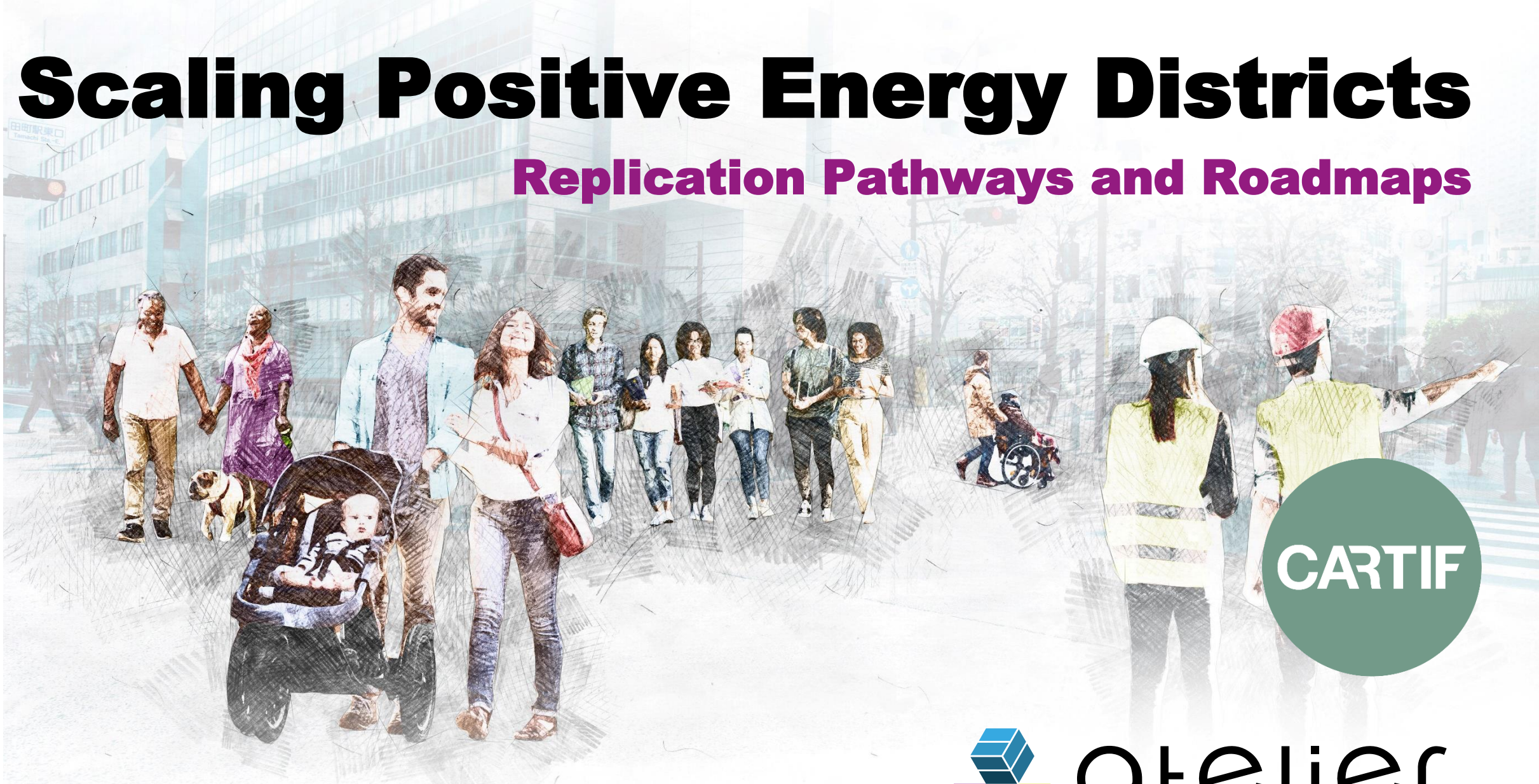
Scaling Positive Energy Districts

Replication Pathways and Roadmaps



CARTIF

AmsTErdam BiLbao cItizen drivEn smaRt cities

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Why replication is the real challenge

Pilots are not transformation

100+ Mission Cities
aiming at climate neutrality

PEDs as building blocks
of climate-neutral cities

Scaling requires:

Data

Governance

Financing

Social acceptance

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Replicating PEDs is not a technical exercise

PED Replication

Spatial intelligence
Where?

Governance and regulation
Under which conditions?

Technical feasibility
How?

Social and economic alignment
For whom?

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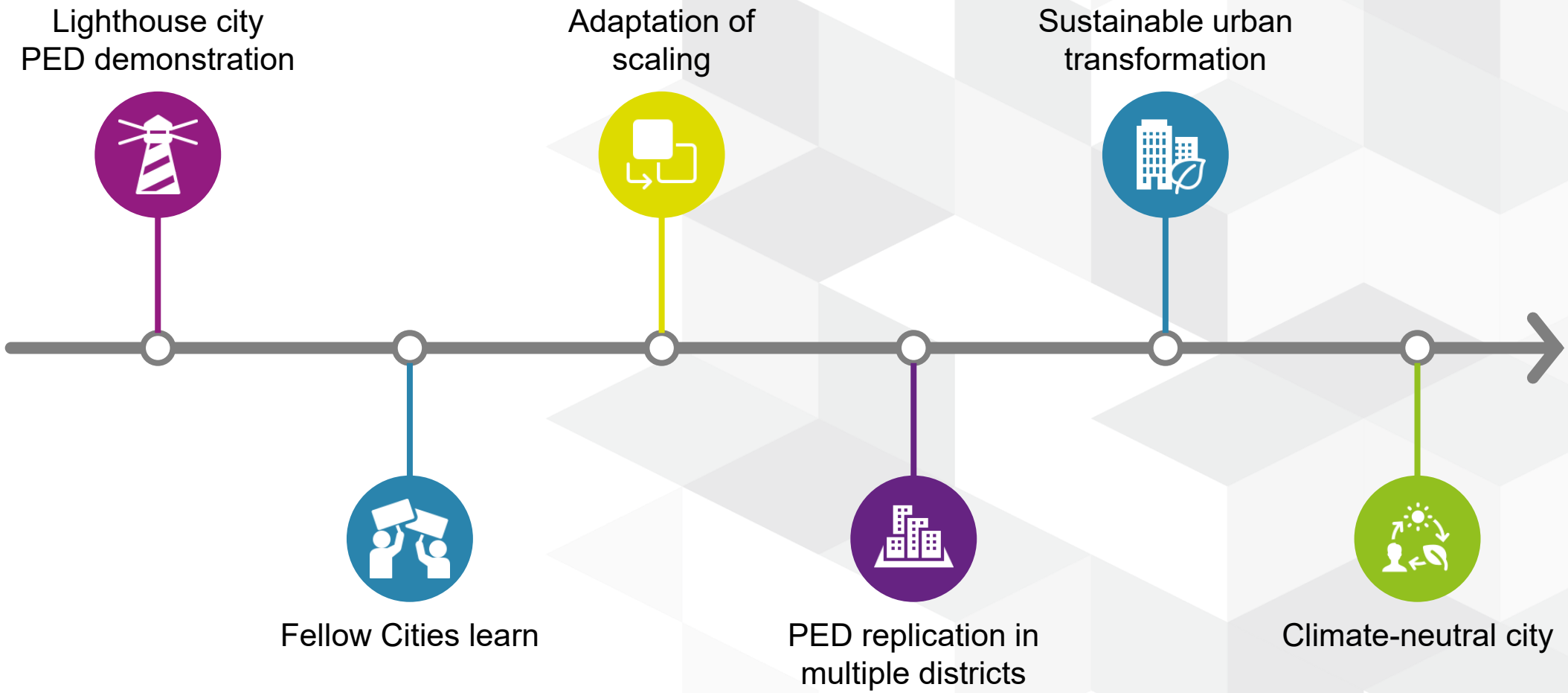
Replication is a systemic transformation process



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In this session, we will explore:

- A data-driven methodology to identify PED potential
- Real replication plans from Fellow Cities
- Lessons from a completed project (MAKING-CITY)
- Discussion

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Replication is not about copying **success.**

It is about **enabling transformation**

under ***different realities.***

GIS-based MCDA methodology for replicating PEDs

José L. Hernández, Iván Ramos

Final Conference – March 12, 2026

Bilbao, Spain

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Positive Energy Districts

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.864374

Outline

- Objectives of the methodology
  - Goals
  - Cities
- Methodology for the replication strategies
- GIS-based MCDA algorithm
- Results for the 6 ATELIER cities
- Conclusions

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Objectives of the methodology

- Development of Replication Plans for 6 fellow cities
  - Aligned with City Vision 2050 (policy session)
- Identification of suitable urban areas for PED development
- Selection and integration of optimal technical solutions and financial schemes
- Equally distributed weights vs customized weights
- Co-creation processes for PED deployment
  - PESTEL and SWOT mixed analysis

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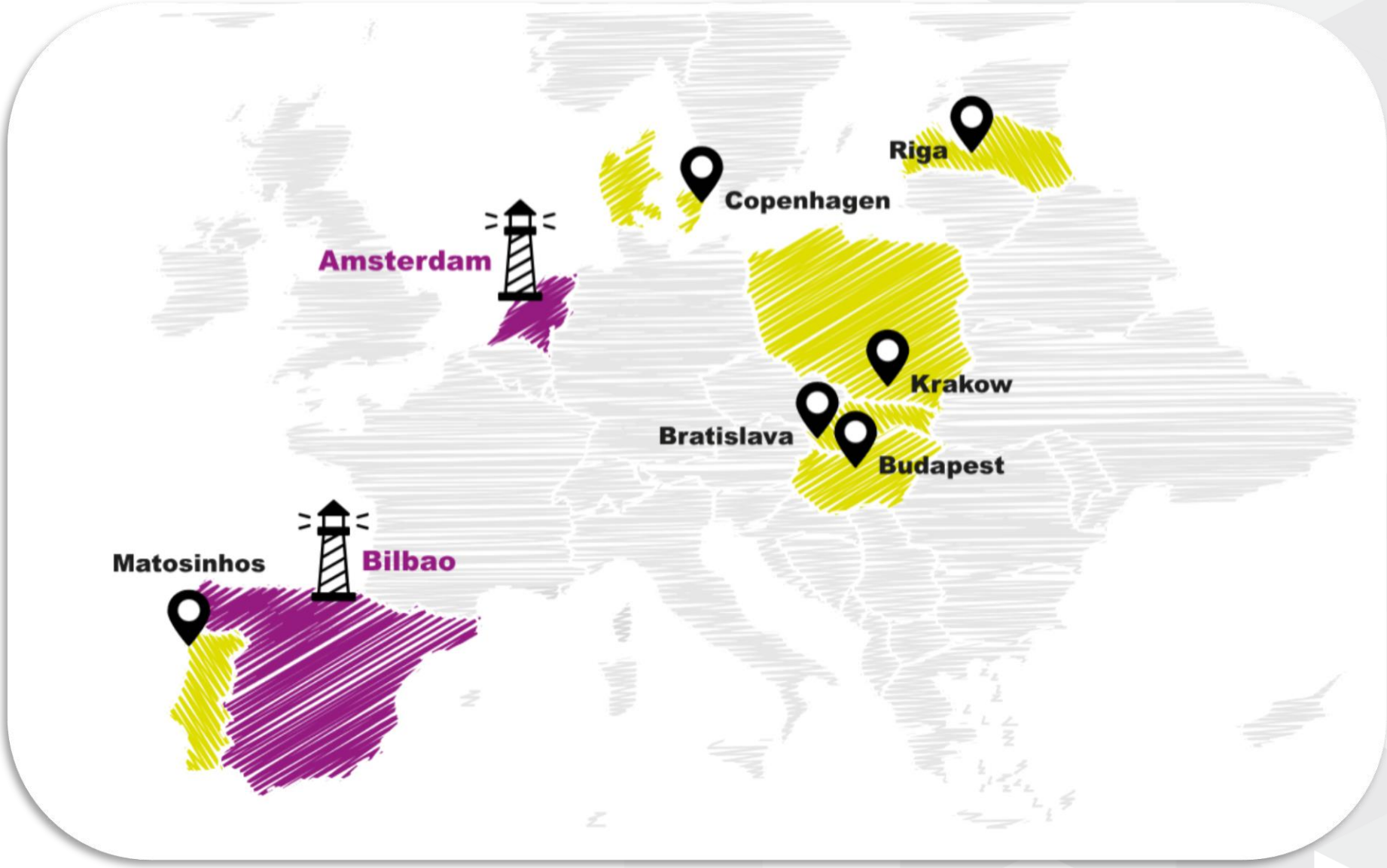
Objectives of the methodology



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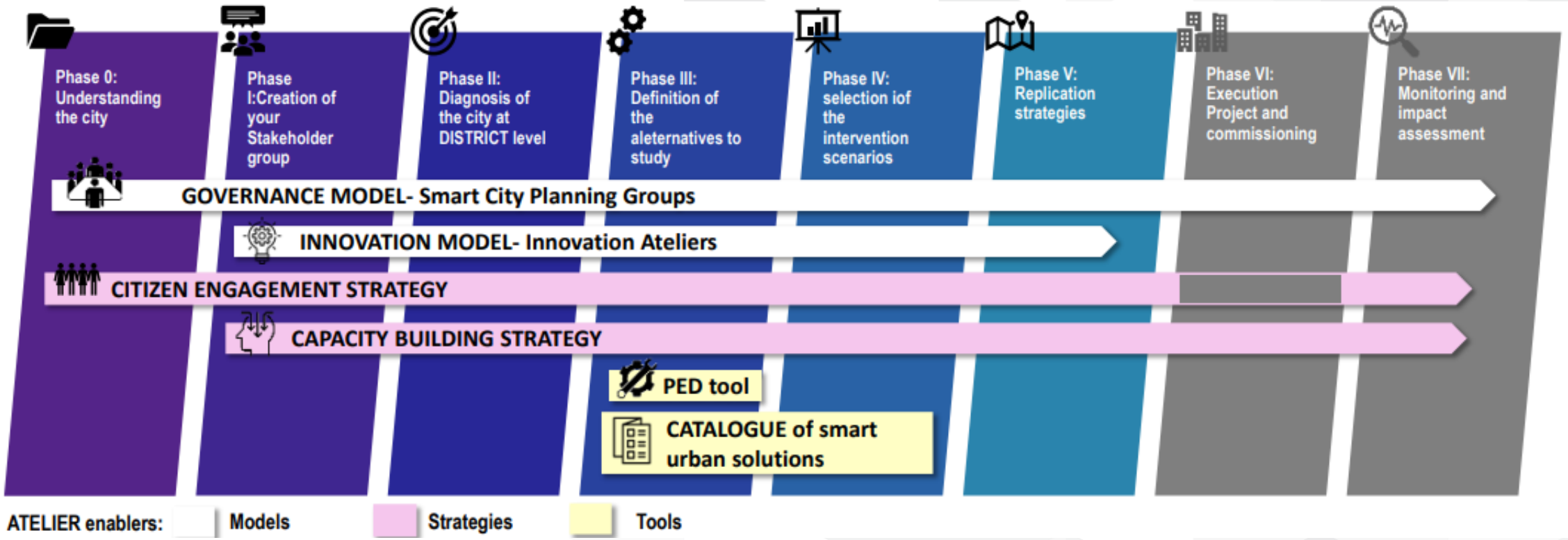
Methodology for the replication strategies



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GIS-based MCDA algorithm

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Positive Energy Districts

STEP 1

- **Analysis of PED components or elements with spatial information**

PED characteristics
- Energy efficiency and flexibility
- Liveability
- Flexibility/Connectivity

Energy demand,
Energy potential,
Distance to different land uses,
Social structure
….

PED factors
- SPATIAL AND LAND USE FACTORS
- TECHNOLOGICAL FACTORS
- SOCIAL FACTORS
- ECONOMIC FACTORS

Type of data
Raster layer at district or building level

STEP 2

- **Selection of suitable area to design a PED**

Weighting or evaluate the values of the layers based on the suitability

*MCDA value = Score * $W_{I1\text{-}In}$*

0 — 1 — 2 — 3

Not suitable … *Most suitable*

Normalization and aggregation

MCDA value per factor and area [0…1]

Result
COMPOSITE INDICATOR PER AREA

STEP 3

- **GIS-based overlay analysis**

Analysis based on the weight of each factor
City Energy Analyst

Selection of potential solutions
Consideration of cities interest areas

Scenario evaluation
City Energy Analyst

Result
PED suitability areas

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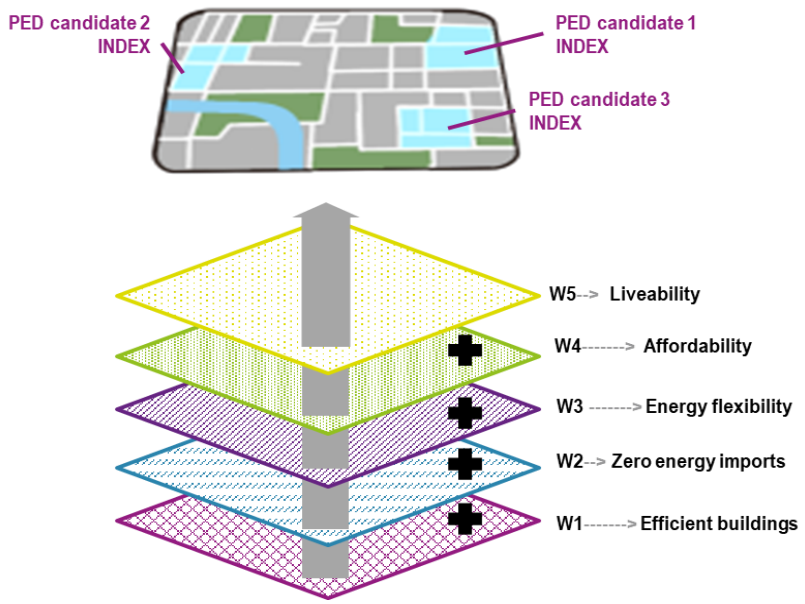
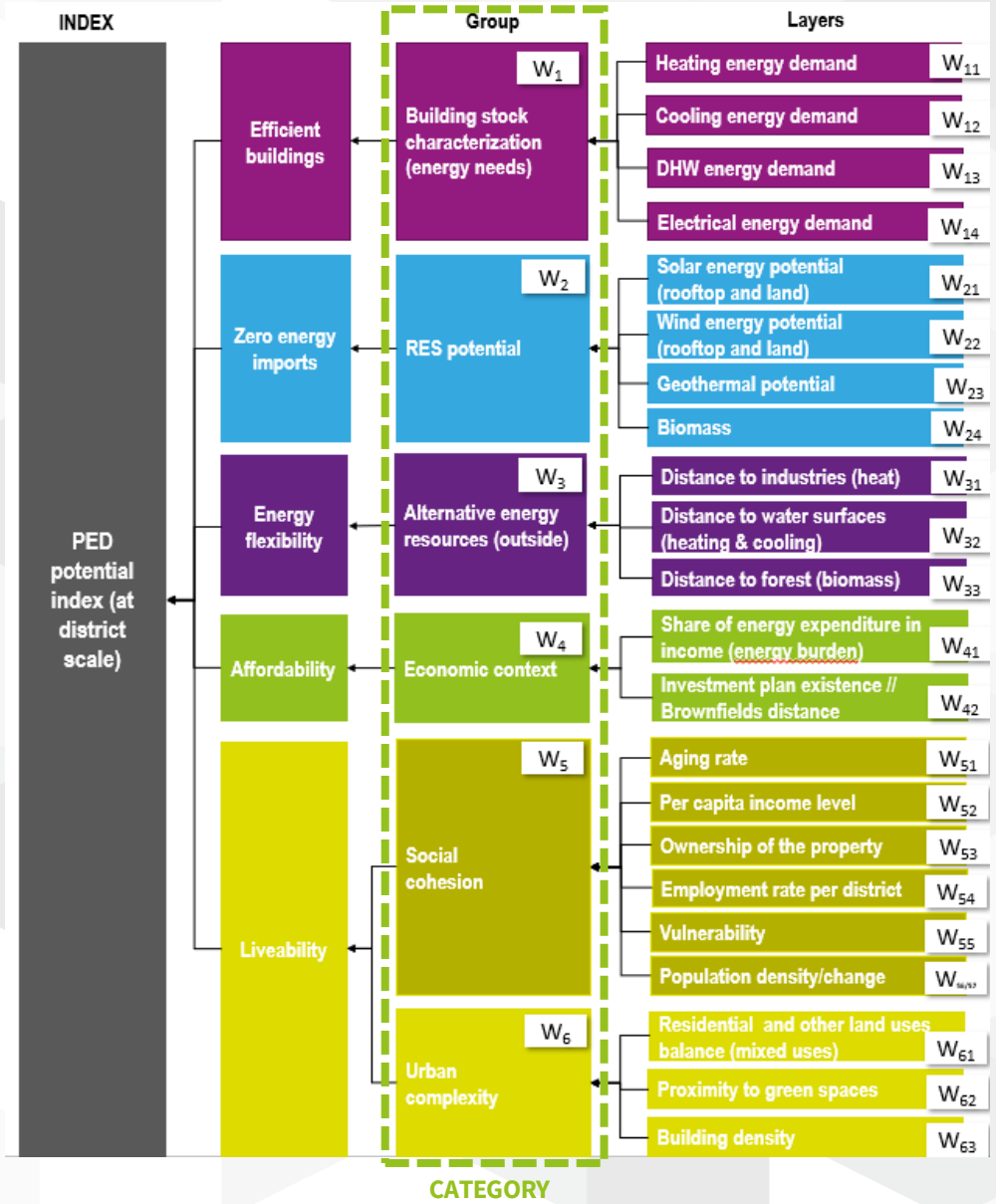
GIS-based MCDA algorithm





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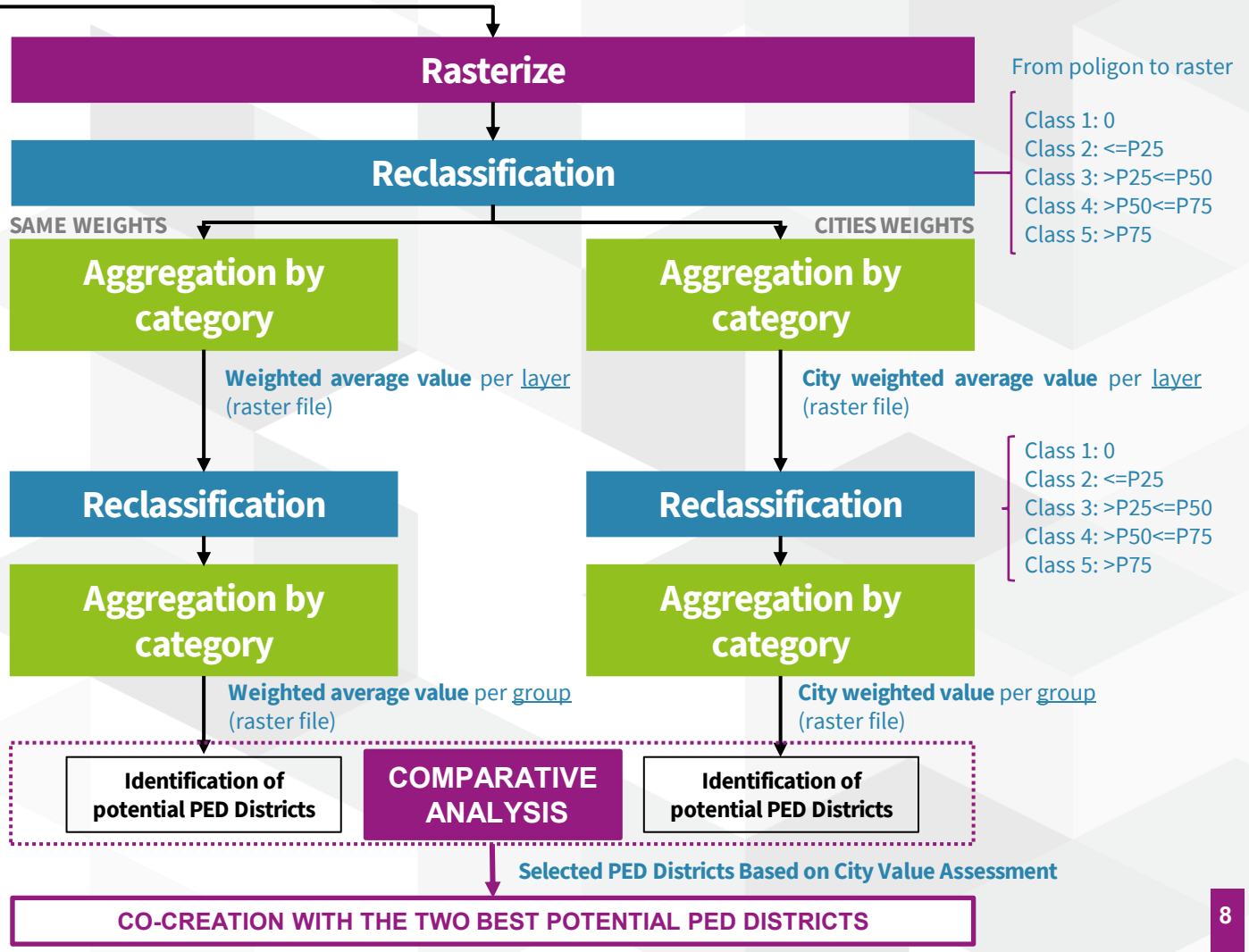
GIS-based MCDA algorithm

Layers

W12	Heating energy demand per m2 (kWh/m2)
W13	Cooling energy demand per m2 (kWh/m2)
W14	DHW energy demand per m2 (kWh/m2)
W15	Electrical energy demand per m2 (kWh/m2)
W211	Solar energy potential rooftop crys (kWh/m2)
W212	Solar energy potential rooftop amf (kWh/m2)
W213	Solar energy potential land crys (kWh/m2)
W214	Solar energy potential land amf (kWh/m2)
W221	Wind energy potential rooftop (kWh/m2)
W…	…



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Results: Replication plans

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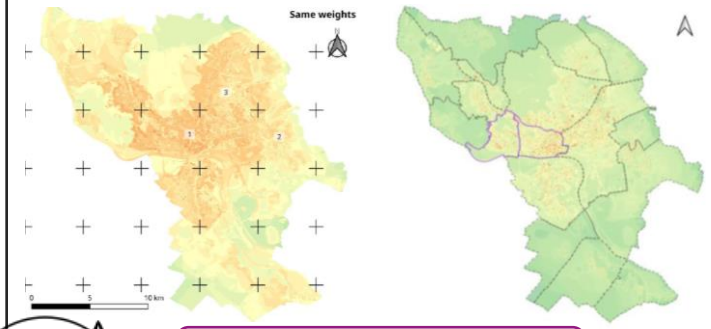
Positive Energy Districts

BRA

Same weights | City weights

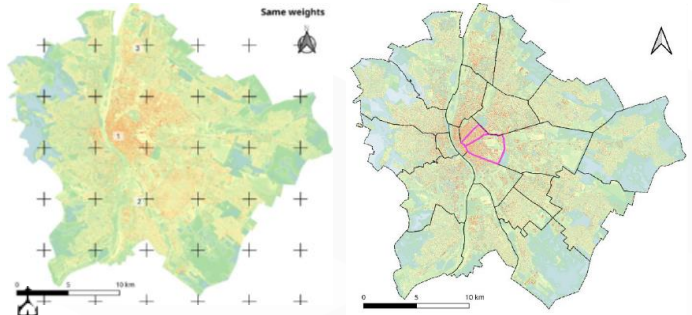


Most suitable PED Districts
(based on city weights)

Karlova Ves & Staré Mesto

BUD

Same weights | City weights



Most suitable PED Districts
(based on city weights)

Jozsefvaros & Erzsebetvaros

COP

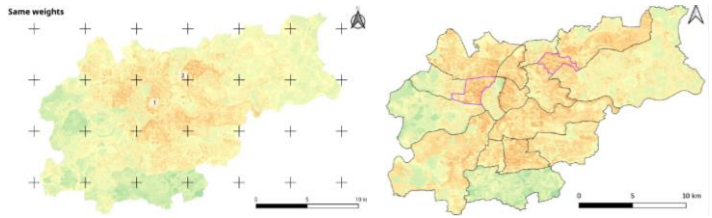
Heat pumps and storage; map rooftop solar potential; New infrastructure with cityscape; advance full transport electrification, involve local actors…

Green transformation of multi-family buildings
Lower temperature district heating
Flexumers4Future

Adapted methodology for city-energy-positive by 2035

KRK

Same weights | City weights

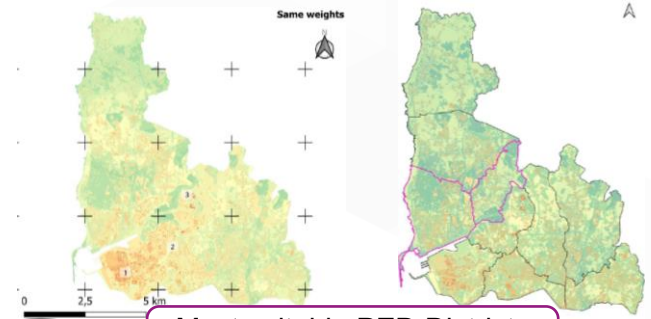


Most suitable PED Districts
(based on city weights)

Bieńczyce & Krowodrza

MAT

Same weights | City weights

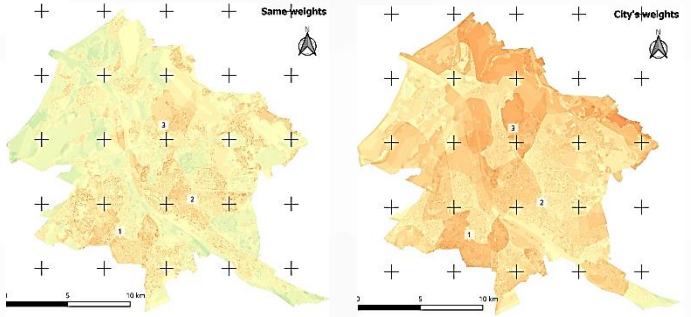


Most suitable PED Districts
(based on city weights)

Santa Cruz do Bispo & Leça da Palmeira

RIGA

Same weights | City weights



Most suitable PED Districts

New development areas

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Conclusions

- Replicable, common, comparable and applicable methodology to define data-driven replication plans
  - Combined with co-creation workshops
- Data availability as a challenge
  - Estimation based on different approaches
- Involvement and engagement of the cities in the process
- Adaptability to the cities needs and criteria
- Data standardisation (data are heterogenous)

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TECHNOLOGY CENTRE CARTIF

Thank you!

www.smartcity-atelier.eu

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Round Table Discussion

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What does it really take to replicate PEDs?

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Do not edit

How to change the design

ATELIER Replicating PEDs: barrie

Question 1 – The real barrier

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In your experience, what is the biggest barrier to replicating PEDs?

Technical, governance, financial, social or something else?

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Question 2 – Adaptation

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How can the replication plans help and support reaching 2050 climate neutrality plans?

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Do not edit
How to change the design

ATELIER Replicating PEDs: requirements (enablers)

Question 3 – The enabler

How do you consider other aspects are accelerating the deployment of PEDs?

Social, regulatory aspects, etc.

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Question 4 – Scaling

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What needs to change for PED replication to move from project-based to policy-driven?

Policy integration, governance, financial mainstreaming, political commitment, long-term planning, etc.

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Question 5 – Context

How should replication roadmaps account for different starting points?

Energy poverty, grid maturity, urban density, etc.

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Question 6 – Data

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How can data-driven tools support decision-making for replication at city scale??

GIS, MCDA, digital twins, etc.

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City of Budapest

ATELIER Final Conference

Daniel Hedari

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The PED context in Budapest

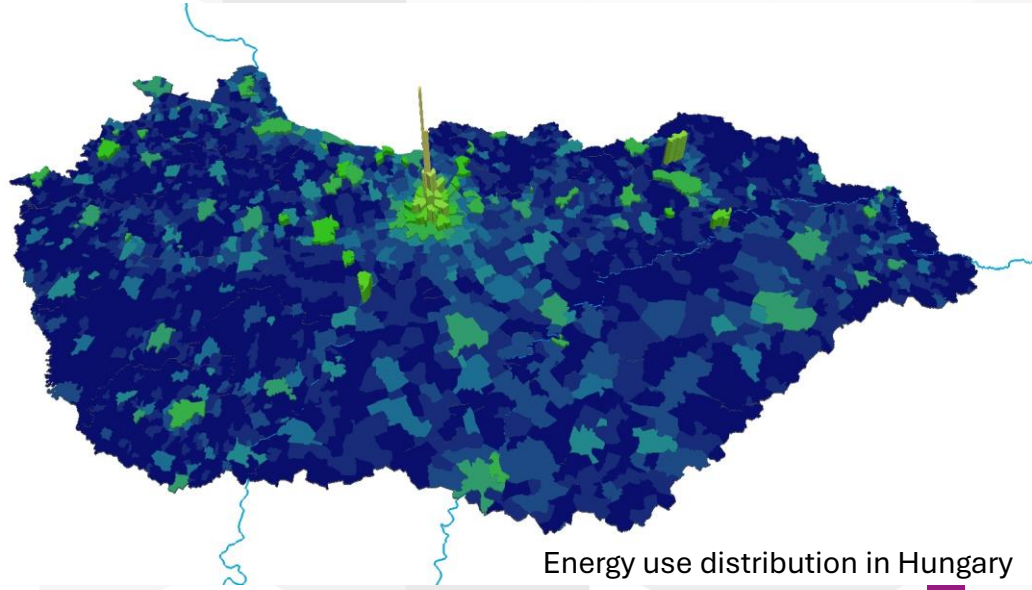
Institutional reasons:

- No significant funding for large scale projects from national budget or own resources
- When financial resources arrive, **we want to be ready to implement!**
- Important to engage private, research and utility sector

→ Therefore, we prioritize projects like ATELIER

Technological and sustainability reasons:

- Manage the growing needs in the capital
- Increase resilience of energy systems
- Provide energy safety for residents
- Opportunity to learn and pilot
- Allignment with the city's goals



Energy use distribution in Hungary

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Hungary energy status

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Net Electricity Importer

30%

Fastest Growing

SOLAR

Grid vs Renewables

RENEWABLES GRID

Energy Security

LOW

Urban Infrastructure

Slow modernization

Energy Consumption

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I. Replication IN ATELIER

II. Replication IN THE MUNICIPALITY

III. Replication IN BUDAPEST

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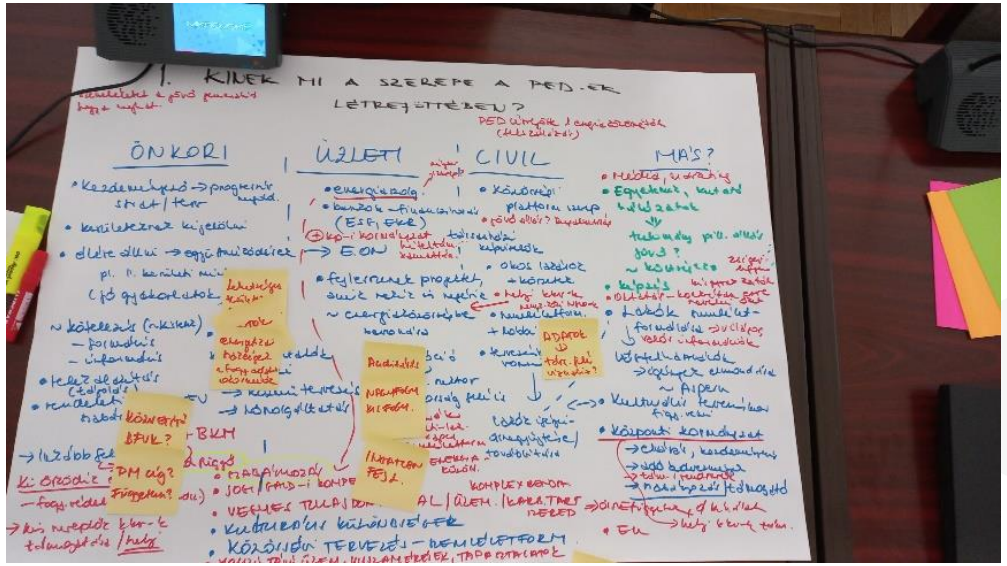
Replication IN ATELIER



WP2 City Vision

- Establish local SCPG
- Revised SECAP
- Climate City Contract
- Environmental programme

WP3 Innovation Atelier

- Stakeholder group (Climate Platform)
- Two workshops:
  - knowledge exchange
  - PED localization, replication

WP6 PED development

- PED design, planning, replication

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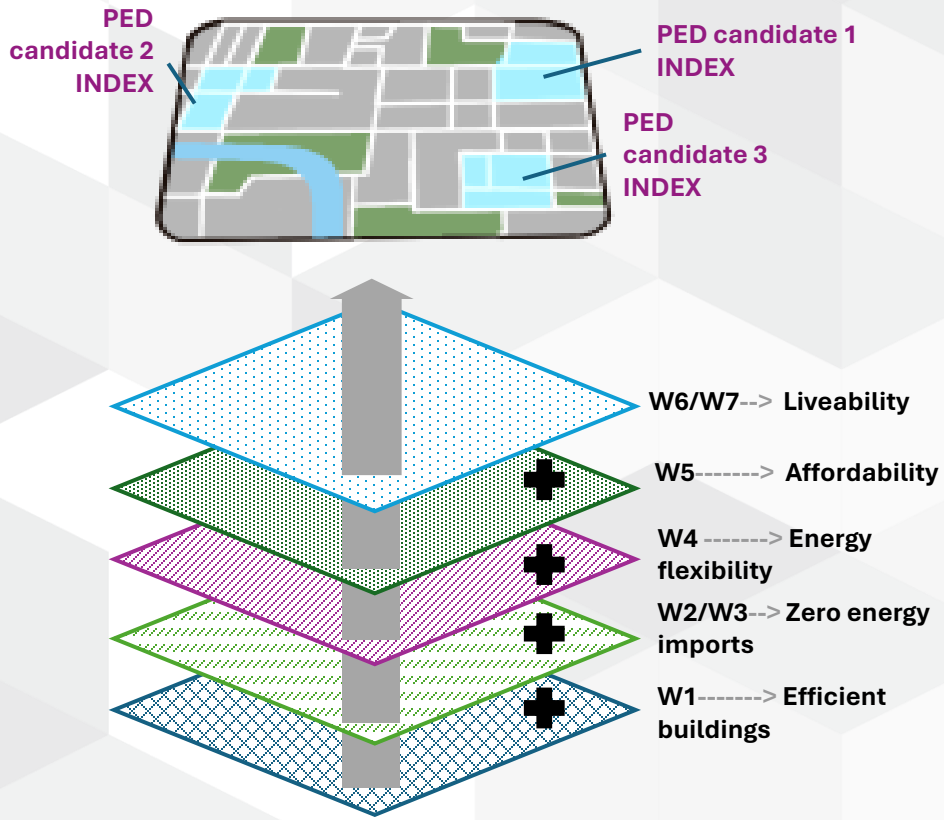
Replication IN ATELIER

CARTIF methodology

- evaluates in GIS layers each PED characteristic
- weight to each layer
- the result of the process is a map where PED potential areas are located



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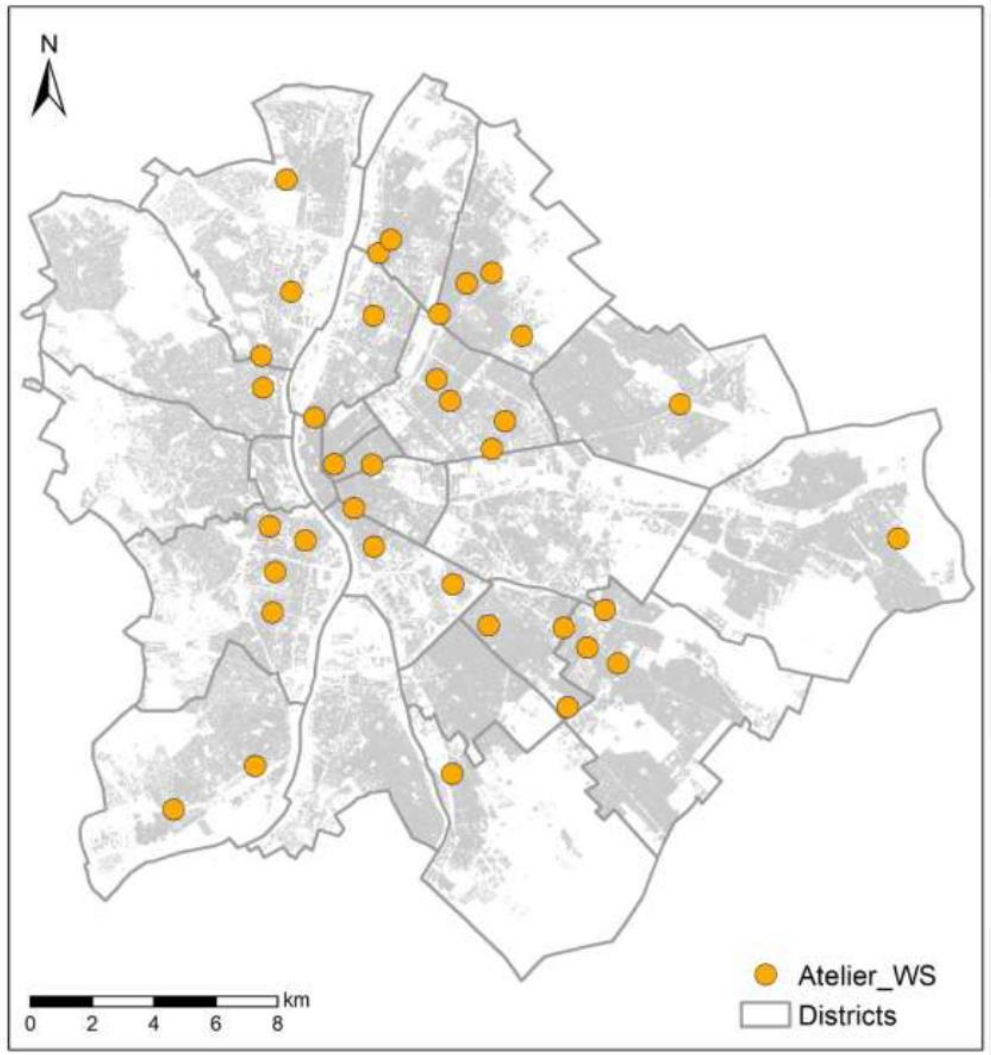
Replication IN ATELIER

Municipal workshops

- Professional stakeholder group
- Examine possibilities in four typical urban typology of the city
  - Metropolitan
  - ‚Small-town'
  - Residential complexes
  - Suburban
- Identify possibile development areas



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Replication IN THE MUNICIPALITY (& Scaling)

- Municipal **‚experts group'**
- **ASCEND**
  - Forming of EC and communication with future members
  - Prosumer behaviour
  - Testing the regulatory environment
- **Other related projects**
  - ENERGY4ALL – social cohesion
  - REALLOCATE - mobility
  - AHA Budapest – social housing
  - Solar4Ce - prosumerism
  - EUKI – solarmap, PV
  - BPCARES – energy renovations

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Replication IN BUDAPEST

Rákosrendező

- One of the largest brownfield development in Budapest
- Tension between investor and public interest
- Strong sustainability and social inclusion requirements
  - **Including PCED as criteria**
- Currently tendering of master plan

Budapest – Rákosrendező brownfield area; to be developed as PCED

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Thank you!

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MAKING CITY

Energy efficient pathway for city transformation, enabling a positive future

Co-funded by
the European Union

Cecilia Sanz Montalvillo – cecsan@cartif.es – CARTIF Technology Centre

Energy efficient pathway for city transformation, enabling a positive future

Making City

2 LIGHTHOUSE CITIES
Groningen (Netherlands)
Oulu (Finland)

6 FOLLOWER CITIES
Bassano del Grappa (Italy)
Kadiköy (Turkey)
León (Spain)
Lublin (Poland)
Trenčín (Slovakia)
Vidin (Bulgaria)

TOWARDS A CITY VISION 2050

Currently, city energy plans for energy transition are designed within a 2030 horizon, which can be considered as a mid-term strategy (part of the 2030 Climate & Energy Framework in Europe). In MAKING-CITY, **the City Vision 2050** is used as a longer timescale to address the urban energy system transformation towards low-carbon cities.

MATURE & INNOVATIVE TECHNOLOGIES

- Retrofitting buildings
- Renewables
- Heating & cooling systems
- Waste recovery
- Innovative storage & transfer technologies

WHAT IS A POSITIVE ENERGY DISTRICT?

A PED is "a delimited area of buildings and public spaces where **the total annual energy balance is positive.** Therefore the area will deliver, in average, an energy surplus to be shared with other urban or peri-urban zones."

34 PARTNERS

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Demo PED in MAKING-CITY

OULU

KAUKOVAINIO district

GRONINGEN

Groningen NORTH

Groningen SOUTHEAST

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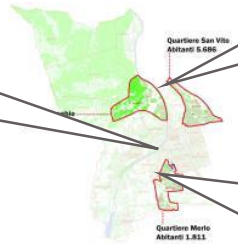
Activities in the Fellow Cities

Bassano (IT)

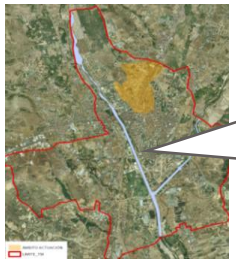
Wind possibilities



Public lighting to be replaced

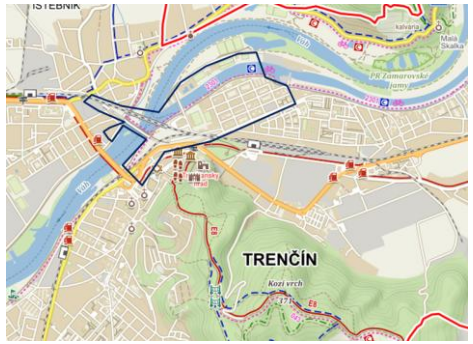
Half of the buildings with PV panels on roofs

León (SP)



Residential & Public buildings

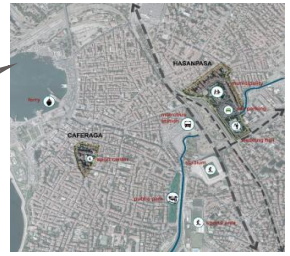
Trenčín (SK)



- Preparing new housing development in PED area
- Key public buildings inside
- Solar and geothermal as main expected renewable sources

Kadikoy (TR)

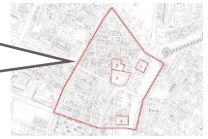
Main mobility hub in Istambul



Vidin (BG)

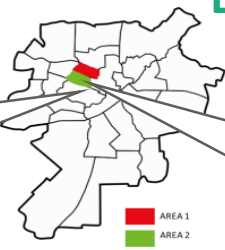
High variety of buildings with passive ECMs implemented

Freedom to design ECMs & RES



Lublin (PL)

Planned the modernization of heating network



Residential & Public buildings

Making City

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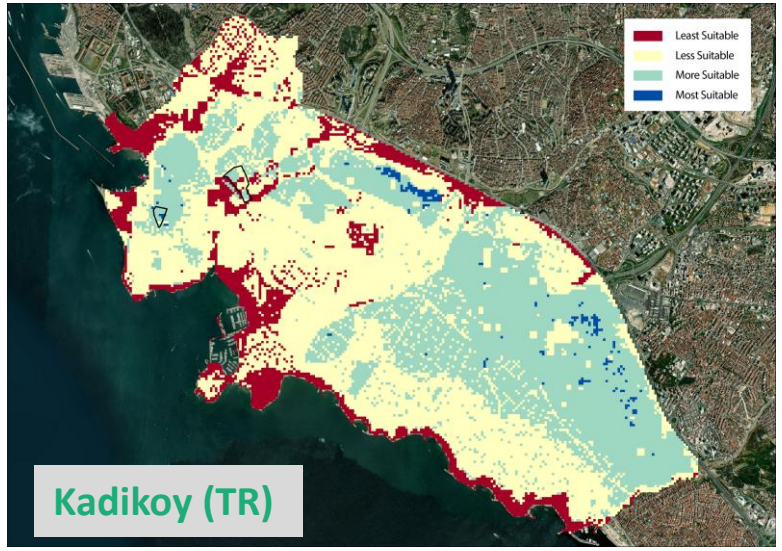
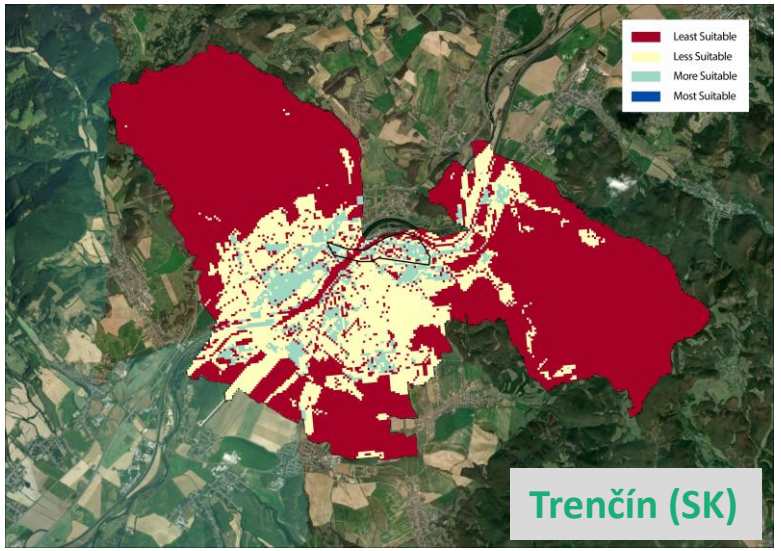
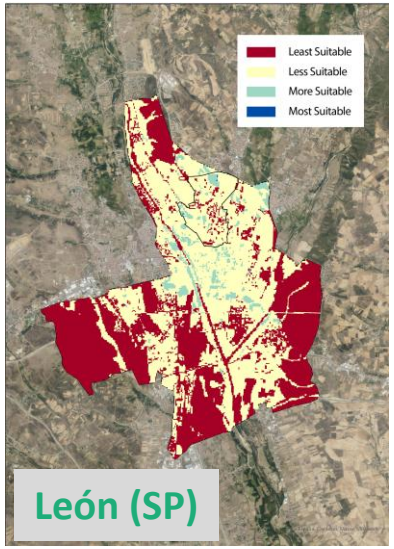
REPLICATION PLANS ->

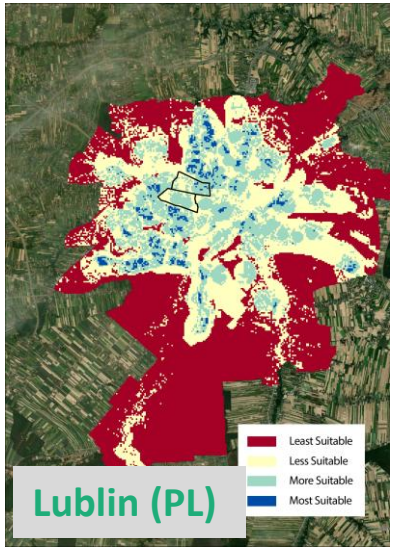
Detail the actions that the follow cities to replicate following the knowledge of the lighthouse PED demostrator (Oulu and Groningen)

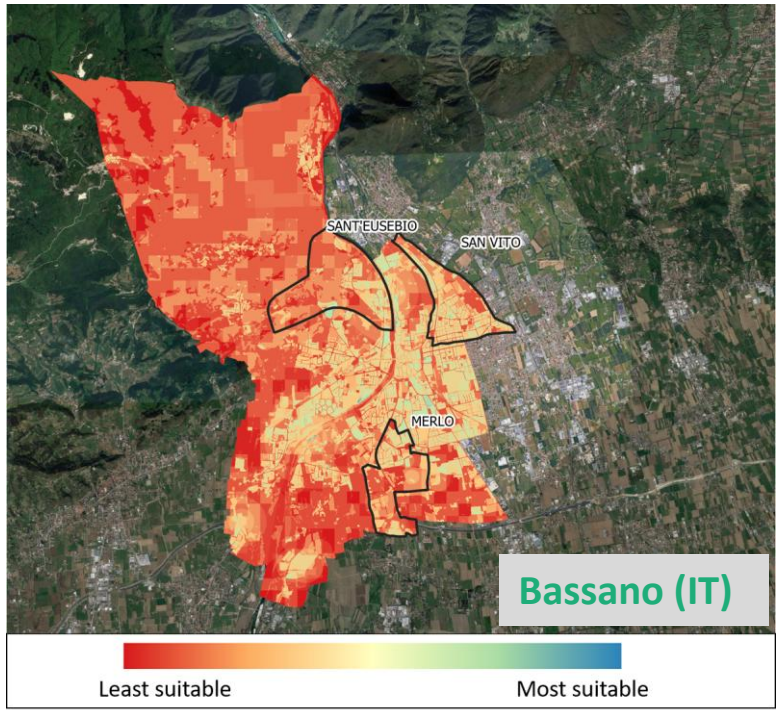
PED in the city center	Bassano used the knowledge generated in the lighthouse demonstrator, to incorporate a **renewable energy generation in a heritage area**	BASSANO
Developed a **PED**	Kadiköy continues with the **implementation of the PED**, using the knowledge generated in the MC **demonstrator to correct and improve the design**	KADIKÖY
Increase **solar energy** generation	León increases solar energy production by implementing new solar facilities in public buildings. With the knowledge generated in the MC, the city aims to develop a PED that primarily uses PV generation and starts increasing zero-energy initiatives	LEÓN
Change **energy model** in the city	Vidin is promoting energy efficiency by using **biomass in district heating, biofuels in transport** and **expanding renewable energy communities**. The city is **installing solar and geothermal energy** to help reduce energy poverty.	VIDIN
New **business model**	Trenčín uses **MC knowledge to create a business model** that integrates **new technologies** and **engages citizens**, ensuring successful project implementation.	TRENČÍN
District heating grid (DHG)	Lublin **aims to expand its DHG network**, allowing more buildings to connect and improving energy efficiency. The project promotes cross-sector collaboration and strategic planning to optimise urban energy use.	LUBLIN

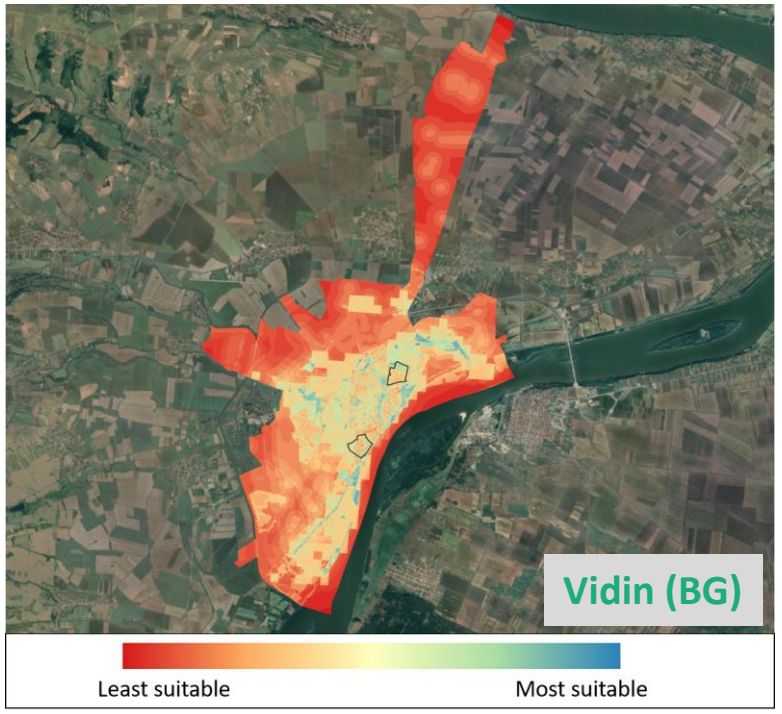








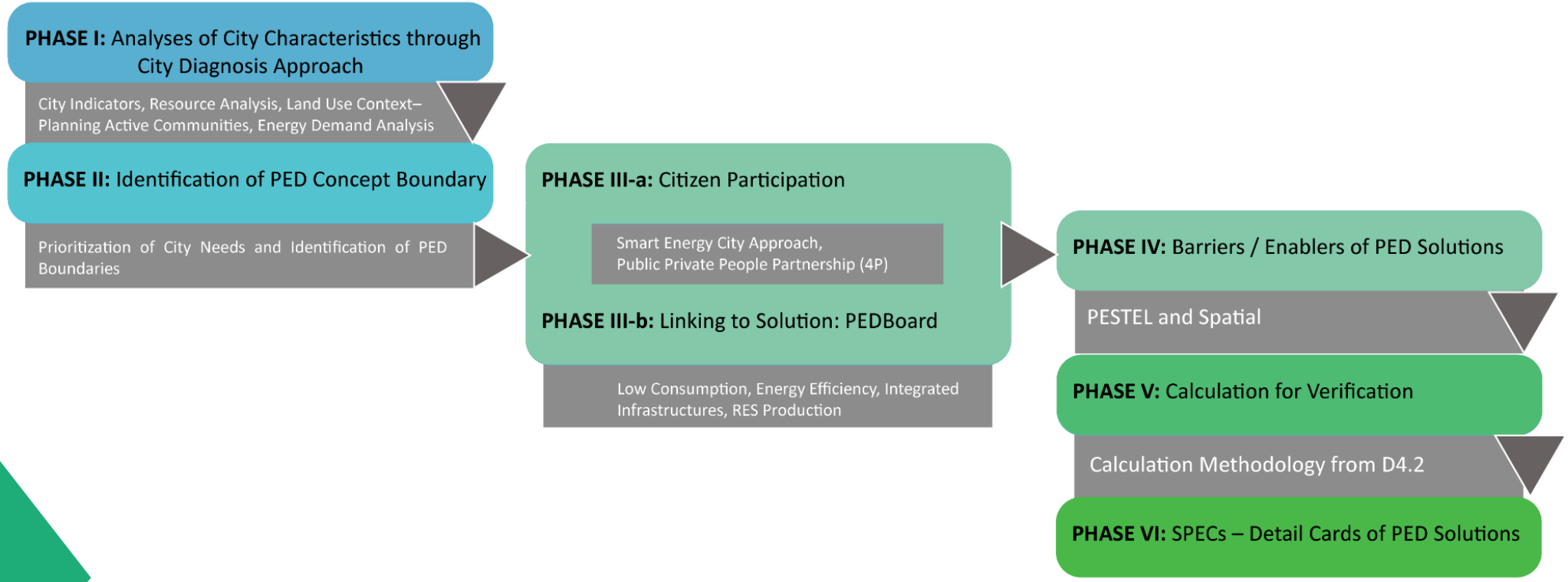


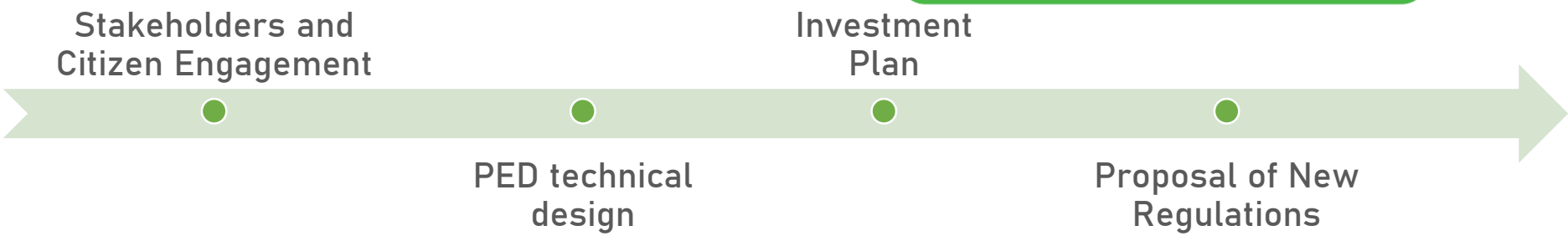


Districts finaly evaluated for becaming a PED

Making City

PED Design Methodology





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PED Design Methodology_León

PHASE I: Analyses of City Characteristics through City Diagnosis Approach

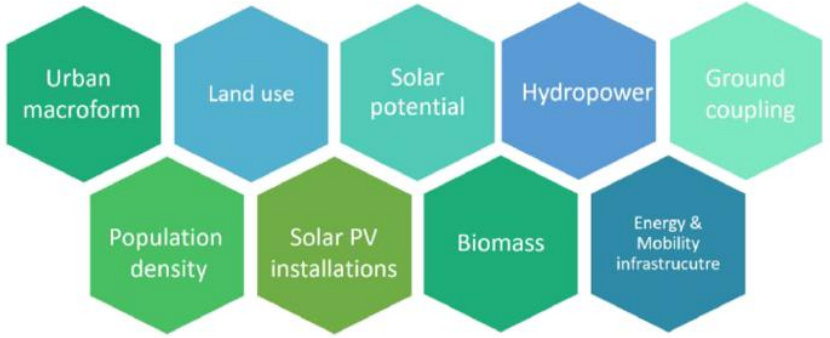
City Indicators, Resource Analysis, Land Use Context– Planning Active Communities, Energy Demand Analysis

Solid Fossil fuels	Natural Gas	Oil and petroleum	Renewables and biofuels	Electricity from the grid
0,00	7,23	13,16	0,05	5,22

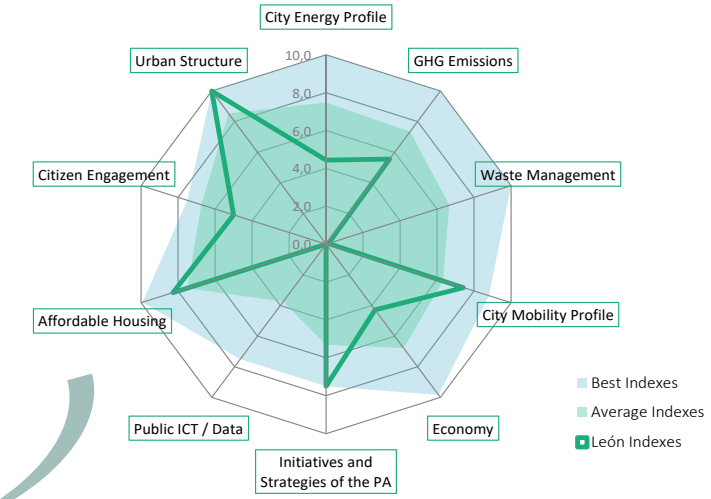
Primary energy sources (MWh/cap)

Average solar radiation (kWh/m²year)	Average Wind power density (W/m²)	Geothermal potential conductivity (W/mk)	Water bodies
1.643,56	43,45	1 – 1,1	Bernesga and Torío rivers

Renewable resources main characteristics



GIS layers considered in the analysis – León



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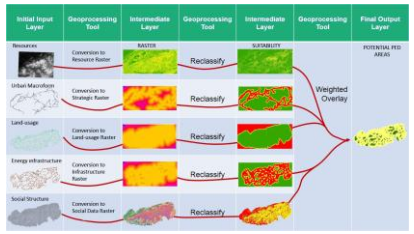

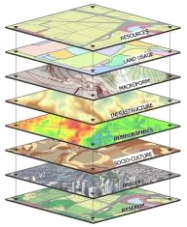

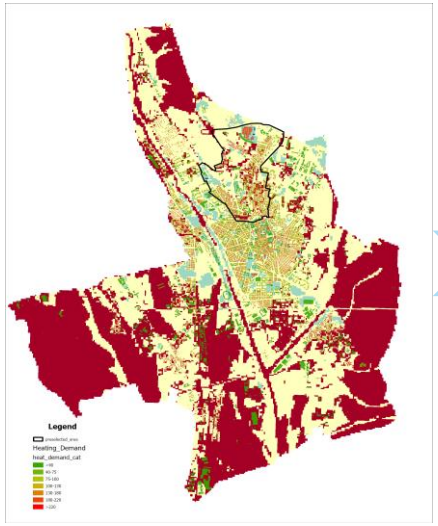

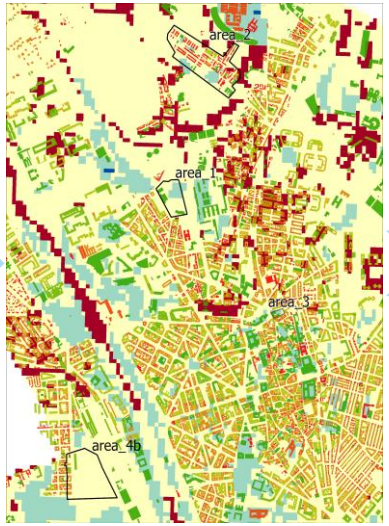

PHASE II: Identification of PED Concept Boundary

Prioritization of City Needs and Identification of PED Boundaries

Selection of potential PED areas using:

- a GIS-based spatial analysis combined with
- a Multi-Criteria Decision Analysis (MCDA)

Different urban, energy, environmental and socio-economic layers were integrated through a weighted overlay analysis to identify and prioritise suitable districts for PED implementation.

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PHASE III-a: Citizen Participation

Smart Energy City Approach,
Public Private People Partnership (4P)

PHASE III-b: Linking to Solution: PEDBoard

Low Consumption, Energy Efficiency, Integrated Infrastructures, RES Production

PHASE IV: Barriers / Enablers of PED Solutions

- Items determined in individual discussions with the cities

- ❑ Objectives: What do you want to ask to your citizens ?
- ❑ Barriers : What are the main barriers or bottelnecks ?
- ❑ Local actors: Mapping of the local actors
- ❑ Tools to be used: Define the tools to implement
- ❑ Agenda: Define the planning for the activities
- ❑ Support/material: What do you need?
- ❑ Contact point

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- Scenario 1: All PV + All heat pumps
  - PV: 895.5 kW (1328.7+5835.3 m2), only 166 kW new
  - 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
  - HP: 1578 kW - 57.02W/m2 of HPs

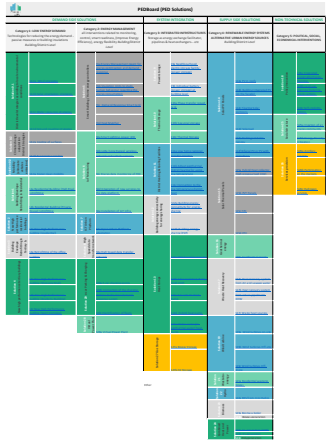
1.

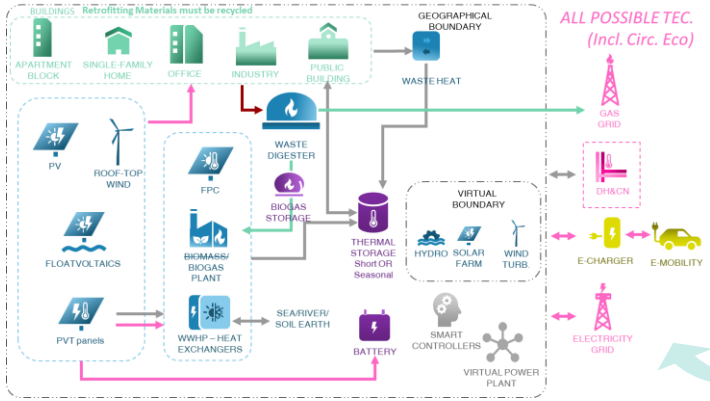
2.

PHASE V: Calculation for Verification

Calculation Methodology from D4.2

PHASE VI: SPECs – Detail Cards of PED Solutions





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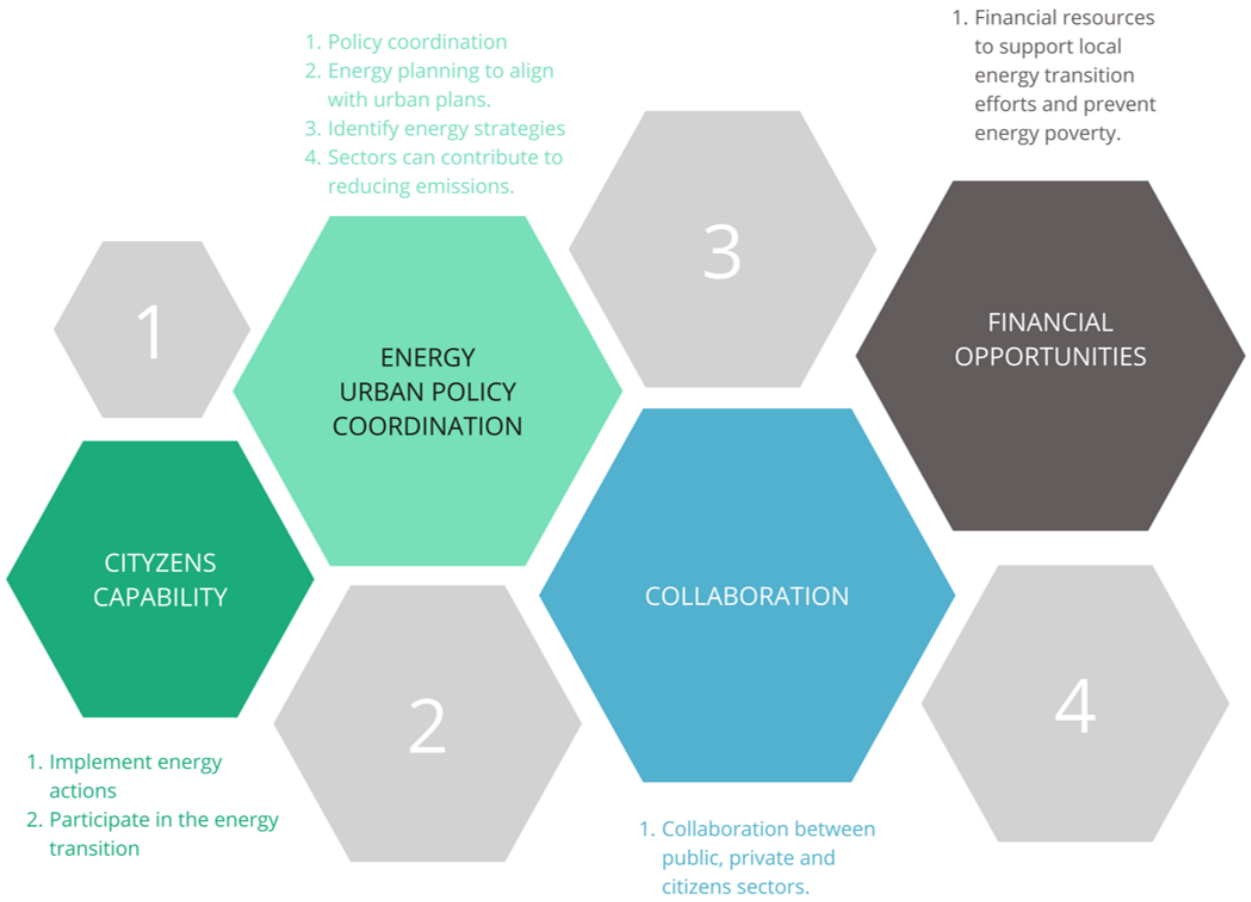
Future steps for the cities



summary of policy recommendations for León

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Thank you
Get in touch for more information!

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REPLICATION IN MATOSINHOS

Ricardo Barbosa

AdEPorto (Matosinhos Municipality)

March, 2026

AmsTErdam BiLbao cItizen drivEn smaRt cities

atelier
Positive Energy Districts

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.864374

City Context

- Matosinhos is located in the northern Porto district of Portugal, bordered in the south by the city of Porto.
- The city covers an area of approximately 62.42km2 and is bathed by the Atlantic Ocean. It has a population of 175 478, which means a density of 2 811 people per km2 .
- Matosinhos is a city where the presence of the sea (ocean) has an important role in its weather and economical activities. The privileged geographic conditions of Matosinhos, makes it the largest seaport in the North of Portugal.
- The climate is temperate oceanic, with mild, rainy winters and pleasantly warm, sunny summers. The average annual temperature is 15 ºC, with an average temperature in the warmest month (August) of 25 ºC, and in the coldest month (January) of 13 ºC.

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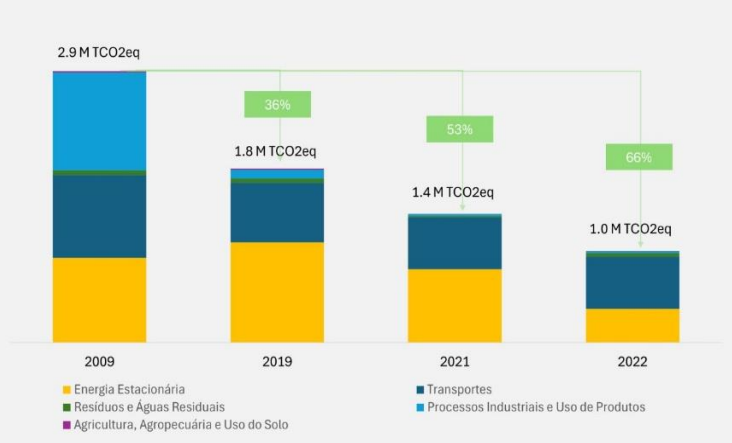
City Context

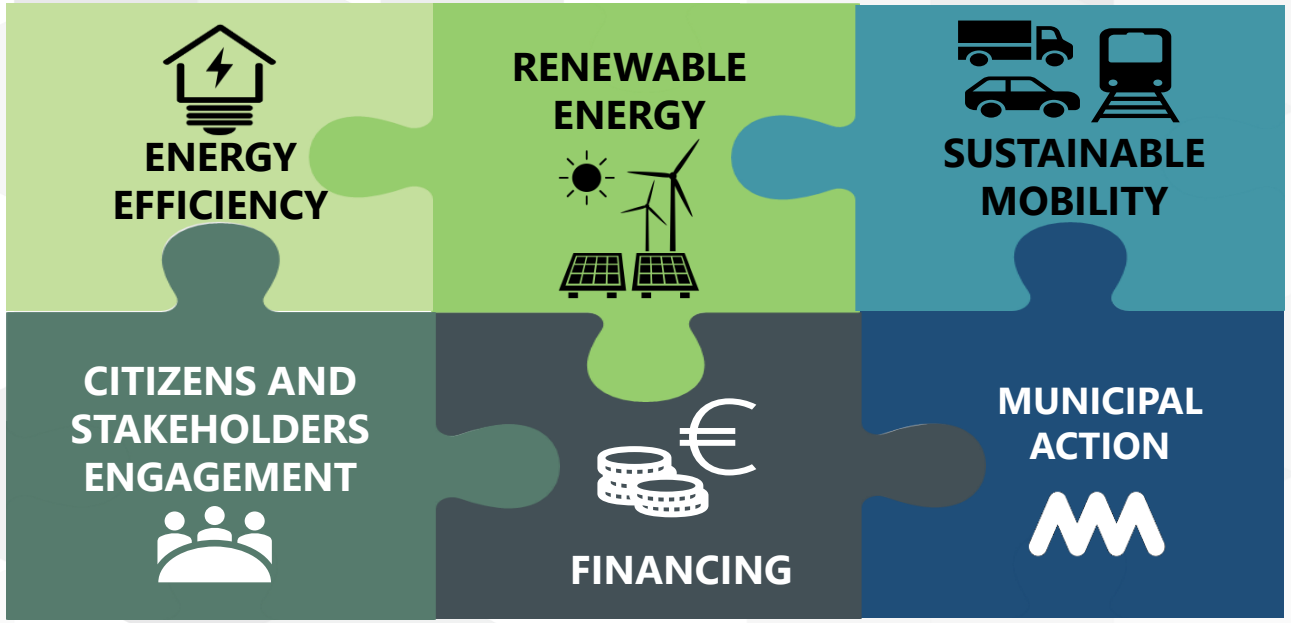
Matosinhos aims to achieve Carbon Neutrality by 2030

Matosinhos aims at reducing carbon emissions by 85% until 2030 (2009)

Current situation



Best practices in Matosinhos



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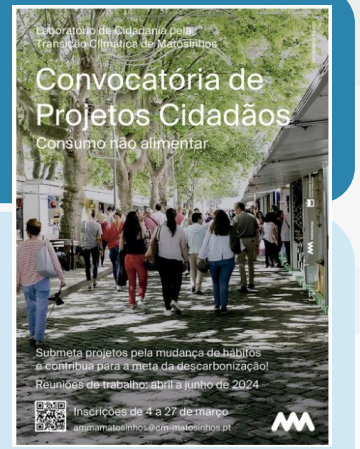
City Context– Citizen and Stakeholders Action

Matosinhos Climate Transition Citizenship Laboratory



- Collaborative space open to all citizens, where prototypes of solutions for the climate transition are being tested, through the implementation of low-cost and quick visibility measures;
- Design and implement experimental behavior change projects for the climate transition in the areas of mobility, food, energy and consumption;
- Promote climate and participatory literacy and bring citizens closer to public policy;
- Collectively consolidate a place-based diagnosis of the global climate and environmental crises;

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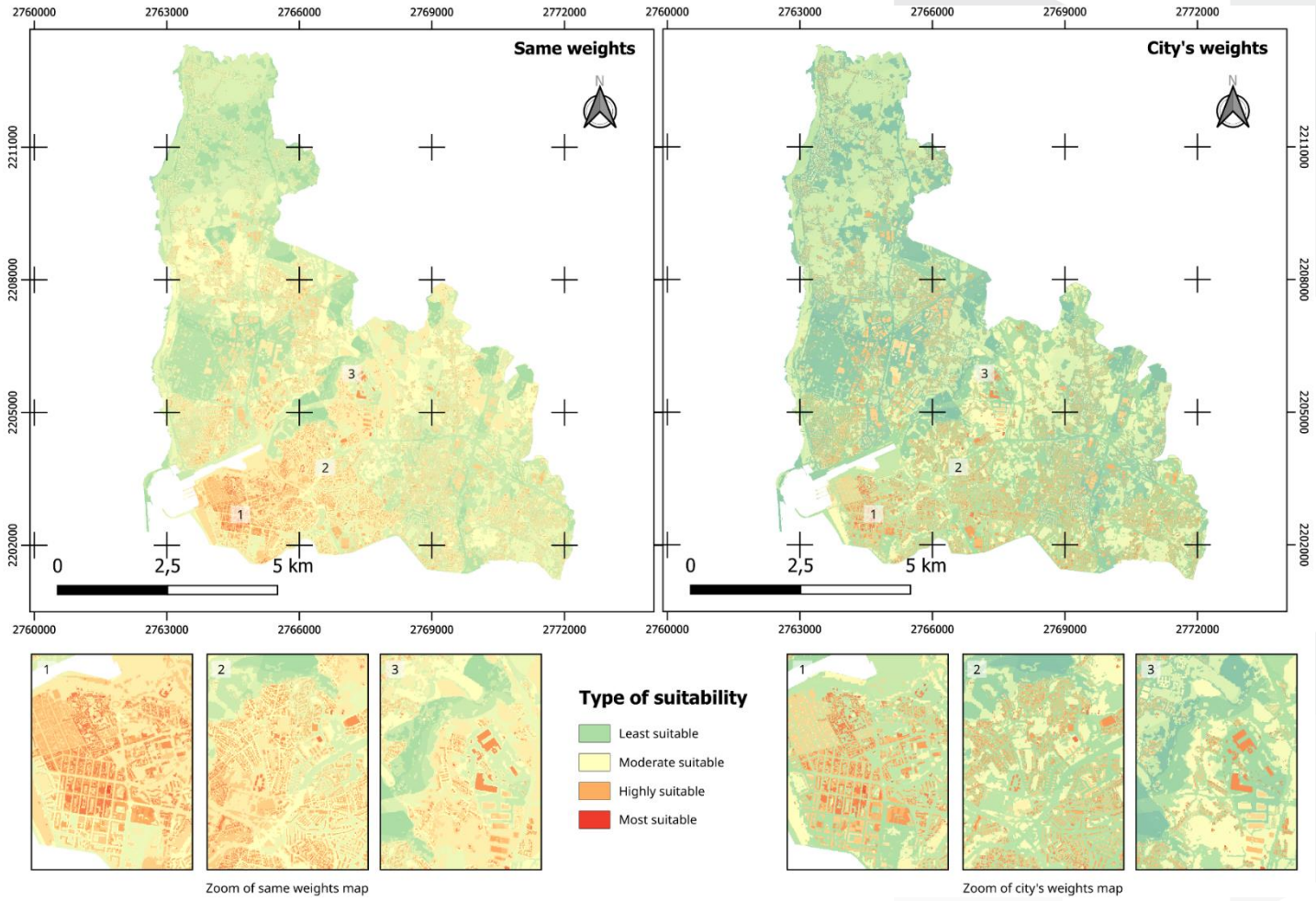
Application of methodology

Replicating the concept



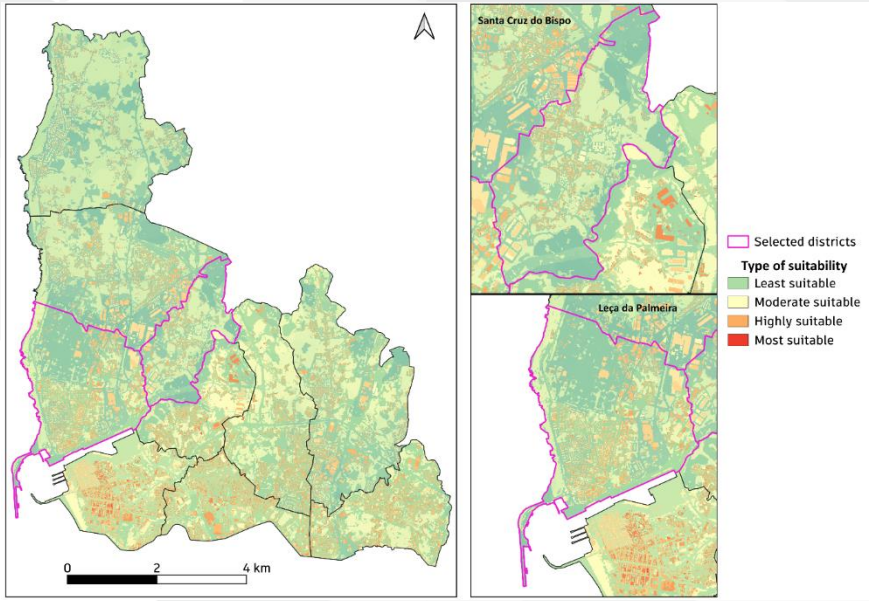


Table 1. Weights per group given by Matosinhos compared to equal weights values.

Group of layers	% of the group on equal weights	% of the group on city weights
Energy demand	20	28
RES potential	20	39
Alternative energy resources (outside)	20	11
Economic context	0	0
Social cohesion	20	17
Urban complexity	20	6

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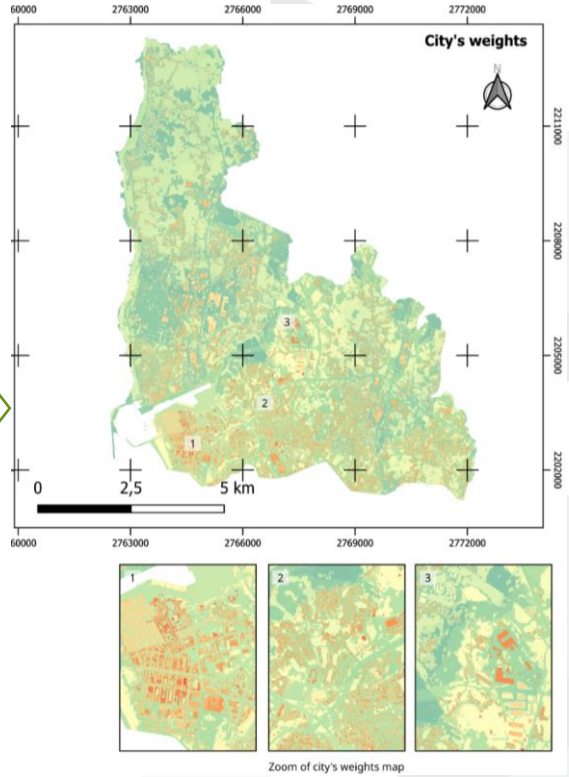
Connecting carbon neutrality and replication plans



- **Translation of aggregate climate targets into place-based programmes**
  - **Spatial disaggregation of targets**: Which streets and buildings and energy systems need to change
  - **Investment pipeline creation:** Replication plans can create bankable project pipelines that attract private capital
  - **Policy coherence:** Replication plans can surface the regulatory, financial and governance adjustments needed to scale.

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Enablers for PED replication

Strategic and Policy Framework

Matosinhos explicitly included in the **Carbon Neutrality Roadmap of the city for 2030**, demonstrating strong political commitment at the municipal level. This strategic positioning ensures that PED development is aligned with broader city goals and benefits from long-term institutional support.

Economic and Financial Drivers

The city is already investing in decentralized renewable energy systems (RES) for public housing and municipal buildings, lowering financial barriers to PED implementation.

Social and Community Engagement

There are **high levels of citizen participation in city initiatives**, indicating a robust civic culture and strong social capital. This creates fertile ground for **community energy projects**, co-creation processes, and bottom-up governance models essential for PED success. Public engagement enhances transparency, local ownership, and long-term commitment to sustainability goals.

Legal and Regulatory Support

A **national-level regulation for decentralized RES and energy communities** is already in place, creating a robust legal foundation for PED deployment. This framework supports the formation of local energy communities and enables decentralized energy models, reducing legal uncertainties and encouraging stakeholder participation across different levels of government and civil society.

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Barriers to PED replication

Economic Constraints

Economic constraints are a **major limiting factor** for PEDs in Matosinhos. The combination of complex funding processes, expensive implementation, and rigid procurement frameworks creates a hostile environment for innovation and investment. Furthermore, the absence of flexibility markets hinders dynamic demand-side management and financial viability. A streamlined funding process and procurement reform are essential.

Social and Cultural Barriers

Despite the efforts and success of initiatives such as the Climate Transition Citizenship Laboratory, there is still work to be done in terms of the limited exposure of citizens and stakeholders to energy communities and renewable energy systems (RES).

Technological Limitations

The city's existing building infrastructure presents a **technological bottleneck**. Retrofitting old and inefficient buildings to meet PED standards involves substantial cost, time, and coordination.

Legal and Regulatory Barriers

The national **legal framework is underdeveloped.** Clear national guidelines and PED-specific legal instruments are urgently needed to unlock action.

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