementer Who is implementing this solution? | Jetitek |
| Financer How / By whom has the implementation of this solution been financed? | Arina |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | When excess heat is fed into the district heating network, the energy company and its customers |
| **Business Model Patterns** | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Distict heating network required to deliver the heat | Political: As an energy-saving concept supported by common policy<br>Economic: A bit more expensive than system based on F-gases, but pays off rather quickly<br>Social: No significant impacts<br>Technical: CO2-refrigeration is an old system in principle, but only recently it has been developed to reliable level. E.g. high pressures must be taken into account.<br>Environmental: Many benefits, no major barriers<br>Legal: Legislation favours CO2 refrigeration, as F-gases get more and more restrictions |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Very high potential, can be applied in principle to all stores, which need refrigeration equipment | Lower electricity consumption for cooling, possibility to feed the excess heat to DH network |

## S13b Advanced Heat Pump (high COP)

| SPEC CARD | SYSTEM INTEGRATION SOLUTIONS | | |
|---|---|---|---|
| | Category 3<br>INTEGRATED INFRSTRUCTURES | | |
| | Solution 13<br>Heat Pumps | | |
| Title | Graphical Detail | | |
| S13b Advanced Heat Pump (high COP) |   | | |
| | - Exhaust air heat pump<br>-The system has also heat exchanger from DH network<br>- Heat factor (output/input) is about 4 | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | Oulu Energy / Sivakka | |
| Implementation Time | 2019-2020 | Initial Investment | About 2000 euros / heat-kW |

| What is Solution? | How does it work? |
|---|---|
| Exhaust air (multi-source) heat pump | Heat is gained from exhaust air, which is extracted mechanically, using fans, from bathrooms, toilets and kitchens. This is a commonplace solution in Finland. In new buildings the heat in exhaust air is recovered by air-to-air heat exchanger to incoming fresh air, but if that system lacks in existing buildings, it is expansive to install afterwards. Therefore, it may make sense to take the heat out of the exhaust air with heat pump (HP) and increase the temperature so that it can be used for heating and domestic water (min. 55°C for DHW). Here this kind of HP is implemented. The system is modular, i.e. built using modules, which are easy to install and replace when needed. The whole installation includes also the heat exchanger from DH network together with HP. The system optimizes the parallel use of these sources.<br>Coefficient of performance (COP) is around 4, when heating water from 10 to 60°C and air source has a temperature of 20°C. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | Many developers |
| Operator Who is operating this solution? | Oulu Energy / Sivakka |

| | |
|---|---|
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Owners of all the buildings, which do not have exhaust air heat recovery already |
| Implementer Who is implementing this solution? | Oulu Energy / Sivakka |
| Financer How / By whom has the implementation of this solution been financed? | Oulu Energy / Sivakka |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | The tenants, even if they will probably notice at all that this has been installed. If the solution is feasible, the rents can be kept moderate and stable. |
| **Business Model Patterns** | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| No obligatory other solutions in connection with this, but in this case HP is used together with DH | Political: Politically favourable, as potentially decrease the energy consumption and emissions<br>Economic: Pay-back time may be quite long, especially in system level. However, if properly implemented and used, feasible investment in long term.<br>Social: No significant impact. May help to keep the living cost tolerable.<br>Technical: Readily available technology, even if there are still details which can be still improved. In this case the target is a turn-key delivery.<br>Environmental: Depends on the ratio of emissions from electricity (for HP) and the alternative heating method. Especially when used as a "smart", i.e. timely flexibly used component, potentially decreases the emissions. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Very high potential for replication. Suitable for all buildings, which have no heat recovery from exhaust air and more or less centralized exhaust air outtake. | Decreases the net energy consumption by e.g. 40%. But, heat is partly replaced by electricity use, so the total benefit depends on the ratio of values of heat and electricity. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| | |
| **Reference Applications of this Solution** | |
| | |

# S13c Acoustic Air Heat Pump

| | | | | |
|---|---|---|---|---|
| SPEC CARD | DEMAND SIDE SOLUTIONS | | | |
| | Category 3<br>INTEGRATED INFRSTRUCTURES | | | |
| | Solution 13<br>Heat Pumps | | | |
| Title | Graphical Detail | | | |
| S13c<br>Acoustic Air Heat Pump | | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | Yes | GPO, GRO | | |
| Implementation Time | | Initial Investment | € 13,000 (€ 7.000 EU) | |
| What is Solution? | | How does it work? | | |
| | | The sound effects are significantly lower compared to regular heat pumps. | | |
| Stakeholder Analysis | | | | |
| **Developer (if relevant)** Who has developed this solution? | | | | |

| | |
|---|---|
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political: Enabler<br>Economic: Currently too expensive, but technique has not yet fully penetrated the market.<br>Social: Reduction of noise<br>Technical:<br>Environmental: Reduces CO2 emissions<br>Legal: Can become an enabler |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | |
| **Reference Applications of this Solution** | |
| | |

## S13d Acoustic Hybrid heat pump

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 3<br>INTEGRATED INFRSTRUCTURES | | |
| | Solution 13<br>Heat Pumps | | |
| Title | Graphical Detail | | |
| S13d Acoustic Hybrid heat pump | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | | | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| | |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |

| | |
|---|---|
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | |
| Potential for Replication | Expected Impacts - Benefits |
| | |
| Reference Applications of this Solution | |
| | |

## S13e Geothermal Heat Pump

<table>
<tr><td rowspan="3">SPEC CARD</td><td colspan="4">DEMAND SIDE SOLUTIONS</td></tr>
<tr><td colspan="4">Category 3<br>INTEGRATED INFRSTRUCTURES</td></tr>
<tr><td colspan="4">Solution 13<br>Heat Pumps</td></tr>
<tr><td>Title</td><td colspan="4">Graphical Detail</td></tr>
<tr><td rowspan="2">S13e Geothermal Heat Pump</td><td colspan="4"></td></tr>
<tr><td colspan="4">- Implementation of geothermal Heat pump for heating and cooling</td></tr>
<tr><td>City / Country</td><td>Making_City</td><td colspan="3">Technical Partner Name & contact Details</td></tr>
<tr><td></td><td>Yes</td><td colspan="3">WAM,</td></tr>
<tr><td>Implementation Time</td><td></td><td>Initial Investment</td><td colspan="2">€ 637,856</td></tr>
<tr><td colspan="2">What is Solution?</td><td colspan="3">How does it work?</td></tr>
<tr><td colspan="2">The installed geothermal heat pump (A26) has the following characteristics:<br>• Type: Mono source, 45 m3/h.<br>• Temperature: 40-50 oC<br>• Cooling capacity: 665 kW, 532 MWh/y<br>• Heating: capacity 713 kW, 949 MWh/y<br>• Energy demand: Cooling: 531.9 MWh, Heating 845.3 MWh<br>• Energy consumption heat pump system: Cooling: 37,020 kWh/y, Heating: 297,578 kWh/y<br>• Energy reduction: Cooling: 79%, heating: 48%, combined: 57%.<br>• CO2 reduction: Cooling: 65 ton, Heating: 88.2 ton, combined: 153.2 ton.<br>• COP Cooling: out of storage 40, regeneration: 6. COP heating: 4.2<br>The heat pump is providing 89% of the heating demand of the building.</td><td colspan="3"></td></tr>
</table>

| | |
|---|---|
| Therefore, the gas installation is still in place. | |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Energy savings will enable for a short payback period compared to the lifetime of the technology<br>Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political:<br>Economic: A positive BC<br>Social:<br>Technical:<br>Environmental: Large reduction in $CO_2$ emissions<br>Legal: |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | |
| **Reference Applications of this Solution** | |
| | |

## S14a PV in roofs and parking lot

| SPEC CARD | DEMAND SIDE SOLUTIONS |
|---|---|
| | Category 4<br>RENEWABLE ENERGY SYSTEMS |
| | Solution 14<br>Solar PV Panels |
| Title | Graphical Detail |
| S14a PV in roofs and parking lot | <br>Part of the PV on Nijestee flat 1 (left) and Nijestee flat 2 (right). |
| | - PV implementation on roofs<br>- PV implementation on parking lot |

| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| | Yes | NIJ, GPO, WAM, GRO | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| PV in roofs and parking lot (600 kWp)<br>*Terraced Houses, (3.14 kWp), GPO<br>After the selection of the three terraced houses completed, the number of PV panels and the capacity will be decided.<br>*Nijestee flats, (50 kWp), NIJ<br>33 kWp has been implemented. Space has been left open on the roof for 20 extra PV panels or around 10 PVT panels per building<br>*Mediacentrale, Building, (77.6 kWp), parking lot (131.1 kWp), WAM<br>GRO is investigating the possibility of realizing innovative PV on a parking lot within the PED boundaries | |

| | |
|---|---|
| *Sport Complex, (335.3 kWp), GRO<br>The building contains 1040 PV panels, each 280 Wp | |
| **Stakeholder Analysis** | |
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| With the generation of electricity, the energy bills will reduce significantly<br>Space rental<br>Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | Political: PV is generally accepted as standard solution to increase energy balance.<br>Economic: The BC is valid for regular PV.<br>Social: Positive<br>Technical: PV keeps improving its performance, but there are no constraints<br>Environmental:<br>Legal: |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| | |
| **Reference Applications of this Solution** | |
| | |

# S14b Building Integrated PV (on the facade)

| SPEC CARD | SUPPLY SIDE SOLUTIONS |
|---|---|
| | Category 4<br>RENEWABLE ENERGY SYSTEMS |
| | Solution 14<br>Solar PV Panels |
| Title | Graphical Detail |
| S14b Building Integrated PV (on the facade) |  On the left PV panel placement on Sivakka building, on the right other examples from Northern Finland <br>Southern facade covered by vertical solar panels |

| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| | Yes | Sivakka | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| An apartment house from 70's has its southern facade covered with PV panels. | When maximising the production of solar, also vertical planes should be used. This gives not only more area, but also a favourable monthly gain of solar power. In Nordic climate enrgy is needed most in the wintertime or, with in this case better definition, outside summertime. Vertical panels may have e.g. 10% lower annual total gain than the "usual ones" with 45...60 degrees angle, but especially in springtime the production of vertical planes may be even manifold compared to angled ones. |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Many developers |
| Operator Who is operating this solution? | Sivakka |
| Customer(s) or user(s) Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | Sivakka or building owner in general |

| | |
|---|---|
| Implementer Who is implementing this solution? | Oulu Energy and Sivakka |
| Financer How / By whom has the implementation of this solution been financed? | Oulu Energy and Sivakka |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | If the solution is feasible, finally the tenants benefit from this. |
| **Business Model Patterns** | |
| Energy consumption decrease due to the use of heat pumps leads to bill decrease<br>Power purchase agreement<br>White label retailing<br>Leasing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| If own consumption can be directed towards solar production, especially so that the peak loads are cut, it gives additional advantage | Political: Subsidies available in many countries, i.e. PV has political support<br>Economic: Long pay-back time<br>Social: Positive and visible image from panels<br>Technical: Fastening the panels to the vertical plane requires some special attention, but if skilfully done, no special barriers<br>Environmental: Vertical installation is advantageous in terms of system impact and emission reduction (more production in cold seasons)<br>Legal: No major issues |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Medium replicability. Shading, which is common in especially urban areas, limits the applicability. The panels are also not suitable for all kind of architectural styles. | Environmental benefits and a bit smaller and more predictable electricity bill |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| | |
| | |

## S14c Floating Solar pontoons

| SPEC CARD | DEMAND SIDE SOLUTIONS | | | |
|---|---|---|---|---|
| | Category 4<br>RENEWABLE ENERGY SYSTEMS | | | |
| | Solution 14<br>Solar PV Panels | | | |
| Title | Graphical Detail | | | |
| S14c Floating Solar pontoons | | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | Yes | GRO | | |
| Implementation Time | | Initial Investment | €217,000 (€105,000 EU) | |
| What is Solution? | | How does it work? | | |
| In the surrounding area of the Sport Complex building [A6] floating solar pontoons are planned. 180 panels (156 kWp) are allocated. These very innovative doubled-sized floating panels will make full use of the reflecting properties of the water allowing the usage of two-sided solar panels increasing the yield of solar power. The intention is to implement more panels than was originally considered in order to maximize the solar energy production and to make a more solid business case. | | | | |
| Stakeholder Analysis | | | | |

| | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | Groningen |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| The energy bill savings achieved by the PVs will be used in other investments<br>Power purchase agreement<br>Municipal utility<br>With label retailing<br>Leasing | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | Political: Competition between building, energy and environmental department.<br>Economic:<br>Social: It is preferred that the profits are reinvested in district energy measures.<br>Technical: Building on water can be done, but is also a challenge<br>Environmental: Can be both an enabler and barrier. The goal is building with nature<br>Legal: |
| Potential for Replication | Expected Impacts - Benefits |
| | The city of Groningen is investigating the possibilities of exploiting RES in public area's and reinvesting the profits in the district energy planning measures. |
| Reference Applications of this Solution | |
| | |

## S14d Solaroad

| | | | |
|---|---|---|---|
| SPEC CARD | SUPPLY SIDE SOLUTIONS | | |
| | Category 4<br>RENEWABLE ENERGY SYSTEMS | | |
| | Solution 14<br>Solar PV Panels | | |
| Title | Graphical Detail | | |
| S14d Solaroad |  | | |
| | General Data for the solution in bullets | | |
| City / Country | Delft | SolaRoad BV, www.solaroad.nl | |
| | Yes/No | | |
| Implementation Time | months | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| SolaRoad's products are based on a simple concept. Robust solar panels with a skid resistant, translucent coating are mounted on a concrete slab. The concrete provides support and loading capacity, the solar panel generates electricity from the sunlight, the coating protects the solar panel, and offers skid resistance for the traffic. The combination is a robust road surface, offering safety and comfort to bikes or vehicles, while harvesting electricity from the sun. | Through the integration of photovoltaic material in a road element, covered with a friction providing transparent coating renewable energy is produced. The PV modules are connected to micro inverters which ensure safety, shading tolerance and optimal yield. The electricity is transported to connection boxes where it is either fed back into the grid or can be used locally. This depends on the application. |

Stakeholder Analysis

| | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Road authority |
| Operator Who is operating this solution? | N/A |
| Customer(s) or user(s) Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | Road authority |
| Implementer Who is implementing this solution? | Road construction company |
| Financer How / By whom has the implementation of this solution been financed? | Road authority |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| The renewable energy generated can either be sold on the energy market, or used to reduce the energy costs of the owner.<br>Power purchase agreement<br>Municipal utility<br>White label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| the combination with the electrification of transport is highly appealing. (the combination with smart charging for instance). | Political: What is the value of integration? (this solution is non0-invasive). The market is a governmental market. A steady market growth is crucial for investors to further develop this concept.<br>Economic: investment cost must, and will decrease when volume grows.<br>Social: the fact that is is perfectly integrated (instead of other renewables) makes that there is a high social acceptance.<br>Technical: durability is still under research. the concept itself is proven.<br>Environmental: The product is under development, amongst others to increase the EOL scenario of the solution<br>Legal: for (very) large scale applications the energy production by road authorities might become an issue. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| System is installed in 2014 in Krommenie, since then multiple projects in the Netherlands and France are realized. | |

## S15a Hybrid Heat collector (high pressurised $CO_2$)

| SPEC CARD | DEMAND SIDE SOLUTIONS<br>Category 4<br>RENEWABLE ENERGY SYSTEMS<br>Solution 15<br>Solar Thermal Panels | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S15a Hybrid Heat collector (high preassurised CO2) | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | JET; VTT | |
| Implementation Time | | Initial Investment | €28,000 (all EU) |

| What is Solution? | How does it work? |
|---|---|
| Low temperature heat collectors will be used in Arina to collect heat even from very low temperatures (-20ºC). The normal vacuum tube type of heat collector is able to harvest energy only when the sun is shining. A new type of heat collector is using high pressurized CO2 to collect heat also in the night time. The new collector is made by open end technology and can collect heat from radiation and from surrounding air. This type of heat collector is efficient because it collects energy 24 hours a day. | |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |
| **Customer(s) or user(s)** Who is this solution targeting ? For instance, who | |

| | |
|---|---|
| is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Power purchase agreement<br>White label retailing | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | Political: No major barriers<br>Economic: To be seen. Low temperature differences and air speeds in the surface increase the needed surface area and thus the size of the collector, but on the other hand the device is possible to build robust and simple.<br>Social: No major barriers<br>Technical: To have defrosting performing properly is essential<br>Environmental: No major barriers<br>Legal: No major barriers |
| Potential for Replication | Expected Impacts - Benefits |
| | Widening of the potential heat sources for heat pumps, also in places, where geothermal heat is not available or too expensive. |
| Reference Applications of this Solution | |
| | |

## S15b PVT Panels

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 4<br>RENEWABLE ENERGY SYSTEMS | | |
| | Solution 15<br>Solar Thermal Panels | | |
| Title | Graphical Detail | | |
| S15b PVT Panels | <br>- Photovoltaic Thermal panels to be implemented in different parts of the city | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | NIJ for Nijestee, GRO for Sport Complex | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| The 88 (200 m2) PVT panels in Sport Complex (type: PowerCollectors) have been placed on top of the sport complex building by Solaris.<br>Heat: 114 kWp, Electricity: 22.8 kWp with 88 panels | Both heat and electricity is generated. These types of innovative solar collectors generate 3 times as much energy compared to regular PV. The heat production is mainly used for the balance of the geothermal district heating system and thereby contributes to the RES of the district heating system. The generated electricity is used for the energy balance of the building. |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |
| Operator Who is operating this solution? | |

| | |
|---|---|
| **Customer(s) or user(s)** Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| **Implementer** Who is implementing this solution? | |
| **Financer** How / By whom has the implementation of this solution been financed? | |
| **Other impacted stakeholder(s)** (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Power purchase agreement<br>White label retailing | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | Political: Enabler<br>Economic: Positive BC<br>Social:<br>Technical: Very interesting connection with geothermal heat pump system. Optimal use of space.<br>Environmental: Avoids CO2 emissions<br>Legal: |
| Potential for Replication | Expected Impacts - Benefits |
| | |
| Reference Applications of this Solution | |
| | |

## S16a Geothermal energy

| SPEC CARD | DEMAND SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 4<br>RENEWABLE ENERGY SYSTEMS | | |
| | Solution 16<br>Geothermal energy | | |
| Title | Graphical Detail | | |
| S16a Geothermal energy |  Figure 13: Schematic overview district heating network North PED.  | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| Groningen | | | |
| Implementation Time | | Initial Investment | |

| What is Solution? | How does it work? |
|---|---|
| Two District Heating systems based on RES are located in PED North and PED South and will be the main responsible to supply thermal energy to the buildings located in both PEDs. Within Warmtenet Noordwest some 10,000 – 12,000 households equivalents will be supplied with sustainable heat via an alternative heating district network. The waste heat from two datacenters (Bytesnet and QTS) will be used for the heating. | WarmteStad receives according to forecasts 1,5 MW waste heat from with a temperature of 23°C. WarmteStad extracts 5°C of the waste heat which is used to raise the return water of the district heating from 50 °C up to 75 °C by using Heat pumps. If necessary during the winter we can raise the temperature up to 90 °C by using a CHP and/or gas boilers. |

| Stakeholder Analysis | |
|---|---|
| **Developer (if relevant)** Who has developed this solution? | |

<table>
<tr><td>Operator Who is operating this solution?</td><td></td></tr>
<tr><td>Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution?</td><td></td></tr>
<tr><td>Implementer Who is implementing this solution?</td><td></td></tr>
<tr><td>Financer How / By whom has the implementation of this solution been financed?</td><td></td></tr>
<tr><td>Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution?</td><td></td></tr>
<tr><td colspan="2">Business Model Patterns</td></tr>
<tr><td colspan="2">Power purchase agreement<br>Municipal utility<br>Cooperative utility<br>White label retailing</td></tr>
<tr><td>Integration with other smart solutions</td><td>BARRIERS / ENABLERS _ PESTEL STUDIES</td></tr>
<tr><td></td><td>Political: In this project the local government and the local politics are involved. Social unrest can lead to political questions. In this project questions from politicians are answered adequately (at the moment there is no open question/ barrier).<br>Economic: The energy transition involves high costs. This requires investments from building owners, external financiers and from the heat company itself.<br>Social: The population is increasingly aware of the fact that something needs to change and we need to combat the climate change. A positive trend is gradually emerging. Our customers understand why this project is needed.<br>Technical: In general, there can be more innovative techniques we don’t know yet, which are better than the technique we will use. But this is for now no issue.<br>Environmental: With this project we will reduce the CO2 footprint.<br>Legal: In the exploitation of our project we have to operate under the national heat law. In general, this law is for protecting consumers for monopoly on heat. The coming years the law will change. The challenge is to be compliant to this law. For now, we do comply</td></tr>
<tr><td>Potential for Replication</td><td>Expected Impacts - Benefits</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Reference Applications of this Solution</td></tr>
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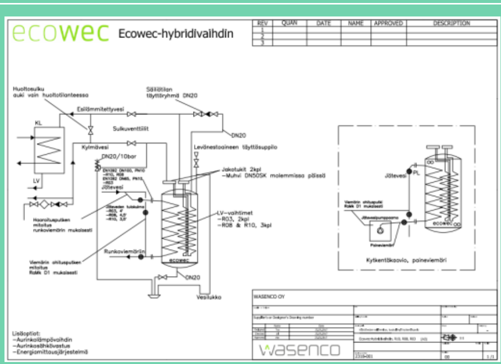
# S17a Heat recovery system from AC and sewage water

| SPEC CARD | SUPPLY SIDE SOLUTIONS | | |
|---|---|---|---|
| | Category 4<br>RENEWABLE ENERGY SYSTEMS | | |
| | Solution 17<br>Waste Heat Recovery | | |
| Title | Graphical Detail | | |
| S17a Heat recovery system from sewage water |   <br>- Heat recovery from wastewater in apartment buildings<br>- Passive system without heat pump<br>- Intermediate, protective water layer between sewage and fresh water | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | Sivakka | |
| Implementation Time | 2019-2020 | Initial Investment | € 45 000 (€13 500 EU) |

| What is Solution? | How does it work? |
|---|---|
| Heat recovery from wastewater to pre-heat cold water for hot tap water | Sewage water from apartments is led through a large-diameter pipe spiral, which is in the water tank. In the tank there is another heat exchanger, from the tank water to fresh, incoming water, for hot tap water pre-heating. The whole installation is made of stainless steel. The tank with exchanger inside is located in the lowest point of the sewage system in the building, to avoid pumping.<br>The efficiency of the recovery is about 20%. In other words, the incoming water is heated by about 10 degrees. |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | Wasenco |
| Operator Who is operating this solution? | Sivakka |
| Customer(s) or user(s) Who is this solution targeting ? For instance, who is saving energy thanks to the implementation of this solution? | Building owner |

| | |
|---|---|
| Implementer Who is implementing this solution? | Building owner |
| Financer How / By whom has the implementation of this solution been financed? | Building owner |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | "Invisible" solution but if it works properly, finally the tenants get an advantage, in addition to environmental gains |
| **Business Model Patterns** | |
| Power purchase agreement<br>Municipal utility<br>Cooperative utility<br>With label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Not necessarily need to have other solutions in place | Political: Promotes energy efficiency and is thus politically supported<br>Economic: Long pay-back time, about 20 years, but also a long lifetime<br>Social: No major barriers/enablers<br>Technical: Simple and robust design, movable parts minimised<br>Environmental: Saves about 20% of hot tap water heating energy<br>Legal: No major barriers. Tight energy regulation gives benefit to also this kind of solutions. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Moderate potential. Requires space under the building (height about 2 m). Sewage system must be arranged so that as many as possible sewage branches are collected to one point, in which the heat recovery device can be installed. | About 20% energy savings in domestic hot water heating. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| | |
| **Reference Applications of this Solution** | |
| Wasenco Oy | http://wasenco.com/ecowec-hybridivaihdin_ottaa_lammon_talteen_jatevedesta/ |

## S17b Heat recovery system from return pipeline to DHW

| | | | |
|---|---|---|---|
| SPEC CARD | SUPPLY SIDE SOLUTIONS<br>Category 4<br>RENEWABLE ENERGY SYSTEMS<br>Solution 17<br>Waste Heat Recovery | | |
| Title | Graphical Detail | | |
| S17b Heat recovery system from return pipeline to DHW |  <br>- District heating return water is cooled down with a heat pump and the heat used for space and domestic hot water heating<br>- Advantage depends on the overall DH system. May be feasible, if there is CHP, solar heat, heat pumps and/or flue gas scrubber in the system. All these benefit from lower return temperature. | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | Oulu Energy | |
| Implementation Time | Year 2020. DH network building is in place, connecting to it takes one day when the essential other construction works around the DH exchangers are in place. | Initial Investment | Ordinary DH exchanger round 3000-10000 euros, DH pipe construction underground > 100 e/m. Heat pump very roughly round 500 euros/heat-kW. |

| What is Solution? | How does it work? |
|---|---|
| Ordinary DH exchanger round 3000-10000 euros, DH pipe construction underground > 100 e/m. Heat pump very roughly round 500 euros/heat-kW. | Heat pump in the DH return side increases the water temperature to suitable level for space and hot tap water heating. Temperature lift is low (under 20 degrees), which may give COP of e.g. 6, i. e. very high.<br>The connection can be done either by cooling the return flow in the secondary circuit inside the building or district heating water in the primary circuit, which connects heat production and buildings together. Primary circuit connection (so-called |

| | |
|---|---|
| | three-pipe installation) gives the most advantage, but requires more work in especially existing buildings. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | Many developers |
| Operator Who is operating this solution? | Oulu Energy |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Building owner and the whole system |
| Implementer Who is implementing this solution? | Oulu Energy |
| Financer How / By whom has the implementation of this solution been financed? | Oulu Energy |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | "Invisible" for inhabitants, but if works well, the whole system gets benefit. |
| **Business Model Patterns** | |
| Power purchase agreement<br>With label retailing | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Requires DH system and certain elements in the production side to be at its best. See "Expected impacts". | Political: If well described, may be have positive value in politics (energy saving and CO2 emission reduction)<br>Economic: Depends very much on the DH system configuration<br>Social: No major barriers or special enablers<br>Technical: Some technical question marks, like the possible changes in DH water flows after implementing this. Separate components are well known and commercial technology, but the whole solution is not common.<br>Environmental: Depends very much on the DH system configuration<br>Legal: No major barriers or special enablers, as far as we know |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Applicable in many DH heated buildings, but suitability to system-specific properties must first be studied. | The solution is the more feasible, the more there are the following in the DH system:<br>- CHP plant. Increases the electricity production due to the lower condensing temperature (which partly compensates the electricity used by heat pump)<br>- Heat pump. Coefficient of performance increases, i.e. electricity consumption decreases, when the incoming water is cooler.<br>- Flue gas scrubber. Cooler return water cools the flue gas to lower temperature, which means that extra heat is gained to DH water.<br>- Solar heat. Lower incoming water temperature to solar collector means more solar gain per m2.<br>- Industrial waste heat. The lower is the incoming water temperature, the higher is usually the waste heat potential. |

| | |
|---|---|
| | - Bottlenecks in the DH network. Decreasing the return water temperature increase the temp difference between supply and return and thus increases the pipe heat transfer capacity. |

## S18a Integrated Sustainable Energy Planning

| SPEC CARD | NON-TECHNICAL SOLUTIONS<br>Category 5<br>POLITICAL, SOCIAL, ECONOMICAL INTERVENTIONS<br>Solution x<br>Policy Innovation | | |
|---|---|---|---|
| Title | Graphical Detail | | |
| S18a Integrated Sustainable Energy Planning | INTENSSS PA<br>Integrated Sustainable Energy Planning<br><br>> Holistic thinking: sustainable energy provision with pursuit of alternative regional ambitions and developments<br>> Integration: improved integration of spatial planning and energy planning to overcome sectorial divided planning<br>> Area-based: sensitive to regional and local conditions (e.g. local resources, institutional conditions, demand etc.)<br>> Societal engagement: bottom-up approach engaging key regional stakeholders and community driven<br>> Knowledge driven: locally appropriate technologies for production and efficiency while matching supply and demand | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | Yes | 11 RUG - c.zuidema@rug.nl | |
| Implementation Time | 2 years | Initial Investment | depends |

| What is Solution? | How does it work? |
|---|---|
| Integrated sustainable energy planning, presented as a holistic approach to combining spatial planning with the pursuit of a more sustainable (i.e. renewables based and efficient) energy system. ISEP is a plan developed based on a distinct approach to decision making including an area-based approach to identify local synergies between alternative societal challenges and ambitions, and explicitly means to be | Integrated sustainable energy planning requires cross-sectoral working and network governance due to the variety of social and economic stakeholders involved. It is supported by a specific protocol for making decisions, which is accessible as appendix. |

| | |
|---|---|
| based on a wide inclusion of a variety of public and private stakeholders. | |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | INTENSSS-PA project; (Dr. C. Zuidema) |
| Operator Who is operating this solution? | Appplied in seven EU regional Living Labs (Groningen (NL), Middelfart (DK), Zemkale (LV), Pomurje (Slo), Karditsa (Gr), Reggio Calabria (It), Casilla y Leon (Sp)) |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Seven EU regions |
| Implementer Who is implementing this solution? | Seven EU regions |
| Financer How / By whom has the implementation of this solution been financed? | EU Horizon 2020 |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | Designer: INTENSSS-PA project; (Dr. C. Zuidema) |
| **Business Model Patterns** | |
| Public investment (Resilient strategy) | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| This is a non-technical solution and essentially helps organize a structured process for energy policy making in regions and cities. It links directly with planning procedures and uses key elements of a living lab approach (co-creation, experiential learning and interactive policy making). Explicitly identifies and aims to use various renewable energy and energy efficiency technologies. | **Political:** B: short term focus (4 years political cycles), limited willingness (due to short term cost, long term benefits)<br>**E:** leadership of aldermen, coalitions with key stakeholders to create continuity<br>**Economic:** B: limited government resources, population decline, poverty (lack of investment opportunities for individuals), short term thinking, uncertainties technological development<br>**E:** dropping prices renewable technologies, synergetic effects between alternative activities (notably agriculture, transport and energy), government backed loans<br>Social: B: social resistance, lack of awareness, energy poverty,<br>**E:** growing social support for renewables, link energy to other issues (e.g. comfort, liveability, financial gain & savings), co-creation in an open setting, create mutual narrative of the future of a place<br>**Technical:** -<br>**Environmental:** -<br>**Legal:** B: lack of legal competences of local governments, inflexibility of policies for allowing novel technologies, fragmentation of regulations<br>**E:** subsidies, feed in tariffs, legal experimental room (pilots) |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Easy to replicate as a conceptual approach, but will vary in its detailed manifestation within each different locality. | The approach allows for identifying synergies and trade-offs betwene varous energy and non-energy related objectives. In doing so, it can make smart use ofr a variety of governmental (scetoral) budgets, attractc private investments and create societal benefits beyond the mere pursued of renewable energy targets. |

| | |
|---|---|
| | |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| Giannouli et al. (2018) | Giannouli,I., C.Tourkolias, C. Zuidema, A. Tasopoulou, S. Blathra, K. Salemink, K. Gugerell, P. Georgiou, T. Chalatsis, C. Christidou, V. Bellis, N. Vasiloglou, N. Koutsomarkos (2018) A methodological approach for holistic energy planning using the living lab concept: the case of the prefecture of Karditsa, European Journal of Environmental Sciences, Vol.8, No.1, DOI: 10.14712/23361964.2018.3 |
| Giannouli et al. (2017) | Giannouli, I. , C. Christidou, A. M. Marinero Peral , S. Cantero Celada, J. L. de las Rivas Sanz , M. Fernández Maroto, C. Zuidema, K. Salemink , K. Gugerell, S. Blathra, K. Leonhart Petersen, A. Tasopoulou, A. Papaioannou , N.Koutsomarkos A Co-planning Approach for Area-Based Holistic Energy Planning: The Experience of INTENSSS-PA project, Proceedings of the international conference Changing Cities III. http://www.intenssspa.eu/wp-content/uploads/2018/02/INTENSSSPA_paper_CCIII_140517_AC.pdf |
| Report 'Area Based Integrated Sustainable Energy Planning Concept' | http://www.intenssspa.eu/wp-content/uploads/2018/11/D3.2_INTENSSS_PA_v1_1.pdf |

## S18b Land use planning fostering energy actions

| SPEC CARD | NON-TECHNICAL SOLUTIONS<br>Category 5<br>POLITICAL, SOCIAL, ECONOMICAL INTERVENTIONS<br>Solution x<br>Policy Innovation |
|---|---|
| Title | Graphical Detail |
| S18bLand use planning fostering energy actions | <br>Picture source: City of Oulu/Department of Urban Planning/Hiukkavaara Center<br>> Land use planning is portrayed as a tool to foster energy actions<br>> Integration: land use planning is considered as a capacity to integrate the aims of the city, energy network operators, private developers and citizens<br>> Knowledge driven: assessments and surveys produced during land use planning process can be utilized to generate knowledge about energy opportunities<br>> Societal engagement: participatory planning process can be utilized for energy-related participation<br>> Implementability: bridges energy targets and implementation |

| City / Country | Making_City | Technical Partner Name & contact Details | |
|---|---|---|---|
| | No | 14/UOU/Sari Hirvonen-Kantola (sari.hirvonen-kantola@oulu.fi) | |
| Implementation Time | 1-10 years | Initial Investment | Public land |

| What is Solution? | How does it work? |
|---|---|
| Cities can utilize land use planning as a tool to foster energy actions, by adopting the integrative urban development approach. The integrative approach takes the development aspirations of all the PED stakeholders as a starting point of land use planning, and creatively develops them further to discover | City of Oulu utilized a district-level structural scheme for Hiukkavaara area and iterative planning process to facilitate discussions and explore opportunities for energy actions with the energy company and construction companies. To establish advantages, Hiukkavaara area was profiled as a sustainable winter city with innovative energy solutions. In Hiukkavaara center area, the city of Oulu utilized innovative plot lease and conveyance for innovation procurement of energy solutions from construction and development companies. Opportunities have been exploited in detailed plans that juridically |

| | |
|---|---|
| mutual gains. In strategic land use planning opportunities can be explored together with energy companies, enterprises, citizens and other relevant stakeholders. | enable implementation of building projects, including energy actions. The cities then can build advantage by profiling areas suitable for implementing energy actions. For exploiting these opportunities for implementation, the cities can utilize detailed land use planning. |
| **Stakeholder Analysis** | |
| Developer (if relevant) Who has developed this solution? | INURDECO-project (University Oulu, City of Oulu) |
| Operator Who is operating this solution? | The City |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Property owners, residents |
| Implementer Who is implementing this solution? | Energy companies, energy solution providers, construction and development companies |
| Financer How / By whom has the implementation of this solution been financed? | The City, construction and development companies, energy companies, property owners, residents |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| Energy savings<br>Public investment<br>(Resilient strategy) | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| Land use planning can be used as a tool to integrate solutions and implement them in specific locations and in collaboration with digital platforms utilizing location intelligence. | Political: B: possible resistance due to e.g. commercial interests, E: well in line national and EU-level targets for climate, energy and land use.<br>Economic: Private interests may be a barrier in some cases. Possible savings in the overall system on the other hand<br>Social: See above.<br>Technical: No major barriers.<br>Environmental: Fosters climate, energy and land use targets.<br>Legal: Well supported by the Finnish Legislation and also EU principles. |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| Easy to replicate as a conceptual approach, but will vary in its detailed manifestation within each different locality. | The approach allows for identifying synergies and trade-offs betwene varous energy and non-energy related objectives. In doing so, it can make smart use ofr a variety of governmental (scetoral) budgets, attractc private investments and create societal benefits beyond the mere pursued of renewable energy targets. |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| Hirvonen-Kantola, S., Ahokangas, P., Iivari, M., Heikkilä, M., & Hentilä, H-L. (2015). Urban development practices as anticipatory action learning: Case Arctic Smart City Living Laboratory. Procedia Economics and Finance, 21, 337–345. Available at: https://www.sciencedirect.com/science/article/pii/S221256711500 | |

| Reference Applications of this Solution | |
|---|---|
| Hiukkavaara area, Oulu, Finland | |

## S19a Wind Turbines

| | | | | |
|---|---|---|---|---|
| SPEC CARD | NON-TECHNICAL SOLUTIONS<br>Category 4<br>RENEWABLE ENERGY SYSTEMS<br>Solution 19<br>Wind Turbine | | | |
| Title | Graphical Detail | | | |
| S19a Wind Turbines | - In Finland the wind power share of electricity production is to be increased from current 7% to about 15% in a couple of years. - the currenty full load hours for wind power in average in Finland is about 3000/year, but will be increased due to longer blades in new turbines<br>- Much more is to come. There are plans for about 18 000 MW, which would cover over half of the Finnish electricity consumption. All of these plans will not be realized, but in every case the future share of wind power will be very high.<br>- The investment cost of the land-based wind power is about 1300 e/kW and the maintenance cost about 7 e/MWh. These mean that wind is the cheapest method to produce electricity, concerning new electiricty only-plants.<br>- A lot of the existing and new plants are situated close to Oulu. Especially in the coastal area of up to 100 km north from Oulu there are a lot of windmills. | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | No | | | |
| Implementation Time | | Initial Investment | | |
| What is Solution? | | How does it work? | | |
| | | | | |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | |
| Operator Who is operating this solution? | |

| | |
|---|---|
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | |
| Implementer Who is implementing this solution? | |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | Political: Generally, well accepted, but some resistance<br>Economic: Good situation. New mills are installed without subsidies.<br>Social: Minor restrictions due to the perceived visual harm and that from noise<br>Technical: No serious technical issues in onshore wind. For offshore, the techniques for the basement etc are still under development.<br>Environmental: Disregarding landscape and noise issues, an environmentally sound solution<br>Legal: Land use planning is crucial also for wind power. In general the Finnish legislation supports wind energy investments. The permission restrictions guide the build windmills in the areas, where they cause the minimum disturbance. |
| Potential for Replication | Expected Impacts - Benefits |
| High, when suitable areas are found | |

## S20a E-car Parking and Charging Points

| | | | |
|---|---|---|---|
| SPEC CARD | NON-TECHNICAL SOLUTIONS<br>Category 4<br>RENEWABLE ENERGY SYSTEMS<br>Solution 20<br>E-car Parking and Charging | | |
| Title | Graphical Detail | | |
| S20a E-car Parking and Charging Points | E-car charging stations | | |
| City / Country | Making_City | Technical Partner Name & contact Details | |
| | | SIV, OEN | |
| Implementation Time | | Initial Investment | |
| What is Solution? | How does it work? | | |
| Electric car charging points for SIV and YIT buildings and Arina mall.<br>The facility will be part of the local energy system. Local electricity will be used to charge when possible | In building 1, the eCar parking area would have 10 charging stations for eCars. The facility will be located in the close walking distance from SIV and YIT buildings. Half of these are reserved for public use (car sharing and eCar charging) others can be rented for eCar private owners who need a parking facility. SIV will be responsible to build the parking facility and OEN to build the charging stations and taking care of the facility and management. There is now to be charging stations in the parking lot of the shopping mall. Electric cars are currently so expensive, that people in rental houses (Sivakka buildings) are not purchasing them.<br>In smaller scale the chargers are however in place. There are normal Schuko-type sockets outside, one for each parking lot, for most of the places. The fuses are 10 or 16 amperes, so the maximum output is 2300 or 3680 watts. This is less than that for special EV chargers, but can be used for plug-in hybrids. For combustion engine cars, the idea of these sockets is to give power for engine and car interior pre-heating in wintertime. | | |
| Stakeholder Analysis | | | |
| Developer (if relevant) Who has developed this solution? | SIV and OEN | | |

| | |
|---|---|
| Operator Who is operating this solution? | SIV, OEN |
| Customer(s) or user(s) Who is this solution targeting? For instance, who is saving energy thanks to the implementation of this solution? | Car renters, public, Arina mall users |
| Implementer Who is implementing this solution? | |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| **Business Model Patterns** | |
| | |
| **Integration with other smart solutions** | **BARRIERS / ENABLERS _ PESTEL STUDIES** |
| | |
| **Potential for Replication** | **Expected Impacts - Benefits** |
| The e-cars are increasing especially in Northern Europe, there is a huge potential especially after the deadlines of forbidding the use of diesel vehicles in major city centers | E-cars are expected to be more efficient than conventional vehicles and with the support of renewable energy the CO2 emissions will decrease |
| **Relevant Publications / Presentations / Services / Products to this Solution** | |
| | |
| **Reference Applications of this Solution** | |
| | |

## S20b E-car Parking and Charging Points

| | | | | |
|---|---|---|---|---|
| SPEC CARD | NON-TECHNICAL SOLUTIONS<br>Category 4<br>RENEWABLE ENERGY SYSTEMS<br>Solution 20<br>E-car Parking and Charging | | | |
| Title | Graphical Detail | | | |
| S20b Connection of the charging stations to the local demand response system | | | | |
| City / Country | Making_City | Technical Partner Name & contact Details | | |
| | | | | |
| Implementation Time | | Initial Investment | | |
| What is Solution? | | How does it work? | | |
| | | | | |

| Stakeholder Analysis | |
|---|---|
| Developer (if relevant) Who has developed this solution? | |
| Operator Who is operating this solution? | |

| | |
|---|---|
| Customer(s) or user(s) Who is this solution targeting For instance, who is saving energy thanks to the implementation of this solution? | |
| Implementer Who is implementing this solution? | |
| Financer How / By whom has the implementation of this solution been financed? | |
| Other impacted stakeholder(s) (if relevant) Who else is impacted by the deployment of this solution? | |
| Business Model Patterns | |
| Public investment (Resilient strategy) | |
| Integration with other smart solutions | BARRIERS / ENABLERS _ PESTEL STUDIES |
| | |
| Potential for Replication | Expected Impacts - Benefits |
| | |
| Relevant Publications / Presentations / Services / Products to this Solution | |
| | |
| Reference Applications of this Solution | |
| | |

# ANNEX III Business model guidelines for PEDs

# 1 Methodology

New business models shall be designed in such a way to:

- satisfy market needs that have not been met yet
- introduce new technologies, new products or new services
- improve / disrupt / transform existing markets
- create new markets

To help the MAKING-CITY partners develop their business models, this report provide support on 3 levels:

- Business model guidance - Business model canvas and its 9 blocks - *chapter 2*
- Listing business model patterns (identified by the inteGRIDy project) - *chapter 3*
- Examples of business model for PEDs - *chapter 4*
  - Description of the common business model for PEDs based on literature review
  - Tagging of each business model for PEDs with the business model patterns
- Tagging each MAKING-CITY Spec Card with the common patterns - *chapter 5*

This will allow easy cross analysis while providing exhaustive and open information (Figure 1):

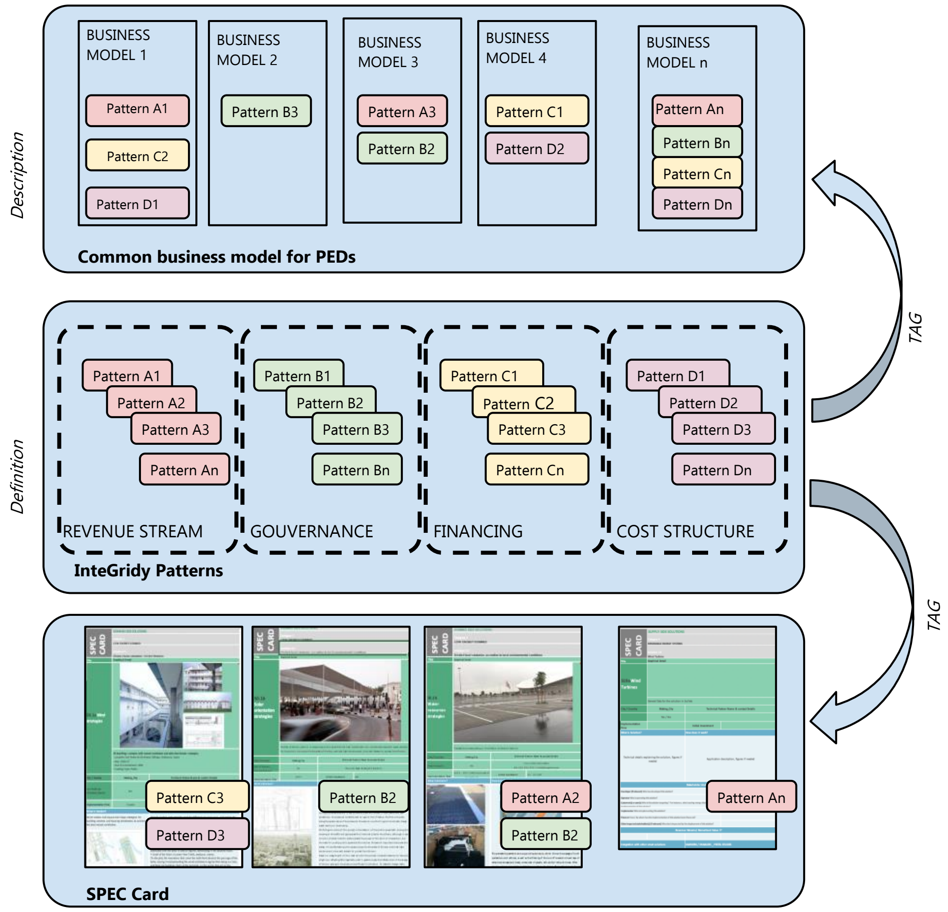



**Figure 1 Methodology for defining Business Models**

# 2 Business model guidance

## 2.1 Business model Canvas

The Business Model Canvas, described in the bestselling book ***Business Model Generation***[45] is a strategic tool that uses visual language to create and develop innovative business models. It allows to visually represent the way in which a company creates, distributes and captures value.

45 Business model generation, Alexander Osterwalder & Yves Pigneur - https://www.strategyzer.com/books/business-model-generation

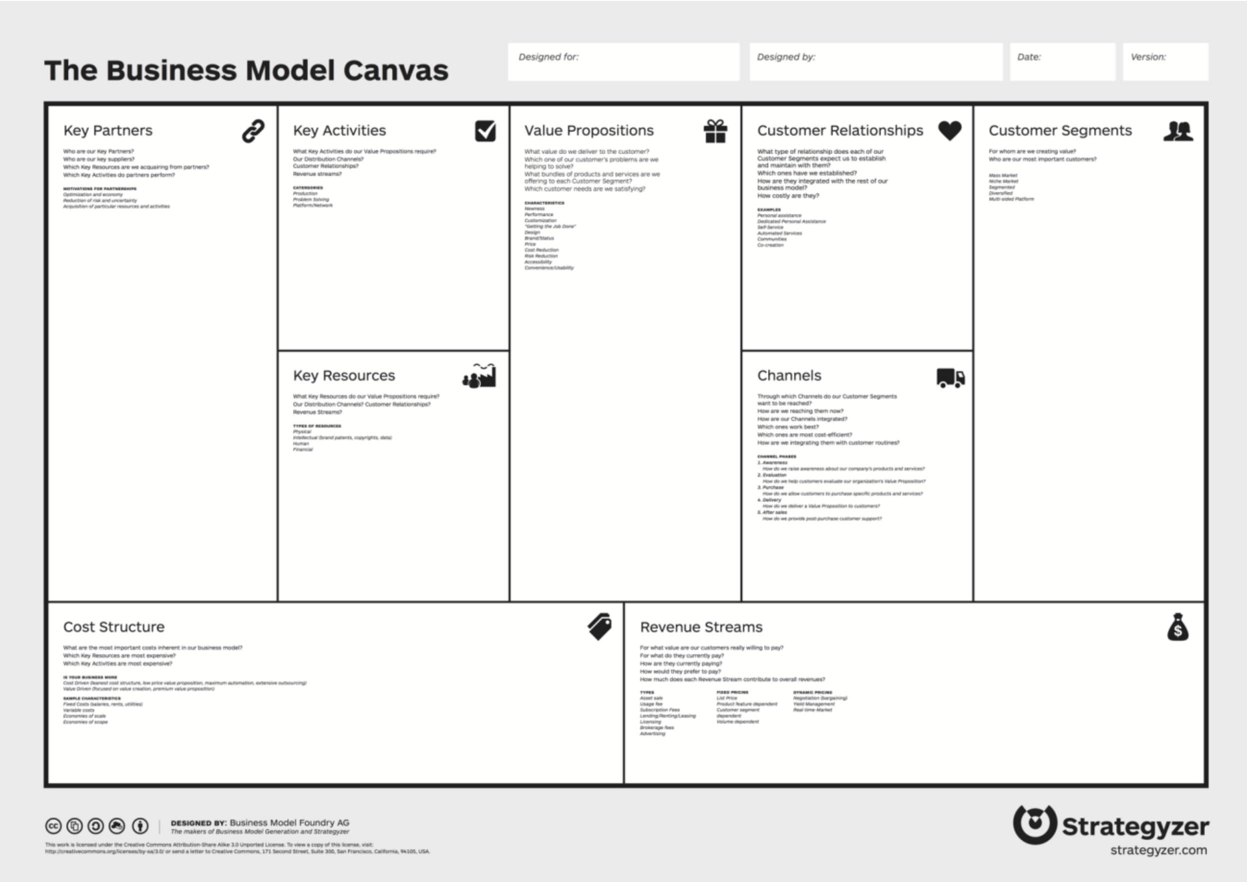



Figure 2 Business Model canvas

The Business Model Canvas is a powerful framework within which the 9 constituting elements of a business are represented in the form of blocks:

1. Customer Segments (CS): the customer segments to which the company addresses
2. Value Proposition (VP): the value proposition containing the products / services that the company wants to offer
3. Channels (Ch): the distribution and customer contact channels
4. Customer Relationships (CR): the type of relationships established with customers
5. Revenue Streams (R $): the revenue stream generated by the sale of products / services
6. Key Resources (KR): the key resources needed for the company to function
7. Key Activities (KA): the key activities needed to make the company business model work
8. Key Partners (KP): the key partners with whom the company can forge alliances
9. Cost Structure (C $): the cost structure that the company will have to bear

Thanks to the intuition of Alexander Osterwalder, this model has revolutionized the way of representing a business model. With ease, everyone has the opportunity to understand complex elements that affect the functioning of an entire company: this is the communicative advantage of the Canvas. In literature there are different conceptualizations that describe the business model, in most cases, however, the visual representation is rather complex and scarcely intuitive[46]. Osterwalder's work, on the other hand, proposes a single model created starting from the similarities of a vast range of other frameworks that have occurred over time, creating a decidedly exhaustive functional synthesis.

The Business Model Canvas was initially proposed by Alexander Osterwalder in his first work Business Model Ontology (2004) and subsequently developed by Osterwalder himself, by Yves Pigneur and Alan Smith together with a community of 470 experts in 45 countries around the world: this has led to the publication of the book Business Model Generation, today a world best seller translated into 30 languages.

The spread of the book around the world and the power of the model has transformed the Business Model Canvas into an international standard and for this reason it is taught in the best business schools in the world such as Standford University and Berkley University.

In summary, the Business Model Canvas is a useful tool for developing new business models or formalizing existing ones. It is a graphic scheme where to visually summarize how a company creates value, the necessary resources and activities, the customer segments, and the economic-financial aspects. It is useful for companies to define the management method, selecting it among all the possible alternatives.

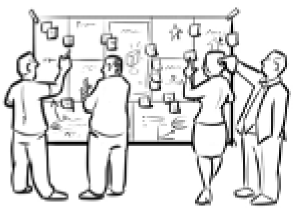
Through the Business Model Canvas, creating the business model of a new company or redesigning the business model of an existing company becomes a participatory, creative and engaging process!

## 2.2 Elaborating a business model

According to the Business Model Generation book, elaborating a business model elaborating a business model takes place in 5 phases:

1. mobilize
2. understand
3. design
4. implement
5. manage

The phases follow each other in a non-linear way, that is, we can have cases in which some of them overlap (as could happen, for example, to the "understanding" and "designing" phases) or even chasing each other (the design activity, during which ideas are produced, it could bring with it the need to return to the understanding phase and so on). It is important to always adapt the processes to your situation: innovation starts first of all from here.



The 5 phases can be described as follows:

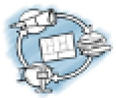
[46] http://www.affarsmodeller.se/Business-Model-Timeline.gif

MOBILIZE: in this phase, the company prepares everything necessary to create the new business model. Among the things to be prepared there are also intangible elements such as the growth of awareness regarding the need to innovate / improve one's business model and the motivation to do so. In addition to this, the right team must be assembled and shared a common language that allows us to discuss during the other phases.

UNDERSTAND: at this stage the company must research and analyze the elements that will then be used during the design phase. The fundamental ability to be implemented is to OBSERVE: what people do, what are the needs of potential customers, what the experts say, what are the existing products / services and how they work ... in a nutshell, during this phase MARKET KNOWLEDGE must be developed.

DESIGN: in this phase it is necessary to generate and test different business models in order to select the best among them; it is necessary to create real prototypes of business models from the information collected previously (or in parallel) and choose, after careful analysis, the one that seems to work best.

IMPLEMENT: at this stage the company enters the market. The business model prototype needs to be tested to analyze customer reactions.



MANAGE: in this phase the prototype is adapted and modified based on the responses received from the market. The required capacity is always that relating to OBSERVATION, this time on real customer reactions combined with the ability to DISCUSS the business model prototype to constantly transform it into an ever better one.

# 3 List of PED patterns

## 3.1 Common patterns

Each of the nine blocks of the business model canvas has common patterns that can be regularly seen from one business model to another. The European project inteGRIDy (http://www.integridy.eu) has developed a business modelling tool to support partners and professionals in the energy sector in prototyping suitable business models. The tool provides a list of common patterns for the different blocks of the Business Models Canvas.

In this report we focus on four of the blocks of Business Models Canvas:

- Revenue streams / Revenues models
- Key partners / Gouvernance mode
- Key resources / Financing
- Cost structure / Pricing logic

Table 1 lists all commons patterns identified by inteGRIDy for these 4 blocks. Patterns are sorted in 4 categories: Energy, classical, digital, sustainable.

**Table 1 Common Patterns identified by inteGRIDy**

| | | Energy model | Classical | Digital | Sustainable |
|---|---|---|---|---|---|
| Revenue models | Pay per use | X | X | X | |
| Revenue models | Shared savings | X | | | |
| Revenue models | Space rental | X | | | |
| Revenue models | Power purchase agreement | X | | | |
| Revenue models | White label retailling | X | | | |
| Revenue models | Pay as you go | X | | | |
| Revenue models | Brokerage | | X | | |
| Revenue models | Licensing | | X | | |
| Revenue models | Subscription | | X | | |
| Revenue models | Advertising | | X | | |
| Revenue models | One-time payment plus regular fees | | X | | |
| Revenue models | Asset sales | | X | | |
| Revenue models | Commission | | X | | |
| Revenue models | Leasing | | X | | |
| Revenue models | Performance based contracting | | | x | |
| Revenue models | Affiliation | | | | |
| Revenue models | Multi-sided revenue model | | | X | |
| Gouvernance mode | Municipal utility | X | | | |
| Gouvernance mode | Cooperative utility | X | | | |
| Gouvernance mode | Active customer | X | | | |
| Gouvernance mode | Virtual power Plant | X | | | |
| Gouvernance mode | Local aggregator | X | | | |
| Gouvernance mode | Microgrid | X | | | |
| Financing | Crowdfunding | X | | | X |
| Financing | Loans | X | | | |
| Financing | Leasing | X | | | |
| Financing | Energy performance contracts | X | | | |
| Financing | Entreprise credit facilities | X | | | |
| Financing | acces to Cross Subsidies | X | | | |
| Financing | Third party ownership | X | | | |
| Financing | Direct finance options | X | | | |
| Financing | Micro finance | | | | X |
| Financing | Social Business Model: no dividends | | | | X |
| Pricing logic | Flat rate | X | X | | |
| Pricing logic | Rising Blocks tariffs | X | | | |
| Pricing logic | Dynamics tariffs | X | | | |
| Pricing logic | Power-based tariffs | X | | | |
| Pricing logic | Cost-based Pricing | X | | | |
| Pricing logic | Complementary pricing | X | | | |
| Pricing logic | Bundling | X | | | |
| Pricing logic | Add-on | | X | | |
| Pricing logic | Cost leadsership | | X | | |
| Pricing logic | Flexible price | | X | X | |
| Pricing logic | Forced scarcity | | X | | |
| Pricing logic | Freemium Shared savings | | X | | |
| Pricing logic | Freemium | | | X | |
| Pricing logic | Pay with data / data as a service | | | X | |
| Pricing logic | Innovative product financing | | | | |
| Pricing logic | differential pricing | | | | X |

The following parts (part 3.2, part 3.3, part 3.4, part 3.5) of this *ANNEX III. Business model guidelines for PEDs of the deliverable D4.1 Methodology and guidelines for PED Design* centralizes the classic definitions of the different business model patterns as defined in the literature.

# 3.2 Revenue models

## 3.2.1 Pay per use / pay as you go (Saas):

*Insight: Consumers pay for the unit or service without gaining ownership over a product.*

The use of a product or service is metered, and customers are charged each time they use the service[47].

The advantages are that the customers pay only for their use and there are no initial subscription costs nor additional costs. The inconveniences for the user ist to have high costs during peak use, they could

[47] Source: https://reasonstreet.co/business-model-pay-per-use/

prefer more balanced expenses. However, this can work very well for customers with fluctuating service usage.

### 3.2.2 Pay per user:

*Short definition:*

Per-user pricing is a Software as a Service (SaaS) pricing model where users pay different amounts depending on the number of people using the service. It's similar to the model used by many companies for physical software licensing, but many experts claim that it's not perfect. According to Price Intelligently agency[48] per user pricing kills your growth and sets you up for long term failure, because the number of users is rarely where value is ascribed to your product (it doesn't take into account that one company could have several users for the same activity, neither the inactive users that are not valuable…).

### 3.2.3 Multi-sided revenue model

*INSIGHT: Developing a multi-sided model which uses the advantages of digital and connected products or services to generate (additional revenues)*

According to the book the Business model generation[49] such platforms are of value to one group of customers only if the other groups of customers are also present. The key is that the platform must attract and serve all groups simultaneously in order to create value[50].

Usually multi-sided platforms solve this dilemma by subsidizing one of the customers segments (low cost or free services to attract them on the platform). To do so, it is very important to understand who should be subsidized and how to price correctly.

The main features of the business model canvas of such platform are the following:

- The key resource required for this business model pattern is the platform.
- The three key activities are platform management, service provisioning, and platform promotion.
- The main costs incurred under this pattern relate to maintaining, developing and supporting the platform.
- The value proposition usually creates value in three main areas: First, attracting user groups (i.e. Customer Segments); Second, matchmaking between Customer Segments; Third, reducing costs by channeling transactions through the platform.
- Two or more customer segments have each their own Value Proposition and associated Revenue Stream. Moreover, one Customer Segment cannot exist without the others.
- Each Customer Segment produces a different revenue stream. One or more segments may enjoy free offers or reduced prices subsidized by revenues from other Customer Segments. Choosing which segment to subsidize can be a crucial pricing decision that determines the success of a multi-sided platform business model.

48 https://www.priceintelligently.com/blog/bid/198499/stop-per-user-saas-pricing-you-re-killing-growth

49 Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers - 2010

50 More info: https://reasonstreet.co/business-model-two-sided-marketplace/

### 3.2.4 Subscription

*INSIGHT: charge a time-based payment to allow access to locations, offerings, or services that non-members do not have*

The subscription-based business model[51] is a business model that charges customers a recurring fee — typically monthly or yearly — to access a product or service. Recurring revenue models lead to higher revenues and stronger customer relationships.

This compounding growth is what makes customers so powerful here. Through subscription, customers become more valuable the longer they use your product.

### 3.2.5 Advertising

*INSIGHT: provide customers with a free service offer and use other sources (such as advertising) to generate revenues.*

Another pricing option is to make the core product free but earn revenue from giving access to the audience through advertising.

Example of a Free ad supported model with Metro a free newspaper that started in Stockholm and is now available in dozens of cities around the world. The genius of Metro lies in how it modified the traditional daily newspaper model. First, it offered the paper for free. Second, it focused on distributing in high-traffic commuter zones and public transport networks by hand and with self-service racks. This required Metro to develop its own distribution network but enabled the company to quickly achieve broad circulation. Third, it cut editorial costs to produce a paper just good enough to entertain younger commuters during their short rides to and from work.


Examples[52]: CNN, Facebook, Forbes, Google, The New York Times, The Washington Post, Twitter, Vox, Yahoo

### 3.2.6 Affiliation

*INSIGHT: charging a commission for referring a customer to a third-party*

The focus lies in supporting others to successfully sell products and directly benefit from successful transactions. Affiliates usually profit from some kind of pay-per-sale or pay-per-display compensation. The company, on the other hand, is able to gain access to a more diverse potential customer base without additional active sales or marketing efforts.

### 3.2.7 Fractional ownership

*INSIGHT:*

[51] Source: https://www.priceintelligently.com/blog/subscription-business-model

[52] Source: https://reasonstreet.co/business-model-library/business-models-advertising-supported/

Fractional ownership[53] describes the sharing of a certain asset class amongst a group of owners. Typically, the asset is capital intensive but only required on an occasional basis. While the customer benefits from the rights as an owner, the entire capital does not have to be provided alone.

Example: Homebuy allows low income households in England to purchase a home. Hereby the government and a housing developer provide part of the capital needed to purchase a house, and the customer only has to pay / get a mortgage for the remaining value of the home. The financier owns part of the home, but the customer has the full right to live in the home.

### 3.2.8 Performance based contracting

*INSIGHT: the fee for a product or a service is determined by the actual outcome*

A product's price is not based upon the physical value, but on the performance or valuable outcome it delivers in the form of a service. Performance based contractors[54] are often strongly integrated into the value creation process of their customers. Special expertise and economies of scale result in lower production and maintenance costs of a product, which can be forwarded to the customer. Extreme variants of this model are represented by different operation schemes in which the product remains the property of the company and is operated by it.

Example: General electric in its service business for pressure control equipment, GE introduced a condition-based monitoring and maintenance service agreement. This allows GE to shift from calendar and event-based maintenance to condition-based monitoring and maintenance. By sharing some of the operating risk with its customer it can provide a risk-adjusted value proposition to the customer and also has more control over state and maintenance of its equipment.

In *a guaranteed-savings EPC* the ESCO assumes the risk of the project's performance[55]. Financing is, usually, provided by the ESCO, but may include capital investment from the client. The ESCO will guarantee a minimum energy savings level (percentage), if savings exceed the guaranteed level, they can be absorbed by the ESCO or the customer depending on the method of payment agreed. Fixed payment contracts mean that all savings belong to the customer while payment by percentage of savings means that all savings besides the ones guaranteed to the client are paid to the ESCO. (EC-JRC, 2016; DAREED, 2014).

**Table 2 - summary of the guaranteed-savings EPC business model**

<table>
<tr><td rowspan="2">7 - Key partners<br>Construction and technical partners</td><td>5 - Key activities<br>Project preparation, development and operation</td><td rowspan="2" colspan="2">1 - Value proposition<br>Guarantees energy savings; Stable cash-flows</td><td>4 - Customer relationships<br>Contractual</td><td rowspan="2">2 - Customer segments<br>Corporate clients willing to invest in EE</td></tr>
<tr><td>6 - Key resources<br>Technical know-how</td><td>3 - Channels<br>Corporate projects; Special events</td></tr>
<tr><td colspan="3">9 - Cost structure<br>Construction cost</td><td colspan="3">8 - Revenue streams<br>Energy savings from the project</td></tr>
</table>

[53] Source: https://businessmodelnavigator.com/pattern?id=16

[54] Source: https://businessmodelnavigator.com/pattern?id=38

[55] Source : http://www.climact.net/siteclimact/wp-content/uploads/2020/01/Easy-Guide-on-EPC-Business-Models.pdf

### 3.2.9 Licensing

| |
|---|
| *INSIGHT: rent intangible assets (such as know-how, brand, processes) for a limited amount of time* |

Efforts are focused on developing intellectual property that can be licensed to other manufacturers[56]. This model, therefore, relies not on the realization and utilization of knowledge in the form of products, but attempts to transform these intangible goods into money. This allows a company to focus on research and development. It also allows the provision of knowledge, which would otherwise be left unused and potentially be valuable to third parties.

### 3.2.10 Space rental

| |
|---|
| *INSIGHT: the developer acquires a power purchase agreement (PPA) from utility. The developer then installs and operates the system on the rented space. Every KWh produced by the system is exported to the grid. Revenue from the sales of electricity goes to the developer. The space owner receives a rental fee as agreed in the contract.* |

Clients pay an amount of money to be able to use a space (building, room, desk…).

Example: In the UK, in 2020 when the government first launched their feed-in-tariff funding scheme for solar panels, tariff payments were so generous that many installers were happy to offer free solar panels throught the "rent a roof" scheme.

### 3.2.11 Power purchase agreement

| |
|---|
| *INSIGHT: A household or a commercial owner signs a long term agreement to purchase energy at an agreed competitive rate at a private firm, which subsequently installs a system at the customer's premise and maintains ownership of the equipment throughout the term.* |

A Power Purchase Agreement (PPA)[57] often refers to a long-term electricity supply agreement between two parties, usually between a power producer and a customer (an electricity consumer or trader). The PPA defines the conditions of the agreement, such as the amount of electricity to be supplied, negotiated prices, accounting, and penalties for non-compliance. Since it is a bilateral agreement, a PPA can take many forms and is usually tailored to the specific application. Electricity can be supplied physically or on a balancing sheet. PPAs can be used to reduce market price risks, which is why they are frequently implemented by large electricity consumers to help reduce investment costs associated with planning or operating renewable energy plants.

Less common models include the Virtual Power Plant (VPP) and cooperative model.

There are various structures for PPAs, but they can be classified into four main types[58] :

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[56] Source: https://businessmodelnavigator.com/pattern?id=26

[57] Sources: https://www.next-kraftwerke.com/knowledge/ppa-power-purchase-agreement & https://europe.solar-asset.management/download-white-paper-ppa-business-models
Solarplaza

[58] Source : https://www.pwc.fr/fr/assets/files/pdf/2019/11/en-france-pwc-corporate-ppa-energy-facts.pdf

- Onsite PPA, a direct physical supply of power where the plant site is in the proximity of the offtaker (behind the metering of the offtaker).
- Physical PPA, physical power supply where the power is delivered through the grid and the plant site does not need to be in the offtaker's operating location.
- Virtual PPA, an indirect power supply that focuses on financial settlement using a contract for difference between the offtaker and the asset owner.
- Guarantees of origin PPA, long-term supply of renewable energy certificates. This PPA can be bundled with other PPA structures.

### 3.2.12 Brokerage

*INSIGHT: Charge a fee for a successful transaction, ie a click a booking*

Brokers are market-makers[59]. They bring buyers and sellers together and facilitate transactions. Usually a broker charges a fee or commission for each transaction it enables.

### 3.2.13 Commission

*INSIGHT: Refer customers to a third party and received a commission for a specific transaction completed (e.g. click, give information, buy product)*

The most popular business model for modern marketplaces is to charge a commission from each transaction[60]. When a customer pays a provider, the platform facilitates the payment and charges either a percentage or a flat fee.

The biggest benefit of this revenue model is that providers are not charged anything before they get some value from the marketplace. This is really attractive to the providers. At the same time, from the marketplace's point of view, this model is usually the most lucrative: you get a piece of all the value that passes through your platform. The best-known marketplace platforms—like Airbnb, Etsy, eBay, Fiverr, TaskRabbit, and Uber—all use commissions as their main business model.

### 3.2.14 Whitelabel retailing

*INSIGHT: producing products without a brand label and allowing other brands to sell them. This allows companies to offer energy supply to customers without the burden of additional regulation or installations of new systems, commonly using those of their fully licensed partners. Commission are paid by the recruiting party.*

[59] Source: http://www.ebusinessprogrammers.com/ebusiness/EbizBrokerage.asp#:~:text=~%20(Groove%201999)-,Brokerage%20Model,for%20each%20transaction%20it%20enables.

[60] Source: https://www.sharetribe.com/academy/how-to-choose-the-right-business-model-for-your-marketplace/

A white label producer allows other companies to distribute its goods under their brands, so that it appears as if they are made by them[61]. The same product or service is often sold by multiple marketers and under different brands. This way, various customer segments can be satisfied with the same product.

### 3.2.15 One-time payment plus regular fees

*INSIGHT: claim an initial one-time payment associated with reoccuring service or transaction fees.*

The customers pay an initial amount of money (administration fees, line opening....) and then pay regular fees.

## 3.3 Gouvernance mode

### 3.3.1 Municipal utility

*INSIGHT: A local authority creates a fully licensed supply company concentrating on local market share, linking geographically proximate generation ton consumption. With this DSO/TSO services may be possible. Also demand side services have greater potential with geographically aggregated customer bases.*

A public utility company (usually just utility) is an organization that maintains the infrastructure for a public service (often also providing a service using that infrastructure). Public utilities are subject to forms of public control and a regulation ranging from local community-based groups to statewide government monopolies.

The term utilities can also refer to the set of services provided by these organizations consumed by the public: coal, electricity, natural gas, water, sewage, telephone, and transportation.

### 3.3.2 Virtual power plant

*INSIGHT: Each of the distributed power generation systems can be represented as aggregated controllable groups to make contracts in the wholesale market and offer services to the System Operator. Through the VPP, the instability defects or different distributed energy resources can be made up. VPPs can be treated as traditional power plants.*

[61] Source: https://businessmodelnavigator.com/pattern?id=55

Virtual power plants are a more comprehensive approach of municipalities to stabilise the grid[62]. These bundle medium and small-scale power-producing and power-consuming units. All units are operated through the Virtual Power Plant's central control room while remaining independent in their ownership and governance. The objective is to smartly distribute supply and demand and to profitably trade the generated and consumed power.

### 3.3.3 Local Aggregator

*INSIGHT: Bringing energy customers together in a group to obtain a certain benefit (ie: better prices, services, market participation). Under this scheme, provision of contracting services of use to the distribution system operators and transmission system operators (DSO/TSO) is possible.*

Aggregators are defined as legal entities whose aim is to optimise energy production and consumption either technically or economically[63]. The aggregated pool can include generators and consumers and can operate in one or multiple electricity markets.

As the levels of distributed energy resources grow, aggregation to provide flexibility is crucial to their integration with the increased variability and price volatility they can bring.

### 3.3.4 MicroGrid

*INSIGHT: Interconnected load and distributed energy resources (DERs) for acting as a single controllable entity with respect to the grid. A microgrid is capable of operating in grid-connecting and standalones modes. In the grid-connected mode, ancillary services can be provided by trading activity between the microgrid and the main grid.*

Microgrid have three typical business model[64] :

- Customer-owned (capital expenses)
- Microgrid as a service (operational expense)
- Pay as you go (small, remote systems)

Any Microgrid (off-grid facility, Grid connected facility, off-grid community, Grid-connected community) can use any of the above business models. Sometimes these models are used in combination.

### 3.3.5 Leasing

*INSIGHT: combining an initial payment with monthly installments. Customers can use the produced electricity or sell it and receive a feed-in tariff. Therefore, the customer received benefits from the installed system in the form of energy savings or feed-in tariff income.*

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[62] Source: http://www.cityenergy.org.za/uploads/resource_406.pdf

[63] Source: https://www.engerati.com/energy-retail/business-models-for-renewable-aggregation-what-is-ready/?register=success

[64] Source: https://download.schneider-electric.com/files?p_Doc_Ref=998-2095-03-10-17AR0_EN

Deriving revenues through the leasing model typically involves three parties: the seller, the buyer (lessee) and the financier (lessor)[65].

In exchange for payment, ownership of an item (usually equipment) is transferred from the seller to the lessor. The lessee then contracts with the lessor for the use of the item in exchange for a periodic fee. The seller may or may not retake ownership of the item once the leasing contract has ended.

Leasing arrangements occur most frequently in transactions involving the exchange of costly physical goods.

Because of their long duration, leasing arrangements create ongoing relationships between sellers and lessors. Often a service agreement will exist alongside the leasing arrangement requiring the seller to provide support to the lessor throughout the term of the contract.

Quality control matters a great deal because leasing opportunities only succeed with equipment items that retain residual value and have demonstrated reliability and durability over time.

### 3.3.6 Active customers

*INSIGHT: Carrying out not only traditional energy consumption but also independent energy production.*

For example, Slack has a pricing model based on the number of active users in an organization. Slack will refund its customers if they have fewer users than they thought.

## 3.4 Financing

### 3.4.1 Crowdfunding

*INSIGHT: Raising money from a large number of people. It may bring in new type of customers, for instance, individuals interested in experimenting with novel service. It can also provide additional legitimacy to renewable energy projects, as the selection process by the "crowd" is per se democratic.*

A product, project or entire start-up is financed by a crowd of investors who wish to support the underlying idea, typically via the Internet[66]. If the critical mass is achieved, the idea will be realized and investors receive special benefits, usually proportionate to the amount of money they provided.

### 3.4.2 Energy performance contracts

*INSIGHT: allowing customers to undertake energy savings projects without up-front capital costs, using operational savings. Under the EPC, the company provides financing for a specified set of measures related to energy efficiency retrofit, along with associated design, engineering and installation services.*

[65] Source: https://learn.marsdd.com/article/the-leasing-revenue-model-and-leasing-arrangements/

[66] Source: https://businessmodelnavigator.com/pattern?id=8

The EPC model is based on delivering energy savings compared to a predefined baseline[67]. In this model, an Energy Service Company (ESCO) enters into arrangements with property-owners to improve energy efficiency of their property by implementing various measures. 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 performance-based remuneration in relation to the savings it achieves. Generally, savings achieved can only be measured indirectly as difference between consumption before and after implementation of the energy efficiency (EE) and renewable energy (RE) measures (relative measurement: savings = baseline – ex post-consumption).

Most EPC projects focus on the implementation of energy efficiency measures (lighting, HVAC, energy management and control, envelope insulation). EPC models run under long-term contracts of typically ten years, depending on the payback time of the energy savings measures and the specification of the building owner (i.e. they may last up to 15 years when they include long payback-period investments such as wall insulation or window replacements).

The most common forms of EPC are shared-savings and performance based contracting (guaranteed-savings), but it is also possible to perform variable contracts.

## 3.5 Pricing logic

### 3.5.1 Flat rate

*INSIGHT: charging a fixed price , allowing the customer to get unlimited access in exchange. Many energy companies offer plans for a wide range of contract term length.*

Same price for everything. Some companies charge a flat rate for all their upgraded services, with no further differentiation[68].

In this model, a single fixed fee for a product or service is charged, regardless of actual usage or time restrictions on it. The user benefits from a simple cost structure while the company benefits from a constant revenue stream.

### 3.5.2 Freemium

*INSIGHT: offer a basic service for free, while charging a premium for advanced or specific features.*

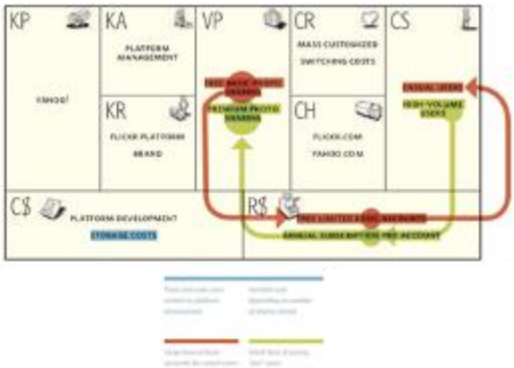
Provide a good amount of functionality for free, then have a range of upgrades. This works well if the add-on services have real value for the target audience, but there's always a danger that most people won't need - or want - to upgrade[69].

[67] Source: https://renovation-hub.eu/business-models/energy-performance-contracting-epc/#:~:text=The%20EPC%20model%20is%20based,property%20by%20implementing%20various%20measures

[68] Source: https://businessmodelnavigator.com/pattern?id=15 and more info: https://reasonstreet.co/business-model-flat-rate/-

[69] Source: https://reasonstreet.co/business-model-freemium/

Example of a Freemium model with Flickr, the popular photo-sharing Web site acquired by Yahoo! in 2005, provides a good example of a freemium business model. Flickr users can subscribe for free to a basic account that enables them to upload and share images. The free service has certain constraints, such as limited storage space and a maximum number of uploads per month. For a small annual fee users can purchase a "pro" account and enjoy unlimited uploads and storage space, plus additional features.




Examples of Freemium: Candy Crush, Survey Monkey, LinkedIn, Evernote, Box, DropBox, Google Apps, Hulu, Skype, Spotify, Slack, Tencent, Trello

### 3.5.3 Data as a service

*INSIGHT: providing a standard, continuous feed of energy data, from any utility, which enables energy solution and technology providers to focus their resources on innovation and differentiation of their offerings.*

Data or data management as a core underlying asset; services are created on top of data that is collected, trained, and labeled. Value in structured, cleaned, or scrubbed data[70].

### 3.5.4 Rising Blocks tariffs

*INSIGHT:. tariff increases as stepped intervals, with a low or zero price block, to cover basic/essential energy use and subsequent blocks charged at higher unit prices.*

The number of products or the number of services permitted increases in bands rather than single digits. For example, a SaaS company can set a cost up to 5 users, then another from 5 to 10 users and so on.

### 3.5.5 Complementary pricing

*INSIGHT: products are priced to maximized sales volume, which in terms stimulate the demand for other products.*

Complementary Product pricing is a method in which one of the products is priced to maximize the sales volume and which in turn stimulates the demand of other product.

One product is priced low, just to cover the costs with little or no profit margin while the other product is priced high with a very high profit margin. Both the products are complementary products i.e use of one product is complemented by the other. This strategy is basically followed to overcome the loss due to product's sale by the profit provided by the sales of the other complementary product[71].

[70] Source: https://reasonstreet.co/business-model-data-as-a-service/

[71] https://www.mbaskool.com/business-concepts/marketing-and-strategy-terms/10797-complementary-product-pricing.html

### 3.5.6 Shared saving

*INSIGHT: Implementing an energy efficient program (considering capital improvements, ie upgrade of the HVAC system, boilers…) in exchange for a portion of energy cost savings.*

Type of contract of sale under which a vendor installs an item (equipment, machine, or system) at a customer's premises free of charge, but shares the subsequent savings realized as compared with the period before the item was installed. The title to the item usually remains with the vendor until its price is fully recovered from the savings[72].

With shared savings EPC the ESCO finances the project for implementation of ECMs at the customer facilities[73]. Measured cost savings during the contract period are shared between the client who owns the facility and the ESCO. Usually, the contract specifies that a percentage of 20 the obtained savings goes to the ESCO, which was previously defined by the client and the ESCO. This percentage is highly dependent on factors like length of the project and project risks.

**Table 3 - Shared-savings EPC business model Canvas**

| | | | | |
|---|---|---|---|---|
| **7 - Key partners**<br>Financial Institutions;<br>Construction and technical partners | **5 - Key activities**<br>Project preparation, development and operation<br>**6 - Key resources**<br>Technical and financial know-how | **1 - Value proposition**<br>Energy savings without prior investment or commitment;<br>Savings from the first moment | **4 - Customer relationships**<br>Contractual (medium-term, 10-15 years)<br>**3 - Channels**<br>Public projects;<br>Special events | **2 - Customer segments**<br>Large buildings:<br>Public bodies;<br>Corporate clients (building owners, commercial and industrial) |
| **9 - Cost structure**<br>Construction cost; Interest rates | | **8 - Revenue streams**<br>Energy savings from the project | | |

The duration of the contract depends on the level of investment that was made. For large refurbishment measures it is expected a long-term contract (8-15 years). For EPC involving low levels of investment (e.g. 'EPC light'), short-term contracts (2-3 years) are also possible (GIZ, 2012).

### 3.5.7 Add-on

*INSIGHT: offering a basic product at a competitive price and charge for several extras.*

The core offering is priced competitively, but there are numerous extras that drive the final price up. In the end, the customer pays more than he or she initially assumed. Customers benefit from a variable offer, which they can adapt to their specific needs[74].

### 3.5.8 Bundling

*INSIGHT: Bundling provides more than one solution, which generally are related to each other, to customers from one supplier in an all-in-one package.*

[72] Source: http://www.businessdictionary.com/definition/shared-savings.html

[73] Source : http://www.climact.net/siteclimact/wp-content/uploads/2020/01/Easy-Guide-on-EPC-Business-Models.pdf

[74] Source: https://businessmodelnavigator.com/pattern?id=1

A bundling business model focuses on packaging together complementary goods and/or services into a single offering.

### 3.5.9 Cost leadership

*INSIGHT: keep variable costs low and sell high volume at low prices.*

Cost leadership is a term used when a company projects itself as the cheapest manufacturer or provider of a particular product or commodity in a competition. It is difficult to deploy the strategy because the management must constantly work on reducing cost at every level to remain competitive[75].

[75] Source: https://economictimes.indiatimes.com/definition/cost-leadership

# 4 Examples of Business models for PEDs

## 4.1 Business models for building renovation

### 4.1.1 One-Stop-Shop business models

TAG: Energy performance contracts, multi-sided revenue, Licensing, One time payment plus regular fees, Commission, Flat rate,

The One-Stop-Shop concept means that 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[76]. 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.

- **One-Stop-Shop provided by a multi-disciplinary team**

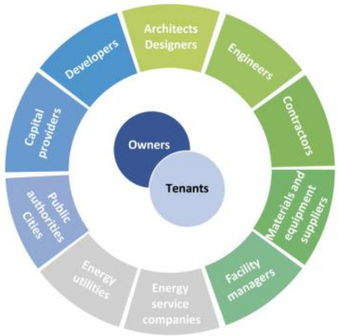
***What (value proposition):***

- Support of a wide network of professional multi-disciplinary team of experts, providing a holistic approach to the renovation project
- Owner directly involved in the definition of the intervention measures to be included in the renovation project
- Optimal integration of different measures thanks to cooperation between different actors involved in the renovation project
- Optimal control of the total costs in an early phase of the project
- Total design and operational concept for retrofitting which covers life cycle of the building
- Responsibilities and risks are shared between the members of the team
- Performance guarantee

***Who (target customer):*** The customer segments targeted by the multidisciplinary team cooperation business model are large buildings (offices) with private owners, or multi-family buildings and terraced houses, with private or public owners, with a specific focus on social housing.

***How (value chain, activities, resources):*** The model covers the complete chain of players of the renovation sector, involving them in a collaborative approach of design, aiming at defining the renovation project, merging a range of expertise and professional capabilities. This leads to a more integrated and innovative result, with an improved quality of implementation.

[76] *Source: https://renovation-hub.eu/business-models/ or https://renovation-hub.eu/wp-content/uploads/2019/09/STUNNING%20Final%20Publication.pdf*




***Why (revenue model and cost structure):*** For the service provider: Saved costs and increased profit with the help of well-structured and well-managed processes.

***Example (out of MAKING-CITY):***

Energiesprong: Energiesprong is a whole house refurbishment and new built standard and funding approachIt originated in the Netherlands as a government-funded innovation programme and has set a new standard in this market. It is now being replicated in the UK, France, Germany and Italy.

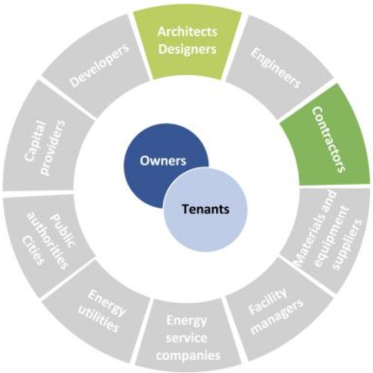
- **One-Stop-Shop supported by a Step-by-Step approach**

***What (value proposition):***

- With a Step-by-Step renovation, one can normally avoid unnecessary renewal of components that are still good in terms of appearance and functionality
- It allows to spread the investment costs for renovation measures over a longer period of time, which is easier to bear for the building owner (and the first generated energy savings can also be used to finance the following measures)
- A Step-by-Step modernisation may be developed even without taking out a loan, i.e. only equity may be used. For many building owners, this is the most important reason for carrying out renovation measures in succession instead of all at once
- Certainty that the agreed energy standard will actually be achieved thanks to the building renovation plan

***Who (target customer):*** The customer segments targeted by the Step-by-Step business model are public or private building owners that intend to renovate their property over a long period of time, targeting high levels of energy efficiency and a certification of the achieved results.

***How (value chain, activities, resources):*** The public or private building owner defines, in collaboration with the designer (planner), a plan for the renovation measures to be carried out and a timeline of their implementation. The designer (planner) is the key player in this business model, because he/she is in charge of the whole renovation plan, including the different steps to be carried out and the time schedule. The owner maintains an important role being responsible, in collaboration with an optional project manager, of the entire project. The different contractors are involved by the owner (or eventually by the project manager) in successive phases, according to the initial plan of the renovation project. The design risk is shared between the owner and the designer, while different contractors assume the construction risks associated with each of their tasks.




***Why (revenue model and cost structure):*** For the designer (planner): The main costs are associated with the training for the use of the tool and accreditation, along with standard design activity costs (salaries, administration and support costs, marketing costs, etc.). Remuneration for the service provided. Additional revenues are related to the certification procedure (optional).

***Example (out of MAKING-CITY):***

iBRoad: iBRoad project is strongly supporting building owners in Step-by-Step deep renovations, removing barriers and lock-in effects. With a proposed innovative approach, the project aims to become a real driver for deep renovation. Representing an evolution of the Energy Performance Certificates and energy audit systems, building renovation roadmaps developed within the project will serve as a tool outlining a customised renovation plan with a long-term horizon for deep Step-by-Step renovation of individual buildings (iBRoad-Roadmap) combined with a repository of building-related information (iBRoad-Logbook).

- **One-Stop-Shop supported by digital tools**

***What (value proposition):***

- Automation of the design process via the ICT tool, that supports for the identification of the best technical solutions and interventions to be implemented
- Comprehensive renovation intervention, including correct evaluation from the life-cycle perspective of energy efficiency and overall costs
- Holistic approach to the renovation project, with the support of an ICT tool
- Effective process management – if sufficient initial information is provided
- Customer satisfaction monitoring and continuous improvement

***Who (target customer):*** The business model specifically targets private buildings' owners in the need of renovation and in particular single and multi-family buildings. Other possible buildings are private office buildings.

***How (value chain, activities, resources):*** The ICT tool supports the key player (designer, contractor) in order to map the main project objectives and to suggest an optimized plan of renovation. This key player needs to be adequately trained. Other involved stakeholders include banks, providing the financing. The One-Stop-Shop and its ICT tool can be provided by manufacturers of renovation solutions (see BetterHome example), public authorities or energy utilities.


***Why (revenue model and cost structure):*** For the service provider:

Saved costs and increased profit with the help of well-structured and well managed process

More efficient sales and thus better profit with the help of effective client profiling, initial data management and well-focused offering.

***Example (from MAKING-CITY or out of MAKING-CITY):***

BetterHome: BetterHome is an industry-driven One-Stop-Shop model, which has proven successful in boosting demand for holistic energy renovations in Denmark, since the model was launched in 2014 by Danfoss, Grundfos and Rockwool.

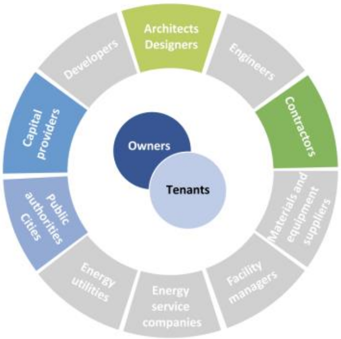
- **One-Stop-Shop provided by Public Private Partnerships and semi-public entities**

***What (value proposition):***

- Holistic and owner-centric approach to the renovation project, with the support of the renovation platform team
- Effective process management – the renovation platform team provides technical assistance and administrative support. It acts as a facilitator and, if asked by the owner(s), as a general contractor
- Support of a network of trained and referenced workers and contractors
- Pre-financing of incentives and in some cases third-party financing of the initial investment
- Comprehensive renovation intervention (not limited to energy), including correct evaluation from the life-cycle perspective of energy efficiency and overall costs. This also enables to better assess the financial risk and support the application for a loan

***Who (target customer):*** The market segments targeted by this business model are residential buildings, mostly owner-occupied single-family houses. Condominiums are also targeted.

***How (value chain, activities, resources):*** The "renovation platforms" providing the OSS are semi-public companies jointly owned by local governments/authorities and private entities such as banks. They develop a network of trained contractors/ installers as well as key partnerships with banks (in some cases they can themselves provide third-party financing). The renovation platform acts as a facilitator between all involved stakeholders, and for specific project – if requested by the owner(s), it can itself be the general contractor.




***Why (revenue model and cost structure):*** For the semi-public entity:

The costs of the renovation platform are mostly related to staff and marketing costs.

Liquidities are also required to cover the pre-financing of investments and, when relevant, the loans to customers.

Revenue types vary from one platform to the other and may include annual fees from the registered contractors / installers (who benefit from training and referencing) and fixed fees from customers (depending on the level of service requested).

Usually public funding (regional, national or European – e.g. ELENA) is required to ensure the financial sustainability of the platform.

***Example (out of MAKING-CITY):***

Île-de-France Énergies: Created by the Île-de-France Region, Île-de-France Énergies (formerly Energies POSIT'IF), is the Paris Region specialist for the energy renovation of condominiums with more than 50 dwellings. It provides a complete offer that makes energy renovation simple and accessible to everyone: audits, project management, implementation of a financing plan, construction monitoring, and performance monitoring.

Oktave: Oktave, the Integrated Service for Energy-Efficient Renovation launched by the region Alsace Champagne-Ardenne Lorraine, aims to considerably increase the number of thermal renovations in housing. Oktave, through a dedicated Mixed Economy Company, offers private households technical support and financing facility for their renovation projects (at present limited to single family homes).

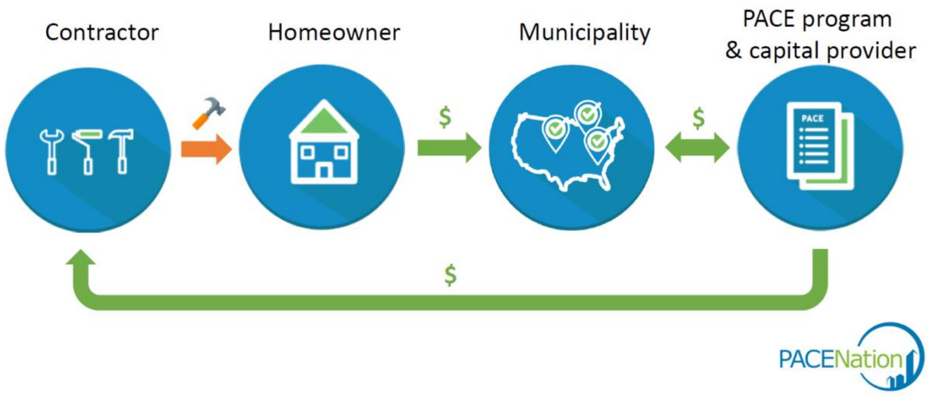
- ### One-Stop-Shop with home-based financing

This business model took inspiration from the Property Assessed Clean Energy (PACE) concept, widely piloted in the US, where local governments issue bonds for renovation projects.

The building owner repays the loan through an additional special "assessment" payment on its property tax bill for a specified term. These "assessments" are comparable to loans as the property owner pays off its debt in instalments over a period of various years but from a legal point of view they are not considered as such.

When the property changes ownership, the remaining debt is transferred with the property to the new owner. In other words, PACE financing is a mechanism set up by a municipal government by which property owners finance energy efficiency and renewable energy measures via an additional tax on their property. The property owners repay the "assessment" over a period of 15 to 20 years through an increase in their property tax bills. In the US, property tax payments are made annually or in arrears but payment modalities may be different in other countries, especially in Europe.

The PACE concept is being adapted to Europe by the EUROPACE project. As in PACE, the innovative character of the EUROPACE mechanism is that financing is linked to the taxes paid on a property. In other words, the financing lent by a private investor is repaid through property taxes and other charges related to the buildings. The EUROPACE mechanism also sets up of One Stop Shop by engaging several stakeholders in the process: local government, investors, equipment installers, and homeowners.

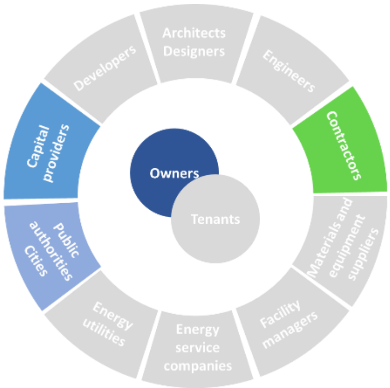



***What (value proposition):***

8 100% upfront financing (mostly through green bonds), with long-term financing of up to 20 years
9 Can be combined with utility, local, regional, and state incentive programs
10 Financing is attached to the property and can be transferred to a new owner upon sale
11 Financing is repaid with regular property taxes
12 Simple and clear value proposition that speaks directly to people's needs
13 Local energy services contractors act as local sales force ("PACE providers")
14 Digital platform allows for quick and easy approvals of applications to the programme
15 Technical and customer assistance is provided throughout the process
16 Comprehensive consumer protection policies

***Who (target customer):*** The customer segments targeted by this innovative financing scheme are in principle all building owners eligible for property taxes with a particular focus on small, residential and commercial buildings since these business models enable a long-term approach where building owners can spread the investment costs across the project life time. The model is relatively new, and current programmes in the U.S. apply to owners of existing free-standing residential houses and commercial buildings.

***How (value chain, activities, resources):*** Payments are collected using existing tax mechanisms: This so called on-tax financing is a type of financing mechanism used to collect repayments for investments in building improvements that meet a 'valid public purpose', e.g. save or produce energy. Typically, investors lend money for deep retrofits up-front and then get repaid regularly through an additional charge on a tax bill. The EU project EuroPACE (see below for more details) is a form of on-tax financing and it builds upon an existing relationship that municipalities have with their citizens – the property tax system. The local tax agency acts as the collecting agent for the repayments. Training is also provided to local contractors.




***Why (revenue model and cost structure):***

- For the owner: Upfront long-term financing: The funding covers 100% of all projects hard and soft costs and frees up disposable income for families and capital for businesses. Low interest rates for terms up to 20 years, while standard bank loans rarely exceed 5 to 7 years. PACE financing instruments aim at selecting energy efficiency and renewable energy solutions in a way that the additional property tax payment is lower than the cost savings achieved, thus aiming at annual net cost savings for the building owner.
- For the local government/ local authorities: unlocking of investment in energy efficiency thanks to green bonds.

***Example (out of MAKING-CITY):***

**EUROPACE Project**: https://www.europace2020.eu

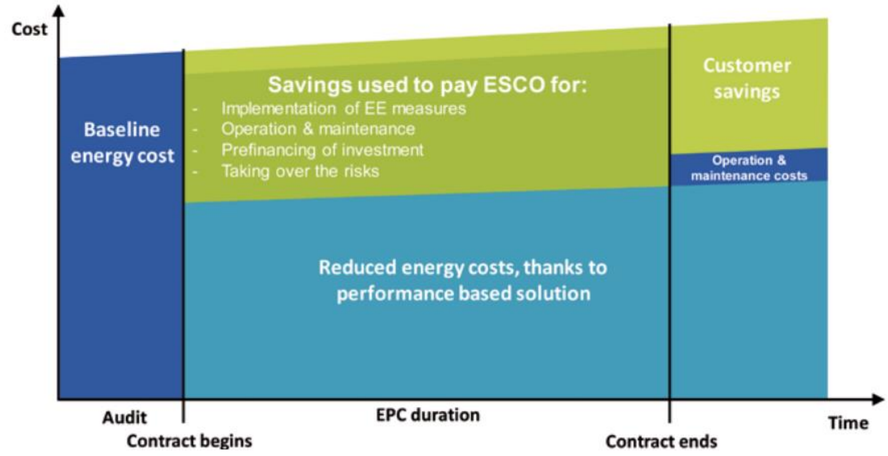
### 4.1.2 Energy as a service / Energy Performance Contracting (EPC)

*TAG: Energy performance contracts*

The EPC model[77] is based on delivering energy savings compared to a predefined baseline. In this model, an Energy Service Company (ESCO) enters into arrangements with property owners to improve energy efficiency of their property by implementing various measures. The ESCO guarantees energy cost savings in comparison to a historical (or calculated) energy cost baseline. For its services and the

77 *Source: https://renovation-hub.eu/business-models/ or https://renovation-hub.eu/wp-content/uploads/2019/09/STUNNING%20Final%20Publication.pdf*

savings guarantee, the ESCO receives performance-based remuneration in relation to the savings it achieves.




Generally, savings achieved can only be measured indirectly as a difference between consumption before and after implementation of the energy efficiency (EE) and renewable energy (RE) measures (relative measurement: savings= baseline – ex post-consumption).

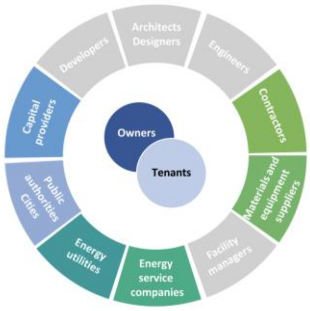
Most EPC projects focus on the implementation of energy efficiency measures (lighting, HVAC, energy management and control, envelope insulation). EPC models run under long-term contracts of typically ten years, depending on the payback time of the energy savings measures and the specifications of the building owner (i.e. they may last up to 15 years when they include long payback period investments such as wall insulation or window replacements).

***What (value proposition):***

- The ESCO provides a customized service package which includes design, installation, (co-) financing, operation & maintenance, optimization and user motivation
- For many customers financing is the most attractive part of EPC services for buildings
- Key benefits include risk transfer, the ability to modernise a building's energy infrastructure without necessarily having the funds and accessing external expertise and the performance guarantee
- The key focus is on saving energy first at the point-of-use before optimizing the respective energy supply

***Who (target customer):*** EPCs are mostly found in the public sector (for e.g. universities, hospitals, swimming & leisure facilities) and to a lesser extent in the industrial and commercial building sectors. This is because a large project is a prerequisite (the minimum energy cost baselines are usually at 200,000 €/year). EPCs have also been trialled for large residential building blocks.

***How (value chain, activities, resources):*** The ESCO acts as a general contractor and is responsible for the implementation and operation of the energy efficiency package at its own expenses and risk, according to the project specific requirements defined by the client and the ESCO. The final energy purchasing (electricity, fuels) usually remains with the building owner. ESCOs can also finance or arrange financing for the operation (with a third-party financier) and their remuneration is directly linked to the demonstrated performance regarding the level of energy savings or energy service. Finally, to ensure that the building is used in the most efficient way, building occupants receive training on energy efficiency practices.




***Why (revenue model and cost structure):***

- Cost structure: Costs for the ESCO include the implementation of the EE/RES measures, their operation & maintenance, pre-financing of the investment and taking over risks according to the project specifications defined in the contract. Transaction, measurement and verification costs of EPC projects are high. Determining and adjusting the baseline is a crucial issue in the EPC business model as it can generate a considerable degree of insecurity and monetary risks for the ESCO and needs to be undertaken for all performance-based billing periods over the entire contractual term.
- Revenue stream: In Energy Performance Contracting, the ESCO's remuneration is performance-based: It guarantees for the outcome and all-inclusive costs of the services; It takes over commercial as well as technical and operational risks over the project term
- Two options exist:
    - EPC with shared savings and EPC with guaranteed savings. In the first case, the
    - ESCO shares an agreed percentage of the actual energy savings over a fixed period with the customer. An ESCO's share of savings typically falls within a range from 50-90 %, with 65-85 % representing the most common range of values. In the second case, if the savings are less than expected, the ESCO covers the shortfall. If the savings are overachieved, the ESCO can recover the excess. After the end of the contract term, the facility owner benefits from the full energy cost savings but all operation and maintenance expenses are on his accounts.

***Example (out of MAKING-CITY):***

**NOVICE**: The "enhanced" version of the EPC model proposed by NOVICE project consists in consolidating services and subsequent revenue streams from both energy savings and flexibility at demand side by combining the classic EPC model with Demand Response Services.

### 4.1.3 Add-on business model

*TAG: Add-on*

The Add-on business model[78] is a renovation strategy corresponding to the construction of one (or a set of) additional building unit(s) – which might include besides facade additions also rooftop "vertical" extensions or even a new side building construction – that are added to the existing building when performing renovation works.

[78] *Source: https://renovation-hub.eu/business-models/ or https://renovation-hub.eu/wp-content/uploads/2019/09/STUNNING%20Final%20Publication.pdf*

When combined with the adoption of EE or RET measures, volume additions are interesting types of intervention since they instantly produce new, commercially valuable dwelling areas which could compensate the costs of energy-optimisation through the sale or the rent of the new dwellings.

***What (value proposition):***

The renovation process is performed through the addition of volume to the building, being it a rooftop "vertical" extension, a facade addition or even a side building. Usually this type of model utilizes industrialised construction methods and prefabricated elements in order to shorten project time and reduce the impact on tenants.

The added building volume and dwelling area generates a bonus and is a complementary economic instrument for investors (real estate investors, construction companies in conjunction with ESCO, etc.).

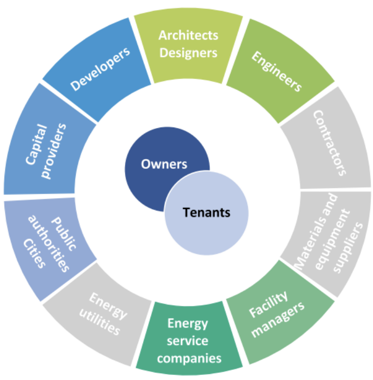
May act as an attractor for private sector financing, playing an extremely important role, in particular in contexts of scarce private finance where the search for smart financing of upfront investments is crucial.

***Who (target customer):*** Preferred target buildings for Add-on business model are large residential buildings in the need of renovation, in particular traditional building stocks built in the 60s or 70s. Also large non-residential buildings could be targeted by the business model.It is also worth mentioning the attractivity of add-ons for single family houses.In this case the financial benefit is not the selling point, but rather the gain in comfort, accessibility and value property generated by a home extension. The decision to extend a home (for instance when a family grows and requires additional space) can therefore be the trigger to carry out a complete energy efficient renovation.

***How (value chain, activities, resources):*** The Add-on business model usually involves a group of experienced architects and design planners working with a particular attention to building quality and architecture, and its structural characteristics (i.e. its capacity to support an extension).

The involvement of a capital provider is also required: the Add-on strategy indeed requires high upfront costs. The construction process usually employs industrialized processes and prefabricated elements that will minimize technical issues and disturbance to tenants.

From a social perspective, the proposed approach has to face a major challenge which should not be underestimated: the collection of the consensus from the inhabitants in case of social housing and condominiums.




***Why (revenue model and cost structure):***

For the building owner:

The Add-on business model is usually financed by a third party.

This model (also in combination with RES measures) can be offered by a commercial bank as future revenues for the loan applicant are expected from either rent or sales.

Results from the ABRACADABRA project prove that additions are very effective in cities and countries characterized by a high real estate value and by a higher difference among the renovation / construction costs and selling price point per square meter (€) in the reference market. In those cases, the economic gains obtained through the sale can compensate both the investment of the energy retrofit and the cost of renewable energy technologies.

***Example (from MAKING-CITY or out of MAKING-CITY):***

ABRACADABRA: The Add-ons business model was studied in depth by the EU funded project Abracadabra: www.abracadabra-project.eu

LIGN2TOIT: The French project LIGN2TOIT, funded by ADEME, investigated the environmental and economic viability of vertical extension to finance deep renovation: www.mecd.fr/lign2toit

### 4.1.4 Business model based on increased rents and/or increased price for apartments

*Tag: Rising block tariff*

***Example from MAKING-CITY:***

Waarborg Mediacentrale (WAM) is the owner of part of the real estate in the MAKING-CITY project (Mediacentrale and PowerHouse). WAM provides real estate and carries out some technical measures to improve energy efficiency and on-site renewable generation.

In Mediacentrale (a building owned by WAM), office spaces are rented to companies. This is the same for the ground floor office space in PowerHouse.

In PowerHouse (recently built building), apartments have been sold to future inhabitants. There is also one company which bought 20 apartments (out of 80 in total) to rent them to some tenants.

Nijestee (NIJ) is a private non-for-profit organisation. It is a social housing corporation that develops houses for people with a small budget and also rents out these houses and maintains them.

Nijestee is the owner of two multi-family residential buildings named Highrise, located in Groningen's North PED. Within MAKING-CITY, Nijestee conducts retrofitting actions on these buildings (insulation, demand-based ventilation, PV, geothermal heat pumps, energy storage…)

Within MAKING-CITY, Nijestee's actions all aim at reducing energy costs, which is for the benefit of tenants, either directly (in relation with energy consumption in apartments) or indirectly (in relation with energy consumption in shared areas: elevators, lights in lobbies and corridors, etc.). In some way, Nijestee is also a beneficiary of the actions since energy in buildings will be better managed.

Oulun Sivakka (SIV) is a housing company owned by the municipality of Oulu. Within MAKING-CITY, SIV conducts the retrofitting of an existing building, and constructs a new, energy-efficient building. For both buildings, they implement a heat recovery system from air conditioning and sewage water, on-demand based heating and ventilation and remote connection for controlling and monitoring technical devices.

YIT is a construction company building two new private buildings in Oulu's PED. These buildings allow for energy-efficient technologies to be installed. For inhabitants, they will generate better standards of living, increased value of the apartments and the feeling of being a part of the more energy-efficient future.

## 4.2 Business models for renewables

### 4.2.1 Lease/rent roof or land

*Tag: Space rental*

The contractor offers to lease the roof for 20-25 years and, in exchange, install and maintain Renewable Energy Sources on it. Building owners do not have upfront investment and they benefit from the free electricity produced by the system. The contractor benefits from the public financing schemes[79].

Many commercial, industrial, and retail buildings can provide the real estate needed for these systems, and are subsequently viewed as excellent candidates for roof rental.

***What (value proposition):*** Provides energy system leasing with no upfront investment for building owners

***Who (target customer):*** Commercial, industrial, and retail buildings

***How (value chain, activities, resources):***

- Cost structure: utility costs, installation costs, maintenance costs, leasing costs
- Revenue streams: the contractor benefit from public financing schemes

***Example (out of MAKING-CITY):*** Sunerg SolarEnergy inItaly

### 4.2.2 Leasing of Renewable Energy Equipment

*Tag: Leasing*

Leasing enables a building owner to use a renewable energy installation without having to buy it. The installation is owned or invested 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[80].

Leasing RE equipment is a new financing way to innovate on business models.

This financial instrument prevents customers from making an up-front investment.

***What (value proposition):***

- Cost-efficient option for acquiring equipment.
- Low risk - can give back, upgrade or keep equipment at the end of the lease.
- Customer benefits from energy efficiency savings and possibly tax exemptions

***How (value chain, activities, resources):*** Financial service offering and expertise. Relationships with key equipment vendors.

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[79] *Source:http://www.lgi-consulting.com/wp-content/uploads/2018/07/D2.3_Report-on-novel-business-models-and-main-barriers-in-the-EU-energy-system_release.pdf*

[80] *Source: http://www.lgi-consulting.com/wp-content/uploads/2018/07/D2.3_Report-on-novel-business-models-and-main-barriers-in-the-EU-energy-system_release.pdf*

***Why (revenue model and cost structure):***

- Cost structure: ability to finance upfront equipment costs; organisation costs.
- Revenue stream: alternative funding option with the added value of equipment expertise. Ability to tap into tax exemptions or other funding routes. Payment built into lease repayments.

***Example (out of MAKING-CITY):*** Belectric Group is a leader in the development, installation, and maintenance of solar photovoltaic systems in the UK. They are supported by a financial scheme that enables them to offer leasing contracts to customers

## 4.3 Business models for district energy systems

The business model for a district energy system is very project-specific[81]. It needs to ensure that all of the players involved – including investors, owners, operators, utilities/suppliers, end-consumers and municipalities – can achieve financial returns, in addition to any wider economic benefits that they seek.

When designing a business model for a new district energy system, it is important to consider site-specific circumstances, including the type of project finance that is available.

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. Public sector involvement can be critical in coordinating multiple, diverse projects around a broader citywide vision. Even projects with a high degree of private sector control are often still facilitated or supported in some way by the public sector.

Although the business models and ownership structures described here vary significantly, they can be grouped along a continuum from public to private. The relative involvement of the public or private sector depends broadly on two factors: 1) the return on investment for project investors, and 2) the degree of control and risk appetite of the public sector.

[81] *Source:* *http://www.districtenergyinitiative.org/sites/default/files/report_pdf/03%20District%20Energy%20Chapter%203_print.pdf; http://www.districtenergyinitiative.org/sites/default/files/publications/districtenergyreportbook-07032017532.pdf*

| FINANCIAL RETURN ON INVESTMENT | DEGREE OF CONTROL AND RISK APPETITE OF PUBLIC SECTOR | TYPE OF BUSINESS MODEL | EXAMPLES |
|---|---|---|---|
| LOW | ↑ High | Wholly public | ■ District energy to meet social objectives related to housing or fuel poverty |
| MEDIUM / LOW | ↑ High | Wholly public | ■ Public sector demonstrating the business case of district energy systems<br>■ Public sector looking to create projects that will improve its cash flow<br>■ Public sector lowering the IRR by allowing cheaper energy tariffs than the private sector would |
| MEDIUM / HIGH | → Medium | Public/private hybrid | ■ Public/private joint venture<br>■ Concession contract<br>■ Community-owned not-for-profit or cooperative |
| HIGH | ↘ Medium / Low | Private (with public facilitation) | ■ Privately owned project with some local authority support, perhaps through a strategic partnership |

## 4.3.1 "Wholly public" business model

*Tag: Municipal utility, Pay per use, One time payment plus regular fees, Differential pricing, Loans, Direct finance option*

Of the various ownership models for district energy systems, the "wholly public" business model is the most common globally. Here, the public sector, in its role as local authority or public utility, has full ownership of the system, which gives it complete control of the project and makes it possible to deliver broader social objectives, such as environmental outcomes and the alleviation of fuel poverty through tariff control. The public sector can achieve these objectives by assessing a potential project based on its economic returns.

**RISK AND GOVERNANCE:** In the "wholly public" business model, the city takes on most of the risk associated with the investment. In expansion or new cities, if a project has a low IRR, typically in the range of 2–6 per cent, an internal department of the local authority can develop and operate the project to reduce administrative costs. Consolidated cities develop such projects via the public

utility, and the low return is spread across other projects that have higher IRRs.

Projects with a higher IRR in expansion or new cities are being developed by creating a "Special Purpose Vehicle" (SPV) or subsidiary (such as a new public utility) to reduce the administrative burden on the local authority, with governance typically

overseen by a board of directors that represents the local authority. Shifting to a subsidiary can provide additional benefits, including limiting the city's financial liability in the event of project failure, increasing the flexibility and speed of decisions, and offering greater transparency and a more commercial operation. The local authority can outsource the technical design and construction (and sometimes operation) of the project to reduce risk related to the delivery cost and time frame.

Because a city typically has a high degree of control over the demand groups targeted for district energy – particularly any anchor loads that are connected – energy demand is typically lower risk. Moreover, customers are connected that may not be prioritized under a private scheme, such as customers with a low connection capacity or those in social housing. The local authority may take a utility approach to tariffs by applying a standard charge for a specific customer group, such as residential consumers, allowing for more equitable billing (rather than, say, basing the connection charges and tariffs on a building's location within the network).

This also encourages expansion of the system: because network costs are borne by all users equally, more connections will lower the overall cost.

**SOURCES OF FINANCE:** A district energy project with a low IRR will compete for financing with other projects that the local authority is considering. To the extent that a district energy system contributes to a city's strategic objectives – such as reducing carbon, improving resilience or energy security, or providing affordable heat supply – projects often leverage the city's cash reserves and/or public debt raised based on the balance sheet of the local authority. The lower interest rate of public debt is why many proponents of district energy systems argue that cities can (and should) be investing in this way, and why several district energy models are locally led.

**CONTROL**: Because the local authority or public utility has complete control and ownership of the district energy project, it has the benefit of receiving all of the profits, which it can then either reinvest in the project (e.g., to reduce energy tariffs) or use to fund other projects. Once the project is built out, costs and revenues will stabilize, and the project will have an asset value above the level of the investment. This provides the local authority with several choices moving forward:

- Continue operating the project, which allows the local authority to retain control of energy tariffs and to use the returned profits to fund other projects.
- If the project was initially set up as an SPV or subsidiary, then it is easier to sell the project to the private sector. Assets can be pooled or split, and control of the project can shift (to varying degrees) to the private sector. Such a move could free up funds at the local authority for other projects and is the principle behind a revolving fund. Allowing private actors to partially own the project (i.e., becoming a public-private partnership) also may result in higher returns, as private actors bring different experiences and may help the company to expand.
- If the project was not initially set up as an SPV, then the local authority could establish a company limited by shares and then transfer ownership of the assets to that company, which can then be fully or partially sold to the private sector.
- Finally, there might be a desire for the company to be owned by the community, in which case the shares can be transferred to community organizations. Alternatively, the company may be established as a not-for-profit company limited by guarantee, with members instead of **shares.**

**Examples from MAKING-CITY**

WarmteStad (WAR) in Groningen. WarmteStad operates a heat grid. The company was founded by the City and the local water company.

Oulun Energia (OEN) in Oulu. Oulun Energia is the leading energy company in Northern Finland. It is wholly owned by the city of Oulu. It is the mother company of several daughter companies, for instance for managing the electricity grid, or for ensuring energy sales. It is the mother company which is involved within MAKING-CITY. The mother company is managing itself the heat network as well as the energy generation facilities (heat and electricity). Oulun Energia has some competitors in the area with regards to electricity sales. By contrast, in accordance with EU and national regulations, electricity grid management is a monopoly. Heat network management is not a monopoly by law; but in practice, there are no competitors.

## 4.3.2 "Hybrid public and private" business models

If a district heating system's technical feasibility study and financial modelling indicate that the project has a return on investment that will attract the private sector, it may be desirable to adopt a "hybrid public and private" model. Here, the local authority is willing to carry some risk and has a desire to exercise some control, but it also wants private sector participation to bring in expertise and/or private capital. A challenge with such projects is ensuring that all parties have a clear, agreed vision of what the objectives are and how they will be achieved.

- **Public and private joint venture**

*Tag: Access to cross subsidies, Pay per use, One time payment plus regular fees, Loans, Direct finance option*

The joint-venture model typically involves the creation of an SPV, with ownership split between the public and private sector.

**RISK AND GOVERNANCE:** Risk can be shared between partners, each of which may have a skillset related to that risk. The public sector (i.e., local authority) can underwrite the sales risk, guaranteeing to commit to long-term heat/cool off-take contracts, and can deal with regulatory barriers to project development. The private sector party, meanwhile, can take on the design, construction and operation risk, transferring this risk away from city taxpayers and on to private sector equity holders. The private party can also benefit from connecting to the network, providing the project with guaranteed demand and potentially granting itself preferential rates.

In a pooled asset model, the different actors combine skill sets through a single company or utility. In a split asset model, these skill sets are separated into the different functions of the district energy system, such as the public sector being responsible for waste incineration and transmission and the private sector for CHP heat production. Between these entities, contracts will exist that define off-take and tariffs.

**SOURCES OF FINANCE**: In this model, both the private and public sectors provide equity. Debt is based on the project's future cash flow but can be underwritten by either party. The presence of the public sector can mean that other sources of finance become available, such as grants, local authority debt and development bank loans. The city also can offer land as an equity contribution to joint ventures, which can help provide collateral in raising financing. Further, the city can provide specific tax incentives that in effect could act as a source of finance. In a split asset model, each entity will be responsible for sourcing finance for the district energy functions they control.

**CONTROL**: In a pooled asset model, governance is typically via a board of directors appointed by each project partner, with board representation reflecting the ownership split and the public/private hybrid model. The exit strategy is either to continue with the status quo, to sell out to the partner or other private sector interests or, conversely, to buy out the partner so that the district energy project becomes wholly municipal.

- **Concession contract**

*Tag: Leasing, Pay per use, One time payment plus regular fees, Loans, Direct finance option*

Under the concession contract model for the private sector, the public authority typically develops a feasibility study of the district energy project and then tenders it to the private sector (usually an energy service company, or ESCO) as a concession that runs for a specified term. The concession contract model for the public-private sector is very similar but usually involves the creation of a utility that is a mixture of public and private ownership (although it can just be public). This utility is then given the concession for the district energy development for a specified time period.

A concession model is particularly applicable for retrofit projects in towns and cities where public streets are used for network routes and where residential, institutional and commercial buildings are connected. The concession provides the option of the city buying back a project after the concession period.

**RISK AND GOVERNANCE**: In this model, the ESCO or utility with the concession (private sector or public-private) bears completely the risks of designing, building and operating the district energy system. The presence of the local authority as designer of the concession contract is likely to mitigate many of the risks associated with gaining project approvals. The ESCO may be limited in the tariffs it can charge due to local competition or by contractual levels set to avoid monopolization of energy distribution.

The fact that the local authority ultimately may own the system, as well as the contracting/financing complexities associated with a concession model, means that the local authority still takes on significant risk. Additionally, the ESCO may transfer risk to the local authority by requiring guaranteed revenues (via a connection policy). The local authority is developing feasibility studies and procuring private sector partners to deliver the project.

**SOURCES OF FINANCE**: ESCOs can vary greatly in size, and this will affect how they finance the district energy system. Large

ESCOs have large amounts of capital, allowing them to finance projects internally rather than having to borrow on a project-by-project basis. Large ESCOs evaluate projects individually and will treat each system as a profit centre; however, they rely on their overall corporate balance sheet to raise the capital for system development. As with public-private partnerships, the city can provide land to the ESCO, which may then be used to accelerate development and potentially reduce energy tariffs.

**CONTROL**: The local authority may have limited control of the concession during the concession period. At the end of the term, the assets can be returned to the local authority through a sale. The local authority then has the choice of placing the assets in municipal or community ownership or issuing a fresh concession.

- **Community-owned not-for profit or cooperative**

*Tag: Active user, Micro finance, Social business model, Differential pricing, Pay per use, One time payment plus regular fees*

As another option, a municipality may wish to establish a district energy system as a mutual, community-owned not-for-profit or cooperative.

**RISK AND GOVERNANCE**: In the not-for-profit or cooperative model, the local authority initially takes on a large share of the risk. Once the mutual is well established, risks to the local authority decrease. Some risks can be passed through to contractors for design and construction.

**SOURCES OF FINANCE**: In this model, the municipality may need to underwrite the risk, as start-up entities will not have the same covenant strength as the municipality to secure low-cost finance. Once the mutual has paid off this lower-rate finance, the risk on the local authority is lowered significantly. The presence of the local authority can leverage low-cost funds for the project.

**CONTROL**: The governance structure is via representatives elected by the members. In return for debt underwriting, the local authority may require or be offered representation on the board.

- **“Private” business model**

*Tag: Third party ownership, Power purchase agreement, pay as you go, loans, Pay per use, One time payment plus regular fees, Cost based pricing,* If a local authority has a proposed district energy project with a high return on investment (usually between 12 and 20 per cent, although it can be 9.5 per cent for lower-risk projects), but the local authority has a low risk tolerance and a relatively low desire for control, it may be able to attract interest from private sector companies. This does not mean that the local authority is removed from the project; many successful privately owned district energy systems still have arms-length local authority involvement. For example, the local authority may have been the original project proponent and/or it could still attract financing and grants for the project. The local authority may help with any connections deemed socially optimal that are too high risk for the private sector. It could also develop initiatives that encourage social or environmental objectives, such as mechanisms that support low-carbon generation.

When designing a business model for a new district energy system, it is important to consider site-specific circumstances, including the type of project finance that is available. 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. Public sector involvement can be critical in coordinating multiple, diverse projects around a broader citywide vision. Even projects with a high degree of private sector control are often still facilitated or supported in some way by the public sector.

Although the business models and ownership structures described here vary significantly, they can be grouped along a continuum from public to private ownership. The relative involvement of the public or private sector depends broadly on two factors: 1) the return on investment for project investors, and 2) the degree of control and risk appetite of the public sector.

**RISK AND GOVERNANCE**: In this model, risk is carried by the private company, although the company could enter into a Joint Cooperation Agreement (JCA) with the local authority to mitigate risks in planning or expansion, or to encourage connection of demand through planning policies. This is often called a Strategic Partnership Model. In return, the local authority may benefit from reduced tariffs, profit sharing, connection of customers with higher credit risk (who are more likely to be in fuel poverty), and other social or environmental objectives.

**SOURCES OF FINANCE**: Financing is provided by the private sector company, through either inter-company debt or external commercial debt. The private sector company may require a capital contribution in the form of a connection charge for any public buildings connected to the network. Local or national authorities may be able to attract international loans or grants for the project.

**CONTROL**: The private sector company determines the governance structure, since the project is wholly owned by the company. The governance structure may include offering the local authority a minor representation on the board of an SPV or on a local project board if the company has entered into a JCA with the local authority.

https://energsustainsoc.biomedcentral.com/articles/10.1186/s13705-018-0161-4

**Table 4 The conventional features of Swedish district heating businesses**

From: Challenges for business change in district heating

| | | | |
|---|---|---|---|
| Key partnerships<br>**Fuel providers** | Key resources<br>**Production unit**<br>**Distribution network** | Customer value<br>**Provider of heat and hot water (utility)** | Customer segment<br>**Business-to-business** (largest segment)<br>**Private homeowners** |
| | Key activities<br>**Production**<br>**Distribution**<br>**Maintenance** | Customer channel<br>**Invoicing**<br>**Campaigns** | Customer relationship<br>**Provider to consumer (push)** |
| Cost structure<br>Large fixed costs | | Income structure<br>Fixed | |

## Table 5 Aggregation of the collected information on district heating development

From: Challenges for business change in district heating

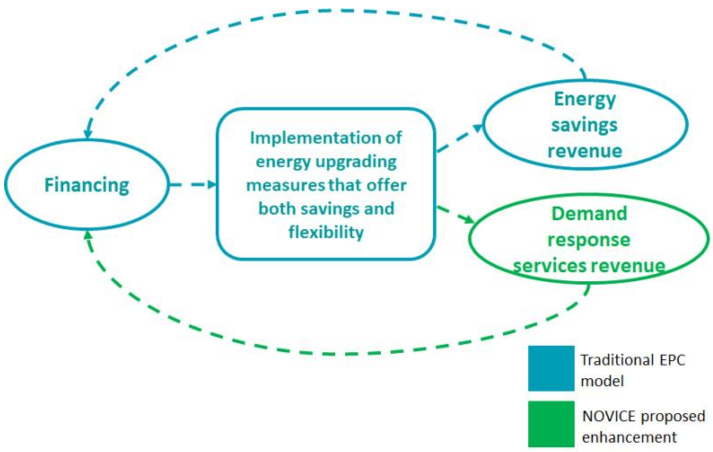
| | | | |
|---|---|---|---|
| Key partnerships<br>**Fuel providers**<br>Customers<br>*Policy makers* | Key resources<br>**Production unit**<br>**Distribution network**<br>Competencies beyond production, distribution and maintenance | Customer value<br>**Provider of heat and hot water** or of a service<br>Support<br>*Flexibility*<br>*Knowledge on energy efficiency* | Customer segment<br>**Business-to-business** (largest segment)<br>**Private home owners**<br>*New usage of heat* |
| | Key activities<br>**Production**<br>**Distribution**<br>**Maintenance**<br>Customer engaging<br>Improved internal efficiency | Customer channel<br>**Invoicing**<br>**Campaigns**<br>Customer engaging | Customer relationship<br>**Provider to consumer (push)**<br>Dialogue building trust, loyalty and long term<br>*Prosumer* |

# 4.4 Business models for the energy market transition

## 4.4.1 Demand response / Enhanced EPC

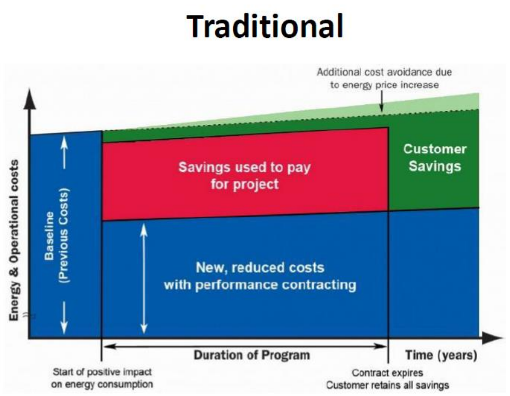
*Tag: Energy performance contracts, Dynamics tariff, Flexible price, Forced scarcity,*

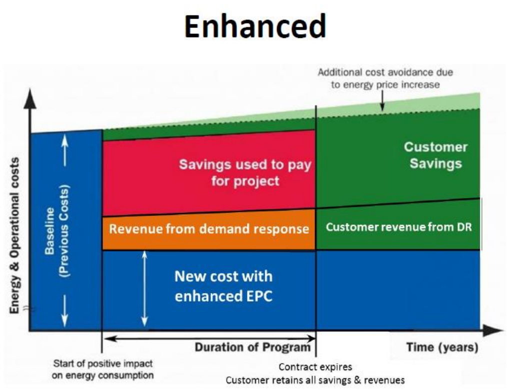
The Enhanced Energy Performance Contracting (EPC) model, proposed by NOVICE project, consists of generating revenues from Energy Savings, as in the classical EPC model, but also to generate revenues from Demand Response Services[82].




Demand response is a way of shifting or reducing electricity usage during peak periods. Indeed, when electricity demand exceeds supply on the grid, clients' electrical asset consumption can be adjusted by using aggregator technology. Thanks to this shift, power returns to the grid and the supply and demand balance is restored in a cost effective and green way. Also, the clients earn revenues simply for participating and being available.

In the Enhanced EPC model, the ESCOs remain the single point of contact for all measures but use the services of a demand response aggregator to provide services to the grid. A Memorandum of Understanding (MoU) governs the relationship between ESCO and Aggregator.

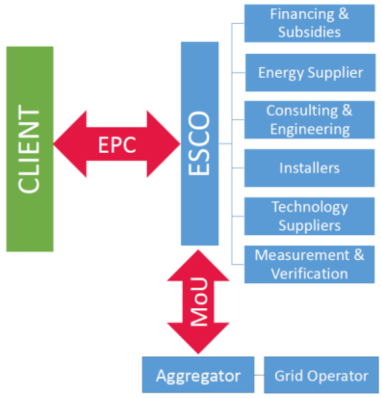



82 *Source:* *https://renovation-hub.eu/business-models/* *or* *https://renovation-hub.eu/wp-content/uploads/2019/09/STUNNING%20Final%20Publication.pdf*

Market readiness for Enhanced EPC is varying across European countries.

Some of them, like France or UK, have well developed or growing ESCO markets and several open DR markets with regulation that encourages aggregators to participate. Other countries (Belgium, Germany, Finland…) have either an advanced ESCO or an open DR market but strict regulations that limit the ability of aggregators to participate. Finally, some EU countries like Italy or Spain have immature ESCO and closed DR markets (or do not legally allow aggregation).




***What (value proposition):*** The Enhanced EPC model considers demand response as well as energy efficiency measures. It creates a dual revenue stream, one from energy efficiency and another from demand response. For ESCOs and aggregators, it brings access to new markets, improvement of ROI and ability to finance more projects. For Building owners, Enhanced EPC is a way to have a faster payback period, a shorter contract duration, and it increases asset value through smart building components.

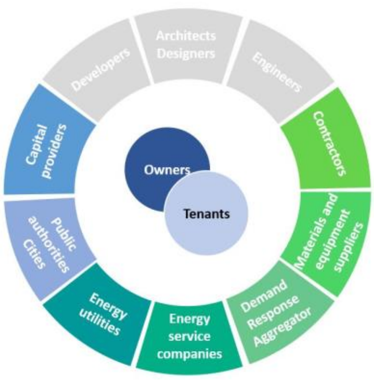
***Who (target customer):*** Aim of the model is the development and demonstration of an innovative business model for Energy Service Companies (ESCOs) that will provide energy savings to buildings and demand response (DR) services to the grid after renovating buildings or blocks of buildings.

***How (value chain, activities, resources):*** The ESCO is the single point of contact and is in charge of the implementation of energy efficiency measures and smart meter components. Aggregators support the ESCOs at the end of the value chain for the adaptation of building consumption.

Enhanced EPC full-service spectrum include financing, planning, construction, energy management, risk transfer, operations, maintenance & repair.

End-consumers don't require upfront capital as finance for the project is provided by the ESCOs or third-party finance providers, and the loan is repaid from the savings on energy bills.

Energy Savings are then guaranteed by the ESCOs, removing the operational risk from client.




***Why (revenue model and cost structure):*** The Enhanced EPC model brings the relevant stakeholders (ESCOs for the implementation of energy upgrade renovations, aggregators for facilitating the provision of demand response to the grid, financiers of energy investments and building operators and owners) together to create an innovative business model that can allow for faster repayment of energy efficiency investments combining revenue streams from both energy savings and grid services into a single offering.

### 4.4.2 Energy cooperatives

*Tag: Cooperative utility, Pay per use, flat rate, Raisins blocks tariffs,*

An Energy Cooperative is a non-profit entity of green energy consumption, which performs the same activities as any other retailer or energy Producer Company[83]. 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, and therefore, helping to democratise it (EnergieWende, 2014).

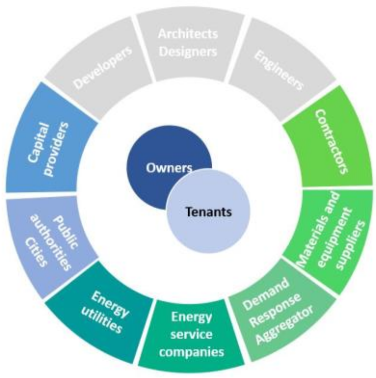
NRECA is the American national service association for almost 900 cooperatives that employs this business model.

On the innovation side, the energy supplier is a cooperative, not a company. Consumers are 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.

***What (value proposition):*** Promote and finance collective renewable energy installations for the members of the cooperative

***How (value chain, activities, resources):***

- Purchase energy on wholesale market
- Supply energy to consumers
- Promote collective renewable energy generation projects




***Why (revenue model and cost structure):***

- Cost structure: Wages, IT infrastructure, purchase energy and maintenance of RES installations
- Revenue stream: sell energy to the end-consumer and to the wholesale market; membership fee (financing)

***Example (from MAKING-CITY):*** GPO in Groningen. Within MAKING-CITY GPO is in charge of citizen engagement activities, and is advising homeowners about retrofitting. NB. Homeowners are paying themselves for the retrofitting of their houses. Supporting retrofitting is not a usual activity for GPO which is mainly focused on citizen engagement activities. There is no third-party investment business

[83] *Source:* *http://www.lgi-consulting.com/wp-content/uploads/2018/07/D2.3_Report-on-novel-business-models-and-main-barriers-in-the-EU-energy-system_release.pdf* See also: https://www.rescoop.eu/the-rescoop-model

model which is implemented. GPO intends to mobilize everybody in the neighborhood, in order to show that innovations work, try to scale up the innovative renovation package in order to make it become cheaper and less risky.

## 4.5 Business models for urban mobility

### 4.5.1 Private urban car sharing mobility service

*Tag: Pay per use, One time payment plus regular fees, licensing, Add-on*

This business model aims at providing an innovative and environmental friendly transportation service in order to complement available transportation alternatives and meet customers' demands that are not satisfied with public transportation services or with the use of private vehicles.[84] This mobility alternative corresponds to on-demand short-term car rentals with the vehicle owned and managed by a private fleet operator, and with large fleets completely composed by vehicles painted with the company name, logo, and slogans to create a strong visual identity that allows the vehicle to serve as a marketing channel, increasing brand recognition.

Car rental companies are the typical actors implementing the car sharing business strategy.

In this case, the main innovation sources come from customer facing elements and partnership. It focuses on creating a new customer experience in the car rental sector. It develops a new way for customers to reserve and pay for the short-term car rentals.

***What (value proposition):***

- Free floating car sharing services with a large scale fleet
- Innovative and environmental friendly transportation service
- Flexibility and mobility
- Convenience, usability and accessibility of vehicles

***Who (target customer):*** Private and corporate users

***How (value chain, activities, resources):*** Car rental maintenance of the vehicles, management of the fleet, customer service and marketing

***Why (revenue model and cost structure):***

- Cost structure: Vehicle fleet acquisition, maintenance, fueling and cleaning vehicles, personnel costs and customer services, insurance, taxes
- Revenue stream: Fixed subscription fees, rental fees, extra fees per kilometer

***Example (out of MAKING-CITY):*** The German company Car2Go, a subsidiary of Daimler currently offers car-sharing service and it is one of the biggest players in the market worldwide in this mobility alternative. It employs about 100 people and currently operates car sharing in 10 cities, covering the US, Canada, the Netherlands, Germany, Austria, and France.

### 4.5.2 Public urban car sharing mobility service

*Tag: Affiliation, Direct finance option, Pay per use, One time payment plus regular fees, licensing, Add-on,*

[84] Source: http://www.lgi-consulting.com/wp-content/uploads/2018/07/D2.3_Report-on-novel-business-models-and-main-barriers-in-the-EU-energy-system_release.pdf

As an alternative of public transit, this business model aims at providing on demand short-term car-sharing services managed by municipalities.[85]

The service operates in small scale and offers a choice of different vehicle types, ranging from compact cars to sport utility vehicles and cargo vans in order to be able to respond to different customer needs. The business model offers two different rental possibilities: the classic modality, in which customers must deliver the car in the same parking area where they started the rental, and the one-way rental, in which the customer can deliver the car in a parking area where the journey was started.

Municipalities are the most common actors implementing the car sharing business strategy.

In this case, the main innovation sources come from partnership and focus on improving customer experience. It focuses on creating a new customer experience in the car rental sector and driven by the public sector. It develops a new way for customers to reserve and pay for the short-term car rentals.

***What (value proposition):***

- Free floating car sharing services with a large scale fleet
- Innovative and environmental friendly transportation service
- Flexibility and mobility
- Convenience, usability and accessibility of vehicles
- SmartForTwo (gasoline and electric powered vehicle fleet)

***Who (target customer):*** Private and corporate users

***How (value chain, activities, resources):*** Car rental maintenance of the vehicles, management of the fleet, customer service and marketing

***Why (revenue model and cost structure):***

- Cost structure: Vehicle fleet acquisition, maintenance, fueling and cleaning vehicles, personnel costs and customer services, insurance, taxes
- Revenue stream: Fixed subscription fees, rental fees, extra fees per kilometer

***Example (out of MAKING-CITY):*** The Italian company IoGuido, is a car-sharing company managed by the city municipalities; it is an associate member of the car-sharing initiative (ICS), a national coordination structure promoted by the Italian Ministry of the environment, which offers support to local municipalities interested in developing local car-sharing services.

# 4.6 Business models based on data

## 4.6.1 Urban data platforms

*Tag: Pay per use, Multi-sided revenue model, freemium, pay with data, data as a service*

Urban data platforms integrate the large amount of data in cities, including energy, transport, crowdsourced data, etc., and provide holistic view of the information with the aim of improvement and development of innovative smart city services.

Four types of data streams can be drawn from urban data:

- demand-side stream which can give better understanding of specific properties and characteristics of urban processes, e.g. buildings services, government-to-citizens services, and provide solutions for improvement

[85] Source: http://www.lgi-consulting.com/wp-content/uploads/2018/07/D2.3_Report-on-novel-business-models-and-main-barriers-in-the-EU-energy-system_release.pdf

- supply-side stream to monitor incidents and crisis situations and the respective responses and solutions with the aim of drawing conclusions and recommendations
- analytical stream to identify data patterns and correlations in order to derive predictions for urban innovation, provide impact assessment, and demonstrate the challenges and opportunities in urban development
- standardization stream to bring the data in line with the international standards.

Urban data platforms enable and stimulate a proper understanding of how infrastructure is used in different domains, the interdependencies between different elements of infrastructure and the effects of external drivers such as public policy, major events and weather patterns and precipitation. [86]

***Example from MAKING-CITY in Groningen:*** The urban platform monitors the data collected from measuring equipment installed in buildings with the aim to evaluate the performance and impacts of solutions implemented in the positive energy districts through specific indicators. With this objective, the information will be aggregated for the calculation of KPIs and the values will be available for the city planners, policy makers and decision makers to help them in the definition of strategies to upscale the concept of PED in other places of the city. Such a data platform can help develop Demand Response, energy data monitoring and new services. It can also help selling excess energy from the PED to through grid operators or energy markets. The Municipality of Groningen wants to create a smart city; in this aim, they need data to help design policies. The city is expecting to have a monitoring tool with real time data for decision making. Data is expected to be aggregated at different levels (building, district, etc.). CGI's platform provides the data insights to make decisions regarding investments and measurements towards a low carbon city, thus achieving the execution of the city's energy transition policy. Electricity grid operators could benefit from this platform if data and models were shared with them to support their forecasting & planning processes and more generally to balance the grid. This would allow a better use of existing infrastructure and would avoid or postpone the need for new infrastructure. Inhabitants would indirectly benefit from such a platform which could be useful to address issues such as increasing energy bills, air pollution and more generally health. The platform would facilitate the achievement of sustainability projects, thus contributing to an improved living environment at affordable costs.

### 4.6.2 Smart home data-based feedback platform

*Tag: Pay per use, Multi-sided revenue model, freemium, pay with data, data as a service*

Smart homes are one of EU's priority action areas in its Strategic Energy Technology Plan[87] with the aim to create smart home control and management solutions to enable and to engage energy consumers, communities and individual citizens to take an active role participating in energy systems and markets. Smart homes are seen as an enabling technology and integrated part of future energy efficient system, helping to optimise an overall Demand Response towards flexibility in distributed generation, storage and consumption of energy resources.

**Example from MAKING-CITY in Oulu:** A prototype for a smart home data-based feedback application for tablets will be piloted in the Oulu PED. The purpose is to test motivational factors of consumer engagement. A simple, pleasant, easy-to-use interface for users will be developed. It will enable testing which kind of information will have the best impact on residents' behaviour. In the application, multiple choices will be set on which environmental indicator the consumer will be informed about whether it is global warming related, or the environmental impact on land use issues, any toxicity level increases, or air quality. The application will help the inhabitants to interpret the effect of their actions.

[86] Source: https://smartcities-infosystem.eu/ict/urban-data-platform

[87] https://op.europa.eu/en/publication-detail/-/publication/771918e8-d3ee-11e7-a5b9-01aa75ed71a1/language-en/format-PDF/source-51344538

Users will choose the indicator(s) they are the most interested in. The application will offer the inhabitants optional ways to follow their energy consumption. Having found the motivational way, the application helps the inhabitants to reduce their energy consumption and decrease their costs. Impacts on other stakeholders:

- Electricity grid and heat network operators aim at building a regional system enabling flexible demand response, with diverse sources of energy.
- Real estate investors have difficulties explaining new services' gains for future buyers. Having such an app for the inhabitants should make it easier.
- Technology providers get new opportunities to test novel solutions and integrate them in the central district heating network.

# 5 PED patterns tag

WP4 has defined solution cards, named SPECs for each one of the technologies relevant for designing a PED area. The table below is listing all the relevant Business model patterns that could be used for each SPEC card.

| Name of the Solution | Short Description | Business model patterns |
|---|---|---|
| Solution 0.1a Wind strategies | Wind strategies to take advantage of urban ventilation corridors | *Public investment (Resilient strategy)* |
| Solution 0.1b Solar orientation strategy | Solar orientation strategies to exploit solar potential or mitigate its effects | Space rental<br>Leasing |
| Solution 0.1c Water ressources strategy | Water resources strategies in order to optimize water management | Municipal utility<br>Rising block tariff |
| Solution 0.1d Ground coupling strategies | Ground coupling strategies: Ground adequation for future ground-source heat exploitation | Municipal utility |
| Solution 0.2a Cooling of surfaces | Cooling of surfaces<br>Shading through native adequate vegetation and other human-made<br>shading elements<br>Cool pavements (high albedo materials - vegetated and non-vegetated permeable surfaces) | *Public investment (Resilient strategy)* |
| Solution0.2d Evaporing cooling | Introducing vegetation for evaporative cooling as well as water bodies. | *Public investment (Resilient strategy)* |
| Solution 0.3 Mobility (eliminate vehicles emissions) | Foster clean mobility (public transport, cycling, walking) through the adequation of roads, pedestrian sidewalks, bike lanes, etc. In order to reduce emissions | *Public investment (Resilient strategy)* |

| | | |
|---|---|---|
| Solution 1a Residential Building (High Rise) retrofitting | Deep Insulation (wall, roof, windows.. Building envelope), Daylighting, Natural Ventilation | Shared savings<br>Power purchase agreement<br>White label retailing |
| Solution 1b Residential Building (Private House) retrofitting | | Shared savings<br>Power purchase agreement<br>White label retailing |
| Solution 2 New High performance residential buildings | Good insulation and windows and heat recoveries from outcoming streams keep the basic heat consumption small. | One time payment<br>Loans |
| Solution 3 Building Envelope Retrofitting in Tertiary buildings | | Shared savings<br>Power purchase agreement<br>White label retailing |
| Solution 4a New High Performance Building (Shopping Mall) | The system is based on advanced heat pump technology using environmentally friendly CO2 instead of F-gases. | One time payment<br>Direct financing<br>Loans<br>Access to cross subsidies |
| Solution 4b New High Performance Building (Academy Building) | No definition yet | One time payment<br>Loans |
| Solution 4c New High Performance Building (Sport Complex) | No definition yet | One time payment<br>Loans<br>Power purchase agreement<br>White label retailing |
| Solution 5a Energy Management Agent for energy optimization and demand response | EMA optimizes the energy usage within a site by controlling flexible resources and trading energy via local markets in order to maximize the reward function (i.e., objective) defined by the end-user. | Municipal utility<br>Cooperative utility |
| Solution 5b Visulation Units to study human behaviour regarding the energy consumption | Making-City project has developed an interface in which participants to the Making-City project can access their energy consumption, water consumption, evaluate their climate comfort and provide feedbacks on it, as well as information on their environmental impacts. | Municipal utility<br>Cooperative utility |

| | | |
|---|---|---|
| Solution 5c<br>Demand Response | Energy flexibility information is collected by Sustainable Buildings, TNO and the EV charging operator. The combined monitoring information is analyzed in the Energy Islands platform. | Municipal utility<br>Cooperative utility |
| Solution 5d<br>Heat Matcher | HeatMatcher is an innovative real-time matching solution for heating and cooling systems. It determines the optimal balance between producers (supply) and consumers (demand) of heat and cold. | Licensing<br>Pay as you go |
| Solution 6a<br>Smart Lighting, power LED | A new lighting system of the area will be installed in order to reduce the energy consumption. The technology deployed will be high power LED | Municipal utility<br>Cooperative utility<br>Virtual power plant<br>Active customers<br>Local aggregator<br>Microgrid<br>Power based tariff |
| Solution 6b<br>LoRa (Long Range) wireless network and activity sensors | Power LED will be combined with smart lighting controller using LoRa (Long Range) wireless network (50 controllers) and activity sensors (50 units) to optimize the lighting level in evening and night time | Municipal utility<br>Cooperative utility<br>One-time investment<br>Leasing |
| Solution 6c<br>Energy data monitoring of PED | Energy data monitoring is a key component for enabling intelligent ICT services. It coves the data collection, data storing and data quality monitoring. In addition the solution provides both technical and non technical views for both real time and historical data. | Pay per use<br>Multiu-sided revenue model |
| Solution 6d<br>Integration of new services to the data platform | The existing ICT platforms in Groningen are adapted and integrated to create an Urban Data Platform.<br>The purpose of the Urban Data Platform is to collect relevant data about the city and make it available to stakeholders in the city via standardized interfaces. It enables services built on these standards to be used within the city. | Multi-sided revenue model<br>Freemium<br>Pay with data |
| Solution 6e<br>Installation of IoT infra | Installation of IoT infra TNO | Multi-sided revenue model<br>Freemium<br>Pay with data |
| Solution 7<br>Open Urban Platform adaptation | The existing data platform will be integrated with other platforms as part of the MAKING-CITY project to create an Urban Data Platform storing and publishing any Open Data created as part of the project | Open data |
| Solution 8<br>High Speed data transfer network | Wireless data transfer network that will cover the whole area for control and data aggregation. (This is already existing as a standard solution in Finland, using common mobile network, so this is realized as a internal network fo practical purposes). | Pay per use<br>Freemium<br>Multi-sided revenue model |
| Solution 9 | Neighbourhood electro storage facility-(600 kWh) NIJ | Pay per use<br>Shared savings |

| | | |
|---|---|---|
| Neighbourhood electro storage facility | | Power purchase agreement<br>Cooperative utiliy<br>Active customer |
| Solution 10a<br>Phase transfer Liquid tank | To increase the energy content of the conventional water based thermal storage we can utilise phase change materials to increase the energy content of the tank. | One-time investment<br>Leasing |
| Solution 10b<br>Seasonal storage | Under the summer period the cooling of cold storages in the shop creates lots of heat<br>Normally this heat is evaporated to air with heat exchangers so all the enrgy is lost<br>In this application the heat is stored to the ground<br>IN the winter when extra heat is needed for the building and hot domestic water the heat will be recovered | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 10c<br>Thermal Storage | Thermal energy storage in building one<br>A11: Thermal energy storage in building two | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 11a<br>Low Temp regional transfer pipeline | Low temperature heating pipes allows the heat transferred for heating to be in lower temperatures.<br>The system uses lower temperatures (<60°C) compared to regional heating (<110°C) in heating and hot water production. Lower temperature means better economy in production, less losses in distribution and lower cost in building the distribution pipelines (plastic instead of steel piping). | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 11b<br>Adjust geothermal district heating for using low temperature | The geothermal district heating network in Groningen NORTH is initially designed as a high temperature network. However the heating source has been changed to waste heat of datacenters instead of geothermal energy. The district heating network has been adjusted to an high to medium temperature district heating network. This means that the temperature would be approximately 75 °C in summer and up to 90 °C during cold days in the winter | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 11c<br>Connection to the low temperature district heat | In the PED South a collective aquifer thermal energy system (ATES) will be connected to a ground source heat pump of the Powerhouse and the Sportscomplex. | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 12<br>Building energy connectivity for energy sharing | Connection to district heating network. Apartment buildings use return pipe as a heat source with heat pump, in addition to the normal connection to the supply side. The grocery store feeds excess heat from refrigeration to supply. | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |

| | | |
|---|---|---|
| Solution 13a<br>CO2 based heat pump | Refrigeration machines of the grocery store, which can also supply heat to district heating network. | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 13b<br>Advanced Heat Pump (high COP) | Heat is gained from exhaust air, which is extracted mechanically, using fans, from bathrooms, toilets and kitchens. This is a commonplace solution in Finland. In new buildings the heat in exhaust air is recovered by air-to-air heat exchanger to incoming fresh air, but if that system lacks in existing buildings, | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 13c<br>Acoustic Air Heat Pump | Acoustic Air heat pump in terraced house (20 kW) GPO | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 13d<br>Acoustic Hybrid heat pump | Acoustic Hybrid heat pump in terraced house (5 kW) GPO | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 13e<br>Geothermal Heat Pump | Geothermal heat pumps for Mediacentrale (45 kW) WAM | Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 14a<br>PV in roofs and parking lot | PV in roofs and parking lot (600 kWp) [NIJ, GRO, WAM, GPO] | Space rental<br>Municipal utility<br>Cooperative utility<br>Shared savings<br>One-time investment<br>Power purchase agreement |
| Solution 14b<br>Building Integrated PV (on the façade) | An apartment house from 70's has its southern facade covered with PV panels. | Power purchase agreement<br>White label retailing<br>Leasing |
| Solution 14c<br>Floating Solar pontoons | In the surrounding area of the Sport Complex building [A6] floating solar pontoons are planned. 180 panels (156 kWp) are allocated. These very innovative doubled-sized floating panels will make full use of the reflecting properties of the water allowing the usage of two-sided solar panels increasing the yield of solar power. | Power purchase agreement<br>Municipal utility<br>With label retailing<br>Leasing |

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| Solution 14d Solaroad | SolaRoad's products are based on a simple concept. Robust solar panels with a skid resistant, translucent coating are mounted on a concrete slab. | Power purchase agreement<br>Municipal utility<br>White label retailing |
| Solution 15a Hybrid Heat collector (high pressurised $CO_2$) | Low temperature heat collectors will be used in Arina (Action 19) to collect heat even from very low temperatures (-20ºC). | Power purchase agreement<br>White label retailing |
| Solution 15b PVT Panels | A20: PVT in Sport Complex (54.8 kWp) GRO, WAR<br>The 88 (200 m2) PVT panels (type: PowerCollectors) have been placed on top of the sport complex building by Solaris. Both heat and electricity is generated. | Power purchase agreement<br>White label retailing |
| Solution 16 Geothermal energy | Two District Heating systems based on RES are located in PED North and PED South and will be the main responsible to supply thermal energy to the buildings located in both PEDs. | Power purchase agreement<br>Municipal utility<br>Coperative utility<br>White label retailing |
| Solution 17a Waste Heat Recovery | Heat recovery from wastewater to pre-heat cold water for hot tap water | Power purchase agreement<br>Municipal utility<br>Coperative utility<br>With label retailing |
| Solution 17b Heat recovery system from DH return pipeline to space heating and DHW | Apartment buildings use district heating return pipe as a heat source with heat pump, in addition to the normal connection to the supply side. | Power purchase agreement<br>With label retailing |
| Solution 18a Integrated Sustainable Energy Planning | ISEP is a plan developed based on a distinct approach to decision making including an area-based approach to identify local synergies between alternative societal challenges and ambitions, and explicitly means to be based on a wide inclusion of a variety of public and private stakeholders. | *Public investment (Resilient strategy)* |
| Solution 18b Land use planning fostering energy actions | The integrative approach takes the development aspirations of all the PED stakeholders as a starting point of land use planning, and creatively develops them further to discover mutual gains | *Public investment (Resilient strategy)* |

# ANNEX IV Guidelines for PED Design - "How to Transform a District into a PED"

MAKING-CITY G.A. N°824418

Annex I

# Guidelines for Positive Energy District Design

**How to Transform a district into a PED**

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# OBJECTIVE

**The main purpose of these guidelines is to provide an approach for planning and designing Positive Energy Blocks (PEB) and Positive Energy Districts (PED) in cities.** Since PEDs play a key role on energy transition in cities, this report highlights the importance of citizen participation, economic, technical, political, regulatory, and spatial issues for a sustainable urbanization. In line with this, definition of the methodology and establishing guidelines are pointed out according to the different application of scenarios to facilitate designers the identification and combination of the solutions to transform a district into a PED. In this guideline, the analyses and conceptions for defining PED boundaries in cities and selection of technologies in parallel with participative processes are intensely examined and presented.

The proposed PED methodology is targeted mainly to municipalities. Nonetheless, the process defined in this report covers citizens, designers, planners, technology providers, energy utilities, grid operators, researches, energy real estate investors, energy generators, energy service providers and public transport operators and mobility planners. The involved stakeholders will depend in the specific urban context.

# MAKING-CITY PED CONCEPT

According to MAKING-CITY project, **a Positive Energy District (PED) is "an urban area with clear boundaries, consisting on buildings of different typologies that actively manage the energy flow between them and the larger energy system to reach an annual positive non-renewable primary energy balance".**

PED is a relatively new concept, derived from the Positive Energy Block (PEB) concept. MAKING-CITY assumes that a single energy transition process can be accelerated if PEDs can be achieved and scaled up, due to the special features and ambition of the approach. Reaching positive balance means a step forward regarding net zero energy districts(NZED) as can obtain better impacts due to the intensive use of RES and high efficiency which can reduce remarkably $CO_2$ emissions. PEB is a group of at least three connected neighbouring buildings producing on a yearly basis more primary energy than what they use[1], whereas a NZEB is understood as a building that has a very high energy performance with nearly zero or very low amount of energy requirements. The NZEB energy needs are covered to a very significant extent by energy from renewable sources(RES) including energy from RES produced on-site or nearby [2]. Several NZEB forms the NZED. PED can have a combination of NZEBs and/or high efficient buildings (that do not necessarily meet NZEB requirements). However, the main difference is that PED produces more energy than what is needed to meet the district needs. In the following section the requirements for the implementation of PEDs are explained. In page 6, a methodology for PED design is stated.

# REQUIREMENTS for IMPLEMENTATION of PEDS

## 1. Collaborative Governance – Potential implementation of PEDs according to the regulations and policies in the cities.

Collaborative governance goes beyond direct **citizen engagement and** moves towards the **creation of networks or coalitions where discussions and negotiations can take place with a wide range of stakeholders** [3]. Collaboration can start with allowing for true open planning processes where affected stakeholders, now also including companies and NGOs. Therefore, this also thrives on communicative planning ideals [4] and co-creation [5]

Collaborative governance goes beyond open planning processes, but also sees the creation of coalitions, platforms or networks for sharing and discussing policy outcomes as an ambition. Larger energy companies, energy network operators, housing assertions, project developers or big companies are all examples of more professional organisations with significant financial capabilities that need to be explicitly included in PED development. These stakeholders might be engaged through establishing economic and social networks together with governmental organisations and departments. The **development of agreements, covenants and public private partnerships** can be the result and ambitions of such networks, addressing wider urban energy challenges such as large solar fields, heat networks, neighbourhood revitalisation, etc. The result is a professional community of practice able to coordinate its work in pursuing PED development.

## 2. Urban Planning, Land Use Planning and Urban Design - Potential implementation of PEDs according to the plans and strategies in the cities

As the integration of various interests is the central aim of urban planning and land use planning, cities can utilize 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 urban structure in the long-term, and search locations for integrated urban functions, such as PEDs.** Moreover, surveys and impact assessments produced during land use planning can be utilized to generate knowledge about energy opportunities. Land use planning can also be utilized to bridge 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 utilized for energy-related participation.

One limitation for utilizing 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 utilized in contexts where new buildings are being built, that is, in PEDs based on new urban development or infill building. **In PEDs that include existing buildings, other planning, and policy tools, such as citizen engagement strategies, might be more applicable.**

### 3. Citizen Empowerment – Identification of Stakeholders at an early stage and Co-designing PEDs in the cities

An important challenge for citizen empowerment is to **move beyond mere interest representation and towards value representation;** i.e. decision making moves beyond negotiating interests or about implementing a 'product' or 'solution', but is contextualized by a shared story for the future of a neighbourhood or town that the PED represents and fits into. Doing so can be a mechanism **to evolve from self-interest to working on common values** and hence, allow for a more efficient form of citizen participation.

A key ingredient to support citizen empowerment by working on common values is also to **financially enable citizens to be part of PED development**. The challenge is thus to develop financial arrangement that allow and stimulate individual companies or individual households to (co)invest and financially participate. While much tends to depend on national legislation, also on a local level key opportunity exist, ranging from cheap loans, subsidies, or facilitating easy access to financial institutions.

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## 4. Investment and Risk Models – Identification of Innovative Business Models for PED Implementations in the cities

There is no predefined single business model for the successful development of a PED. Instead, a **combination of different business models** must 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.

## 5. Impact Assessment – Potential Impacts of PEDs to the city's overall Sustainable Energy Vision

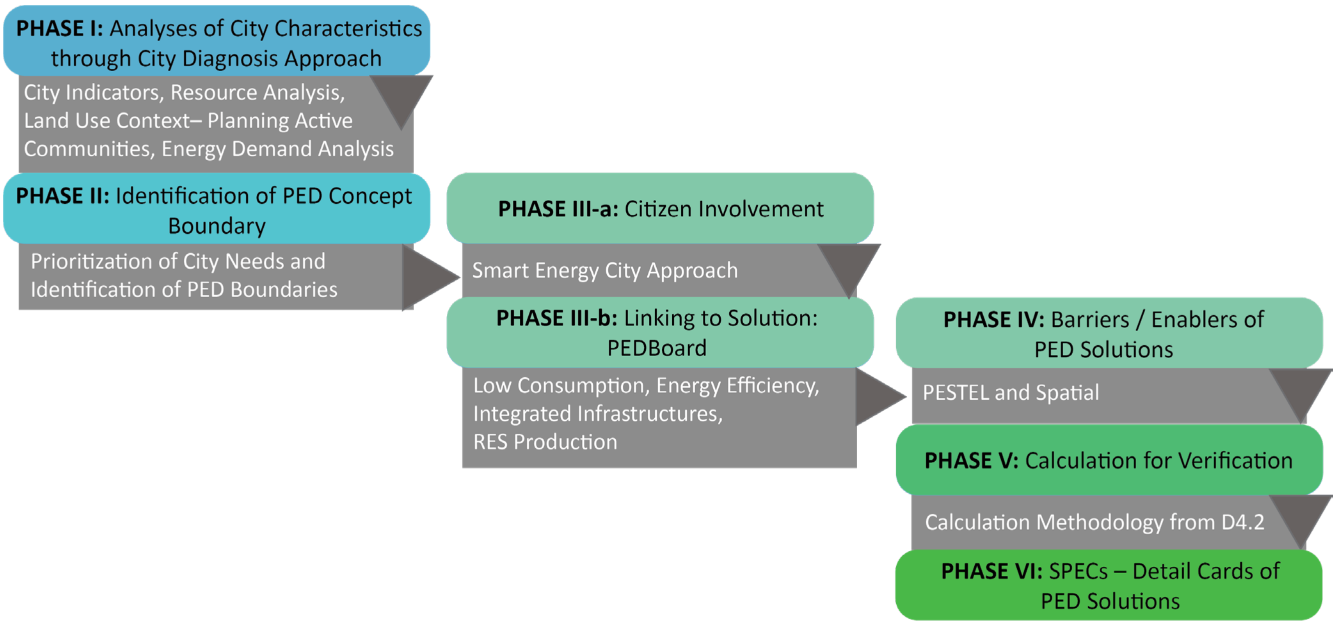
In order to verify the coherence of PEDs with the needs and demand of the citizens of the city, region neighbourhood or area where the project is intended to be implemented, the interrelation among the urban challenges has to be highlighted. These challenges need to be identified with the different PED implementations in the city.

A standardized matrix could be created to assess the impact of PEDs in terms of political, economic, social, technical, spatial or legal aspects. The matrix should summarize all elements and allow to identify how each city challenge is addressed by the project elements. Since PEDs support minimizing the impact on the connected centralized energy networks, the impact assessment on the innovative integration of technologies (such as sustainable energy services solutions, storages, smart control – demand response, e-mobility, DERs ...etc.) gains importance for encouraging decentralized systems.

# METHODOLOGY for PED DESIGN

The following PED Design Methodology focuses on the procedure considering the identification process of the PED concept boundary and selection of proper PED solutions peculiar to the cities. It is composed of the phases encompassing a decision-making route that underlines citizen engagement throughout this process. The procedure aims to understand what the city is looking for, described as state of play in cities (city characterization) for figuring out the priorities, objectives and needs of the cities. Therefore, 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.

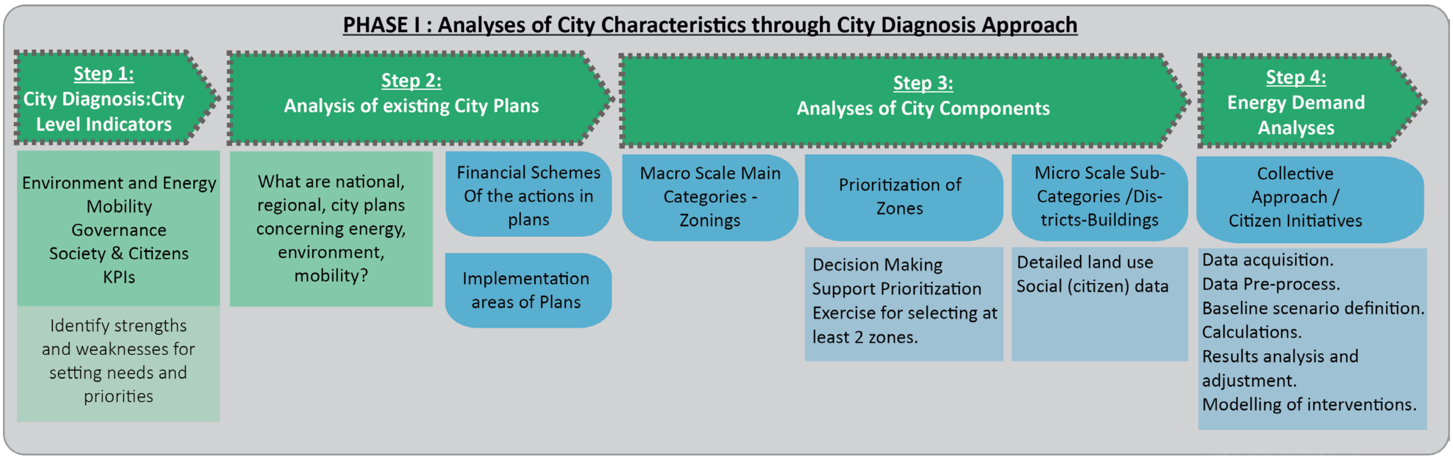
# PED DESIGN METHODOLOGY




## Phase I: Analyses of City Characteristics through City Diagnosis Approach

Phase I addresses main city needs in terms of energy aligned with integrated urban planning, land-use planning and urban design. This phase includes robustly local authorities, citizens, researchers, planners and designers in the process. In doing so, city characteristics and priorities are analysed under four steps:

- Analysis of the main city characteristics: Calculation of City Level Indicators
- Analyses of existing City Plans and identification of implementation areas in these plans
- Analyses of City Components
- Energy Demand Analyses



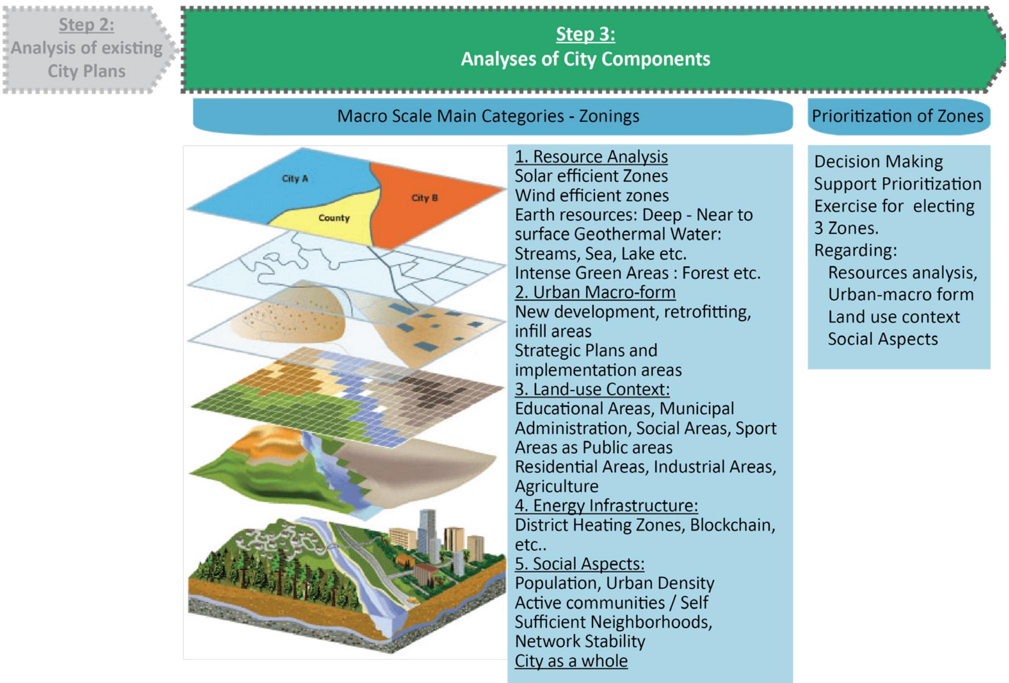

## Step 1: City Diagnosis: City Level Indicators

The city level indicators are used to show to what extent overall policy goals have been reached. In the process to become a smart city, establishing a reliable metric is a key point to support cities to identify strengths and weaknesses and consequently set priorities for action.

## Step 2: Analyses of existing City Plans and identification of implementation areas in these plans

A first approach the description of the plan, the implementation period, the scope of the plan, and the topics covered (energy, mobility, ICT, social) is collected. At this phase, cities can also utilize their strategic land use plans to explore opportunities for PED implementation, by taking into account the aims of the city, the energy network operators, private sector and citizens.

## Step 3: Analyses of City Components



Analyses of City components play a key role for identification of peculiar and efficient PED concept boundary in cities. Until today, smart cities were particularly evaluated with energy, mobility and ICT (rarely with waste, water, too) domains. In fact, the challenge is that local energy production and distribution, connected with digitalization, have not previously been a part of the integrated urban planning and design approaches, while they have included many other environmental and social topics. MAKING-CITY PED Methodology underlines energy sustainability in urban planning, land use planning and urban design and therefore repeats deep analysis in macro/micro scale in the city/neighbourhood/district/building level. A harmonization of these diverse modes of spatial planning with energy planning is the main aspect of PED Methodology for pointing out city characterization.

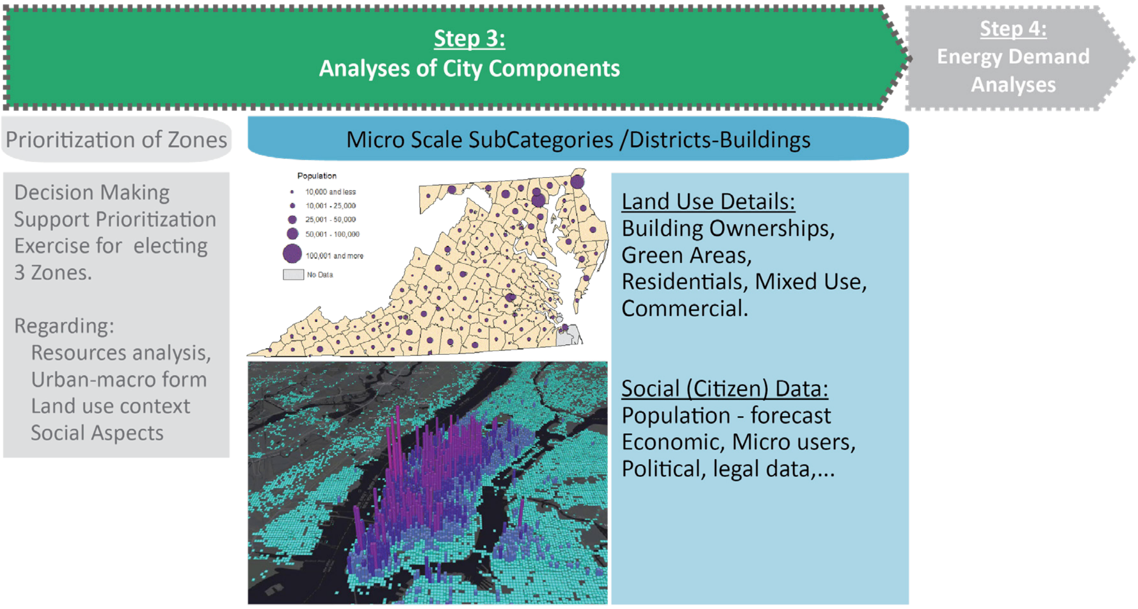
Likewise, MAKING-CITY PED Methodology indicates that inclusiveness, co-creation and participatory planning shall rule the energy transition since an inclusive city is a city in which the processes of development include a wide variety of citizens and activities. These cities maintain their wealth and creative power by avoiding marginalization, which compromises the richness of interaction upon which cities depend[6].

The main analyses of integrated energy planning, spatial planning and data is divided into two categories, comparatively macro and micro scale main categories. Macro scale main categories involve GIS based spatial data as zonings. Cities start to assess zones of efficiency for PED areas peculiar to their characteristics, climate, demography, geography in different macro scale categories listed below:

1. Resource Analysis
2. Urban Macro-form Analysis
3. Land-use Context
4. Energy Infrastructure Analysis
5. Energy Service Analysis
6. Social Structure

After all of macro-scale analysis have been realized and zones have been determined regarding resources, implementation areas of strategic plans, land-use context, energy infrastructures and social aspects (and embedded in GIS based maps as spatial data), cities and **relevant stakeholders are encouraged to construct a prioritization study to specify** at least 2 most proper zones **for implementing PED according to the most prioritized zones by** overlay mapping. Since these zones will cover large areas, next step is going through micro-scale analysis and identifying PED areas in the city. Cities will develop micro-scale analysis in the following subcategories:

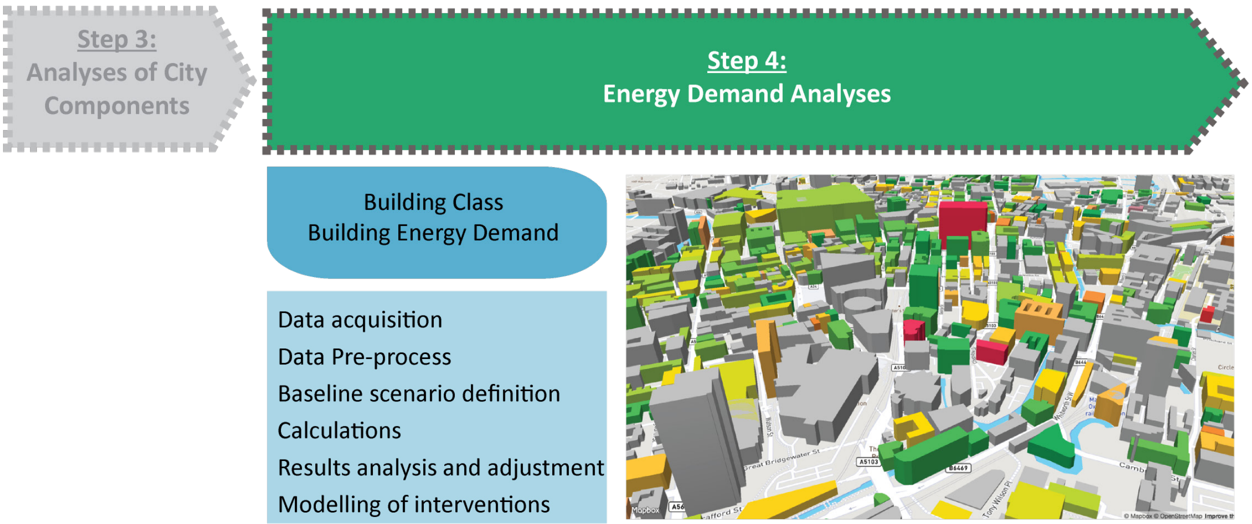
1. Land-use Detail Maps
2. Social (citizen) Data Maps
3. Energy Demand Analysis




## Step 4: Energy Demand Analyses

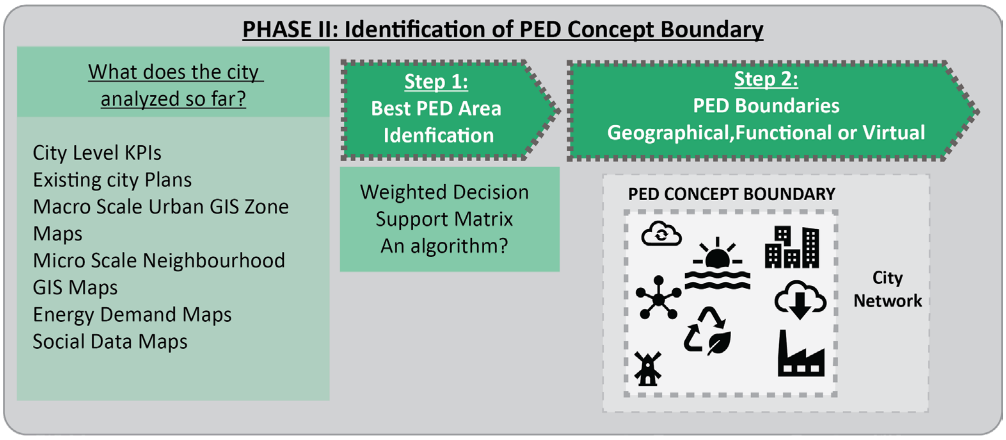
There are several bottom up methodologies and techniques for making building stock energy models to analyse energy demand, and they can be applied at any level, local (district, municipal) or national level.

This section, presents a bottom up methodology for modelling the building stock of urban districts based on publicly available data and describes the workflow from the collection of the data to the adjustment, calibration and visualization of the simulation results.



## Phase II: Identification of PED Concept Boundary

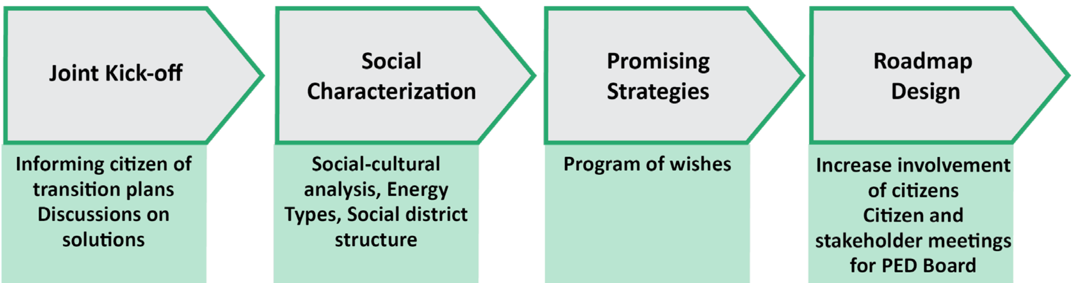
Once the city needs and priorities are identified, land use context of the city is clarified and resources are listed, the boundary for the PED concept may be formed. This phase is connected with city and district scale and accommodates the participation of the local authorities, all relevant stakeholders and citizens.




## Phase III-a: Citizen Participation – Smart Energy City Approach

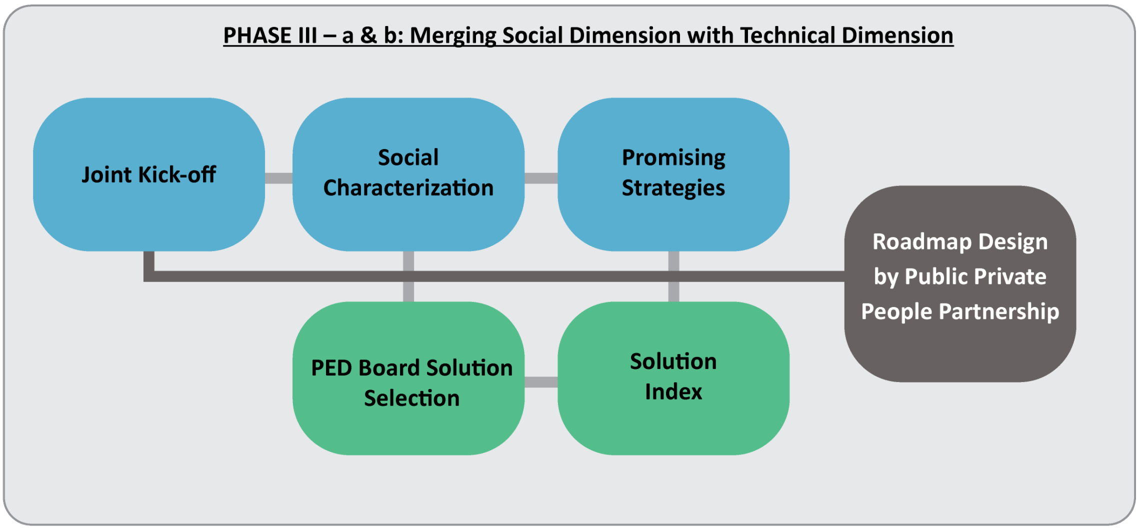
As explained by the Covenant of Mayors of the EU, “all members of society have a key role in addressing the energy and climate challenge with their local authorities”. Public participation is useful to determine needs, desires and requirements and to increase transparency. Their implication is also useful to increase citizens’ engagement with the environmental challenge.

Essential part in understanding the wider context of an existing urban district, identifying priorities and most urgent needs to address in designing and planning of a sustainable Positive Energy District, is to include the perspective of citizens and end users of the district itself. One of the methods to include the citizens in the process of involvement, being part of planning and prioritizing, is potentially the approach of Smart Energy Cities.



## Phase III-b: Linking to Solution: PEDBoard

In parallel with Phase III-a Citizen Involvement, a technical study on PED technologies is realized. Within this phase, the inputs of Phase I and Phase II are evaluated by a decision-making mechanism and the particular technical and non-technical solutions are linked to the according to the data obtained from Phase I and Phase II. The solutions are classified under main solution categories of demand side, supply side and integrated infrastructures. The concept will enable the delivery of energy services, allow the management and trading of locally generated energy and grid-based energy supplies, and potentially link with other local and cloud-based services such as security/safety and e-mobility in order to progress towards energy positive districts.




## Phase IV: Barriers / Enablers of PED Solutions

In this phase, impact-based evaluation is integrated in selection of solutions process and political, economic, social, technical, environmental, legal and spatial barriers, constraints, supporting factors are recognized for each selected solution. A PESTLE anlaysis can be performed followed by a brainstorming on how to overcome the barriers. If the results are negative to continue to the next phase, a feedback loop (a system for improving a product, process, etc. by collecting and reacting to users' comments) mechanism can be formed to find another particular solution for the PED area. The discussion is expected to be developed by an open dialogue and consensus between technical designers, citizens and local authorities.

## Phase V: Calculation of PED for Verification

With the solutions selected, a PED calculation can be performed. The calculation methodology is detailed in “MAKING-CITY Guidelines to Calculate the Annual Primary Energy Balance of Positive Energy District” . If the PED balance is not positive (i.e. more energy is exported than what is imported to the district), new selections from PEDBoard must be assessed in order to achieve a PED.

## Phase VI: SPEC Cards

This Phase presents the detail cards of each solution categorised in PEDBoard. The solution cards, named SPECs, involve general data, technical and graphical details, implementation time, initial investment and financial models, stakeholder mapping, integration with other smart solutions, potential for replication, expected impacts of all of the solutions. This is the main output of proposed PED Methodology, guiding cities with a detailed information on the technical and non-technical issues of solutions presented in PEDBoard.

# INNOVATIVE BUSINESS MODELS FOR PEDS

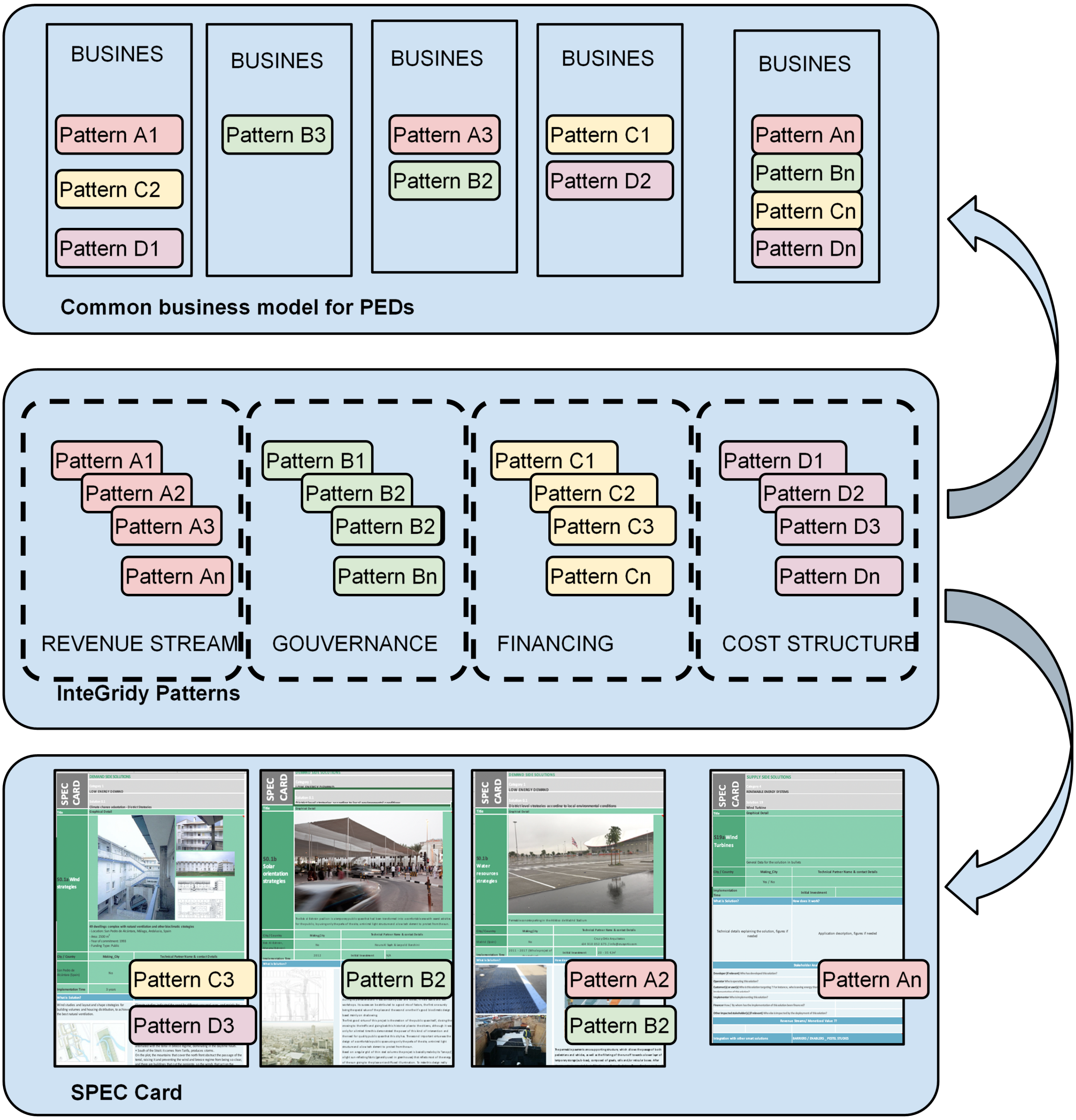
The design of a new business model has as its final purpose the creation of business models that:

- satisfy market needs that have not been met yet
- introduce new technologies, new products or new services
- improve / disrupt / transform existing markets
- create new markets (see Blue Ocean Strategy)

To help the MAKING-CITY partners develop their business models, this method provides support on 3 levels:

- Business model guidance - Business model canvas and its 9 blocks
- Listing business model patterns (identified by the inteGRIDy project)
- Example of business model for PEDs
- Description of the common business model for PEDs based on literature review
- Tag each business model for PEDs with the business model patterns
- Tag each MAKING-CITY Spec Card with the common patterns

This will allow easy cross analysis while providing exhaustive and open information.


BUSINES
Pattern A1
Pattern C2
Pattern D1
BUSINES
Pattern B3
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Pattern C1
Pattern D2
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Pattern An
Pattern Bn
Pattern Cn
Pattern Dn
Common business model for PEDs
Pattern A1
Pattern A2
Pattern A3
Pattern An
REVENUE STREAM
Pattern B1
Pattern B2
Pattern B2
Pattern Bn
GOUVERNANCE
Pattern C1
Pattern C2
Pattern C3
Pattern Cn
FINANCING
Pattern D1
Pattern D2
Pattern D3
Pattern Dn
COST STRUCTURE
InteGridy Patterns
SPEC CARD
Pattern C3
Pattern D3
SPEC CARD
Pattern B2
SPEC CARD
Pattern A2
Pattern B2
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