D5.4 Implementation Plan Maia

30/09/2022

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Note: For full list of contributors please refer to Annex

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Deliverable administration

No & name	**D5.4 Implementation plan Maia**				
Status	Released	**Due**	M36	**Date**	2022-09-30
Author(s)	CMM, FHG				
Description of the related task and the deliverable. Extract from DoA	**T5.3 Fellow City Replication Strategy** The objective of this task is to provide an evidence base and in-depth understanding for key systems in the SPARCS Fellow Cities as basis for the development of long-term visions, smart city strategies and the development of locally adapted interventions in the area of positive energy blocks. To this end, Fraunhofer IAO, supported by VTT, will adapt and apply the joint assessment framework as lined out in WP2, T2.1 to each FC within the course of the first 18 months. Subtask 5.3.1 Fellow Cities profile development: a targeted data collection process will take place with different municipal actors from all FCs providing their data inputs into the data repository. The comparison of city-level indicators with corresponding benchmarks and action fields will allow to draft a profile for each city, highlighting the quantifiable sustainability performance in selected sectors (energy, emissions, transportation, buildings) and the current strengths and weaknesses around acting towards a low carbon transformation of the city system. The profile will become the background for an individual smart city strategy and urban transformation plan, as well as the baseline for monitoring progress in the city and for deriving actions and measures in an integrated way (linking governance, strategies and technologies). Subtask 5.3.2 Onsite assessment in Fellow cities: A one-week onsite assessment will be conducted in all FCs consisting of ca. 25 -30 interviews with key local actors and workshops with different urban stakeholders. This will allow the identification and systematization of city specific framework conditions and provide the basis for adapting the packaged solutions to the local conditions. The outcomes of subtask 5.3.2 will consist in ca. 10 – 15 early stage project outlines per city that are based on the packaged solutions and the Lighthouse City interventions. They will then be related back to the results of the assessment (subtask 5.3.1) in order to prioritize activities and design an early-stage roadmap of interconnected projects on the level of technology / infrastructure, strategy and governance. The results of subtask 5.3.2 will be compiled into a local implementation plan and provided as deliverable (one deliverable per FC: D5.4 – D5.8.)				
Participants	FHG, CMM, SPI, NEW, AdEPorto				
Comments					

V	Date	Authors	Description
0.0		FHG	Draft before assessment of data
0.1	01/09/2021	CMM	First draft filling all key sections with information of onsite assessment and replication workshop and works
0.2	23/02/2022	CMM	Second draft filling the remaining sections
0.3	23/05/2022	FHG	Second draft review
0.4	07/07/2022	CMM	Third draft updating and alteration according to FHG review
0.5	01/08/2022	FHG	Third draft review

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0.6	15/08/2022	CMM	Updating and review
0.7	30/08/2022	FHG	Final draft review
0.8	07/09/2022	BABLE	External review of final draft
0.9	27/09/2022	WP Leader	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1	30/09/2022	VTT	Coordinator submits the deliverable to the EC

Dissemination level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

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About SPARCS

Sustainable energy Positive & zero cARbon CommunitieS demonstrates and validates technically and socioeconomically viable and replicable, innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen centred zero carbon & resource efficient economy. SPARCS facilitates the participation of buildings to the energy market enabling new services and a virtual power plant concept, creating VirtualPositiveEnergy communities as energy democratic playground (positive energy districts can exchange energy with energy entities located outside the district). Seven cities will demonstrate 100+ actions turning buildings, blocks, and districts into energy prosumers. Impacts span economic growth, improved quality of life, and environmental benefits towards the EC policy framework for climate and energy, the SET plan and UN Sustainable Development goals. SPARCS co-creation brings together citizens, companies, research organizations, city planning and decision-making entities, transforming cities to carbon-free inclusive communities. Lighthouse cities Espoo (FI) and Leipzig (DE) implement large demonstrations. Fellow cities Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) prepare replication with hands-on feasibility studies. SPARCS identifies bankable actions to accelerate market uptake, pioneers innovative, exploitable governance and business models boosting the transformation processes, joint procurement procedures and citizen engaging mechanisms in an overarching city planning instrument toward the bold City Vision 2050. SPARCS engages 30 partners from 8 EU Member States (FI, DE, PT, CY, EL, BE, CZ, IT) and 2 non-EU countries (UA, IS), representing key stakeholders within the value chain of urban challenges and smart, sustainable cities bringing together three distinct but also overlapping knowledge areas: (i) City Energy Systems, (ii) ICT and Interoperability, (iii) Business Innovation and Market Knowledge.

Partners

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EXECUTIVE SUMMARY

Sustainable energy Positive & zero cARbon CommunitieS, also referred to as SPARCS, demonstrates and validates technically and socioeconomically viable, replicable, and innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen-centred zero carbon and resource efficient economy.

The city of Maia, which is located in the northern region of Portugal is one of the most dynamic cities in the North and one of the most industrialised municipalities of the country. It is crossed by major transport infrastructure, e.g. metro lines, railroads, and main road connections. The region's international airport is also located in Maia.

The city has a long-term experience in using European and national funding for urban rehabilitation, sustainable mobility and most recently, smart cities initiatives. Under these challenges, the Horizon 2020 Smart Cities and Communities project 'SPARCS' is playing an important role for the uptake and development of these smart city solutions and processes in the city. It addresses urban transformation, energy, mobility, ICT, monitoring and assessment tools, business models, and financing mechanisms through an integrated approach.

The Implementation Plan includes an in-depth analysis of Maia in the Morgenstadt assessment framework and describes the city's context through analysing its smart city initiatives, strategic plans, and official documents, with a focus on the city's energy and mobility profile.

A City Lab Methodology for sustainable urban development was applied, consisting of a virtual onsite assessment, interviews, and a City Lab Innovation Workshop, where project outlines were identified, two of which were selected for further development following local and internal discussions. Some of these projects will have effective implementation during the SPARCS project, while the rest of the project outlines will be aligned with the Draft City Vision 2050 and depend on the availability of funding and other resources.

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1. INTRODUCTION

The city of Maia holds the ambition to become a smart, sustainable, inclusive and carbon neutral community. To achieve that, Maia realised that all these efforts could be supported and accelerated through the strategy of the SPARCS project, leading it to become a Positive Energy & Zero Carbon Community by 2050.

Maia started to build a City Vision for 2050 in five strategic areas that were considered decisive for carbon neutrality and energy transition. These five areas are: Urban Development; Energy Transition; Mobility; Smart and Sustainable City; Inclusive and Integrated City. Additionally, work on its replication strategy as a Fellow City was guided by the city team, namely during the broad debate that took place throughout the onsite assessment, challenging stakeholders to think prospectively and formulate problems, solutions and specific situations related with each one of the mentioned strategic areas. These co-creative sessions allowed for the identification of projects which could be moved towards implementation.

This fruitful dialogue between the people involved was of extreme importance for the upcoming activities regarding the Maia Replication Strategy as well as for a solid and effective collaboration between the city and all its stakeholders.

The Implementation Plan Maia is financed by the European project SPARCS, under the research and innovation programme H2020, reference number 864242.

1.1 Purpose and target group

Maia seeks further support in developing solutions in the context of sustainable energy consumption. Fraunhofer IAO, with its Morgenstadt Initiative and in a strategic cooperation with the municipality of Maia, co-designed a project for supporting the city in the development of a list of project ideas for transformation and support of the development plans envisioned by the city. The goal of this City Lab is to help the city to become a role model in Portugal for an energy efficient city on its way to becoming a zero-carbon community, with improved mobility and quality of life. The project was brought towards realisation through a joint effort between the Municipal Council of Maia, the Portuguese Society of Innovation Consultancy S.A., AdEPorto - Porto Energy Agency, and Centre for New Energy Technologies S.A. The results of the City Lab constitute an integrated set of innovative energy projects, tailored to Maia's unique needs and are meant to support the city in addressing its specific challenges. The proposed projects are combined with the already ongoing and planned activities in the city and aim to strengthen its position within the region further, establishing the grounds to evolving into a Lighthouse City in Portugal and beyond.

1.2 Contributions of partners

The revision of the assessment framework prepared by Fraunhofer, was performed by SPI and Suite5. The data collection of indicators and action fields was carried out by the City of Maia. Likewise, Maia, supported by NEW and AdePorto has revised this report and contributed with feedback to the assessment carried out by Fraunhofer.

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1.3 Relations to other activities

This report is linked with the overall SPARCS City Vision 2050 in Work Package 1, the Monitoring and Impact Assessment in Work Package 2 and the Replication Potential of SPARCS projects and frameworks in Work Package 5. Additionally, the replication in Follower Cities within Work Package 5 is connected to the demo projects in Lighthouse Cities in Work Package 3 and 4.

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2. METHODOLOGY CITY LAB

The basis for the in-depth analysis of Maia is the Morgenstadt assessment framework and more specifically its City Lab Methodology for sustainable urban development. The model was developed in the course of the "Morgenstadt: City Insights" joint research project in which ten Fraunhofer Research Institutes have pooled their expertise with a further 37 partners from municipal governments and industry to offer cities wide-ranging support for sustainable city development. The project was established in 2011 and is since then the methods are undergoing continuous adaptation and refinement (Fraunhofer IAO, 2022; Radecki, 2019).

In order to achieve an in-depth understanding of the sustainability performance of cities both qualitatively and quantitatively, the Morgenstadt Model is structured into three levels of analysis:

1. Key performance indicators (quantitative analysis)
2. Action fields (qualitative analysis)
3. Impact factors (qualitative analysis)

To create the current report, the relevant indicators and action fields from the Morgenstadt Model, developed in 2011 by the Morgenstadt Initiative led by Fraunhofer IAO together with the University of Stuttgart, were applied. The analysis of this information shows a status quo inventory of Maia and addresses the following question: "What is the sustainability performance of the city?" Additionally, it assesses the type of data being measured and available at the city level to provide a well-rounded understanding of the city's sustainability within the energy sector and other related sectors. This understanding of the city's challenges, plans and opportunities create a common ground as the foundation for the co-creation and design activities described below.

The third level of analysis utilizes impact factors to identify the city-specific drivers and barriers which are determined by unique historic, cultural, economic, climatic, and morphological characteristics. Impact factors thus extend the general model and adjust it to the needs of each city, providing for an objective performance profile while laying out the basis for an individual sustainability roadmap.

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2.1 City Lab process

The process in the setting of City Lab is divided into four main steps, as illustrated in Figure 1.

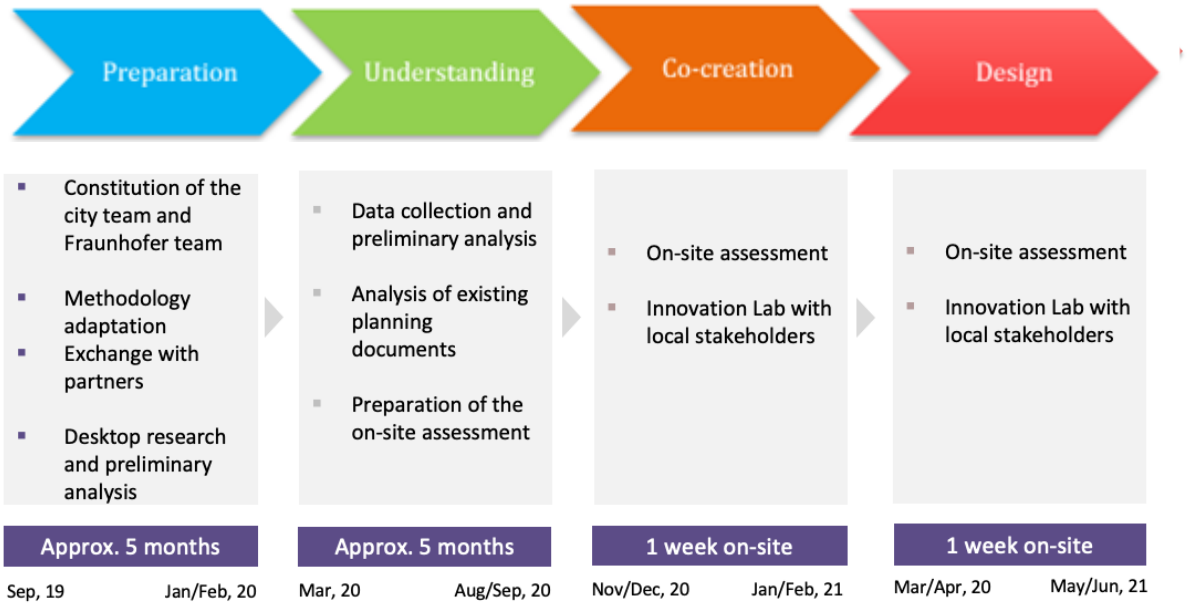

Figure 1: Structure of the City Lab process in Maia

The first phase of the development of the City Lab comprised the overall **preparation** and with it, the constitution of the local team in Maia as well as the assessment team from the Fraunhofer side. The city team of Maia is composed of:

- Marta Susana Moreira, public manager, local project coordinator, head of Strategy, Development and Innovation Cluster, City of Maia
- Adelina Rodrigues, chemistry engineer, head of Energy and Mobility Division
- Norberto Gregório, electro technical engineer, Energy and Mobility Division
- Rita Sousa, public manager, head of Quality and ICT Division
- Miguel Azevedo, computer scientist, technician in the Quality and ICT Division
- Joana Calvet, architect, head of Urban Planning Division
- Márcia Batista, geographer, technician, Urban Planning Division
- Marta Campos Moreira, public relations, head of the Environment Division
- Susana Pinho, public relations, technician in the Environment Division
- Cristina Pinto, public relations, technician in the Communication, Marketing and Citizenship Office
- Marisa Alves, financial manager, head of Financial Division
- Virgílio Noversa, lawyer, head of Legal Affairs Division

Diogo Teixeira, Mechanical Engineering student and technical assistant in the Energy and Mobility Division. In specialisation in mobility management. Ana Sofia Vinhas, geographer, technician in Strategy, Development, and Innovation Cluster SPI Team:

- Alessandro Colombo, senior consultant and project manager
- Francisco Melo, senior consultant and project manager

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Fraunhofer Team:

- Marielisa Padilla, project manager, Urban Governance Innovation
- Pieter Bult, researcher, Urban Governance Innovation
- Reef Quabailat, research assistant, Urban Governance Innovation
- Niklas Effenberger, research associate, Urban Governance Innovation
- Ariunsanaa Ganbat, research assistant, Urban Governance Innovation
- Pelumi Akinmade, research assistant, Urban Governance Innovation

AdEPorto team:

- Emanuel Sá, project coordinator at the Strategic Planning department
- Carolina Gonçalves, project manager at the Strategic Planning department
- Alexandre Varela, technical director

NEW team:

- Luísa Serra, project manager and senior research engineer
- João Cravinho, research and development engineer

The **understanding phase** consisted of the analysis of strategic documents relevant to the energy sector and the initial data collection. It also included the initiation of data collection through online research and desktop analysis. Existing strategic papers and plans of the city were inquired and studied by the Fraunhofer assessment team. Data collection of the indicators and action fields is described more detailed in Chapters 5, 6 and 7. Gaps in the information and data collected were identified, discussed, and cleared with the local team via several conference calls. Preparations with regard to content (such as the formulation of research questions for the onsite assessment) and organization for the onsite assessment were also included.

This was taken forward in the **co-creation phase** during the onsite assessment, which was dedicated to formulating project ideas together with local experts and the local team in Maia. As the efforts in these activities are part of the replication work package within the project, the developed measures were inspired, among others, by the projects implemented in the Lighthouse Cities.

The data collected in the aforementioned phases and onsite results, especially the outputs of the interviews and workshop, was then compiled during the **design phase**. This culminated in the final version of the implementation plan; it includes concrete project ideas based on the interventions taking place in the Lighthouse Cities within the SPARCS project.

2.2 The Morgenstadt Framework in the SPARCS project

Since the SPARCS project is focused on energy and related mobility impacts, a carefully considered selection of indicators and action fields from the original framework related to these sectors was carried out. SPARCS partners leading activities related to the replication strategy such as SPI, VERD and CiviESCo gave feedback on the updated/shortened model. A second round of filtering further refined the framework before it was sent to the city for the respective data collection. Alongside this effort, benchmarks were updated, and a scoring system was developed to evaluate the city for

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international comparison. This framework is divided into the following two levels of analysis.

Assessment of indicators: Measuring the current status quo of urban systems and showing the sustainable performance of the city with a focus on the energy sector (quantitative assessment). They were also tailored to cover the most important aspects of such city categories as mobility, society, economy, ICT, and environment. Out of the initial list of more than 100 Morgenstadt indicators (Radecki, 2019), 62 were selected for this purpose.

Assessment of action fields: Analysis indicates how the city addresses sustainability and which activities it is focused on. It gives an overview of relevant fields of actions and related sub-aspects. In total, 35 action fields consisting of 118 'yes/no'-type questions to understand municipal challenges, select priority areas and identify key activities were defined. The adaptation of the existing framework tailored the action fields and questions to the SPARCS objectives. After that, each question was linked to an evaluation factor, which has been designed such that each action field could receive up to a maximum of 10 points if completely developed or implemented. The grading system has been developed to emphasize important fields including the use of renewable energy and heat sources, intelligent traffic management, promotion of multimodal transport and building stock refurbishment.

- ICT: These action fields address ICT specifically in the areas of data and governance, with applications in traffic management and participatory government. Intelligent traffic management allows for the public transit system as well as individualised transit solutions to respond to evolving conditions and for the city to use historical data to study the cost effectiveness of investments in infrastructure or new mobility solutions.
- Governance: These action fields include the topics of municipal strategy and planning, organisation and structure, and regulations and incentives. They can be loosely divided into concrete measures and structural action fields, with the first sections providing insight into the city's long-term vision and goals and the political stability necessary to implement them. The structure and networks for sustainability-related policy management, innovation and reporting are assessed as the necessary predecessors for effective policy. Then, a few more specific action fields survey the existence of municipal level policies in place for transportation, air quality, and buildings. These areas provide a concrete starting point for the city in case of a lack of such measures.
- Transport and Mobility: These action fields survey infrastructure for soft mobility such as pedestrian and cycling modes and the corresponding uptake. Studying the linkages between soft mobility and the pricing and infrastructure for public transit, the questions assess the intermodality and vehicle-sharing availability. E-mobility prioritization and visibility through policies and charging infrastructure as well as traditional automotive decreasing measures through policies related to emissions, parking, tolls, and charging, e.g. in congested zones, are addressed. Finally, questions relating to urban freight assess a key component of traffic, the optimisation of which represents a significant environmental impact factor.
- Energy: These action fields assess municipal energy generation and distribution with respect to renewables share, networks for intersectoral resource sharing and the existence of district heating as well as its sources. As citizens are a crucial part

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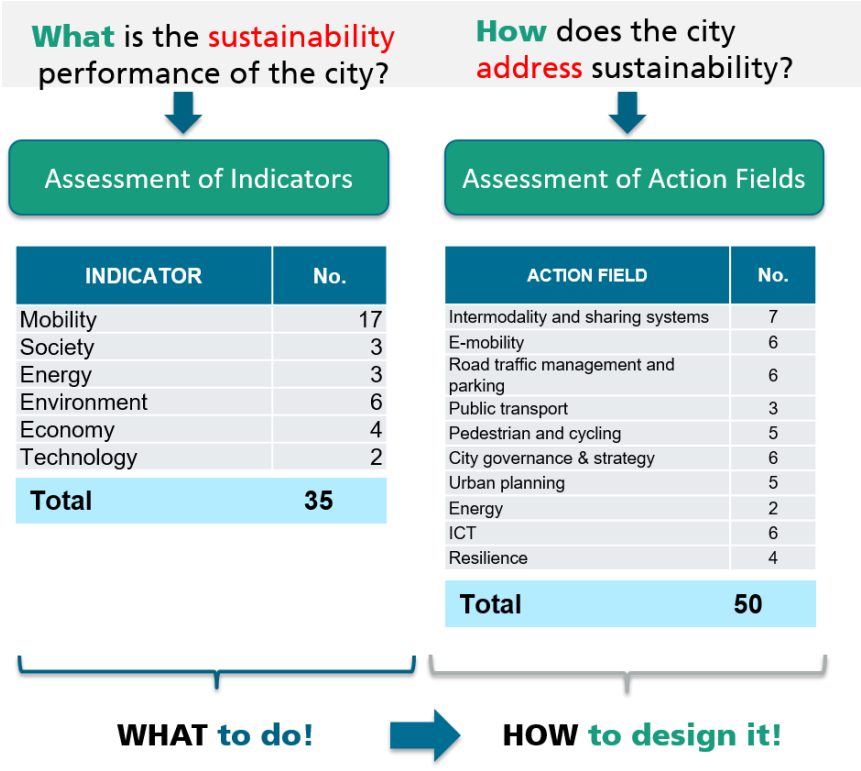
of the energy transition, questions also focus on educational outreach to promote efficient consumption, the use of smart grids and meters and distributed energy generation.

- Building transformation: These action fields seek to understand the development of the various fields for building performance in the municipality, beginning with refurbishment of pre-existing stock. Questions regarding regulations for construction, demolition, and materials recycling technologies as well as the recognition of national and international certifications and standards aim to assess impact potential for pre-existing transformative processes. Finally, the level of use of new technologies related to energy and building performance represents the cutting edge of building transformation and indicates a city's ongoing investment into this area.

The sum of all assessment levels allows the research team to obtain an understanding of **the baseline sustainability city profile,** which is the current performance of the city in energy and closely linked key areas, assisting in the development of coherent strategies. The process simultaneously respects the impact factors of the city that are conditioned by external pressures, socio-cultural dynamics, geography, and historical pre-determinations, among others. Moreover, a standardised data assessment throughout the whole evaluation process helps to identify critical challenges and opportunities, which are crucial for the development of project outlines and the roadmap. The assessment process is outlined in the following graph:



INDICATOR	No.
Mobility	17
Society	3
Energy	3
Environment	6
Economy	4
Technology	2
Total	**35**

ACTION FIELD	No.
Intermodality and sharing systems	7
E-mobility	6
Road traffic management and parking	6
Public transport	3
Pedestrian and cycling	5
City governance & strategy	6
Urban planning	5
Energy	2
ICT	6
Resilience	4
Total	**50**

Figure 2: City Lab assessment framework for Maia

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3. CITY PROFILE MAIA

3.1 Portugal

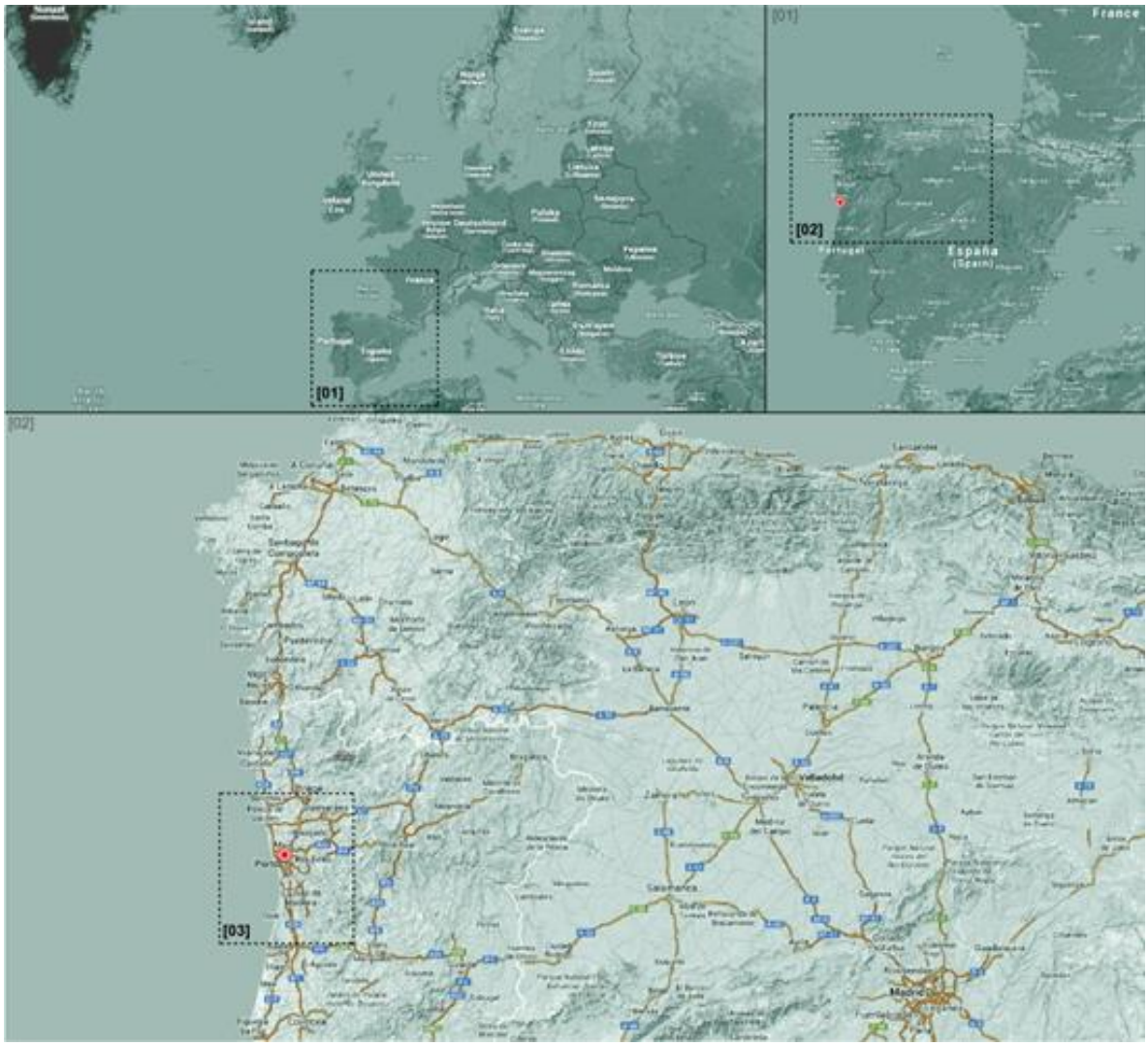

Figure 3: Map of Portugal pointing out Maia in different perspectives. Location within [1] Europe, [2] Iberian Peninsula, [3] North Atlantic Archipelagos (Visitar Portugal, n.d.)

As represented in Figure 3, Portugal is a sovereign unitary country located in south-western Europe, located in the western part of the Iberian Peninsula and in the archipelagos of the North Atlantic. It is a developed nation, described as a country with a very high human development according to the Human Development Index (HDI) of United Nations (UNDP, 2018). It is a member of the United Nations (UN), the European Union (including the Euro Zone and the Schengen Area), the North Atlantic Treaty Organisation (NATO), the Organisation for Economic Cooperation and Development (OECD), and the Community of Portuguese Language Countries (CPLP) (European Union, n.d.).

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The total population of Portugal was determined to be 10,344,802 in 2021 (Instituto Nacional de Estatística [INE], 2021b); 64.65% of Portugal's total population lives in (INE, 2021a) urban areas and cities (Statista, 2021), with more than 40% of its citizens located in its two main urban areas: Lisbon, with a population of 2.8 million, and Porto, with a population of 1.7 million (URBACT, n.d.). In contrast, there are a few medium-sized cities, with over 50,000 residents, mainly located near the sea, constituting a 400-km-long line of urban areas on the western coast of the mainland (URBACT, n.d.).

The Portuguese economy continues to recover from the financial crisis starting in 2008; with past structural reforms and more favourable global economic conditions contributing to the upswing. The economy has largely been sustained by strong export performance since 2010, but domestic demand is now also growing solidly. After receding in the five years following the 2010-2014 Portuguese financial crisis, employment has picked up. The unemployment rate has fallen from 13.2%, in 2011, to 6.5%, in 2021 (INE, 2021a). Over the same period, the economy has notably increased its reliance on renewable energy sources, such as wind power (OECD, 2019). Overall, Portugal has considerable resources of wind and hydropower. Since the turn of the 21st century, there has been a trend towards developing a renewable resource industry and reducing the use of fossil fuels in the country. The Moura Photovoltaic Power Station, the world's largest solar power plant at that time, began operating in 2006 (Acciona, n.d.), and the Aguçadoura Wave Farm, the world's first commercial wave power farm, opened in the North Region in 2008 (MI News Network, 2019). By the end of 2017, 50% of the country's energy consumption was derived from fossil oil products, 10% from natural gas, and 37% from electricity and biofuels (International Energy Agency [IEA], 2017). Around 25% of the energy supply generated in Portugal comes from wind-, solar-, hydro-, biofuel, and waste energy sources (IEA, 2018).

The transport sector accounts for a large share of GHG emissions and has been reducing its environmental impact at a slower pace than other sectors in the economy. The energy sector, encompassing transport, energy production, combustion in industry, remains the main driver of GHG emissions throughout the period of 1990 and 2019, accounting for 69.9% of national emissions in 2019. In this large sector, transport and energy production and transformation are the most important sources of GHG emissions, accounting for about 20.5% and 28.0% of total national GHG emissions (Agência Portuguesa do Ambiente [APA], 2021). In the transport sector, this partly reflects the remarkably high share of passenger cars that are used relative to public transport (OECD, 2019).

Portugal is on course to reach the target agreed with the European Union to reduce greenhouse gas emissions not covered by the EU Emissions Trading System (ETS) by 17% by 2030 relative to 2005. Further reductions will be needed to move closer to net-zero.

As shown in Figure 4, the Industrial Processes and Product Use (IPPU), agriculture and waste sectors have approximate weight, representing 12.1%, 10.8%, and 7.2%, respectively (APA, 2021). Portugal disposes close to half of its municipal waste to landfills, even though the method generates environmental burderns in water and air pollution. Since 2015, Portugal has remained as a waste importing country, because the waste input processes exceed the output processes (APA, 2019).

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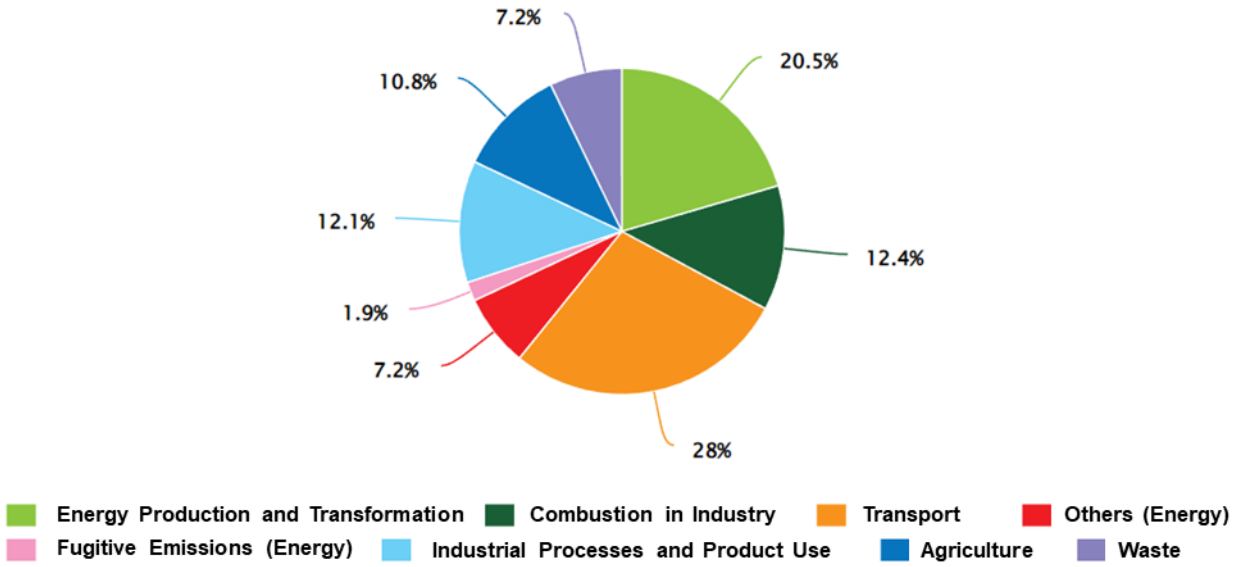

Figure 4: Sectoral emissions of carbon dioxide equivalent, in Portugal 2021 (APA, 2021)

Portugal follows a **National Energy and Climate Plan (PNEC)** and its connected **Strategy for Climate Change** (Portuguese Republic, 2019). The Plan aims at the establishment of goals and objectives in terms of greenhouse gas emissions, renewable energies, energy efficiency, energy security, internal market and research, innovation and competitiveness, as well as a clear strategy to reach those. The PNEC will be the main energy and climate policy instrument for the decade 2021-2030. With the Paris Agreement, in 2015 came the explicit recognition that only with combined effort it is possible to overcome the challenge of climate change and stop global warming at 2°C above pre-industrial levels. In this sense, the European Union has set ambitious targets aimed at achieving a 32% share of energy from renewable sources in gross final consumption, a 32.5% reduction in energy consumption, a 40% reduction in greenhouse gas emissions effect compared to 1990 levels by 2030 (Portuguese Republic, 2019).

The PNEC, as a decisive national policy instrument for the definition of strategic lines for the next decade towards carbon neutrality, will necessarily be aligned with the visions and narratives defined in the Roadmap to Carbon Neutrality 2050. Likewise, being a decisive instrument for the definition of strategic investments for the next decade in the energy area, the PNEC will be aligned with the National Investment Plan 2030 (Portuguese Republic, 2019).

Generally, Portugal aims to develop a more innovative, inclusive, and productive economy, ensuring that the following benefits are widely distributed, regionally and socially. The key document setting out Portugal's innovation strategy is the Technological and Business Innovation Strategy 2018-2030 (Agência Nacional de Inovação, S.A. [ANI], 2022) and AI Portugal 2030 the Portuguese National Initiative on Digital Skills (INCoDe, 2022). It aims to converge Portugal with the rest of Europe by increasing the Portuguese economy's competitiveness through research, development, and innovation. Another document published by the Minister for Science, Technology, and Higher Education is a

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document with Portugal's perspectives for 2030 regarding to research and innovation approaches (EURAXESS, 2020).

3.2 Maia

Located in the North-West part of Portugal, Maia, in 2021 and according to provisional results of the Census 2021 (INE, 2021b) has 134,988 inhabitants; 0.2% less than in 2011 - with a population density of 1,626.5 inhabitants/km^2. The city is divided into ten districts, as shown in Figure 5 (Reorganização administrativa do território das freguesias: Annex I. Law no. 11-A/2013., 2013).

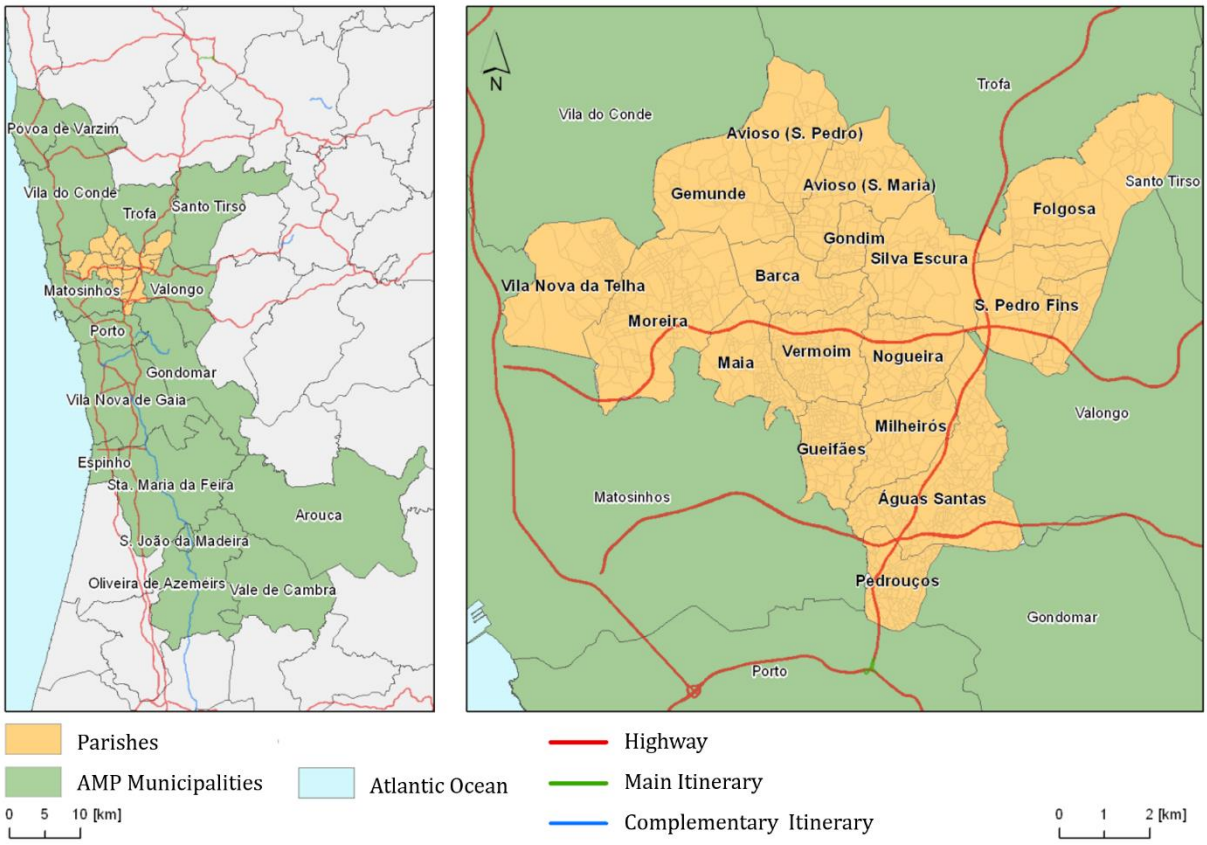

Figure 5: Map of the region and the administrative division of Maia (Maia Municipality, 2021a)

In the territory there is one of the region's major businesses and industrial parks which also includes a Science & Technological Park, TECMAIA (TECMAIA, n.d.). Several companies have chosen Maia as their headquarters, with 16,306 non-financial companies registered, 94.6% of which have less than ten employees (PORDATA, 2020b). As shown in Figure 6, Maia is also one of the most industrialised municipalities of Portugal and an important transportation hub. The productive structure of the city is the following: services 82.4%, 15.3% for industry, and 2.3% for agriculture (PORDATA, 2020a). Maia was the third leader in the volume of exports in the Metropolitan Area of Porto in 2017, with a total of €1,595,575.298. Compared to the previous year, the volume of exports increased by 9.98% (Noticias Maia, 2018).

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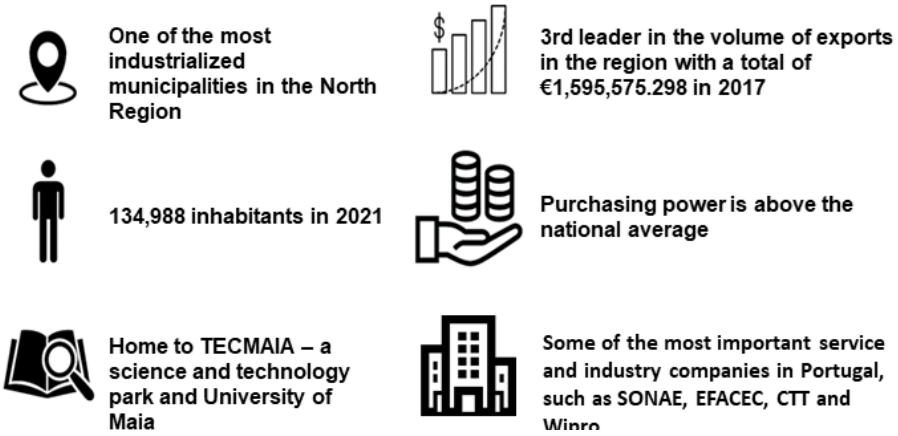

Figure 6: Maia – on the way to becoming a zero-carbon community (Noticias Maia, 2018; PORDATA, 2020b)

Maia is one of the municipalities with an essential and influencing role in industry, innovation, and new technology. Additionally, the city provides an example of an urban settlement with economic and environmental development, although still typified by a low population density (Maia Municipality, 2016b).

Table 1: Data from Maia Municipality (INE, 2021c)

Area	**83 km²**
Density	1,626.5 inhabitants/km²
Income (in Portugal) subject to state taxation median	12,499 EUR/year
Main economic pillars	Manufacturing industry (SAKTHI, CIN, CEREALIS, FICO CABLES, SONAE, EFACEC, among others)
Main emissions sources	Industrial emissions & Road Transport
Main export Products	Machinery, chemicals, minerals and metals

In 2018, Portugal´s declared gross income was around €99,530 million, resulting in a median value of €12,499 per tax aggregate as shown in the table above, with an increase of 4% over the previous year. As illustrated in Table 1, Maia has national values above the reference, corresponding to €14,476 per aggregate per year (INE, 2021c). At the same time, the population is ageing rapidly, with the ratio of retired to working-age population anticipated to rise from around 35% in 2015 to just below 80% by 2075. Holding all else constant, this trend will have a significant impact on public finances and lead to a reduction in economic growth over the coming years (OECD, 2019).

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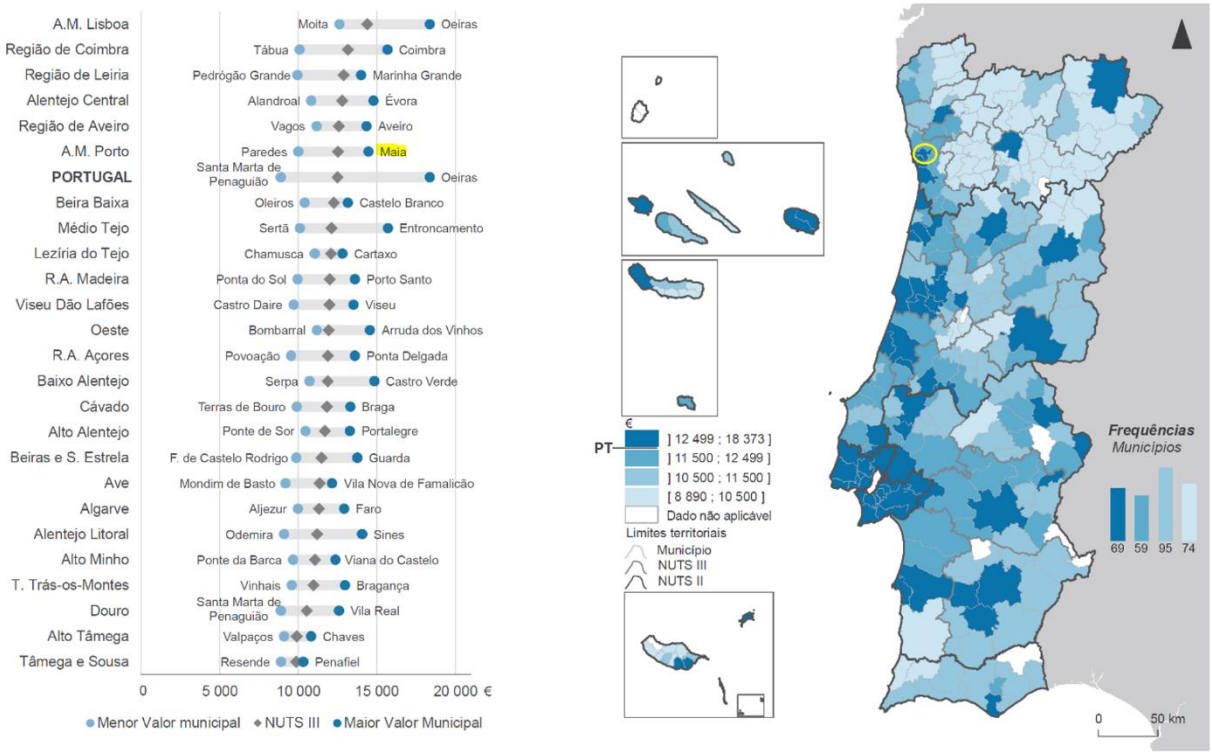

Figure 7: Declared median gross income per tax household, Portugal, NUTS III and municipality (INE, 2021c)

Aware of the emerging need for a change of attitude in the direction of global development, the municipality of Maia incorporated the principles of Agenda 21, through the **Maia Charter for Sustainability** (Maia Municipality, 2018b). This Charter, approved by the Chamber of Deputies on 22 April 1999, states that it considers the principles of the Charter of European Cities and Towns towards Sustainability (Aalborg Charter) and the Lisbon Action Plan. In 2009, **Maia's Local Agenda 21** marked the formalisation of the Local Sustainability Policy that the municipality has been developing, at various levels, through the signing of Aalborg's commitments. Thus, in July 2010, the first Progress Report of the Aalborg Commitments was prepared.

Maia started its work in the field of sustainable energy in 2012 with the development of the energy matrix for the municipality (Porto Energy Agency [AdEPorto], 2012). In 2020, the **Sustainable Energy Action Plan** (PAES) has been created consisting of a set of technical measures, planned to be applied until 2030 (Maia Municipality & AdEPorto, 2020). Maia's municipality goal is to become exemplary to all other actors with regards to energy efficiency by creating rankings among public entities, managing, and disseminating the best practices, developing an evolutionary barometer model for targeted improvements for each year. Besides that, Maia is promoting for the change in citizens' habits and behaviours, as well as taking specific actions resulting in the decrease of energy waste and energy inefficiency. Energy efficiency is thought to be achieved through various measures focusing on service and residential buildings, the transport sector and public lighting.

Maia City sees itself in 2050 as an energy-efficient city, on the way to becoming a **Zero Carbon community** with better mobility, efficient buildings, and improved life quality. Moreover, Maia strives to create favourable conditions for a significant energy efficiency

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policy development by increasing its energy efficiency and reducing GHGs by 40% until 2030. To achieve this goal, Maia privileges efficient energy districts within densified urban spaces, with citizens that prefer to use soft transport modes and an intermodal and efficient public transport system as well as buildings renovation. Objectives of the **Energy Policy** of the City focus on the diversification of the primary energy sources and increasing the economy's energy efficiency, associated with the lowered consumption and public expenditure (Maia Municipality & AdEPorto, 2020). Besides being associated with **AdEPorto**, Maia Municipal Council has initiated programmes to reduce electricity, gas, and water use by altering electricity tariffs and the feasibility study to alter the supply of electricity to the Town Hall to a medium voltage.

4. SMART CITY VISION

Maia's Draft City Vision 2050 is constituted by 26 'vision statements', synthetising the co-creation and the visionary perspectives from the work group participants of the 'Maia City Vision 2050' workshop. Maia's 'Final City Vision 2050' will be developed by the end of the project (M60).

SPARCS is set to trigger urban transformation while keeping a high quality of life for citizens in the seven project cities. The project will support the participating cities in developing a shared bold City Vision 2050, focusing on digitalisation, sustainable energy, improved air quality, electro-mobility solutions and a framework for performance monitoring of the developed solutions. The top priority is to establish integrative management and planning models and participatory processes in cooperation with companies' urban ecosystem, urban planning and other specialist departments, research institutions, and, above all, citizens. In SPARCS, citizens are at the centre of the decision-making process, and the project ensures that they are informed about all activities.

Maia will co-create locally adapted solutions inspired by projects and achievements of the LHCs to foster urban transformation into carbon-free spaces and favourable energy districts. Urban transformation towards energy transition, aiming for energy positivity and carbon neutrality by 2050 is of great importance to Maia's Draft City Vision 2050. Also, the City Vision can be seen as a co-creation process between city managers, industries, SME's, entrepreneurs, the educational community, and citizens (Maia SPARCs internal team, Sociedade Portuguesa de Inovação [SPI], NEW RESEARCH & DEVELOPMENT [NewR&D], AdEPorto, & Institute of Science and Innovation in Mechanical and Industrial Engineering [INEG], 2018).

The structural elements of the City Vision for the City of Maia 2050 were depicted, namely the 'vision statements', related to the key strategic areas (Urban Development; Energy Transition; Mobility; Smart and Sustainable City; Integrated and Inclusive City) as the main outcome of the workshop, and reconciled in the D1.11 Draft City Vision 2050. Their validity will be checked and integrated in the Final City Vision 2050 (D1.12).

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5. SMART CITY INITIATIVES

The municipality of Maia stated that once the total coverage of the territory with drinking water supply and basic sanitation network has been achieved, the focus will be working to offer people a special 'family tariff', making a significant investment in the modernisation of the supply networks, with a view to effectively reduce losses and improve the efficiency of distribution, in order to reverse these gains for the benefit of consumers (Smart Cities Network, 2019).

Striving towards the goal of total decarbonisation, the municipality is focused on moving from the current 90% to 100% in the elimination of reactive energy[1] in municipal infrastructure and machinery, in disseminating the integration of renewable energy, namely through the installation of solar panels in its buildings, as well as the conversion of its automobile fleet to electric vehicles (Smart Cities Network, 2019).

The city established the "**Living Lab: Maia Net Zero Carbon City**" project, which aims to establish a low-carbon, resilient, accessible, participatory, and connected environment (Smart Cities Network, 2019). The Living Lab is promoting the decarbonisation in the city through the integration of solutions in areas such as transport and mobility, energy efficiency in buildings, innovative environmental services and promotion of the circular economy through the interaction between the municipality, knowledge centres, companies, industries and citizens (Smart Cities Network, 2019). Within this project "**Maia SMART Lab**" is a building whose main objective is focused on providing a unique space that would be a place for sharing experiences, knowledge and innovative products. This space was established to enable people to share and develop their repairing skills, co-working on problem-solving for damaged or outdated items and for creating new and innovative prototypes (Maia SPARCs internal team et al., 2018).

The city of Maia is connected to the 'TOMI Go' app which is free to download for all smartphones. It is a user-friendly platform to promote multiple activities and points of interest in the city such as tourism, culture, local commerce and public services, while collecting the metrics of the interactions (TOMI, n.d.).

The municipality is also participating in the smart waste management project aimed at the introduction of Pay-As-You-Throw (PAYT) system (Maia Municipality, n.d.b). Users are charged for the amount of waste they present for collection. It includes the supply of domestic recycling points fitted with RFID (Radio Frequency Identification). Collection of waste is carried out with vehicles powered by compressed natural gas (CNG) and with the capacity for reading and registering RFIDs. The project provides cost saving opportunities as well as reduction in noise levels.

Under innovative environmental services and promotion of the circular economy activities, Maia has an ongoing pilot project of smart irrigation in the Central Park, using weather forecasting tools, sensors, and monitoring systems to reduce water consumption. The Living Lab project also includes the installation of a green roof in a reference cultural

[1] *Reactive energy is the demand for extra energy necessary for some equipment such as motors, transformers or machinery to operate*

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building in the City Centre (Fórum da Maia), as well as the installation of air quality sensors, measuring and providing data for the urban data platform.

Regarding sustainable mobility, Maia together with EDP Comercial, a Portuguese energy provider, has opened the largest public sustainable mobility hub in a Portuguese city, provided with the MOBI.E network. The hub will make a contribution to increase the charging options available to electric mobility clients in the municipality, while also promoting a cleaner and more sustainable city. It is installed in a central area of the city, near most of the city services. Additionally, 4 "Omniflow"-lights poles, powered by solar and wind power, have been set up nearby the charging hub.

A smart parking has been installed, considering all types of transport modes. An e-scooter service is being provided by a private operator.

All these actions will be constantly monitored, and the results achieved, combined with other data sources, will be disseminated to the population through an interactive and integrative urban data platform[2]. Data from devices installed from August to September (Omniflow, parking, traffic, energy, water) will be integrated in the prototype until the end of 2022.

In order to evaluate different tools for data management, Maia purchased a pilot license of Open Data Software.

Living Lab **Maia Net Zero Carbon City** project is promoting the decarbonisation of the city not only through the implementation of technological solutions that increase efficiency and reduce energy consumption, but also with stakeholders and citizen's engagement initiatives. The city believes that only with integrative measures and the citizens' sustainability literacy, a holistic transition will be possible. With SPARCS, Maia strives to be the starting point of a journey towards carbon neutrality.

5.1 Strategic Plans

Strategic plans provided by the city were studied and form the basis for this implementation plan. Maia's history shows that the city is rich in culture and traditions. The essential matter of this is the time and the ability to practice the notion of continuity. City of Maia has developed a **Sustainability Strategy** that answers the need to strategize and plan the city in a sustainable, coherent, and balanced manner (Maia Municipality, 2013). There is a need for continuous implementation of Maia's municipality's sustainability strategy to improve city processes. The goal is related to sustainable development, citizen participation, and deepening consolidation of low-carbon strategies in various areas of development and spatial planning (Maia Municipality, 2016b).

Generally, Portugal has defined strategic objectives that allow a close collaboration with relevant actions of the territory. As a result, Maia established an **Action Plan for Urban Regeneration** (PARU) in 2016, and adopted four **Urban Rehabilitation Areas** (ARU),

[2] Prototype results can be accessed at https://s.fhg.de/s25 and https://s.fhg.de/AH2

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with a **Strategic Urban Rehabilitation Plan** (PERU). The PARU action plan has already been constituted in 2015 and has been in force since. Recognition of urban rehabilitation as an indispensable component for local socio-economic and urban development is a responsibility to ensure the promotion of necessary measures and rehabilitate urban areas with local authorities (Maia Municipality & Espaço Municipal, 2016). There is also an intention to strengthen territorial and strategic coherence and ensure the integration of the developing projects and actions. The main focus is associated with the strategic objectives in consolidating a central historic centre of the city to improve Maia's urban quality. Through rehabilitation and occupation of building stock, the dimensions of the energy efficiency and the requalification of collective public and private living spaces is emphasized. Furthermore, social interest promotion and greater integration of urban and social housing projects are planned to finally, gradually, dissipate the vacant or underused buildings problem, the unscheduled areas (sites with potential for urban development but that are not considered as a priority within 2–5-year horizon), and empty urban spaces (Maia Municipality, 2016b).

The **Municipal Strategy for Adaptation to Climate Change** (2019) and its vision is a congregation of various contributions. Thus, Maia's strategic vision, based on the National Adaptation Strategy on Climate Change, aims to improve the level of knowledge about climate change, promotion of actions leading to the reduction of greenhouse gas (GHG) emissions, implementation of adaptation measures, and integration of mitigation options and sectoral policies (Maia Municipality, 2019a).

Pursuing these efforts, Maia adopted its Climate Adaptation Action Plan in December 2020, completing the documentation and actions under the Covenant of Mayors agreement, signed in 2018. The plan has 62 measures to be developed, distributed by eight Thematic Intervention Areas: Monitoring and Public Awareness; Biodiversity; Water; Agriculture; Health and Civil Security; Urban Development; Buildings; and Forest. Further actions that the city of Maia is driving forward are poured into the **Plan on Environmental Education - PEA** (Maia Municipality, n.d.a). The PEA embodies a set of proposed activities, such as building an environmentally responsible, economically viable, culturally diverse, politically active, and participatory society. Also, strengthening the integration of science and technology by encouraging sustainable practices to minimize society's negative impacts on the environment.

Maia's **Strategy of Local Housing**, 2019, and the integrated **Action Plan for Disadvantaged Communities**, 2016, aim to support the programmes allowing improved access to housing in the city. The strategy is a municipal instrument to regulate housing developments and policies in defined urban rehabilitation areas, coordinated by the **Municipal Master Plan** (Espaço Municipal, 2020).

5.2 Indicators and Action Fields Analysis

The need to ensure economic stability to reduce poverty and unemployment rate

By analysing the economy and governance indicators of Maia, presented in Table 2, the need to ensure economic stability is visible. A nominal GDP per capita of €16,853 is below

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Portugal's average of € 24,170 (equivalent to $ 24,262) (The World Bank, 2021). Also, the performance regarding the unemployment rate (14.1%) is higher than the average benchmark threshold (7 to 12%), likewise for the city's population living in poverty (23.2%) (INE, 2021a). It should be mentioned that these figures refer to the North Region and not specifically to Maia, as the Statistical Office in Portugal does not publish these indicators for other Nomenclature of Territorial Units for Statistics (NUTS). Regarding homeownership over the building stock, the relatively high value of ownership might be an opportunity for the city to implement big energy efficiency projects in the housing and other buildings in general. The indicators also point out that the spending on rent accounts for 22.5% of the household's income which places it slightly above the yellow benchmark threshold.

Table 2: Sample economy and governance indicators for Maia (INE, 2021a; The World Bank, 2021)

Indicator Description	City Value	Green	Yellow	Red
City population living in poverty (%)	23.2	< 9	9 – 15	> 15
GDP per Capita (€)	16853.2	> 40000	10000-40000	< 10000
Percentage of homes owned by residents (%)	71.83	> 79.3	59.3 - 79.3	< 59.3
Unemployment rate (%)	14.07	< 7	7 – 12	> 12
Spendings on rent (% of net household income)	22.46	< 20	20 – 40	> 40
Green area (ha/100,000 residents)	118	> 50	20 – 50	< 20

Long-term goals towards a sustainable development

Maia's governance **action fields** show the city's aptitude for implementing sustainable policies involving a set of structuring investments in urban regeneration, particularly in public and private sectors. The city has a long-term strategy and sustainable vision for its climate adaptation and mitigation, where goals were developed in cooperation with key stakeholders. Maia shows readiness by analysing its economic dynamics; it actively seeks local stakeholders' expertise where needed. Thus, the municipality's annual expenditures are planned towards a Smart City transition and respond to the citizens' needs in the city development. One of Maia's strengths is the cooperation of municipality stakeholders and cross-sectoral units who are responsible for processing cross-cutting themes, including public participation in the city.

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6. ENERGY PROFILE MAIA

Strategic plans, provided by the city of Maia and partners, were studied and form the basis of this city profile, especially regarding urban development, sustainable mobility, energy efficiency and climate adaptation. Maia municipality has already adopted its PAES 2030, using 2008 as a reference year. For this reason, and for a more consistent energy profile and annual evolution, the same baseline will be used in this document.

The municipality of Maia had a resident population of approximately 132,927 inhabitants in 2008, spread over an area of 83 square kilometres and a large part of its territory is highly urbanised. The municipality had an exceedingly high population growth, particularly in the 80s and 90s, with annual growth rates of almost 3%. Thus, the city with highly functioning mobility infrastructures, such as the airport, has become one of the most industrialised parts of Porto's Metropolitan Area and a place for one of the most dynamic industrial areas of Portugal (AdEPorto, 2012).

Maia is part of nine municipalities that fall into the Energy Headquarters of Porto's Metropolitan geographical area in the North Douro River margin (AMPN). Maia's municipality's estimated use of primary energy was 4,300 GWh in 2008, which is relatively high for the region's average. Maia's primary energy consumption at 32.4 MWh ep/hab is substantially higher when compared to the national average, which is 24.3 MWh ep/hab.

On the energy demand side, Industry appears as the most representative sector in the total use of primary energy with 49%, followed by the Transport sector - 29% of PE use, with similar weights regarding the GHG emissions, 50% and 30%, respectively.

In terms of final energy, the difference decreases significantly, leaving the two sectors with remarkably similar values, 42% for Industry and 38% for Transport. These values are consistent with the context of the municipality of Maia, known for the great penetration of Industry in its territory.

As shown in Figure 8, primary energy is the energy resource found in nature, e.g. oil, hydropower, wind, biomass, solar, etc. Usually expressed in terms of the mass of oil equivalent (kilogram of oil equivalent - kgep - or tonne of oil equivalent - toe). Some forms of primary energy (natural gas, firewood, sun) can also be made available directly to users as final energy. Final energy is made available to users in different forms, e.g. electricity, petrol, and firewood, and generally expressed in units with commercial significance (kilowatt-hour, cubic meters, kilograms, etc.).

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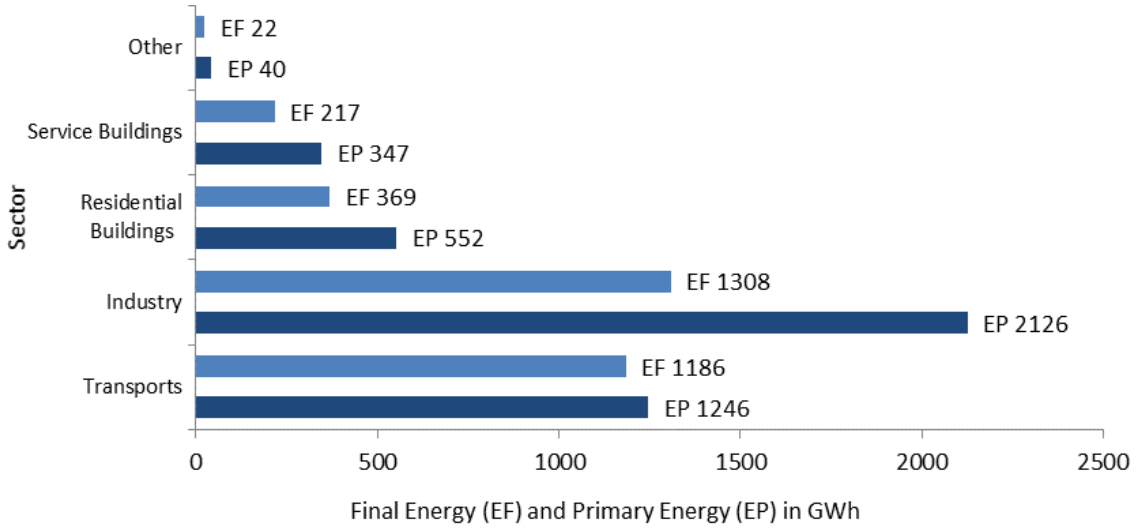

Figure 8: Total primary (EP) and final energy (EF) use by sector in the municipality of Maia in 2008in GWh (Maia Municipality & AdEPorto, 2020)

The energy supply refers to the final energy vectors (i.e. electricity, diesel, gasoline, natural gas, etc.) used in the municipality of Maia to satisfy different uses, for example, lighting, space heating or travel in individual transports.

The following figure shows the breakdown by the various energy vectors of the energy offer, expressed in primary and final energy, as well as the breakdown of associated GHG emissions (Maia Municipality & AdEPorto, 2020).

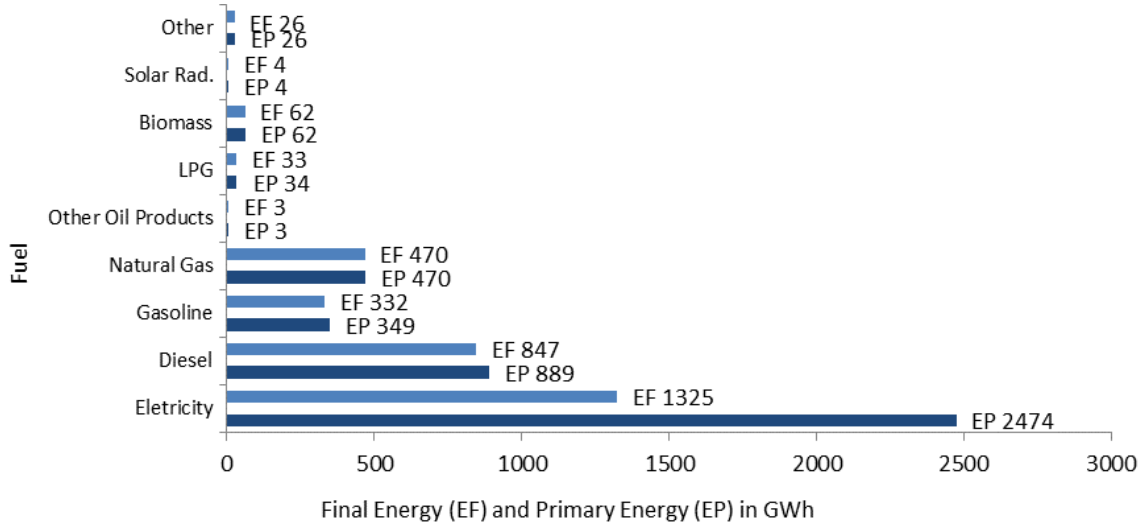

Figure 9: Total primary energy use by vector in the municipality of Maia in 2008 (Maia Municipality & AdEPorto, 2020)

In Figure 9, you can see that the most representative energy vector in the municipality of Maia was electricity, representing 43% of final energy, 57% of primary energy and 60% of GHG emissions. Gasoline and diesel for road use together represented 29% of the primary energy used in the municipality, more specifically 21% for diesel, 8% for gasoline. The remaining primary energy was divided between natural gas (11%) and the rest of the energy vectors (3%).

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Within the scope of its competences and in interconnection with the Maia's municipality, the Porto Energy Agency has been preparing and updating the city's energy matrix annually since 2017, included in the city's annual Energy and Emission Report. This matrix establishes the monitoring and strategy defining instrument. With this tool, it becomes possible to monitor the evolution of energy use, evaluating the impact of reduction and rational use measures in the municipality. Using the most recent consolidated and available data (2018), it is possible to sketch the profile of energy use and GHG emissions since the base year of 2008 (AdEPorto, 2018).

As demonstrated in Figure 10, primary energy use in 2018 was about 11% lower than the baseline year. The biggest contribution comes from the transport sector, since the primary energy use associated with diesel and gasoline had a significand decrease in this ten-year period.

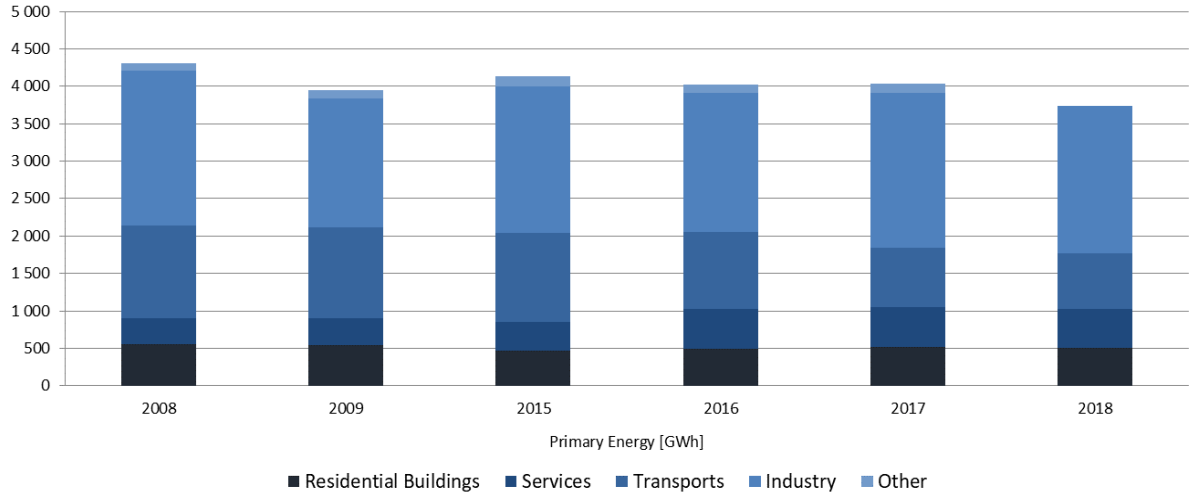

Figure 10: Energy profile evolution (annual primary energy use) (AdEPorto, 2018)

For the GHG emissions, the total reduction observed in the past ten years is about 21%, also profiting from the lower fuel use in the transport sector, but also significantly from the decarbonisation of electricity.

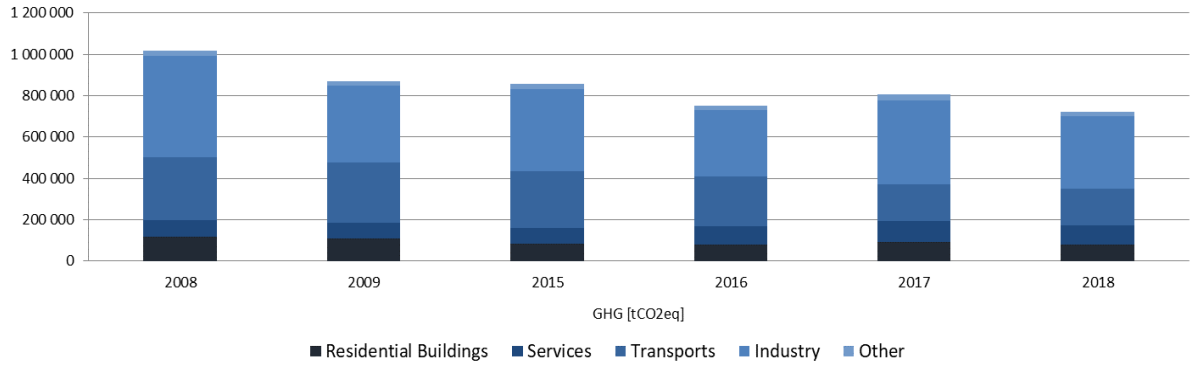

Figure 11: Energy profile evolution (annual GHG emissions) (AdEPorto, 2018)

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Figures 10 and 11 show the evolution for the demand side in Maia, but it also shows the importance of the supply side in the reduction of GHG emission through decarbonisation of the final energy vector such as electricity, natural gas, and fuels.

6.1 Strategic Plans and Goals

The **Portuguese Environmental Agency (APA)** and **Ministry for the Environment and Energy Transition**, following its national entity attributions, are responsible for the overall coordination and reporting of the Portuguese inventory of air pollutant emissions. Each year the national inventory of Greenhouse Gas Emissions has to comply with the international commitments (AdEPorto, 2014). In recent years, there has been a decreasing trend in emissions resulting from a period of economic stagnation in Portugal and the implementation of measures that positively impacted the reduction of emissions. These include introducing lower carbon-intensive fuels, the installation of combined cycle thermoelectric plants and cogeneration units, and renewable energy sources. The relative importance of total GHG emissions from the energy sector has decreased, from 67% in 1990 to 64.6% in 2017. By far, the essential gas emitted by this sector in 2017 is GHG, with 98.1% of sector emissions expressed in CO_2eq. The largest contributor to the Portuguese emissions is the energy sector (71% of total emissions in 2017), with the energy industries and the transport activities amounting, respectively, to 29.4% and 24.2% of total emissions (Delbeke & Vis, 2016).

In 2014 Maia concluded its first proposal for a PAES. Furthermore, Maia's municipality is pledging to reduce carbon emissions by at least 40% by 2030, mainly through enhanced energy efficiency and greater use of renewable energy sources. The timesheet ensures a convergent path with the GHG emission target of reaching two tons of CO_2 eq. per capita in 2050. For the municipality of Maia, the target set corresponds to lower its per capita GHG emissions of 7.67 tons of CO_2eq. per capita in 2008, and to 3.25 in 2030 (AdEPorto, 2014).

The **Sustainable Energy Action Plan 2030 – PAES 2030**, adopted in November 2020, a result of the municipality's adhesion to the Covenant of Mayors for Climate and Energy, compared to the base year of 2008, proposes a carbon emissions reduction objective of 40% by 2030. Although the general commitment is to reduce 40% of GHG, Maia's plan provides ambitious measures that, if successful, could result in a reduction of around 60% (Maia Municipality & AdEPorto, 2020).

Different energy sector development scenarios are introduced for the next years. One of the strategies considers the closure of coal-based power generation by 2029 and the continuation of natural gas-based generation by 2040. As shown in Figure 12, in large numbers, for the electricity mix generated in 2030, 79.5% is estimated to come from renewable energy sources (RES), 12.5% from natural gas, 7.9% from other fossil sources, and 0.1% from imports (Direção-Geral de Energia e Geologia [DGED], 2018).

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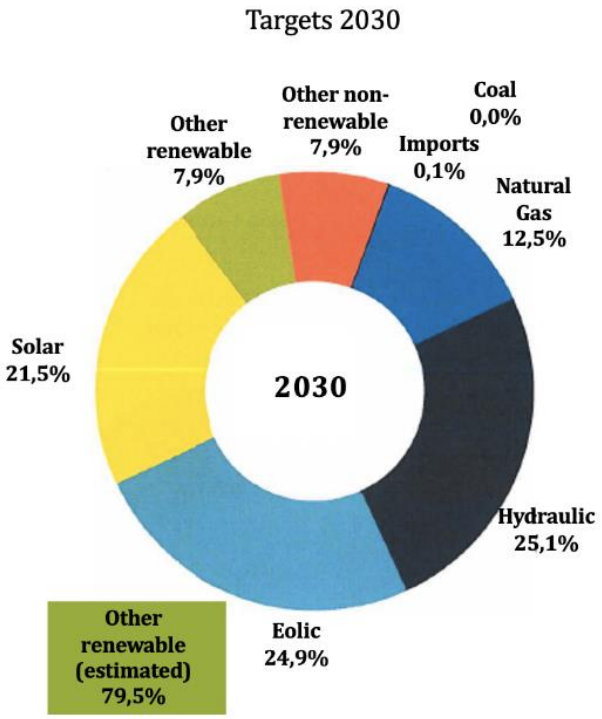

Figure 12: Mix of the Portuguese electricity supply in 2030 - RMSA 2019-2040 (DGED, 2018)

Thus, the subscription "Declaration Basque - Roadmap for Environmental Sustainability"- represented in the assumption ten specific commitments concerning mitigation. For example, decarbonising energy systems, reducing total energy consumption and creating standards for sustainable urban mobility and accessibility for everyone. Ongoing mitigation actions demonstrate Maia municipality's positioning in implementing low-carbon strategies in development and spatial planning. In this context, Maia's municipality already has assumed various commitments and undertakes multiple efforts to reduce carbon emissions. As an example, it should be mentioned the **Sustainable Mobility Action Plan**, 2016, which is already under implementation, has the main objective of promoting responsible mobility, environmental protection and improving energy efficiency (Maia Municipality, 2019a).

The initiatives contained in the plan are based on the diagnosis of energy use and emissions in the municipality and the areas of greater direct action by local authorities, focusing on buildings and transport. In the particular case of the municipality of Maia, the industry sector, which has a remarkable preponderance, will also be considered a contributor to the global emissions reduction target. The initiatives considered may lead to an overall reduction of 60% in emissions compared to the base year emissions. The plan has 22 action measures, distributed to the sectors of buildings, transport, industry, agriculture and public lighting. This makes it clear that the major contribution to the reduction of emissions is less related to the infrastructures under direct management of local authorities and more to the action of the various actors that develop their activity in the municipality.

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The municipality of Maia approved a Public Lighting Master Plan (PDIP) in July 2021, which aims to be a modern and effective management tool that facilitates the organic and sustained development of the Public Lighting (IP) infrastructure, contributing to the most suitable rationalisation of investment and maintenance costs and to minimize both environmental impacts and energy consumption. It was conceived in a dynamic way, being able to follow the territory planning and its growth and change, providing the viability to perform interventions in the network over the years.

The PDIP aims to frame the use of light as an orientation and mobility tool, individualising specific paths and ambiences, namely through the hierarchy of lighting levels and the use of differentiated colour temperatures. In this sense, the PDIP intends to provide guidelines for the interventions in the public lighting of the municipality of Maia, both in the modernisation and in the enlargement. This document aims at fulfilling the basic needs of lighting in an effective way, with low energy consumption and with aesthetic quality, framing the main guidelines provided by the existing normative documents at a European level. It will serve as support to any intervention process in the public lighting of the municipality of Maia, as for example, amongst others, project offices, contractors, and architectural offices, regardless of the respective scope, must respect all the provisions foreseen in this PDIP.

The municipality of Maia is also participating in a metropolitan project "Porto Solar Metropolitano", which involves the installation of photovoltaic panels on the roofs of various municipal buildings to produce electricity for self-consumption. With this intervention, there is a significant increase in contribution of renewable energy for municipal use.

The municipality of Maia is also part of the "Energy Observatory of the Metropolitan area of Porto", in which the energy of the MPA is continuously monitored.

6.2 Indicators and Action Fields Analysis

High total energy use of the city but also ambitious renewable energy infrastructure

In general terms, Maia performs relatively well regarding its energy demand that is covered through renewable energies. Maia's energy-related indicators reveal a high performance in renewable energies' share of production, with a 26.5% share of primary energy demand based on the National Electroproducer System (DGED, 2018). This is without considering transport and distribution losses covered by renewable energy sources. Additionally, Maia scores well above the European average in terms of renewable energy contribution to the total energy generation (Eurostat, 2018).

To come closer to the targets of total decarbonisation, reduction of the city's energy consumption is required, which is currently at 18.8 MWh/yr/capita (AdEPorto, 2019). In this case, the city has an opportunity to use its progressive renewable energy share of supply to enhance their utilization in different fields. Nevertheless, the final energy use in 2017 at 3,400 kWh/household/year shows a positive value falling in the green benchmark threshold. As shown in Table 3, the share of electricity demand generated by

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renewable energies at 45% is above the specified reference value of 40%. The only poorly performing value of the annual rate of refurbishment of existing buildings stock is worth mentioning. In this regard two values have been provided for the rate of building refurbishments of the existing stock. The first value, 0.11%, refers to the percentage of buildings owning a reconstruction license, and the other value, 0.05% - to the percentage of household units renovated during 2018. In this area, a window for improvement and an opportunity to tackle building refurbishments arises, addressing the challenge in the special context of Maia as a municipality.

Table 3: Sample energy indicators for Maia (AdEPorto, 2019)

Indicator Description	City Value	Green	Yellow	Red
Annual rate of refurbishment as a percentage of existing building stock (%)	0.11 (of building stock) 0.05 (of household stock)	> 5	5 - 2	< 2
Total energy use of the city per cap (MWh/a/cap)	18.7	< 15	15 - 20	> 20
Electricity consumption per household (kWh/household/year)	3,400	1,500–3,500	900–1,500; 3,500–5,000	< 900 or > 5,000
Share of end energy demand covered with renewable energies (% of end energy demand)	26.5	> 23	23 - 13	< 13
Share of electricity demand generated by renewable energies (% of electricity demand)	45	> 40	30 - 40	< 30

Increasing energy efficiency and promotion of renewable energies

Maia's collected data for the action fields in electricity production and use within the city reflects an adequate score. The municipality focuses on eliminating reactive energy in municipal infrastructures through disseminating the integration of renewable energy, installing solar panels in municipal buildings, and amongst other measures, the conversion of its automobile fleet to electric mobility. Moreover, the city of Maia should concentrate on the holistic promotion of the renewable energies use. Investors can be motivated to install or use renewable energies in new buildings or when renovating them with new strategic pilot projects. Since Maia is an industrialised city, there is enormous potential to identify industrial districts with energy and resource flows for optimisation.

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7. MOBILITY PROFILE MAIA

The **Sustainable Urban Mobility Plan** takes in the state of current mobility, described as highly individual and motorised due to improvements in quality of life and general sprawl. It identifies the need specifically for local or regional solutions. It continues to define a set of operational measures for a modal shift towards sustainable travel with a focus on responsibility, social cohesion, environment, energy efficiency, and increased quality of life (Maia Municipality, 2013).

The 2016 **Action Plan for Sustainable Urban Mobility** (PAMUS) begins with a mobility pattern study that notes 61% of students commute within their region, while 61% of employees commute to different regions. Within districts, most commutes take less than 15 minutes, with a low percentage of over 30 minutes. Employees and students tend to have similar-length commutes, while students generally have shorter trips. Mapping the destinations for employment trips, most end in Porto, followed by much smaller numbers in Matosinhos, Vila Nova de Gaia, Gondomar, and Valongo. The destinations for students are similar but comprise much smaller numbers (Maia Municipality, 2016a).

The majority (47%) of residents perform two trips per day, with 20% performing four trips. There were 2.53 motorised trips per mobile inhabitant, or 2.14 per capita. The survey found that increased household income coincides with an increased number of trips. Overall, the car trips make up 60 % of the modal split, with a greater distribution weight on longer trips (see Figure 14). Public transit represents 12% of travel and 19% of distances covered. Finally, trips on foot have a modal split of 23% of all trips. Still, they only account for 3% of total distance covered, indicating walking as useful for only short trips (Município da Maia, 2016a).

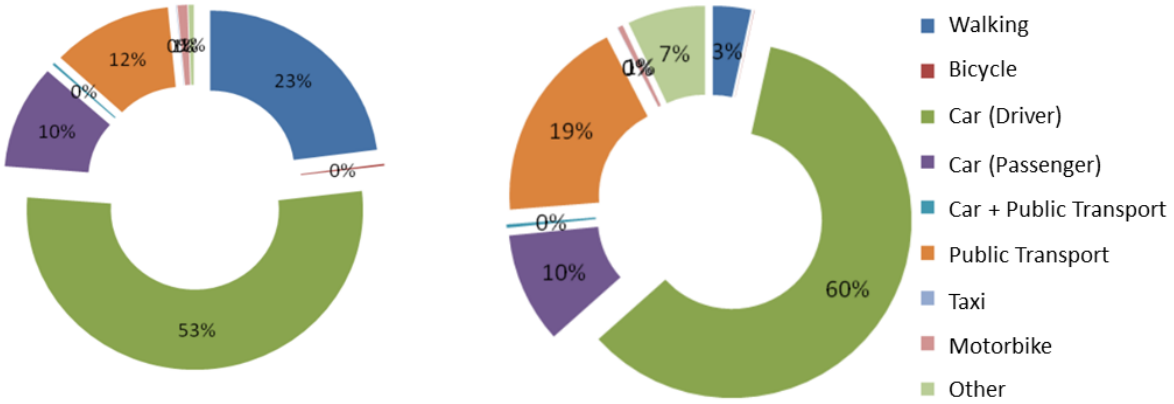

Figure 13: Modal split for distances and number of trips (Maia Municipality, 2013)

Thus, for the surveyed population, trips to and from school and work represent 42% of all trips. Key findings include the fact that the car is mainly used (74%) for work/home trips, and public transportation is the most common mode only for school/home trips. Leisure and shopping trips are done mostly by foot, which indicates these activities occur

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close to the place of residence. For public transit, the average of 0.4 transfers per trip suggests that convenience is crucial for regular use. Among the different types of public transport, bus is the most frequently used at 61.6%, reflective of a wider area served, followed by light rail metro lines with 27.7%, railway - 8.8%, and finally, taxi - 1.9% (Maia Municipality, 2016a). Considering the results of the sample-based mobility survey, the results follow the trend for the last intercensal period, as well as the survey conducted along the elaboration of the first sustainable urban mobility plan, with the predominance of the use of individual cars accounting for almost 70% of the total trips made per day (INE, 2018).

As shown in Figure 15, that summarizes the modal split observed in Maia and Porto Metropolitan Area (AMP), in Maia the use of individual cars adds up to 69.5% of total daily trips, higher than the AMP average. The walking trips share corresponds to 17.4%, compared to 18.5% of AMP. Public transport values between the two areas are similar, however, in Maia the use of public road transport is lower compared to the use of this mode in the whole AMP, at 7.5% and 8.2%, respectively. Public rail transport has a use ratio of 3.4% in Maia, higher than in the AMP as a whole, which is only 2.8%. It should be mentioned that the use of bicycles still has residual importance compared with other transport modes, especially in Maia, with only 105 trips declared.

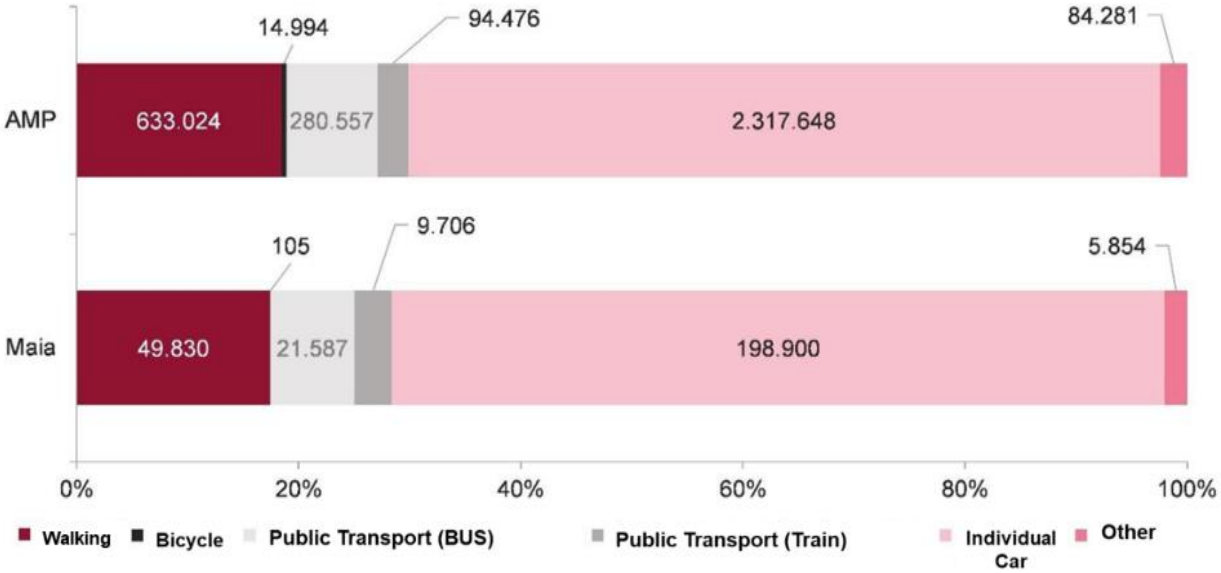

Figure 14: Modal split for number of trips (INE, 2018; Maia Municipality, 2021a)

Within districts, the average commuting time takes 22 minutes, and the average distance is of 8.9 km.

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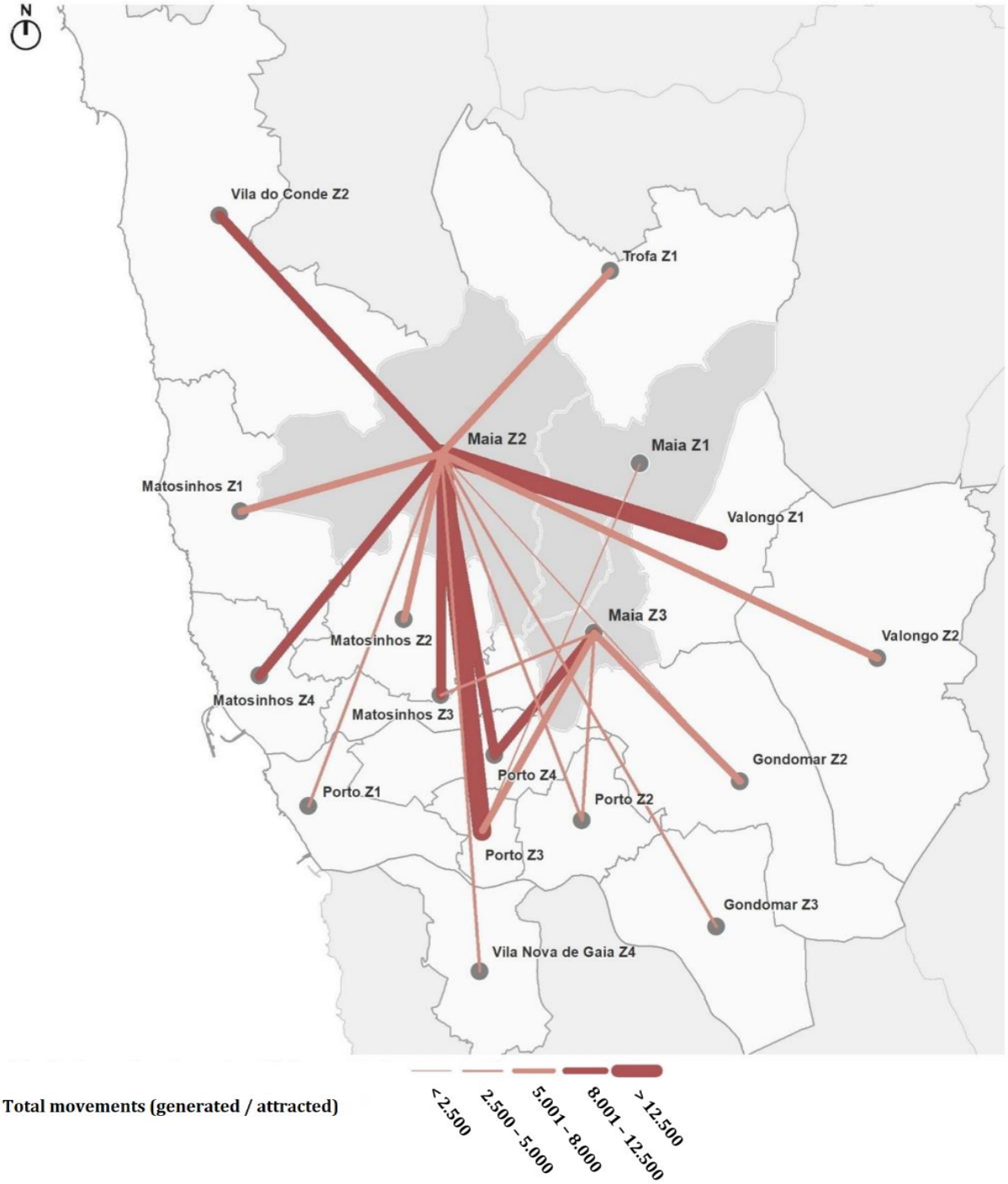

Figure 15: Main movements between Maia and its hinterland (INE, 2018; Maia Municipality, 2021a)

In Figure 16, we can observe the origin-destination matrix of the main flows, summing the movements generated and attracted to the Maia zones. The movements between zone 2 of Maia and zone 3 of Porto, and zone 2 of Maia and zone 1 of Valongo stand out with, respectively, 15,523 and 14,769 trips.

Maia's residents take, on average, 2.8 trips per day. The average occupancy rate of personal cars is 1.55 persons per car, which means a high percentage of vehicles in circulation with only one occupant. The motorisation rate is still growing, and in 2019

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Maia registered 602 vehicles per 1000 inhabitants in 2019. The most used type of fuel being road diesel, representing almost 80% of the existing options (Maia Municipality, 2021a).

The 2016 PAMUS based on the first Maia Sustainable Urban Mobility Plan (SUMP) in 2013 predicted an estimated overall investment of approximately €14 million to be allocated to soft modes of transportation. Specific project-oriented goals include dedicating 28.1 km of road to soft mobility, increasing the distance (km) of public transit-served in modal split by 2% per year, and 7% in soft modes (Maia Municipality, 2016a).

Concerning pedestrian mobility, the plan identifies issues in discontinuity of pedestrian routes, poor pavement conditions, and parked cars within pedestrian space, inappropriate bus stop locations, and inadequate signage, especially at crosswalks. Each of these represents a safety risk and thus a barrier to uptake of the pedestrian mode. Therefore, recommendations are due to public spaces improvements focusing on the pedestrian mode. Also, there should be an improvement in crossings for more security and safety, especially focusing on disabled persons, strict policy of maintenance of walking and cycling infrastructures, and in making firmer parking policies. Within Maia, dedicated bike lanes are currently rare, although potential areas for development have been identified. However, there are also disadvantages regarding the bike modes, including inadequate pavement quality and lack of connection with other modes. Further points include the importance of citizen education and promotion of sustainability, not merely providing the infrastructures (Maia Municipality, 2016a).

Regarding the importance of public awareness, the city of Maia also focused its work on the annual participation in the European Mobility Week, which aims to inform citizens and promote behavioural change among the community (Maia Municipality, 2019b).

7.1 Strategic Plans and Goals

Regarding the PAMUS of Maia, actions and targets were set, defining various projects at the municipal level. However, a significant part of these projects is effectively planned in the metropolitan area. Sustainable urban mobility is understood, for several years, as a priority by the municipality of Maia. According to the Urban Development Strategic Plan and supplementary information and funds, the mobilisation in Maia is related to the promotion of low-carbon strategies, including the advancement of sustainable multimodal urban mobility and relevant adaptation measures of mitigation (Maia Municipality, 2013).

The PAMUS is a part of the **Strategic Plan for Urban Development** (PEDU). The specific objectives encompass substantial improvements of intermodality between urban public transport and cycling modes. Maia´s Plan for Sustainable Mobility intends to seek a worked out strategic document of interventions for the municipality in terms of accessibility and mobility management by defining a set of operational measures to shift to a more sustainable modal split with more public transport and soft modes (Maia Municipality, 2013, 2016b). As a result, Maia identified specific areas that shall be improved in the city, for instance, the promotion of intra-urban displacement of cars (inner and outer area) and an allocation of the metropolitan territory for urban

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development measures. Targets which Maia pursues are to promote cycling modes and reduce motorised trips. These are implemented by building bicycle paths and walking paths to eliminate accident accumulation points involving pedestrians and cyclists (Maia Municipality, 2016a).

In the Action Plan for Sustainable Urban Mobility, which is already under implementation, Maia defines the following strategic objectives:

- reduce individual car use rate;
- promotion of flexible public transport solutions for low density areas;
- improved structuring of urban corridors of high demand;
- adoption of information systems to users in real-time;
- to invest in intelligent systems equipment and road traffic control;
- assist the acquisition, management, and the development of supporting innovative and experimental solutions (e.g. information systems).

In 2021, the municipality completed the revision of Maia's Sustainable Urban Mobility Plan (PMUSCM), whose first edition was approved in 2013. The PMUSCM rises as a reference instrument in the decision-making process by the municipality of Maia, in respect to mobility in its various aspects and modalities. The present revision process follows the strategy outlined on previous documents, and contemplates a set of operational measures, whose general objectives are (Maia Municipality, 2021a):

a) The promotion of sustainable mobility, ensuring universal accessibility to the transport system and encouraging the use of active and soft transport modes, such as pedestrian, cycling and public transport, to the detriment of the use of individual motorised vehicles;
b) Reducing noise and air pollution and energy consumption, enhancing the attractiveness and quality of the urban environment and design, and the economic efficiency and cost-effectiveness of transporting people and goods;
c) The improvement of travel safety, tending towards the goal of zero deaths on the road;
d) Ensuring interoperability between different modes of transport and also between the various components of the transport chain, taking into account not only the public road and sidewalks but also various support structures such as communication platforms between modes, stops, stations, shelters, etc.;
e) The reinforcement of urban information, including not only traffic signs but also signs about transportation and generic orientation, which not only corrects the deficiencies that exist today but also culturally rehabilitates travel, promoting the use of more sustainable modes;
f) The guarantee of articulation between territorial planning and transport planning.

7.2 Indicators and Action Fields Analysis

Need for decreasing motorized traffic

The assessment of Maia's mobility indicators, showcased in Table 4, shows a need to decrease the total number of passenger motorised vehicles. The mobility system's central

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issue is the dependence on personal vehicles, with the ownership rate of 602 cars per 1000 inhabitants, which is even higher than poorly performing German cities. As mentioned previously, key findings include the fact that the car is used in 74% of work/home trips, and public transportation is the most common mode in only school/home trips (Maia Municipality, 2016a). Leisure and shopping are done mostly on foot, which indicates these activities take place close to the area of residence. This number also reflects that most journeys were made by private motorised transportation, meaning there is an opportunity to shift most car users to public transport. The share of traffic by public transport of total traffic is relatively low, at 11.2%. Thus, for the surveyed population, trips to and from school/work represent 42% of all trips made and refer to the average distance of 8.9 kilometres. This gap should be closed; the public transport system needs to become more attractive for residents and commuters in the entire metropolitan region.

Nevertheless, there is a visible shift in the modal split. The modal split for walking was 17.4% in 2017, demonstrating increase in contrast to 11.2% in 2011. However, there is an opportunity to promote walking and trips made by bicycle, which is now only made by 0.4% of Maia's population. The city of Maia is already focusing on a smooth and sustainable mobility policy.

Table 4: Sample mobility indicators for Maia (INE, 2018)

Indicator Description	City Value	Green	Yellow	Red
Refers to the average distance, in kilometres, between the citizens's residence and his or her usual workplace location (from home to work and back again) (km/day)	8.9	< 10	10-20 km/day	> 20
Share of traffic by public transport of total traffic (%)	11.22	> 40	25 - 40	< 25
Share of traffic by pedestrian mode to total traffic (%)	17.42	> 40	20 - 40	< 20
Personal Vehicles (including private vans, excluding motorcycles and trucks) to total traffic volume (%)	69.5	< 15	15 - 40	> 40
The ratio between the total number of passenger motorised vehicles (incl. cars and taxis) within the urban agglomeration and the population (passenger vehicles per 1000 city inhabitants)	602	< 250 (Amsterdam)	250 - 400	> 400 (poorly performing German cities)

Promotion of cycling modes and actions to reduce motorized trips

The action fields show that enhanced road management would help to provide safe cycling and pedestrian paths. Efforts shall be focused on the promotion and encouragement of active mobility. Likewise, the need to actively seek the enhancement and development of car-free areas is evident. Maia has already started initiatives, one of

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which is providing incentives for employees switching to bike or public transport, implementing low speed zones and enlarging the extension of cycling lanes. This can support the change and decrease private vehicles on the road, aligning with the Strategic Plan for Urban Development of Maia to promote sustainable mobility modes.

8. PROJECT IDEAS FOR THE TRANSFORMATION OF MAIA

8.1 Virtual Onsite assessment

Due to the limitations caused by the pandemic COVID-19, the onsite assessment week was held remotely, between 2 November 2020 and 13 May 2021. During that time, two set of interviews were conducted with local stakeholders, including city managers, industries, SME's, entrepreneurs of the main key strategic areas that were considered along the City Vision Workshop: Urban Development; Energy Transition; Mobility; Smart and Sustainable City and Inclusive and Integrated City.

A total of 13 interviews, involving 11 city representatives (2 city councillor's, representing areas such as urban planning, energy, mobility, environment, and ICT, and 9 city managers and technicians of those technical subjects) and 18 stakeholders, including elements of the civil society and of relevant public and private institutions and entities were held. Subjects involved related to all key strategic areas selected for this purpose, namely: transport and logistics, energy companies and institutions, commercial companies, construction companies, non-governmental associations in the field of energy, environment and mobility, scientific and technological systems, representatives of residents' associations and professional orders.

35 project ideas were developed during the internal co-creating sessions with the local team together with the interviewees.

8.2 Project filtering

A Project Filtering tool was developed by Fraunhofer to aid in the process of narrowing down the project ideas developed in the previous steps and to guide the discussion on the projects to be taken forward. Therefore, the project filtering was conducted by the city team in order to select a group of projects to discuss within the City Lab Innovation Workshop. For this, seven criteria were used:

- **Stakeholder engagement**: It refers to the citizen backup/interest/acceptance that has been shown, e.g. during the interviews, or is expected for the implementation of this measure;
- **Regulation constraints**: Addresses the extent to which a regulation should be introduced/modified in order to be able to implement the project;
- **Funding potential**: Refers to the existence of possible funding budget for the implementation, being it private or public;
- **Political support**: Focuses on the political interest and back-up that the implementation will have;

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- **City Strategy alignment**: It refers to how much the project would be in accordance with the agenda the city is pursuing, and how well aligned it is to their established goals;
- **Quick win**: Concerns the action implementation level of difficulty. Allows the choice of the low hanging fruit projects;
- **Potential to be a lighthouse project**: Refers to how big the potential of the idea is to be a typical lighthouse project, as known in H2020 proposals.

The project ideas were classified by the SPARCS local team, supported by SPI and NEW R&D, and the 'political support' criteria was answered by the city councillors responsible for following the SPARCS project, representing the city's political administration, and the results can be found in the appendices - Maia's Project Rating (see Table 8, p.84).

Besides the quantitative results, a qualitative analysis was also conducted to select implementation projects. These were analysed in several perspectives: complexity, stakeholders' engagement, political support, funding needs and the potential to be a lighthouse project. From the 35 projects evaluated, five of them were selected to be the focus in the **Innovation Workshop**. These addressed 5 key topics: Sustainable Mobility; Citizen Engagement; Energy Transition; Information and Communications Technologies; and Environment and Circular Economy. The following are the chosen projects:

- M.4 - Improve the Competitiveness of the Public Transport System;
- CE.2 - Integration of New Local Eco-Neighbourhoods;
- E.2 - Pilot a Smart Grid and VPP at City District, considering an energy community (housing or industrial, considering the project idea E.4 - Industry Based Virtual Power Plants);
- IC.3 - City Digital Transformation;
- W.4 - Smart Waste Heat Valorisation.

8.3 Innovation Workshop

As part of the SPARCS Task 5.3. Fellow City Replication Strategy, a half-day workshop was held in Maia on 13 May 2021 in remote mode, with the aim of presenting, verifying, discussing, and further developing the existing ideas for innovation projects and measures developed during the onsite assessment, with the stakeholders involved.

The workshop was organised in a collaborative effort between the Fraunhofer Research Institute and an internal multidisciplinary technical team, accompanied by the Portuguese SPARCS partners SPI - Portuguese Society of Innovation and NEW R&D, as well as with AdEPorto.

The Maia City Lab Innovation Workshop consisted of the following phases, presented here in order of completion over four hours of collaborative work, and summarised in the agenda below:

- Welcome & Introduction: The SPARCS project; Strategic objectives of the SPARCS project in the City of Maia.

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- Methodology & onsite assessment facts, results: Highlighted the importance of the City Lab co-creative methodology and the main results of the onsite assessment held in Maia.
- Workshop methodology: Discuss, verify, and improve first ideas for innovation projects and measures developed during the onsite assessment.
- Five work groups on the selected project ideas: Structured discussions based on own expertise and background.
- Presentation of the results and open discussion: Project ideas further developed and concrete next steps for implementation defined, as well as first concepts and approaches for integrating public and private stakeholders from the city, and possible financing opportunities identified.
- Conclusions and next steps.

In the workshop a total of 30 participants (in addition to members of the SPARCS local team) were present, as well as around 18 members of the civil society representing relevant public and private institutions and entities related to projects under discussion, as shown in Figure 17.

The co-creation process was organised within five working groups addressing the previously defined main project ideas, using interaction techniques and methodologies. Each group was led by one city representative, and structured discussions were made, allowing an active dialogue between the groups of stakeholders and each member to be able to contribute from own expertise and background, thinking prospectively and formulate problems, solutions and specific situations related with each one of the discussed projects.

Finally, each group shared their work among all participants, promoting the collaborative sharing of experiences and facilitating a close and fruitful dialogue between all the people involved.

Figure 16: Screenshot of the online workshop

The process of selecting the 'champion project' was not concluded during the workshop. All the five projects were considered relevant, and the decision was left for the SPARCS

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local team to inform and make a proposal for the political representatives to select two of five, based on the workshop results.

The local team developed a final analysis to identify two projects to feed the next phase of the WP5 Replication, particularly under Task 5.4, called "Project Development in FCs". For that, criteria such as the complexity of the project associated with the components of the project, some of them related with other project ideas, and the cross-sectional character of the project ideas and the alignment with the SPARCS main themes were considered. In this exercise, the following projects were identified:

- E.2 - Pilot a Smart Grid and VPP at City District, considering an energy community (housing or industrial, considering the project idea E.4 - Industry Based Virtual Power Plants);
- IC.3 - City Digital Transformation;
- W.4 - Smart Waste Heat Valorisation.

The first two projects have full alignment with SPARCS' main objectives, complexity, dimension, and integrates into their components other identified project ideas, which allows us to expect to have better results during the project development phase, considering the considerable alignment with the collaborative process carried out before. A third project was identified, the W.4 - Smart Waste Heat Valorisation, and can be considered in case Task 5.4 admits additional projects.

It is important to highlight that all project ideas are still at an initial stage (scoping). Maia will now develop the first two under the task "5.4 Project Development in Fellow City".

The project idea "E.2 - Pilot a Smart Grid and VPP at City District" will involve an energy community for three different pilot sites: (i) the business hub "TecMaia", (ii) a social housing neighbourhood and (iii) a municipal building (to be selected among a broad equipment typology such as schools, sport facilities or administrative buildings, selected to work in a virtual context.

Concerning "IC.3 – City Digital Transformation", and the experience from the pilot project "BaZe – Living Lab Maia", the municipality is testing the interoperability of different types of data and sources, as well as different tools, hardware and software solutions, in order to assess their feasibility and scalability potential.

The next methodological steps for the mentioned projects will be focused on planning and project design, ToR preparation, securing investment and financing, organisation of the public tenders and stakeholders and citizens engagement.

Finally, regarding the "W.4 – Smart Waste Heat Valorisation", taking into account that Maia does not have an urban thermal network, the next steps will involve the assessment of waste heat potential (sources/supply and customers/demand) and technical and economic feasibility studies, which will only to be conducted if the main identified stakeholders keep their interest on exploring this yet untapped energy source. This project, along with the energy efficiency and mitigation aspects, adds to circularity and also fighting energy poverty

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The selected projects and its ranking have the political agreement of the political representatives that have participated in the onsite assessment.

8.4 Project Ideas for Maia

From the onsite assessment, the 15 project ideas that were chosen as the top contenders are listed in Table 5. Their evaluation detail is thoroughly presented in the appendices section.

Table 5: Top 15 of project ideas solutions worked in the City Lab Innovation workshops (Maia Municipality, 2021b)

Sr. No.	Solution description	Total
M.4	**Improve the competitiveness of the Public Transport System**	**36,4**
IC.1	**Urban Data Platform for Maia**	**35,6**
E.1	**Rehabilitation of municipal buildings and installation of RES-e generation technologies**	**34,4**
W.6	**Environmental Zone in Maia**	**34,4**
M.5	**Mobility hubs in Maia that offer and connect alternative modes of transport**	**33,7**
E.2	**Pilot Smart Grid at city district, considering an energy community**	**33,2**
IC.3	**City Digital Transformation**	**33,2**
W.4	**Smart Waste Heat Valorisation**	**33,2**
E.4	**Pilot a VPP and energy community in the Industrial district**	**32,2**
W.7	**Green roofs on the majority of the municipal buildings**	**32,2**
CE.2	**Integration of new local „eco-neighbourhoods“**	**31,4**
E.5	**Replicate social enterprises like Coopernico, in Maia.**	**28,4**
W.5	**Material Bank for sustainable building**	**26,9**
G.1	**Development of policies that guarantee that urban data remains open and in the public domain.**	**38,1**
W.3	**Smart Irrigation in park management**	**36,1**

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Solution 1: Improve the competitiveness of the public transport system

BUS Only Lanes

Description and Objectives

Maia has a high weight of private car use on its modal split, something that has to be changed in the next years. One of the solutions appointed is to improve the use of the Public Transport System shown in Figure 18. One of the ideas is to dedicate some corridors between Maia and the municipalities, especially around Porto and Matosinhos, such as the ancient national roads EN13 and EN14, in order to develop a Bus Rapid Transit (BRT), ensuring the competitiveness of this transport mode, in comparison with private cars. Other components of this project idea include improving bus stops and shelters with new technologies allowing real time information and transforming these structures into 'leisure spaces' and/or intermodal hubs.

Objectives:

- Increase the attractiveness of using public transport
- Decrease travel time in public transport
- Reduce emissions
- Incentivize the use of public transports
- Reduce the use of private cars

Components	Stakeholders
• Improvement of stops and shelters, transforming them into leisure spaces; • New technologies, to allow real time communication between PTs and users; • Intermodal hubs; • Sustainable and flexible vehicles to meet needs; • Dedicated corridors for PT; • Awareness campaigns to change behaviour.	• Municipality; • Private Public Transport Operators; • TIP – Porto Intermodal Transport; • Porto Metropolitan Area; • Citizens.
Next steps	**Possible funding options**
• Design the needs; • Design the ToR; • Organize a Public Tender;	• Municipal; • European Union Funds; • Private Investors; • Publicity; • Others.

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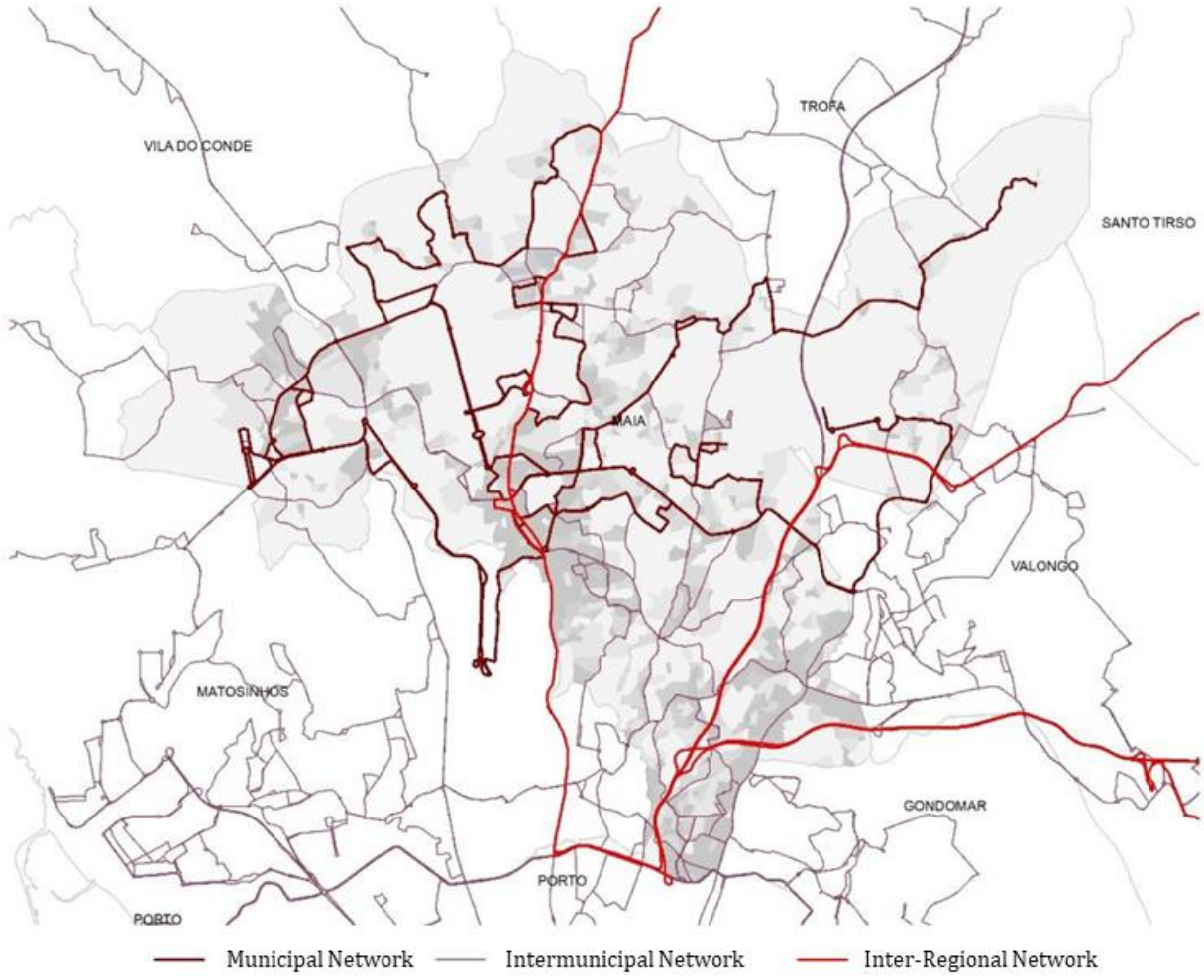

Figure 17: Transport Network in Maia municipality (Maia Municipality, 2021a)

Solution 2: Urban data platform for Maia

Creating a Platform for the City of data collection and processing
Description and Objectives
Maia sees the need for creating a horizontal platform for the collection, processing and integration of urban data. It allows for better decision making based on data that is being collected and is available. Co-relation of different information. For example, bike information with traffic, environmental data related to tourism, etc. KPIs important to create value need to be identified. The experiences from other cities e.g. in Denmark, Switzerland, etc. doing this can be replicated. Such a platform allows for more accurate prediction and problem avoiding. For this the collaboration of key stakeholders, producing data is needed. The municipality is already working on the integration of different data on a google platform, as you can see on the examples of Figure 19. This needs to be expanded in the creation of an own platform in collaboration with strategic partners in the development such as ISMAI and the Porto University.

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Objectives:

- Design a systematic data collection process
- Identify all data sources that could feed in the platform
- Bring all relevant actors and data together
- Allow for modelling for predictive processes
- Reduce costs

Stakeholders: R&D Institutions, Altice, NOS, ICT Department, COMPTA, Yunex Mobility, LIPOR, MOBI-E, Omniflow.

Components	Stakeholders
• 'General' Digital Infrastructure; • Dedicated IoT infrastructure; • Public awareness; • Digital and Scientific Citizenship (Including Open Data maturity); • Monitoring infrastructure to measure and manage change.	• Citizens / Local agents (public authorities, business, etc.); • ICT Companies working mainly in 'Digital Transformation' / 'Smart Cities'; • Schools, Universities, Innovation Companies.
Next steps	**Possible funding options**
• Prototyping and small-scale experiments; • Citizens & Organisations (public, private, schools, universities, etc.) engagement; • Scale good practices across the territory.	• Municipal; • Public/Private Partnership; • European Union Funds; • Private Investors; • Others.

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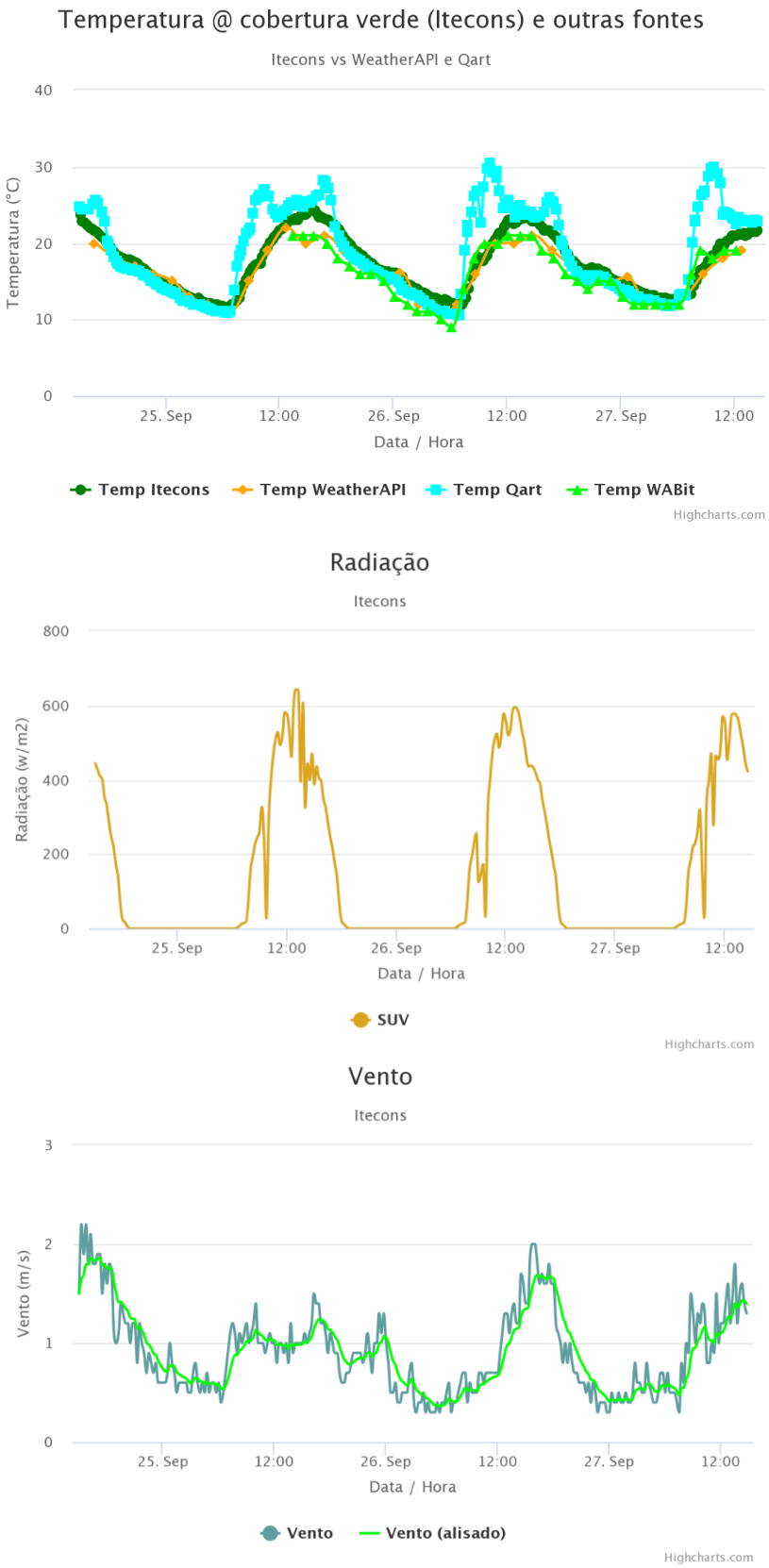

Figure 18: Data harvesting experiments from meteorological sensors, for purpose of the interactive and integrative platform prototype, under BaZe – Living Lab Maia (Maia Municipality, 2022)

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Solution 3: RES-e production on the majority of the municipal buildings – E.1

Rehabilitation of municipal buildings and installation of RES-e generation technologies

Description and Objectives

Several ongoing initiatives to use building roofs in sustainable solutions are being developed in the municipality and involve several stakeholders, such as the examples shown in Figures 20 and 21. The municipality is leading with example by installing green roofs and photovoltaic panels in the majority of the municipal buildings. It is believed that municipal embodiment of the initiatives will encourage the use of roofs for sustainability solutions by other stakeholders.

This solution is focused in:

- supporting the municipality on implementing sustainable solutions in municipal buildings;
- supporting the communication efforts to showcase the examples and promote them to the private and civic sectors.

This solution can also be a keystone for the implementation of Energy Communities, by providing non-centralised RES generation that can be integrated into the local energy community.

Objectives:

- Set an example of good practices
- Promote local RES implementation
- Promote the financing of RES projects
- Support the creation of energy communities

Components	Stakeholders
• Equipment: RES-e technologies metering equipment; • Infrastructure: distribution network, buildings.	• Municipality; • Technology providers/Project developers; • DSO (Distribution System Operator).
Next steps	**Possible funding options**
• Characterise the potential for RES-e generation in publicly owned buildings; • Project design (incl. identification of buildings, sizing of installations, business model, financing sources, etc.);	• Municipality and Municipal enterprises; • EU and national funding programmes; • Public Private Partnership; • Others.

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Ficha individual de informação

Instalação	Instituto do Bom Pastor	Potência a instalar [kWp]	25,0	Inclinação dos painéis	30	Coordenadas	41.208405
		Produção Específica [kWh/kWp]	1 449	Azimute dos painéis	15		-8.554058
Nível de tensão	BTN	Quantidade de painéis (500Wp)	50	Área considerada [m2]	82	Base de Dados	PVGIS
Potência Contratada [kW]	41,4	CPE	PT0002000076722497NC			Data Estudo	19/04/2022
Morada	Largo da Oliveiras SN, 4445-538 Ermesinde						

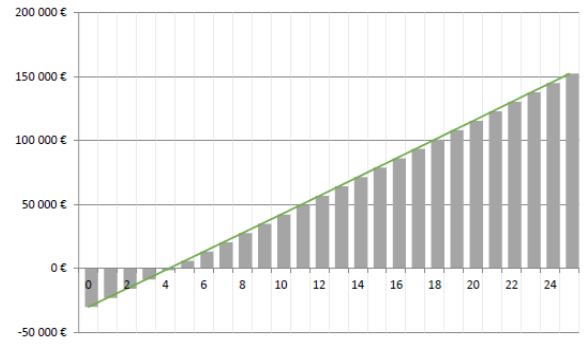
Condições técnico-financeiras

Período de análise	25 anos
Taxa de atualização de capital	3%
Aumento anual da tarifa de energia	1%
Depreciação de produção anual de eficiência dos painéis	0,80%
Custo com a manutenção anual [€/Wp]	0,05 €

Desempenho Financeiro a 25 anos

Investimento (s/IVA)	**30 000 €**	
Manutenção >>>	Não	Sim
Payback Simples	3,6	**4,2**
Valor Atualizado Liquido (VAL)	118 542 €	96 776 €
Taxa Interna de Rentabilidade (TIR)	28%	24%
LCOE [€/kWh]	-	0,0896 €
Custo por kWp instalado	1 200 €	

Fluxo de caixa com manutenção



Informação financeira a 1 ano (valores sem IVA)

Redução de custos com energia em autoconsumo	8 186 €
Redução de custos com venda de energia à rede	219 €
Redução de custos com PHP	0 €
Ganhos Totais	**8 405 €**

Para os ganhos totais não foram consideradas reduções na potência contratada, impostos e taxas com eletricidade.

Informação energética a 1 ano

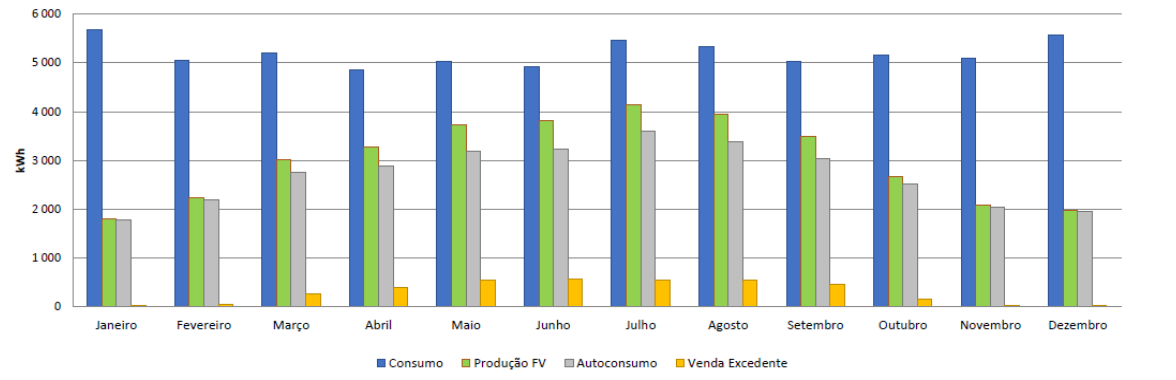
Consumo anual da instalação [kWh]	62 364
Energia total produzida [kWh]	36 225
Energia utilizada em autoconsumo [kWh]	32 570
Energia vendida à rede [kWh]	3 656
Emissões evitadas [Ton CO2e]	13
Redução de consumo de energia pelo Autoconsumo	**52,2%**
Injeção na rede face ao total de energia produzida	10,1%

Informação energética a 25 anos

Energia total produzida [kWh]	818 693
Energia utilizada em autoconsumo [kWh]	736 071
Energia vendida à rede [kWh]	82 622
Emissões evitadas [Ton CO2e]	294,7

Foto aérea com possível implementação

Perfis Mensais - Consumo/Produção FV/Autoconsumo/Venda Excedente - 2021



Perfil diário - Consumo anual de energia e potência média - 2021

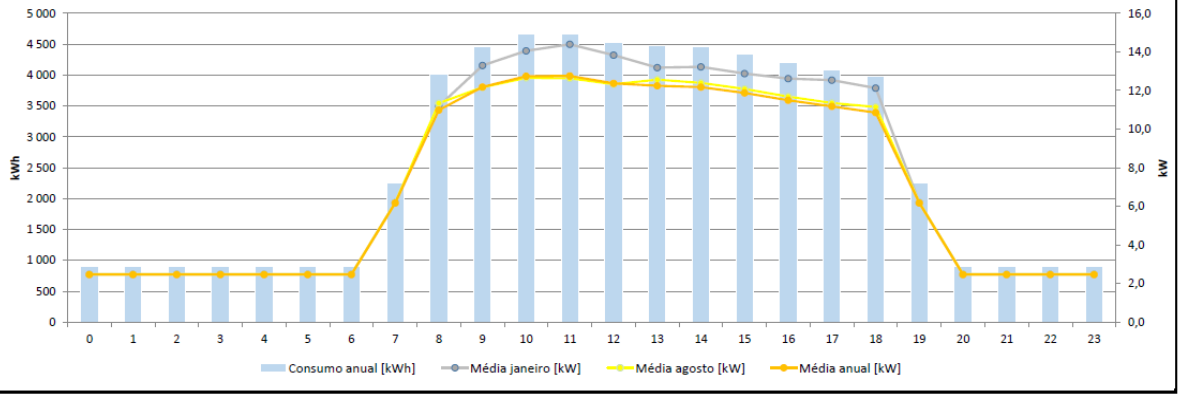


Figure 19: Example of technical and energy information (AdEPorto, 2021)

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Figure 20: Example of technical and energy information (AdEPorto, 2021)

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An estimative, held in 2019, for 73 municipal buildings proposed the installation of 73 small production units, with a nominal installed power of 3.45 MW (average production of 5.5 GWh/year) (AdEPorto, 2021). This facility would represent an estimated investment of €4,968,506.00 (installation), with an approximated energy generation equivalent to the annual consumption of 2,228 households, resulting in an expected reduction of 2,246 Tons of CO2 eq/year.

At the present moment, Maia is planning to participate in a public tender to install RES Production on 17 buildings, 15 owned by the municipality and 2 owned by two municipal companies. The ToR – terms of reference is under preparation.

Solution 4: Environmental zone for Maia – W.6

<table>
<tr><td colspan="2">Living Lab Maia - Net Zero Carbon City, a project, which aims to establish itself as a low-carbon, resilient, accessible, participatory, and connected environment</td></tr>
<tr><td colspan="2">Description and Objectives</td></tr>
<tr><td colspan="2">The on-going ‘BaZe - Living Lab Maia’ intents to promote an environmental zone in the city centre as illustrated in Figure 22, where several efforts are being taken around the promotion of soft modes, public transport and, more recently, smart parking and traffic counting systems, associated with air quality sensors. Pilot projects with green roofs, energy efficient systems in buildings and RES production are under way, as well as water efficiency, conceived in a logic of interaction and integration to enhance the city knowledge and sustainability. These efforts can be enhanced through the creation of environmental zones.

Objectives:
• Promote and complement other efforts done to promote non-motorised transport
• Reduce emissions
• Reduce the number of cars in the city centre
• Improve air quality in the city centre

Stakeholders: Environmental Department, Quercus, Mobility Department</td></tr>
<tr><td>Components</td><td>Stakeholders</td></tr>
<tr><td>• City Lab;
• Smart Solutions: Energy, Mobility; Environment and Circular Economy and Others;
• Social Engagement tools (events; fairs, games, art, sports, training activities);
• ICT Integration (data harvesting, data analysis).</td><td>• Municipality;
• Private owners (commercial and services) and companies;
• Energy providers (EDP and others);
• Transport Operators;
• Public interest entities (e.g. LIPOR for environmental education; universities, schools);
• Citizens, local community-based associations / groups to be constituted; Community Center.</td></tr>
</table>

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Next steps	Possible funding options
• Proceed with the ongoing pilot project; • Citizen engagement and training; • Monitoring, assessment, and scalability analysis; • Revisiting financial models and identifying adequate resources (human and financial) for scalability process.	• Municipal; • EU and national funding programmes; • Public-private partnerships; • Others.

Public Administration

1 – Town Hall
2 – Forum
- Auditoriums
- Library
- Exhibition Gallery

3 - Tourism Store
4 - Tax and Customs Authority

Parking lots

5 - Central Park (public access)
6 - City Hall (restricted access)
7 - Forum (conditional access during the day)
8 - Services Hub (public access)

Services

9 - Service Hub
- Court
- Maia Day Hospital
- Andante store
- Catering

10 - Restaurants

Mixed Area

11 - Mixed Area
- Residential
- Business
- Services
- Catering

Figure 21: Maia Living Lab Central Area (Maia Municipality, 2018a)

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Solution 5: Creation of Intermodal hubs – M.5

Mobility hubs in Maia that offer and connect alternative modes of transport

Description and Objectives

There is a need in Maia to promote the use of public transport and alternative modes. Maia is already starting some efforts toward intermodality in the context of the Living Lab pilot project, but this needs to be expanded and coordinated with other important stakeholders, mainly the public transport operators - STCP, Metro and CP. As an example, the Parque Maia can be planned as an intermodal hub, where different types of services are offered: public transport, bike sharing, car sharing, e-scooters, etc., (see Figure 23). The central idea is to make mobility accessible and attractive for the users, providing an alternative for the use of the private car and enhance quality of life in the city. The hubs should, when possible, be built as smart grids, with local generation of energy that can be directly used for charging the fleets.

Objectives:

- Increase the use of public transport by facilitating door-to-door transit
- Offer various mobility options at strategic locations to improve user experience and comfort
- Promote participation in initiatives organised by the city
- Promote solar energy

Components	Stakeholders
• Improve the quality of the hubs (shelters; no. of services provided; different and diverse modes of transport; integrate ticket systems); • New technologies, to allow real time communication between PTs and users; • Sustainable and flexible vehicles to meet the needs; • Awareness campaigns to change behaviour.	• Municipality; • Private Operators; • TIP – Porto Intermodal Transport.
Next steps	**Possible funding options**
• Selection of possible locations; • Design the needs; • Design the ToR; • Organize a Public Tender.	• Municipal; • European Union Funds; • Private Investors; • Publicity; • Others.

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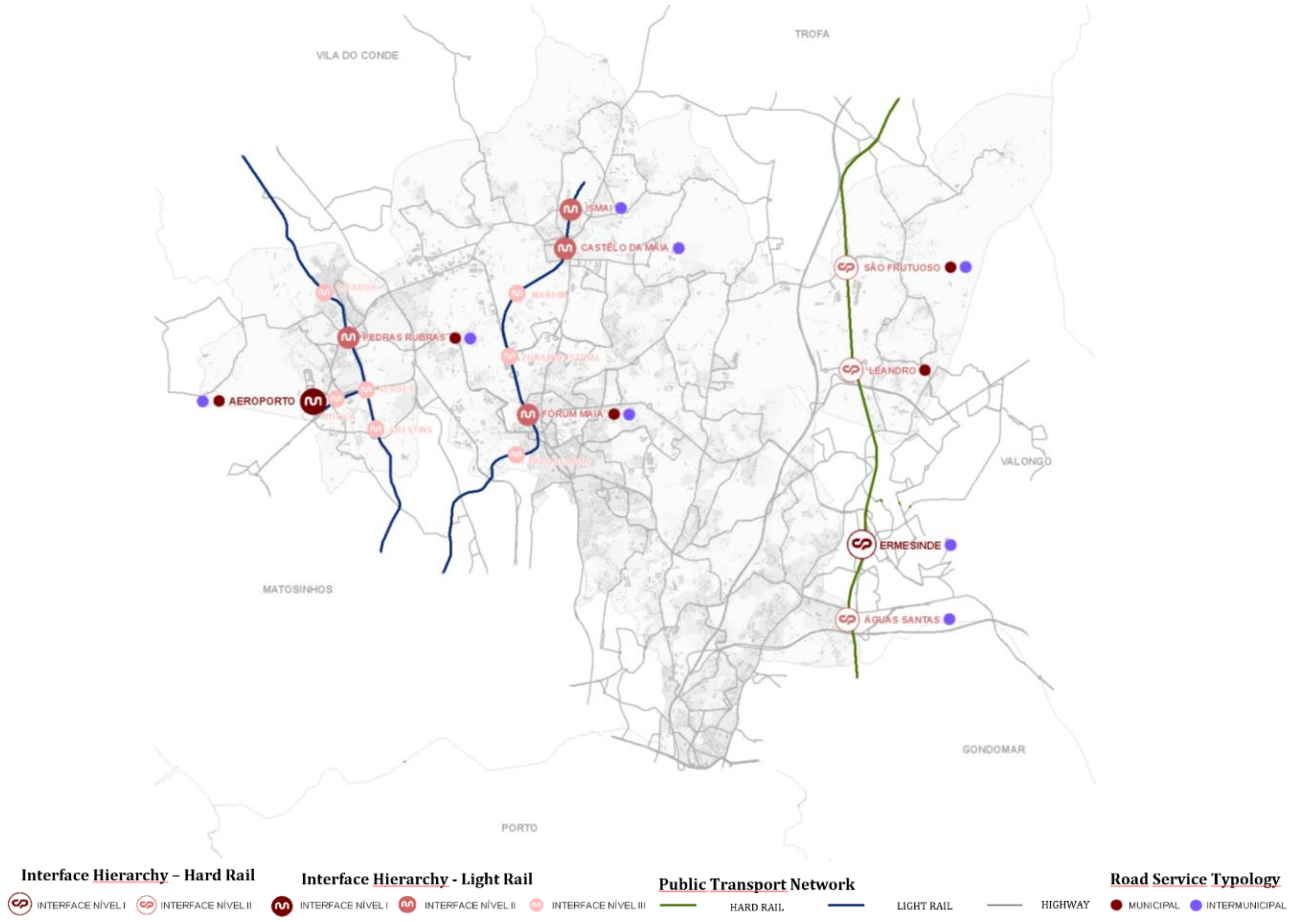

Figure 22: Transport network (Maia Municipality, 2021a)

Regarding Maia's Interfaces network, there is a set of sixteen transport interfaces, all related to collective rail transport, either heavy or light rail services, presented in the figure above (Maia Municipality, 2021a).

At least 19,520 inhabitants have a public transport (railway) interface, 400 m away from their dwellings. However, most of them still need improvement and complementary services, in order to be fully attractive to citizens.

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Table 6: Distances between interfaces and dwellings (Maia Municipality, 2021a)

Interfaces	População Residente			Alojamentos		
	400m	800m	1200m	400m	800m	1200m
Estação de Metro Aeroporto	421	2.808	4.960	225	1.317	2.283
Estação Ferroviária de Ermesinde	-	2.083	5.663	-	929	2.422
Apeadeiro de Águas Santas	3.242	6.460	9.675	1.452	2.917	4.436
Apeadeiro de Leandro	545	1.284	1.944	220	531	812
Apeadeiro de São Frutuoso	559	831	1.713	214	330	709
Estação de Metro Castêlo da Maia	3.158	6.388	8.198	1.512	3.126	3.858
Estação de Metro Fórum Maia	5.812	11.120	20.875	2.787	5.195	9.290
Estação de Metro ISMAI	2.671	6.664	9.420	1.383	3.165	4.323
Estação de Metro Pedras Rubras	3.112	7.120	12.226	1.360	3.170	5.417
	19.520	**44.758**	**74.674**	**9.153**	**20.680**	**33.550**

Solution 6: Pilot Smart Grid at a city district – E.2

Pilot a Smart Grid at a city district, considering an energy community

Description and Objectives

Maia should gain more experience with the implementation of smart grids and positive energy blocks. These experiences would produce data that can be taken as basis for concrete research on different solutions for peak shaving, local electricity generation, decrease in energy consumption, and analyse the best replication strategies. The Energy Distribution company has already some experience with smart grids in other municipalities and can transfer the knowledge gained for the implementation in Maia. The company is already in the process of installing smart grids, which will provide necessary data for managing the loads and network. Also, the municipality is currently implementing a project for the installation of EV charging stations city wide. The planning of this project should include charging stations in the selected areas for piloting the smart grids. The project aims to be piloted in different areas with different characteristics. Public buildings can be screened to identify possible locations for initial roll outs of pilots. This implementation would allow to gain more insights regarding the network loads and future needed adjustments.

This solution needs the DSO participation in order to succeed.

Objectives:

- Reduce energy consumption
- Promote the use of local RES
- Develop adequate regulations for promoting the transition
- Increase environmental awareness
- Promote the use of EV

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Components	Stakeholders
• 36 Buildings with about 6.750.00 m²; • 4 Tower Buildings with about 1,470 m²; • Total of about 8.220,00 m² of surface for installing PV (should be considered a deduction of about 10% because of the presence of other technical installations on the roofs).	• Municipality; • Espaço Municipal, EM (Municipal Social Housing Company); • DSO (Distribution System Operator).
Next steps	**Possible funding options**
• Feasibility Studies; • ToR; • Investment & Funding opportunities; • Organize a Public Tender; • Engage Citizens.	• Municipality; • EU and national funding programmes; • Public Private Partnership; • Others.

Solution 7: City Digital Transformation – IC.3

Scale up the pilot projects on going and integration of other digitalisation efforts on the municipal ecosystem

Description and Objectives

At the moment, the municipality has investments on digitalisation of some key urban facilities/services: waste collection, water distribution and several pilot projects regarding energy efficiency, sustainable mobility, irrigation system for public green spaces, air quality, noise, among others.

There are funds available to support the scale up of this transformation. At the same time, investing in new technologies (hardware and software) has been considered. Consideration also extends to changes in the key operations/processes as well as in the organisational structures and management concepts (orgware).

One possible solution can be a definition of areas in the municipality to start with the deployment of additional devices or areas where other energy efficiency projects are being planned.

Objectives:

- Enable the City Digital Transformation by applying new technologies
- Promote innovation assuring transformation of services, processes and structural aspects along with the technology integration.

Components	Stakeholders
• OpenDataSoft platform - mainstream, official, public open data access/sharing; • BaZe prototype https://bit.ly/3cOLDKx partial digital twin for the territory metabolism;	• R&D Institutions/Schools/Universities; • Altice; NOS; • ENDESA X; • ENDESA;

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• Sensors (air quality; traffic; parking; electric mobility; public lighting; water, energy efficiency); • Data harvesting (energy production; electric mobility; others).	• AdEPorto; • LIPOR; • EMEM, EM; • Mobi-e; • COMPTA; • Yunex; • Citizens Associations; • FAHR 021.3.
Next steps	**Possible funding options**
• Activate OpenDataSoft and collect users feedback; • Interoperate data with Lipor / EMEM, EM and monitor / collect user feedback; • Raise public awareness through school; projects/collaboration and monitor initiatives / collect user feedback; • Digital twining / gamification for GHG emissions; • Digital City Art / Citizens awareness.	• Municipal; • Public/Private Partnership; • European Union Funds; • Private Investors; • Others.

Solution 8: Smart Waste Heat Valorisation – W.4

Improving circularity by adding value to industrial waste heat

Description and Objectives

The municipality and industrial stakeholders, presented in Figure 24, have identified residual heat produced that can be used for Heating, Ventilation, and Air Conditioning (HVAC) in service buildings or indoor heating in residential buildings.

Residual heat potential from LIPOR and identified industrial sites is yet to be tapped, presenting opportunity for both heating and cooling in HVAC applications (by using auxiliary absorption refrigeration cycles).

The assessment and implementation of a thermal urban network, based on waste heat, includes the assessment of both technical and financial models since urban thermal networks operation and viability in Portugal differ from those in Northern/Central Europe (as the also differ weather conditions). The business model for Portugal relies more heavily on securing anchor, more intensive users, of heat/cold to ensure financial feasibility, while also connecting a more reticulate network of smaller end users.

This project also has the potential to help mitigate energy poverty while increasing the companies' social engagement.

As an initial trial - 2 to 4 km radius from the low heat resource will be assessed.

Objectives:

- Increase circularity
- Reduce energy use and related GHG emissions

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• Improve thermal comfort and wellbeing of the population • Enhance collaboration with the private sector **Stakeholders:** Environmental Department, LIPOR, Siderurgia Nacional (Megasa).

Components	Stakeholders
• Residual heat source(s); • Low enthalpy grid (2~3 km) + monitoring and control system; • Clients: for heat, cold, co and tri-generation; • Entity to explore the heat grid (industrially and commercially).	• LIPOR - Airport/ EFACEC; • Siderurgia/ Megasa - School/sports infrastructure; • AdEPorto; • Municipality; • Others - Airport, Schools.
Next steps	**Possible funding options**
• Assessment of waste heat potential • Feasibility Studies • Find an investor for the grid (technical and financial) • Pre-project the infrastructure with Waste Heat producers (Lipor/Megasa) in order to identify technical boundaries for the project.	• Municipal; • EU and national funding programmes; • Private Investors; • Others.

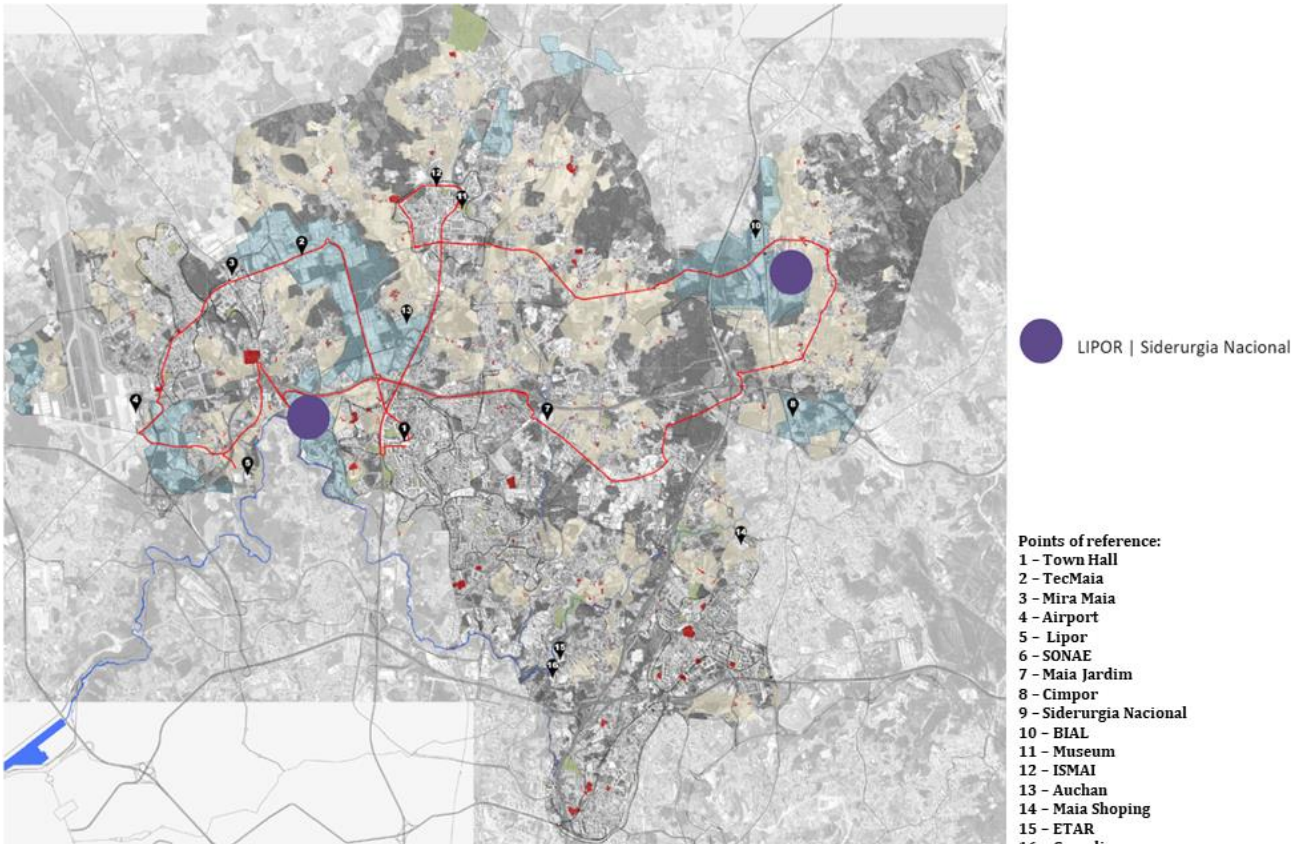

Figure 23: Location of residual low heat main producers (Own elaboration)

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Solution 9: Industry based Virtual Power Plants – E.4

Pilot a Virtual Power Plant and an energy community in the industrial district

Description and Objectives

Portugal is one of Europe's countries with more hours of sun in a year. This great potential still needs to be explored in Maia. The installation of large size plants would allow for greater efficiency in the production. Industrial sites have been identified as ideal locations, as illustrated in Figure 25; the roofs of industries can be used for the project, creating an important showcase for the city.
The industrial sector is the main producer of GHG emissions in Maia, accounting for around half of the GHG emissions in 2018. In order to be able to implement an energy community project, the current regulation needs to be changed to allow for a smart grid concept. The city/AdEPorto can then support with necessary studies to find solutions in terms of energy optimisation. To proceed, the target industry must be identified and through an assessment of historical energy consumption per industry.

Objectives:

- Increase the production and use of renewables in the city
- Increase environmental awareness
- Reduce energy consumption
- Increase energy efficiency
- Increase the private involvement in smart city projects
- Reduce emissions
- Enhance circularity

Suggested partners: TECMAIA, SONAE, EFACEC, EDP, ENDESA, Others

Components	Stakeholders
• Feasibility Studies; • RES Investment; • Possibilities for local and foreign investment; • Monitoring and assessment.	• Municipality; • AdEPorto; • Private companies; • Energy providers; • Environmental department, Altice, Goparity, Sonae Garcia Garcia.
Next steps	**Possible funding options**
• Design the needs; • Make analysis of market demands and interests; • Energy demand analysis.	• Municipal; • Public/Private Partnership; • European Union Funds; • Private Investors; • Others.

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Figure 24: Maia 1 Industrial District - Approximately 102 ha of roof area as a potential for PV installation. (Own elaboration; Credits: Nuno Antunes Lopes)

Solution 10: Green Roofs on the majority of the Municipal Buildings – W.7

Refurbishment of municipal buildings, considering the integration of green roofs and/or vertical gardens

Description and Objectives

Several ongoing initiatives to incentivize the use of building´s roofs as grounds for sustainable solutions are in the making in the municipality, as pictured in Figure 26, and with several stakeholders. Around this debate, there is the perception that the municipality should act as an example and display good practices by providing green roofs and photovoltaic panels to all publicly owned municipal buildings. This solution is based on the assumption that municipal examples will encourage transition towards the use of roofs for sustainability solutions in other sectors of the society.

This solution could focus on supporting the municipality on its task to cover municipal buildings with sustainable solutions and support the communication efforts to display the examples and promote it to the private and civic sectors.

Objectives:

- Set an example of good practices
- Promote biodiversity

Components	Stakeholders
• Building structural evaluation; • Project design; • Construction; • Best practices communication; • Support for replication by private owners (incentives).	• Construction and Maintenance Department; • Espaço Municipal, EM – Municipal Social Housing Company; • Constructors; • Private Companies; • R&D Institutions.

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Next steps	Possible funding options
• Finalize the project ongoing under BaZe – Living Lab Maia and monitoring its results; • Develop other projects for municipal buildings; • Develop regulations for private interventions • Communication for replication and scalability.	• Municipal; • EU and national funding programmes; • Others.

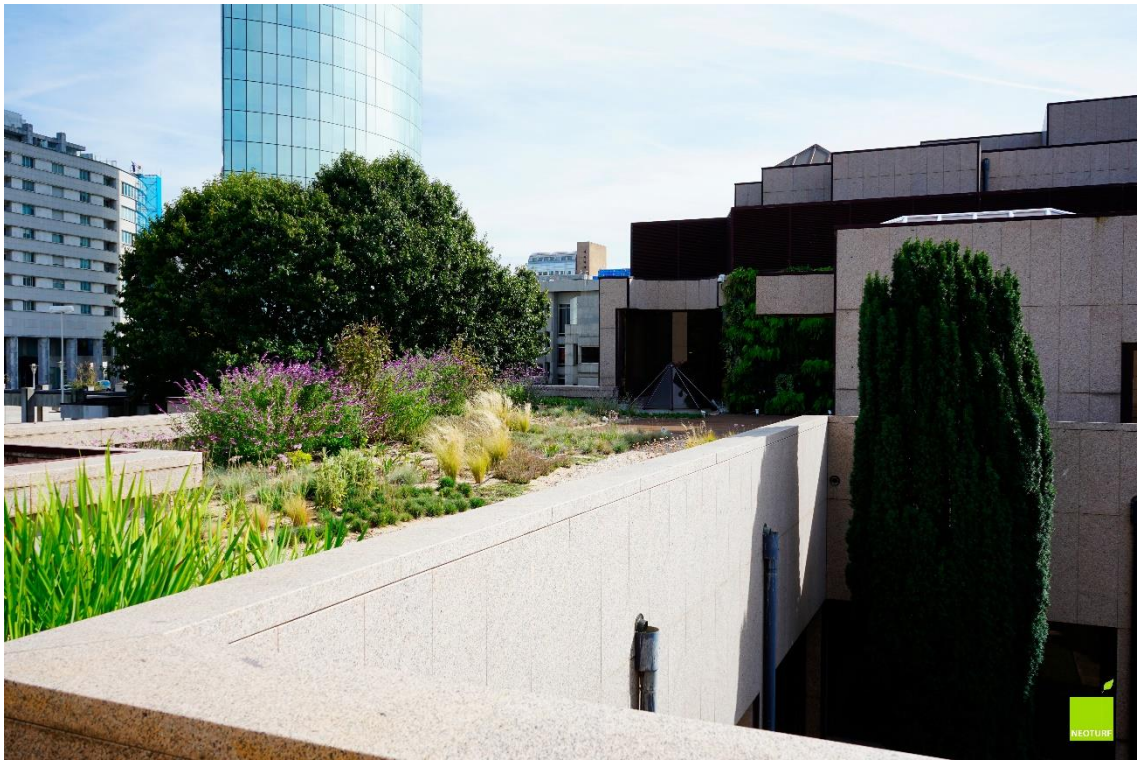

Figure 25: Green roof of Fórum Maia (Image credits: Neoturf)

Solution 11: Eco-Neighbourhoods – CE.2

Integration of new local, 'eco-neighbourhoods'
Description and Objectives
There is a desire to see more integrated planning and management of buildings, blocks and neighbourhoods in what concerns energy consumption, waste management, and facilities arrangements (e.g. PV panels, collective organic waste/water treatment, collective semi-private laundry areas, etc). 'Eco-neighbourhoods'[3] would correspond to an effort to re-design and plan building blocks, and neighbourhood-level communities

[3]Examples: https://s.fhg.de/6Au; https://s.fhg.de/9Fr

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to optimise energy, waste, and socio-spatial relations for interested communities in Maia.

Objectives:

- Integrate and optimize waste management
- Integrate and optimize energy consumption
- Integrate and optimize facilities of collective use

Components	Stakeholders
• Infrastructures ('Intelligent' waste collection system; commercial and services activities in the neighbourhood in a '15 min city' perspective; green spaces and water retention areas - rain gardens; energy efficiency in each house with RES; • Smooth mobility and design for all; • Public Spaces Events: fairs, games, art, social engagement, sports; • Training people: health literacy and mobilisation for the 'maintenance' of the neighbourhood and community engagement (of people and not for people); • Local (public) support office within the neighbourhood.	• Municipality, Espaço Municipal, EM.; • Private Owners (commercial and services); • Energy providers (EDP and others); • Transport Operators; • Public interest entities (e.g. LIPOR for environmental education, Universities, schools); • APJAR- Literacy for architecture and urbanism Community Centre; • Citizens, local community-based associations / groups to be constituted Community Centre.
Next steps	**Possible funding options**
• Design and Project Development; • Choose locations; • Citizen's engagement and training; • Revisiting financial models and identifying adequate resources (human and financial); • Implementation.	• Municipal; • EU and national funding programmes; • Public-private partnerships; • Third sector involvement; • Private involvement to create conditions for medium and long-term investments for maintenance; • Financial integration between physical and immaterial funding programs.

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Figure 26: Sobreiro District - Refurbishment Project ongoing under PARU- Maia (Own elaboration)

Solution 12: Energy cooperatives Replication – E.5

Replicate social enterprises like Coopernico, in Maia.
Description and Objectives
Due to the change in paradigm of the energy system - decentralised, high RES penetration, prosumers - energy cooperatives or non-traditional energy entities will gain space in the energy market. As of today, in Portugal, Coopernico is an example of a cooperative entity that has started as a RES cooperative and currently aggregates a myriad of sustainable peer-to-peer investments that operates in Portugal. Over the last years it has promoted investments mostly in renewable energy technologies, but also in other sustainable projects, with the involvement of individual citizens.

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Based on the experience of Coopernico and taking advantage of the establishment of the framework for Renewable Energy Communities[4], there is an opportunity to promote the development of similar social enterprises and emphasise its potential for empowering local communities and fostering local benefits. This would enhance, enable flexibility, and further develop the network of renewable energy investments in Portugal and in Maia.

Objectives:

- Replicate social enterprises like Coopernico
- Bring energy and economic autonomy to the region
- Expand and improve flexibility of the sustainable energy providers market

Components	Stakeholders
• Feasibility Studies; • Social enterprise support; • Expansion of sustainable energy providers; • Possibilities for local and foreign investment; • Monitoring and assessment.	• Municipality; • Coopernico; • Cooperatives syndicates or unions; • Private companies/Citizens; • National bureau for cooperative enterprises; • Others.
Next steps	**Possible funding options**
• Design the needs; • Make analysis of market demands and interests; • Initiatives to increase awareness and knowledge regarding the advantages and possibilities for community energy initiatives;	• Municipal; • Public/Private Partnership; • European Union Funds; • Private Investors; • GoParity (or other crowdfunding investment platforms); • Others.

Solution 13: Material Bank for sustainable building – W.5

Demolition waste management and recycling

Description and Objectives

The municipality aims to cooperate with an expert from university on circular buildings design. This should address residential housing and industrial facilities. The idea is to categorise each building according to their age and their life cycle assessment, as shown in Figure 28. Based on this classification, the materials and their potential for recycling are identified, as well as when the demolition should take place. The materials are then properly recycled for reuse in new constructions. The project can be implemented by the city or the private sector. The main objective is to match future needs of

[4] Under the Renewable Energy Directive (EU) 2018/2001, (REDII), a common framework for the promotion of energy from renewable sources in the EU was established and set a binding target of 32% for the overall share of energy from renewable sources in the EU's gross final consumption of energy in 2030.

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construction materials with materials available from demolition. The initiative can be promoted through a legislation obliging the use of a higher percentage of recycling materials in new constructions.

Objectives:

- Reduce emissions
- Promote recycling
- Promote awareness
- Enhance collaboration with the private sector

Stakeholders: Environmental department, LIPOR, Industry sector, universities and ASWP - Smart Waste Portugal Association

Components	Stakeholders
• Data on the potential urban mining.	• Municipality; • Construction companies; • Industry sector; • Universities and Research & Development Institutions.
Next steps	**Possible funding options**
• Identify the urban mining potential; • Regulate the access to the urban mining.	• Municipal; • EU and national funding programmes; • Private Investors; • Others.

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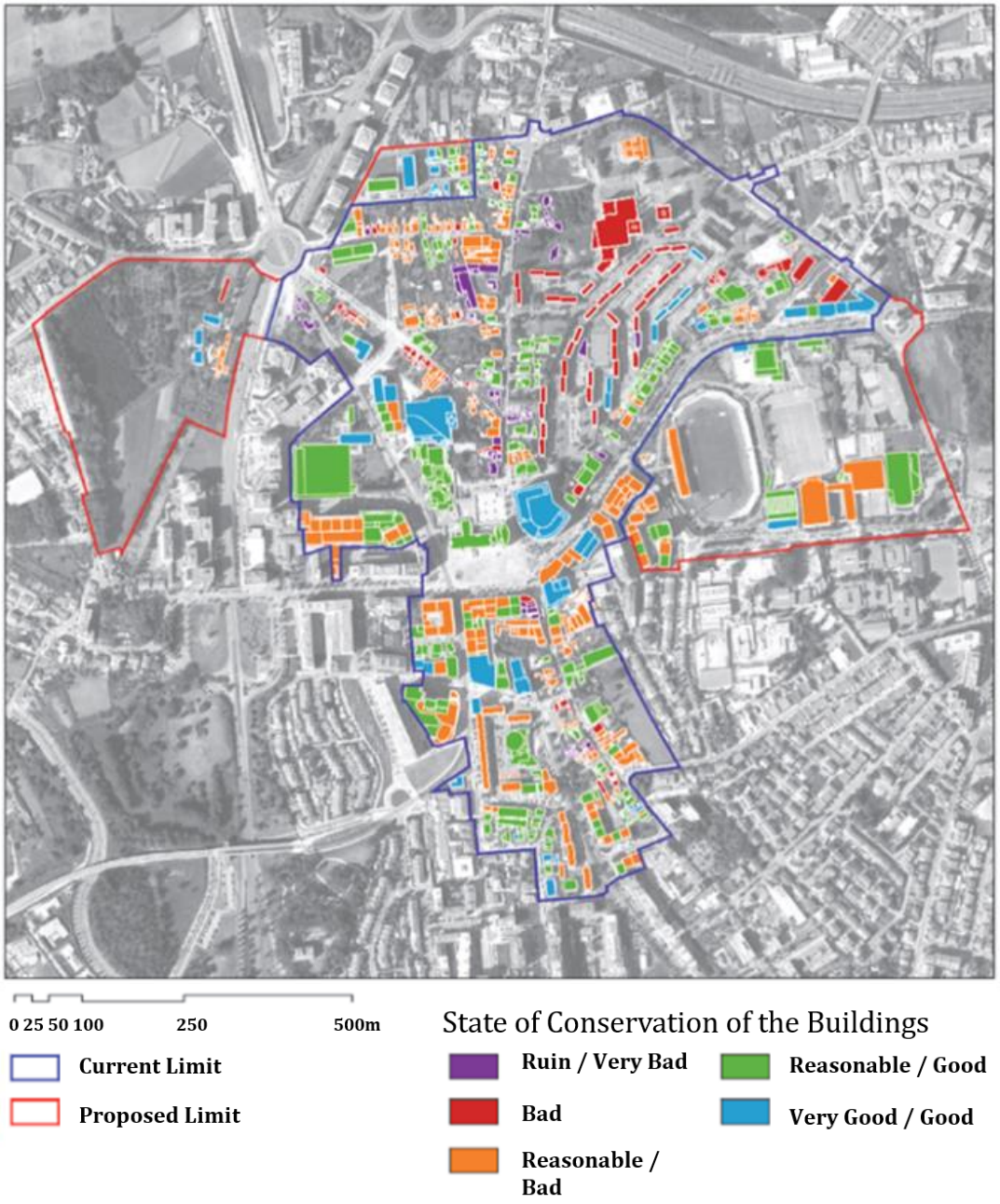

Figure 27: State of the existing building stock - Maia City Centre (Maia Municipality, 2015)

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Solution 14: Policies to guarantee public domain data– G.1

Development of policies that guarantee that urban data remains open and in the public domain.

Description and Objectives

Based on practicality and efficiency issues for urban management (gathering, validation, and processing), data should remain as a public good and be openly accessible. For this, policies and agreements should be crafted between sectors of the society to guarantee this goal. These policies and agreements should also aim to facilitate the provision and accessibility of information for the general public.

Objectives:

- Reach agreements to guarantee that urban data remains open and in the public domain
- Craft policies that facilitate the access to data for the general public

Components	Stakeholders
• 'General' Digital Infrastructure; • Dedicated IoT infrastructure; • Public awareness; • Digital and Scientific Citizenship (including Open Data maturity); • Monitoring infrastructure to measure and manage change.	• Citizens/Local agents (public authorities, business, etc); • ICT Companies working mainly in 'Digital Transformation'/'Smart Cities'; • Schools, Universities, Innovation Companies.
Next steps	**Possible funding options**
• Prototyping and small-scale experiments; • Citizens & Organisations (public, private, schools, universities, etc) engagement; • Scale good practices across the territory.	• Municipal; • Public/Private Partnership; • European Union Funds; • Private Investors; • Others.

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Solution 15: Smart Irrigation– W.3

Smart Irrigation in park management	
Description and Objectives	
Maia is implementing a pilot project for smart irrigation in Parque Maia. The implementation should be upscaled to more or all parks and green areas, where irrigation is used. This would allow for savings in water, energy, and municipal costs in general. **Objectives:** • Reduce water consumption • Reduce maintenance costs • Promote awareness **Stakeholders:** Environmental department, COMPTA	
Components	**Stakeholders**
• Define park locations; • Sensors; infrastructures; • ICT solution.	• Municipality; • Private Companies.
Next steps	**Possible funding options**
• Analyse the pilot project results and develop a scalability plan; • ToR; • Public Tender.	• Municipal; • EU and national funding programmes; • Others.

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9. CONCLUSIONS

The process of working on the Implementation Plan in Maia included the City Vision Workshop, the onsite assessment, the City Lab Innovation Workshop, and all the collaborative work done between different city departments, partners and the key local stakeholders. This collaborative work included not only the identification and definition of the local specific context conditions but also visions and solutions for the future, providing the basis for replication and urban transformation, towards the envisioned future.

Furthermore, it allowed for a better understanding of the city's baseline, what needs to be achieved and how it should be done to get the best results with the minimum efforts or constraints.

9.1 Summary of achievements

The different planning instruments such as the SEAP – Sustainable Energy Action Plan, the CAAP - Climate Adaptation Action Plan, and the SUMP – Sustainable Urban Mobility Plan, amongst others can be highlighted. The plans serve as information and strategy database to enable the municipality for informed decision making in the light of its goal of climate neutrality.

It sparked synergies with other ongoing projects on implementing necessary actions identified in the planning instruments. Such as the rehabilitation and refurbishment works in social housing districts, as well as the investments in promoting soft modes, the public transport system, and e-mobility.

BaZe – Living Lab integrates different actions addressing energy efficiency in buildings, RES production, public charging hub for electric vehicles, smart parking, vehicle traffic counting systems, air quality, green roofs, Pay-As-You-Throw solutions, and water irrigation management systems, among others.

The municipality is collecting data from sensors and other sources to test its urban data platform. Several types of data and several different sources are integrated in the platform to inform and support stakeholders, citizens and other target audiences.

This will help not only the work that is being done under the WP2 – Monitoring and Impact Assessment, but also contribute to the citizen's literacy for sustainability in order to assure better decisions and reach the visioning expectations.

Regarding the importance of measuring impacts, Maia is working on implementing the international standard ISO 37120 - Sustainable development of communities (International Organization for Standardization (ISO), 2018).

The project to create a City Open Data Portal was started.

Maia is featured by a substantial GHG emission reduction during the last decade. However, as the GHG emission share inventory shows, the industry sector plays a main role in the cities' emissions. Further savings are needed.

Towards 2050, the city has to work closely with different stakeholders and further progress both the collaborative work done along this process and the project outlines, which played an important role as a first step on engaging a whole community around a common desired future.

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9.2 Impacts

The implementation plan, accorded with the key strategic areas, is an important instrument and holds the opportunity of aligning the city on a common mission to achieve carbon neutrality and energy positivity in the shortest possible time.

The participation process, including City Vision 2050, the onsite assessment and the City Lab Innovation Workshop, helped on gaining the attention and support of the relevant key stakeholders, e.g. transport and logistics, energy companies and institutions, commercial companies, construction companies, non-governmental associations in the field of environment and mobility, scientific and technological systems, representatives of residents' associations, and representatives of professional entities, for the project outlines identified and based on the five strategic areas.

The selection of two projects, PED with an Energy Community – Methodology and Implementation in Maia and the City Digital Transformation, offers the opportunity to intensify the work and knowledge exchange between different partners towards digital transformation and energy transition.

A SWOT analyses is systematized bellow in Table 6.

Table 7: SWOT Analysis

Strengths	Weaknesses
Aptitude for implementing sustainable policies involving a set of structuring investments in urban transformation. **Existence of a long-term strategy and sustainable vision, envisioned by the main planning instruments: SEAP, CAAP, SUMP, Public Lighting Master Plan.** **Cross-sectional ongoing pilot projects, such as "Living Lab Maia".** **Integrated monitoring system being implemented:** **City Data Platform,** **Energy Observatory of the Porto Metropolitan Area,** **ISO:37120 - Sustainable Development in Cities.** **Scores above the European average of renewable energy contribution in the total energy generation (26,5 % share of final energy demand).**	**Industry with the highest weight of the demand for energy, representing about 50% of the emissions.** **Poor annual rate of refurbishment of existing buildings stock in 2018:** **0.11% - Percentage of buildings having a reconstruction license,** **0.05% - Percentage of household units renovated.** **Lower use of public transport which is only 10.9%.** **Predominance of the use of individual cars, accounting for almost 70% of the total trips made per day.** **Residual values for the use of bicycle with only 105 trips declared, corresponding to 0.4%.** **Lack of data or interoperability agreements between different institutions.** **Lack of collaborative work culture.**

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Rehabilitation works ongoing on several social housing districts.

Investments in promoting soft modes, public transport system, and e-mobility.

Active engagement with local stakeholders' expertise and citizen's engagement activities to promote a participatory decision-making process.

Existence of an Energy and Mobility Division.

Existence of a Strategy, Development and Innovation Office with the aim of promoting the cooperation between different municipal departments on cross-sectoral projects.

Little tradition and internal experience in the management of change/innovation.

Lack of human resources.

Opportunities

"Porto Solar Metropolitano", which involves the installation of PV panels on municipal buildings for RES production, achieving increased efficiency in terms of consumption.

Several industrial sites, with enormous potential to identify industrial districts with energy and resource flows for optimisation.

The average commuting travel distance is of 8.9km, there is an opportunity to promote more sustainable modes of transportation (e.g., walking, bicycle trips).

The need to actively seek the enhancement and development of car-free areas is evident.

Technical Skills internalisation.

Threats

The major contribution to the reduction of emissions is less related to the infrastructures under direct management of the local authority.

Energy Regulations.

The impact of industry and major transport infrastructures on achieving the long-term goals.

Customisation and adaptation of technical solutions to the specific local context.

Data availability.

Resources allocation.

Climate changes (severe drought).

Limitations caused by the pandemic COVID-19.

With these results, anchored in the existing strategic municipal policy frameworks and within the collaborative discussion provided by the interviews and workshops, the city administration and relevant key actors have obtained the necessary principal information to identify the projects that best suit the long-term vision.

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9.3 Other conclusions and lessons learned

The chosen integrated approach helped identify the importance of a structured communication strategy to engage and inspire all the necessary key actors.

The national energy regulation context was assessed. Several barriers to the energy transition were identified. Particularly regarding the decentralized renewable energy production and the uptake of renewable energy communities mainly due to bureaucratic constraints, associated business models and unfair and dissuasive charges.

The changes needed for the urban transformation can be very disruptive and the city is to pay additional attention to disadvantaged citizen's groups.

The interactions and knowledge sharing with other cities and partners and the opportunity to know other projects and their experiences facilitated to be persistent, resilient, and coherent towards the devised goals and the future vision.

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ACRONYMS AND TERMS

AdEPorto – Porto Energy Agency

AMP – Metropolitan Porto Area

APA – Portuguese Environmental Agency

ARU – Urban Rehabilitation Areas

BaZe – Balanço Zero de Carbon

BRT – Bus Rapid Transit

CNG – Compressed Natural Gas

CP – Comboios de Portugal

CPLP – Community of Portuguese Language Countries

DSO – Distribution System Operator

EDP – Energías de Portugal

EM – Espaço Municipal

EMEM - Empresa Metropolitana de Estacionamento da Maia

ETS – Emissions Trading System

EV – Electric Vehicles

EU – European Union

FC – Follower City

FE – Final energy

GHG – Greenhouse Gas

GPD – Gross Domestic Product

HDI – Human Development Index

HVAC – Heating, Ventilation, and Air Conditioning

ICT – Information and Communications Technology

IoT – Internet of Things

IPPU – Industrial Processes and Product Use

KPI – Key performance indicator

LED – Light Emitting Diode

LHC – Lighthouse City

LIPOR - Serviço Intermunicipalizado de Gestão de Resíduos do Grande Porto

NATO – North Atlantic Treaty Organisation

NUTS – Nomenclature of Territorial Units for Statistics

OECD – Organisation for Economic Cooperation and Development

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PA – Paris Agreement

PAMUS – Action Plan for Sustainable Urban Mobility

PARU – Action Plan for Urban Regeneration

PE – Primary energy

PEA – Plan on Environmental Education

PED – Positive Energy Districts

PEDU – Strategic Plan for Urban Development

PERU – Strategic Urban Rehabilitation Plan

PMUSCM – Maia's Sustainable Urban Mobility Plan

PNEC – National Energy and Climate Plan

PT – Public Transports

PV – Photovoltaic

RES – Renewable Energy Sources

RFID – Radio Frequency Identification

STCP – Sociedade Transportes Colectivos do Porto

TIP – Porto Intermodal Transport

ToR – Terms of Reference

UN – United Nations

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APPENDICES

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Replication solutions from workshops

The detail of the solutions is presented in section 8.4. Project Ideas

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Table 8: Maia's Project Rating

Sr. No.	Project	Stakeholder Engagement	Stakeholder	Regulations constraints	Regulations	Eventual funding potential (incl. Private co-funding)	Eventual funding potential (incl. Private co-funding) Score	Political support	Political support score	City Srategy alignment	City strategy slignment score	Quick Win	Quick Win Score	Potential to be a lighthouse project	Potential to be a lighthouse project Score	Total
M.4	Improve the competitiveness of the Public Transport System	High	3	Medium	2	High	3	High	3	High	3	Low	1	High	3	36,4
IC.1	Urban Data Platform for Maia	Medium	2	Low	3	High	3	High	3	High	3	Low	1	High	3	35,6
E.1	Rehabilitation of municipal buildings and installation of RES-e generation technologies	High	3	Medium	2	High	3	Medium	2	High	3	Medium	2	High	3	34,4
W.6	Environmental Zone in Maia	Medium	2	Medium	2	High	3	High	3	High	3	Low	1	High	3	34,4
M.5	Mobility hubs in Maia that offer and connect alternative modes of transport	High	3	High	1	Medium	2	High	3	High	3	Low	1	High	3	33,7
E.2	Pilot Smart Grid at city district, considering an energy community	High	3	High	1	High	3	Medium	2	High	3	Medium	2	High	3	33,2
IC.3	City Digital Transformation	Medium	2	High	1	High	3	High	3	High	3	Low	1	High	3	33,2
W.4	Smart Waste Heat Valorisation	Medium	2	High	1	High	3	High	3	High	3	Low	1	High	3	33,2
E.4	Pilot a VPP and energy community in the Industrial district	High	3	High	1	High	3	Medium	2	High	3	Low	1	High	3	32,2
W.7	Green roofs on the majority of the municipal buildings	High	3	High	1	High	3	Medium	2	High	3	Low	1	High	3	32,2
CE.2	Integration of new local „eco-neighbourhoods"	Medium	2	Medium	2	High	3	Medium	2	High	3	Low	1	High	3	31,4
E.5	Replicate social enterprises like Coopernico, in Maia.	Medium	2	Medium	2	High	3	Low	1	High	3	Low	1	High	3	28,4
W.5	Material Bank for sustainable building	Medium	2	Medium	2	Medium	2	Low	1	High	3	Low	1	High	3	26,9
G.1	Development of policies that guarantee that urban data remains open and in the public domain.	Medium	3	Low	3	High	3	High	3	High	3	High	3	Medium	2	38,1
W.3	Smart Irrigation in park management	High	3	Low	3	High	3	High	3	High	3	Low	1	Medium	2	36,1

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Table 9: List of the solutions identified during the onsite assessment – project filtering

Sr. No.	Project	Stakeholder Engagement	Stakeholder	Regulations constraints	Regulations	Eventual funding potential (incl. Private co-funding)	Eventual funding potential (incl. Private co-funding) Score	Political support	Political support score	City Srategy alignment	City strategy alignment score	Quick Win	Quick Win Score	Potential to be a lighthouse project	Potential to be a lighthouse project Score	Total
G.1	Development of policies that guarantee that urban data remains open and in the public domain.	Medium	3	Low	3	High	3	High	3	High	3	High	3	Medium	2	38,1
M.4	Improve the competitiveness of the Public Transport System	High	3	Medium	2	High	3	High	3	High	3	Low	1	High	3	36,4
W.3	Smart Irrigation in park management	High	3	Low	3	High	3	High	3	High	3	Low	1	Medium	2	36,1
IC.1	Urban Data Platform for Maia	Medium	2	Low	3	High	3	High	3	High	3	Low	1	High	3	35,6
IC.2	Open Data Platform for Maia	Medium	2	Low	3	High	3	High	3	High	3	Medium	2	Medium	2	35,1
E.1	Rehabilitation of municipal buildings and installation of RES-e generation technologies	High	3	Medium	2	High	3	Medium	2	High	3	Medium	2	High	3	34,4
W.6	Environmental Zone in Maia	Medium	2	Medium	2	High	3	High	3	High	3	Low	1	High	3	34,4
E.3	Smart Public Lighting	High	3	Medium	2	Medium	2	High	3	High	3	Medium	2	Medium	2	34,4
CE.1	Information desk for informing citizens about energy, sustainability, and other related topics.	High	3	Low	3	Medium	2	High	3	High	3	Medium	2	Low	1	34,1
M.5	Mobility hubs in Maia that offer and connect alternative modes of transport	High	3	High	1	Medium	2	High	3	High	3	Low	1	High	3	33,7
M.2	Creation of more pedestrian zones	Medium	2	Low	3	High	3	High	3	High	3	Medium	2	Low	1	33,6
E.2	Pilot Smart Grid at city district, considering an energy community	High	3	High	1	High	3	Medium	2	High	3	Medium	2	High	3	33,2
IC.3	City Digital Transformation	Medium	2	High	1	High	3	High	3	High	3	Low	1	High	3	33,2
W.4	Smart Waste Heat Valorisation	Medium	2	High	1	High	3	High	3	High	3	Low	1	High	3	33,2
E.6	Smart metering in Social Housing	High	3	Medium	2	High	3	Medium	2	High	3	Medium	2	Medium	2	32,9
E.7	Development and use of modelling tool for decision making regarding rehabilitation measures.	High	3	Medium	2	High	3	Medium	2	High	3	Medium	2	Medium	2	32,9
M.1	Bike sharing system pilot	High	3	Low	3	Medium	2	Medium	2	High	3	Medium	2	Medium	2	32,6
CE.5	Carbon Free Contest	High	3	Low	3	High	3	Medium	2	High	3	Medium	2	Low	1	32,6
E.4	Pilot a VPP and energy community in the Industrial district	High	3	High	1	High	3	Medium	2	High	3	Low	1	High	3	32,2
W.7	Green roofs on the majority of the municipal buildings	High	3	High	1	High	3	Medium	2	High	3	Low	1	High	3	32,2
CE.3	Monthly community event that closes one street to celebrate games for kids, and gathering for adults	Medium	2	Low	3	Medium	2	High	3	High	3	Medium	2	Low	1	32,1
M.3	Program to organize school parents to share cars according to routes	Medium	2	Low	3	High	3	Medium	2	High	3	High	3	Low	1	31,6
CE.2	Integration of new local „eco-neighbourhoods“	Medium	2	Medium	2	High	3	Medium	2	High	3	Low	1	High	3	31,4
W.1	Enhancing circularity in the industrial area	Medium	2	Low	3	High	3	Medium	2	High	3	Low	1	Medium	2	31,1
M.6	Services stations that provide for a diversity mobility needs.	Medium	2	Medium	2	Medium	2	High	3	High	3	Medium	2	Low	1	30,9
IC.4	Digital Transformation applied in the building process	Medium	2	Medium	2	High	3	Medium	2	High	3	Low	1	Medium	2	29,9
IC.5	Smart Fire Management	Medium	2	Medium	2	High	3	Medium	2	High	3	Medium	2	Low	1	29,4
CE.4	Extension of the movement „Cidade Mais“ to Maia	High	3	Low	3	Medium	2	Low	1	High	3	High	3	Low	1	29,1
E.5	Replicate social enterprises like Coopernico, in Maia.	Medium	2	Medium	2	High	3	Low	1	High	3	Low	1	High	3	28,4
M.8	Installation of EV charging stations to promote electric mobility in the public transport	Medium	2	Low	3	Medium	2	Low	1	High	3	Medium	2	Medium	2	27,6
G.2	Conceptualize possible forms of support for the Municipality of Maia to more effectively offer incentives to buildings that wish to install solar panels	Medium	2	Low	3	Low	1	Medium	2	High	3	Medium	2	Low	1	27,6
W.2	Exchange Program on Circularity	Medium	2	Low	3	High	3	Medium	2	Medium	2	Medium	2	Low	1	27,6
W.5	Material Bank for sustainable building	Medium	2	Medium	2	Medium	2	Low	1	High	3	Low	1	High	3	26,9
M.7	Car sharing	Medium	2	Low	3	Medium	2	Low	1	High	3	Medium	2	Low	1	26,1
G.3	Establishing and dynamizing energy communities in Maia	High	3	High	1	Medium	2	Medium	2	Medium	2	Low	1	Low	1	24,7

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