Innovation Action

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D4.4 - Technical design of PEDs in FWCs (Bassano, Kadikoy, León, Vidin, Trenčín, Lublin)

WP4, Task 4.3

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Abbreviations and acronyms

Acronym	Description
CAPEX	Cxapital expense
FWC	Follower Cities
GIS	Geographical Information System
LHC	Lighthouse Cities
MCDA	Multi-Criteria Decision Analysis
OPEX	Operating expense
PED	Positive Energy District
PESTEL	Political, Economic, Social, Technological and Legal
RES	Renewable Energy
SC	Space Cooling
SET	Strategic Energy Technology
SH	Space Heating

Executive summary

MAKING-CITY Methodology for PED design (D4.1) presents six phases to guide cities for identifying their city needs and priorities, identifying potential PED areas, designing PEDs not only from technological but also from economic, social, political, legal, spatial and environmental point of view and also engaging citizens and stakeholders along with this process. Methodology for identifying PED concept boundaries (macro-scale analyses) was validated in FWCs in the second year of MAKING-CITY and summarized in D4.3. Whereas, this deliverable is concentrated on defining exact and detailed PED boundaries (conducting micro-scale analyses), defining engagement strategies for co-designing PEDs, selection of PED solutions from PEDBoard (that was generated in D4.1) by the help of the technology selection tool and calculating energy flows of FWCs.

Starting from M24, intense research was held between DEM, CAR and TEC for generating a methodology for micro-scale analysis on the PED area identifications in FWCs. Between M12-M24 (reported in D4.3) macro-scale analyses were conducted to identify potential PED areas (at island/zoning scales), and this year these areas are discussed from scientific point of view (by the help of DEM and TEC) together with the municipalities' opinions from legal, political, social, and economic context of their cities. The results of these discussions and visualizations as outcomes of these meetings are summarized in the annex of this deliverable.

After the PEDs are identified in each FWC, parallel research for developing citizen engagement strategies were conducted together with WP5 - T5.7 Social Innovation team. The lighthouse cities have developed a series of questionnaires and tools with the aim of facilitating the co-creation of PED-designs in six follower cities (FWC) (León – Spain, Kadikoy – Turkey, Bassano del Grappa – Italy, Lublin – Poland, Trenčín – Slovakia, Vidin – Bulgaria). These modular questionnaires include a variety of topics relating to energy, such as consumption, generation, efficiency, and flexibility as well as questions pertaining mobility, and social cohesion (development of local communities). The data from the questionnaires will be utilized to construct potential indicators that will help the FWCs to realize their own PEDs and encourage them to further develop City Visions 2050. These results will be presented under T5.1 activities.

Along with the citizen engagement strategies, a technology selection tool is developed for supporting cities in decision-making processes. The methodology, the backend and frontend design of the tool and the results are summarized in this deliverable. Once the cities completed PED technologies selection step, barrier/enablers analysis that were already presented in D4.1 is checked whether to understand the technologies match the city context in PESTEL aspects. Each technology is matched with the associated one in the Solution catalogue (again developed in D4.1 – so called "PEDBoard"), and cities are able to check the detail SPEC Cards of the technologies. A few scenarios are developed by CAR, DEM, and TEC to further conduct the PED energy flows. All calculations are done according to the scenarios from technical point of view. Technical partners utilized the MAKING-CITY tables for calculation that were generated within D4.2).

Finally, PED Designs in FWCs are ready to be included in cities execution plans. D4.5 will be concerning with the financial plans of the PED designs. The technologies identified in this deliverable will be transferred to the financial plans research. If the PEDs are not feasible, a new technology selection process will be conducted with M42, and a new financial plan will be created.

Keywords

Positive Energy Districts, PED Design, PED Planning, PED Solutions, Geographical Information System (GIS), Multi-Criteria Decision Analysis (MCDA), PED Technologies, Technology Selection Tool

1 Introduction

From the macro-scale analysis for PED concept boundary identification that is held under T4.2, zones/islands that have potential to be PEDs are generated. In order to select the building/district scale positive energy areas, micro scale analyses is first to be conducted and the definition of transformation process in each follower city will be addressed.

Once the district is identified and the boundary is framed, several actions will be taken by FWCs to design PEDs in their areas. First action will be developing a solid stakeholder and citizen engagement strategy to ensure acceptance. After that, the technical design process will be carried out, under co-creation criteria, by the FWCs and partners supporting them. Selection of PED solutions and calculating the annual positive energy flows will be integrated at this phase.

Hereafter, a full investment plan will be developed, considering innovative financial schemes and business models that are presented in D4.1 Methodology for PED design and finally a set of recommendations for local regulations and policies will be delivered in order to ensure scalability and replicability.

Webinars and workshops were held until M36 for encouraging knowledge / experience transfer from LHCs to FWCs to support an impact-based design procedure. Webinars are related with Citizen engagement strategies, PED calculation methods, PED technologies selection and PED business cases. Methodologies are also developed for generating citizen engagement strategies, PED calculations, PED Technologies selection and PED Area Selections. These methods are all be validated in this deliverable by FWCs to design PEDs in their city contexts.

This deliverable presents the Methodology of PED Area selection (at macro and micro scales) in a nutshell in Chapter 2.

Chapter 3 introduces the PED Design procedures, as the methodology for defining citizen engagement strategies, methodology for identification of PED solutions, barriers / enablers of each solution and methodology for calculating the annual energy balance in cities.

Chapter 4 summarizes the 3 webinars and workshops conducted between M24-M36 on Citizen Engagement Strategies, Selection of PED Technologies and PED Calculation Methodology. Another webinar and workshop on business cases will be conducted during M36-M42.

In chapter 5, the first attempts for the validation of the methodology for identifying citizen engagement strategies is presented. More information regarding the cities will be presented regarding the activities under T5.7

From Chapter 6 to Chapter 11 (where all of the methods are validated), PED designs regarding each FWC is presented starting with the selection of PED technologies by the help of the Technology Selection Tool, generating scenarios and calculation of annual energy balance regarding each scenario developed. The results are presented in each associated section, such as PED boundaries definition, Energy needs inside PED boundaries, Energy Use, RES production inside the PED, Energy delivered, Primary Energy Balance and Energy Flow Diagrams

1.1 Purpose and target group

The purpose of task 4.3 is to validate the PED design procedures in FWCs. Therefore, the target group of tasks 4.3 are the follower cities as it is shown in Table 1: Target Group of T4.3

Table 1: Target Group of T4.3

Bassano del Grappa	Kadikoy	León	Lublin	Trenčín	Vidin

1.2 Contribution partners

Table 2: Contribution partners to this deliverable

Partner nº and short name	Contribution
25-DEM	PED design Methods, Micro-scale Analyses, Methods for Development of Citizen engagement strategies, methods for technology selection, Validation of each method in León, Lublin, Trenčín and Kadikoy
01-CAR	Calculation Methodology Definition and energy flows in FWCs, methods for technology selection, Validation, and control of each method in all FWCs
02-TEC	Micro-scale Analysis development, Validation of each method in Bassano del Grappa and Vidin

1.3 Relation to other activities in the project

Table 3: Activities related with this deliverable

Deliverable / Task nº	Relation
T4.1/D4.1	Validation of Methodology for PED Design
T 4.1/D4.2	Validation of Methodology for PED Annual Energy Balance Calculation
T4.2 / D4.3	Conducting micro-scale analysis as a following procedure of macro-scale analyses for the identification of PED Concept Boundaries
T4.3 / D4.18	Financial plans of PED designs in FWCs – Identified Technologies
WP1 /T1.5.2	Citizen Engagement Strategies in D1.28-D1.32.
WP5 / T5.7	Development of Questionnaires to be conducted in FWCs for co-designing PEDs
WP8	Collaboration activities with other SCC Projects for Workshops and Webinars

2 Methodology of PED Concept Boundary Definition in a nutshell

Methodology developed for defining PED concept boundaries is consisting of phases that connect spatial information system of the cities aligned with technical, economic, social, environmental and legal framework within their context. First Phase is the identification of PED Analytical components and collect GIS based spatial data, in parallel with generation of a Multi-Criteria Decision Analyses Questionnaire for supporting cities to evaluate the PED Components from PESTEL point of view. Then an overlay analysis will be conducted by the help of the results of MCDA Questionnaire and the results will be displayed at macro and in a more detailed approach at micro scales. In D4.3 macro scale analyses are presented in each FWC and micro scale analyses were conducted between M24-M36 and summarized in this deliverable. Throughout the whole process, the harmonization of urban planning and energy planning is targeted.

Overlay analysis is a group of methodologies applied in optimal site selection or suitability modelling. It is a technique for applying a common scale of values to diverse and dissimilar inputs to create an integrated analysis. Spatial based overlay analysis often requires the analysis of many different factors. For instance, defining PED concept boundaries in cities requires assessing PED analytical components that are identified in MAKING-CITY. In this context, spatial analyses will be conducted at two scales: from macro scale to micro scale analysis through Weighted Overlay Analysis in parallel with for the identification of the city's potential PED areas.

FIRST Approach; **Macro scale analysis** requires GIS-based city context data on resources availability, urban macroform, landusage, energy and e-mobility structure, energy service availability and social structure of the city. These city data layers play a decisive role on creation of potentials and resources for PED implementation and called as PED analytical components. The full list of data layers are given in in section 4.1 that city needs to provide in order to run the macro scale analysis.

All data at this stage will be gathered in zoning/island scale. No building scale data will be integrated in the analysis. a Geoprocessing analysis will be conducted in order to realize Spatial Weighted Overlay and prioritizate potential areas to be PEDs. At the end of this phase 2-3 potential zones will be selected further to go on with micro-scale analysis in order to define the PED boundary.

SECOND Approach; Micro-scale analysis will be conducted within the identified potential PED zones that are calculated from macro-scale analysis. PED Analytical compontents that will be collected in building scale from selected zones are as follows: Resources, Land Usage, Socio-economic and Legal Data and Building Based Energy Demand Maps coming from WP1 analysis. This stage is detailed in this deliverable while desiging PEDs.

All data at this stage is gathered at building scale. A Geoprocessing analysis is conducted in order to realize Spatial Weighted Overlay and prioritizate on district to be PED concept boundary.

Geoprocessing Analysis: Collected city data (both macro and micro) needs to be organized. Values in each layers will be organized accorging to PED Analytical Components criteria. Then if the layers are in vector format, the layers need to be converted into raster format since Weighted Overlay Analysis and its whole steps work with raster layers that have integer values **(Step 1)**. Afterwards, Reclassification of all input layers will be conducted to manage layers in accepted format (integer values) **(Step 2)**. Finally, all raster layers will be ready to utilize Weighted Overlay Analysis Tool in order to conduct **Suitability analysis** in GIS-based process to determine the appropriateness of a PED boundary. Detailed information regarding the steps of geoprocessing analysis may be found in the next sheet.

Geoprocessing Analysis will be enriched with a **Multi-Criteria Decision Analysis (MCDA)** in which a detailed questionnaire is integrated for cities to understand and participate to the PED Analytical Components determined by MAKING-CITY project. Each city will evaluate city data layers in consideration of its own resources, networks, spatial planning, land use plans, finance, infrastructure, technology, dynamics, priorities, policy instruments, regulations and legislations for identification of weightining these layers. Multi-criteria evaluation process will be performed through multi-actor decision making approaches (MCDA). Evaluation results will be an output of one or a series of participatory, co-design activities that will be determined by each city within its City Urban planning Department that was founded within MAKING-CITY project (T1.1), where a cross-departemental approach to adopt decisions. This department may also engage private authorities, academicians, business sector stakeholders, energy cooperatives and citizens for decision-making process. This multi-criteria and, multi-actor evaluation process will be conducted as a paralel analysis to collection and evaluation of GIS-based data, furthermore, cities that cannot provide GIS-based data, will only identify the PED concept boundaries by getting advantage of the **MCDA Questionnaires.**

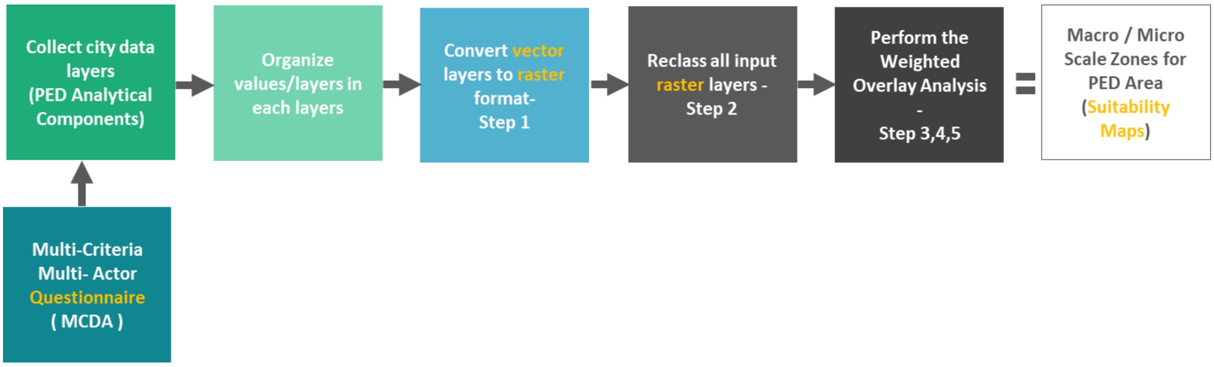


Figure 1: GEOPROCESSING Steps and MCDA integration for identification of macro and micro scale potential PED areas

Multi Criteria Decision Analysis (MCDA) may consist of one or a series of multi-actor participatory workshops or focus group meetings. Macro and micro scale PED Analytical Components of the city will be evaluated during this participatory process in consideration of a number of criteria such as technical and technological capability, financial resources, national policy instruments and regulations on energy and sustainable urbanization, urban planning decisions and policies, legislation, energy resource availability and priority and also socio-economic structure of the citizens within the country/city. Criteria list which consist of decisive factors for PED implementation in the city can be updated or identified by City Authority (Municipality). MCDA Questionnaire is explained in detail in MCDA sheet in D4.3 Analysis of FWC candidate areas to become a PED.

Following sections describe firstly, the identification of PED analytical Components followed by how the MCDA questionnaire was created and the role that plays in the assessment and finally, how the analysis was supported in GIS software tools (geoprocessing steps for ARCGIS and QGIS).

2.1 Macro Scale Analysis

Macro-scale Analysis (city-based) for defining larger zones/islands that have potential for PED implementations are presented in detail in “D4.3 Analysis of FWC candidate areas to become a PED” in Chapter 4, as indicated before. The analysis was conducted by the support of the MCDA Questionnaire for figuring out political, economic, social, technological, environmental, legal (PESTEL) and spatial concerns / barriers / challenges that the cities may have, evaluated together with GIS-based tools.

Once the zones are selected, micro-scale (building-based) analyses will be conducted in order to achieve the exact boundary (geographical, functional or virtual) in FWCs.

2.2 Micro Scale Analyses

The same approach that is validated by macro-scale analyses is developed and tested in FWCs in the third year of MAKING-CITY to identify the peculiar PED boundary for the design stage.

First PED Analytical Components are identified, then MCDA Questionnaires are reviewed and a Prioritization study will be conducted within GIS-based tools for each city.

Intense studies that were held for developing Methodology for PED design in T4.1 – D4.1, provided a light for the research in figuring out what elements are critical for PED planning, design and implementation in cities. As explained in detail, in D4.1 "Section 2.1 From smart cities towards Positive Energy Districts", how energy transition requires the evolution from one single building to the extended boundaries into blocks, districts, neighbourhoods etc., PEDs require extensive analyses on resources, urban planning/design and land-use planning, energy planning as in physical and virtual infrastructure and socio-economic and socio-cultural aspects. All of the components are tried to be collected in GIS-based spatial data, since the analyses that are going to conducted will utilize overlay analyses in GIS-based software.

In line with this approach 4 categories are generated for defining PED Analytical Components, in micro scale. Here in this section PED components that are valid for micro-scale analysis will be mentioned. First category is the resource availability in cities, consisting of solar, wind, water, site specific potentials. The resources, their spatial references and detailed descriptions are displayed in Table 4.

Table 4: Category 1 Resource Availability

	Sub-Categories	Spatial Reference	DESCRIPTION
1	RESOURCE AVAILABILITY		
A	Solar efficient zones	Latitude dependent potential for solar gains in buildings	Maps indicating the suitability of areas for the implementation of small-scale measures for the use of solar energy, depending on density of dwellings and building form (In relation to an optimal definition of housing density and shape of buildings for the use of solar energy).
		Irradiance Level in Cities for solar energy generation	Irradiance Level at the exact zone selected - findings from City Solar Atlas
B	Wind efficient zones	Areas with favourable wind currents	Map showing the areas of unobstructed range of the various local dominant winds that are favourable for natural ventilation and other passive energy-saving measures.
		Wind Power Density and Wind Speed for wind energy generation	Wind Power Density at the exact zone selected - findings from Global Wind Atlas
C	Water	Availability of running water	Availability of running water by zones. (Water availability may be essential in warmer climates. Water shortage in certain areas can become a limiting factor for certain energy measures, for example, there may be restrictions on the use of running water for cooling purposes.)
		Micro scale water-saving systems	Areas with enhanced water cycle measures. Existing large-scale, energy-saving water recovery (grey water) or collection systems.

D	Site-specific	Topographical characteristics	Topographical conditions (inclination, orientation, etc.) that may affect microclimate (For example, a southern slope can determine sun-dependent environmental conditions).
		Soil surface characteristics	Ratio of paved soil, which can have an impact on microclimate conditions (heat island effect) affecting energy demand.

Second category is related with related with the land-use cover at building scale. Sub-categories are categorized in building ownership, building functions and open areas that are displayed in Table 5.

Table 5: Category 2 Land Usage Context

	Sub-Categories	Spatial Reference	DESCRIPTION
2	LAND USAGE CONTEXT		
A	Building Ownership	Public / Private / Semi-Public	PED Implementations heavily depend on building owners and citizens
B	Building Functions	Residential / Commercial / Mixed Use / Industrial / Educaitonal / Social / Sport / Public Administration	Spatial information of building use in selected zones from macro-scale analysis
C	Open Areas	Vegetation / Carpark / Public Spaces	Ratio of plant area or potential for planting (depending on latitude, altitude and soil type), with the capacity to impact on the microclimate that affects energy demand.

Third category is socio-economic and legal data in spatial information. Sub-categories are categorized as building based population density, economic data, legal data and social data that are displayed in Table 6.

Table 6: Category 3 Land-Usage Context

	Sub-Categories	Spatial Reference	DESCRIPTION
3	SOCIO-ECONOMIC and LEGAL DATA		
A	Current and Projected Population	Population Density identified in Buildings	Popoulation density calculated in a range to be conducted at building scale.
		Population Projections for new deveopment zones	Identified population projections for new developments zones (if exist)
B	Economic Data	Economic condition of inhabitants	Economic Situation calculated in a range to be conducted at building scale referring GDP of inhabitants

C	Legal Data	Potential districts for favoring political context	Spatial information of incentives / funds provided by national laws / strategic Plans in retrofitting, new development, infill areas for energy generation
D	Social Data	Micro-users / Communities for energy generation - Energy Citizenship	Spatial information of energy Communities / cooperatives / housing associations

Fourth category is analysis that were conducted in WP1 as energy demand analysis in cities that is introduced in Table 7.

Table 7: Category 4 Energy Demand Analyses

	Sub-Categories	Spatial Reference	DESCRIPTION
5	ENERGY SERVICE AVAILABILITY		
A	City Building Based Energy Demand Maps coming from WP1 analysis	Heating Demand	Existing Building Stock and Heating Demand Analysis
		Cooling Demand	Existing Building Stock and Cooling Demand Analysis

Once the data and analysis will be collected from cities, a comparison matrix will be generated to understand the potential demand and the potential generation inside the chosen PED areas.

2.3 Prioritization Study

It was before planned to follow the same approach that was conducted for macro-scale analysis in D4.3. GIS-based tools would be utilized for weighted overlay analysis. But, after the matrixes were prepared with the collected data and the data derived from WP1 – building-scale energy demand analyses (may be reviewed in D1.27-D1.32 for the FWCs), discussions with the municipalities were held verbally and the scientific perspective of DEM and TEC guided the prioritization study for defining the exact boundaries for PEDs. The results may be reviewed in Annex I. For each city, around 5-6 areas are selected to be detailed in terms of surface, buildings, population, resources (hydro, hydrothermal, solar, wind etc.) for energy generation and energy demand analyses from EnerKad models derived from WP1. A comparison and prioritization study were conducted between the selected 5-6 areas for each city also considering the preselected areas chosen at proposal stage (these areas may be reviewed in D4.3). Finally, one district is identified for each city to further detail and design for PED. The key performance indicators that are considered in the prioritization study may be reviewed in Table 8.

Table 8: Indicators to detail PED areas in cities to identify a potential PED area

Info	Item	Info	Item
Surface (UM)	Total (m2)	**Population**	Population density (hab/km2)
	Retrofitting areas (m2)	**Hydrothermal**	Ground water potential
	New development areas (m2)		Surface available for hydrothermal installation (m2)
	Reuse Areas (m2)	**Solar**	Building surface availability ratio
	Public (m2)		Building surface availability ratio (Also considering the non-evaluated – without building-use or year)
	Other (m2)		Nº of solar PV installations
Buildings	Total Nº of buildings (total)		Power of Solar PV installation (kW)
	Total M2 of buildings (floor area) (considering the buildings that haven´t been analyzed with Enerkad too)		Potential solar installation (kWh/m2)
	Total M2 of buildings (total built) (considering the buildings that haven´t been analyzed with Enerkad too)	**Enerkad Analysis from WP1**	Theoretical Heating demand (kWh)
	Total Nº of buildings (analyzed with Enerkad)		Theoretical Heating demand - Single Family Housing + Residential(kWh/m2)
	Total M2 of buildings (floor area)		Theoretical Heating demand - Sport (kWh/m2)
	Total M2 of buildings (total built)		Theoretical Heating demand - Healthcare (kWh/m2)
	Nº of municipal/public buildings (all, also municipal-residential buildings)		Theoretical Heating demand - Commerce (kWh/m2)
	m2 constructed area - public buildings (all also municipal-residential buildings)		Theoretical Heating demand - Education (kWh/m2)
	Nº of municipal/public buildings (excluding municipal-residential buildings)		Theoretical Heating demand - Office (kWh/m2)
	m2 constructed area - public buildings (excluding municipal-residential buildings)		Theoretical Cooling demand (kWh)
	Nº of residential buildings		Theoretical Cooling demand - Single Family Housing + Residential(kWh/m2)
	m2 constructed area - residential buildings		Theoretical Cooling demand - Sport (kWh/m2)
	Nº of commercial buildings		Theoretical cooling demand - Healthcare (kWh/m2)
	m2 constructed area - commercial buildings		Theoretical Cooling demand - Commerce (kWh/m2)
	nº education-sport-health		Theoretical Cooling demand - Education (kWh/m2)
	m2 education sport-health		Theoretical cooling demand - Office (kWh/m2)
	Other nº		
	Other m2		

3 PED Design Procedures in FWCs

Until this deliverable, as mentioned before, methodologies for PED design were developed aligned with MAKING-CITY replication / upscaling activities. Already developed methodologies are as follows:

- Methodology for calculating the annual energy balance (Phase V in Methodology for PED Design – D4.1)
- Methodology for Identifying PED areas in cities (Phase II in Methodology for PED Design – D4.1)

Below you may review the missing methods (generated within 3rd year of MAKING-CITY) for the finalization of PED designs in FWCs.

- Methodology for Identifying Citizen Engagement Strategies in Cities
- Methodology for Identification of PED Solutions + Technology Selection Tool

3.1 Methodology for Identifying Citizen Engagement Strategies in FWCs

For developing citizen engagement strategies in cities, a methodology is developed. The strategies that are being tested in LHCs and literature review on strategies at district scale support this method, as well. Below is presented the initial steps of the procedure to define citizen engagement strategies in FWCs.

1. Identify the ACTORS: civil society, professionals from Energy, Mobility, ICT sectors, urban related fields, public administration, research and knowledge creation (From WP6)
2. The main objectives, PURPOSE to be achieved with the strategy:

What do we want to reach? Examples: Co-creation, Open innovation, resource efficiency, inclusiveness, legitimacy, ETC.

Note: Think on the culture of the city: the customs and beliefs, way of life and social organisation of a particular group of people. Cultures can be country, region, city or even district-specific.

Where? In what sectors: in Energy, Mobility, ICT, Environment, Policy and Planning, Social.

When? When would they come into action during the process, in what phase? In planning & design (when all options are still opened) or implementation (when most of the decisions have been already taken). What the timing is?

Note: This influences the potential impact stakeholders can still have and the type of activities the city can organize. Ideally, citizen engagement is initiated even before the start of any other activity. This allows citizens to be involved in the problem definition, and even the governance of the engagement activities themselves.

3. To detect the main BARRIERS or bottlenecks to achieve the objectives identified and the ENABLERS. Identify also the lessons learnt from other past experiences if any.

Note: Consider problems' size: simple or complex, well known or new, impact a limited number of people or have far-reaching consequences for a large community.

4. To define **SOLUTIONS** to overcome the identified barriers or bottlenecks.
5. In what FORMAT? Offline/Online?

Note: Online activities and tools can be very useful (can be organised quickly, high degree of responsiveness, broad reach, etc.). Offline and face-to-face engaging actions are also important to establish personal connections. Online platforms to be complemented by more small scale, neighbourhood level face-to-face meetings. Besides, even today not everyone is active online.

6. What tools/resources would be needed or desirable to implement it. Are them available? What would be the budget required?

Experts from Lighthouse Cities (HANZE, TNO, DEM) will come together with T5.7-WP5 experts (CAP & VTT) and prepares ***Questionnaires*** that will help cities to understand the PED concept and raise awareness on PED implementations that have 3 dimensions: **Reducing Energy demand, integrating RES generation and supporting energy flexibility** that help the user to understand when the best time is to use energy.

3.2 Methodology for Identification of PED Solutions

Considering different questions on resources, land use, urban macroform, energy infrastructure, energy services and social structure**, a decision tree in Miro was developed by CAR and DEM, to guide cities in the PED solutions identification.**

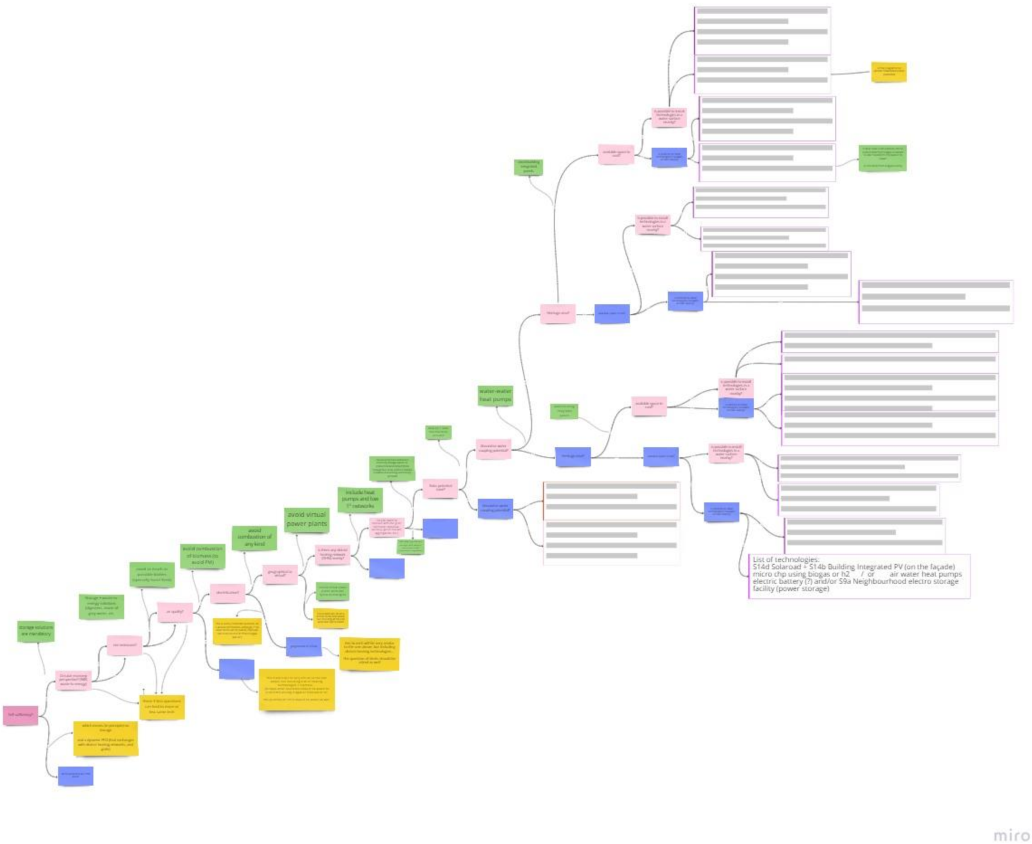


Figure 2: Miro brainstorming of the tool

As the tool could be potentially linked with the SPEC cards already developed in T4.1 Methodology for PED Design, an excel based macro tool including the questions, an algorithm for recommending technologies accompanied with a glossary of definitions (to let the user to understand the terminology and also speak the same language in terms of understanding the energy concept) and schematics were developed.

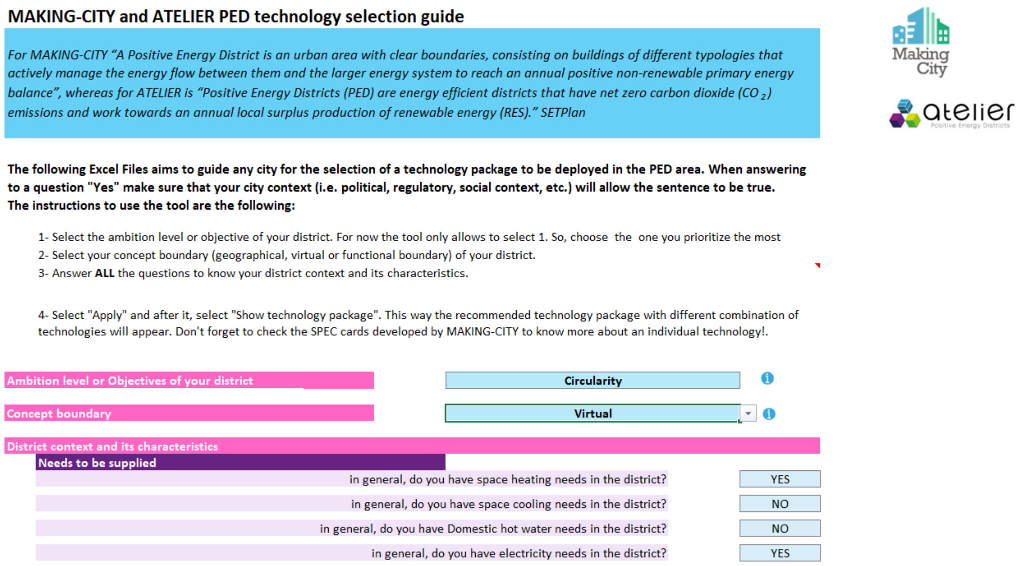


Figure 3: Overview of the macro tool.

This tool is a procedure to guide cities in the decision-making route for selecting different technical and non-technical solutions that could help them to achieve a Positive Energy Balance and at the same time, fulfil their city objectives. The decision tree will be programmed in a web-based tool (which is under development now) accessible to all cities, where different YES/NO questions are asked and as a result, several technology packages (**technology groups define PEDs** instead of stand-alone technologies that would be suggested by the tool) are recommended. For now, a memo macro tool in excel is provided to the cities. Figure 4 shows how it looks like in the macro tool:

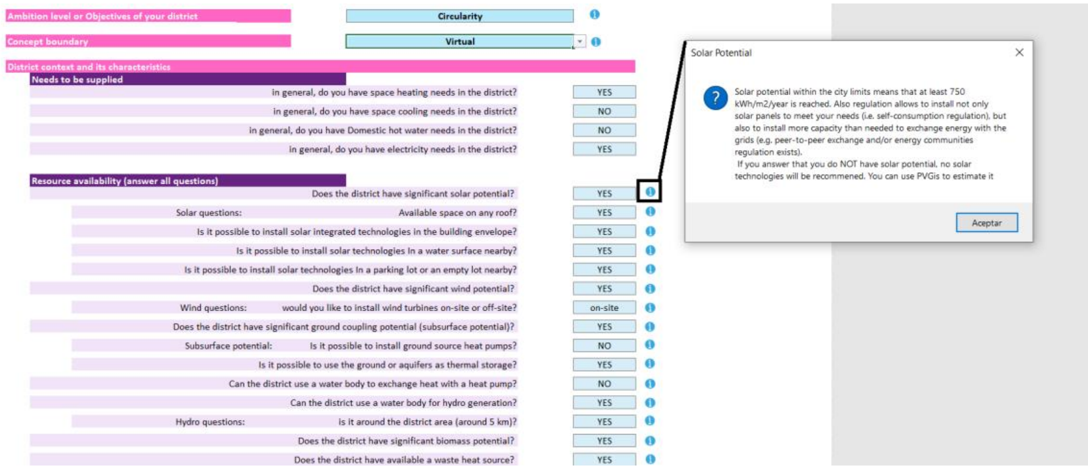


Figure 4: Macro tool interface

The questions are divided in three blocks:

- Main objective to be reached by the PED implementation (Target of the district): Such as Self-sufficiency, Net-zero emissions / Climate Neutrality, Circularity, Electrification, Air quality
- Concept boundary of the district: whether it will be geographical, virtual, or functional boundaries
- And then, questions to know about the district context are asked in terms of resources available, urban macroform (new or retrofitted area), land usage (residential, commercial…), energy infrastructure around the district, energy services to be provided by the district, social

structure (PED analytical Components that were also identified in D4.3 for Methodology to identify PED Areas in Cities)

The answer to each question will add/discard some technologies. For example, if your ambition level is to achieve self-sufficiency technologies such as thermal and electric storage are recommended. When geographical limits are chosen, big power plants such as wind turbines or hydropower plants are not recommended unless the user thinks they can be located on-site the boundaries. If there is space available in any roof, solar photovoltaics on roofs is recommended. If it is possible to install solar panels in the building envelope, solar BIPV is recommended. The combination of the technologies will result in a recommend technology package such as this one:

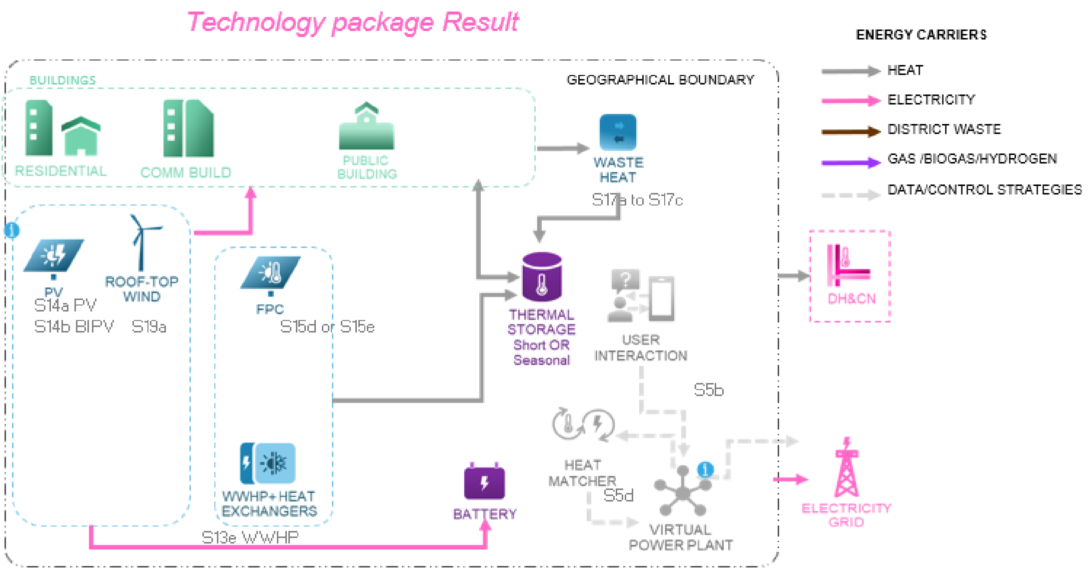


Figure 5: Technology package results

Where there is interaction with the electricity grid, PV panels supplying the demand of the buildings and the demand of a water-water heat pump or if not needed neither by the grid or the demand, it will be stored to be later used by e-cars. The heat pump can store energy in a geothermal seasonal storage or supply the heating demand through the short thermal storage. A heat recovery unit is installed to recover part of the heat from grey water, that can be stored, and later use by the buildings or, if desired, supply heat to the DH&CN.

The recommendations are meant to inform the city about the possibilities of technologies, connections between technologies, buildings, storage, and mobility solutions, and possibly, about non-technical solutions, such as business models could be recommended. This way, the city will be capacitated to prioritize some of the recommended technology packages at step III. At step IV, the city will analyse possible barriers/enablers of the chosen PED solutions (if there are any). At step V, several scenarios (with possibly different capacities of the supply side) will be generated to assess which one is more suitable for the district to become a PED. Results of the scenarios could be related with the objective to be achieved, as well as the positive energy balance achieved, and other KPIs such as co2eq emission saved, etc.

Figure 6: Steps of PED technology solution tool

When the technology package is recommended, the user/city can access to more information individually per technology: through the SPEC cards that have been developed in MAKING-CITY by the light house cities. The SPEC cards include information about the solution, where is applied, the implementation time/investment, explanation of the solution, stakeholder analysis, pestle analysis, and benefits of the implementation of the solution.

The memo macro has been shared among the cities, so they can play with it and give us already feedback for the future tool. As mentioned before, this is an Easy-going questionnaire with (yes/no questions) and with definition of each question in each step. A glossary is included in the Annex II: Glossary for the Technology Selection Tool of this document, showing the explanations and definitions of each question, and the recommendations given by the tool. At the end of the tool, an "apply" button will show the recommended technology packages.

At the web-based tool (that will be developed within ATELIER project, soon), it would be possible for other projects and initiatives to provide their technologies if they prefer.

Within MAKING-CITY the process to be followed with the cities will be:

1. Define the ambition level of the PED (the main objective to be followed)
2. Answer all the questions of the macro tool (by cities and supported by DEM and TEC)
3. See the result from the tool, and decide some technologies from the recommended ones
4. Analyse, if needed and not done before (a barrier analysis was done in D4.1 Methodology for PED Design) any potential barrier or enabler of the selected solutions. If there are barriers come back to step 2 and repeat the process. If there is a barrier but it can be overcome, then continue
5. Make some scenarios of the solutions with different capacities
6. Analyse PED balance results and potential CAPEX and OPEX (These analyses will be found in D4.5 Financial Plans of PEDS in FWCs – M42)

3.3 Barriers / Enabler Analysis for each Solution

Within the first year of MAKING-CITY project, a matrix including all PED solutions has been shared with all FWCs to be evaluated for barriers and enablers analyses. All FWCs contributed to this matrix, and the results are presented in D4.1 Methodology and Guidelines for PED design.

3.4 Methodology for calculating the annual energy balance

After defining a possible PED in each city, it will be necessary to reach the final design to quantify how positive is the district in terms of primary energy. Therefore, 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” and the main steps have been summarized in the simplified version of these guidelines. Eight are the steps identified in this methodology (Figure 7) where the annual energy balance is carried out in terms of non-renewable primary energy.

Figure 7: The eight-step methodology to calculate the primary energy balance

The methodology explained in D4.2, goes step by step from explaining the district boundaries to the primary energy balance calculation answering the questions launched in the Figure 8.

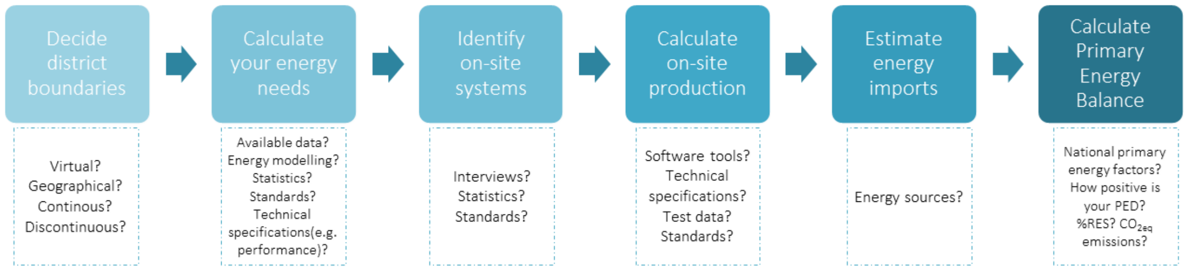


Figure 8: Questions to answer in each step of the methodology

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.

At the end, the overall Sankey diagram (Figure 10) can be performed to describe the energy flows firstly identified in the definition of the PED (Figure 9). 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).

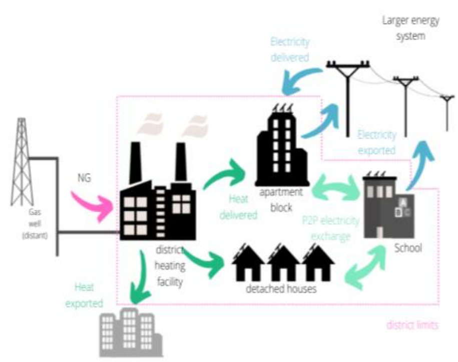


Figure 9: PED energy scheme

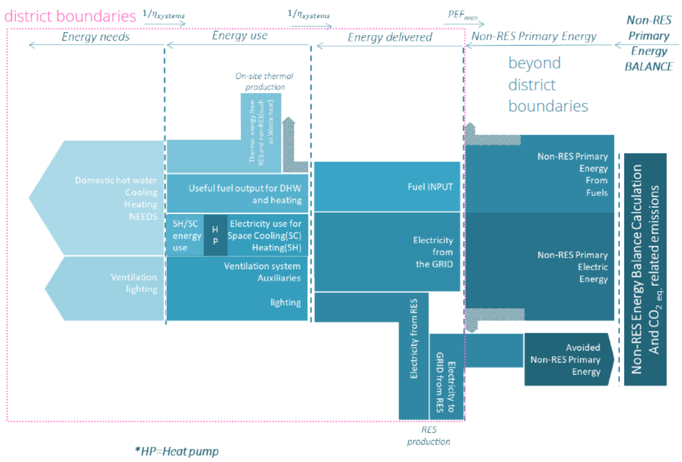


Figure 10: Sankey Diagram of the energy flows in a PED

4 Webinars / Workshops for co-designing PEDs in FWCs

Three webinars were held between M24-M36 for replication activities that were announced in replication action plan developed by DEM. The main purpose of these webinars is for sharing knowledge and experience from LHCs of MAKING-CITY and other SCC projects to MAKING-CITY FWCs to guide them in their journey to design PEDs. First webinar is about involving citizens in design and planning phase of PEDs, second is about the PED Technologies selection and third is on the PED Calculation Methodologies. All three webinars are associated with phases of the Methodology for PED design that was developed in M12 and reported in D4.1.

4.1 Webinar 1º on Citizen Engagement Strategies

Webinar 1º was conducted in 19th of January 2021 with the following agenda:

Time	Agenda
9:30 – 9:35	Introduction
9:35– 10:00	Connection between City Vision and Citizen & Stakeholder Engagement – WP1 PED Co-Designs in FWCs – WP4 Social Innovation Methodologies – WP7
10:00 – 10:30	Interaction with the other Smart City and PED Projects (10min each) • MySmartLife • Atelier • +CityxChange
10:30 – 10:35	Coffee Break
10:35 – 11:35	Citizen Engagement Strategies and Experience of LHCs (30min each) • Presentation by Oulu • Presentation by Groningen
11:35 – 11:45	Social KPIs Evaluation Framework – WP5
11:45 – 11:50	Conclusions of the 1st session
11:50 – 11:55	Coffee Break
11:55 – 12:25	Citizen Engagement Strategies and What is needed in FWCs? Presentations of FWCs (5min each)
12:25 – 12:55	Workshop of FWCs and LHCs for Knowledge Sharing and Replication Which approaches / Activities / Tools may be replicated in FWCs?
12:55 – 13:00	Conclusions

The objective of the webinar was to create an atmosphere for sharing / transferring knowledge and experience from LHCs to FWCs and how to develop city visions (in accordance with WP1 – T1.5.2). The scope is consisting of the generation of City Visions in FWCs and LHCs and the aspects to consider involving citizens and stakeholders in the process and involving citizens in the co-design process of PEDs in FWCs.

Some screenshots are presented below from the webinar presentations. The slides are related with presenting the methodology developed by TEC and DEM for generating citizen engagement strategies in FWCs.

Figure 11: Key questions of the Webinar 1 on Citizen Engagement Strategies

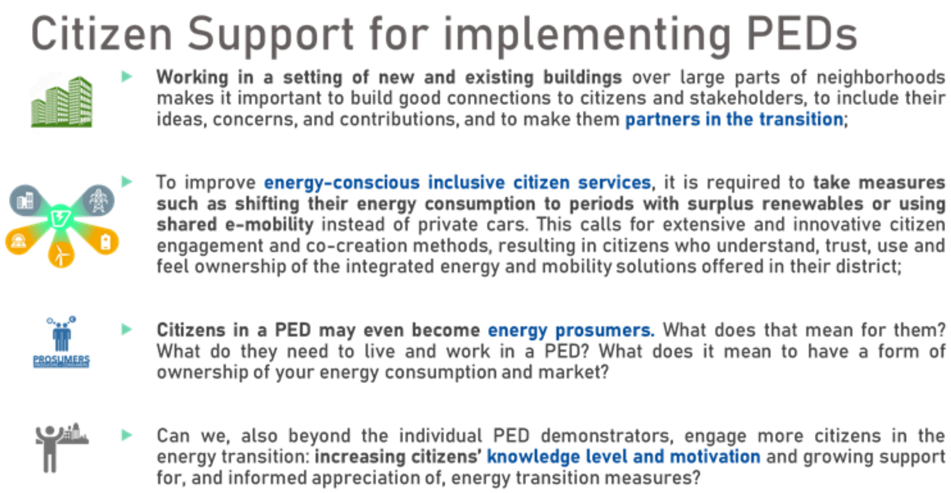


Figure 12: Citizen support reason for implementing PEDs - the Webinar 1 on Citizen Engagement Strategies

At the end of the webinar, a workshop was held for the FWCs after listening to LHCs and their strategies. The purpose of the workshop is to measure the potential of replicaitng the solutions from LHCs to FWCs. FWCs tried to identfy which engagement solutions / tools would match to their city context. The results are presented in MURAL screen.

Figure 13: Mural screen results of the Webinar 1 on Citizen Engagement Strategies

4.2 Webinar 2° on Selection of PED Technologies

Webinar 2° was conducted in 26th of April 2021 with the following agenda:

Time	Agenda
9:30 – 9:40	Introduction
9:40– 10:00	MAKING-CITY Methodology for PED Technologies Selection How to fulfil City objectives through PED implementation and energy solutions?
10:00 – 10:30 10min each	Interaction with the other Smart City and PED Projects • ATELIER • POCITYF • SPARCS
10:30 – 10:35	Coffee Break
10:35 – 11:35 30min each	PED Technologies Selection and Implementation _ Experience of LHCs of MAKING-CITY Presentation by Oulu Presentation by Groningen
11:35 – 11:50	Conclusions of the 1st session
11:50 – 11:55	Coffee Break
11:55 – 12:25	GIVING THE FLOOR TO PED FELLOW CITIES Workshop on Knowledge & Experience Sharing
12:25 – 12:30	Conclusions

The tool was presented in a webinar explaining the scope of the tool, the idea behind it (how the design process was made) and what will be the potential results (technology package, link with SPEC cards) of the tool and assistance to cities.

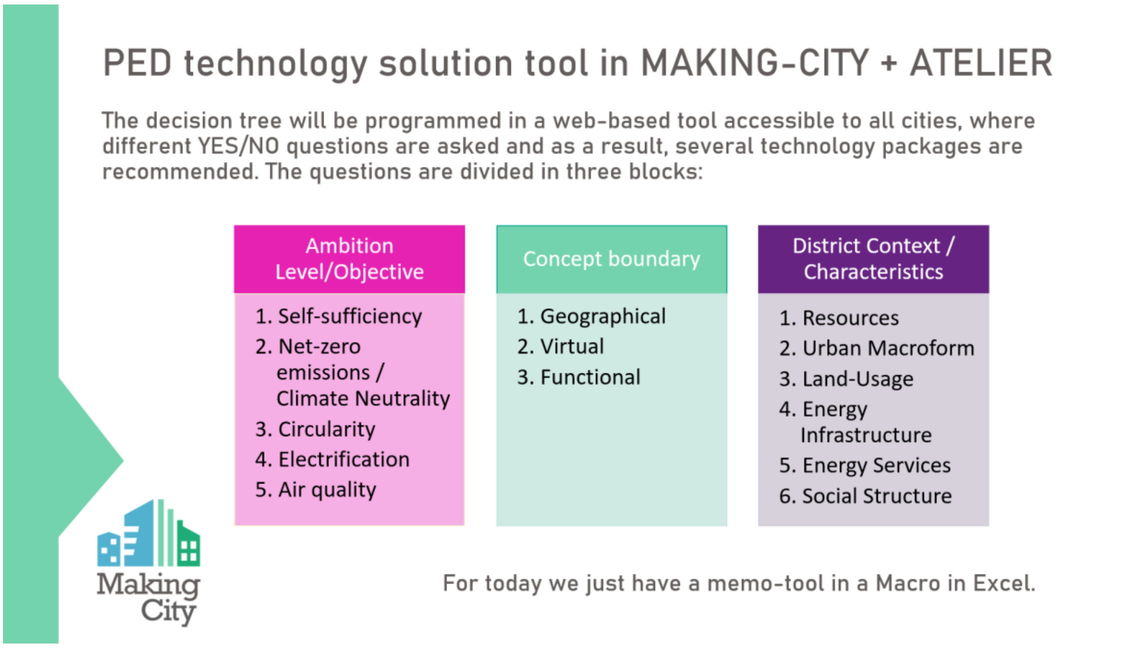


Figure 14: Example of slides used within webinar 2º

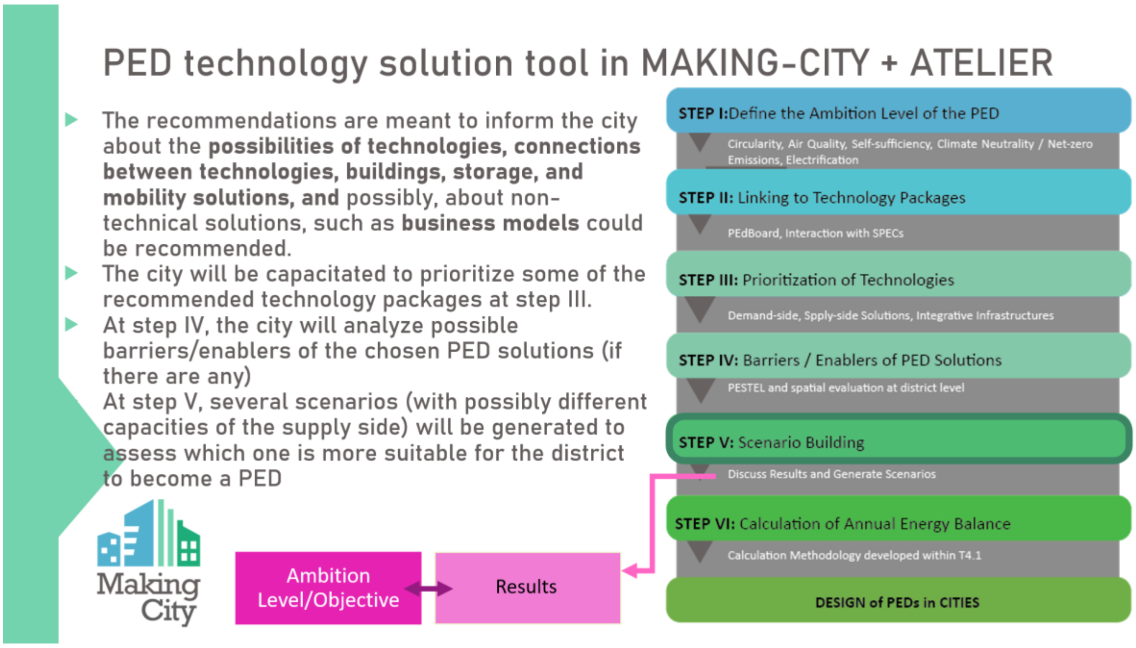


Figure 15: Example of slides used within webinar 2º

Furthermore, a MURAL workshop was conducted to get feedback. The gaps identified were: questions may be linked with the local innovation ecosystems; affordability and cost of the technologies must be addressed in order to identify the target of the district; questions regarding nature-based solutions, waste/materials/water reuse should be integrated; the tool should support the pre-feasibility stage.

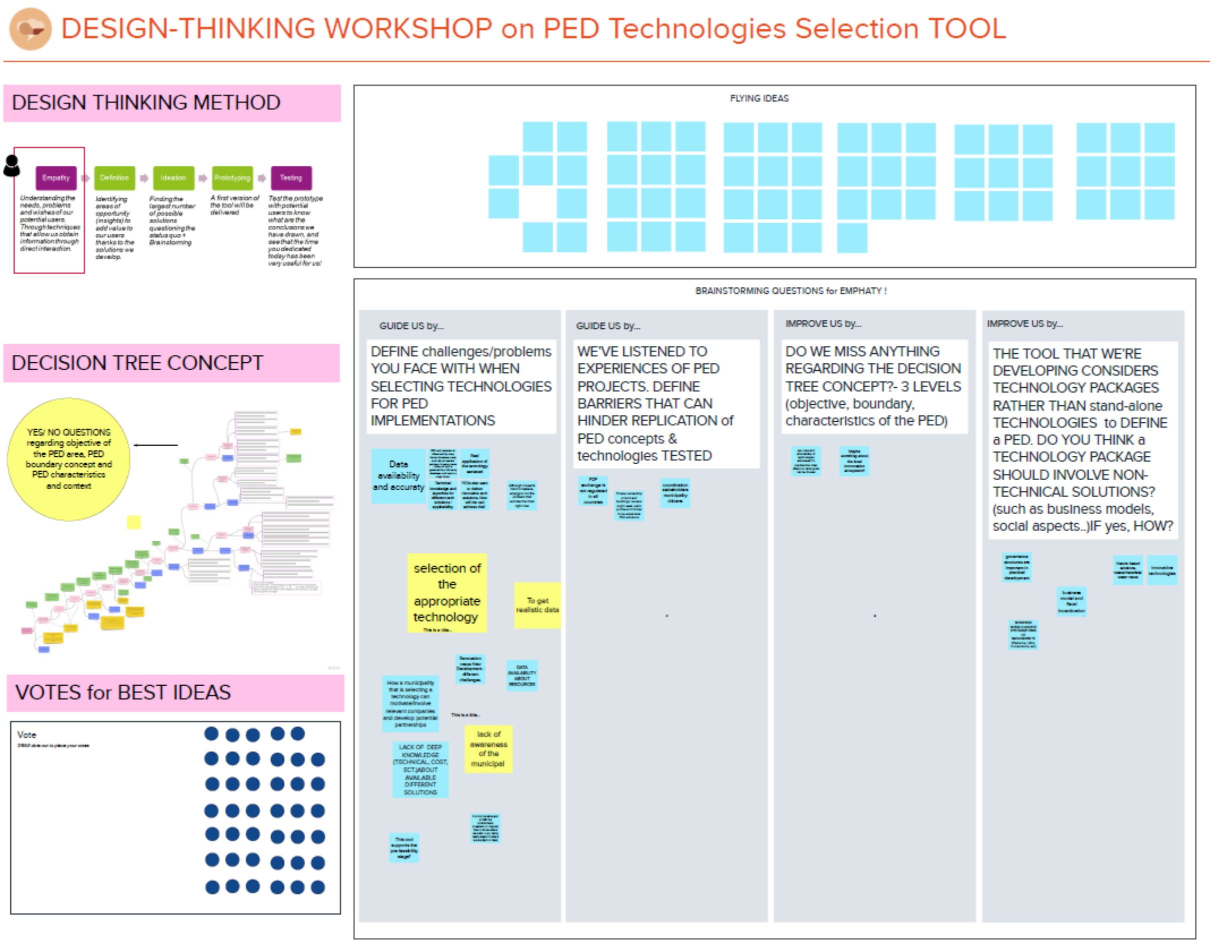


Figure 16: Mural screen "Design-Thinking workshop on PED technologies selection Tool"

4.3 Webinar 3º on PED Calculation Methodology

Webinar 3º was conducted in 30th of September 2021 with the following agenda:

Time	Agenda
5 min	Introduction
25 min	MAKING-CITY Methodology for PED Annual Energy Balance Calculation
15 min	Interaction with other Smart City and PED Projects: PED concept is still under discussions, differences between projects • ATELIER
15 min each	Giving Floor to MAKING-CITY Lighthouses for their assumptions / efforts for PED Calculations Presentation by Oulu Presentation by Groningen
10 min	Conclusions

Energy balance and calculation procedure for PEDs: the general methodology comprised in (Gabaldon et. al, 2020) was explained, explaining all assumptions made in MAKING-CITY in each step.

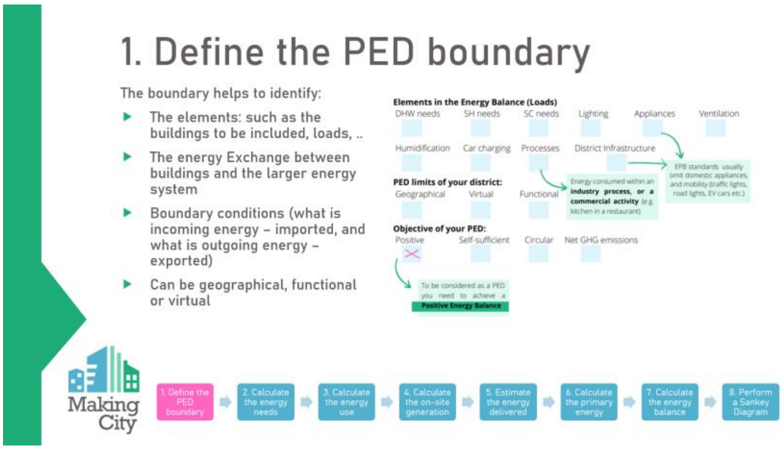


Figure 17: Example of slides used within webinar 3º

Integrated tool for PED framework calculation used in T4.1 was explained, as well as future of PED Calculation Methodologies and what to consider in future works.

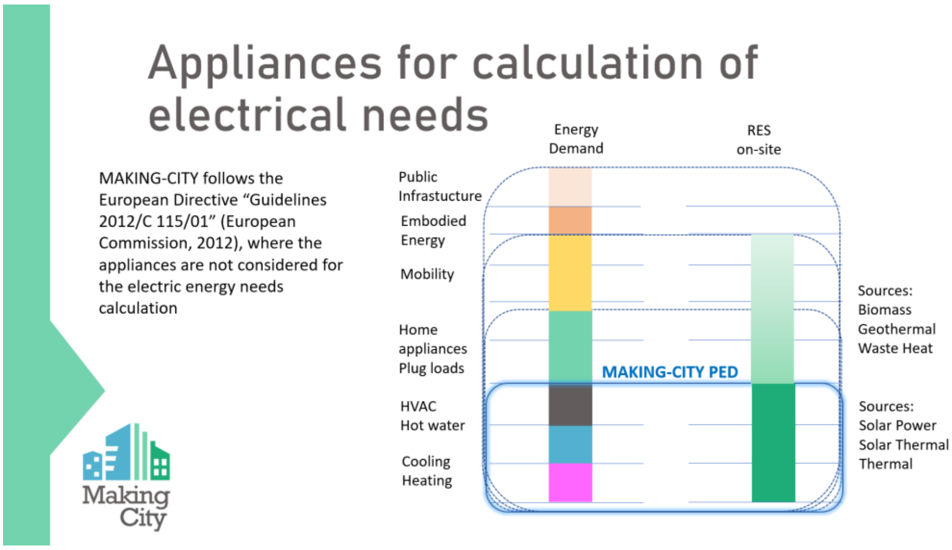


Figure 18: Example of slides used within webinar 3º

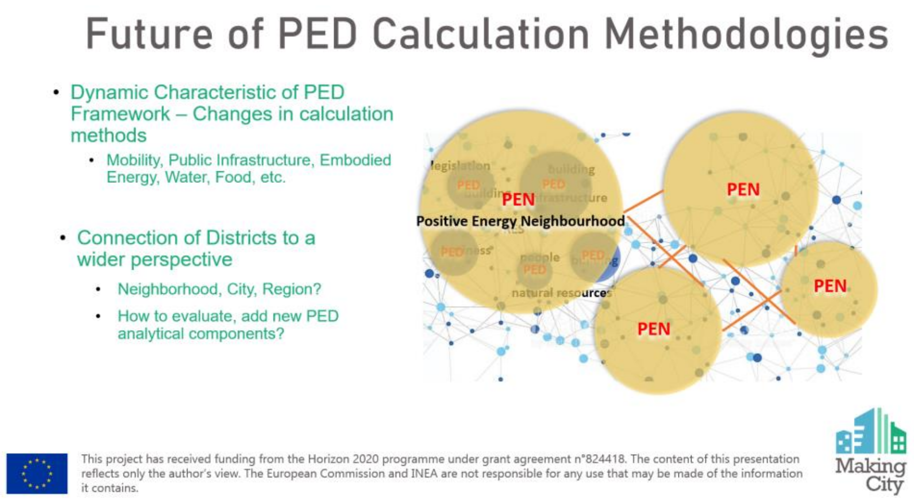


Figure 19: Example of slides used within webinar 3º

5 Unified Approach on Citizen Engagement Strategies in FWCs

The lighthouse cities have developed a series of questionnaires and tools with the aim of facilitating the co-creation of PED-designs in six follower cities (FWC) (León – Spain, Kadikoy – Turkey, Bassano del Grappa – Italy, Lublin – Poland, Trenčín – Slovakia, Vidin – Bulgaria). These modular questionnaires include a variety of topics relating to energy, such as consumption, generation, efficiency, and flexibility as well as questions pertaining mobility, and social cohesion (development of local communities). The modules are as follows:

- Module 1 – Energy consumption
- Module 2 - Energy efficiency
- Module 3 - Energy generation
- Module 4 - Energy flexibility
- Module 5 - Mobility
- Module 6 – (Local) Energy communities

The data from the questionnaires will be utilized to construct potential indicators that will help the FWCs to realize their own PEDs and encourage them to further develop City Visions 2050. The objectives of the cities vary from each other depending on local community development readiness in their context. Four of six FWCs want to know citizens' needs/vision on city district directly or indirectly related to energy. The desired insights range from creating awareness about energy transition/needed measures, to gathering opinions about measures/concepts, to insights in the needs/visions on how to improve the living standard of citizens. Most of the FWCs have an overall plan (eg. SEAP, SECAP) and two of them has taken action to consult citizens on their preferences in specific solutions. They have already utilized a few tools such as hackathons, workshops, webinars, ateliers, online surveys, online platforms, meetings, door-to-door surveys, thematic games, debates, public consultations. On the other hand, they would like to develop festivals, conferences and workshops organized in the city, webinar platforms, mobile applications, educational materials and e-participation and consultations. Most of the cities face barriers for realizing citizen engagement activities. These barriers may be counted as COVID-19 measures prohibit certain activities, measures, events, low awareness and interest in citizens in the topic, limited time, high costs, limited authorization to take action and difficulty to reach target groups (e.g. elderly). These barriers could be overcome by financial and technical support and subsidies from public bodies and energy markets, by raising awareness and performing measures by involving the local community and selecting the right platforms at the right time, by training programs for several stakeholders (on sharing information and to promote better collaborations) and by sharing information on renewable energy through open data platforms. The initial recommendations for the citizens of FWCs may be listed as follows:

- Unified citizen engagement strategy incorporates different stakeholders and provides insights in what to share and communicate and how to collaborate in each phase of the transition of a neighbourhood
- This strategy also provides a good framework to recommend usage of specific measures, methods, and tools in the different phases of the energy transition
- There are two main activities at the start of the energy transition: a social(-economic) analysis with citizens and a technical analysis of the target neighbourhood. Citizen engagement starts in this first phase.

A detailed analysis will be conducted soon to encourage FWCs on developing energy communities for sustaining the energy transition and PED implementations in the already designed areas under MAKING-CITY project.

The modules that are chosen by the FWCs are as follows:

Table 9: Chosen modules in each FWCs

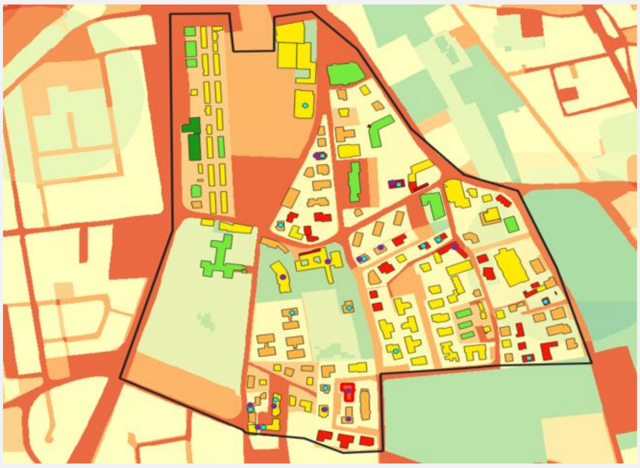
FWCs	General Section	Module 1	Module 2	Module 3	Module 4	Module 5	Module 6
VIDIN	×	×	×	×		×	
BASSANO DEL GRAPPA	×	×	×			×	
LEÓN	×		×	×			×
TRENČÍN	×	×	×	×	×	×	×
LUBLIN	×	×	×	×		×	
KADIKOY	×		×				×

6 PED Design in Bassano Del Grappa

Once the PED boundary is identified in Bassano del Grappa (Annex I: Microscale analysis results), the step is the development of the stakeholder and citizen engagement strategy for co-designing PEDs, identify and select technology packages and verify the annual primary energy balance to figure out if the district is positive or not.

The theoretical heating/cooling demand and the renewable installations are derived from the energy demand maps that were developed within WP1 and first estimations are discussed with the municipality representatives in previous steps of WP4 for figuring out the PED potential not only from technical but also economic, legal, social and political point aspects. The main characteristics of selected area are displayed in Table 10.

Table 10: Main characteristics of area selected to become PED – Bassano del Grappa

Area to become PED	Main characteristics of selected area	
	Surface: 300.849 m^2	
	*Built roof area: 55.274m^2	*Public roof area: 10.567m^2
	Total nº of buildings: 180	
	*Residential: 163 *Commercial: 3 *Other: 3	*Public buildings: 11
	Heat demand: 8.309kWh Cooling demand: 1.017.618kWh	
	Renewable installations: 160kW of Solar PV	

6.1 Stakeholder and Citizen Engagement Strategy

Bassano Municipality is developing a tailored strategy to target three main typology of stakeholders and position them in the centre of the energy transition process. After the identification of the main relevant drivers a specific action and plan has been identified in D1.27 Long-term city plan of León (city vision 2050) – Intermediate version – Section 3.3 Engagement strategies to place citizens at the centre of the energy transition

As mentioned before in Section 5, the results of the questionnaires will be evaluated with T5.7 experts (CAP, VTT, TNO, HANZE and DEM) and will be shared in deliverable of this task later.

6.2 Selected PED Solutions

According to the MCDA analysis done in previous steps of the WP4 (See D4.3[1]), the Technology selection tool was conducted by TEC and City of Bassano del Grappa validated the content. The answers to the questions are listed (Figure 20) and the macro tool was activated and technology package with recommendations are displayed (Figure 21).

Ambition level or Objectives of your district	Self-sufficiency
Concept boundary	Virtual
District context and its characteristics	
Needs to be supplied	
in general, do you have space heating needs in the district?	YES
in general, do you have space cooling needs in the district?	YES
in general, do you have Domestic hot water needs in the district?	YES
in general, do you have electricity needs in the district?	YES
Resource availability (answer all questions)	
Does the district have significant solar potential?	YES
Solar questions: Available space on any roof?	YES
Is it possible to install solar integrated technologies in the building envelope?	NO
Is it possible to install solar technologies In a water surface nearby?	NO
Is it possible to install solar technologies In a parking lot or an empty lot nearby?	NO
Does the district have significant wind potential?	NO
Wind questions: would you like to install wind turbines on-site or off-site?	on-site
Does the district have significant ground coupling potential (subsurface potential)?	NO
Subsurface potential: Is it possible to install ground source heat pumps?	NO
Is it possible to use the ground or aquifers as thermal storage?	NO
Can the district use a water body to exchange heat with a heat pump?	NO
Can the district use a water body for hydro generation?	YES
Hydro questions: is it around the district area (around 5 km)?	YES
Does the district have significant biomass potential?	NO
Does the district have available a waste heat source?	NO
Urban macroform (answer YES if applicable)	
Is the district a new development area?	NO
Is the district going to be retrofitted?	YES
Is the district an infill area?	NO
Is the district a transformation area?	NO
is the district a heritage area?	NO
Select the type of buildings (use) within your district (answer YES if applicable)	
Residential use?	YES
Commercial?	NO
Active Green / Open Parking Lot?	NO
Public Administration?	YES
Social / Cultural/Educational/Sport ?	YES
Industrial?	NO
Energy infrastructures (answer all questions)	
is there any district heating network (DHN) nearby?	NO
Is the district off-grid?	NO
does the district have a private electricity grid?	NO
Is the district connected to the gas network?	NO
Do you want to include e-mobility aspects?	NO
Do you want to include hydrogen-mobility aspects?	NO
Do you want to apply soft-mobility aspects?	NO
Energy services and management (answer all questions)	
Do you want to interact with the gas grid? (injection of hydrogen or biogas)	NO
Do you want to offer ancillary services?	NO
do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	NO
Do you want to offer hydrogen to industry or for electricity generation?	NO
Do you want to interact with the users/consumers?	NO
Would you need a data platform?	NO
Do you want that the electricity and thermal production is matched (by optimization, etc.)?	NO
Social structure	
Do you want to form an energy community in the district?	YES
Is there any people suffering from energy poverty in the district?	NO

Figure 20: Answers of City of Bassano del Grappa for the macro tool

[1] D4.3 Analysis of FWC candidate áreas to become PEC

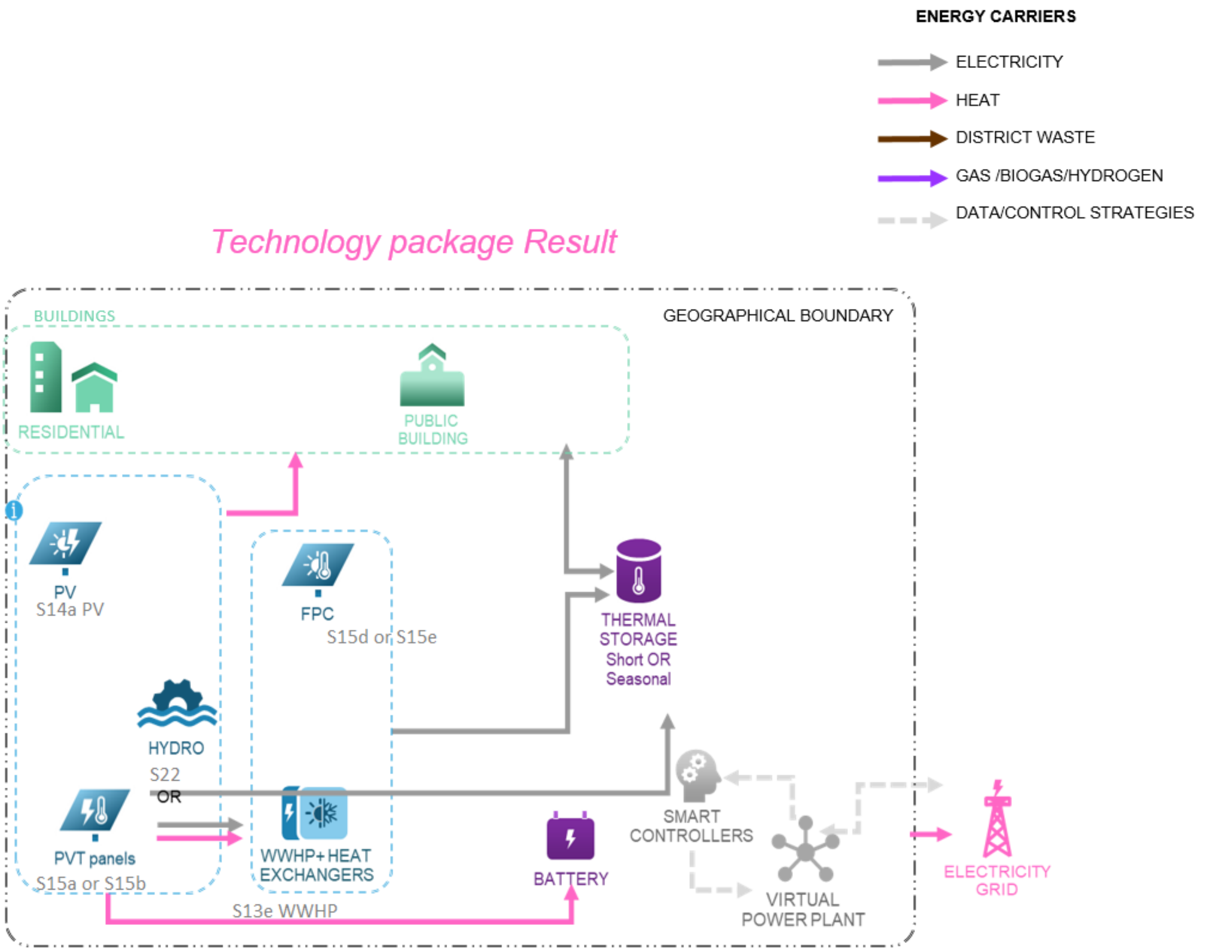


Figure 21: Technology Package Result for Bassano del Grappa PED Boundary

Results of Bassano del Grappa in a nutshell:

You have achieved a self-sufficient technology package. To achieve self-sufficiency, i.e. avoid always consuming/importing energy from the wider grids. Plus, retrofitting is a must and RES combined with storage are always recommended to balance the supply side. As biomass is usually imported from outside the PED boundaries, it is not recommended, but it could be used if the PED is close to the forest waste and does not need much transport. Biogas could be installed, but it is not the priority (as it does not aim circularity). Smart controllers (to predict energy production, store energy, perform demand shifting, etc.) are recommended as otherwise it would be hard to assess when to export energy and when to self-consume it. The interaction with the wider grids could be to export to the natural gas pipeline if hydrogen or/and biogas is/are produced, to the district heating network if heating is produced, and/or to the power grid.

Recommendations for other Technologies:

- To reduce space heating needs, it is recommended to insulate the building as much as possible and replace emitters by systems that require less temperature supply (Such as ground floor heating, fan coils, etc.)
- DHW requires (generally in most countries) 60ºC when is stored (to avoid legionella), but if the volume from the supply system to the demand is less than 3 m3, in Germany is allowed to reduce the temperature to 45ºC. Generally, in most countries if DHW is prepared instantaneously (with heat exchanger between storage and demand), then it can also be

reduced to 45ºC. Another way to reduce the demand, is to preheat the cold-water mains with waste heat (e.g., heat exchanger to extract heat from the grey water from the shower).

- Efficient lighting and appliances should be prioritized. Avoid stand-by modes when possible, using smart plugs to cut off power when not needed.
- You can check the SXX Creation of an energy community, to know a bit more about Renewable Energy Communities.

6.3 PED Calculation for Verification

Once PED technologies are identified in Vidin PED Boundary, a calculation process has been held to figure out if the identified technologies already provide a surplus of annual energy balance. If the technologies do not provide positivity, new solutions such as decreasing the energy demand, increasing energy efficiency and energy generation will be conducted within the PED boundary. 2 scenarios to convert the district in energy positive were conducted for Bassano del Grappa selected zone. The results of the solution selected by the municipality are presented in the following chapters.

6.3.1 PED boundaries definition

The boundaries for Bassano del Grappa PED Area are virtually bounded. There are 3 hydropower plants in Bassano del Grappa, none of them are within the PED boundaries, but one of them is less than 2 kilometres far and a 10% of its production has been assigned to the PED. Geothermal installations cannot be more than 1-2metters deep, because of that the use of air-to-air heat pumps is more extended in Italy.

Figure 22: Bassano del Grappa PED Boundary

The characteristics of the scenario for energy generation in Bassano del Grappa zone are: 10% of the generation of the closest hydropower plant is assigned to the zone; half of the electric demand is covered by solar PV and the thermal demand is covered by Air-to-air heat pumps.

6.3.2 Energy needs inside PED boundaries

All data related to thermal and electric energy needs are based on the data calculated in WP1 New long-term urban planning towards 2050.

ENERGY NEEDS

THERMAL ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
residential	DHW needs	141000	x	15	=	2.115 +
	SH needs	141000	x	25	=	3.525 +
	SC needs	141000	x	10	=	1.410 +
non-residential buildings	DHW needs	12000	x	5	=	0.060 +
	SH needs	12000	x	15	=	0.180 +
	SC needs	12000	x	20	=	0.240 +
				Total Thermal Energy Needs	=	7.53

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
residential	Lighting	141000	x	3	=	0.423 +
	Ventilation	141000	x	1	=	0.141 +
non-residential buildings	Lighting	12000	x	5	=	0.060 +
	Ventilation	12000	x	5	=	0.060 +
				Total Electric Energy Needs	=	0.684

Figure 23: Energy needs in MAKING-CITY tables for Bassano del Grappa in GWh/year

6.3.3 Energy Use

Thermal and electric energy uses are calculated considering the energy needs and the distribution losses since the systems are centralized for DHW, space heating and cooling.

The difference between energy needs and energy use are due to air to air heat pumps consumption (accounted in electricity use). Thermal energy uses only the energy provided by the air-to-air heat pumps that are very popular in Italy. A COP of 3,5 was considered for them.

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
residential	DHW use	2.115	/		=	
						+
	SH use	3.525	/		=	
						+
	SC use	1.41	/		=	
						+
non-residential buildings	DHW use	0.06	/		=	
						+
	SH use	0.18	/		=	
						+
	SC use	0.24	/		=	
						+
				Total Thermal Energy use	=	0.00

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
residential	SH electric use	3.525	/	3.5	=	1.01
						+
	SC electric use	1.41	/	3.5	=	0.40
						+
	DHW electric use	2.115	/	3.5	=	0.60
						+
	Ligthing needs (usually losses	0.423	/	1	=	0.42
						+
	Ventilation needs (usually loss	0.141	/	1	=	0.14
						+
non-residential buildings	SH electric use	0.18	/	3.5	=	0.05
						+
	SC electric use	0.24	/	3.5	=	0.07
						+
	DHW electric use	0.06	/	3.5	=	0.02
						+
	Ligthing needs (usually losses	0.06	/	1	=	0.06
						+
	Ventilation needs (usually loss	0.06	/	1	=	0.06
						=
				Total Electric Energy use	=	2.84

Figure 24: Energy uses in MAKING-CITY tables for Bassano del Grappa in GWh/year

6.3.4RES production inside the PED

Within the geographical PED boundary, the local generation of renewable heat and electricity in Bassano PED area is consisting of solar photovoltaic and air to air heat exchangers. Moreover, a 10% of the electricity generation of one of the 3 hydropower plants of Bassano is assigned to the PED area. Therefore, since the production is outside the PED boundaries, it is considered a virtual PED.

For electricity, Solar PV panels are installed on 10,000 m2 of the 55,000 m2 roof areas existing within the PED boundaries (some of these installations already exist). It was considered a production of 268 kWh per square meter installed[2]. Therefore, solar PV panels electricity output is 2,68GWh. The PV Solar potential[3] in Bassano del Grappa is 1375.5 kWh/kWp and the Solar irradiation is 1769.13

[2] Global Solar Atlas

[3] https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#PVP

kWh/m2. The ratio for area (m2) PV per kWp is considered to be 8. Moreover, from the hydropower plant, 1.067GWh relate to the PED area.

For Thermal RES, air-to air heat exchangers with a COP of 3.5 are installed covering the whole thermal demand of the PED area.

The useful energy (output) from renewable energy sources is calculated:

GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	CHP_biomass: Biomass_heat
buildings	2.68					
industry process						
utility						
district		1.067				
Total=	2.68	1.067	0	0	0	0.00

Total energy from RES(electric)		=	3.747
Total energy from RES(thermal)		=	0.000
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.0
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	- 0.91

Figure 25: RES production in MAKING-CITY tables for Bassano del Grappa in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use and Surplus energy (-) to be exported outside limits for electric use.

6.3.5 Energy delivered

In Bassano del Grappa, thermal energy is provided by air-to-air heat exchangers and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy	Efficiency		**Delivered energy to district GWh**
Last check: Any remaining energy to be covered??				
electr_grid national	**-0.91**		=	**-0.91**
THERMAL	**0.00**			**0.00**

Figure 26: Energy delivered in MAKING-CITY tables for Bassano del Grappa in GWh/year

6.3.6 Primary Energy Balance

PED is achieved. Primary Energy Balance = -2.42 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
nuclear energy	-0.91	x	2.65225	=	-2.42
			PRIMARY ENERGY BALANCE (NON-RENEWABLE)	=	**-2.42**
					PED Achieved!

Figure 27: non-RES Balance in MAKING-CITY tables for Bassano del Grappa in GWh/year

6.3.7 Energy Flow Diagrams

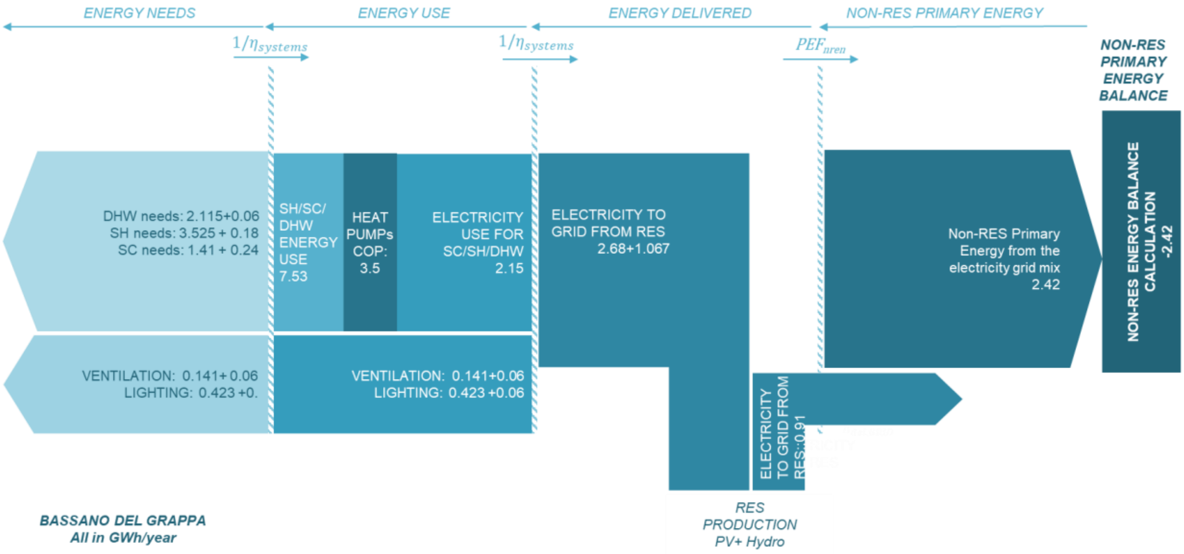


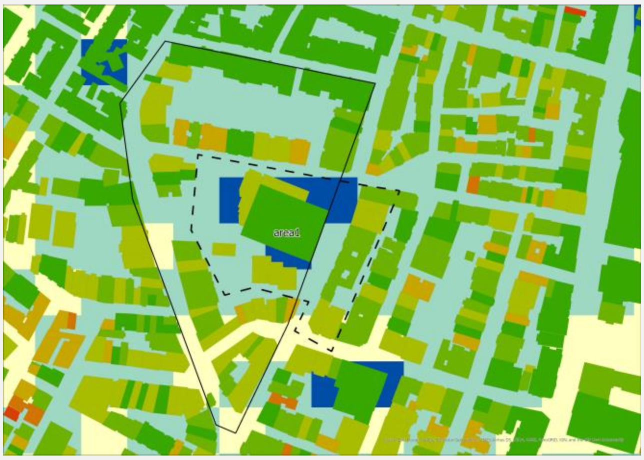
Figure 28: Sankey diagram energy flow Bassano del Grappa PED (in GWh/yr)

7 PED Design in Kadikoy

Once the PED boundary is identified in Kadikoy (Annex I: Microscale analysis results), the next step is the development of the stakeholder and citizen engagement strategy for co-designing PEDs, identifying and selecting technology packages and verify the annual primary energy balance to figure out if the district is positive or not.

The theoretical heating/cooling demand and the Potential Renewable installations on rooftops are derived from the energy demand maps that were developed within WP1 and first estimations are discussed with the municipality representatives for figuring out the PED potential not only from technical but also economic, legal, social, and political point aspects. The initial results on the selected area (Area 1 for Kadikoy) are displayed below.

Table 11: Main characteristics of area selected to become PED – Kadikoy

Area to become PED	Main characteristics of selected area	
	Surface: 11,517.27m^2	
	*Total built roof area: 5,092.84m^2	*Public roof area: 2,593.61m^2
	Total nº of buildings: 13	
	*Residential: 11 (Mixed Use)	*Public buildings: 2 (Culture + Sport)
	Heat demand: 547,307.41kWh Cooling demand: 229,977.62kWh	
	Potential Renewable installations on rooftops: 414kW of Solar PV	

7.1 Stakeholder and Citizen Engagement Strategy

Kadikoy Municipality already has the engagement strategies that are currently active in its functioning. The city is open to new engagement mechanisms and residents are always willing to be part of the process. The Municipality always discusses new approaches for engaging the stakeholders in the issues. Kadikoy are currently using several combined mechanisms and tools explained in detail in D1.29 Long-term city plan of Kadikoy (city vision 2050) – Intermediate version – Section 3.3 Engagement strategies to place citizens at the centre of the energy transition.

As mentioned before in Section 5, the results of the questionnaires will be evaluated with T5.7 experts (CAP, VTT, TNO, HANZE and DEM) and will be shared in deliverable of this task later.

7.2 Selected PED Solutions

According to the MCDA analysis done in previous steps of the WP4 (See D4.3[4]), the Technology selection tool was conducted by DEM and City of Kadikoy validated the content. The answers to the questions are

[4] D4.3 Analysis of FWC candidate áreas to become PEC

listed (Figure 29) and the macro tool was activated and technology package with recommendations are displayed (Figure 30).

Ambition level or Objectives of your district	Net-zero emissions / Climate Neutrality
Concept boundary	Geographical
District context and its characteristics	
Needs to be supplied	
in general, do you have space heating needs in the district?	YES
in general, do you have space cooling needs in the district?	YES
in general, do you have Domestic hot water needs in the district?	YES
in general, do you have electricity needs in the district?	YES
Resource availability (answer all questions)	
Does the district have significant solar potential?	YES
Solar questions: Available space on any roof?	YES
Is it possible to install solar integrated technologies in the building envelope?	YES
Is it possible to install solar technologies In a water surface nearby?	NO
Is it possible to install solar technologies In a parking lot or an empty lot nearby?	YES
Does the district have significant wind potential?	NO
Wind questions: would you like to install wind turbines on-site or off-site?	NO
Does the district have significant ground coupling potential (subsurface potential)?	YES
Subsurface potential: Is it possible to install ground source heat pumps?	YES
Is it possible to use the ground or aquifers as thermal storage?	NO
Can the district use a water body to exchange heat with a heat pump?	NO
Can the district use a water body for hydro generation?	NO
Hydro questions: is it around the district area (around 5 km)?	NO
Does the district have significant biomass potential?	NO
Does the district have available a waste heat source?	NO
Urban macroform (answer YES if applicable)	
Is the district a new development area?	NO
Is the district going to be retrofitted?	YES
Is the district an infill area?	NO
Is the district a transformation area?	NO
is the district a heritage area?	NO
Select the type of buildings (use) within your district (answer YES if applicable)	
Residential use?	YES
Commercial?	YES
Active Green / Open Parking Lot?	NO
Public Administration?	YES
Social / Cultural/Educational/Sport ?	YES
Industrial?	NO
Energy infrastructures (answer all questions)	
is there any district heating network (DHN) nearby?	NO
Is the district off-grid?	NO
does the district have a private electricity grid?	NO
Is the district connected to the gas network?	YES
Do you want to include e-mobility aspects?	YES
Do you want to include hydrogen-mobility aspects?	NO
Do you want to apply soft-mobility aspects?	NO
Energy services and management (answer all questions)	
Do you want to interact with the gas grid? (injection of hydrogen or biogas)	NO
Do you want to offer ancillary services?	YES
do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	YES
Do you want to offer hydrogen to industry or for electricity generation?	NO
Do you want to interact with the users/consumers?	YES
Would you need a data platform?	YES
Do you want that the electricity and thermal production is matched (by optimization, etc.)?	YES
Social structure	
Do you want to form an energy community in the district?	YES
Is there any people suffering from energy poverty in the district?	YES

Figure 29: Answers of City of Kadikoy for the macro tool

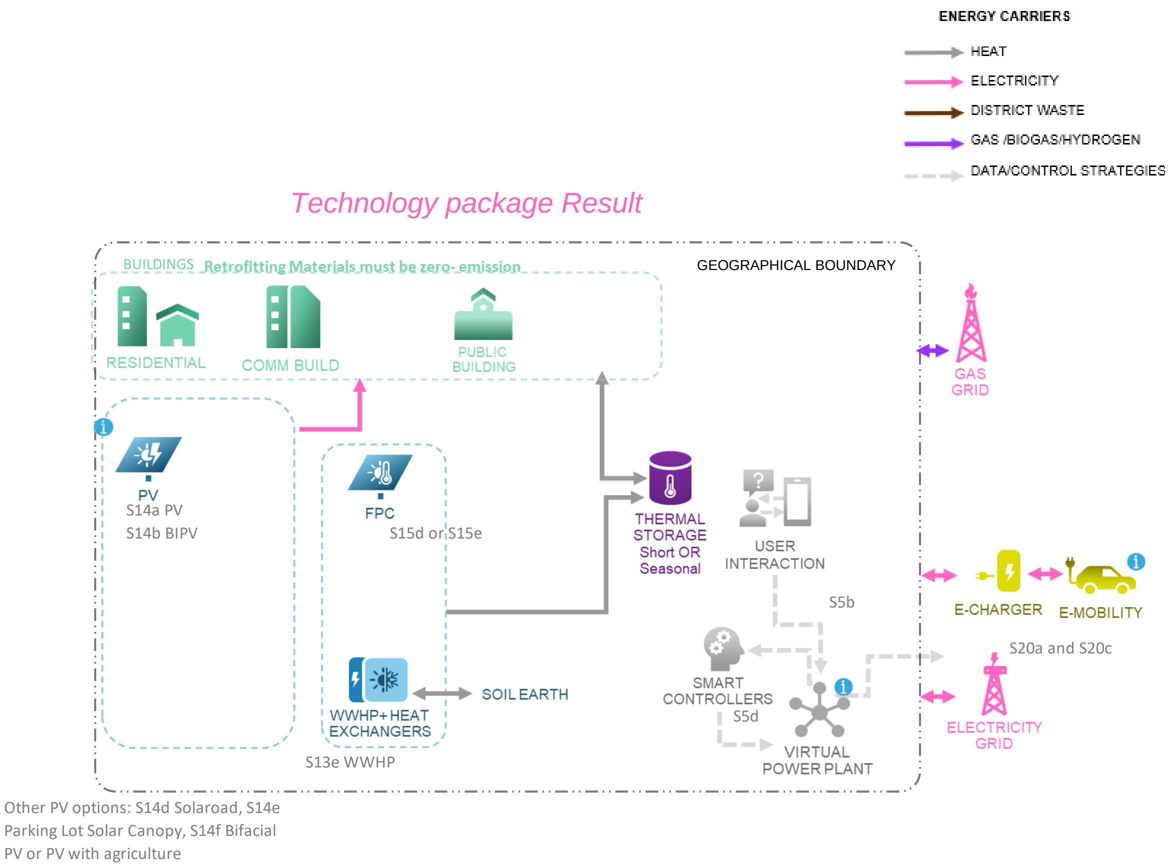


Figure 30: Technology Package Result for Kadikoy PED Boundary

Results of Kadikoy in a nutshell:

You have achieved a climate neutral technology package. To achieve net-zero emissions or climate neutrality in energy terms, retrofitting materials must be zero-emission. If an industry is included, carbon capture is recommended. If biomass or biogas is included, very high filters and carbon capture are needed, to avoid realising it to the environment. But finally, a techno-economic study needs to be performed, to know exactly how to realise the technology package. In any case, you will need to achieve NET zero emissions, so any emission related with biomass/biogas or from imports from wider grids, needs to be compensated with your exports or by carbon capture.

Recommendations for other Technologies:

- To reduce space heating needs, it is recommended to insulate the building as much as possible and replace emitters by systems that require less temperature supply (Such as ground floor heating, fan coils, etc.)
- To reduce space cooling needs, it is recommended to insulate the building as much as possible, take advantage of free cooling during the night and use controllable external shading
- DHW requires (generally in most countries) 60ºC when is stored (to avoid legionella), but if the volume from the supply system to the demand is less than 3 m3, in Germany is allowed to reduce the temperature to 45ºC. Generally, in most countries if DHW is prepared instantaneously (with heat exchanger between storage and demand), then it can also be reduced to 45ºC. Another way to reduce the demand, is to preheat the cold-water mains with waste heat (e.g. heat exchanger to extract heat from the grey water from the shower).

- Efficient lighting and appliances should be prioritized. Avoid stand-by modes when possible, using smart plugs to cut off power when not needed.
- To allow the participation in the market, you can check solution SXX Participation on the market, and the following solutions: S5a, S5b, S5c, S5d
- To offer ancillary services, you can check solution SXX Ancillary services. For example, to offer demand shifting or demand response, you will need controllable loads (e.g. be able to switch off/on heat pumps, appliances, etc.)
- You can check the SXX Creation of an energy community, to know a bit more about Renewable Energy Communities
- Energy poverty is a distinct form of poverty associated with adverse consequences for health (respiratory, mental health, etc.) due to low temperatures (caused by switching off the heating system) and stress associated with unaffordable energy bills. To reduce energy poverty is recommended to increase training, to improve energy efficiency of buildings and to have special taxes (or rates, or special financial support) in houses with low incomes. Check more in SXX Energy Poverty mitigation
- Data Platforms are recommended, such as Sd, Se or S7a
- To allow the optimization of heat and electricity production, the smart controller will include both in the optimization process
- To allow user feedback to consider, phone apps or user-interface could be used, such as S5b

Prioritizing the following technologies as generation technologies: PV and solar thermal panels (FPC). Storage is needed for electricity and thermal demand (batteries, and thermal storage, respectively) and high-level controllers for optimizing the energy uses within the buildings. Furthermore, e-mobility could be integrated.

7.3 PED Calculation for Verification

Once PED technologies are identified in Kadikoy PED Boundary, a calculation process has been held to figure out if the identified technologies already provide a surplus of annual energy balance. If the technologies do not provide positivity, new solutions such as decreasing the energy demand, increasing energy efficiency and energy generation will be conducted within the PED boundary. 2 Alternative scenarios were conducted to provide different options and financial plans. The municipality may decide later, which one to go further for detailed execution plans and potential implementation of PED area after the MAKING-CITY project lifetime.

7.3.1 PED boundaries definition

The boundary for Kadikoy PED Area is geographically bounded. There is a sports hall with a huge roof-top solar generation capacity built in 1987. This building will be reconstructed by an architectural competition that will be conducted, soon. The specifications and the tender documents for this competition will be prepared aligned with PED concept and carbon neutral ambition. For this reason, the theoretical demand of the sports hall building is estimated and considered as highly efficient regarding the new structure. Besides, the residential buildings need to be retrofitted and the rooftops will be used for solar generation. The efficiency of the mechanical equipment and the lighting equipment for the will be increased for the Cultural Centre Building.

Figure 31: Kadikoy PED Boundary

2 scenarios for energy generation are generated to achieve PEDs according to the technologies identified in the previous section.

Scenario 1: All PV+ All heat pumps

PV: 390.5 kW (2499.23+2300+200 m2 rooftop area available) - All new

HP: 458.58.3kW – 39.5W/m2 of HPs

Scenario 2: PV + Solar thermal & heat pumps for residential and PV + HPs for the new sports hall and the new cultural center

PV: 376 kW (1124.65+1610+140 m2 rooftop area available)

Solar thermal: 81.2 kW (115 m2)

HP: 261.27kW – 22.5W/m2 of HPs

7.3.2 Energy needs inside PED boundaries

All data related to thermal and electric energy needs of the residential buildings are based on the data calculated in WP1 New long-term urban planning towards 2050. Regarding Sports Hall and Baris Manco Cultural Center, electricity and gas consumptions were shared by the municipality (for 2019) since it is the owner of these buildings. As mentioned before, an assumption regarding the new sports hall demand is estimated.

Scenario 1 + Scenario 2: Same approach is followed in both scenarios for calculating the energy needs inside the PED boundary. Residential buildings will be retrofitted, and the sports hall and the cultural centre will be reconstructed. For doing so, 30% of heating demand reduction in residentials (deep retrofitting will be provided); new building for sports hall: 27% efficiency in lighting, 37% efficiency in heating when compared to the old building will be obtained. On the other hand, 55% efficiency of lighting, 54% efficiency of DHW, 19% efficiency of cooling, 47% efficiency of heating is foreseen in the new cultural centre building. Both scenarios are united in for energy needs in figure below.

ENERGY NEEDS

THERMAL ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	DHW needs	8304.63	x	13.90	=	0.12
	SH needs	8304.63	x	34.80	=	0.29
	SC needs	8304.63	x	15.98	=	0.13
Sport	DHW needs	2300.00	x	36.55	=	0.084
	SH needs	2300.00	x	55.00	=	0.13
	SC needs	2300.00	x	40.00	=	0.09
Culture	DHW needs	1000.00	x	15.00	=	0.015
	SH needs	1000.00	x	55.37	=	0.06
	SC needs	1000.00	x	30.00	=	0.03
						=
				Total Thermal Energy Needs	=	0.94

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	Lighting	8304.63	x	3.15	=	0.03
	Ventilation	8304.63	x	1.00	=	0.01
Sport	Lighting	2300.00	x	10.00	=	0.02
	Ventilation	2300.00	x	7.00	=	0.0161
	Other (e.g. Process)		x		=	0.00
Culture	Lighting	1000.00	x	22.00	=	0.02
	Ventilation	1000.00	x	7.00	=	0.01
				Total Electric Energy Needs	=	0.10

Figure 32: Energy needs in MAKING-CITY tables for Kadikoy – Scenario 1 +2 in GWh/year

7.3.3 Energy Use

Thermal and electric energy uses are calculated considering the energy needs and the distribution losses since the systems are centralized for DHW, space heating and cooling. The potential losses for thermal uses may be reviewed in Table 12 and for electric losses in Table 13

Table 12: Distribution Losses for Thermal Use

Distribution Losses (DHW)	Distribution Losses (SH & SC)	Heat exchanger
10%	15%	90%

Table 13: Distribution Losses for Electric Use

Ventilation losses	Lighting losses	Distribution losses	Distribution Losses (SH & SC)
5%	2%	5%	15%

The difference between energy needs and energy use are due to air to water heat pumps consumption (accounted in electricity use).

Scenario 1: All HVAC, DHW systems are facilitated by HPs (capacity of 458.5kW in total) with COP of 4. The existing heating system of the residential buildings will either be changed to fan coil or the sizes of the existing radiators will be enlarged in order to connect to HPs.

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use		/	0.95	=	0.00
	SH use		/	0.95	=	0.00
	SC use		/		=	0.00
Sport	DHW use		/	0.95	=	0.00
	SH use		/	0.95	=	0.00
	SC use		/		=	0.00
Culture	DHW use		/	0.95	=	0.00
	SH use		/	0.95	=	0.00
	SC use		/		=	0.00
						=
				Total Thermal Energy use	=	0.00

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	0.29	/	4.00	=	0.07
	SC electric use	0.13	/	4.00	=	0.03
	DHW electric use	0.12	/	4.00	=	0.03
	Ligthing needs (usually losse:	0.03	/	1.00	=	0.03
	Ventilation needs (usually loss	0.01	/	1.00	=	0.01
Sport	SH electric use	0.13	/	4.00	=	0.03
	SC electric use	0.09	/	4.00	=	0.02
	DHW electric use	0.08	/	4.00	=	0.02
	Ligthing needs (usually losse:	0.02	/	1.00	=	0.02
	Ventilation needs (usually loss	0.02	/	1.00	=	0.02
	Other(process)		/	1.00	=	0.00
Culture						
	SH electric use	0.06	/	4.00	=	0.01
	SC electric use	0.03	/	4.00	=	0.01
	DHW electric use	0.02	/	4.00	=	0.00
	Ligthing needs (usually losse:	0.02	/	1.00	=	0.02
	Ventilation needs (usually loss	0.01	/	1.00	=	0.01
	Other(process)		/		=	0.00
						=
				Total Electric nergy use	=	0.34

Figure 33: Energy uses in MAKING-CITY tables Kadikoy – Scenario 1 in GWh/year

Scenario 2: HPs (with a capacity of 261kW) for all new buildings for DHW and SH&SC. Just, DHW for the sports building will be provided by Solar thermal Panels. Moreover, DHW of residentials will be covered by Solar Thermal and SH of residential will be provided by 85% efficient boilers (existing heating systems) (the ambition of the district may not be evaluated as climate neutrality) and SC by existing air conditioning systems (no new HPs).

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use	0.12	/	0.85	=	0.14
	SH use	0.29	/	0.85	=	0.34
	SC use		/		=	0.00
Sport	DHW use	0.08	/	1.00	=	0.08
	SH use		/		=	0.00
	SC use		/		=	0.00
Culture	DHW use		/		=	0.00
	SH use		/		=	0.00
	SC use		/		=	0.00
						=
				Total Thermal Energy use	=	0.56

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use		/		=	0.00
	SC electric use	0.13	/	2.50	=	0.05
	DHW electric use		/		=	0.00
	Ligthing needs (usually losse:	0.03	/	1.00	=	0.03
	Ventilation needs (usually loss	0.01	/	1.00	=	0.01
Sport	SH electric use	0.13	/	4.00	=	0.03
	SC electric use	0.09	/	4.00	=	0.02
	DHW electric use		/		=	0.00
	Ligthing needs (usually losse:	0.02	/	1.00	=	0.02
	Ventilation needs (usually loss	0.02	/	1.00	=	0.02
	Other(process)		/	1.00	=	0.00
Culture						
	SH electric use	0.06	/	4.00	=	0.01
	SC electric use	0.03	/	4.00	=	0.01
	DHW electric use	0.02	/	4.00	=	0.00
	Ligthing needs (usually losse:	0.02	/	1.00	=	0.02
	Ventilation needs (usually loss	0.01	/	1.00	=	0.01
	Other(process)		/		=	0.00
						=
				Total Electric nergy use	=	0.24

Figure 34: Energy uses in MAKING-CITY tables Kadikoy – Scenario 2 in GWh/year

7.3.4RES production inside the PED

Within the geographical PED boundary, the local generation of renewable heat and electricity in Kadikoy PED area is consisting of solar photovoltaic, solar thermal panels and air to air heat exchangers.

Scenario 1: For electricity, Solar PV panels are installed on 55% roof usage for PV on residential, 70% roof usage for PV on sports hall and 70% roof usage for PV on cultural center. This refers to 3125m2 rooftop area available for PV RES production and of which 1750m2 refers to tertiary buildings. Therefore, solar PV panels electricity output is 2,68GWh. The PV Solar potential[5] in Kadikoy is 1366.44 kWh/kWp and the Solar irradiation is 1735.47 kWh/m2. The ratio for area (m2) PV per kWp is considered

[5] https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#PVP

to be 8. It is considered a capacity of 390.5 kW PV installed. Therefore, solar PV panels electricity output is 0.53GWh.

The useful energy (output) from renewable energy sources is calculated:

GWh	PV	wind/hydro	Geothermal	Solar Thermal	CHP_biomass: Biomass_el	Biomass_heat
Residentials	0.23					
Sport	0.27					
Culture	0.02					
Total=	0.53	0.00	0.00	0.00	0.00	0.00

Total energy from RES(electric)		=	0.53
Total energy from RES(thermal)		=	0.00
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.00
Remaining (Electric)	**= Total Electric Use - Total RES Thermal**	=	-0.20

Figure 35: RES production in MAKING-CITY tables for Kadikoy – Scenario 1 in GWh/year

Surplus energy (-) to be exported outside limits for electric use.

<u>Scenario 2:</u> 55% roof usage for PV for residentials, 70% for cultural center and 65% for PV and 5% solar thermal for sports hall are considered. DHW demand is provided by solar thermal in sports hall. This refers to 3010m2 rooftop area available for PV RES production and of which 1635m2 refers to tertiary buildings. On the other hand, 115m2 rooftop area available for Solar Thermal RES production and all of this space refers to tertiary buildings. It is considered a capacity of 376.2 kW PV and 81.2 kW ST installed. Therefore, solar PV panels electricity output is 0.51GWh and ST panels thermal output is 0.08GWh.

The useful energy (output) from renewable energy sources is calculated:

GWh	PV	wind/hydro	Geothermal	Solar Thermal	CHP_biomass: Biomass_el	Biomass_heat
Residentials	0.23			0.00		
Sport	0.26			0.08		
Culture	0.02			0.00		
Total=	0.51	0.00	0.00	0.08	0.00	0.00

Total energy from RES(electric)		=	0.51
Total energy from RES(thermal)		=	0.08
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.48
Remaining (Electric)	**= Total Electric Use - Total RES Thermal**	=	-0.28

Figure 36: RES production in MAKING-CITY tables for Kadikoy – Scenario 2 in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use, Surplus energy(-)to be exported outside limits for electric use

7.3.5 Energy delivered

Scenario 1: In Kadikoy, thermal energy is provided by air-to-water heat exchangers and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Last check: Any remaining energy to be covered??					
electr_grid national	-0.20			=	-0.20
national gas network	0.00				0.00

Figure 37: Energy delivered in MAKING-CITY tables for Kadikoy – Scenario 1 in GWh/year

Scenario 2: Thermal energy is generated via Solar thermal panels and heat exchangers and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Gas boiler	0.48	/	0.81	=	0.59
Last check: Any remaining energy to be covered??					
electr_grid national	-0.28			=	-0.28

Figure 38: Energy delivered in MAKING-CITY tables for Kadikoy – Scenario 2 in GWh/year

7.3.6 Primary Energy Balance

Scenario 1: PED is achieved. Primary Energy Balance = -0.46 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
national gas network	0	x	1.05	=	0.00
electr_grid national	-0.20	x	2.36	=	-0.46
			PRIMARY ENERGY BALANCE (NON-RENEWABLE)	=	**-0.46**
					PED Achieved!

Figure 39: non-RES Balance in MAKING-CITY tables for Kadikoy of Scenario 1 in GWh/year

<u>Scenario 2:</u> PED is achieved. Primary Energy Balance = -0.09 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Imported(+) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
national gas network	0.59	x	1.05	=	0.62

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
national gas network	0	x	1.05	=	0.00
electr_grid national	-0.28	x	2.36	=	-0.66

PRIMARY ENERGY BALANCE (NON-RENEWABLE) =	**-0.04**
	PED Achieved!

Figure 40: non-RES Balance in MAKING-CITY tables for Kadikoy of Scenario 2 in GWh/year

As observed from the results, Scenario 1 leads to a higher positivity with an ambitious climate neutrality target since utilization of air to water HPs for covering all heating and cooling and electric needs (through electrification) provide not only a cleaner environment but also does not need any technology with combustion mechanisms.

7.3.7 Energy Flow Diagrams

Scenario 1:

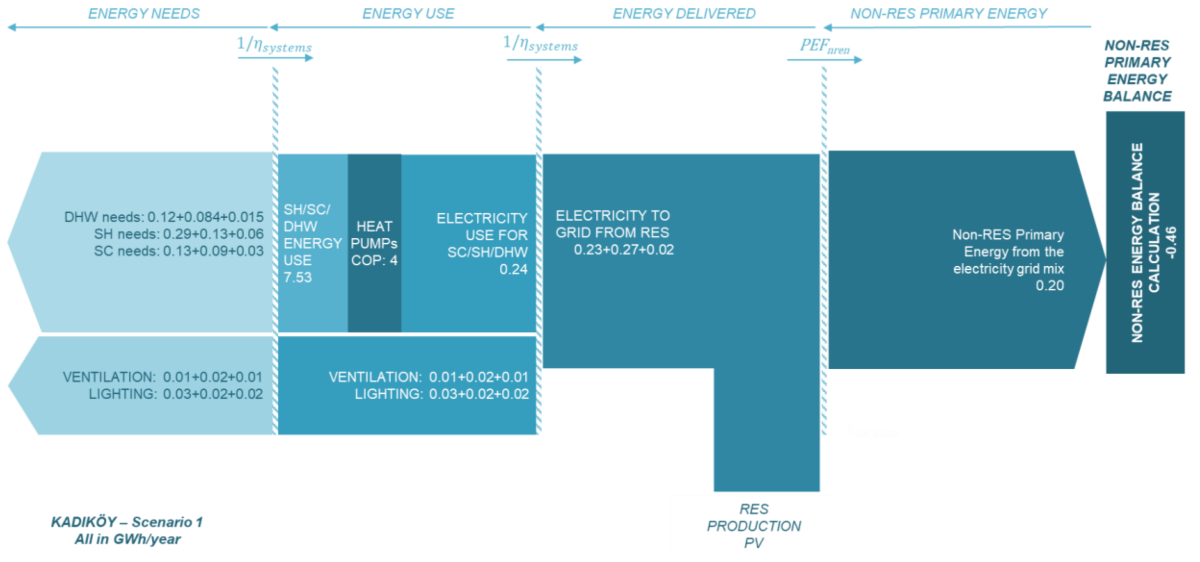


Figure 41: Sankey diagram energy flow Kadikoy PED Scenario 1 (in GWh/yr)

Scenario 2:

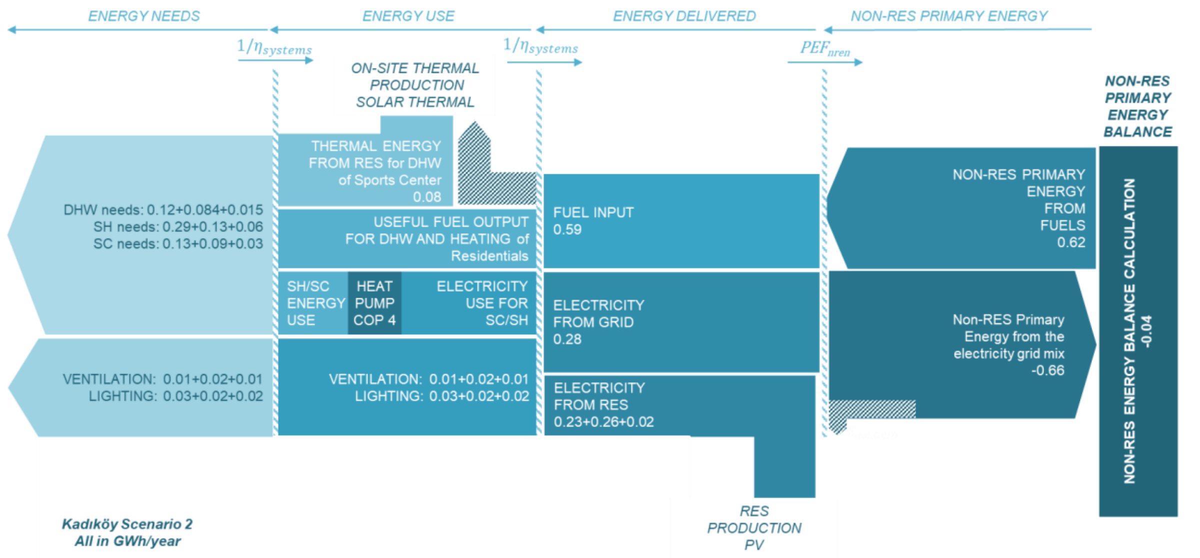


Figure 42: Sankey diagram energy flow Kadikoy PED Scenario 2 (in GWh/yr)

8 PED Design in León

Once the PED boundary is identified in León (Annex I: Microscale analysis results), the next step is the development of the stakeholder and citizen engagement strategy for co-designing PEDs, identifying and selecting technology packages and verify the annual primary energy balance to figure out if the district is positive or not.

The theoretical heating/cooling demand and the renewable installations are derived from the energy demand maps that were developed within WP1 and first estimations are discussed with the municipality representatives for figuring out the PED potential not only from technical but also economic, legal, social, and political point aspects. The initial results on the selected area (Area 4b for León) are displayed below. First, area 4 is identified for León, then an adaptation analysis was conducted, and more residential buildings were taken into the boundary to enlarge the impact area.

Table 14: Main characteristics of area selected to become PED – León

Area to become PED	Main characteristics of selected area	
	Surface: 73,145.69m^2	
	*Total built roof area: 8,488.53m^2	*Public roof area: 3,796.41m^2
	Total nº of buildings: 21	
	*Residential: 19 (Mixed Use)	*Public buildings: 2 (Pavilion + Old Sugar Factory)
	Heat demand: 1,310,963.4kWh (pavilion not included) Cooling demand: 244,147.15kWh	
	Renewable installations: a small hydro-generation plant (around 500m away. power 0,674 MW in 2018) Solar PV over the trade fair pavilion (4014 PV with a power of 1,04MWp)	

8.1 Stakeholder and Citizen Engagement Strategy

The City of León department of citizen participation is working for a *"León for All"*. To achieve this, the department is carrying out the tasks explained in D1.28 Long-term city plan of León (city vision 2050) – Intermediate version – Section 3.3 Engagement strategies to place citizens at the centre of the energy transition. As mentioned before in Section 5, the results of the questionnaires will be evaluated with T5.7 experts (CAP, VTT, TNO, HANZE and DEM) and will be shared in deliverable of this task later.

8.2 Selected PED Solutions

According to the MCDA analysis done in previous steps of the WP4 (See D4.3[6]), the Technology selection tool was conducted by DEM and City of Leon validated the content. The answers to the questions are listed (Figure 43) and the macro tool was activated and technology package with recommendations are displayed (Figure 44

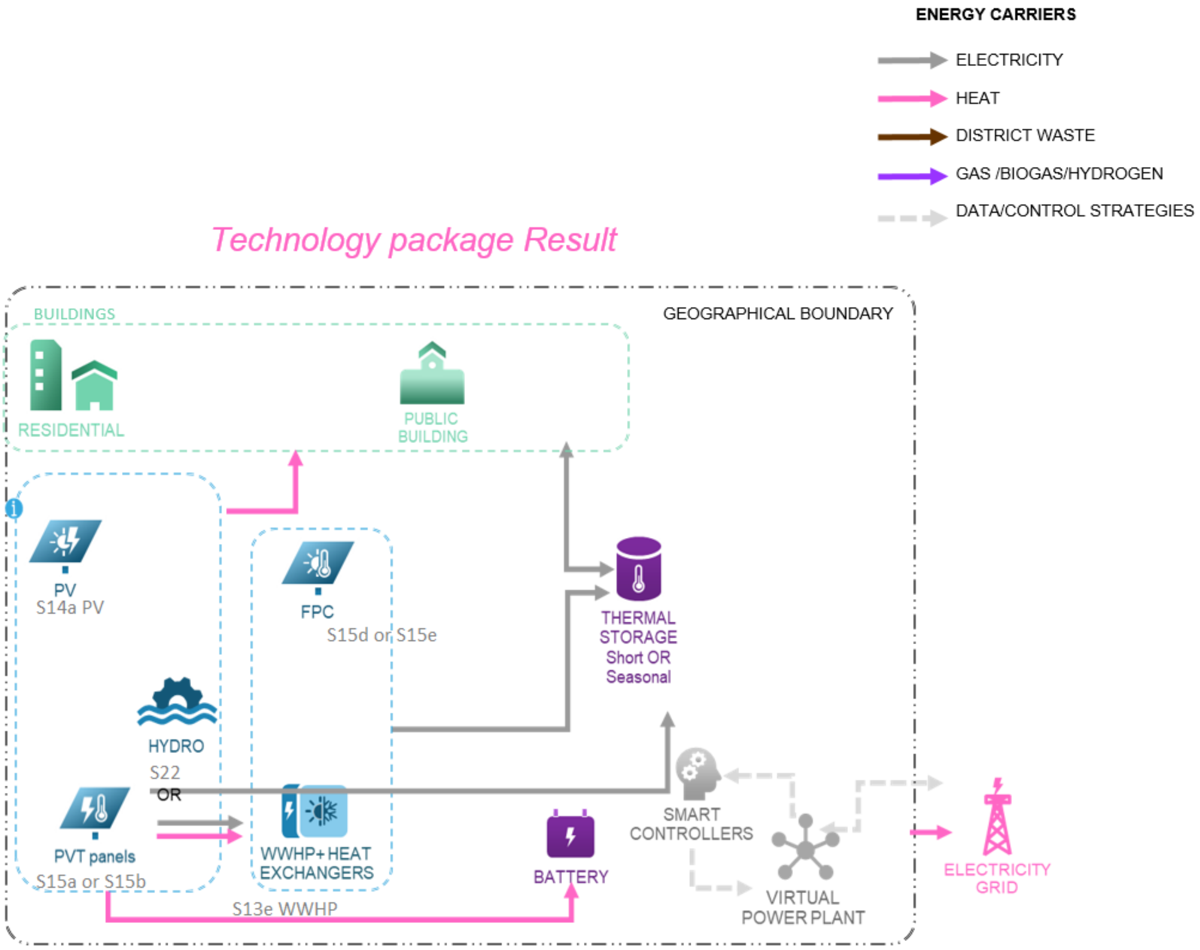


Figure 21). Results are validated by the city for the PED boundary, and it results in Figure 45

[6] D4.3 Analysis of FWC candidate areas to become PEC

Ambition level or Objectives of your district	Self-sufficiency	
Concept boundary	Virtual	
District context and its characteristics		
Needs to be supplied		
	in general, do you have space heating needs in the district?	YES
	in general, do you have space cooling needs in the district?	YES
	in general, do you have Domestic hot water needs in the district?	YES
	in general, do you have electricity needs in the district?	YES
Resource availability (answer all questions)		
	Does the district have significant solar potential?	YES
Solar questions:	Available space on any roof?	YES
	Is it possible to install solar integrated technologies in the building envelope?	YES
	Is it possible to install solar technologies In a water surface nearby?	NO
	Is it possible to install solar technologies In a parking lot or an empty lot nearby?	YES
	Does the district have significant wind potential?	YES
Wind questions:	would you like to install wind turbines on-site or off-site?	on-site
	Does the district have significant ground coupling potential (subsurface potential)?	NO
Subsurface potential:	Is it possible to install ground source heat pumps?	NO
	Is it possible to use the ground or aquifers as thermal storage?	NO
	Can the district use a water body to exchange heat with a heat pump?	NO
	Can the district use a water body for hydro generation?	YES
Hydro questions:	is it around the district area (around 5 km)?	YES
	Does the district have significant biomass potential?	NO
	Does the district have available a waste heat source?	NO
Urban macroform (answer YES if applicable)		
	Is the district a new development area?	NO
	Is the district going to be retrofitted?	YES
	Is the district an infill area?	NO
	Is the district a transformation area?	YES
	is the district a heritage area?	NO
Select the type of buildings (use) within your district (answer YES if applicable)		
	Residential use?	YES
	Commercial?	YES
	Active Green / Open Parking Lot?	YES
	Public Administration?	YES
	Social / Cultural/Educational/Sport ?	YES
	Industrial?	NO
Energy infrastructures (answer all questions)		
	is there any district heating network (DHN) nearby?	NO
	Is the district off-grid?	NO
	does the district have a private electricity grid?	NO
	Is the district connected to the gas network?	YES
	Do you want to include e-mobility aspects?	YES
	Do you want to include hydrogen-mobility aspects?	YES
	Do you want to apply soft-mobility aspects?	NO
Energy services and management (answer all questions)		
	Do you want to interact with the gas grid? (injection of hydrogen or biogas)	NO
	Do you want to offer ancillary services?	YES
	do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	YES
	Do you want to offer hydrogen to industry or for electricity generation?	YES
	Do you want to interact with the users/consumers?	YES
	Would you need a data platform?	YES
	Do you want that the electricity and thermal production is matched (by optimization, etc.)?	YES
Social structure		
	Do you want to form an energy community in the district?	YES
	Is there any people suffering from energy poverty in the district?	YES

Figure 43: Answers of City of Leon for the macro tool

In León virtual boundaries and self-sufficiency objectives are chosen for the PED implementation. Furthermore, the different yes/no questions are answered to characterise the district context.

As a result, the following technology package is obtained:

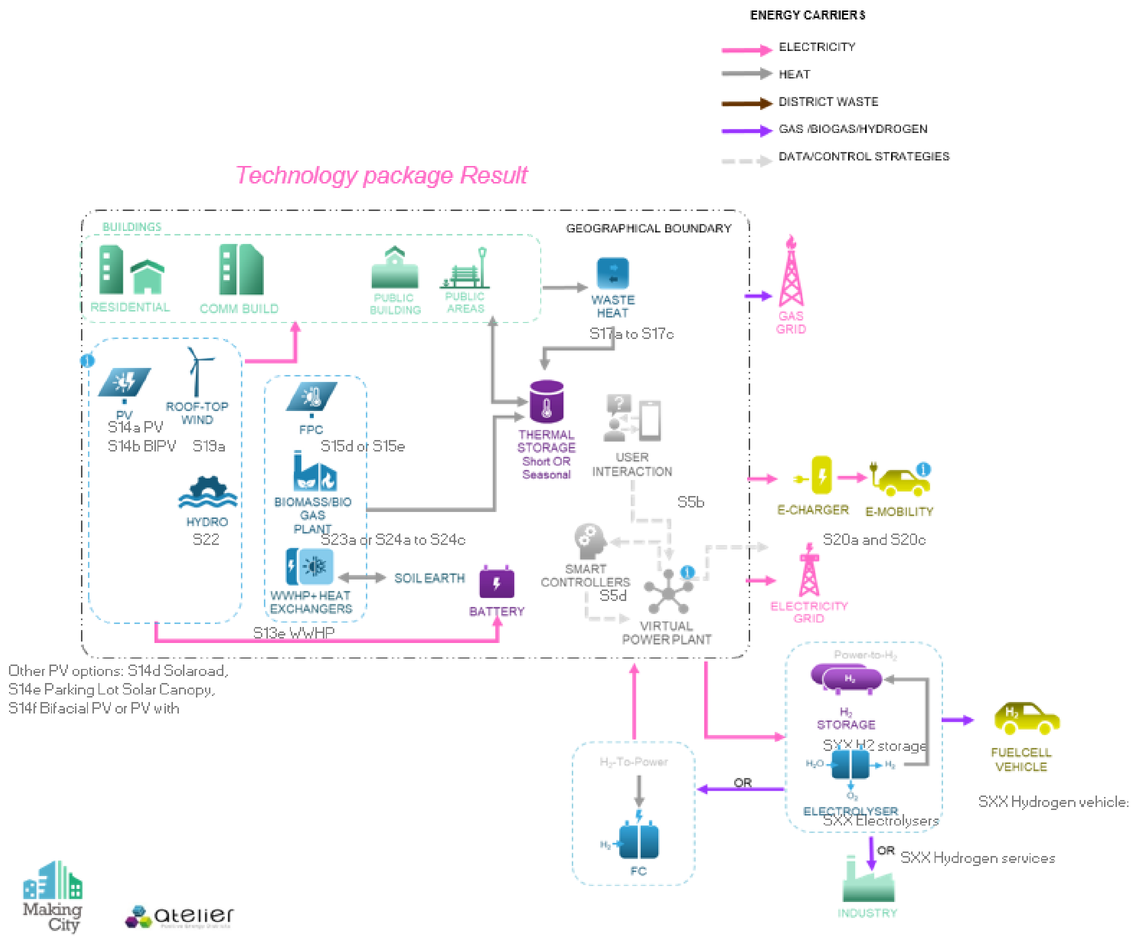


Figure 44: Complete result for Leon case

These will be the ideal setup for the PED, according to their answers and objectives. No virtual boundaries are recommended as self-sufficiency is chosen (which is mainly recommended to be achieved within geographical boundaries). Nevertheless, León reviewed the technologies, realises the following:

- Solar panels can be installed on the residential roofs, on small parking areas, etc., but considering the area that already exist, the possibility of extension exits, but are small. Furthermore, there is a need for optimize this potential through optimal management, monitoring, control, efficiency...etc. As there is a mismatched between demand and production (demand is higher in winter and solar production is higher in summer).
- There is some wind potential available, to be installed on-site (in the ex-sugar factory roof)
- There is a hydro plant within 500m outside the boundaries. Thus, it is discarded for the moment. Nevertheless, it could be considered if the potential in the area is not enough. According to León the small hydro-generation plant is around 500m away, with a power 0,674 MW and a production 1279 MWh in 2018.
- Ground source and geothermal energy potential is interesting, but there might be legal barriers for real implementation. Thus, it is discarded.

- Biomass is interesting as clearly the regional government and our own SECAP go for and are committed to biomass resources. Within the city limits there are small forest areas, and we can consider the pruning of the green areas of the city. Nevertheless, it is not a priority for this PED area, so it is discarded
- There is water treatment plant is 4.3 km away, and there are also some industrial areas within the city limits, so there might be potential waste heat sources. Nevertheless, there is no existing district heating network to reuse them, so it is discarded.
- E-mobility can be considered, but the internal use for heating and electricity uses of the buildings is prioritized
- There are plans to produce green hydrogen in La Robla (25 km from León). At city level this could imply in the future a network of hydrogen stations and public vehicles running on hydrogen. Nevertheless, the internal use for heating and electricity uses of the buildings is prioritized
- PED area is too small to apply “soft-mobility” aspects such as banning the entrance of cars to the area. The city is considering something related to that, but we still do not know if there will be soft measures for the whole city or tough measures for small areas.
- Social structure: there might be a need to legalise the PED area, so energy communities can be considered.

Considering these answers, the resulting technology package is the following:

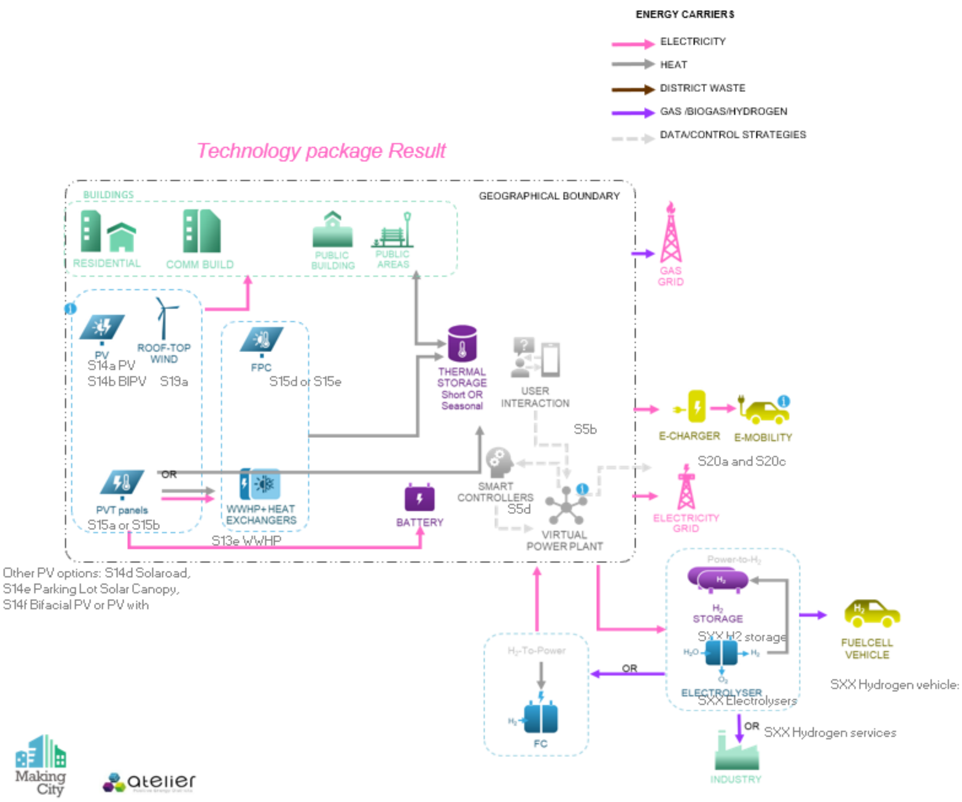


Figure 45: Validated Technology Package for Leon PED Boundary

Prioritizing the following technologies as generation technologies: PV, roof-top wind, PVT panels coupled with heat pumps and solar thermal panels (FPC). Storage is needed for electricity and thermal demand (batteries, and thermal storage, respectively) and high-level controllers for optimizing the energy uses within the buildings. With the exports, hydrogen could be obtained through electrolysers, when there is no demand and excess of energy that could be used for La Robla or other uses (such as fuel cell vehicles or export to the gas grid). Furthermore, e-mobility could be integrated.

8.3 PED Calculation for Verification

Once PED technologies are identified in León PED Boundary, a calculation process has been held to figure out if the identified technologies already provide a surplus of annual energy balance. If the technologies do not provide positivity, new solutions such as decreasing the energy demand, increasing energy efficiency and energy generation will be conducted within the PED boundary. 3 Alternative scenarios were conducted to provide different options and financial plans. The municipality may decide later, which one to go further for detailed execution plans and potential implementation of PED area after the MAKING-CITY project lifetime.

8.3.1 PED boundaries definition

The boundary for León PED Area is geographically bounded and the ambition is to reach Self-Sufficiency. There is an old sugar factory – newly refurbished as an exhibition hall, a pavilion (Convention Center and Exhibition Hall Complex) with a huge roof-top solar generation capacity (already running). There are also a few residential blocks that are counted in the PED boundary. There is also a hydro-generation plant nearby (within 500m limits – flexibility options for self-consumption according to the Spanish Law) The theoretical demand of the residentials is estimated and considered as buildings to be retrofitted for better energy efficiency and reducing demand. Besides, the consumption data of the pavilion is shared by the municipality and the demand is calculated according to the systems defined in the design phase.

Figure 46: León PED Boundary

3 scenarios for energy generation are generated to achieve PEDs according to the technologies identified in the previous section.

Scenario 1: All PV + All heat pumps

PV: 895.5 kW (1328.7+5835.3 m2), only 166 kW new needed

HP: 1732 kW - 61.9W/m2 of HPs

Scenario 2: PV + Solar thermal & heat pumps in residential and sugar factory

PV: 1314.2 kW (3037+6576 m2) -> needs 472.3 kW of new PV

Solar thermal: 218.2 kW (189.8 + 119.2 m2) -> it needs (189+1141.7 m2) to be self sufficient

HP: 1130 kW - 40.83W/m2 of HPs

Scenario 3: PV + Solar thermal & heat pumps in residential and sugar factory + Hydro generation

Hydro: power 0,674 MW and a production 1279 MWh in 2018.

PV: 729.4 kW (5835.3 m2) -> no need of new PV

Solar thermal: 218.2 kW (189.8 + 119.2 m2) -> it needs (189+1141.7 m2) to be self-sufficient (or all HPs as scenario 1)

HP: 1578 kW - 57.02W/m2 of HPs

8.3.2 Energy needs inside PED boundaries

All data related to thermal and electric energy needs of the residential buildings and the ex-sugar factory are based on the data calculated in WP1 New long-term urban planning towards 2050. Regarding Pavilion (Exhibition and Convention Center) electricity and gas consumptions and the HVAC equipment specifications together with already installed PV on roof-top were shared by the municipality (for 2019, 2020 and 2021) since it is the owner of these buildings. The cadastral data and the architectural drawings of the complex are also shared by the municipality for estimating and simulating the energy needs and check with the consumption data.

Scenario 1 + Scenario 2 + Scenario 3: Same approach is followed in all scenarios for calculating the energy needs inside the PED boundary. Residential buildings and the ex-sugar factory will be retrofitted for reducing the heating and cooling demand. For doing so, 20% of heating demand reduction is expected in residentials (deep retrofitting will be provided); again 20% reduction in heating and cooling demand is considered for ex-sugar factory. All scenarios are united in for energy needs in figure below.

ENERGY NEEDS

THERMAL ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	DHW needs	3796.40	x	45.29	=	0.17
	SH needs	3796.40	x	266.04	=	1.01
	SC needs	3796.40	x	37.11	=	0.14
Convention Center + Sugar Factory + Exhibition Hall	DHW needs	23889.29	x	1.29	=	0.03
	SH needs	23889.29	x	51.51	=	1.23
	SC needs	23889.29	x	38.01	=	0.91
						=
				Total Thermal Energy Needs	=	3.49

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	Lighting	3796.40	x	5.00	=	0.02
	Ventilation	3796.40	x	1.30	=	0.0049
Convention Center + Sugar Factory + Exhibition Hall	Lighting	23889.29	x	22.44	=	0.54
	Ventilation	23889.29	x	0.27	=	0.01
				Total Electric Energy Needs	=	0.57

Figure 47: Energy needs in MAKING-CITY tables for León – Scenario 1 + 2 + 3 in GWh/year

8.3.3 Energy Use

Thermal and electric energy uses are calculated considering the energy needs and the distribution losses since the systems are centralized for DHW, space heating and cooling. The potential losses for thermal uses may be reviewed in Table 15 and for electric losses in Table 16

Table 15: Distribution Losses for Thermal Use

Distribution Losses (DHW)	Distribution Losses (SH & SC)	Heat exchanger
10%	15%	90%

Table 16: Distribution Losses for Electric Use

Ventilation losses	Lighting losses	Distribution losses	Distribution Losses (SH & SC)
5%	2%	5%	15%

The difference between energy needs and energy use are due to air to air heat pumps consumption (accounted in electricity use).

<u>Scenario 1:</u> All HVAC, DHW systems are facilitated by HPs (capacity of 402.03kW in total) with COP of 4.17, 3 and 2.5. The existing heating system of the residential buildings will either be changed to fan coil or the sizes of the existing radiators will be enlarged in order to connect to HPs. Same approach will also be conducted for ex-sugar factory.

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use	0.00	/	1.00	=	0.00
	SH use		/		=	0.00
	SC use		/		=	0.00
Convention Center + Sugar Factory + Exhibition Hall	DHW use		/	1.00	=	0.00
	SH use	0.00	/	1.00	=	0.00
	SC use		/		=	0.00
						=
				Total Thermal Energy use	=	0.00

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	1.06	/	4.17	=	0.25
	SC electric use	0.15	/	3.00	=	0.05
	DHW electric use	0.17	/	2.50	=	0.07
	Ligthing needs (usually losses ne	0.02	/	1.00	=	0.02
	Ventilation needs (usually losses n	0.00	/	1.00	=	0.00
Convention Center + Sugar Factory + Exhibition Hall	SH electric use	1.23	/	4.17	=	0.04
	SC electric use	0.91	/	2.33	=	0.38
	DHW electric use	0.03	/	1.00	=	0.03
	Ligthing needs (usually losses ne	0.54	/	1.00	=	0.54
	Ventilation needs (usually losses n	0.01	/	1.00	=	0.01
						=
				Total Electric nergy use	=	1.39

Figure 48: Energy uses in MAKING-CITY tables León – Scenario 1 in GWh/year

Scenario 2: HPs (with a capacity of 264.5kW) for all except the space heating of exhibition hall and DHW of residential where both will be provided by solar thermal. Exhibition hall demand is covered completely, but the gas boiler can remain in case there is insufficient solar production (please keep in mind: if you want to be self-sufficient, probably a HP is also needed as back up to replace the boiler).

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use	0.17	/	1.00	=	0.17
	SH use		/		=	0.00
	SC use		/		=	0.00
Convention Center Exhibition Hall	DHW use		/	1.00	=	0.00
	SH use	1.03	/	1.00	=	1.03
	SC use		/		=	0.00
				Total Thermal Energy use	=	1.20

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	1.06	/	4.17	=	0.25
	SC electric use	0.15	/	3.00	=	0.05
	DHW electric use		/		=	0.00
	Ligthing needs (usually losses neg	0.02	/	1.00	=	0.02
	Ventilation needs (usually losses n	0.00	/	1.00	=	0.00
Convention Center Exhibition Hall	SH electric use	0.20	/	4.17	=	0.04
	SC electric use	0.91	/	2.33	=	0.38
	DHW electric use	0.03	/	1.00	=	0.03
	Ligthing needs and others (usually loss	0.54	/	1.00	=	0.54
	Ventilation needs (usually losses n	0.01	/	1.00	=	0.01
				Total Electric nergy use	=	1.32

Figure 49: Energy uses in MAKING-CITY tables León – Scenario 2 in GWh/year

<u>Scenario 3:</u> HPs (with a capacity of 264.5kW) for all except the space heating of exhibition hall and DHW of residential where both will be provided by solar thermal. Exhibition hall demand is covered completely, but the gas boiler can remain in case there is insufficient solar production (careful: if you want to be self-sufficient, probably a HP is also needed as back up to replace the boiler)

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use	0.17	/	1.00	=	0.17
	SH use		/		=	0.00
	SC use		/		=	0.00
Convention Center Exhibition Hall	DHW use		/	1.00	=	0.00
	SH use	0.11	/	1.00	=	0.11
	SC use		/		=	0.00
						=
				Total Thermal Energy use	=	0.29

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	1.06	/	4.17	=	0.25
	SC electric use	0.15	/	3.00	=	0.05
	DHW electric use		/		=	0.00
	Ligthing needs (usually losses neg	0.02	/	1.00	=	0.02
	Ventilation needs (usually losses n	0.00	/	1.00	=	0.00
Convention Center Exhibition Hall	SH electric use	1.12	/	4.17	=	0.04
	SC electric use	0.91	/	2.33	=	0.38
	DHW electric use	0.03	/	1.00	=	0.03
	Ligthing needs and others (usually loss	0.54	/	1.00	=	0.54
	Ventilation needs (usually losses n	0.01	/	1.00	=	0.01
						=
				Total Electric nergy use	=	1.32

Figure 50: Energy uses in MAKING-CITY tables León – Scenario 3 in GWh/year

8.3.4RES production inside the PED

Within the geographical PED boundary, the local generation of renewable heat and electricity in León PED area is consisting of solar photovoltaic, solar thermal panels, air to air heat exchangers and hydro generation.

Scenario 1: For electricity, 35% roof usage (1328.75 m2) for PV in residential, plus the energy coming from the existing PV (1.24 kW installation capacity on 5835m2 roof-top area) in exhibition hall. This refers to 7164.05m2 rooftop area available for PV RES production and of which 5835m2 refers to tertiary buildings. It is considered a capacity of 895.5 kW PV installed. The PV Solar potential7 in Leon is 1700 kWh/kWp and the Solar irradiation is 2261.07 kWh/m2. The ratio for area (m2) PV per kWp is considered to be 8. Therefore, solar PV panels electricity output is 1.52GWh.

[7] https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#PVP

The useful energy (output) from renewable energy sources is calculated:

	kwh				CHP_biomass:	
GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	Biomass_heat
Residentials	0.28			0.00		
Convention Center + Sugar Factory + Exhibition Hall	1.24			0.00		
Total=	1.52	0.00	0.00	0.00	0.00	0.00

Total energy from RES(electric)		=	1.52
Total energy from RES(thermal)		=	0.00
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.00
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-0.13

Figure 51: RES production in MAKING-CITY tables for León – Scenario 1 in GWh/year

Surplus energy (-) to be exported outside limits for electric use.

<u>Scenario 2:</u> 80% roof usage for PV (3037.13 m2 – residentials and 6576.73m2 - tertiary) , 5% (189.82m2 – residentials) usage for solar thermal for residential and 13.7% for solar thermal (119.28m2 – tertiary) for exhibition hall. It is considered a capacity of 1314.2 kW PV and 218.2 kW ST installed. The district needs (189+1141.7 m2) to be self-sufficient It is considered a capacity of 1201.75 kW PV installed. As a result, solar PV panels electricity output is 2.04GWh and ST panels thermal output is 0.28GWh.

The useful energy (output) from renewable energy sources is calculated:

	kwh				CHP_biomass:	
GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	Biomass_heat
Residentials	0.65			0.17		
Convention Center Exhibition Hall	1.39			0.11		
industry process						
utility						
district						
Total=	2.04	0.00	0.00	0.28	0.00	0.00

Total energy from RES(electric)		=	2.04
Total energy from RES(thermal)		=	0.28
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.92472
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-0.72

Figure 52: RES production in MAKING-CITY tables for León – Scenario 2 in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use, Surplus energy (-) to be exported outside limits for electric use

<u>Scenario 3:</u> No PV installation on residentials, energy coming from the existing PV in exhibition hall (5835.3 m2), 5% usage (190 m2) for solar thermal for residential and 13.7% (119.3 m2) for solar thermal for exhibition hall. It is considered a capacity of 729.4 kW PV installed. As a result, solar PV panels electricity output is 1.24GWh and ST panels thermal output is 0.28GWh. The existing hydro plant is within500m distance to the PED boundary. The hydro generation of 1.28GWh is connected to the boundary and will contribute to the trading mechanisms.

The useful energy (output) from renewable energy sources is calculated:

	kwh				CHP_biomass:	
GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	Biomass_heat
Residentials	0.00			0.17		
Convention Center Exhibition Hall	1.24			0.11		
industry process						
utility						
district		1.28				
Total=	1.24	1.28	0.00	0.28	0.00	0.00

Total energy from RES(electric)		=	2.52
Total energy from RES(thermal)		=	0.28
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.92472
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-1.19

Figure 53: RES production in MAKING-CITY tables for León – Scenario 3 in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use, Surplus energy (-) to be exported outside limits for electric use

8.3.5 Energy delivered

Scenario 1: In León, thermal energy is provided by air-to-air heat exchangers and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Last check: Any remaining energy to be covered??					
electr_grid national	-0.13			=	-0.13
DH_national av.	0.00				0.00

Figure 54: Energy delivered in MAKING-CITY tables for León – Scenario 1 in GWh/year

Scenario 2: Thermal energy is generated via Solar thermal panels and heat exchangers and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Gas boiler	0.92	/	0.81	=	1.14
Last check: Any remaining energy to be covered??					
electr_grid national	-0.72			=	-0.72

Figure 55: Energy delivered in MAKING-CITY tables for León – Scenario 2 in GWh/year

Scenario 3: Thermal energy is generated via Solar thermal panels and heat exchangers and there is a surplus of electric energy that can be exported by the help of hydro generation plant pavilion roof for solar PV generation.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Gas boiler	0.92	/	0.81	=	1.14
Last check: Any remaining energy to be covered??					
electr_grid national	-1.19			=	-1.19

Figure 56: Energy delivered in MAKING-CITY tables for León – Scenario 2 in GWh/year

8.3.6 Primary Energy Balance

Scenario 1: PED is achieved. Primary Energy Balance = -0.25 GWh

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
DH_national av.	0	x	1.2	=	0.00
electr_grid national	-0.13	x	2.007	=	-0.25
				PRIMARY ENERGY BALANCE (NON-RENEWABLE) =	-0.25
					PED Achieved!

Figure 57: non-RES Balance in MAKING-CITY tables for León of Scenario 1 in GWh/year

Scenario 2: PED is achieved. Primary Energy Balance = -0.08 GWh

Nren Primary Energy Imported(+) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
national gas network	1.141633426	x	1.19	=	1.36

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
electr_grid national	-0.72	x	2.007	=	-1.44
				PRIMARY ENERGY BALANCE (NON-RENEWABLE) =	-0.08
					PED Achieved!

Figure 58: non-RES Balance in MAKING-CITY tables for León of Scenario 2 in GWh/year

Scenario 3: PED is achieved. Primary Energy Balance = -2.39 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
DH_national av.	0	x	1.2	=	0.00
electr_grid national	-1.19	x	2.007	=	-2.39
				PRIMARY ENERGY BALANCE (NON-RENEWABLE) =	-2.39
					PED Achieved!

Figure 59: non-RES Balance in MAKING-CITY tables for León of Scenario 3 in GWh/year

8.3.7 Energy Flow Diagrams

<u>Scenario 1:</u>

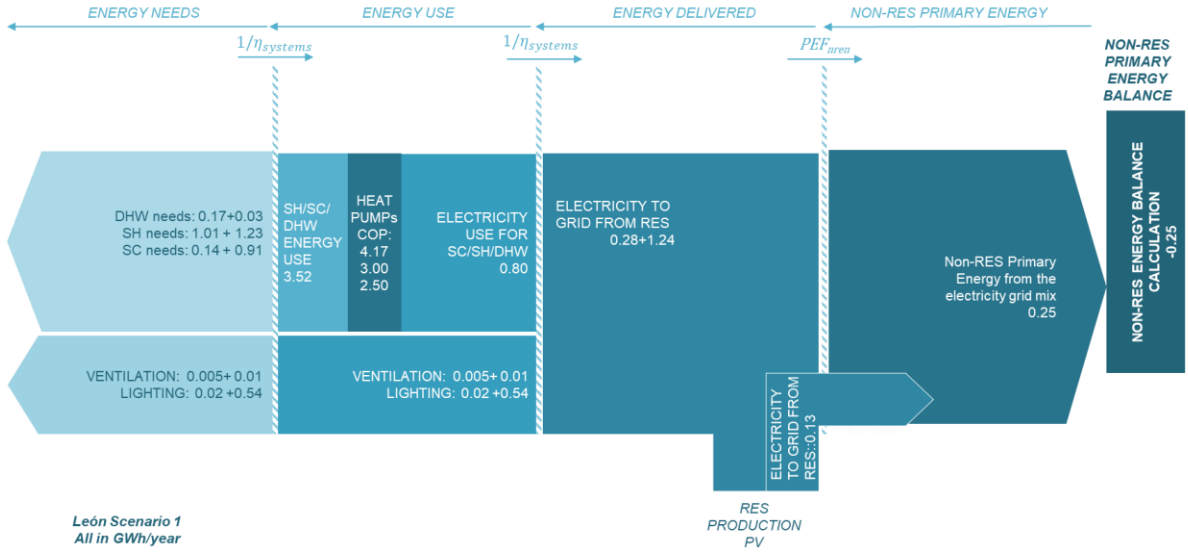


Figure 60: Sankey diagram energy flow León PED Scenario 1 (in GWh/yr)

<u>Scenario 2:</u>

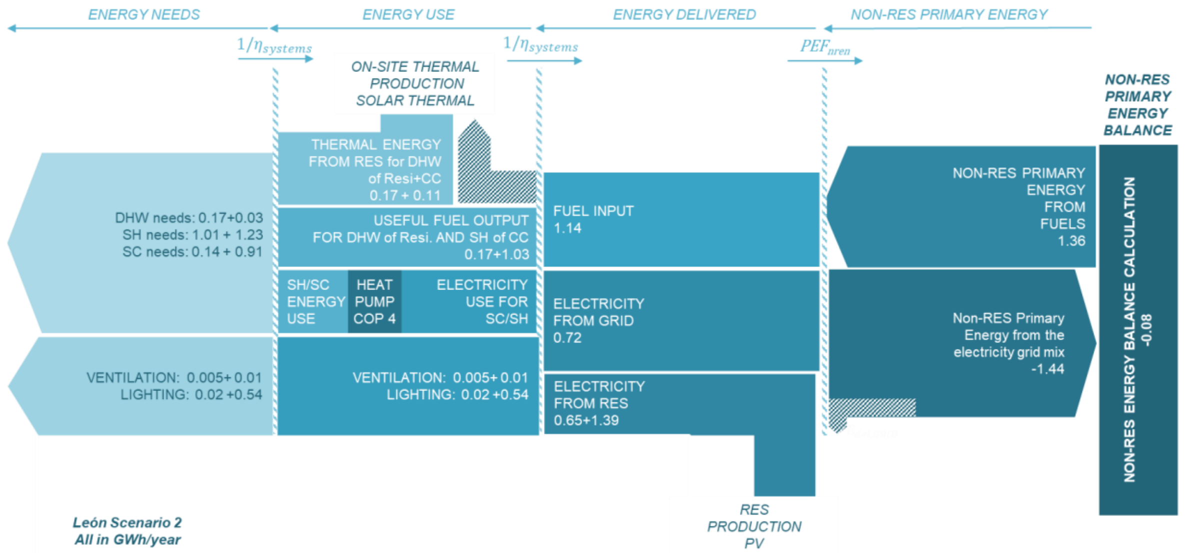


Figure 61: Sankey diagram energy flow León PED Scenario 2 (in GWh/yr)

Scenario 3:

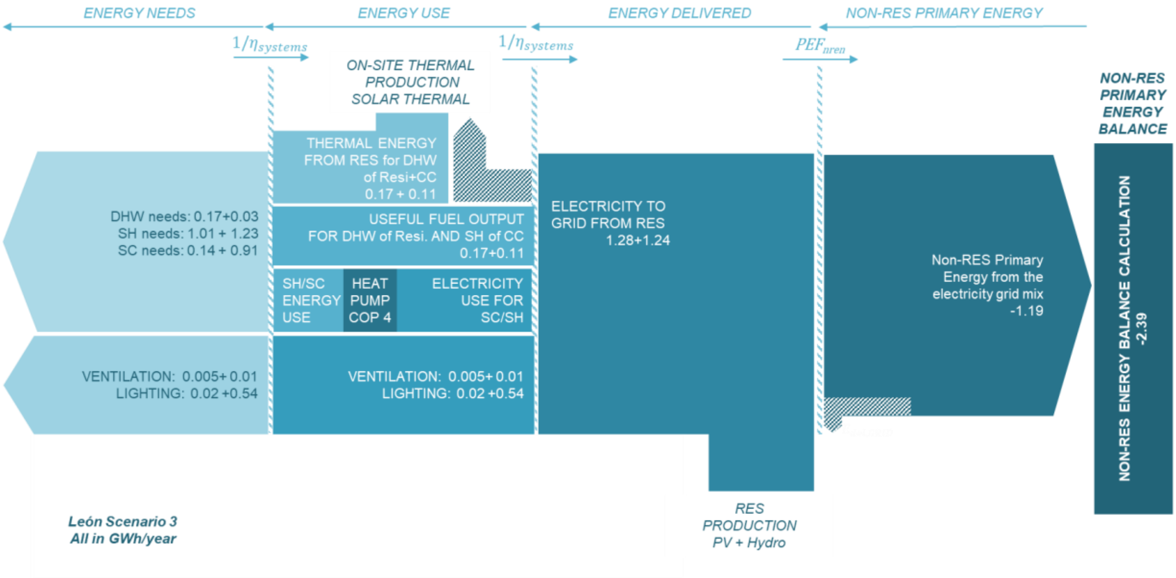


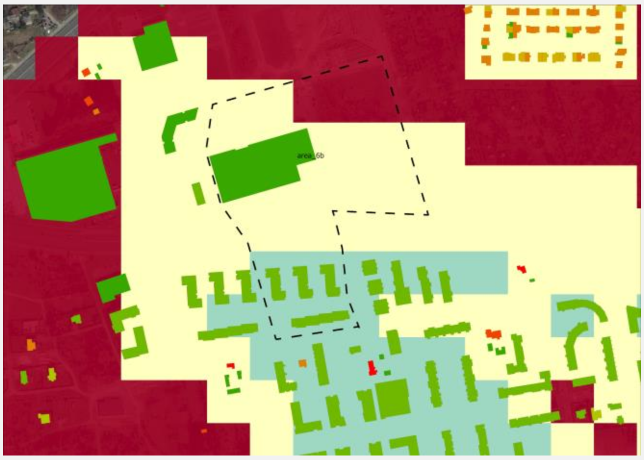
Figure 62: Sankey diagram energy flow León PED Scenario 3 (in GWh/yr)

9 PED Design in Lublin

Once the PED boundary is identified in Lublin (Annex I: Microscale analysis results), the next step is the development of the stakeholder and citizen engagement strategy for co-designing PEDs, identifying and selecting technology packages and verify the annual primary energy balance to figure out if the district is positive or not.

The theoretical heating/cooling demand and the renewable installations are derived from the energy demand maps that were developed within WP1 and first estimations are discussed with the municipality representatives for figuring out the PED potential not only from technical but also economic, legal, social and political point aspects. Area 6 consisting of several buildings were identified first as the potential area, but due to energy surplus ambition and on-site solar generation needs, the area is revaluated and decreased to Area6b. The preliminary results on the selected area (Area 6 for Lublin) are displayed below.

Table 17: Main characteristics of area selected to become PED – Lublin

Area to become PED	Main characteristics of selected area	
	Surface: 72,832.47m^2	
	*Built roof area: 12,547.03m	*Commercial roof area: 9,117.7m^2
	Total nº of buildings: 5	
	*Residential: 4	*Commercial buildings: 1
	Heat demand: 793,023 kWh/year Cooling demand: 202,264.3 kWh/year	
	Potential Renewable installations on rooftops: 1568kW	

9.1 Stakeholder and Citizen Engagement Strategy

Social innovation activities are essential in decarbonisation process to maximize citizen engagement and technology appropriation. To empower citizens, the cornerstone of the city's transformation, a very ambitious citizen engagement strategy has been defined, including co-creation and co-design strategies to turn citizens into active actors of the city's energy transition. The City of Lublin intends to implement the participatory instruments proposed in the process to shape a smart and engaged society. The aim is to involve the city's key stakeholders comprising representatives of citizens, business and academia in the process and to programme a vision of the city's energy transition that is acceptable to all. The public inclusion process will consist of the steps explained in D1.32 Long-term city plan of Lublin (city vision 2050) – Intermediate version – Section 3.3 Engagement strategies to place citizens at the centre of the energy transition.

As mentioned before in Section 5, the results of the questionnaires will be evaluated with T5.7 experts (CAP, VTT, TNO, HANZE and DEM) and will be shared in deliverable of this task later.

9.2 Selected PED Solutions

City of Lublin has conducted the Technology selection tool developed by CAR and DEM answering to the relevant questions to their city and identified district context. Since a preliminary research has been conducted with all the FWCs regarding the resource availability, urban macroform, land use context, energy infrastructure and services and social structure before (M24 – D4.3 Candidate Areas to become PED – Macro-scale Analyses) at city level and also regarding the barrier and enabler analysis of all the technologies (M24 – D4.1 Methodology and Guidelines for PED Design) also at city level, it became easier for city of Lublin to answer these questions of the tool for the identified PED district (Micro-scale Analysis results). The answers to the questions are listed in Figure 63and the macro tool was activated and technology package with recommendations are displayed (Figure 64).

Ambition level or Objectives of your district	Self-sufficiency
Concept boundary	Geographical

District context and its characteristics

Needs to be supplied

in general, do you have space heating needs in the district?	NO
in general, do you have space cooling needs in the district?	YES
in general, do you have Domestic hot water needs in the district?	NO
in general, do you have electricity needs in the district?	NO

Resource availability (answer all questions)

	Does the district have significant solar potential?	YES
Solar questions:	Available space on any roof?	YES
	Is it possible to install solar integrated technologies in the building envelope?	NO
	Is it possible to install solar technologies In a water surface nearby?	NO
	Is it possible to install solar technologies In a parking lot or an empty lot nearby?	YES
	Does the district have significant wind potential?	NO
Wind questions:	would you like to install wind turbines on-site or off-site?	NO
	Does the district have significant ground coupling potential (subsurface potential)?	YES
Subsurface potential:	Is it possible to install ground source heat pumps?	YES
	Is it possible to use the ground or aquifers as thermal storage?	YES
	Can the district use a water body to exchange heat with a heat pump?	NO
	Can the district use a water body for hydro generation?	NO
Hydro questions:	is it around the district area (around 5 km)?	NO
	Does the district have significant biomass potential?	NO
	Does the district have available a waste heat source?	NO

Urban macroform (answer YES if applicable)

Is the district a new development area?	NO
Is the district going to be retrofitted?	NO
Is the district an infill area?	NO
Is the district a transformation area?	NO
is the district a heritage area?	NO

Select the type of buildings (use) within your district (answer YES if applicable)

Residential use?	YES
Commercial?	YES
Active Green / Open Parking Lot?	YES
Public Administration?	NO
Social / Cultural/Educational/Sport ?	NO
Industrial?	NO

Energy infrastructures (answer all questions)

is there any district heating network (DHN) nearby?	YES
Is the district off-grid?	NO
does the district have a private electricity grid?	NO
Is the district connected to the gas network?	YES
Do you want to include e-mobility aspects?	YES
Do you want to include hydrogen-mobility aspects?	YES
Do you want to apply soft-mobility aspects?	NO

Energy services and management (answer all questions)

Do you want to interact with the gas grid? (injection of hydrogen or biogas)	NO
Do you want to offer ancillary services?	YES
do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	NO
Do you want to offer hydrogen to industry or for electricity generation?	NO
Do you want to interact with the users/consumers?	YES
Would you need a data platform?	YES
Do you want that the electricity and thermal production is matched (by optimization, etc.)?	YES

Social structure

Do you want to form an energy community in the district?	YES
Is there any people suffering from energy poverty in the district?	NO

Figure 63: Answers of City of Lublin for the macro tool

The city has answered to the heating, DHW and electricity needs as "NO" but it is evaluated as not correct and reconducted the technology selection tool by selecting "YES" to DHW, Electricity and heating needs in Lublin PED.

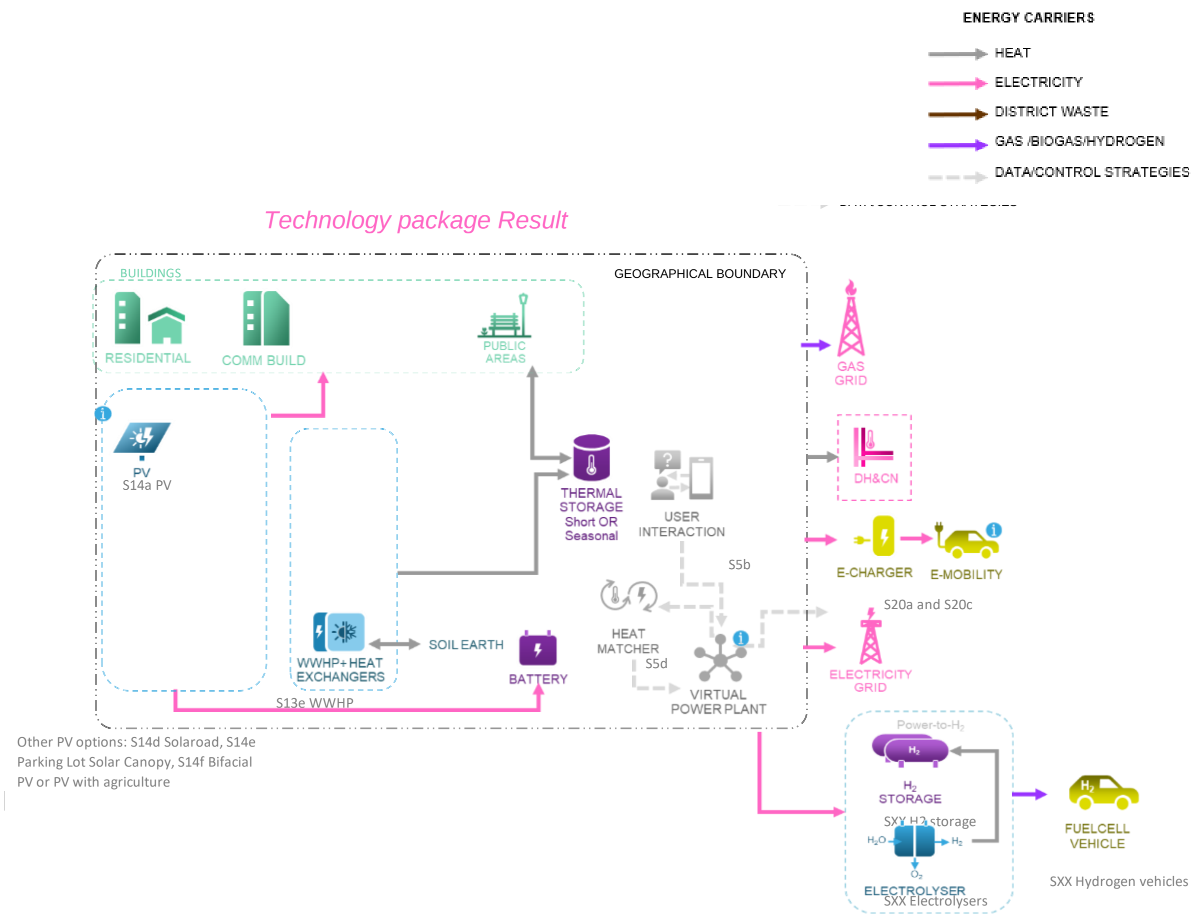


Figure 64: Technology Package Result for Lublin PED Boundary

Results of Lublin in a nutshell:

You have achieved a self-sufficient technology package. To achieve self-sufficiency, i.e. avoid always consuming/importing energy from the wider grids. Plus, retrofitting is a must and RES combined with storage are always recommended to balance the supply side. As biomass is usually imported from outside the PED boundaries, it is not recommended, but it could be used if the PED is close to the forest waste and does not need much transport. Biogas could be installed, but it is not the priority (as it does not aim circularity). Smart controllers (to predict energy production, store energy, perform demand shifting, etc.) are recommended as otherwise it would be hard to assess when to export energy and when to self-consume it. The interaction with the wider grids could be to export to the natural gas pipeline if hydrogen or/and biogas is/are produced, to the district heating network if heating is produced, and/or to the power grid.

Recommendations for other Technologies:

- As thermal storage options you can install short (S10c) or long-term storage(S10b), PCM (S10a), among others.
- To offer ancillary services, you can check solution SXX Ancillary services. For example, to offer demand shifting or demand response, you will need controllable loads (e.g. be able to switch off/on heat pumps, appliances, etc.)

- You can check the SXX Creation of an energy community, to know a bit more about Renewable Energy Communities
- Data Platforms are recommended, such as Sd, Se or S7a
- To allow user feedback to take into account, phone apps or user-interface could be used, such as S5b

9.3 PED Calculation for Verification

Once PED technologies are identified in Lublin PED Boundary, a calculation process has been held to figure out if the identified technologies already provide a surplus of annual energy balance. If the technologies do not provide positivity, new solutions such as decreasing the energy demand, increasing energy efficiency and energy generation will be conducted within the PED boundary. **2 Alternative scenarios** were conducted to provide different options and financial plans. The municipality may decide later, which one to go further for detailed execution plans and potential implementation of PED area after the MAKING-CITY project lifetime.

9.3.1 PED boundaries definition

The boundary for Lublin PED Area is geographically bounded and the ambition is to reach Self-Sufficiency. There is a shopping centre with a large rooftop area for solar generation and there are also an empty lot (just on the east side of the building) and a carpark area (on the north side) next to the commercial centre. These areas can also be evaluated for on-site (on the ground – or canopies for cars) energy generation. There are also new built (mainly in 2012) residential blocks with high efficiency and this district is so-called an "eco-district". Thanks to the District Heating Grid (DHN), all buildings are connected to each other the network has potential for sharing mechanisms in the PED Area. Another opportunity for renewable energy is that these buildings are connected to more or less the end point of DHN and for this reason, a waste heat potential from the return pipe may also be considered. There are also small size residentials, that are not connected to the DHN, around the PED area and this enlightened the technical team for exporting energy from PED to these areas with a new infrastructure.

Figure 65: Lublin PED Boundary

2 scenarios for energy generation are generated to achieve PEDs according to the technologies identified in the previous section and also considering the potentials of the district based on the discussion technical team had.

<u>Scenario 1: All PV+ All heat pumps + Solar Thermal for commercial building</u>

PV: 3466.25 kW (19411 m2 rooftop area available)

Solar Thermal: 952.94 kW (1350 m2 rooftop area available)

HP: 755.25 kW – 30.8 W/m2 of HPs

Scenario 2: All PV+ All heat pumps + Solar Thermal for commercial building + Export energy with the nearby buildings by heat pumps at the building sites

PV: 3466.25 kW (19411 m2 rooftop area available)

Solar Thermal: 952.94 kW (1350 m2 rooftop area available)

HP: 1010.60 kW – 41.20W/m2 of HPs

9.3.2 Energy needs inside PED boundaries

All data related to thermal and electric energy needs are based on the data gathered from municipality regarding the actual demand analyses of the Residential Buildings. Energy savings and data regarding the building envelope of all the residential buildings were also shared, thanks to energy certificates of these buildings. The Shopping mall energy demand analyses are gathered from the work conducted under WP1 for the theoretical energy demand analyses of all cities of MAKING-CITY. Lublin space heating and domestic hot water needs are being supplied by a district heating network (as mentioned above), whose heat is generated by gas boilers in the central heating plant of the network. In Poland, according to the EPB regulation the non-renewable primary energy factor of gas-driven district heating networks is 1.2, which will be used in the step of calculating the primary energy. The energy needs of the buildings for both scenarios are the same. A 17% efficiency is considered for DHW needs for residentials as it was indicated in the demand certificates of these buildings shared by the municipality.

ENERGY NEEDS

THERMAL ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	DHW needs	10222.05	x	54.18	=	0.55
	SH needs	10222.05	x	83.75	=	0.86
	SC needs	10222.05	x	6.27	=	0.06
Shopping Center	DHW needs	14305.35	x	3.20	=	0.05
	SH needs	14305.35	x	17.36	=	0.25
	SC needs	14305.35	x	9.66	=	0.14
						=
				Total Thermal Energy Needs	=	1.91

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	Lighting	10222.05	x	4.93	=	0.05
	Ventilation	10222.05	x	1.00	=	0.01
Shopping Center	Lighting	14305.35	x	104.39	=	1.49
	Ventilation	14305.35	x	7.00	=	0.10
				Total Electric Energy Needs	=	1.65

Figure 66: Energy needs in MAKING-CITY tables for Lublin in GWh/year

9.3.3 Energy Use

Thermal and electric energy uses are calculated considering the energy needs and the distribution losses since the systems are centralized for DHW, space heating and cooling. The potential losses for thermal uses may be reviewed in Table 18 and for electric losses in Table 19

Table 18: Distribution Losses for Thermal Use

Distribution Losses (DHW)	Distribution Losses (SH & SC)	Heat exchanger
10%	15%	90%

Table 19: Distribution Losses for Electric Use

Ventilation losses	Lighting losses	Distribution losses	Distribution Losses (SH & SC)
5%	2%	5%	15%

The difference between energy needs and energy use are due to heat pumps consumption (accounted in electricity use).

Scenario 1: Energy uses are supplied with heat pumps, which upgrade the heat of the return of the district heating network (i.e. from low temperatures to 60 ºC); furthermore, PV is installed at the roof of the residential and commercial buildings as well as in parking and empty lots. The commercial building space heating is supplied by solar thermal panels (flat plate collectors = FPC) and the excess solar heat is exported to the DHN. District scale SC uses and SC Uses for the shopping centre are the exports from SC which are transferred to electric energy use for SC.

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use		/		=	0.00
	SH use		/		=	0.00
	SC use		/		=	0.00
Shopping Center	DHW use	0.05	/	0.95	=	0.05
	SH use	0.25	/	0.95	=	0.26
	SC use		/		=	0.00
District						
	Consumption from DHN	0.89	/	0.95	=	0.94
	SC use	-0.10	/	1.00	=	-0.10
						=
				Total Thermal Energy use	=	1.15

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	0.90	/	2.50	=	0.36
	SC electric use	0.06		2.50		0.03
	DHW electric use	0.58	/	2.50	=	0.23
	Ligthing needs (usually losse	0.05	/	1.00	=	0.05
	Ventilation needs (usually loss	0.01	/	1.00	=	0.01
Shopping Center	SH electric use		/	1.00	=	0.00
	SC electric use	0.14	/	3.50	=	0.04
	DHW electric use		/		=	0.00
	Ligthing needs (usually losse	1.49	/	1.00	=	1.49
	Ventilation needs (usually loss	0.10	/	1.00	=	0.10
						=
				Total Electric nergy use	=	2.31

Figure 67: Energy uses in MAKING-CITY tables for Lublin - Scenario 1 in GWh/year

Scenario 2: In addition to the previous mentioned technologies, a new area is connected to a low temperature ring (at 40/60 ºC), that is consuming from the return of the existing DHN (48/38ºC) and upgraded (up to 60º) with heat pumps at the building sites. District scale thermal energy use and electric energy use this need to be provided by the central district heating network (in addition), to be able to export -0.59 GWh/y. District scale SC uses and SC Uses for the shopping centre are the exports from SC which are transferred to electric energy use for SC.

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use		/		=	0.00
	SH use		/		=	0.00
	SC use		/		=	0.00
Commercial 1	DHW use	0.05	/	0.95	=	0.05
	SH use	0.25	/	0.95	=	0.26
	SC use		/		=	0.00
District	District heating waste heat minus the heat rejected by cooling	0.39	/	1.00	=	0.39
	Consumption from DHN	0.89	/	0.95	=	0.94
	SC use	-0.10	/	1.00	=	-0.10
						=
				Total Thermal Energy use	=	1.54

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	0.90	/	2.50	=	0.36
	SC electric use	0.06		2.50		0.03
	DHW electric use	0.58	/	2.50	=	0.23
	Ligthing needs (usually losse:	0.05	/	1.00	=	0.05
	Ventilation needs (usually loss	0.01	/	1.00	=	0.01
Commercial 1	SH electric use		/	1.00	=	0.00
	SC electric use	0.14	/	3.50	=	0.04
	DHW electric use		/		=	0.00
	Ligthing needs (usually losse:	1.49	/	1.00	=	1.49
	Ventilation needs (usually loss	0.00	/	1.00	=	0.00
District						
	district HP	0.59	/	4.00	=	0.15
						=
				Total Electric nergy use	=	2.36

Figure 68: Energy uses in MAKING-CITY tables for Lublin Scenario 2 in GWh/year

9.3.4RES production inside the PED

The local generation of renewable heat and electricity in Lublin PED area is consisting of solar and solar thermal and heat pumps connected to the DHN at district scale. They are all generated within the geographical PED boundary. For electricity PV panels are utilized on the roofs of all residential buildings and the shopping center (estimated 70% efficient area for installation). The PV Solar potential[8] in Lublin is 1041.4 kWh/kWp and the Solar irradiation is 1293.94 kWh/m2. The ratio for area (m2) PV per kWp is considered to be 8. For this reason, 300kWp installation is calculated for the residentials (covering 2401m2) and 2100kWp (6300 m2) for roof of the shopping center. The open carpark area (4300m2*70%) and the empty lot next to the shopping center (11000m2*70%) is also included for solar energy generation with a value of 1338.75kWp.

[8] https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html#PVP

Scenario 1: For Thermal RES, heat pumps are utilized, which upgrade the heat of the return of the district heating network (i.e. from low temperatures to 60 ºC. The commercial building space heating is supplied by solar thermal panels (flat plate collectors = FPC) and the excess solar heat is exported to the DHN.

The useful energy (output) from renewable energy sources is calculated:

					CHP_biomass:	
GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	Biomass_heat
buildings	0.31					
commercial	0.82			0.70		
district	1.39					
Total=	2.53	0.00	0.00	0.70	0.00	0.00

Total energy from RES(electric)		=	2.53
Total energy from RES(thermal)		=	0.70
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.45
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-0.21

Figure 69: RES production in MAKING-CITY tables for Lublin – Scenario 1 in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use and Surplus energy (-) to be exported outside limits for electric use.

Scenario 2: For Thermal RES, in addition to the previous mentioned technologies, a new area (surrounding buildings) is connected to a low temperature ring (at 40/60 ºC), that is consuming from the return of the existing DHN (48/38ºC) and upgraded (up to 60º) with heat pumps at the building sites.

The useful energy (output) from renewable energy sources is calculated:

	kwh				CHP_biomass:	
GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	Biomass_heat
buildings	0.31					
commercial	0.82			0.70		
industry process						
utility						
district	1.39					
Total=	2.53	0.00	0.00	0.70	0.00	0.00

Total energy from RES(electric)		=	2.53
Total energy from RES(thermal)		=	1.38
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.16
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-0.17

Figure 70: RES production in MAKING-CITY tables for Lublin – Scenario 2 in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use and Surplus energy (-) to be exported outside limits for electric use.

9.3.5 Energy delivered

In Lublin, part of the thermal energy is provided by DHN at dwelling and commercial level while there is a surplus of electric energy that can be exported.

Scenario 1: Particularly, 0.94 GWh/year are imported from the return pipe of the DHN and upgraded by the heat pumps inside the PED. Nevertheless, as there are also 0.1 GWh/year of waste heat from space cooling systems of the commercial buildings, and 0.39 GWh/year of solar heat exported, the remaining energy (0.45 GWh/year) indicated in Figure 57 is the net energy that needs to be additionally provided by the gas boilers at the central stations of the DHN.

At the delivered energy section, the 0.45 GWh/year are transformed in gas energy imports to the district. Similar result will be obtained if 0.45 is directly multiplied by the 1.2 primary energy factor of the DHN.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Gas boiler	0.45	/	0.90	=	0.50
Last check: Any remaining energy to be covered??					
electr_grid national	-0.21		1.00	=	-0.21

Figure 71: Energy delivered in MAKING-CITY tables for Lublin – Scenario 1 in GWh/year

PV production supplies the electric energy uses of the residential and commercial buildings, plus the electricity consumption of the heat pumps. As there is more production than what is needed inside the boundaries, 0.35 GWh/year are exported to the grid.

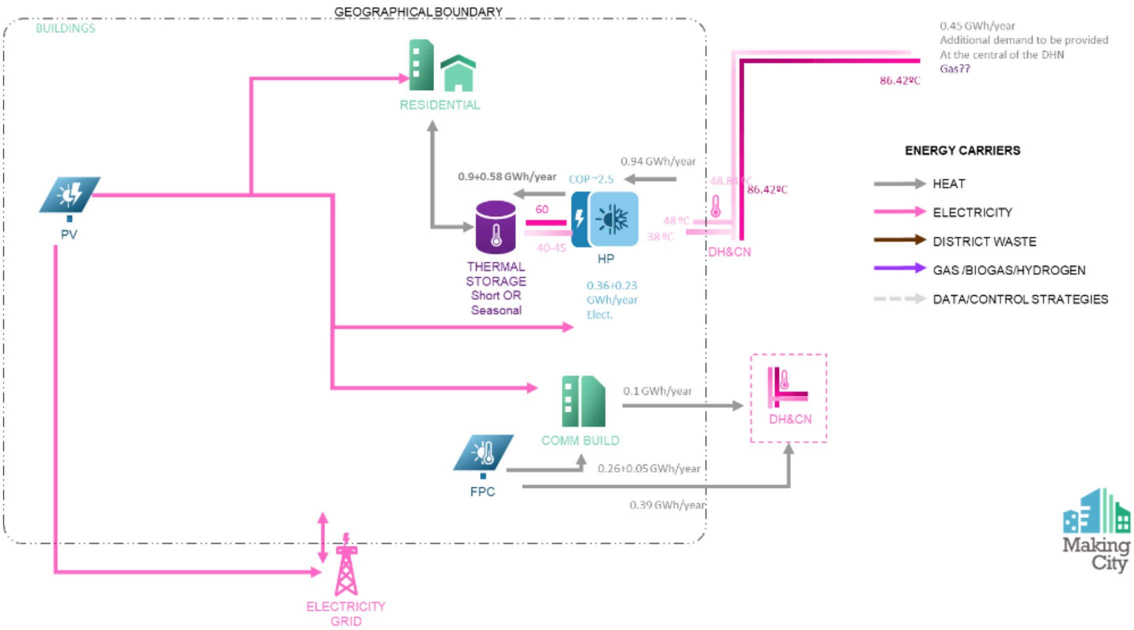


Figure 72: Diagram of the production from Scenario 1

Scenario 2: Particularly, 0.94+0.44 GWh/year are imported from the return of the DHN and upgraded by the heat pumps inside the PED. Nevertheless, as there are also 0.1+0.05 GWh/year of waste heat from space cooling systems of the commercial buildings and the heat pumps supplying the needs of outside the PED (in cooling mode); 0.39 GWh/year of solar heat exported to the DHN and 0.59 GWh/year of heat produced inside the PED and exported to neighbouring buildings, the remaining energy (0.84 minus 0.59 GWh/year) indicated in Figure 73 is the net energy. But at the delivered energy section, the 0.84 GWh/year are transformed in gas energy imports to the district, whereas the 0.59 are exported to outside the boundaries. Similar result will be obtained if 0.84 is directly multiplied by the 1.2 primary energy factor of the DHN.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy		Efficiency		Delivered energy to district kWh
Gas boiler	0.84	/	0.90	=	0.93
Last check: Any remaining energy to be covered??					
electr_grid national	-0.17		1.00	=	-0.17
DH_national av.	-0.68		1.00		-0.68

Figure 73: Energy delivered in MAKING-CITY tables for Lublin – Scenario 1 in GWh/year

PV production supplies the electric energy uses of the residential and commercial buildings, plus the electricity consumption of the heat pumps. As there is more production than what is needed inside the boundaries, 0.20 GWh/year are exported to the grid.

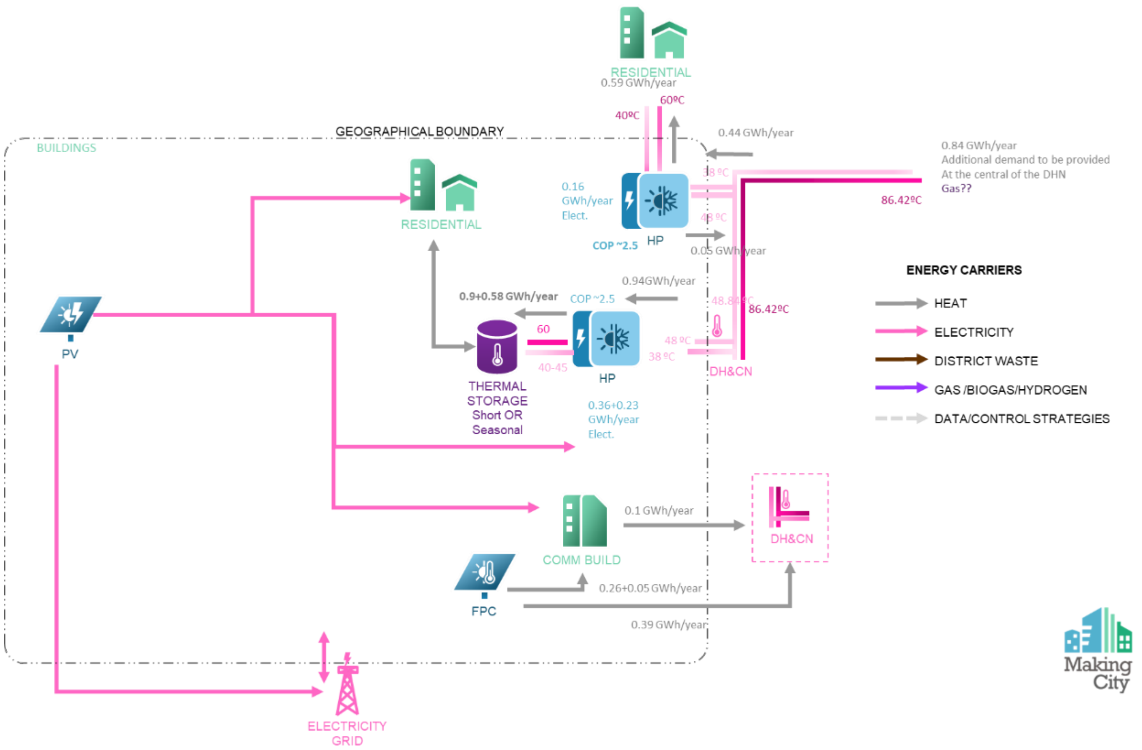


Figure 74: Diagram of the production from Scenario 2

9.3.6 Primary Energy Balance

Scenario 1: PED is achieved. Primary Energy Balance = -0. 09 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Imported(+) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
national gas network	0.4995315	x	1.1	=	0.55

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
electr_grid national	-0.21	x	3	=	-0.64

PRIMARY ENERGY BALANCE (NON-RENEWABLE) = **-0.09**

PED Achieved!

Figure 75: non-RES Balance in MAKING-CITY tables for Lublin - Scenario 1 in GWh/year

Scenario 2: PED is achieved. Primary Energy Balance = -0. 29 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Imported(+) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
national gas network	0.934818579	x	1.1	=	1.03

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
DH_national av.	-0.68	x	1.2	=	-0.82
electr_grid national	-0.17	x	3	=	-0.50

PRIMARY ENERGY BALANCE (NON-RENEWABLE) = **-0.29**

PED Achieved!

Figure 76: non-RES Balance in MAKING-CITY tables for Lublin - Scenario 2 in GWh/year

9.3.7 Energy Flow Diagrams

Scenario 1:

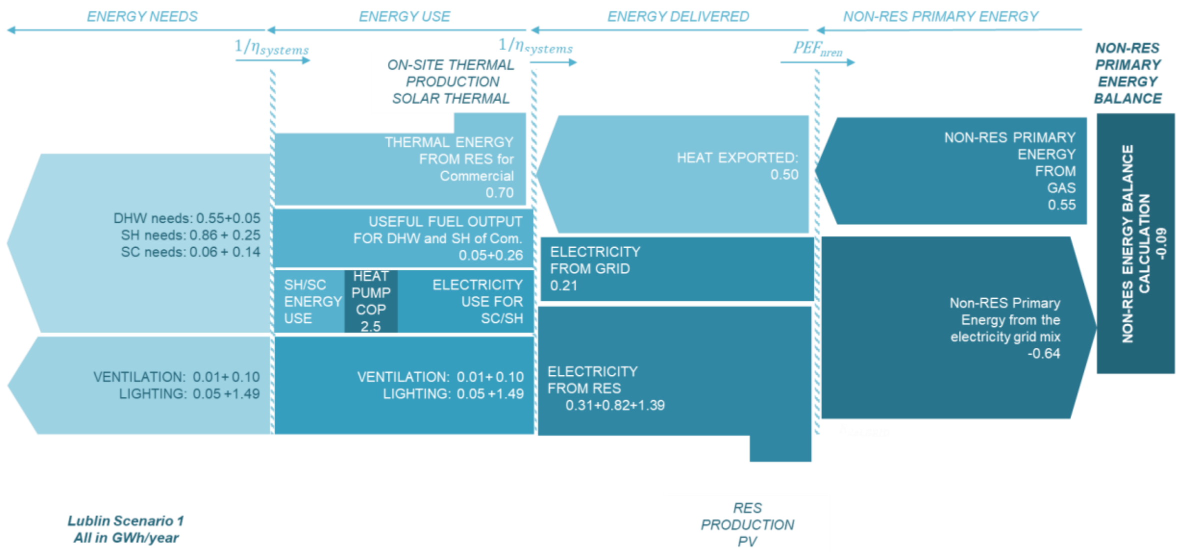


Figure 77: Sankey diagram energy flow Lublin PED Scenario 1 (in GWh/yr)

Scenario 2:

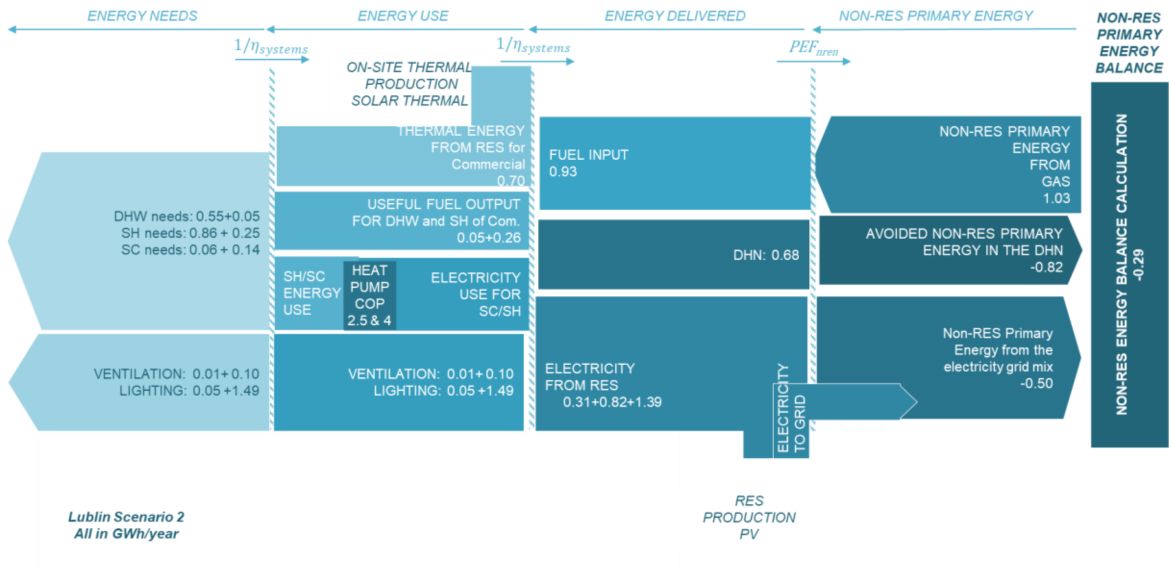
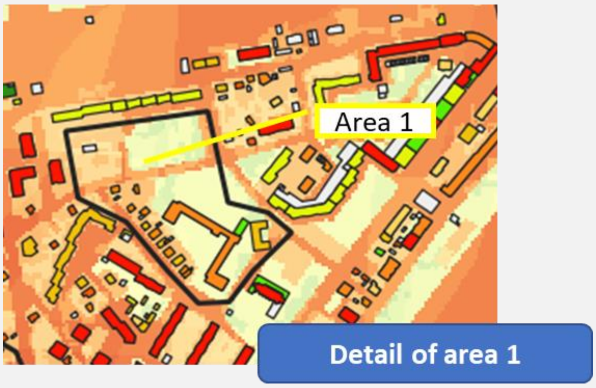


Figure 78: Sankey diagram energy flow Lublin PED Scenario 2 (in GWh/yr)

10 PED Design in Vidin

Once the PED boundary is identified in Vidin (Annex I: Microscale analysis results), the step is the development of the stakeholder and citizen engagement strategy for co-designing PEDs, identify and select technology packages and verify the annual primary energy balance to figure out if the district is positive or not. Area selected by Vidin to become energy positive and the main characteristics of it are summarized in Table 20.

Table 20: Main characteristics of area selected to become PED – Vidin

<table>
<tr><th>Area to become PED</th><th colspan="2">Main characteristics of selected area</th></tr>
<tr><td rowspan="6">
</td><td colspan="2">Surface: 35.135 m^2</td></tr>
<tr><td>*Built roof area: 5.193m^2</td><td>*Public roof area: 3.876m^2</td></tr>
<tr><td colspan="2">Total nº of buildings: 33</td></tr>
<tr><td>*Residential: 16
*Commercial: 0
*Other: 10</td><td>*Public buildings: 7</td></tr>
<tr><td colspan="2">Heat demand: 511.700kWh/year
Cooling demand: 170.274kWh/year</td></tr>
<tr><td colspan="2">Renewable installations: #NA</td></tr>
</table>

10.1 Stakeholder and Citizen Engagement Strategy

The city has experience in engaging the citizens in urban planning processes through applying the traditional procedures defined by the legislation for public debates. Other similar traditional practices for citizen involvement may include activities such as signing petitions, conducting surveys, conducting public consultations and meetings between representatives of local authorities and citizens. The selection of these tools within the MAKING-CITY project is focused on their applicability and their potential for change among the citizens. Within the traditional approaches for citizen engagement, the city has identified in D1.31 Long-term city plan of Vidin (city vision 2050) – Intermediate version – Section 3.3 Engagement strategies to place citizens at the centre of the energy transition.

As mentioned before in Section 5, the results of the questionnaires will be evaluated with T5.7 experts (CAP, VTT, TNO, HANZE and DEM) and will be shared in deliverable of this task later.

10.2 Selected PED Solutions

According to the MCDA analysis done in previous steps of the WP4, the Technology selection tool was conducted by TEC and City of Vidin validate the content. The answers to the questions are listed (Figure 79) and the macro tool was activated and technology package with recommendations are displayed (Figure 80).

Ambition level or Objectives of your district	Self-sufficiency
Concept boundary	Virtual
District context and its characteristics	
Needs to be supplied	
in general, do you have space heating needs in the district?	YES
in general, do you have space cooling needs in the district?	NO
in general, do you have Domestic hot water needs in the district?	YES
in general, do you have electricity needs in the district?	YES
Resource availability (answer all questions)	
Does the district have significant solar potential?	YES
Solar questions: Available space on any roof?	YES
Is it possible to install solar integrated technologies in the building envelope?	NO
Is it possible to install solar technologies In a water surface nearby?	YES
Is it possible to install solar technologies In a parking lot or an empty lot nearby?	YES
Does the district have significant wind potential?	NO
Wind questions: would you like to install wind turbines on-site or off-site?	NO
Does the district have significant ground coupling potential (subsurface potential)?	NO
Subsurface potential: Is it possible to install ground source heat pumps?	NO
Is it possible to use the ground or aquifers as thermal storage?	YES
Can the district use a water body to exchange heat with a heat pump?	YES
Can the district use a water body for hydro generation?	NO
Hydro questions: is it around the district area (around 5 km)?	YES
Does the district have significant biomass potential?	NO
Does the district have available a waste heat source?	NO
Urban macroform (answer YES if applicable)	
Is the district a new development area?	NO
Is the district going to be retrofitted?	NO
Is the district an infill area?	NO
Is the district a transformation area?	NO
is the district a heritage area?	NO
Select the type of buildings (use) within your district (answer YES if applicable)	
Residential use?	YES
Commercial?	NO
Active Green / Open Parking Lot?	YES
Public Administration?	YES
Social / Cultural/Educational/Sport ?	YES
Industrial?	NO
Energy infrastructures (answer all questions)	
is there any district heating network (DHN) nearby?	NO
Is the district off-grid?	NO
does the district have a private electricity grid?	NO
Is the district connected to the gas network?	NO
Do you want to include e-mobility aspects?	NO
Do you want to include hydrogen-mobility aspects?	NO
Do you want to apply soft-mobility aspects?	NO
Energy services and management (answer all questions)	
Do you want to interact with the gas grid? (injection of hydrogen or biogas)	NO
Do you want to offer ancillary services?	NO
do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	NO
Do you want to offer hydrogen to industry or for electricity generation?	NO
Do you want to interact with the users/consumers?	NO
Would you need a data platform?	NO
Do you want that the electricity and thermal production is matched (by optimization, etc.)?	NO
Social structure	
Do you want to form an energy community in the district?	NO
Is there any people suffering from energy poverty in the district?	YES

Figure 79: Answers of City of Vidin for the macro tool

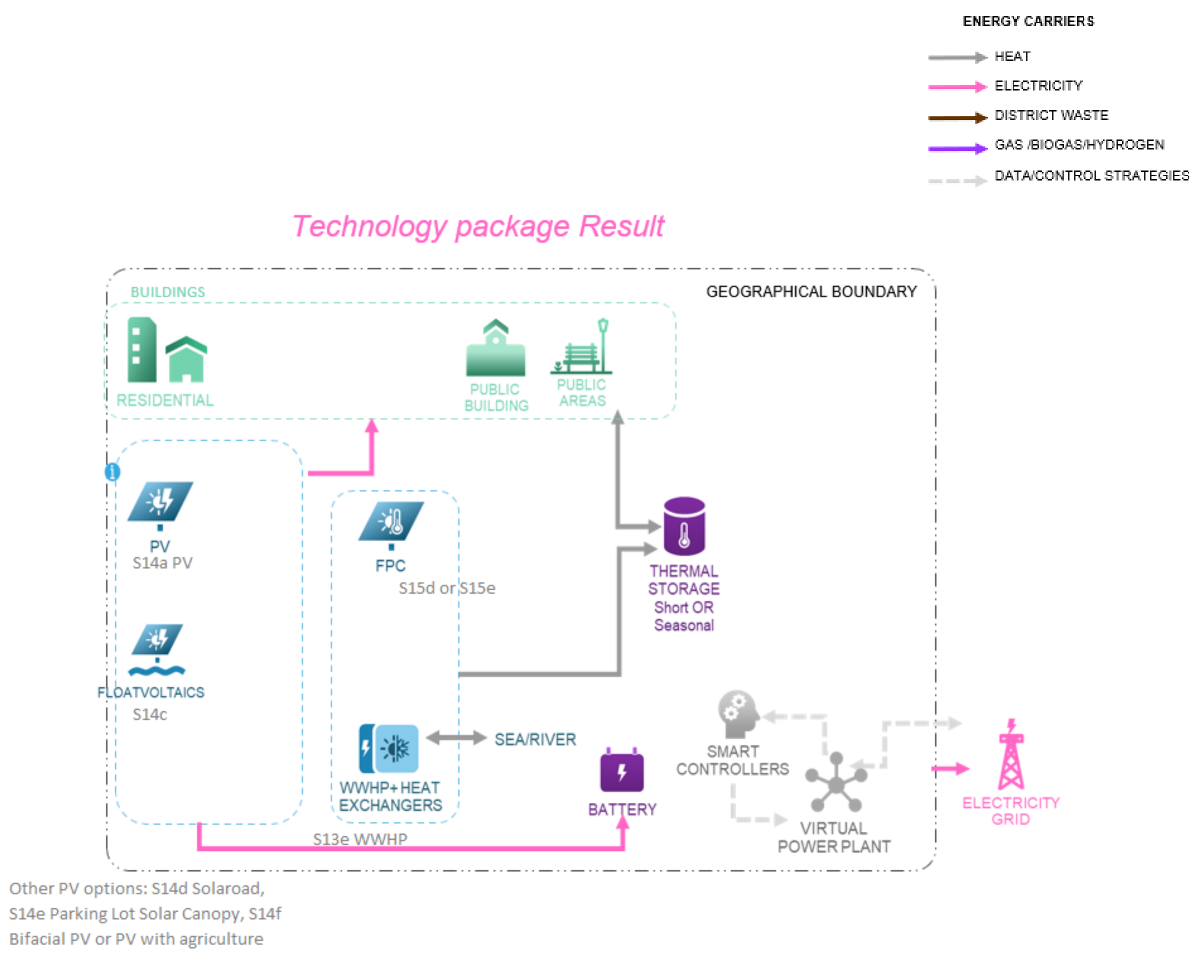


Figure 80: Technology Package Result for Vidin PED Boundary

Results of Vidin in a nutshell:

You have achieved a self-sufficient technology package. To achieve self-sufficiency, i.e. avoid always consuming/importing energy from the wider grids. Plus, retrofitting is a must and RES combined with storage are always recommended to balance the supply side. As biomass is usually imported from outside the PED boundaries, it is not recommended, but it could be used if the PED is close to the forest waste and does not need much transport. Biogas could be installed, but it is not the priority (as it does not aim circularity). Smart controllers (to predict energy production, store energy, perform demand shifting, etc.) are recommended as otherwise it would be hard to assess when to export energy and when to self-consume it. The interaction with the wider grids could be to export to the natural gas pipeline if hydrogen or/and biogas is/are produced, to the district heating network if heating is produced, and/or to the power grid.

Recommendations for other Technologies:

- To reduce space heating needs, it is recommended to insulate the building as much as possible and replace emitters by systems that require less temperature supply (Such as ground floor heating, fan coils, etc.)
- DHW requires (generally in most countries) 60ºC when is stored (to avoid legionella), but if the volume from the supply system to the demand is less than 3 m3, in Germany is allowed to reduce the temperature to 45ºC. Generally, in most countries if DHW is prepared instantaneously (with heat exchanger between storage and demand), then it can also be

reduced to 45ºC. Another way to reduce the demand, is to preheat the cold-water mains with waste heat (e.g. heat exchanger to extract heat from the grey water from the shower).

- Efficient lighting and appliances should be prioritized. Avoid stand-by modes when possible, using smart plugs to cutting off power when not needed.
- As thermal storage options you can install: short (S10c) or long-term storage(S10b), PCM (S10a), among others.
- Energy poverty is a distinct form of poverty associated with adverse consequences for health (respiratory, mental health, etc.) due to low temperatures (caused by switching off the heating system) and stress associated with unaffordable energy bills. To reduce energy poverty is recommended to increase training, to improve energy efficiency of buildings and to have special taxes (or rates, or special financial support) in houses with low incomes. Check more in SXX Energy Poverty mitigation.

10.3 PED Calculation for Verification

Once PED technologies are identified in Vidin PED Boundary, a calculation process has been held to figure out if the identified technologies already provide a surplus of annual energy balance. If the technologies do not provide positivity, new solutions such as decreasing the energy demand, increasing energy efficiency and energy generation will be conducted within the PED boundary.

10.3.1 PED boundaries definition

The boundaries for Vidin PED Area were expected to be virtual. The area mainly contains residential and private buildings. There is neither district heating nor gas infrastructure. There is geothermal potential in the area and an installation is being designed for the school highlighted in the Figure 81. Nowadays is not possible to share electricity produced unless the sharing infrastructure is created.

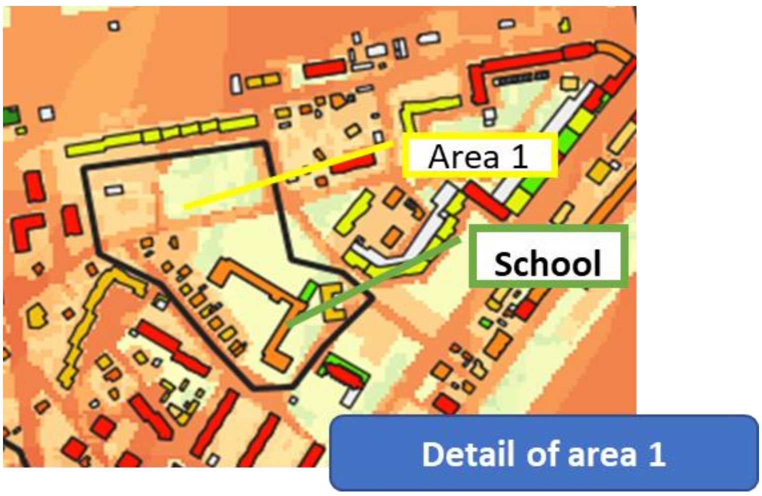


Figure 81: Vidin PED Boundary

The scenario selected by the municipality to convert the zone in energy positive consisted of: Solar PV + Geothermal HP.

10.3.2 Energy needs inside PED boundaries

All data related to thermal and electric energy needs are based on the data calculated in WP1 New long term urban planning towards 2050. The kWh/unit of thermal energy needs were defined according to Vidin building code.

ENERGY NEEDS

THERMAL ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
BUILDINGS	DHW needs	11335,00	**x**	15,00	=	0,17
	SH needs	11335,00	**x**	50,00	=	0,57
	SC needs	11335,00	**x**	5,00	=	0,06
						=
				Total Thermal Energy Needs	=	0,79

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
BUILDINGS	Lighting	11335,00	**x**	3,00	=	0,03
	Ventilation	11335,00	**x**	2,00	=	0,02
				Total Electric Energy Needs	=	0,06

Figure 82: Energy needs in MAKING-CITY tables for Vidin in GWh/year

10.3.3 Energy Use

Thermal and electric energy uses are calculated considering the energy needs and the distribution losses since the systems are centralized for DHW, space heating and cooling. The potential losses for thermal uses may be reviewed in Table 21 and for electric losses in Table 22.

Table 21: Distribution Losses for Thermal Use

Distribution Losses (DHW)	Distribution Losses (SH & SC)	Heat exchanger
10%	15%	90%

Table 22: Distribution Losses for Electric Use

Ventilation losses	Lighting losses	Distribution losses	Distribution Losses (SH & SC)
5%	2%	5%	15%

The difference between energy needs and energy use are due to heat pumps consumption (accounted in electricity use). The heat pumps have a COP of 4 and are connected to geothermal installations. In thermal energy uses only the energy provided by the geothermal installations is considered.

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
BUILDINGS	Lighting	11335,00	x	3,00	=	0,03
	Ventilation	11335,00	x	2,00	=	0,02
				Total Electric Energy Needs	=	0,06

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
BUILDINGS	DHW use	0,17	/		=	
	SH use	0,57	/		=	
				Total Thermal Energy use	=	0,00

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
BUILDINGS	SH electric use	0,57	/	4,00	=	0,14
	SC electric use	0,06	/	4,00	=	0,01
	DHW electric us	0,17	/	4,00	=	0,04
	Ligthing needs (usually loss	0,03	/	1,00	=	0,03
	Ventilation needs (usually los	0,02	/	1,00	=	0,02
				Total Electric energy use	=	0,26

Figure 83: Energy uses in MAKING-CITY tables for Vidin in GWh/year

10.3.4 RES production inside the PED

The local generation of renewable heat and electricity in Vidin PED area is consisting and geothermal heat pumps and solar photovoltaic respectively. They are all generated within the geographical PED boundary. Therefore, the initial expected virtual boundary is, in fact, geographical. For electricity PV panels are utilized on the roofs of residential buildings and the school. The installations cover the 25% of the total roof area (4918*0.25) and 245kWh of electricity production per square meter were considered for Vidin (according to solar map).

On the other hand, for Thermal RES, geothermal heat exchangers are installed and connected to heat pumps, which allows to achieve a COP of 4. The heat output coming from the geothermal wells is considered as an input for the heat pump, which upgrades the heat to the desired temperature.

The useful energy (output) from renewable energy sources is calculated:

	kwh				CHP_biomass:		
GWh	PV	wind/hydro	Geothermal	Solar Thermal	Biomass_el	Biomass_heat	Waste heat+HP
buildings	0,30			0,00			
district			0,78	0,00			0,00
Total=	0,30	0,00	0,78	0,00	0,00	0,00	0,00

Total energy from RES(electric)		=	0,30
Total energy from RES(thermal)		=	0,78
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0,00
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-0,05

Figure 84: RES production in MAKING-CITY tables for Vidin in GWh/year

Remaining energy to be covered by fossil fuels or external sources for thermal use and Surplus energy (-) to be exported outside limits for electric use.

10.3.5 Energy delivered

In Vidin, thermal energy is provided by geothermal installations and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

	Remaining energy	Efficiency		**Delivered energy to district kWh**	
electr_grid national	-0,05		=	-0,05	Surplus energy(-)to be exported outside limits
DH_national av.	0,00			0,00	Surplus energy(-)to be exported outside limits

Figure 85: Energy delivered in MAKING-CITY tables for Vidin in GWh/year

10.3.6 Primary Energy Balance

PED is achieved. Primary Energy Balance = -0.14 GWh

NON-RENEWABLE PRIMARY ENERGY BALANCE:

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
DH_national av.	0	x	1,2	=	0,00
electr_grid national	-0,05	x	3	=	-0,14
			PRIMARY ENERGY BALANCE (NON-RENEWABLE)	=	**-0,14**
					PED Achieved!

Figure 86: non-RES Balance in MAKING-CITY tables for Vidin in GWh/year

10.3.7 Energy Flow Diagrams

Scenario 1:

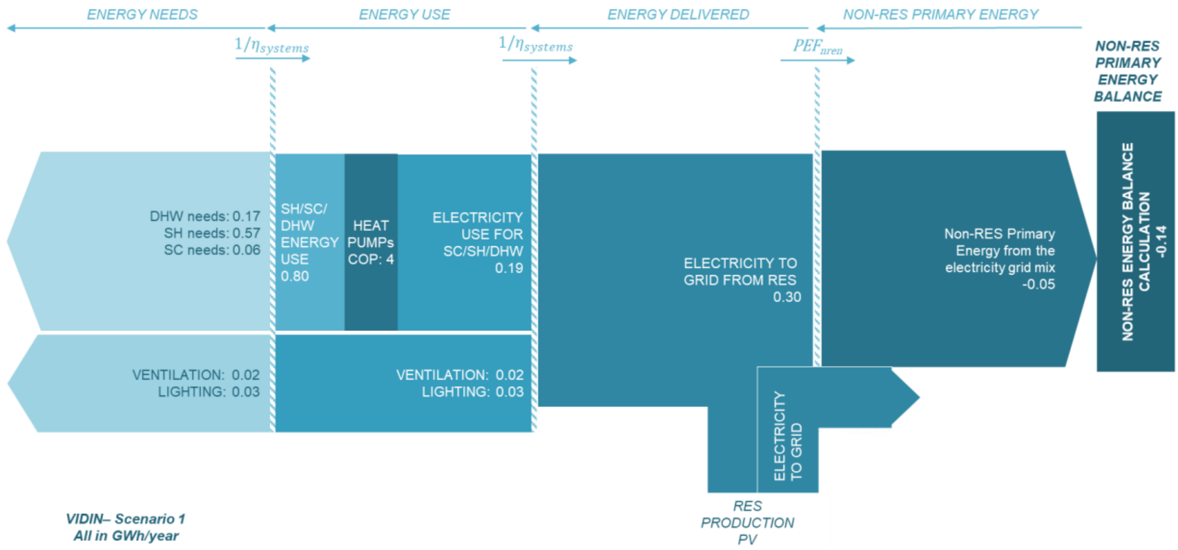


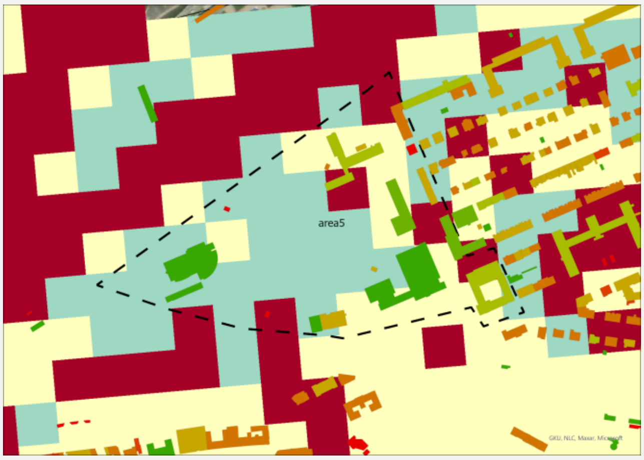
Figure 87: Sankey diagram energy flow Vidin PED Scenario 1 (in GWh/yr)

11 PED Design in Trenčín

Once the PED boundary is identified in Trenčín (Annex I: Microscale analysis results), the next step is the development of the stakeholder and citizen engagement strategy for co-designing PEDs, identifying and selecting technology packages and verify the annual primary energy balance to figure out if the district is positive or not.

The theoretical heating/cooling demand and the renewable installations are derived from the energy demand maps that were developed within WP1 and first estimations are discussed with the municipality representatives for figuring out the PED potential not only from technical but also economic, legal, social and political point aspects. The initial results on the selected area (Area 5 for Trenčín) are displayed below.

Table 23: Main characteristics of area selected to become PED – Trenčín

Area to become PED	Main characteristics of selected area	
	Surface: 234827.11m^2	
	*Total built roof area: 5,092.84m^2	*Public roof area: 2,593.61m^2
	Total nº of buildings: 10	
	*Residential: 3	*Public buildings: 7 : 3 sport buildings and 4 education buildings
	Heat demand: 3,399,933kWh Cooling demand: 315,307.80kWh	
	Potential Renewable installations on rooftops: 4692.75kW of Solar PV	

11.1 Stakeholder and Citizen Engagement Strategy

The city of Trencin is aware of the importance of wide and effective participation of relevant stakeholders in the preparation and also implementation of the long-term city plan Vision to 2050. The effectiveness of the whole transformation process will be jeopardised without real social innovation in the behaviour of inhabitants and other stakeholders' groups. Proposed processes and tools of citizens engagement offer a useful variety of tools for targeting all relevant groups of stakeholders within the city.

The motto of the city within the preparation of the City Vision 2050 is: **from awareness through engagement to the partnership.**

The city set up participation guidelines to support the participation and engagement processes of citizens and stakeholders. The main principles of participation were defined in D1.30 Long-term city plan of Trencin (city vision 2050) – Intermediate version – Section 3.3 Engagement strategies to place citizens at the centre of the energy transition.

As mentioned before in Section 5, the results of the questionnaires will be evaluated with T5.7 experts (CAP, VTT, TNO, HANZE and DEM) and will be shared in deliverable of this task later.

11.2 Selected PED Solutions

According to the MCDA analysis done in previous steps of the WP4 (See D4.3[9]), the Technology selection tool was conducted by DEM and City of Trencin validated the content. The answers to the questions are listed (Figure 88) and the macro tool was activated and technology package with recommendations are displayed (Figure 89

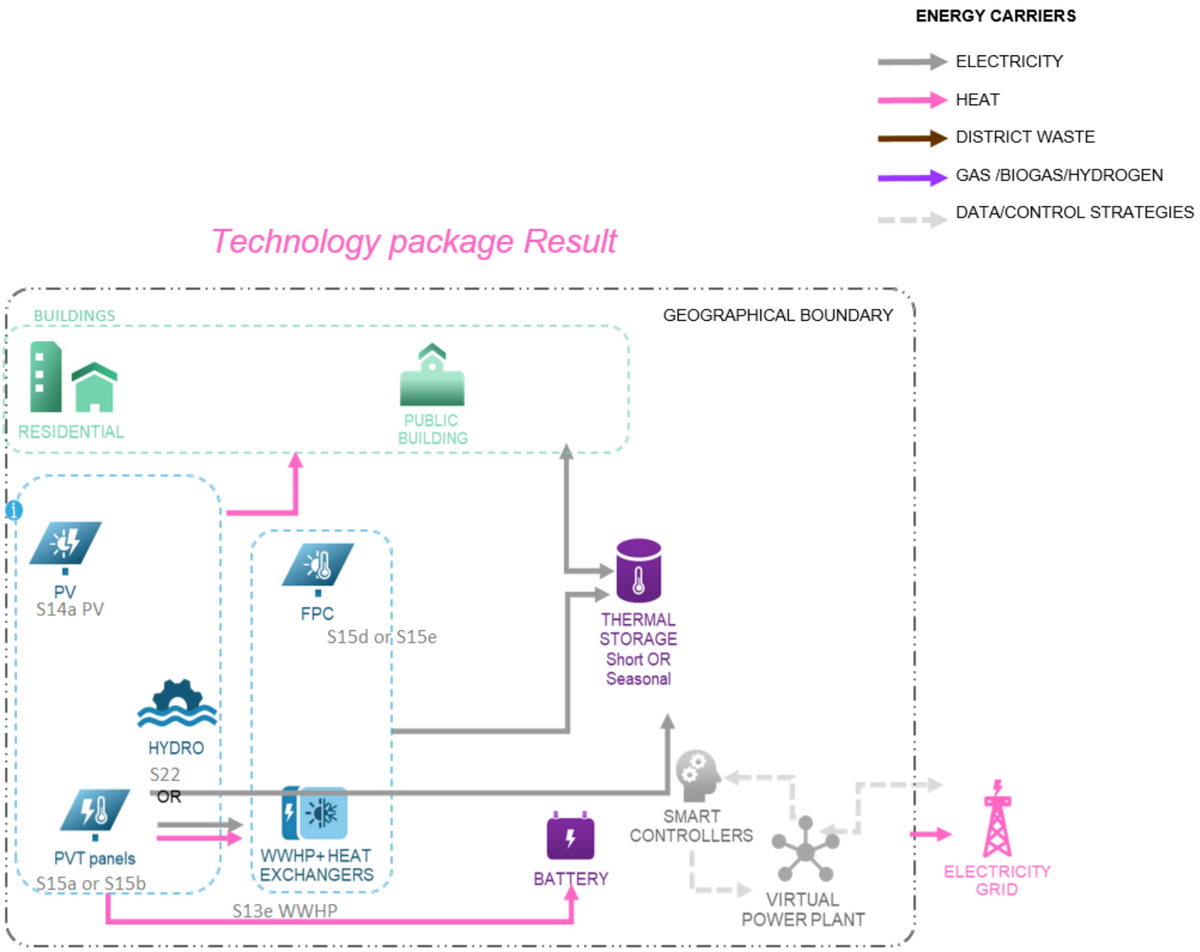


Figure 21).

[9] D4.3 Analysis of FWC candidate áreas to become PEC

Ambition level or Objectives of your district		**Net-zero emissions / Climate Neutrality**
Concept boundary		**Geographical**
District context and its characteristics		
Needs to be supplied		
	in general, do you have space heating needs in the district?	YES
	in general, do you have space cooling needs in the district?	YES
	in general, do you have Domestic hot water needs in the district?	YES
	in general, do you have electricity needs in the district?	YES
Resource availability (answer all questions)		
	Does the district have significant solar potential?	YES
Solar questions:	Available space on any roof?	YES
	Is it possible to install solar integrated technologies in the building envelope?	YES
	Is it possible to install solar technologies In a water surface nearby?	NO
	Is it possible to install solar technologies In a parking lot or an empty lot nearby?	YES
	Does the district have significant wind potential?	NO
Wind questions:	would you like to install wind turbines on-site or off-site?	NO
	Does the district have significant ground coupling potential (subsurface potential)?	NO
Subsurface potential:	Is it possible to install ground source heat pumps?	NO
	Is it possible to use the ground or aquifers as thermal storage?	NO
	Can the district use a water body to exchange heat with a heat pump?	YES
	Can the district use a water body for hydro generation?	YES
Hydro questions:	is it around the district area (around 5 km)?	NO
	Does the district have significant biomass potential?	NO
	Does the district have available a waste heat source?	NO
Urban macroform (answer YES if applicable)		
	Is the district a new development area?	NO
	Is the district going to be retrofitted?	YES
	Is the district an infill area?	NO
	Is the district a transformation area?	NO
	is the district a heritage area?	NO
Select the type of buildings (use) within your district (answer YES if applicable)		
	Residential use?	YES
	Commercial?	NO
	Active Green / Open Parking Lot?	NO
	Public Administration?	YES
	Social / Cultural/Educational/Sport ?	YES
	Industrial?	NO
Energy infrastructures (answer all questions)		
	is there any district heating network (DHN) nearby?	YES
	Is the district off-grid?	NO
	does the district have a private electricity grid?	NO
	Is the district connected to the gas network?	YES
	Do you want to include e-mobility aspects?	YES
	Do you want to include hydrogen-mobility aspects?	YES
	Do you want to apply soft-mobility aspects?	YES
Energy services and management (answer all questions)		
	Do you want to interact with the gas grid? (injection of hydrogen or biogas)	NO
	Do you want to offer ancillary services?	YES
	do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	YES
	Do you want to offer hydrogen to industry or for electricity generation?	NO
	Do you want to interact with the users/consumers?	YES
	Would you need a data platform?	YES
	Do you want that the electricity and thermal production is matched (by optimization, etc.)?	YES
Social structure		
	Do you want to form an energy community in the district?	YES
	Is there any people suffering from energy poverty in the district?	NO

Figure 88: Answers of City of Trencin for the macro tool

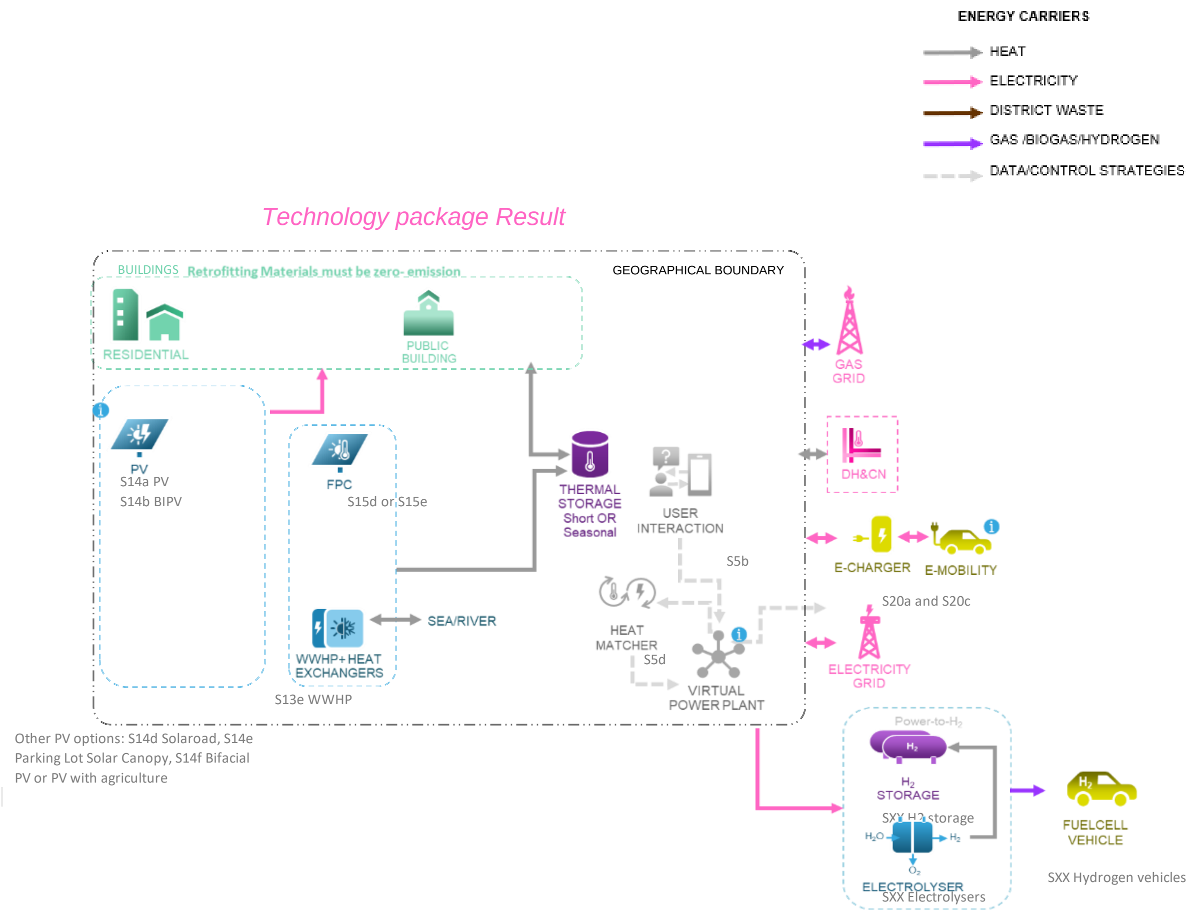


Figure 89: Technology Package Result for Trencin PED Boundary

Results of Trenčín in a nutshell:

You have achieved a climate neutral technology package. To achieve net-zero emissions or climate neutrality in energy terms, retrofitting materials must be zero-emission. If an industry is included, carbon capture is recommended. If biomass or biogas is included, very high filters and carbon capture are needed, to avoid realising it to the environment. But finally, a techno-economic study needs to be performed, to know exactly how to realise the technology package. In any case, you will need to achieve NET zero emissions, so any emission related with biomass/biogas or from imports from wider grids, needs to be compensated with your exports or by carbon capture

Recommendations for other Technologies:

- To reduce space heating needs, it is recommended to insulate the building as much as possible and replace emitters by systems that require less temperature supply (Such as ground floor heating, fan coils, etc.)
- To reduce space cooling needs, it is recommended to insulate the building as much as possible, take advantage of free cooling during the night and use controllable external shading
- DHW requires (generally in most countries) 60ºC when is stored (to avoid legionella), but if the volume from the supply system to the demand is less than 3 m3, in Germany is allowed to reduce the temperature to 45ºC. Generally, in most countries if DHW is prepared instantaneously (with heat exchanger between storage and demand), then it can also be reduced to 45ºC. Another way to reduce the demand, is to preheat the cold-water mains with waste heat (e.g. heat exchanger to extract heat from the grey water from the shower).

- Efficient lighting and appliances should be prioritized. Avoid stand-by modes when possible, using smart plugs to cutting off power when not needed.
- To allow the participation in the market, you can check solution SXX Participation on the market, and the following solutions: S5a, S5b, S5c, S5d
- To offer ancillary services, you can check solution SXX Ancillary services. For example, to offer demand shifting or demand response, you will need controllable loads (e.g. be able to switch off/on heat pumps, appliances, etc.)
- You can check the SXX Creation of an energy community, to know a bit more about Renewable Energy Communities
- Data Platforms are recommended, such as Sd, Se or S7a
- To allow user feedback to take into account, phone apps or user-interface could be used, such as S5b

11.3 PED Calculation for Verification

Once PED technologies are identified in Trenčín PED Boundary, a calculation process has been held to figure out if the identified technologies already provide a surplus of annual energy balance. If the technologies do not provide positivity, new solutions such as decreasing the energy demand, increasing energy efficiency and energy generation will be conducted within the PED boundary. 1 scenario was conducted to provide different options and financial plans. This design will be used to go further for detailed execution plans and potential implementation of PED area after the MAKING-CITY project lifetime.

11.3.1 PED boundaries definition

The boundary for Trenčín PED Area is geographically bounded. There are 3 residentials (Bytový dom (private multi-family housing, Rodinný dom (private single housing), Bytový dom 2 (private multi-family housing); 4 education buildings (Budova Obchodnej akadémie – High School, Budova university – 3 University buildings) and 3 sports buildings (Municipality owned Sports Hall, Municipality owned Indoor swimming Pool and a sports gym) inside the boundary. Most of the buildings are from 1950, just the swimming pool is from 1995. The buildings need to be retrofitted and the rooftops will be used for solar generation. There are also empty lots and carpark areas that can be utilized for on ground energy generation. The efficiency of the mechanical equipment and the lighting equipment for the will be increased for education and sports buildings, if needed.

Figure 90: Trenčín PED Boundary

1 scenario for energy generation are generated to achieve PEDs according to the technologies identified in the previous section.

Scenario: All PV+ All heat pumps at District scale connected to the river

PV: 2025 kWp (959.084+4693.57+5296.89+2550+2700m2) - All new

HP: 1888.3 kW 50.3W/m2 of HPs

11.3.2 Energy needs inside PED boundaries

All data related to thermal and electric energy needs of the residential buildings and the educational buildings are based on the data calculated in WP1 New long-term urban planning towards 2050. Regarding Sports Buildings – the ones owned by the municipality (the indoor swimming pool and the sports hall), electricity and gas consumptions were shared by the municipality (for 2019). The breakdown for the HVAC, lighting, DHW, plug loads are estimated by the help of percentages in consumption behaviours according to the building uses in Trenčín.

Residential buildings, educational and sports buildings will be retrofitted. For doing so, 30% of heating demand reduction in all buildings (deep retrofitting will be provided) is expected. The efficient results may be seen below.

ENERGY NEEDS

THERMAL ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	DHW needs	3654.00	x	21.45	=	0.08
	SH needs	3654.00	x	89.58	=	0.33
	SC needs	3654.00	x	8.53	=	0.03
Education	DHW needs	16376.71	x	40.04	=	0.66
	SH needs	16376.71	x	51.10	=	0.84
	SC needs	16376.71	x	17.84	=	0.29
Sport	DHW needs	17511.20	x	22.09	=	0.39
	SH needs	17511.20	x	59.48	=	1.04
	SC needs	17511.20	x	18.01	=	0.32
						=
				Total Thermal Energy Needs	=	3.97

ELECTRIC ENERGY NEEDS

		Units (m2 or people)		kWh/unit		GWh (divide by 10^6)
Residentials	Lighting	3654.00	x	5.49	=	0.02
	Ventilation	3654.00	x	0.00	=	0.0000
Education	Lighting	16376.71	x	20.31	=	0.33
	Ventilation	16376.71	x	7.00	=	0.11
Sport	Lighting	17511.20	x	11.23	=	0.20
	Ventilation	17511.20	x	4.89	=	0.09
				Total Electric Energy Needs	=	0.75

Figure 91: Energy needs in MAKING-CITY tables for Trenčín in GWh/year

11.3.3 Energy Use

Thermal and electric energy uses are calculated considering the energy needs and the distribution losses since the systems are centralized for DHW, space heating and cooling. The potential losses for thermal uses may be reviewed in Table 24 and for electric losses in Table 25

Table 24: Distribution Losses for Thermal Use

Distribution Losses (DHW)	Distribution Losses (SH & SC)	Heat exchanger
10%	15%	90%

Table 25: Distribution Losses for Electric Use

Ventilation losses	Lighting losses	Distribution losses	Distribution Losses (SH & SC)
5%	2%	5%	15%

The difference between energy needs and energy use are due to **water to water heat pumps** consumption (accounted in electricity use).

Scenario: All HVAC, DHW systems are facilitated by HPs (capacity of 107.5kW in total) with COP of 5 since the source is water (there is a river nearby the PED boundary). Buildings are connected to each other by a centralized heating system, and it is considered as a DH Grid in the calculation tables. The existing heating system of the residential, sport and educational buildings will either be changed to fan coil, or the sizes of the existing radiators will be enlarged in order to connect to HPs.

ENERGY USE

THERMAL ENERGY USE

		Energy needs		Efficiency of the emitter+distribution losses		GWh (divide by 10^6)
Residentials	DHW use		/	0.95	=	0.00
	SH use		/	0.95	=	0.00
	SC use		/		=	0.00
Education	DHW use		/	0.95	=	0.00
	SH use		/	0.95	=	0.00
	SC use		/		=	0.00
Sport	DHW use		/	0.95	=	0.00
	SH use		/	0.95	=	0.00
						=
				Total Thermal Energy use	=	0.00

ELECTRIC ENERGY USE

		Energy needs		Efficiency of the emitter		GWh (divide by 10^6)
Residentials	SH electric use	0.33	/	5.00	=	0.07
	SC electric use	0.03	/	3.00	=	0.01
	DHW electric use	0.08	/	5.00	=	0.02
	Ligthing needs (usually losse:	0.02	/	1.00	=	0.02
	Ventilation needs (usually loss	0.0000	/	1.00	=	0.00
Education	SH electric use	0.84	/	5.00	=	0.17
	SC electric use	0.29	/	3.50	=	0.08
	DHW electric use	0.66	/	5.00	=	0.13
	Ligthing needs (usually losse:	0.33	/	1.00	=	0.33
	Ventilation needs (usually loss	0.11	/	1.00	=	0.11
Sport						
	SH electric use	1.04	/	5.00	=	0.21
	SC electric use	0.32	/	3.50	=	0.09
	DHW electric use	0.29	/	5.00	=	0.06
	Ligthing needs (usually losse:	0.20	/	1.00	=	0.20
	Ventilation needs (usually loss	0.09	/	1.00	=	0.09
	Other(process)		/		=	0.00
						=
				Total Electric nergy use	=	1.58

Figure 92: Energy uses in MAKING-CITY tables Trenčín in GWh/year

11.3.4 RES production inside the PED

Within the geographical PED boundary, the local generation of renewable heat and electricity in Trenčín PED area is consisting of solar photovoltaic panels and water to water heat exchangers with high COP of 5.

Scenario : For electricity, Solar PV panels are installed on 70% roof usage for PV on residential, 70% roof usage for PV on sports buildings and 70% roof usage for PV on educational buildings. This refers to 959.084m2 rooftop area available for PV RES production and 9990.47m2 refers to tertiary buildings. On ground generation is also conducted on 2550+2700m2. It is considered a capacity of 2,025 kW PV installed. Therefore, solar PV panels electricity output is 2.19GWh.

The useful energy (output) from renewable energy sources is calculated:

GWh	PV (kwh)	wind/hydro	Geothermal	Solar Thermal	Biomass_el (CHP_biomass:)	Biomass_heat
Residentials	0.13			0.00		
Education	0.63			0.00		
Sport	0.72			0.00		
utility				0.00		
district	0.71			0.00		
Total=	2.19	0.00	0.00	0.00	0.00	0.00

Total energy from RES(electric)		=	2.19
Total energy from RES(thermal)		=	0.00
Remaining (thermal)	**= Total Thermal Use - Total RES Thermal**	=	0.00
Remaining (Electric)	**= Total Thermal Use - Total RES Thermal**	=	-0.61

Figure 93: RES production in MAKING-CITY tables for Trenčín – Scenario 1 in GWh/year

Surplus energy (-) to be exported outside limits for electric use.

11.3.5 Energy delivered

Scenario: In Trenčín, thermal energy is provided by water-to-water heat pumps and there is a surplus of electric energy that can be exported.

The delivered energy is calculated (separating streams: thermal and electricity) :

Last check: Any remaining energy to be covered??

	Remaining energy	Efficiency		**Delivered energy to district kWh**
electr_grid national	-0.61		=	-0.61
DH_national av.	0.00			0.00

Figure 94: Energy delivered in MAKING-CITY tables for Trenčín – Scenario 1 in GWh/year

11.3.6 Primary Energy Balance

Scenario : PED is achieved. Primary Energy Balance = -1.34 GWh

Nren Primary Energy Exported(-) :

	Delivered energy (kWh)		PEFnren		Nren Primary Energy (GWh_PE_nren)
DH_national av.	0	x	1.35	=	0.00
electr_grid national	-0.61	x	2.2	=	-1.34

PRIMARY ENERGY BALANCE (NON-RENEWABLE) = **-1.34**

PED Achieved!

Figure 95: non-RES Balance in MAKING-CITY tables for Trenčín of Scenario 1 in GWh/year

11.3.7 Energy Flow Diagrams

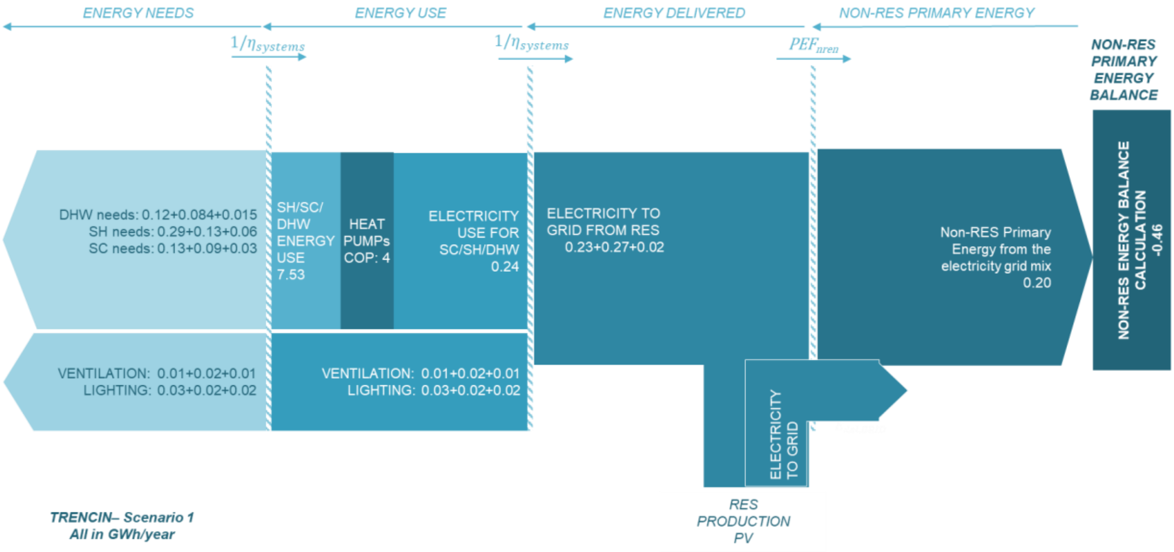


Figure 96: Sankey diagram energy flow Trencin PED Scenario 1 (in GWh/yr)

Conclusions

Replication and Upscaling activities under MAKING-CITY project started with a so-called early replication process by defining a methodology for PED design including PED calculation procedures followed by identification of PED areas in FWCs and creating a tool for PED selection of PED technologies and a parallel process by developing citizen engagement strategies for designing PEDs in FWCs.

This report presents the PED Technical designs and all steps of design procedures in six FWCs of MAKING-CITY. In this report, the sizing of the technologies is optimized in technical terms to demonstrate that a positive energy balance is achieved. With the size of the technologies and the boundaries of the FWCs can launch tendering procedures where more detail studies can be presented, and the demonstration of the PED energy balance and environmental co-benefits can happen.

The proposed process makes different assumptions on how the boundaries are defined and how to calculate the district balance despite it is still under discussion in most of the relevant scientific forums. Energy needs coming from the mobility and transport sector are not considered. The results could be improved if hourly simulations could be performed, which could help to size storages, and decide the best control strategies to be followed by the district. Because it is possible to achieve a PED through huge on-site generation, lowering the energy needs of the buildings are always recommended to cities.

The approaches of the FWC public authorities were also one of the main points for identifying PED boundaries in cities. For this reason, (i) the area identified in Bassano del Grappa is larger when compared to others (ii)district scale HPs are considered in Lublin, Trencin to get advantage from water resources nearby the districts (iii) the buildings will be reconstructed for better efficiencies in Kadikoy (iv) the existing roof-top solar plant is included in Leon and (v) geothermal based HPs are utilized in Vidin. Different scenarios are also developed in most of the districts to understand the mechanism for going surplus by getting advantage of different technologies.

New scenarios may be developed while working on the financial plans to reach a diverse set of CAPEX, OPEX and revenue streams for the identified boundaries and technologies. The financial plans for realizing PEDs will be reported in M42.

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Annexes

Annex I: Microscale analysis results

Bassano de Grappa

1) Overlay result + Heating demand

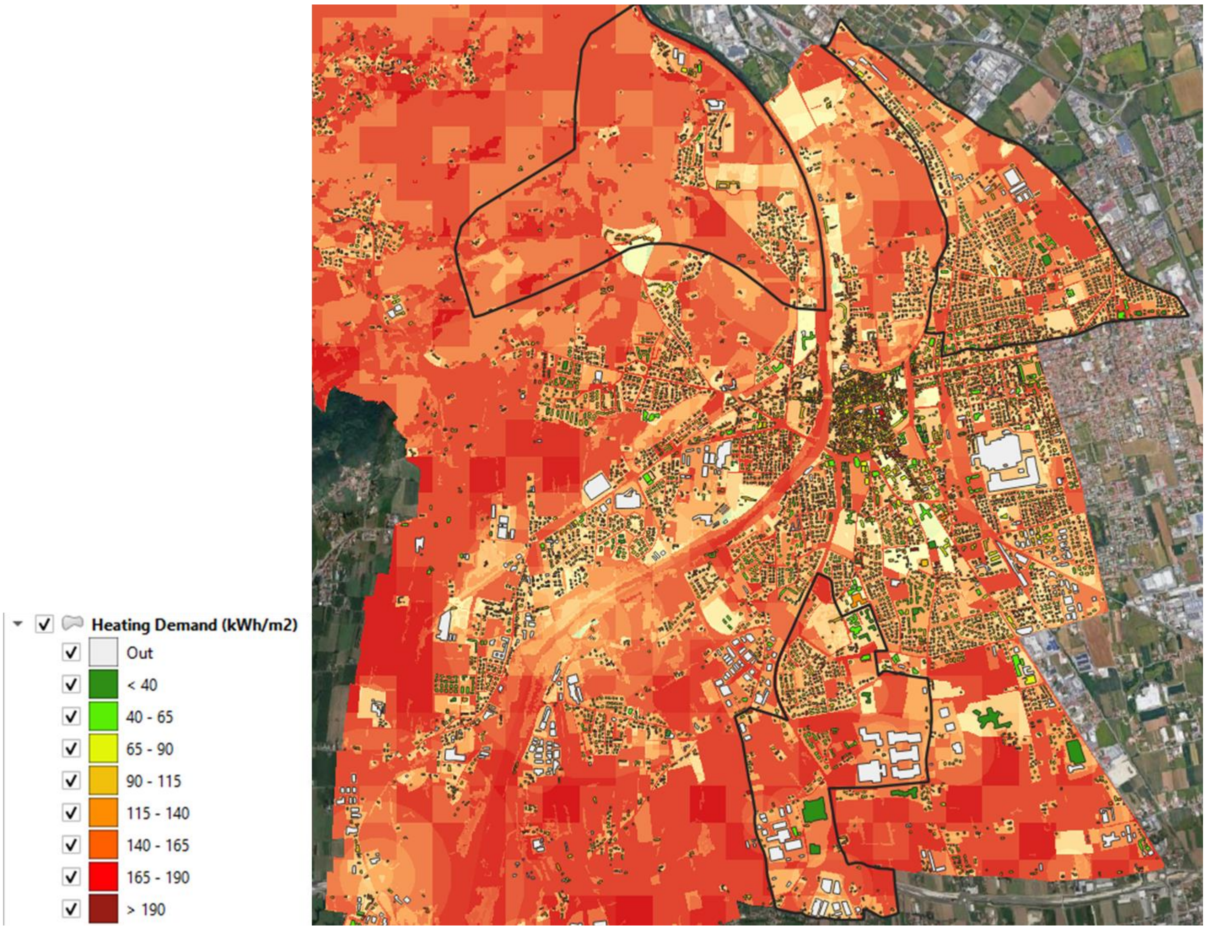

Figure 97: Macroescale overlay result and heating demand – Bassano del Grappa

2) Questionnaire results

- Q1. Where do you want to design the PED? Within the limits of preselected districts? → Bassano del Grappa is open to work outside the limits of the preselected areas
- Q2. Do you want to work with high density zones? → The population density will be studied and considered but won´t define que selection of the areas
- Q3. Hydropower. How is connected to the grid? → Generated electricity is sold to the grid.
- Q4. Hydropower ownership: Public? Private? → The hydropower plants are public. Maybe in the future are privatized., thus is ok working with the proximity to the power plants. The municipality is thinking in making another installation. There is no regulated distance for self consumption.

- Q5. It is mandatory the selection of areas that are public to some extend? → Involve the private areas.
- Q6. It is possible to use space to install, for instance, solar photovoltaic? → Do not consider green areas as space available for installations. For instance, solar installations will be implemented in roofs.
- Q7. Which is the desired impact of the intervention? High impact: select zones with high demand. Less efforts in the intervention: select zones with low demand → Work with high heating demand
- Other – consider wind power as part of the microscale analysis.

3) Preselected areas to become PED

According to previous answers, 7 areas were considered as potentially suitable to become PED (Figure 98). For the final selection, more detailed data from these areas was collected.

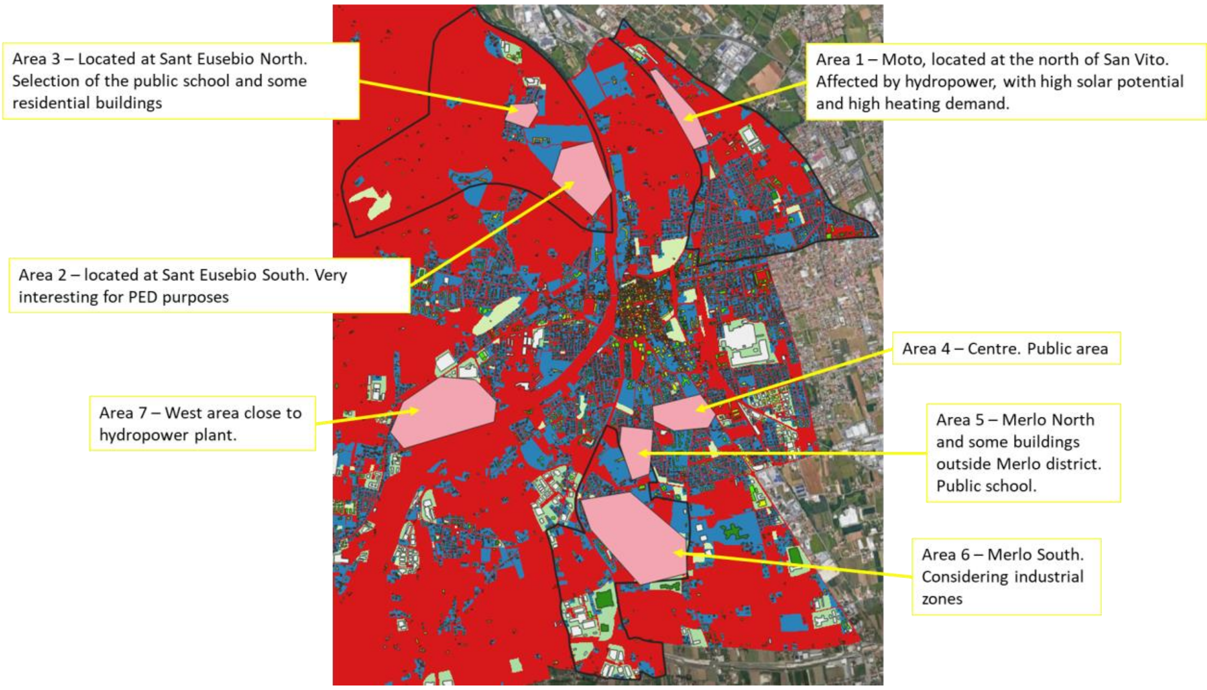

Figure 98: Preselected areas to become PED – Bassano del Grappa

4) Data collection and final selection of the area where implement the PED

In order to make the final selection, detailed data that characterized each of the preselected zones was collected. This data includes the surface of different land uses, the amount and surface of the different building typologies, population, distance to hydropower plants, surface availability for solar installations and number and power of existing ones, heating and cooling demand, other renewable installations, refurbishment, power and heat infrastructure and biomass installations.

Showing the characterization of the areas, a new area #8 was defined and selected for the design (Figure 99). Bassano del Grappa municipality considers that "the new Area 8 is very important for urban regeneration projects and it would be interesting to combine project MAKING-CITY with future planning of the town. Inside the bundary there is an intesting mixetè of property, use, age of the building, etc."

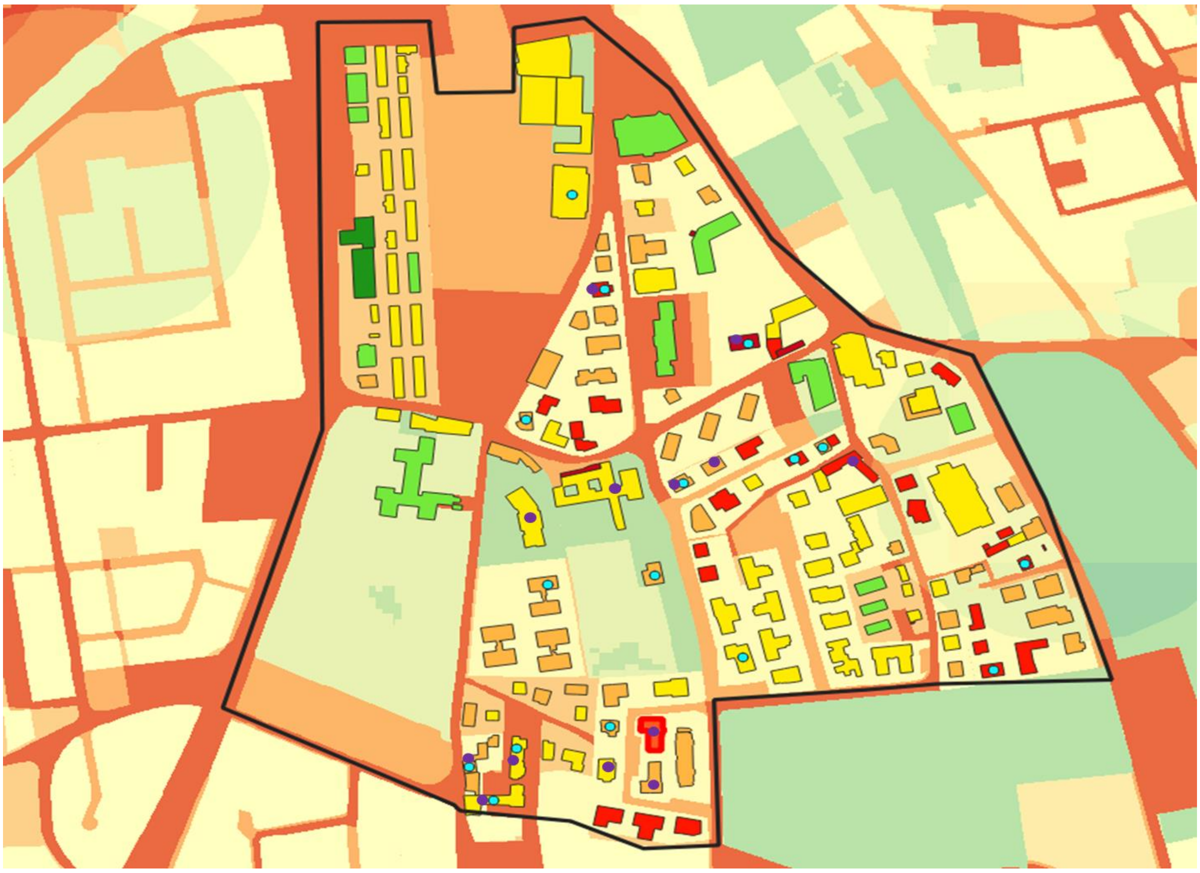

Figure 99: Area to become PED – Bassano del Grappa

Kadikoy

1) Overlay result + Heating demand

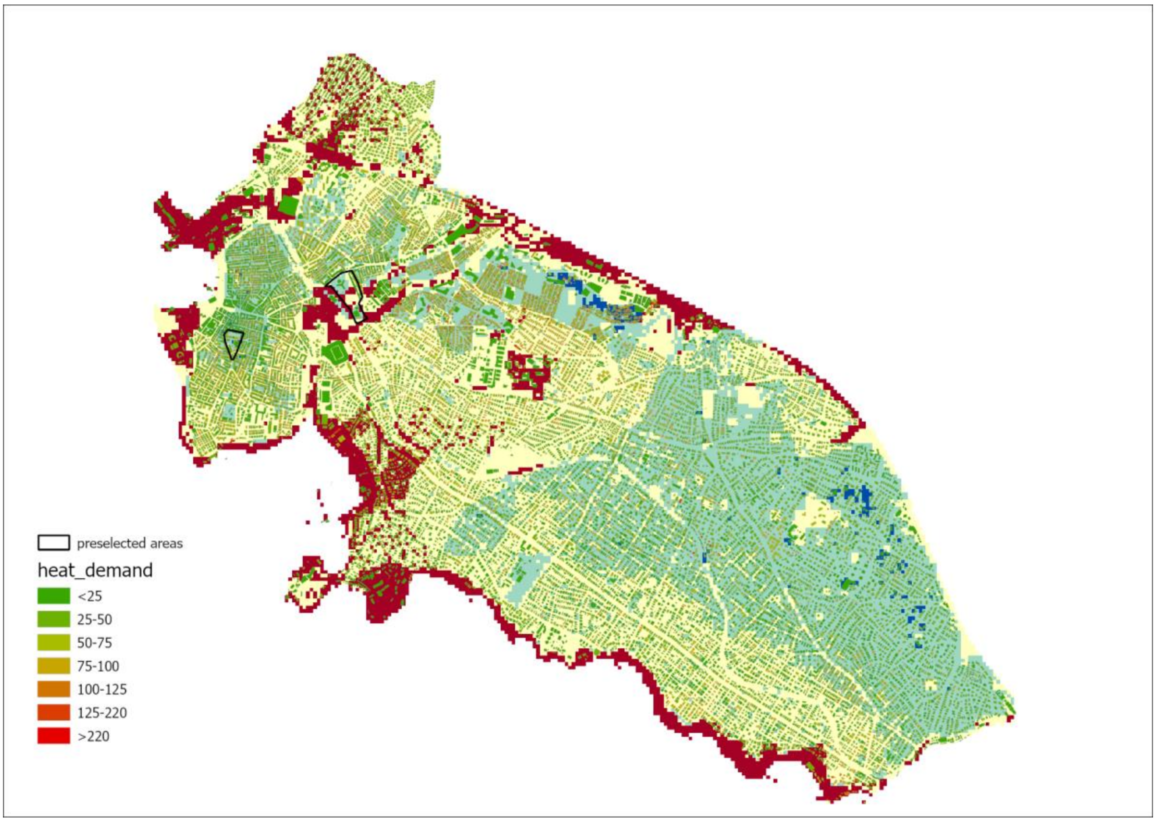

Figure 100: Macroscale overlay result and heating demand – Kadikoy

2) Questionnaire results

- Q1. Where do you want to design the PED? Within the limits of preselected districts? → Other potential areas rather than preselected one are also considerable for PED designs. (Municipality is open to discussions)
- Q2. Do you want to work with high density zones? → New transformation areas (that are in planning stage) will be shared by municipality.
- Q3. Are the existing public and social/cultural buildings promoted for energy efficiency? → Public Buildings have potential for roof-top solar generations.
- Q4. Do you want to work with high density zones? → Population criteria will be reconsidered.
- Q5. Are these open carpark areas suitable for solar energy generation? → The solar generations areas would change. Municilaplity building may move to another areas near Fikirtepe and a solar generation car park space will be added to these areas.
- Q6. Are you interested in trading for the charging stations?→ Charging Stations are now under Real Estate Department (Emlak Departmanı). They will consult this department for the new charging stations. FOr trading mechanisms, it is not allowed to sell energy to the client directl, but municipality may sell the charging or any coffee to the clients.

- Q7. Which is the desired impact of the intervention? High impact: select zones with high demand. Less efforts in the intervention: select zones with low demand → Retrofiiting and high perofrmance areas are both considerable for PED implementations

3) Preselected areas to become PED

According to previous answers, 5 areas were considered as potentially suitable to become PED (Figure 110). For the final selection, more detailed data from these areas was collected. Main building use characteristics of the areas are as follows:

- Area 1 – Caferaga Sports Center + Baris Manco Cultural Center + School + 3 Residential Buildings
- Area 2 – School (Kadikoy Anadolu Lisesi) + Dormitory
- Area 3 – Municipality Building + Residentials + Commercial
- Area 4 – New Municipality Building + Carpark + Residential + School
- Area 5 – 2 Residential Complex (Disbak + As Camlik) Carpark + Residential + School

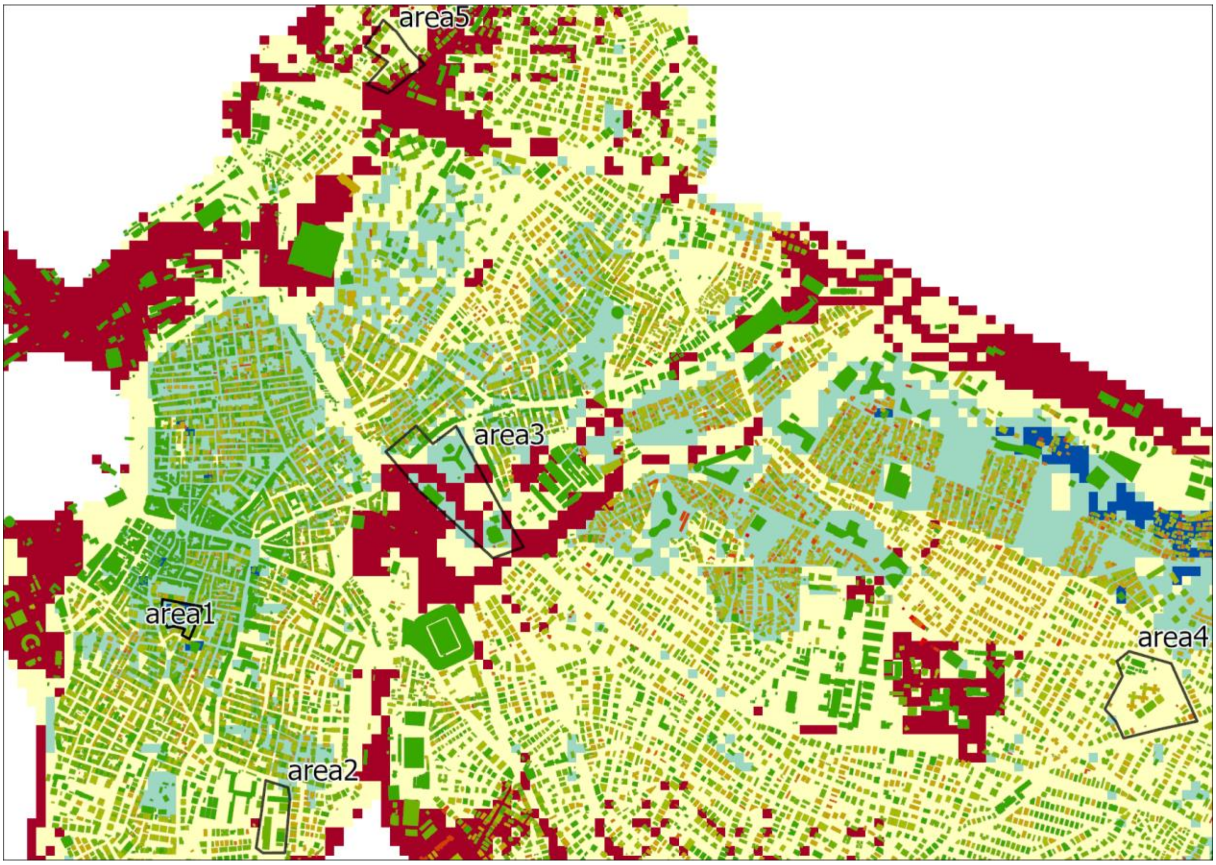

Figure 101: Preselected areas to become PED – Kadikoy

4) Data collection and final selection of the area where implement the PED

Kadikoy decided to select 5 different areas to make the design. One of them (Area 1) is being developed in the context of the project and results are presented in Section 7.3. Area 1 is extended with a few more residential buildings that are next to the sport buildings, in order to support min 15,000m2 requirement of MAKING-CITY.

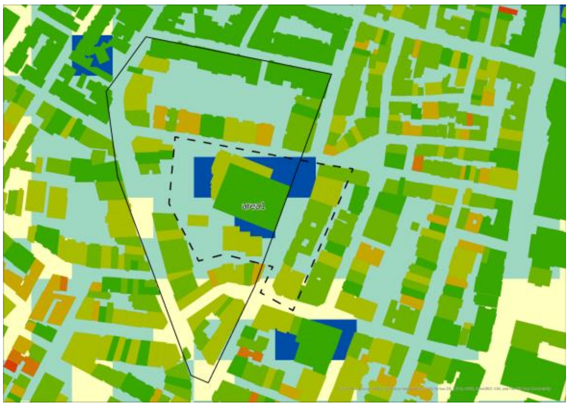

Figure 102: Areas to become PED – Kadikoy

León

1) Overlay result + Heating demand

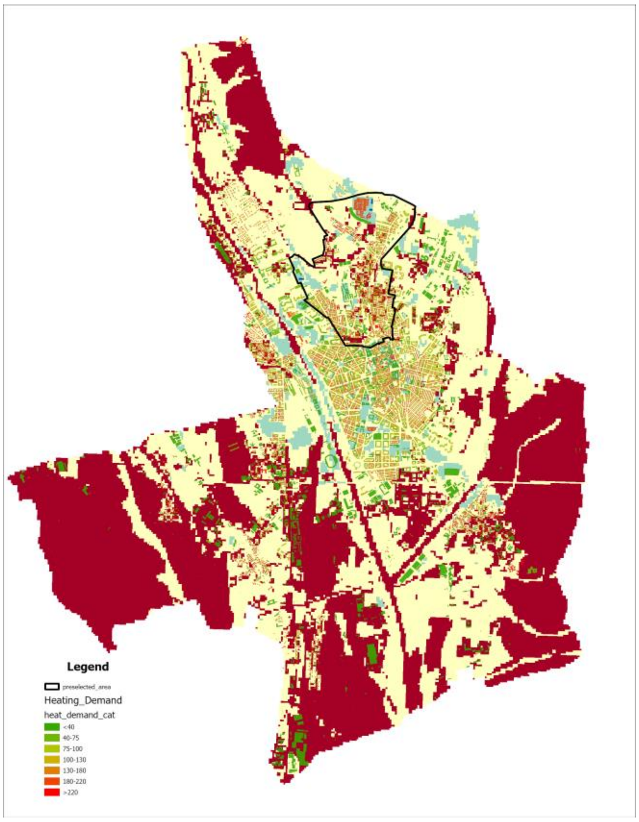

Figure 103: Macroscale overlay result and heating demand – León

2) Questionnaire results

- Q1. Where do you want to design the PED? Within the limits of preselected districts?
  → Political decision of León city is important to go on with the preselected area.
- Q2. Are the old public buildings promoted for retrofitting purposes??→ Retrofitting areas and public adminisration buildings are mostly promoted in EDUSI-preselected PED area.
- Q3. Do you want to work with high density zones? → Population Density is still not so clear for the city to identify as a potential for PEDs. They will reconsider it.
- Q4. Evaporative Potential of Water surfaces – Do you foresee this potential interesting?
  → Cooling demand in León is very low thus, evaporative potential is not an issue for León. Chilly city!
- Q5. Subsoil with geomorphological structure that goes from 80W/m to less than 25 W/m of thermal power potential. Is that enough for heat exchange Installations? → Charging stations and trading is considerable within the PED area. A new reulaiton indicating the neccesity to have charging stations in every municipality has been launched.
- Q6. Are you interested in trading for the charging stations?→ – CAR will check the geothermal earth potential for heat exchanger installations.
- Q7. It is possible to use this space (biomass) to install, for instance, solar photovoltaic León city will check and reconsider the potentail of EV charging stations' trading potential.

- Q8. Which is the desired impact of the intervention? High impact: select zones with high demand. Less efforts in the intervention: select zones with low demand – Instense green areas for biomass potential cannot be considered for solar installations.
- Other – León will reconsider the PED paramters within the city team.

3) Preselected areas to become PED

According to previous answers, 4 areas were considered as potentially suitable to become PED (Figure 110). For the final selection, more detailed data from these areas was collected. Main building use characteristics of the areas are as follows:

- Area 1 – Sport Centre (public) + Primary School
- Area 2 – A few residential Buildings with high solar installation capacity + City Council is also included within the area
- Area 3 – museum
- Area 4 – Pavilion + Residential buildings to the west.

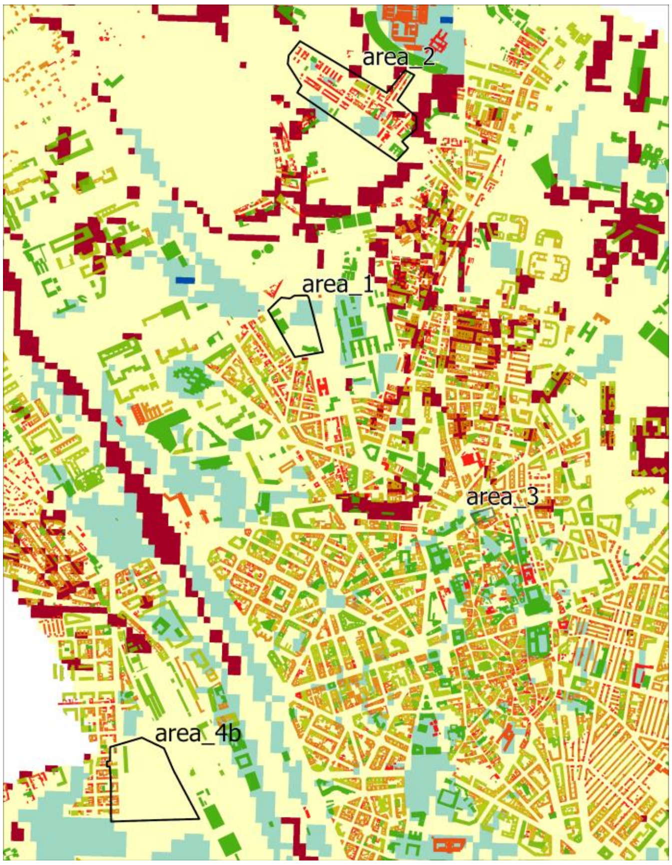

Figure 104: Preselected areas to become PED - León

4) Data collection and final selection of the area where implement the PED

León decided to select 4 different areas to make the design. One of them (Area 4) is being developed in the context of the project and results are presented in Section 8.3. Area 4 has the potential to reach an attractive public space.

Figure 105: Areas to become PED – León

Lublin

1) Overlay result + Heating demand

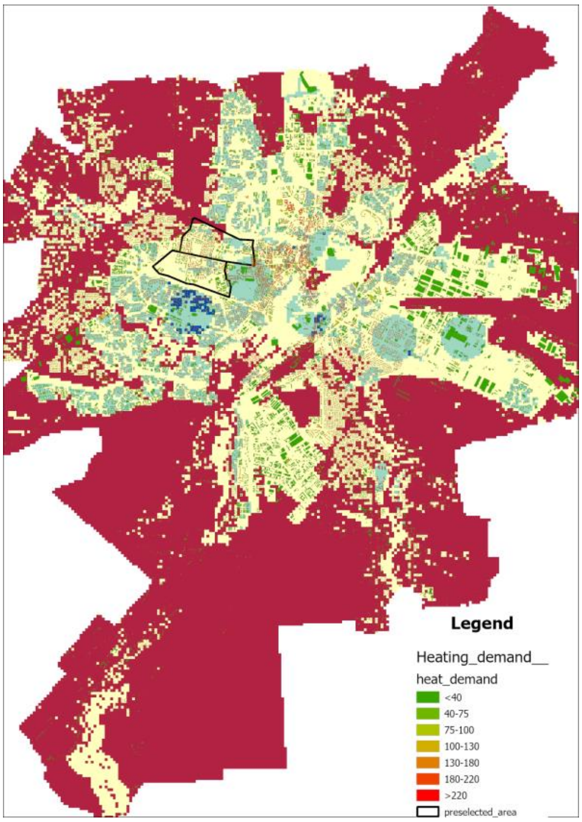

Figure 106: Macroscale overlay result and heating demand – Lublin

2) Questionnaire results

- Q1. Where do you want to design the PED? Within the limits of preselected districts? → Other potential areas rather than preselected one are also considerable for PED designs.
-
- Q2. Are the newly built commercial and public buildings promoted for energy efficiency?→ newly built and also retrofittingcommercial and public buildings are promoted for energy efficiency
- Q3. Is there a regulatory framework for heat trading? Any P2P platform? → LPEC is the leader of the heat grid. Regulation for trading will be overviewed by the municipality.
- Q4. Hydropower ownership: Any private initiatives for Hydro generation? → The hydropower has no potential anymore. The only private hydro plant was closed 3 years ago because of the flood risk.
- Q5. Are you interested in trading for the charging stations?→ Charging stations and trading is considerable within the PED area. A new reulaiton indicating the neccesity to have charging stations in every municipality has been launched.
- Q6. IS there a PV Farm at the sewage treatment plant? What is the capacity? Is there self-consumption→ – the roof of the sewage plant can be considered as a PV farm. It has the capcity to almost provide power to 1000 houses but it is not connected to the residentials. It

shouldn't be taken into account for PED area. Waste heat potential of the industrial areas also not an option anymore.

Q7. Which is the desired impact of the intervention? High impact: select zones with high demand. Less efforts in the intervention: select zones with low demand → High and low demand buildings are both considerable for PED implementaitons.

3) Preselected areas to become PED

According to previous answers, 6 areas were considered as potentially suitable to become PED (Figure 110). For the final selection, more detailed data from these areas was collected. Main building use characteristics of the areas are as follows:

- Area 1 – Academic area – (educational Buildings) + Residential + Dormitories (Zone 2 preselected area)
- Area 2 – Residential + Commercial (Zone 1 – Preselected Area)
- Area 3 – Single-family housing – Mostly Elderly People living
- Area 4 – residential + Commercial (shopping mall) Potential for charging stations for e-vehicles
- Area 5 – Residential + Office + shopping malls + Shops (business City Centre)
- Area 6 – Eco Residentials (high-performance buildings – RE integrated to the roofs) – new

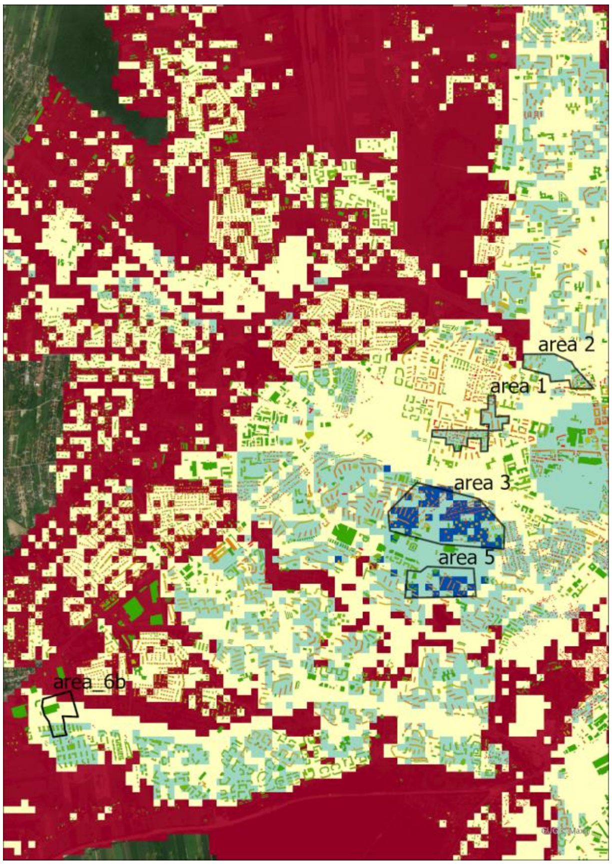

Figure 107: Preselected areas to become PED – Lublin

4) Data collection and final selection of the area where implement the PED

Lublin decided to select 6 different areas to make the design. One of them (Area 6) is being developed in the context of the project and results are presented in Section 9.3. Area 6 has the potential to reach an eco-district classification since the buildings are new and highly energy efficient.

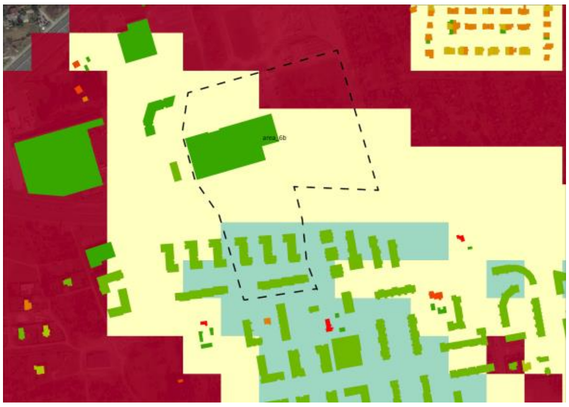

Figure 108: Areas to become PED – Lublin

Vidin

1) Overlay result + Heating demand

Figure 109: Macroescale overlay result and heating demand – Vidin

2) Questionnaire results

- Q1. Where do you want to design the PED? Within the limits of preselected districts? → Preferably within the limits of preselected districts
- Q2. Do you want to work with high density zones? → More density zones prioritized
- Q3. How is the regulation framework of geothermal energy installations and use?. Q4. It is possible to use space to install, for instance, solar photovoltaic? → Ground water potential and suitable legal framework, but there are problems with the infrastructure and investment. There are no experience in peer to peer practices. Metering is not allowed. Not easy for prosumers. On-going process that will facilitate it.
- Q5. Which is the desired impact of the intervention? High impact: select zones with high demand. Less efforts in the intervention: select zones with low demand → Work with high heating demand

3) Preselected areas to become PED

According to previous answers, 3 areas were considered as potentially suitable to become PED (Figure 110). For the final selection, more detailed data from these areas was collected.

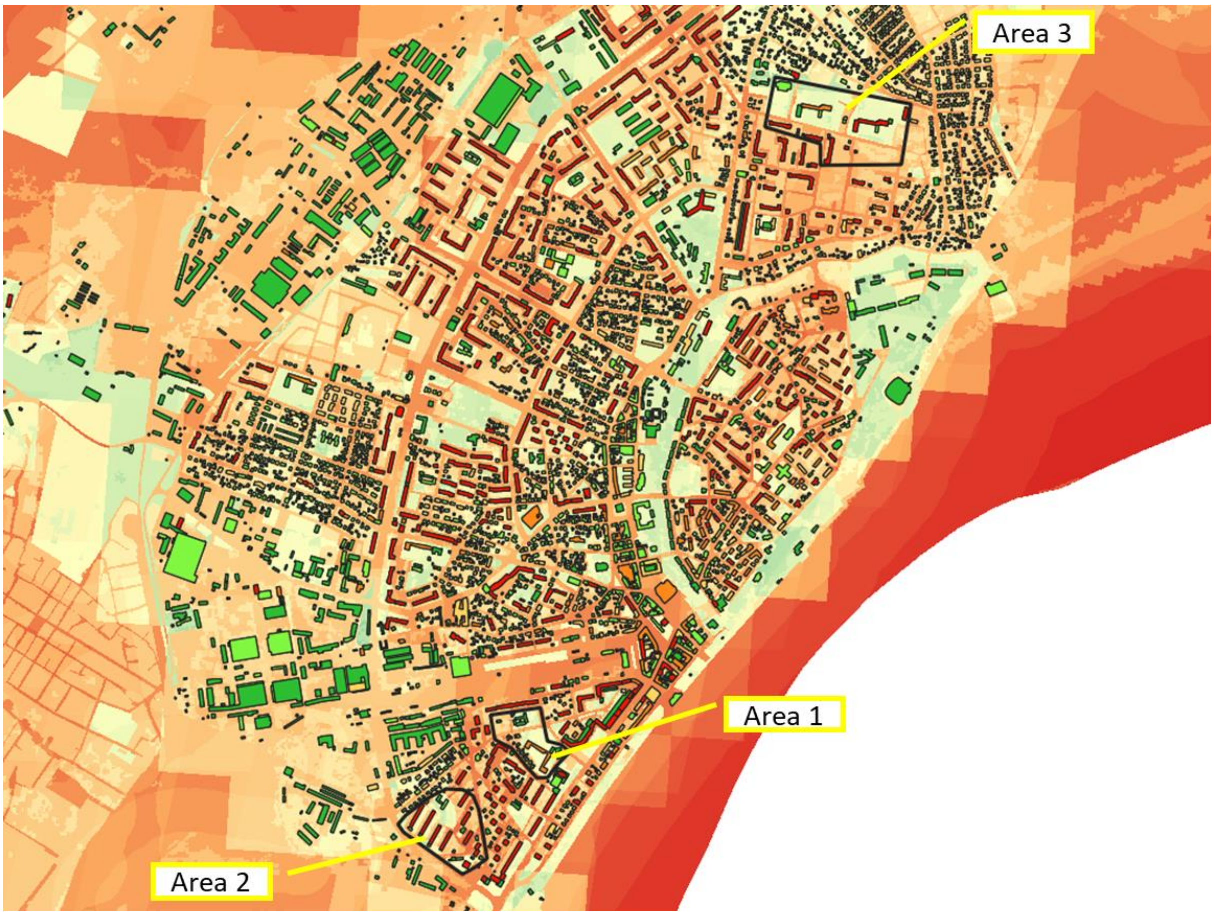

Figure 110: Preselected areas to become PED – Vidin

4) Data collection and final selection of the area where implement the PED

Vidin decided to select 2 different areas to make the design. One will be developed in the context of the project (#1) and the results will be replicated in the other selected area (#3).

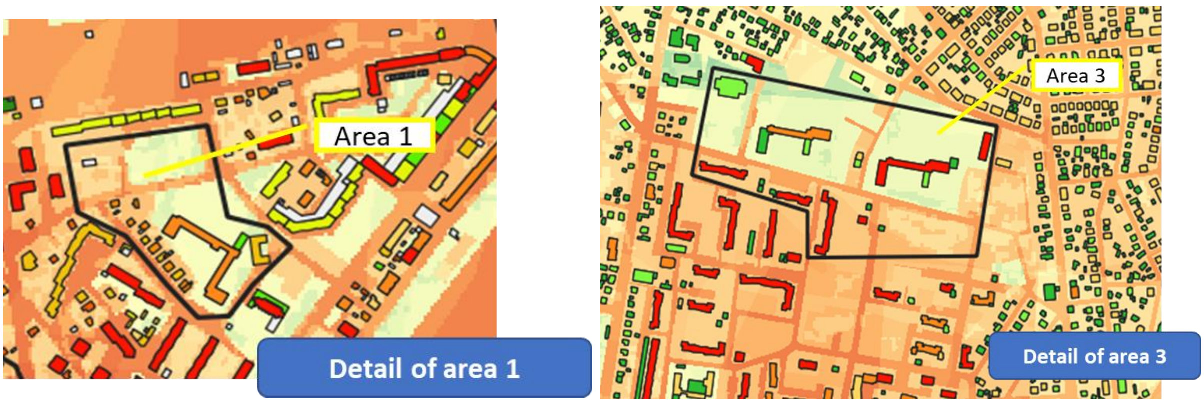

Figure 111: Areas to become PED – Vidin

Trenčín

1) Overlay result + Heating demand

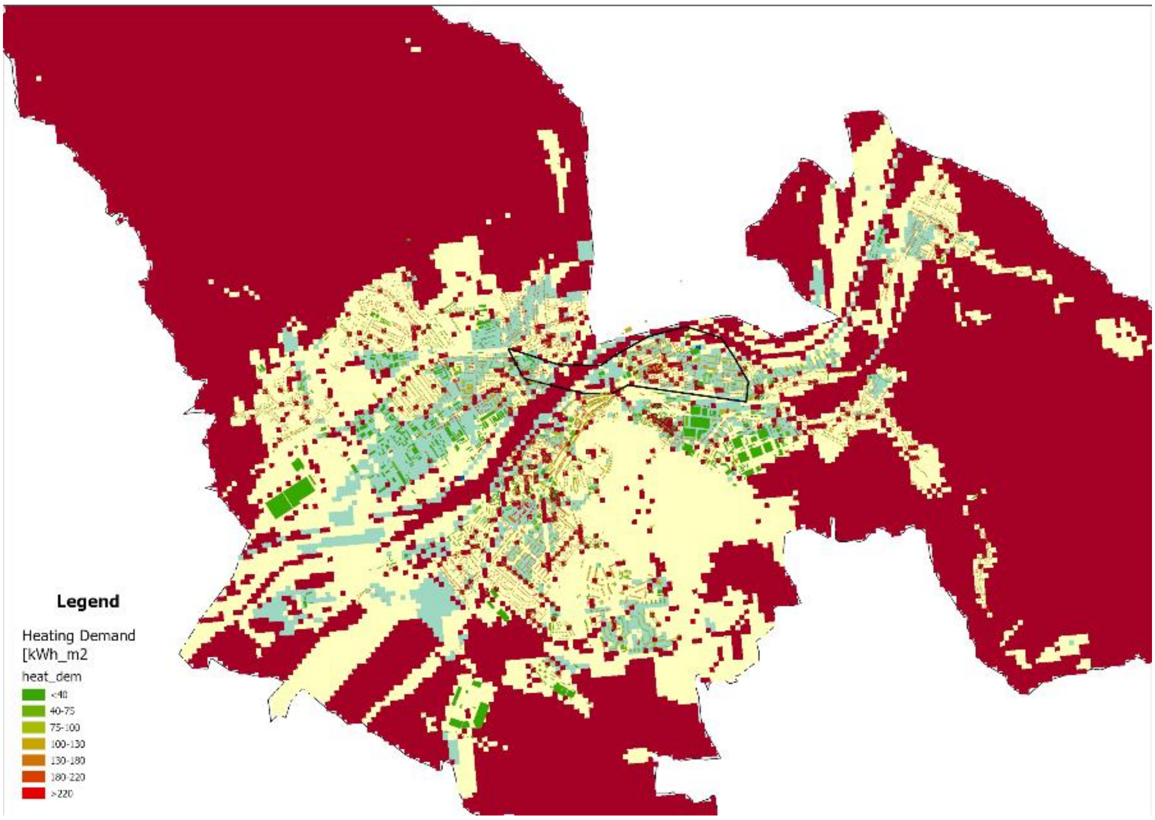

Figure 112: Macroscale overlay result and heating demand – Trenčín

2) Questionnaire results

- Q1. Where do you want to design the PED? Within the limits of preselected districts? → Other potential areas rather than preselected one are also considerable for PED designs. (Municipality is open to discussions)
- Q2. Do you want to work with high density zones? → existing commercial and residential are promoted by some EU funds. Preselected area is more promoted when compared to retrofitting purposes. Legistrative problems for elec. Trading. No regulations yet, but will be within 2 years for selling to the grid from the buildings.
- Q3. How is the regulation framework of geothermal energy installations and use? → Trenčín is not geothermal intense city. But keep it in mind for technology purposes. (Geothermal based heat pumps)
- Q4. Hydropower ownership: Any private initiatives for Hydro generation? → The hydro generation inside the preselected area is privately owned. There are 3 more in the preferia.
- Q5. What is the potential of the sewage system? Are you interested in taking it into the PED boundary? → Biogas production outside the city boundary.
- Q6. Do you want to work with high density zones? → Avoiding high density is better because it represents the old building stock with buildings from 50s-60s.

- Q7. Which is the desired impact of the intervention? High impact: select zones with high demand. Less efforts in the intervention: select zones with low demand → High and low demand buildings are both considerable for PED implementations

3) Preselected areas to become PED

According to previous answers, 5 areas were considered as potentially suitable to become PED (Figure 110). For the final selection, more detailed data from these areas was collected.

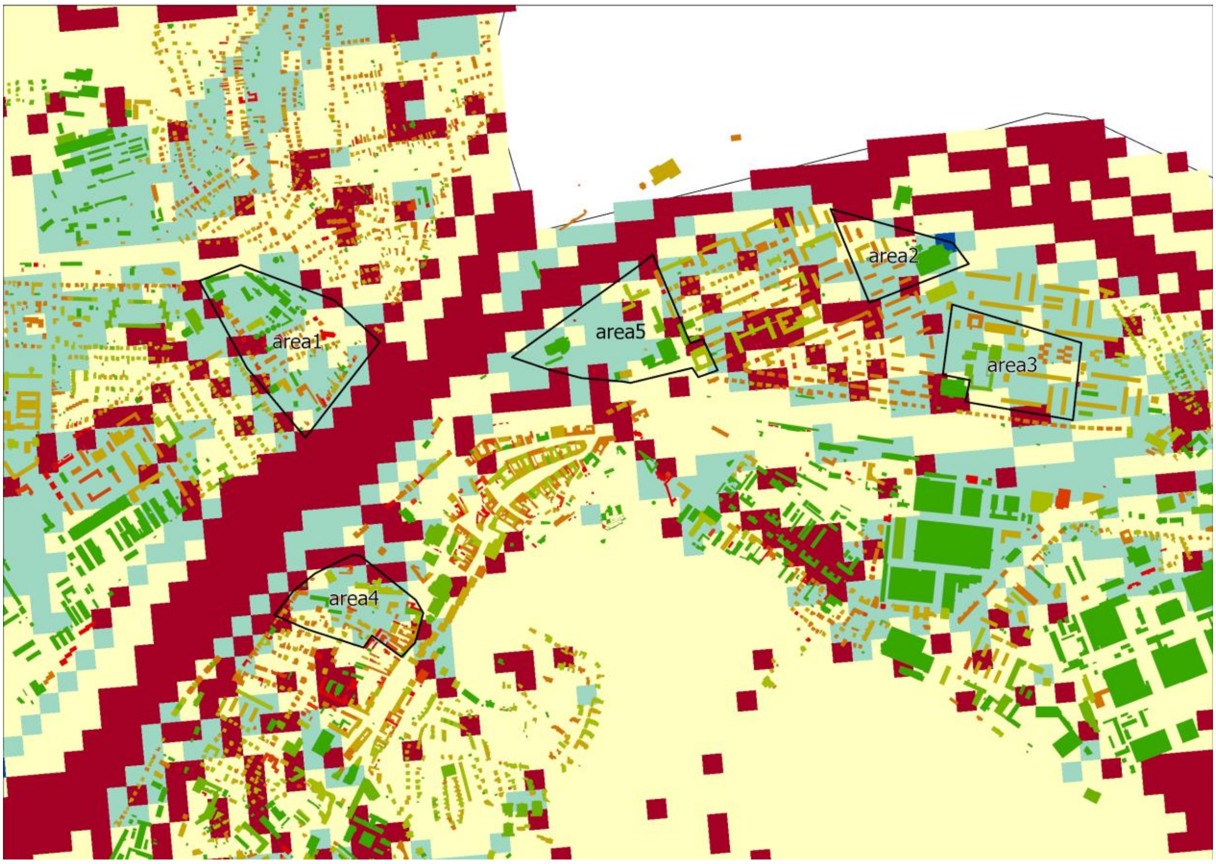

Figure 113: Preselected areas to become PED – Trenčín

4) Data collection and final selection of the area where implement the PED

Trenčín decided to select 5 different areas to make the design. One of them (Area 5) is being developed in the context of the project and results are presented in Section 10.3.

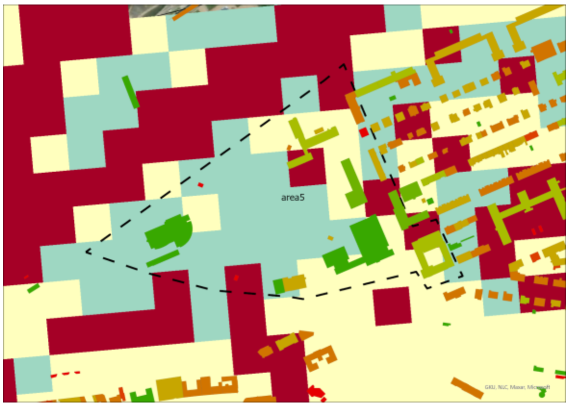

Figure 114: Areas to become PED – Trenčín

Annex II: Glossary for the Technology Selection Tool

Questions	Definitions
Select the ambition level or objective of your district	- SELF-SUFFICIENCY means that within a year, the district will never import energy from outside the boundaries (e.g. consume electricity or gas from the grids) - CLIMATE NEUTRALITY means that on a period basis the carbon dioxide emissions within the limits of the district are compensated with the exported energy or by carbon capture. - A CIRCULAR system is a closed loop system that reuse resources and waste minimizing raw resources. In the case of PED, the revalorisation of waste (such as residues from the different sectors) for the energy production is prioritized, but many other pathways could be taken considering the cycle of water, food, etc. - ELECTRIFICATION is the process in which the supply of any energy needs of a district and/or city, such as the heating needs or the mobility sector, are supplied by electricity-driven technologies. - The objective of improving AIR QUALITY is aimed in reducing the concentration of the 5 main pollutants: O3, NO2, SO2, PM2.5 and PM10
Concept boundary applied:	- GEOGRAPHICAL boundaries are delimited by spatial-physical limits, including delineated buildings, sites, and infrastructures. - If the buildings are not close to each other, but are interconnected, thanks to a gas, electric, or heating network, the PED has FUNCTIONAL boundaries. - If the energy demand is covered by a generation unit, which is shared with other consumption points (e.g., a wind turbine located outside) and located outside the geographical boundaries of the PED, then it could be considered a VIRTUAL boundary.
Needs:	in general, do you have space heating needs in the district? in general, do you have space cooling needs in the district? in general, do you have Domestic hot water needs in the district? in general, do you have electricity needs in the district?
Does the district have significant solar potential?	Solar potential within the city limits means that at least 750 kWh/m2/year is reached. Also regulation allows to install not only solar panels to meet your needs (i.e. self-consumption regulation), but also to install more capacity than needed to exchange energy with the grids (e.g. peer-to-peer exchange and/or energy communities regulation exists).If you answer that you do NOT have solar potential, no solar technologies will be recommened. You can use PVGis to estimate it
Available space on any roof?	Roofs from residential, public or industrial buildings can be used to install solar panels. Answer yes if you think any of the roofs considered within the district can be used to install solar panels (i.e. regulation and owners will accept it).
Is it possible to install solar integrated technologies in the building envelope?	Solar integrated technologies, such as BIPV, are solar photovoltaics materials that substituted part of the building envelope (façade, roofs, skylights…). Also, it could substitute a window or a canopy.

Is it possible to install solar technologies In a water surface nearby?	A water surface can be a lake, an industrial pool, pontoon or a reservoir, and the idea is to install a structure with photovoltaic panels that floats on the water body. Answer yes if it is possible and the regulation allows it.
Is it possible to install solar technologies In a parking lot or an empty lot nearby?	If there is a parking lot, canopies can be installed with solar PVs on it or use bifacial PVs as the canopy itself for electricity generation. If there is an empty lot nearby, it could be used for the same purpose, but future city plans should be prioritized (e.g. transform it in a green area might be more beneficial). If the empty lot is meant to be a solar farm, then it is recommended that, if possible, photovoltaic technology is installed in structure (agrovoltaic design) to also allow the growth of plants below the panels (allowing dual land productivity).
Does the district have significant wind potential?	Wind potential within the city limits can be considered if an air velocity above 8 km/h is reached. Also regulation allows either mini wind turbines be installed within the city (on the roofs) and/or owning a wind farm (that is around the city limits). If there is potential but it is outside the limits, you can select YES and then select off-site. You can use Wind Atlas to estimate your potential
would you like to install wind turbines on-site or off-site?	Wind turbines, can be located on-site when there is possibilities to install them in rooftops or in the neighboorhood (e.g. street, empty lot, etc.). If there is potential, but it is outside the limits (then is recommended a higher velocity) you can select off-site
Does the district have significant ground coupling potential (subsurface potential)?	Ground coupling potential means that the soil conditions allows the installation of geothermal heat pump systems (direct use if the emitter in the house requires low temperature) or ground-coupled heat exchanger systems (Which also avoid heat island effect by placing the 'cooling towers' underground) or use it as thermal energy storage (aquifer, clay soil)
Is it possible to install ground source heat pumps?	A ground source heat pump is a technology that exchanges thermal energy with the ground to supply heating or cooling needs. It is possible to install such technology when: 1) regulation allows it. 2) soil properties allow the feasibility of the technology.
Is it possible to use the ground or aquifers as thermal storage?	Underground thermal storage (UTES) with both boreholes (BTES) and aquifers (ATES) are the most developed storage concepts and are mostly used for seasonal storage. They can be applied to provide heating and cooling to buildings. Storage and recovery of thermal energy is achieved by extraction and injection of heat from aquifers or ground using wells or boreholes.
Can the district use a water body to exchange heat with a heat pump?	Water resources can be used to exchange heat with a heat pump, which sometimes increases the efficiency due to its constant temperature. As water resources you can find rivers, sea, lake, an industrial pool, pontoon or a reservoir
Can the district use a water body for hydro generation?	Min flow rate as 100 m3/h can be counted as a potential for micro hydro generation, to produce electricity with it.
Hydro generation location: is it around the district area (around 5 km)?	If there is hills or a difference of height between the water reservoirs and supply pipe to the district, there might be possibilities for on-site generation with, for example, Pumps as a Turbines technology. If there is within the city limits, any waterfall, hills, etc. it could be possible to study micro or mini hydro generation

Does the district have significant biomass potential?	If the district has the opportunity to utilize the biomass products nearby (such as intense green areas for wood production, forest waste, agricultural or domestic waste, landfill) or if the district is connected via a district heating system that is combusting biomass, this PED area may have potential for biomass for energy generation. Consider the biomass potential within the city limits only
Does the district have available a waste heat source?	A waste heat source is an unused heat that is usually rejected to the ambient, that can come from industrial areas, supermarkets or thermal plants. Waste heat from the sewage system has also potential for energy generation by heat pumps. The aim is to use this waste heat within the district for different purposes, for example, depending on its temperature it can be used for preheating some stream, or directly in the return of a district heating network, or, if the temperature is not enough, it can be upgraded with a heat pump. Only consider those waste heat sources within 5-15 km around the district
New area	New development areas are new urban areas where there are no existing buildings.
Retrofitted area	Retrofitting Areas are development or upgrading of buildings or technology within existing infrastructure.
Infill area	Infill Areas are redevelopment or land recycling that occurs on previously developed land.
Transformation area	Industrial or historical areas for urban transformation purposes.
Heritage area	Heritage area refers to a site that is defined as protection area in municipal plans, like historic buildings. Therefore, if there is some protected or heritage building in your area answer YES
Residential usage	Any residential or mixed-use building with energy licences. Typically, the loads to be covered in these kind of buildings are: domestic hot water, space heating, space cooling, electric appliances, lighting and ventilation.
Commercial usage	Any commercial building with energy licences, such as shopping malls, supermarkets, etc.
Open lots	Parking lots and green areas may have potential for solar generations such as solar trees, canopies.
Public land usage	Any public building such as town halls, administration buildings, schools, hospitals, etc. with energy licences.
Private land usage	Private or public ownership of these buildings may affect the financial plans for PED implementations.
Industrial area	Industrial area such as business centers, technology centers, industries (ceramic, paper, chemical, etc.), that could be part of the PED area.
is there any district heating network (DHN) nearby?	District Heating and/or Cooling network or any central system that is involved within the PED boundaries, or that can be potentially connected with the PED (e.g. the PED has a low temperature district heating network and has a conventional DHN very close to it).
Is the district off-grid?	If the district is off grid, it means that it is not connected nor intended to be connected to the public electricity grid.
does the district have a private electricity grid?	A private grid is a power grid that is not owned by the grid operator of the country neither the distribution company, nor therefore it can be managed by its owners (from the substation to the citizen's consumption points) without the need to follow the national grid electricity rules (e.g. they can make peer-to-peer transactions, etc.).

Is the district connected to the gas network?	The gas network consists of pressurized pipelines that bring methane (from fossil fuels or syngas from biogas) to the citizens living in the area for cooking and/or heating purposes.
Do you want to include e-mobility aspects?	An electricity-driven vehicle has an electric motor driven by electricity which has been previously stored in a battery. E-mobility application means that charging stations and a float of vehicles is intended to be installed.
Do you want to include hydrogen-mobility aspects?	A hydrogen(H2) vehicle has an electric motor, but electricity is self-produced by a fuel cell inside the vehicle that consumes H2. H2 is stored in a tank in a similar way than in a conventional vehicle. The vehicle can be a car, a truck, a train, a boat, etc. (note that: depending on the vehicle, the system's explanation above might differ).H2 application means that refuelling H2 stations and a float of vehicles is intended to be installed.
Do you want to apply soft-mobility aspects?	Such as Car-free zones or ban the entrance of very pollutant vehicles in the district.
Do you want to interact with the gas grid? (injection of hydrogen or biogas)	When answering yes, you know that there are possibilities to inject hydrogen (to a certain amount) and/or biogas, and regulation allows it.
Do you want to offer ancillary services?	Ancillary services such as demand response (e.g. when the grid needs it, it will ask you to switch off part of your appliances to lower the demand consumption), scheduling (like scheduling a generator to produce a certain amount of power in a certain moment), dispatch (real-time control of the available resources), operating reserves (have a certain technology that is able to quickly produce energy for the grid when needed), control of frequency, reactive energy, etc.
do you want to participate in the market? (sell/buy, go to market, aggregation, etc.)	Aggregators bundle the distributed energy sources (DER) within the PED to act as a single entity in the power or service market. Usually this is done through virtual power plants. They can participate in the market to sell/but energy, forecast the DER within the PED, etc.
Do you want to offer hydrogen to industry or for electricity generation?	In some context, it can be possible to generate hydrogen with the excess of electricity and sell it/export it to industry (for direct use) specially when the industry is next to the district. Furthermore, it could be also interesting to, instead of exporting it, store it and use it for power generation, when needed. In some contexts, it is also common to use hydrogen for generation of heat and electricity (such as in Japan)
Do you want to interact with the users/consumers?	Give and receive feedback from the user, for example in terms of setpoint temperature, comfort, energy bills or energy consumption. This can be done by a web-based user-interface or a phone app, among others
Would you need a data platform?	A data platform is an integrated technology solution that allows data located in database(s) to be governed, accessed, and delivered to users, data applications, etc.
Do you want that the electricity and thermal production is matched (by optimization, etc.)?	Energy flow optimization means that energy models or linear equations are used to predict and match in a efficient way the demand and supply of the district/Building. Depending on the objective, different rules and strategies can be used, for example, minimizing the primary energy, maximizing the renewable energy use, reduce costs, etc.
Do you want to form an energy community in the district?	Energy communities consist of a group of actors (citizens, public entities, private investors, etc.) that form a legal entity and manage their energy production. They organise collective and citizen-driven energy actions that will help pave the way for a clean energy transition, while

	moving citizens to the fore. They contribute to increase public acceptance of renewable energy projects and make it easier to attract private investments in the clean energy transition. At the same time, they have the potential to provide direct benefits to citizens by advancing energy efficiency and lowering their electricity bills.
Is there any people suffering from energy poverty in the district?	Energy poverty is lack of access to modern energy services. People's well-being is negatively affected by very low consumption of energy, use of dirty or polluting fuels, and excessive time spent collecting fuel to meet basic needs.