D1.7 Scaling Up and Replication Guideline

31/05/2021

Luisa Almeida Serra & Ricardo Ramos[1], Giorgios Papadopoulos[2], Aristotelis Dafalia[3], Jana Helder & Gretel Schaj[4], Alessandro Colombo[5], Kazi Sami[6] and Angelo Giordano[7]

[1]NEWR&D, [2]SUITE5, [3]VERD, [4]BABLE, [5]SPI, [6]VTT and [7]CiviESCO

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Dissemination level

PU	Public	

Deliverable administration

No & name	**D1.7 Scaling Up and Replication Guideline**				
Status	Released	**Due**	M20	**Date**	2021-May 31
Author(s)					
Description of the related task and the deliverable. Extract from DoA	**T1.3 Visualization framework for assessing city performance (SUITE5) M6 – 20** Under this task, guidelines will be provided on how successful scaling up and replication should be done (D1.7 Scaling up and Replication Guideline), in order to get a framework that is able to suit challenges of a different dimension, in dissimilar contexts, with different cultures, different environments and in different scales of cities and complexities, therefore fitting FCs and other European and world cities diverse realities.				
Participants	NEWR&D, SUITE5, VERD, VTT, BABLE, SPI and CiviESCO				

V	Date	Authors	Description
0	02.06.2020	NEWR&D	Basic structure
0.1	3.12.2020	NEWR&D	Basic structure with scale-up methodology to be filled by partners
0.2	5.02.2021	NEWR&D SUITE5 VERD BABLE	First version with the complete content on all chapters
0.3	15.03.2021	CiviESCO	Version with New Economy and Urban Innovation
0.4	16.04.2021	NEWR&D	Version with the complete description of the Scaling up and replication methodology
0.5	23.04.2021	SUITE5 VERD BABLE	Revised version
0.6	29.04.2021	NEWR&D	Check against the Grant Agreement to identify discrepancies
0.7	15.05.2021	SUITE5 VERD FHG SPI	Final revision by all partners
0.8	15.05.2021	SPI	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
0.9	28.05.2021	VTT	Quality check. Minor issues to address
0.10	30.05.2021	NEWR&D	Deliverable revised and sent to coordinator
1	31.05.2021	VTT	Coordinator submits the deliverable to the EC

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

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

List of figures

List of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Acronyms and terms

BM	business models
CAPEX	capital expense
CO_2	carbon dioxide
CHP	combined heat and power
DER	demand energy response
DH	district heating
DSM	demand side management
DSO	distribution system operator
EMS	energy management system
EPB	energy positive blocks
EV	electrical vehicle
GHG	greenhouse gases
GDP	gross domestic product
GDPR	General Data Protection Regulation
ICT	information and communication technologies
IT	information technologies
km	kilometre
kW	kilowatt
KPI	key performance indicator
OER	on-site energy ratio
OPEX	operating expense
P2P	peer-to-peer
PEB	positive energy block
PED	positive energy district
PV	photovoltaic
RES	renewable energy source
RoI	return on investment
R&D	research and development
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index
V2G	vehicle-to-grid
VPP	virtual power plant
5G	fifth generation network

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

EXECUTIVE SUMMARY

The present deliverable D1.7 *Scaling Up and Replication Guideline* sets the stage for the SPARCS activities regarding replication and scaling up of the holistic solutions developed within the project. This deliverable will ensure the impactful legacy of SPARCS even after the end of the project.

The SPARCS project has two Lighthouse Cities: Espoo and Leipzig, with large demonstrations where more than forty interventions will be developed across five solutions: buildings and positive energy districts, new economy and business models, information and communications technology, mobility and urban innovation. During SPARCS, the Fellow Cities of Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) will replicate part of the solutions developed in the Lighthouse Cities. Therefore, the replication guideline presented in this deliverable is intended to be useful for them and later on for other cities that might be taking the same road towards positive energy districts and low emissions. These Fellow Cities will be the first to test this replication methodology. In this deliverable, for the sake of clarity, the methodology is applied to the city of Maia, thus providing a real demonstration. The fact that the methodology applies to any city strengthens the wide impact that SPARCS aims to achieve in cities in Europe and is much more transformational than the impact solely accomplished in the seven cities of the project.

The scale-up and replication methodologies proposed in this deliverable seek to provide a framework that ensures the effective implementation of SPARCS solutions in different contexts and environments, as these can differ in a multitude of factors (size, culture, geography, weather conditions, challenges and complexity). Therefore, this deliverable aims to provide a methodological framework that can evaluate the potential of SPARCS solutions in different cities and different realities. Furthermore, the solutions of SPARCS are integrated urban solutions, meaning that they cannot be analysed individually since they present cross effects and synergetic relations. Moreover, the SPARCS solutions are holistic, thus being more than the simple addition of its components and need to be evaluated as a whole, instead of individually. Therefore, this deliverable intends to provide a guideline methodology that captures and evaluates the possible synergies of different energy vectors in different cities and that can define a replication plan for any city, nevertheless its singularities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

1. INTRODUCTION

This report is part of the T1.3 *Visualization framework for assessing city performance.* It intends to provide the guidelines for successful replication and scaling up, thus enabling SPARCS methodology and solutions to be applied to the Fellow Cities or any other European or city in the world. Espoo and Leipzig are two large demonstration cities where SPARCS solutions will be deployed. With the help of this reporting guideline, the Fellow Cities of Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) have at their disposal, a framework to analyse which solutions are more suitable for their particular context. The framework will be applied to Maia city but already provides the methodology for all the other Fellow Cities to implement. The Fellow cities can be the pioneers in the replication and scale-up methodology of this deliverable, testing it first-hand, so that afterwards, this methodology is robust and adaptable to any city worldwide.

This deliverable 1.7 is structured as follows:

- Chapter 2 - *Challenges*: Presents the common challenges cities face when implementing Positive Energy Districts (PEDs) with net-zero CO_2 emissions. These challenges are divided into 7 different topics: City Energy Infrastructure, Buildings, Integration, Mobility, Public Recognition, Economy and Environment.
- Chapter 3 - *Solutions for positive carbon zero districts*: Addresses the solutions under which all the SPARCS interventions are organized. These solutions contribute to the PEDs with net-zero CO_2 emissions and are divided into 5 different topics: Energy, Mobility, New Economy, Urban Innovation and ICT. The requirements necessary for the implementation of these solutions, both technical and social, are described in detail in this chapter.
- Chapter 4 - *Impact*: Presents the impacts of SPARCS' solutions, namely how they can be assessed, what is the necessary data to evaluate them. In this chapter, the indicators that will be utilized to measure the expected impacts are described and grouped according to the technical solutions presented in the previous chapter.
- Chapter 5 - *Replication guideline*: Proposes a step by step methodology to evaluate the impact of a set of holistic solutions, *i.e.* the solutions have more impact conjointly than the sum of their individual impact. This replication methodology enables the identification of which SPARCS solutions are more suited to be implemented in a specific city, based on a set of requirements, and evaluating the impact of that (holistic) replication.
- Chapter 6 – *Scalability*: Addresses the impacts of scaling-up per solution of SPARCS, i.e. the impact of applying each solution in a larger system.
- Chapter 7 – *Conclusions and Recommendations for Upscaling*: Ends up the deliverable presenting the main conclusions and recommending the implementation of the methodologies developed.

In the next sections of this introductory chapter, it is described what is the purpose and target group of this deliverable, the work and contributions performed by the partners to the present report and the relations to other activities of SPARCS.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

1.1 Purpose and target group

This report establishes the guidelines for scaling up and replication of the SPARCS solutions implemented in the Lighthouse cities of Espoo and Leipzig and the fellow Cities of Maia, Reykjavik, Kladno, Kifissia and Lviv.

This deliverable provides a framework with a methodology for the scale-up and replication for the SPARCS solutions developed in the Lighthouse Cities. It aims to pave the way for their smooth and bespoken replication.

The scale-up and replication are based on a holistic, modular, flexible concept. It begins with the ***Challenges*** identified in SPARCS, after which it considers the ***Solutions*** implemented in the Lighthouse Cities of Espoo and Leipzig, namely its contributions to the overall SPARCS concept[1]:

> *…to demonstrate, and validate, the technical and socio-economic viability, and impacts, of scalable, innovative solutions for planning, deploying and rolling out* ***smart*** *and* ***integrated energy systems*** *as an efficient mean for the urban transition into a* ***citizen centred zero carbon ecosystem****, enabling a high quality of life. … urban energy transition (…), by demonstrating the measurable evidence of the benefits of these integrated solutions, on a large scale, for* ***developing blocks of buildings and districts into active energy ecosystems*** *and pioneering business models tailored on interactions between the citizen, building and the urban energy systems.*

For all solutions, the necessary conditions for their implementation were identified, as well as the indicators that allow the Impacts evaluation. This information allowed the evaluation, for any specific city, of the solution's replication and scalability potential.

This report targets all cities that want to develop Positive Energy Districts. Within the SPARCS extended ecosystem, the report is aimed for the follower cities of Maia, Reykjavik, Kladno, Kifissia and Lviv. Nevertheless, it is also of interest for other cities and all the public interested in energy positive smart city developments and in complex holistic solutions scale-up and replication.

[1]SPARCS Grant Agreement.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

1.2 Contributions of partners

The following Table 1 depicts the main contributions from partners in this deliverable and work planned and performed.

Table 1: Contributions of partners

Partner	Contributions
NEW	Editor of the deliverable. Content planning, allocation of writing responsibilities. Leader author of: 1. Introduction; 3. Solutions, 5. Replication Guideline; 6. Scalability. Integrator of the many contributions. Leader author of the replication evaluation methodology. Leader author of Replication chapter (content and text). Leader author of Scaling up chapter (content and text). Leader author of Executive summary (content and text). Leader author of Introduction (content and text). Leader author of Conclusions (content and text).
VTT	Overall concept contributor. Overall text revision.
Suite5	Overall concept contributor. Overall text revision. Lead author of 4. Impact.
VERD	Overall concept contributor. Overall text revision. Lead contributor of 4. Impact regarding Benefit/cost and Stakeholders.
FGH	Main revision.
Bable	Leader author of 2. Challenges. Overall text revision.
CiviESCO	Overall concept contributor. Contributed to New Economy and Urban Innovation concepts.
SPI	Overall concept contributor. Specific contributions regarding social issues. Main revision

1.3 Relation to other activities

The following Table 2 depicts the main relationship of this deliverable to other activities or deliverables within the SPARCS project.

Table 2. Relation to other activities in the project

Deliverable / Milestone	Contributions
D1.4 - Energy Solutions Catalogue for Positive Energy Blocks/Districts	Provides a base of solutions that might be interesting to use in the solutions catalogue.
D1.6 - Visualization framework for assessing city performance	Helps to showcase which are the main SPARCS solutions and how to integrate them in a visualisation.
D1.8 - Strategy for developing interoperability and ecosystems for positive energy districts	Contributes to the assessment of the interoperability needs of the SPARCS solutions.
D2.6 - Holistic Impact Assessment of Demonstration Activities	Contributes to the holistic assessment of the SPARCS solutions impacts.

D2.9 - Long-term High-level Impact Assessment through Wide Replication of SPARCs	Contributes to the holistic assessment of the SPARCS solutions, in the short but also in the long run.
D3.7 - Replicating the smart city lighthouse learnings in Espoo: technical, social and economic solutions with validated business plans	Provides a replication and scale-up methodology that is useful for the Lighthouse Cities to share the knowledge achieved in the SPARCS project with other cities.
D4.7 - Replicating the smart city lighthouse learnings in Leipzig: technical, social and economic solutions with validated business plans	Provides a replication and scale-up methodology that is useful for the Lighthouse Cities to share the knowledge achieved in the SPARCS project with other cities.
D5.4 - Implementation plan Maia **D5.10 Implementation plan Reykjavik** **D5.11 Implementation plan Kladno** **D5.12 Implementation plan Lviv** **D5.13 Implementation plan Kifissia**	Contributes to better replication and scale-up activity methodology that is useful both for the Lighthouse Cities and in the Fellow Cities by presenting a structured approach to the sharing of the knowledge and experience achieved in the SPARCS Lighthouse Cities.
WP01 – Urban Transformation Strategy	Provides direct visualization of the SPARCS solutions and their holistic nature.
WP02 - Monitoring and Impact Assessment	Contributes to the baseline of the current situation in the cities, provides straightforward identification of possible solutions to be implemented.
WP05 - Replication	Helps to implement the replication activities, namely the Tasks: T5.3 Fellow City Replication Strategy, T5.4 Project Development in Fellow City and T5.5 Upscaling & Replication in Lighthouse Cities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

2. CHALLENGES

SPARCS aims to support and encourage cities to pave the way for Positive Energy Districts and reduce carbon emissions (e.g., Paris Agreement[2]). To do so, the SPARCS cities and project partners identified that the core mechanism of the urban transformation strategy should be to bring together citizens, companies, cities planning departments and decision-making bodies to create meaningful instruments and use them to transform the current urban ecosystem into a CO_2 inclusive community leading to a carbon-free revolution.

The SPARCS objective is to achieve citizens' inclusive free carbon urban communities by integrating technologies for energy positivity in buildings and districts, citizen engagement, city planning and governance, flexible grid management and energy storage and; e-mobility as an energy system element.

SPARCs targets to tackle the multifaceted challenges that cities are called to solve by creating the ecosystems necessary for the urban transformation based upon energy transition in cities towards a citizens-inclusive Sustainable energy Positive & zero cARbon CommunitieS. To reach the SPARCS project it is important to address the city challenges by presenting several topics. Under the works developed in the SPARCS project, the cities have agreed on a list of central challenges that are of key relevance. The list is presented in *Figure 1* which will be further described in the following.

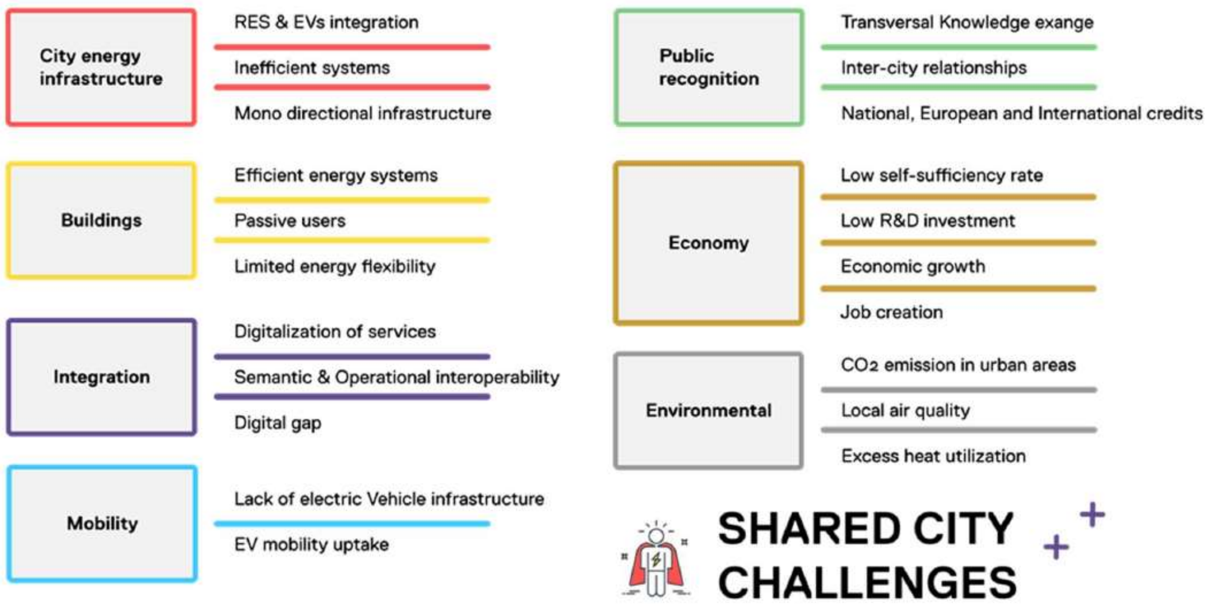


Figure 1 - Shared City Challenges

For all the central challenges presented in the previous figure, the SPARCS project has developed a set of analysis with the details of how these challenges can be opportunities to develop solutions that enable PEDS with zero CO_2 emissions. The analysis is presented in the tables in the next sections and aim to be guidelines for the cities when taking the first steps in their journey towards PEDS with zero CO_2 emissions.

---

[2] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

2.1 Challenges regarding City Energy Infrastructure

The SPARCS challenges presented in the previous figure address the adequate city energy infrastructure needed to achieve carbon-zero energy systems. To further present city challenges and to help any city in improving the knowledge about their own challenges, Table 3 presents the challenges related to the energy infrastructure that cities face.

Table 3. Main challenges regarding city infrastructure

Main challenges	Description
RES & EV integration	1. To improve the integration of renewable energies and the charging of electric vehicles. 2. To address temporal differences between energy production and energy consumption.
Inefficient systems	1. To increase the efficiency of current energy. 2. To research different energy measures 3. Within the project e.g. the reduction of transport losses utilizing decentralised local energy systems.
Monodirectional Infrastructure	1. To increase the energy efficiency and ease the integration of renewable energies into the grid using bidirectional infrastructures and digital services, such as smart microgrids and virtual power plants can be used

2.2 Challenges regarding Buildings

Within the SPARCS project, several challenges regarding the contribution to PEDs with zero CO_2 emissions in the buildings sector were identified. To improve the city stakeholder's know-how on how the technology used in building energy management can contribute to PEDs with low CO_2 emission, the Table 4 presents the main challenges.

Table 4. Main challenges regarding city's buildings

Main challenges	Description
Inefficient energy systems	1. Reduce the energy demand via energy retrofitting projects in constructed buildings. Example by using insulating materials. 2. For new buildings develop measures to harvest low-temperature energy thus reduce primary energy demand. 3. Evaluate the life cycle energy consumption of the materials used (embodied energy).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Passive Users	1. Increase the Energy Consumption of buildings. 2. The energy demand of most of the buildings can be reduced using efficient building energy management systems.
Limited Energy Flexibility	1. Limited Energy Flexibility can e.g. result from user behaviour. To reduce the energy demand of inhabitants of buildings, it is essential to promote and facilitate sustainable behaviour, e.g. with Smart Home Systems

2.3 Challenges regarding IT digitalization

One of the major aspects when developing PEDs with zero CO_2 emissions is the ICT integration. ICT enables data harvesting, big data processing, running AI algorithms to rapidly develop and test innovative solutions and simultaneously share real time information with the stakeholders. In order to clarify how the ICT challenges are important Table 5 presents the main challenges cities face regarding the ICT integration in different components of energy systems.

Table 5. Main challenges regarding city IT Integration

Main challenges	Description
Digitalization of services	1. To improve the integration of different building blocks of a cities' energy system the digitalization of services is essential. For digital planning, e.g., digital twins can be introduced. 2. To enable the issue of smart contracts performed thanks to the digitalization
Semantic and operational interoperability	1. For integration of different services, generation, storage and consumption systems semantic and operational interoperability are essential – especially when it comes to increased digitalization.
Digital gap	1. Due to a long lifecycle and high-security requirements the integration of new innovative and digital solutions can be challenging and has been leading to a digital gap.

2.4 Challenges regarding Mobility

Mobility is without any doubt one key factor when developing PEDs with zero CO_2 emissions. Mobility is a complex problem involving technology, human behaviour, cities' planning. To enable cities to start addressing the challenges presented by Mobility, the SPARCS project presents Table 6, in which public, as well as private modes of mobility, are considered.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 6. Main challenges regarding city's mobility

Main challenges	Description
Lack of electric vehicle infrastructure	1. To increase the number of people using an electric vehicle, the availability and affordability of public charging infrastructure for electric vehicles are crucial.
Electric mobility uptake	1. Besides increasing infrastructure for electric vehicles, new use cases for electric mobility can foster an uptake. Electric bus systems, vehicle sharing systems, smart parking systems as well as las mile logistic systems with zero-emission vehicles are examples of such use cases.

2.5 Challenges regarding Public Recognition

From the SPARCS activities, it is clear that cities can only create PEDs with zero CO_2 emissions when citizens are involved and fully aligned. Thus, it is crucial to increase public recognition of these projects. In Table 7, the main challenges regarding public recognition are presented.

Table 7. Main challenges regarding city's Public Recognition

Main challenges	Description
Transversal knowledge exchange	1. To foster knowledge exchange and enable sustainable user behaviour transparent communication measures such as an Urban Data Platform are essential. 2. Acknowledge the users about the possibility to exploit their data and be part of the data revenue stream
Inter-city relationships	1. The exchange of knowledge and experiences between different cities is a crucial part of the project.
National, international and European credits	1. To incentivise and encourage the reduction of carbon emissions a wide communication of best practices can be essential.

2.6 Challenges regarding Economy

Another important group of challenges for PEDs with zero CO_2 emissions are the main challenges regarding a city's economy. In Table 8, the main challenges regarding the city economy are presented.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 8. Main challenges regarding city's Economy

Main challenges	Description
Low self-sufficiency rate and low R&D investment	1. The economic competition from conventional energy solutions results in the slow uptake of carbon-zero energy solutions. 2. Investigate certain funding mechanisms to overcome the barrier of the upfront cost and gamification the potential savings coming from the comparison between business-as-usual and SPARCs solutions
Economic growth and job creation	1. Investment in zero-carbon solutions although leading to economic growth and job creation, need patient capital (in opposition to commercial one) and deliver different yield distribution, thus requiring different financing structures. 2. Embrace the capital requirement of the Green Economy and the Impact Funds, and deliver financial statements that show revenues and savings

2.7 Challenges regarding Environment

Finally, to address PEDs with zero CO_2 emissions SPARCS takes into consideration several challenges regarding the environmental effects. In Table 9, the main challenges regarding the city's environment are presented.

Table 9. Main challenges regarding city's environment

Main challenges	Description
CO_2 emissions in urban areas and local air quality	1. Various activities of the project result in the reduction of carbon emissions. Communication tools, such as an urban air quality platform can support the quantification of these effects and facilitate the replication.
Excess heat utilization	1. To optimize the current energy systems excess heat can be reused, e.g. in form of a district heating and cooling system.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

3. Solutions for positive carbon zero districts

Positive Energy Districts (PED) are:

> *"… energy-efficient and energy-flexible urban areas which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while optimizing the liveability of the urban environment in line with social, economic and environmental sustainability."*[3]

In this chapter, the main solutions in SPARCS that contribute to PED are described in detail.

3.1 Solutions regarding the Positive Energy Districts

The first section addresses the technological solution in SPARCS that contribute to PEDs that are mainly focused on energy. The section begins with a presentation of the solutions, their description and the partners in charge of developing them, see Table 10. To allow their replication, in Table 11 the technical requirements are presented. So, each city can evaluate if they have the technical conditions to implement the solutions. Finally, since the solutions regarding PED depend heavily on social acceptance, in Table 12 the social requirements for their implementation are presented.

Table 10. General description of the solutions regarding the Positive Energy District

Technology	Description	Partner in charge
Renewable energy	1. Clean energy from natural sources like wind, sun or geothermal. 2. Depends on geophysical variables such as weather.	CIT or VTT
Virtual power plants	1. A virtual power plant aggregates virtually the capacities of heterogeneous distributed energy resources (DER). 2. This holistic integration of different resources can enhance power generation as opposed to an individual approach of DER.	SIE
Energy storage	1. Energy storage is the capture of energy at a certain time for later utilisation, reducing demand, reducing generation imbalances and providing technical and economic benefits for the whole energy system.	SIE, ULEI
Demand response	1. Adoption of new energy consumption patterns by end-use consumers in response to price signals to shift consumption from periods of high demand to low demand periods.	FHG or CEN

[3] JPI-urbaneurop3, Europe Towards positive energy districts, February 2020 at https://jpi-urbaneurope.eu/wp-content/uploads/2020/06/PED-Booklet-Update-Feb-2020_2.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	2. Increases the system reliability, produces economic benefits by avoiding peak electricity consumption (avoid capital investment in powerplants and consequent underuse).	
Energy infrastructure planning	1. Planning of the energy infrastructure allowing it to be: open to emergent and innovative technologies, expandable, flexible, fair, controllable, reliable, dynamic. 2. This should include options on increasing buildings energy efficiency, demand side management and other infrastructure that can provide bi-directional energy transfers.	ESP and LPZ
EMS (Energy Management Systems)	1. Buildings acting as prosumers, allowing a dynamic role in the system. 2. Smart metering solutions, providing the relevant data for the prosumer's role.	KONE

Table 11. Technical requirements regarding the Positive Energy District

Technology	Technical requirements
Renewable energy - PV	PV: 1. City's sun exposure ("Specific photovoltaic power output (SPO)") 2. Area of around 2 m^2 per panel available
Renewable energy - Wind	Wind:[4] 1. Average wind speed of more than 5 m/s – in this case small wind turbines can be a good alternative to PV panels 2. No obstacles nearby the turbine that may interfere with wind speed 3. Availability of at least one acre of clear land, i.e. around 4000 m^2, recommended by most installers
Renewable energy - Geothermal	Geothermal: 1. Availability of temperatures in the range (20°C to 150°C) to provide **direct** heat for residential, industrial, and commercial uses 2. Availability of temperatures in the range (150°C to 370°C) to provide high enthalpy fluid for geothermal electricity generation 3. Distance of the geothermal reservoirs below 3 km – since electricity production demands an earth imbedded surface. 4. For geothermal heat pumps existence of excavations of around 2 meters for the installation of the coiled pipes. Geothermal heat pumps take advantage of the soil moderate temperatures both in winter and summer to cool or heat houses. So, these systems do not require geothermal reservoirs but will require excavations of around 2 meters for the installation of the coiled pipes. The more space available, the easier the installation. Areas with a lot of external space will use horizontal loop installation of the pipes, as areas with less space require vertical installation which is harder and consequently more expensive. The soil should not be shallow or hard rock and the higher the water saturation of the soil the better.

[4] Source: https://news.energysage.com/small-wind-turbines-overview/

Virtual power plants	1. Existence of EMS, sensors and actuators 2. Existence of a VPP controller 3. Existence of regulation and contracts with prosumers 4. Existence of a transparent, accountable, fair transaction ledger system
Energy storage	1. Does the battery increase the PV self-consumption by about 50% and simultaneously the battery system represents less than 50% of the total investment cost (PV + battery)? If so, that's a GO situation for battery acquisition 2. Available space: about 1 to 2 m2 of wall area (batteries are usually placed on the wall)
Demand response	1. EMS and at least 3 kW of controllable loads (examples washing machine, dishwasher machine, water heater, heating/cooling devices, etc)
Microgrids	1. Grid that allows independent blocks operation 2. Microgrid controller 3. Existence of regulation and contracts
Energy infrastructure planning	1. Energy infrastructure planning developed with relevant stakeholders– Stakeholders identified, existing communication channels 2. Integration of the outputs of the work with relevant stakeholders in the Energy infrastructure planning
EMS (Energy Management Systems)	1. Existence of EMS, sensors, actuators

Table 12. Social[5] requirements regarding the Positive Energy District

Technology	Social requirements
Positive Energy Districts	1. Policies and regulation frameworks to support PED conceptualization, implementation and stakeholder's engagement, including co-creation 2. Incorporation of innovative investment valuation methodologies such as dynamic evaluation[6], scenario analysis, or at least cost-benefits analysis, risk analysis and RoI (Return on Investment), all integrating social impacts. 3. Community energy initiatives led by citizens and households 4. Community energy initiatives funding 5. Transparency, openness and inclusiveness in the decision making process and procedures to guarantee trust/fairness in the technology implementation and in the decision-makers/relevant stakeholder relation 6. Existence of short, medium and long term strategies at the city level that involve the local community in planning PED projects.

[5] Under the "Social" denomination are a set of requirements, not all of them being only social, but also economic, geographic, etc.

[6] Mazzucato, *Mission Economy A Moonshot Guide to Changing Capitalism*, page 179, Allen Lane, Dublin, 2021.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

3.2 Solutions regarding Mobility

This section addresses the Mobility solutions in SPARCS that contribute to PEDs. The section begins with a presentation of the Mobility solutions, their description and the partners in charge of developing them, see Table 13. To allow their replication, in Table 14 the technical requirements are presented. So, each city can evaluate if they have the technical conditions to implement the solutions. Finally, since the Mobility solutions are heavily dependent on social acceptance, in Table 15 the social requirements for their implementation are presented.

Table 13. General description of the solutions regarding Mobility

Technology	Description	Partner in charge
E-mobility	1. Integration of EV-charging with local grid and its impacts on the energy system, peak load monitoring and control, EV-charging economy and services, community and residential EV-parking solutions, EV as storage, city planning measures, electrification of the public transport and E-bus charging, Mobility as a Service (MaaS).	FHG
Mobility hubs	1. Community and residential EV-parking solutions. 2. City planning measures to enable and support e-mobility solutions.	CIT
V2grid	1. EV charging micro grid stabilisation	FHG
EV integration in VPP	1. EV charging usage for VPP optimization purposes	FHG
Last-mile electrification	1. Multi-modal transport solutions with a focus on last-mile. 2. Sustainability strategy connecting Metro and e-bicycle modes, boosting e-mobility in the whole district.	VTT

Table 14. Technical requirements regarding Mobility

Technology	Technical requirements
E-mobility	1. Existence of fast charging capabilities (around 50 kW) 2. Existence of sufficient parking space for charging 2 to 4 vehicles and preferably near a transformer substation (less than 50 meters) 3. Existence of EV charger equipment that is universal and compatible with most automobile brands 4. Existence of Contract with energy retailer for the supply of the charging station
Mobility hubs	1. Identification of the spots where it is more interesting to install EV charging stations, for example railway stations, light rail stations. 2. The mobility infrastructure works in an integrated way in terms of connections between public transportation (light rail, boats, buses, etc) and their schedules 3. Integration of public transportation, car sharing and last-mile electrification 4. Discounts for integrated passes of public transportation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	5. Management of the electric scooter's logistics to the places/stations with higher demand
V2grid	1. Cars equipped with V2G technology (bidirectional vehicles) 2. Existence of V2G regulation and contracts 3. System integration with VPP controller or DSO 4. Adequate V2grid infrastructures (charge points) at the city level
EV integration in VPP	1. Cars equipped with V2G technology (bidirectional vehicles) 2. Existence of V2G regulation and contracts 3. System integration with VPP controller or DSO
Last-mile electrification	1. Availability of well-located charging points 2. Existence of safe roads and dedicated lanes for soft mobility

Table 15. Social requirements regarding Mobility

Technology	Social requirements
Mobility	1. Policy frameworks and political commitment at the city level to directly promote e-mobility 2. Policy frameworks and political commitment at the city level to support the V2grid infrastructures 3. Foster user acceptance for electric vehicles through engagement activities focused on advantages/benefits/positive externalities (environmental sustainability; cost-effectiveness, etc.) 4. Develop end-users (citizens) profiling (e.g. surveys; questionnaires) related to environmental/technology-friendly driving, behaviours and preferences to adequate the offer (complying with the GDPR). 5. Orography of the District (important for the e-bikes and e-scooters) 6. Transport infrastructure (km of roads for cars, bicycles,) 7. Transport infrastructure (Public transportation lines, # of stops) 8. Stock of vehicles (Cars, Motorcycles, Bikes, Buses,) 9. Modal Split; the distribution of transport over the modalities of public and collective transport, private vehicles, biking and walking.

3.3 Solutions regarding New Economy

This section addresses the New Economy solutions in SPARCS that contribute to PEDs. The New Economy solutions in SPARCS aim at developing new financial structures suited to address the assets, the operation, the risks and yields that the PED solution encompass. The section begins with a presentation of the NEW Economy solutions, their description and the partners in charge of developing them, see Table 16. To allow their replication, in Table 17 the technical requirements are presented. So, each city can evaluate if they have the technical conditions to implement the New Economy solutions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 16. General description of the solutions regarding New Economy

Technology	Description	Partner in charge
Smart business models	1. Engaging (lead) users and co-creating PED business models 2. Shared RES ownership 3. Participation in alternative markets	CiviESCo
New Funding Schemes	1. Drafting new funding schemes for PED development	CiviESCo
Smart governance models	1. Co-creation for sustainable city development 2. Urban transformation financing & governance models 3. New procurement and co-creation models, new mechanisms for networked urban development	
Engaging users in new business	1. Personalized Informative billing based on real-time energy prices 2. Prices for engaging users in energy saving actions 3. Peer-to-peer energy marketplace 4. Demonstration of Dynamic Thermal Energy Tariff schemes available to consumers that allow them to alter energy consumption patterns and shave peak periods 5. Develop normative benchmarking mechanisms to allow consumer's consumption comparison against best performing peers, enhancing energy bill savings potential via energy consumption flexibility	CiviESCo
Co-creating new business models	1. Co-create business models supporting energy positive behaviour and mobility among lead users	CiviESCo
Bankable smart cities solutions	1. Creating bankable vertical user-centric carbon-free building, district and mobility smart technologies and services 2. Innovation ecosystem as a facilitator for developing bankable smart city solutions for worldwide replication	CiviESCo
V2grid monetization	1. Utilisation of activity-based models for load prediction and development of energy demand response services (V2G), control strategies based on business models (Park&Charge concept).	CiviESCo
Dynamic pricing of EV charging	1. Dynamic pricing models for electric vehicle charging and pricing of electricity depending on the flexibility resource the EV can bring	CTT

Table 17. Technical requirements regarding New Economy

Solution	Technical requirements
Smart business models	1. Literacy regarding New Business 2. Users engaged – users identified, efficient and effective communication channels 3. Regulation on New Business
Smart governance models	1. Literacy regarding Urban transformation 2. Urban transformation co-creation – users identified, existing communication channels

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	3. Urban transformation financing models 4. Urban transformation governance models 5. Urban transformation procurement 6. Regulation on smart governance models 7. Coordination mechanisms for networked urban development 8. Promotion of direct social engagement activities involving local communities in planning, implementation of smart governance models
Engaging users in new business	1. Literacy regarding New Business 2. Existence of a Peer-to-peer energy marketplace 3. Existence of personalized Informative billing using real-time energy prices 4. Existence of a benchmarking informative system to compare user consumption.
Co-creating new business models	1. Literacy regarding New Business 5. Users engaged – users identified, efficient and effective communication channels 6. Regulation on New Business 7. Urban transformation co-creation – users identified, existing communication channels 8. Develop new financing models through partnerships involving community cooperatives/public/private sector.
Bankable smart cities solutions	1. Existence of a catalogue with bankable solutions encompassing user-centric, carbon-free buildings, smart technologies applied to the district and to mobility and all connected services 2. Existence of an innovation ecosystem enabling the development of the bankable smart city solutions to be worldwide replicated 3. Promote dissemination activities focused on bankable smart cities solutions reaching out the hard-to-reach group
Smart local sustainable businesses	1. Existence of an ecosystem enabling the creation of smart local sustainable businesses: market potential, prospective businesses plans, municipal support, joint procurement
V2grid monetization	1. Existence of grid connection points permitting the bidirectional charging of vehicles 2. Existence of a metering system enabling the electrical bidirectional flow quantification 3. Regulation allowing the electricity grid charging and monetization 4. Existence of a demand response system facilitating V2G flexibility use 5. Existence of a life cycle cost evaluation of the V2G operation 6. Clear definition of the V2G overall costs (OPEX, CAPEX) allocated
Dynamic pricing of EV charging	1. Existence of grid connection points permitting the bidirectional charging of vehicles 2. Regulation allowing the electric vehicle charging and dynamic pricing 3. Existence of a demand response system facilitating V2G flexibility use 4. Existence and application of dynamic pricing models for electric vehicle charging and price of electricity depending on the flexibility resource the EV can bring.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

3.4 Solutions regarding Urban Innovation

This section addresses the Urban Innovation solutions in SPARCS. The Urban Innovation solutions in SPARCS aim at developing different ways of engaging users in the city life, promoting a sustainable lifestyle, engaging users in co-creating PED, among others. The section begins with a presentation of the Urban innovation solutions, their description and the partners in charge of developing them, see Table 18. To allow their replication, in Table 19 the technical requirements are presented. So, each city can evaluate if they have the technical conditions to implement the Urban Innovation solutions.

Table 18. General description of the solutions regarding the Urban Innovation

Technology	Description	Partner in charge
Engaging users	1. Co-creation models, new mechanisms for networked urban development	Kone
Sustainable lifestyle	1. Define and validate solutions for optimizing people's flow (urban) regarding energy and user experience. Identifying benefits and the added value for citizen and other stakeholders in different district lifecycle phases. 2. Promoting mobility, construction and energy solutions, through offering teaching and education on sustainable lifestyle. By providing culture, sports and social and health care services enhancing wellbeing and by maintaining comfortable nature in the nearby green areas.	ESP and LPZ
Co-creation for PEB developments	1. Co-creation models to support land use planning in collaboration between industry, SMEs, citizens and other stakeholders to support functional solutions of new development areas regarding e.g. energy, mobility, and service solutions based on digital platforms and networks.	ESP and LPZ
Induce citizens behaviour towards energy positiveness	1. City apps and eParticipation tools. 2. Idea Management and Open Innovation: citizens are engaged in the proposition and discussion of ideas/projects to improve urban sustainability 3. Desk Support: as a means to involve people and facilitate communication, incentivizing their participation and the adoption of sustainable behaviours	Kone and SEE
Optimize people's flow	1. Conveying insights to city planning authorities of citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives	Kone
City planning district development	1. Setting up inclusive management, cooperation and planning models (including companies, city planning departments, citizens and research organizations) 2. Co-creation models for smart city planning.	ESP and LPZ
Promotion of soft mobility	1. Conveying insights to city planning authorities of citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives	Kone

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	2. Sustainability strategy connecting Metro and e-bicycle modes, boosting e-mobility in the whole district	

In this section, the main solutions that contribute to the Urban Innovation ecosystem are described.

Table 19. Technical requirements regarding Urban Innovation

Technology	Technical requirements
Engaging users	1. Literacy regarding Urban innovation 2. Urban innovation user involvement in co-creation– users identified, existing communication channels
Sustainable lifestyle	1. Definition by the municipality of a Sustainable lifestyle roadmap 2. Literacy regarding Sustainable lifestyle (includes the adoption by the municipality of a Sustainable lifestyle definition) 3. User involvement in Sustainable lifestyle – users identified, existing communication channels (includes the implementation by the municipality of a Sustainable lifestyle paradigm) 4. The Sustainable lifestyle roadmap should include solutions for optimizing people's flow (urban) regarding energy and user experience, should identify benefits and the added value for citizen and other stakeholders in different district lifecycle phases. 5. The Sustainable lifestyle roadmap should include Mobility, construction and energy solutions, by offering teaching and education supporting a sustainable lifestyle, by providing culture, sports and social and health care services enhancing wellbeing and by maintaining comfortable nature and the nearby green areas.
Co-creation for PEB developments	1. Existence of an established PEB/PED methodology by which all players agree to abide. PEB/PED should encompass energy, mobility, and service solutions based on digital platforms and networks 2. Stakeholders involvement in PEB/PED co-creation, guaranteeing that their inputs are considered in new development areas– users identified, existing communication channels orchestrated by the municipality or other governing institution. Should include all relevant stakeholders such as industry, SMEs, citizens, among others.
Induce citizens behaviour towards energy positiveness	1. Literacy regarding Energy Positiveness 2. Stakeholders involvement in energy positiveness, guaranteeing that their inputs are considered – users identified, existing communication channels orchestrated by the municipality or other governing institution. This must be supported by an *Idea Management* and/or *Open Innovation* system and/or *Desk Support*. In these systems, citizens are engaged in the discussion of ideas/projects to improve positiveness in urban sustainability, as well as they are invited to participate in adopting sustainable behaviours. 3. Existence of a system – APPs and eParticipation tools to allow bi-directional communication between users and the municipality. 4. End-users (citizens/owners) characterization (preferences/expectations/behaviour) to adapt the technology (e.g through surveys; questionnaires, etc.)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Optimize people's flow	1. Existence of data regarding citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives 2. Use of the data on people's mobility to optimize the people flow from energy and user experience perspectives
City planning district development	1. Existence of inclusive management, cooperation and planning models (includes the participation of companies, city planning departments, citizens and research organizations) 2. Definition by the municipality of the smart city paradigm 3. Stakeholders involvement in co-creation models for smart city planning, guaranteeing that their inputs are considered – users identified, existing communication channels orchestrated by the municipality or other governing institution 4. Clear political commitment with the local community 5. Public accountability involving policymakers at different levels of governance/government.
Promotion of soft mobility	1. Existence of data regarding citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives 2. Use of the data on people's mobility in city planning optimizing people flow (from energy and user experience perspectives) 3. Existence of integrated sustainable strategies connecting Metro and e-bicycle modes, to boost e-mobility in the district

3.5 Solutions regarding ICT

This section addresses the ICT solutions in SPARCS. The ICT solutions in SPARCS are developed to support the PED's implementation. The section begins with a presentation of the ICT solutions, their description and the partners in charge of developing them, see Table 20. To allow their replication, in Table 21 their technical requirements are presented. So, each city can evaluate if they have the technical conditions to implement the ICT solutions.

Table 20. General description of the solutions regarding ICT

Technology	Description	Partner in charge
ICT for PEB	1. Improving the prediction of the energy performance via smart energy management, both heat and electricity; optimal use of local PV generation, electricity and heat storage, air conditioning, lighting and emergency power systems. 2. Smart infrastructure 5G, utilized as a service enabler for management of the smart power grid, optimization, bi-directional energy flows, energy demand side management and demand flexibility. 3. Blockchain technology enabling energy transfer and tracking in bi-directional power grids	Siemens, KONE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Smart business models	1. Engaging lead users and co-creating energy positive business models	KONE, CiviESCco
Virtual power plants	1. Find and connect in a Virtual Power Plant flexible loads from local building stock, to balance RES boosted local power network, identifying new business opportunities for aggregators in order to combine small demand response loads and offering them to reserve market. 2. Blockchain technology options for supporting demand response and virtual power plant in positive energy districts	Siemens, VTT
Virtual twins	1. Simulation of a real demo for a positive energy building block, creating a showcase and support replication by providing both the visual of the building and the operational behaviour for the building energy system. 2. Same energy load as in the real buildings and the block.	VTT

Table 21. Technical requirements regarding ICT

Technology	Technical requirements
ICT for PEB	1. Digital platforms availability 2. Availability of historical data, data streams , consumption, generation, etc. 3. Data analysts 4. Internet connections and mobile phones 5. 5G infrastructure availability 6. Blockchain infrastructure availability
Smart business models	1. Business model's creation expertise 2. Budget for engagement activities 3. Engagement tooling 4. Citywide ecosystem with local SME and start-ups 5. Regulatory incentives for new services and models
Virtual power plants	1. Availability of controllable flexible loads 2. Minimum capacity of flexibility according to the national energy market rules 3. Aggregator business model availability 4. Historical data for controllable flexible assets 5. Continuous data collection infrastructure
Virtual twins	1. Digital twin platform populated with city models to simulate complex real scenarios 2. Historical data regarding city assets operation 3. Detailed models for city evolution

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

3.6 Solutions Social Requirements

For the SPARCS solutions to be successful implemented in cities, it is needed that the main stakeholders understand them and implement them. For this to happen, it is necessary that a minimum social economic level exists. The list of social requirements regarding the overall solutions is presented in Table 22, so that cities can assess if they have the conditions to implement the PEDs.

Table 22. Social requirements regarding the overall solutions

Technology	Social requirements
All	1. Population – number of people that enable the feasibility of the solutions 2. Social-economic level of the population 3. Population literacy on PED, e-mobility, New Economy, Urban innovation 4. Inclusion of ethical requirements/social objectives & priorities (e.g. improve health conditions; include hard-to-reach groups, etc.) in contracts with end-users (citizens/owners) 5. Social acceptance (perception of advantages/positive externalities - in terms of environmental sustainability, cost-effectiveness, risks - from technology implementation) 6. Technology's flexibility to address user's (citizens) needs 7. Friendliness of ICT technologies 8. Integration of privacy/security mechanisms for end-users data treatment on energy consumption 9. Existence of support for the solution/product through its life.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

4. IMPACT

This chapter presents more information about the SPARCS solutions, their impacts, addressing how they can be assessed, what is the necessary data to evaluate them. In this chapter, the indicators that will be utilized to measure the expected impacts are described and grouped according to the technical solutions presented in the previous chapter.

The solutions captured in chapter 3 of this deliverable, cover a broad field of domains like Energy, ICT, Mobility, New economy and Urban Innovation ecosystems and thus demand a holistic monitoring and assessment framework to be utilized, in order to be able to capture the overall impact of the project activities. Consequently, the developed SPARCS ICT Ecosystem shall provide a holistic view and utilisation of available data by the relevant stakeholder (citizens, decision-makers, app developers/companies, etc.), and be capable, with the provision of appropriate tools, to visualize the various citywide data and Key Performance Indicators (KPIs), allowing monitoring and evaluation activities to take place.

Based on the work done on SPARCS WP2 – impacts, where the impacts were detailed, the following sections presents indicators that will be utilized to measure the planned impacts. The indicators are obtained and grouped based on the solutions presented in Chapter 3.

4.1 Impacts regarding the Positive energy Districts

To enable cities to further understand the solutions and their holistic impact Table 23 and Table 24 present the benefits and costs per solution and the relevant stakeholders of the Positive Energy District Solutions. This enables the cities to do an ex-ante analysis of the impacts of the solutions.

Table 23. Benefits per solution for Positive Energy District – table 01

Solution	Description	Benefits /Cost	Stakeholder (that captures benefit/bears the cost)
Renewable energy	Fossil fuels usage reduction	Benefit	Citizens – less pollution Citizens - long term energy price reduction
		Cost	Citizens- Job loss
	Improvement of air quality	Benefit	Citizens – health improvement Municipalities- Improvement of the urban environment and well being Municipalities- competitive advantage
	Facilitation of decarbonization targets	Benefit	Governments- mitigate climate change Municipalities – monetarize the indirect benefits
	RES usage increase	Benefit	Citizens- Job creation Citizens- Business opportunities Financial Institutions- profit from tech conversion
		Cost	Citizens – extra cost for tech conversion

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 24. Benefits per solution for Positive Energy District – table 02

Solution	Description	Benefits /Cost	Stakeholder (that captures benefit/bears the cost)
Virtual Power Plants	Use of renewable energy through decentralized energy production systems	Benefit	Citizens-energy safety/ grid's stability Citizens- increase of energy efficiency Citizens- energy price reduction
Demand response	Demand response services Improved Network stability	Cost	Municipalities- Cost for integration of individual systems Municipalities- OPEX for new infrastructures Citizens – Extra cost for tech conversion
		Benefit	Citizens- Energy Safety Industry- Reduction of energy curtailment
Energy storage	Storage systems	Benefit	Citizens- Energy safety and reliability Citizens- increase of energy efficiency Industry- Reduction of energy curtailment Citizens- Energy cost reduction
		Cost	Citizens –cost for infrastructures
HEMS	Home energy management systems	Benefit	Citizens- Installation of cost-effective energy systems Citizens - Improvement of households' income Citizens – Optimization of energy use Citizens - Improvement of indoor air quality
		Cost	Citizens - Capex for new infrastructures

To identify and evaluate the Key Performance Indicators Table 25 present short descriptions and corresponding data needs for the Positive Energy Solution.

Table 25. Key Performance Indicators and data needs for Positive Energy District

Solution	KPI	Description	Data needed
Renewable energy	RES Generation increase	The increase of energy generation via Renewable Energy Sources	RES Generation (MW)
	Fossil fuels Energy Generation decrease	The decrease of fossil fuels for energy generation	Fossil fuels Energy Generation (MW)
	Share of RES increase	Indicates the penetration of the RES in energy production	Total Energy Production (MWh) Energy production using RES (MWh)
	Onsite energy ratio OER	Local renewable supply compared with the demand over one year	Energy production using RES (MWh) Total energy demand (MWh)
Virtual power plants	Peak Load Reduction	Peak Load Reduction, heating and/or electricity	Peak demand (MWh)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Reduced System Average Interruption Duration Index (SAIDI)	The reduction of the network's average interruption duration	System Average Interruption Duration
	Reduced System Average Interruption Frequency Index (SAIFI)	The reduction of the network's average interruption frequency	System Average Interruption Frequency
	Services dispatch success rate in VPP	VPP related indicators that tracks the success rate of the dispatch rate	# of Positive responses # of Total responses
	Activation quality in VPP	The activation quality corresponds to the share of values within the fulfilment corridor.	Activation Quality %
Energy storage	Energy Storage type	The type of storage used	Type of storage introduced
	Energy Storage number of equipment Increase	The number of storage equipment installed	Number of storage equipment introduced
	Energy Storage capacity Increase	The energy storage capacity used	Capacity of storage introduced (kWh)
	Storage State of Charge	The storage percentage state at a specific point in time	Storage State of Charge %
Demand response	Total flexibility Available Increase (kW)	The total flexibility made available from Buildings/Prosumers, EV smart chargers, escalators/elevators	Total flexibility available (KW)
	Flexibility increase (%) of normal load.	The flexibility provided compared to the normal load	Flexibility % of normal load
	Flexibility provided (kWh)	The flexibility provided in a specific timeframe	Flexibility provided (kWh)
	# of demand requests	The number of flexibility demand requests	# of demand requests
	# of demand responses	The number of flexibility response requests	# of demand responses

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	remuneration due to flexibility delivered (Euro) penalty due to flexibility refusal (Euro) Accuracy of flexibility available	The monetary remuneration through the provided flexibility The monetary penalty of flexibility refusal The flexibility calculated compared to the flexibility provided	remuneration due to flexibility delivered (Euro) penalty due to flexibility refusal (Euro) Accuracy of flexibility available
Energy infrastructure planning	Increase of utilization of the Espoo 3D City model Increase of simulations executed via the Virtual Twins concept Reduction of network infrastructure investment	The use of the Espoo 3D City Model by users The Virtual Twins concept tool usage for simulation The investment reduction managed via the utilization of planning activities	Average utilization time # of simulations executed via the Virtual Twins concept Network infrastructure investment
HEMS (Home energy management systems)	Total energy demand reduction Energy performance prediction deviation Accuracy of Generation/storage forecasting	The energy demand of the PED The forecasting of energy performance accuracy The forecasting of energy generation and storage accuracy	Total energy demand Electricity/Heating (MWh) Predicted energy performance compared to the actual performance kWh/m^2 Predicted generation/storage compared to the actual generation/storage

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

4.2 Impacts regarding Mobility

To enable cities to further understand the mobility solutions and their holistic impact Table 26 presents the benefits and costs per solution and the relevant stakeholders.

Table 26. Benefits/costs per solution for Mobility

Solution	Description	Benefits /Cost	Stakeholder (that captures benefit/bears the cost)
E-mobility	EVs	Benefit	Citizens - Improvement of local air quality Citizens- Mentality shift towards active citizens in regards to sustainable transportation Municipalities- Economic growth Municipalities- Improvement of the urban environment and well being
		Cost	Citizens- cost for vehicles' replacement Municipalities – less collected taxes Municipalities – incentives scheme
Mobility hubs	New mobility hubs	Benefit	Municipalities/Citizens – Reduction of traffic congestion Municipalities/Citizens- Improvement of transportation Municipalities- Improvement of the urban environment and well being Citizens- Investment opportunities/ job creation Municipalities - Promotion of e-mobility services Municipalities- Competitive advantage
		Cost	Municipalities- Capex for new infrastructures and public vehicles
Last-mile electrification	Transport solutions focused on the last mile	Benefit	Municipalities- Reduction of traffic congestion Municipalities/Citizens- Improvement of transportation Municipalities- Improvement of the urban environment and well being Citizens- Property value increase Municipalities- promotion of soft means of transport
EV integration in VPP	V2grid Dynamic pricing of EV charging	Benefit	Citizens- Grids' stability Citizens- Energy security and reliability Citizens- Monetary benefits for EV owners Citizens- Energy cost reduction
		Cost	Municipalities- Capex for new e-infrastructures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Key Performance Indicators, with short descriptions and corresponding data needs for the Mobility Solutions, are listed in Table 27:

Table 27. Key Performance Indicators and data needs for Mobility

Solution	KPI	Description	Data needed
E-mobility	Increase of EVs share in local transportation (%) Increase in shared EVs availability District EV parking/charging places (car and bicycle) Increased level of utilization of EV charging stations	Number of Electric Vehicles in the local transportation The number of electric vehicles that are available for sharing The electric vehicle charging stations The energy consumed via the electric vehicle charging stations	Total number of vehicles in local transportation (#) Electric vehicles in local transportation (#) #EVs available for sharing EV Car parking/charging places (#) EV Bicycle parking/charging places (#) ∑kWh charged
Mobility hubs **Last mile electrification**	Increase of citizens using EV modes Increase of the annual number of public transport trips per capita	Number of citizens using EV modes The number of annual trips using public transportation	Total number of citizens (#) Citizens using public transportation to go to work (#) Citizens going to work using a personal (EV) vehicle (#) Citizens going to work using a personal non EV vehicle (#) Total number of citizens (#) Number of public transportation trips
V2grid	Increase of integrated smart EV charging units Level of customer acceptance for V2G or dynamic charging Acceptable price for V2G or dynamic charging [€]	The number of smart EV charging stations The customer acceptance of the EV charging level provided The customer acceptable price for the EV charging service	# of smart EV charging stations Level of customer acceptance for V2G or dynamic charging Price for V2G or dynamic charging
EV integration in VPP	Peak Load Reduction Reduced System Average Interruption Duration Index (SAIDI)	The reduction of the energy peak load The reduction of the network's average interruption duration	Peak demand (MWh) System Average Interruption Duration

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Reduced System Average Interruption Frequency Index (SAIFI)	The reduction of the network's average interruption frequency	System Average Interruption Frequency

4.3 Impacts regarding New Economy

In Table 28 and Table 29, benefits per solution, as well as the relevant stakeholders of the New Economy Solution are listed.

Table 28. Benefits/costs per solution regarding New Economy – table 01

Solution	Description	Benefits/Cost	Stakeholder (that captures the benefit/bears the cost)
Smart business models	Improvement of innovation capacity	Benefit	Citizens- New market opportunities Citizens- Investment opportunities
Smart Governance models	New policy/ regulatory framework	Benefit	Citizens- Investment opportunities Municipalities- Enabler for growth Municipalities/Citizens- Sustainable urban planning Municipalities – new models for procurements Municipalities – new funding and financing schemes Municipalities – new models for drafting annual balance sheet
Engaging users in new business	Citizens engagement	Benefit	Citizens- Mentality shift towards active participation
Co-creating new business models			Citizens- job creation Citizens- Investment opportunities Citizens- Improvement of households' income
Bankable smart cities solutions	Bankable smart cities solutions	Benefit	Municipalities- Economic growth Municipalities- Economies of scale Citizens- Increase investors' confidence Municipalities – capabilities in drafting economic plans

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 29. Benefits/costs per solution regarding New Economy – table 02

Solution	Description	Benefits/Cost	Stakeholder (that captures the benefit/bears the cost)
Smart local Sustainable businesses	Smart local sustainable businesses	Benefit	Citizens- Job creation Municipalities/Citizens – Neighbourhood transformation Municipalities/Citizens- Improvement of citizens quality of life, health and well -being Citizens- Property value increase Citizens- Improvement of households' income Municipalities- Ecotourism and growth opportunities
V2grid monetization **Dynamic pricing of EV charging**	Dynamic pricing models for electric vehicle charging	Benefit	Citizens- Monetary benefits from the participation in dynamic services Citizens- Energy cost reduction Municipalities- Promotion of electromobility

Key Performance Indicators, with short descriptions and corresponding data needs for the New Economy Solution, are listed in Table 30:

Table 30. Key Performance Indicators and data needs for New Economy

Solution	KPI	Description	Data needed
Smart business models	# of smart business models created	The number of smart business models created in the context of the project	# of smart business models created
Smart governance models	Stakeholder awareness	The stakeholder awareness of the energy initiatives related to SPARCS	Awareness values via Likert Scale
	Relation of the project with the city strategy	How relevant are project goals towards the city goals?	Relevance via Likert Scale
	Market orientation	The extent to which the project was planned based on a market analysis	Market Orientation via Likert Scale
Engaging users in new business	Increase of citizens that contribute to business model creation	The number of citizens that participate in the business model creation	Number of citizens contributing

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	How many people tried new solutions? # of piloted solutions	The number of citizens that participated in the new solution implementation The number of piloted solutions in the context of SPARCS	Number of citizens participation Number of piloted solutions
Co-creating new business models	# of co-created business models # of co-creation sessions with youngsters for positive energy districts	The number of business models that were co-created with the citizens Involvement of youngsters in the sessions related to PEDs	Number of co-created business models Number of PED related sessions with youngsters
Bankable smart cities solutions	# of bankable smart city solution created Payback period time of the system	Solutions receive financing from a bank the amount of time it takes to recover the cost of an investment	Number of bankable solutions Time in years
Smart local sustainable businesses	Local job creation Increase of the employment rate Increase citizens quality of life	The number of jobs created in the context of SPARCS Percentage of employed persons in relation to total population Standard of health, comfort, and happiness experienced by an individual or group.	Number of new jobs in the city/district Employment rate of the city/district Quality of life available values for the city/district
V2grid monetization **Dynamic pricing of EV charging**	Monetary gains for EV charging operator (energy costs vs service revenues + gains from the market) Monetary gains for user (charging costs vs flexibility revenues)	The monetary gains of the operator of the EV charging infrastructure The monetary gains for the end-user of the EV charging infrastructure	Cost of energy for the EV charging operator Service revenue for the EV charging operator flexibility remuneration from Network Operator remuneration share provided to EV owners EV User charging costs EV flexibility revenues for the user Energy cost for the customer; price/kWh/a

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Reduction of the customer energy cost	The energy cost reduction achieved via the EV charging service	

4.4 Impacts regarding Urban Innovation Ecosystem

In Table 31 and Table 32, benefits per solution, as well as the relevant stakeholders of the Urban Innovation Ecosystem Solution are listed.

Table 31. Benefits /costs per solution regarding Urban Innovation ecosystems - table 02

Solution	Description	Benefits/Cost	Stakeholder (that captures the benefit/bears the cost)
PED development	Cocreation for PED development	Benefit	Citizens/Municipalities- PED Knowledge exchange Citizens- Replication strategy in city's districts Citizens- Improvement of innovation capacity
Induce citizens behaviour towards energy positiveness	Citizens' and stakeholder's involvement	Benefit	Citizens- involvement and engagement Citizens- Mentality shift towards active citizens (demand response, smart buildings, energy sharing, local energy communities, sustainable transportation)
Optimize people's flow	Optimize people's flow from energy and user experience perspectives	Benefit	Citizens- Improvement of transportation Municipalities/Citizens- Improvement of citizens quality of life, health and well -being Municipalities/Citizens- Improvement of local air quality
		Cost	Citizens- Capex for new components and infrastructures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 32. Benefits /costs per solution regarding Urban Innovation ecosystems – table 02

Solution	Description	Benefits/Cost	Stakeholder (that captures the benefit/bears the cost)
City planning district development	City planning district development	Benefit	Municipalities- Bold sustainable urban vision deployment Citizens- involvement and engagement Citizens/Municipalities- PED Knowledge exchange Citizens- Replication strategy in city's districts
Promotion of soft mobility	Promotion of soft mobility	Benefit	Citizens- Improvement of transportation Municipalities/Citizens- Improvement of citizens quality of life, health and well -being Municipalities- Competitive advantage
		Cost	Municipalities - Capex for new infrastructures
Sustainable lifestyle	Eco-friendly lifestyle	Benefit	Municipalities- Ecotourism and growth opportunities Municipalities- Competitive advantage Citizens- job creation Citizens- Improvement of households' income Municipalities- Crime reduction

Key Performance Indicators, with short descriptions and corresponding data needs for the Urban Innovation Ecosystem Solution, are listed in Table 33:

Table 33. Key Performance Indicators and data needs for Urban Innovation ecosystems

Solution	KPI	Description	Data needed
Engaging users	% of people are aware of the existing solutions before and after interventions	Intervention awareness increase	Awareness increase via Likert Scale
	Number of actively involved partners in energy solutions	The number of partners that are actively involved in the solutions	Number of partners participating in the energy solution
	Number of active market participants in prosumer models	The number of participants that are active in prosumer models	Number of prosumers
Sustainable lifestyle	Increase citizens quality of life	Standard of health, comfort, and happiness experienced by an individual or group.	Quality of life available values for the city/district
	Comfort preservation	Preserve the comfort zones of the participants Population leaving in affordable houses	Comfort preservation via Likert Scale

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

SPARCS

	Increase in the percentage of population leaving in affordable housing		Available values defining affordable houses and percentage of the population leaving in it
Cocreation for PED developments	# of co-creation sessions for positive energy districts # of citizens involved in planning initiatives for positive energy districts Number of ideas that have come up during the process with stakeholders.	Involvement of citizens in the sessions related to PEDs Citizens involved in the planning of PEDS Ideas generated during the PED sessions	Number of PED related sessions with citizens Number of citizens involved Number of ideas created
Induce citizens behaviour towards energy positiveness	Number of active market participants in prosumer models Did you feel that you were able to affect and participate in the ideation of future directions? How much was the awareness of the city planning people improved?	The number of participants that are active in prosumer models Participation feeling towards defining new directions Improvement of awareness of city planners	Number of prosumers Feeling of Involvement in new directions via Likert Scale Awareness improvement via Likert Scale
Optimize people's flow	Clean mobility utilization Increase of citizens using EV modes	The indicator that assesses the number of km in clean vehicles and the number of trips in clean vehicles as a means of sustainable mobility Number of citizens using EV modes	#of km from EV #of total km from all vehicles #of trips from EVs #of total trips Total number of citizens (#) Citizens using public transportation to go to work (#) citizens going to work using a personal (EV) vehicle (#)
City planning district development	Total investment increase Financial Municipal involvement	Amount of total investment in green infrastructures Financial support of the municipality towards the project	Monetary value of the investment % from the total project's costs
Promotion of soft mobility	Modal Split	A modal share is the percentage of travellers using a particular type of	Values available for types of transportation and relevant number of trips

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Increase citizens quality of life, health and well-being	transportation or the number of trips using said type. Standard of health, comfort, and happiness experienced by an individual or group.	Quality of life available values for the city/district

4.5 Impacts regarding ICT

In Table 34, benefits per solution, as well as the relevant stakeholders of the ICT Solution are listed.

Table 34. Benefits /costs per solution regarding Urban ICT

Solution	Description	Benefits /Cost	Stakeholder (that captures the benefit/bears the cost)
ICT for PED	Procurement of services and technologies in PEDs	Benefit	Citizens- Services and technologies not available on an individual building scale Citizens- Availability and analysis of data to reduce consumption and increase efficiency Citizens- Energy cost reduction Citizens- Energy consumption optimisation Municipalities- 5g infrastructures
		Cost	Citizens- Procurement of smart components Municipalities- cost for new infrastructures
Smart Business models	New ICT business models	Benefit	Municipalities- New business models from the expertise Municipalities- Stakeholders engagement Citizens- New services Citizens- Job creation
Virtual power plants	ICT services to establish and efficiently manage the Virtual Power Plans	Benefit	Citizens- Energy cost reduction Citizens- Energy transfer in bi-directional power grids Citizens- Energy consumption optimisation Municipality- RES penetration increase
		Cost	Citizens- Procurement of smart components
Virtual twins	Simulation of a real demo for a positive energy building block	Benefit	Municipalities- Prediction of malfunctions Citizens- Cost-effectiveness of transactional energy performances

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Key Performance Indicators, with short descriptions and corresponding data needs for the ICT Solution, are listed in Table 35:

Table 35. Key Performance Indicators and data needs regarding ICT

Solution	KPI	Description	Data needed
ICT for PEB	Increased hosting capacity for RES, electric vehicles and other new loads # of digital platforms used Platform Downtime	The indicator determines the improvement of hosting capacity with regards to additional loads and installations in the network when R&I solutions are applied and also compared to the baseline scenario. # of digital platforms used in the City The indicator quantifies the platform downtime per selected timeframe.	Volume of hosting capacity # of digital platforms used The downtime of the platforms being used
Smart business models	Number of new and improved 5G services 5G utilization increase Number of innovative energy technologies incorporated in virtual twin for simulation purposes	The number of 5G services in the context of SPARCS Capturing the increase of 5G utilization as part of the project activities Innovative energy technologies simulated in virtual twins	Number of new or improved services with the introduction of 5G 5G endpoints in use Number of technologies introduced in virtual twin to improve simulations
Virtual power plants	ICT response time Amount of energy managed through digital platforms	The response time of ICT infrastructure is related to the services developed and the payload (information exchanged) between them, applicable to the various ICT actions and services in the project. Describes the use of digital platforms measuring the amount of energy managed through them	ms/byte; sec/byte; min/byte - amount of energy managed through digital platforms

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

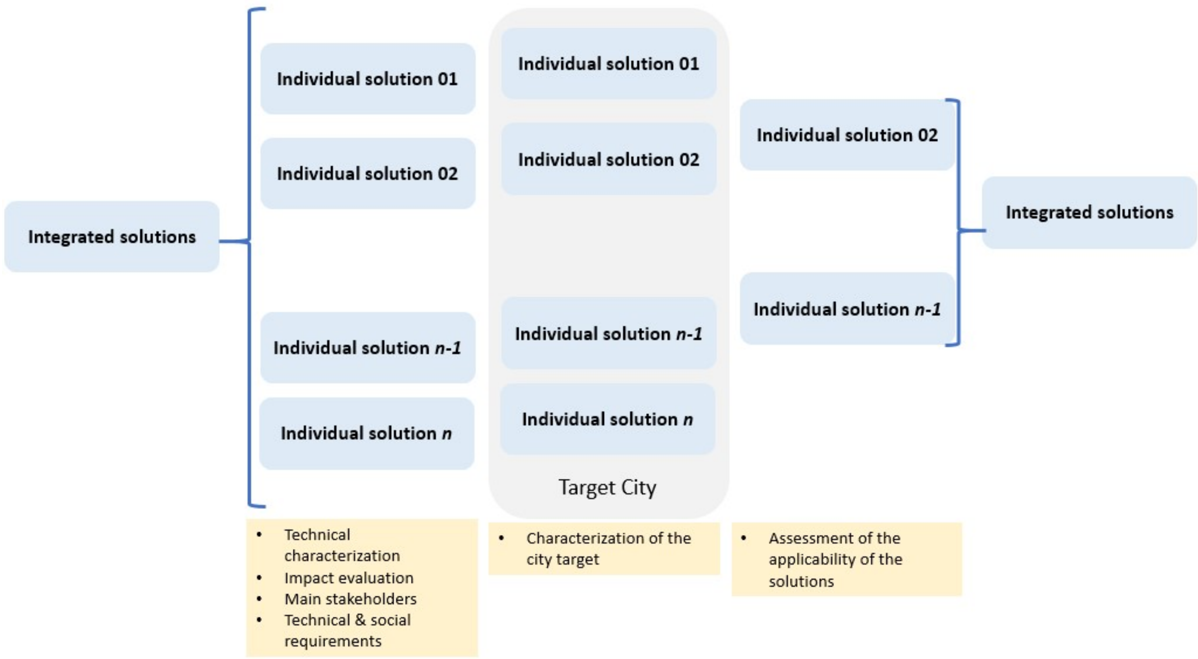
Virtual twins	Increase of utilization of the Espoo 3D City model Increase of simulations executed via the Virtual Twins concept	Describes the use of Espoo's 3d model Increase of simulations executed via the Virtual Twins concept	Average utilization time # of simulations executed via the Virtual Twins concept

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

5. REPLICATION GUIDELINE

The SPARCS project addresses the smart cities challenges by implementing sets of integrated solutions that produce Positive Energy Districts with zero CO_2 emissions. Replication means *"repeating successful smart city initiatives in another locale or replicating the same type of smart city in other cities"*[7]. This means that the SPARCS solutions must adapt to the local city context. Also, in the SPARCS project, this concept must be adapted to the holistic nature of its implementation. That is, the solutions have value *per se* (individually), and have value from their joint impact, which can be different than the linear sum of the individual impacts, thus it can be holistic. This creates some difficulties in the evaluation of their replication potential, as if we were facing a one of a kind solution and not a scalable concept. To solve this conundrum, we propose a structured step by step approach that will be exemplified in Maia's city case.

Figure 2 – Replication methodology



The methodology that we propose (see Figure 2 – Replication methodology) has the following steps:

1. Separation of the integrated solutions in their components (detailed in Chapter 3)
2. Evaluation of the components of the integrated solutions:

---

[7]https://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

a. Technical characterisation (detailed in Chapter 3, in D3.1[8] and D4.1[9])
b. Impact evaluation (see D2.1[10])
c. Main stakeholders (see Chapter 4)
d. Requirements for their implementation (see Chapter 3)

3. Characterization of the city (target city) – evaluation of the city needs, and potential regarding the components of the integrated solutions
4. Assessment of the applicability of the solutions - individually and holistic - in the city – as of today

The methodology aims at supporting cities in the replication of the SPARCS solutions. In **Step 01** the integrated solutions are divided into their elemental components allowing the cities to be able to work individually on each component and later on build up their holistic solutions.

In **Step 02**, the elementary components are presented in terms of technical characterisation, impact evaluation, main stakeholders impacted and requirements for implementation. This step allows the cities to assess the applicability of the solutions in the real context.

In **Step 03**, each city verifies its conditions and needs and evaluates its potential regarding the solutions. This is done through a batch of *142 questions* divided in the five PED solutions of SPARCS (see Annex 01). After answering the questions focused in the Target city biophysical, social and economic context, the replication tool produces 58 indicators that will be the base for the evaluation of the replicability potential.

In **Step 04**, the applicability of the solutions is evaluated both individually and holistically for the specific city. To do so, it is advised to schedule workshops with the municipality civil servants and with relevant stakeholders, the time we suggest for these workshops should be at least 5 hours (in total), in case the interviewer already knows well the city, its needs and main characteristics. Otherwise, the workshops should have a longer duration. Also, the workshop sessions should be divided by themes and each day the themes discussed should be 2 at the most.

During the workshop sessions, each requirement (technical and social) listed in *Chapter 3 - Solutions for positive carbon zero districts* is evaluated by answering the questions that contribute to the requirement (see *Annex 01 – Requirements Methodology*) on a scale from 0 to 3, produced from qualitative scales, via a Likert conversion, or via an "on/off" scale. In order to integrate the different components of each requirement a calculation methodology is provided for each one of them (see *Annex 01 – Requirements Methodology and 8.2* Annex 02 – Excel Tool). The results of the methodology application are divided in:

- Replication Potential evaluation for the city – Technical Requirements (general)
- Replication Potential evaluation for the city – Social Requirements (general)
- Replication Potential evaluation for the city – PED Social Requirements
- Replication Potential evaluation for the city – Mobility Social Requirements

[8] **D3.1 Detailed plan of the Espoo smart city light house**
[9] **D4.1 Detailed plan of the Leipzig smart city light house**
[10] **D2.1 Definition of SPARCS Holistic Impact Assessment Methodology and kPIs**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Only PED and Mobility have specific social requirements presented separately, other solutions such as New Economy, Urban innovation ecosystem and ICT have the specific social requirements incorporated in their analysis.

The Replication Methodology allows the main stakeholders to evaluate the current status and the potential progress regarding the solutions that contribute to creating positive low emission energy districts. Namely, to:

- Evaluate the current status of the target city – which are the main developed solutions
- Evaluate the gaps – which high potential solutions are not developed
- Prioritize the solutions that should be addressed first.

From this exercise, the city can assess its potential, choose the solutions and prioritize them.

5.1 Complex solutions replication strategy applied to the city of Maia

In this section the methodology previously described is showcased.

Step 1 *Separation of the integrated solutions in their components* was done in *Chapter 3*. In this step the main outputs are the individual solutions.

Step 2 *Evaluation of the components of the integrated solutions* was done in *Chapter 3*, in *D3.1*, *D4.1*, *D2.1* and *Chapter 4*. In this step the main outputs is the description and requirements of the individual solutions.

Step 3 *Characterization of the city (target city)* applied to the city of Maia:

Maia is one of the Porto Metropolitan Area municipalities. It is located in the north region of Portugal, in Southwestern Europe. Maia has 135,306 inhabitants (61,052 active residents). Maia plays an important role in this hinterland, due to its centrality and proximity to Porto, mostly because of its major transport infrastructures, which includes the international airport, 3 light metro lines and 2 railroad Lines, and is crossed by 3 different highways. In the last five decades, Maia showed some of the most significant values within the dynamics of population, economic and housing growth.

Maia's population density totals 1,627.6 inhabitants/km^2, while its growth rate is 10% of the metropolitan population. The city is a home to 14 business and industry districts, 1 science park and more than 15,000 companies. It is also one of the most industrialized municipalities of Portugal and an important transportation hub. The productive structure of the city is 74% services, 25% industry and less than 1% agriculture. Maia began seriously paving the way to be a sustainable city in 2012, first by tackling energy issues and in 2014 by creating the Sustainable Energy Action Plan addressing the RES penetration, energy efficiency, CO_2 emissions, mobility (including soft mobility, promotion of public transport, e mobility, among others), citizen's engagement, among others.

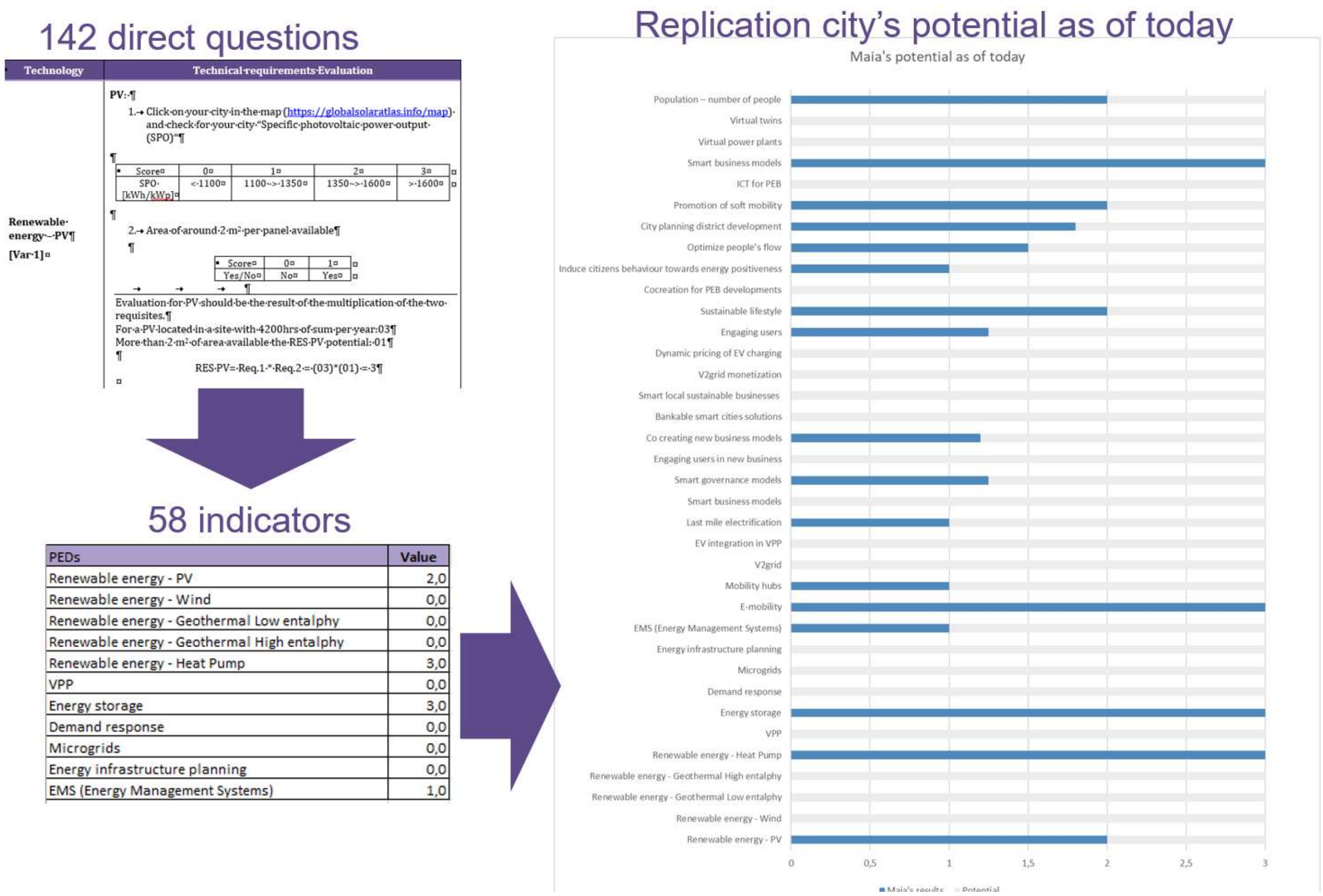
Maia's potential for zero emission PEDs is characterized in detail in the task 5.3 Fellow City Replication Strategy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Step 4 *Assessment of the applicability of the solutions- individually - in the city – as of today*

In this step the target city evaluates the replication potential by answering to the 142 questions regarding the pre-requisites (see Annex 01). These questions are the inputs of an Excel Tool, whose outputs are the evaluation of the city potential as of today (see Figure 3). After this first step, the tool evaluates and displays the target city potential (see Figure 4 through Figure 7).

Figure 3 – Replication potential evaluation city of Maia



The technical requirements are applied for the city - in this demonstration for Maia, and the results are presented in the next figures for Maia in 2020.

The first set of results are related to the overall technical requirements, see Figure 4. In which:

- The **red dots** represent the solutions potential theoretical impact that is the impact of the solution *per se* in contributing to positive energy districts (PED) with zero emissions. Example: for RES PV[11] can greatly contribute to zero emissions PEDs.

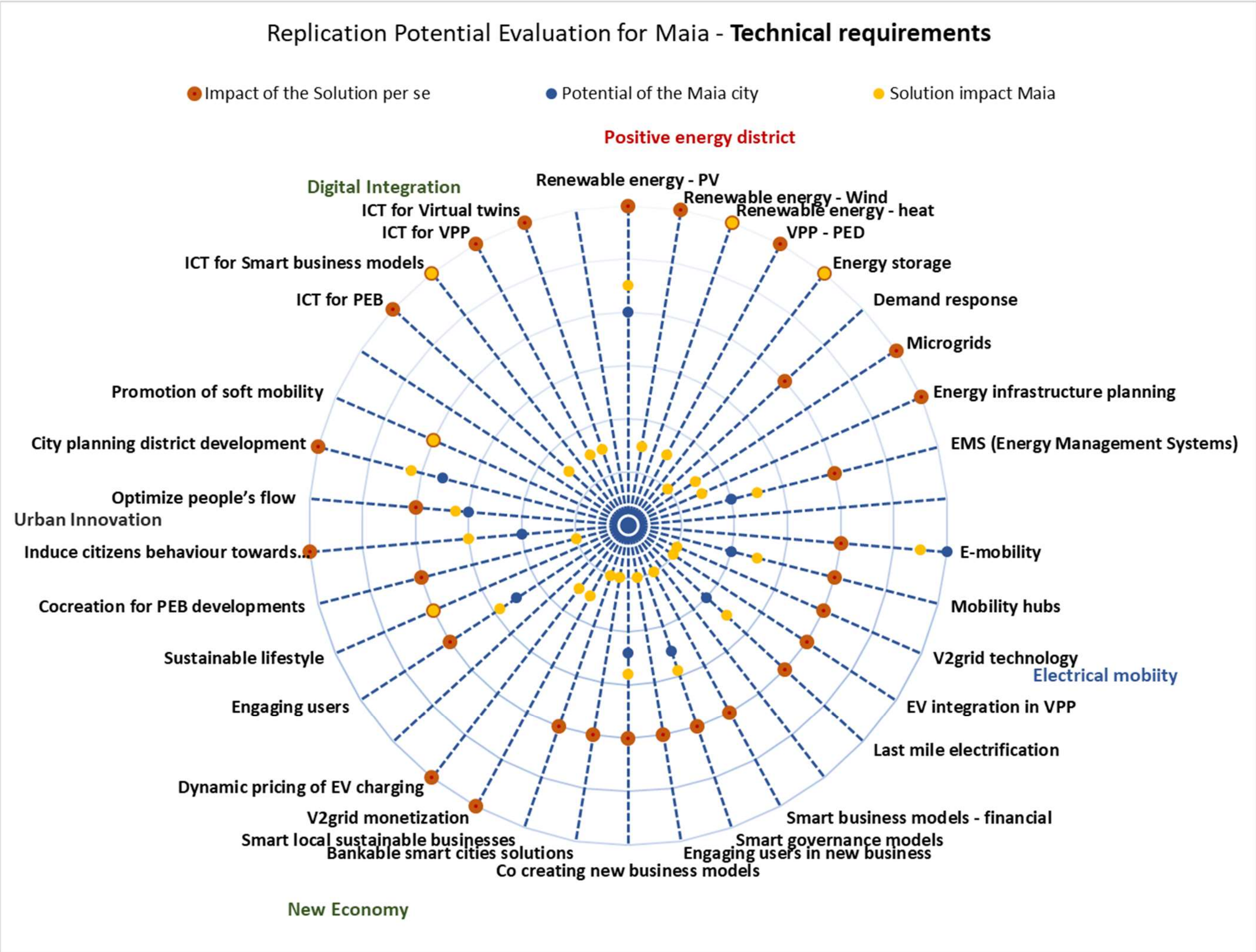
[11] Renewable energy Generation Photovoltaic

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

- The **blue** dots represent the potential of the solutions in the target city, that is, for this specific solution in this specific city what is its potential as of today. Example: for RES PV, the blue dot assesses the amount of solar insulation available at the target city.
- The **yellow dots** represent the solutions potential in the target city, that is, the contribution to zero emission PEDs that the solution can provide once fully implemented in the target city.

Sometimes in the graph the blue dot is not visible because the three dots: red, yellow and blue are in the same position, thus the blue being hidden by the yellow and red.

Figure 4 – Replication potential evaluation city of Maia – Technical requirements



From the Figure 4, one can identify that in the Maia city the solutions already implemented with some extension (success) are: *E-mobility*, *Energy Storage* and

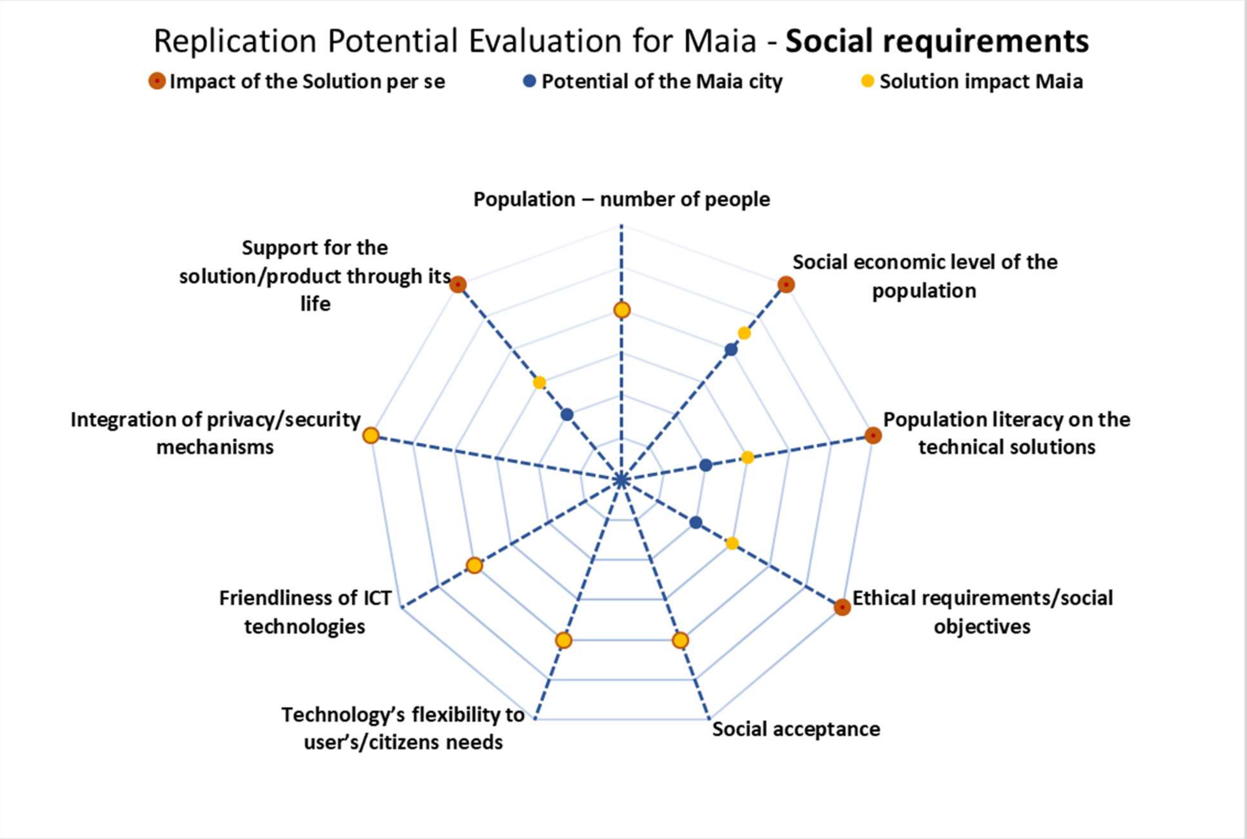
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Renewable Energy and *ICT for Smart Business Models*[12] that is in the graph solutions where the yellow dots are superimposed in the red dot, thus being visible a yellow dot with a red outer line.

The solutions with higher potential are *Virtual Twins*, *VPP*[13] *PED*, *Microgrids*, *V2Grid monetization*, among others, that is the solutions where the distance between the inner yellow dot and the outer red dot is higher.

The next results are related to the *Overall Social Requirements*, see Figure 5. Although they were named Social Requirements, they include a variety of requirements, being this denomination a simplistic one.

Figure 5 – Replication potential evaluation city of Maia – Social requirements



In what regards the social requirements, from Figure 5 one can conclude that in several aspects Maia's municipality has already the highest potential for replication, namely: *Social Acceptance*, *Technology's Flexibility to Users/citizen's Needs*, *Friendliness of ICT Technologies*, *Integration of Privacy/security Mechanisms and Population*, *Number of People*. These are the vectors in which the yellow, red and blue dots are overlapping.

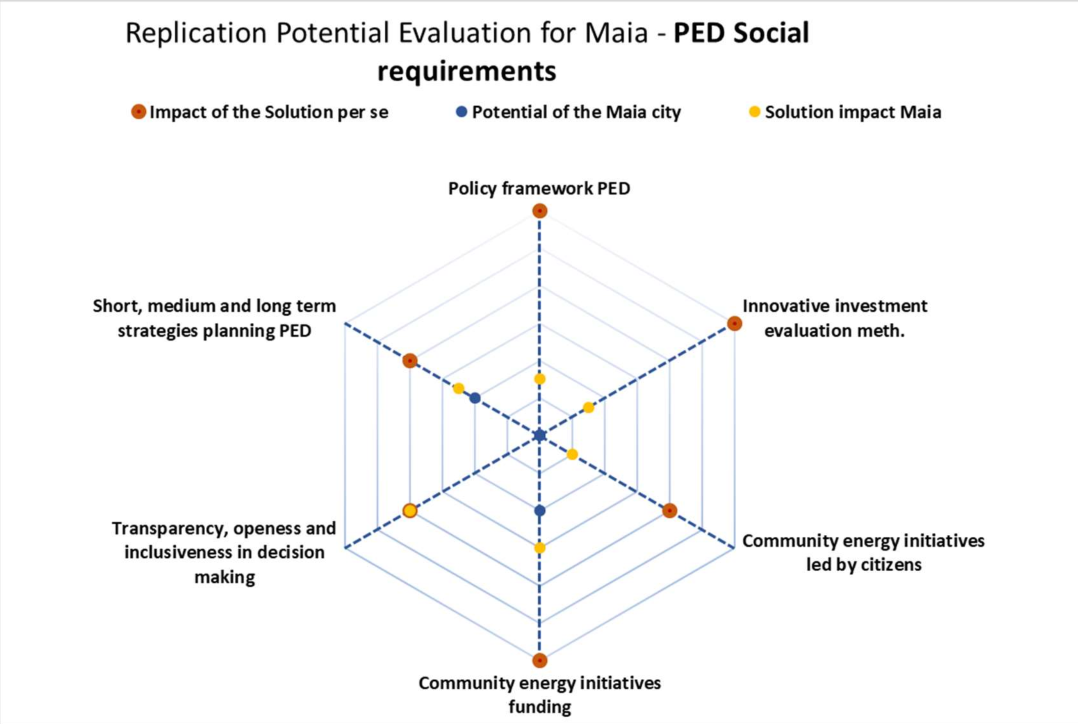
[12] In the graph there are two smart business models , the first is within the electrical mobility and addresses the e-mobility smart business models, the other is within the Digital integration and addresses the ICT smart business models.

[13] Virtual Power Plants

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The *Social Requirements for the PED solutions* are presented in the next figure. Once again under this designation one can find a variety of vectors.

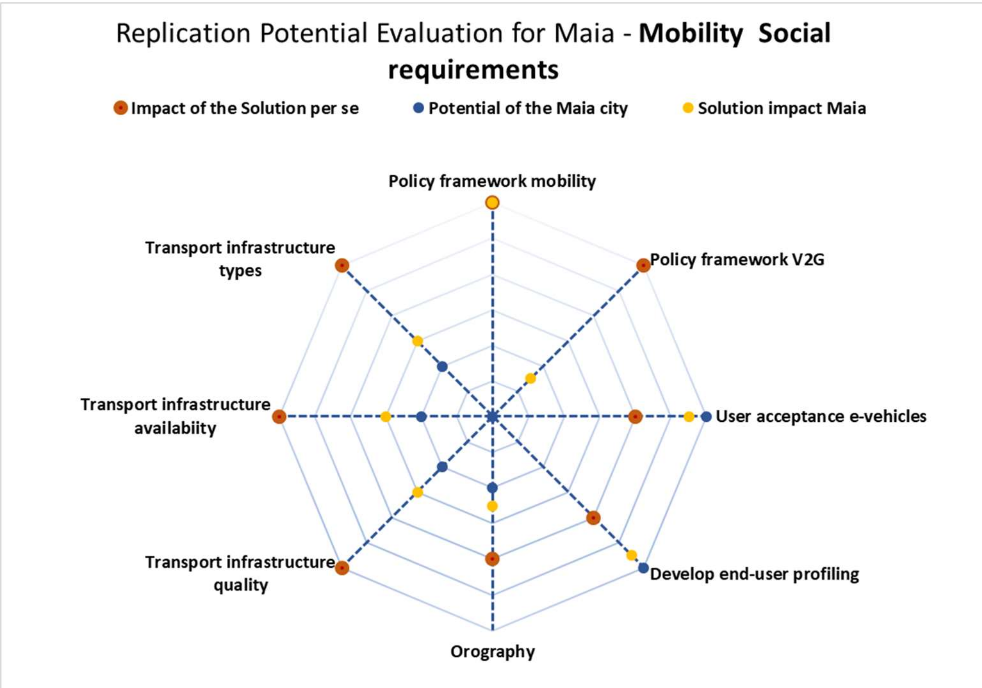
Figure 6 – Replication potential evaluation city of Maia – PED Social requirements



Regarding the PED social requirements, from Figure 6 one can conclude that Maia's municipality has the highest potential for replication in *Transparency*, *Openness and Inclusiveness in decision making*. In all other replication vectors there is some room for improvement.

The *Mobility Social Requirements* are presented in the next figure.

Figure 7 – Replication potential evaluation city of Maia – Mobility Social requirements



This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The replication methodology allows the diagnosis of the current status for the target city, namely the **most developed areas** (the ones in which the blue dot is in an outer position):

- For PEDs technology:
  - Renewable energy - Heat Pump
  - Energy storage
  - Renewable energy - PV
- For the PEDs social acceptance:
  - Community energy initiatives funding
  - Transparency, openness and inclusiveness in decision making
  - Short, medium and long term strategies planning PED
- For the Electrical Mobility technical solutions:
  - E-mobility
  - Mobility hubs
  - Last mile electrification
- For the Electrical Mobility social acceptance:
  - Policy framework mobility
  - User acceptance e-vehicles
  - Develop end-user profiling
  - Orography
  - Transport infrastructure quality
  - Transport infrastructure availability
  - Transport infrastructure types
- New Economy
  - Smart governance models
  - Co-creating new business models
- Urban innovation
  - Sustainable lifestyle
  - Promotion of soft mobility
  - City planning district development
  - Optimize people's flow
  - Engaging users
- ICT
  - Smart business models
- Overall social acceptance
  - Integration of privacy/security mechanisms
  - Population – number of people
  - Social economic level of the population
  - Social acceptance
  - Technology's flexibility to user's/citizens needs
  - Friendliness of ICT technologies
  - Population literacy on the technical solutions
  - Ethical requirements/social objectives
  - Support for the solution/product through its life

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The replication methodology also enables the identification of the main solutions that **represent interesting development opportunities** via the Gap Analysis of the tool. In Maia's case the solutions with the highest unharvested potential that should be prioritize are:

- For the Positive Energy blocks
  - Renewable energy - Wind
  - VPP
  - Demand response
  - Microgrids
  - Energy infrastructure planning
- E-mobility
  - V2grid
  - EV integration in VPP
- New Economy
  - Smart business models
  - Engaging users in new business
  - Bankable smart cities solutions
  - Smart local sustainable businesses
  - V2grid monetization
  - Dynamic pricing of EV charging
- Urban Innovation
  - Co-creation for PEB developments
- Digital Integration
  - ICT for PEB
  - Virtual power plants
  - Virtual twins
- Specific Social Requirements PED
  - Policy framework PED
  - Innovative investment evaluation methodologies
  - Community energy initiatives led by citizens
- Specific Social Requirements Mobility
  - Policy framework V2G

From the use of the methodology, the holistic final package of solutions applied to the city starts to emerge.

To assess the holistic value of the package one should evaluate the impact of the solutions *per se* and then their synergetic effects. To assess the synergetic effects for the target city, the cross effects are presented in the next tables.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

From Table 36 to Table 40 the solutions are jointly considered to evaluate their combined effects, mostly being synergic. Each cell of the table accesses the cross effects that happen when the two solutions are present. For example, when a system has simultaneously a VPP and a renewable energy system with wind turbines, the co-joint result is a reduction in the electricity infrastructure, namely the generation and transport facilities.

Table 36. Target city cross effects (general) – table 01

	RES- Wind	VPP	Demand response	Microgrids	E-infra./ planning
PEDs					
Renewable energy - Wind					
VPP	Reduction in electric generation and transport infrastructure				
Demand response	Supply Electrical flexibility	Supply Electrical flexibility			
Microgrids	Energy supply	Supply Electrical flexibility	Supply Electrical flexibility		
Energy infrastructure planning	Reduction in electric generation and transport infrastructure	Reduction in electric generation and transport infrastructure	Reduction in electric generation and transport infrastructure	Reduction in electric generation and transport infrastructure	
Mobility					
V2grid	Energy supply	Supply Electrical flexibility Energy supply	Supply Electrical flexibility	Supply Electrical flexibility	Supply Electrical flexibility
EV integration in VPP	Energy supply	Supply Electrical flexibility	Supply Electrical flexibility	Supply Electrical flexibility	Supply Electrical flexibility
New Economy					
Smart business models	New products /services: trading green energy	New products /services: trading energy, flexibility, emissions.	New products /services: trading flexibility	New products /services: trading energy, flexibility, emissions.	New products /services: trading energy, flexibility, emissions.
Engaging users in new business	Enables via innovative Business Models	Enables via innovative Business Models	Enables via innovative Business Models	Enables via innovative Business Models	Enables via innovative Business Models
Bankable smart cities solutions	Enables	Enables	Enables	Enables	Enables
Smart local sustainable businesses	Enables	Enables	Enables	Enables	Enables
V2grid monetization	Enables	Enables	Enables	Enables	Enables
Dynamic pricing of EV charging	Enables	Enables	Enables	Enables	Enables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 37. Target city cross effects (general) – table 02

	RES- Wind	VPP	Demand response	Microgrids	E-infra./ planning
PEDs					
Urban Innovation					
Cocreation for PEB developments	Enables	Enables	Enables	Enables	Enables
ICT					
ICT for PEB	Enables integration – PED, VPP, microgrids	Enables integration – PED, VPP, microgrids	Enables integration – PED, VPP, microgrids	Enables integration – PED, VPP, microgrids	Enables integration – PED, VPP, microgrids
VPP ICT	Enables integration Improves performance	Improves operation	Enables the overall system integration and performance improvement	Enables the overall system integration and performance improvement	Enables the overall system integration and performance improvement
Virtual twins	Improves operation	Improves operation	Improves operation	Improves operation	Improves operation

Table 38. Target city cross effects (general) – table 03

	V2grid	EV integration in VPP
Mobility		
V2grid		
EV integration in VPP	Supply Electrical flexibility	
New Economy		
Smart business models	New products /services: energy and flexibility	New products /services: energy and flexibility
Engaging users in new business	Users provide flexibility User access transport	Users provide flexibility User access transport
Bankable smart cities solutions	Enables	Enables
Smart local sustainable businesses	Enables	Enables
V2grid monetization	Enables	Enables
Dynamic pricing of EV charging	Enables	Enables
Urban Innovation		
Cocreation for PEB developments	Enables	Enables
ICT		
ICT for PEB	Improves performance	Enables integration Allows innovative BM Improves performance
VPP ICT	Reduction in electric generation and transport infrastructure	Enables integration Allows innovative BM Improves performance Reduction in electric generation and transport infrastructure
Virtual twins	Improves performance	Improves performance

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 39. Target city cross effects (general) – table 04

	Smart business models	Engaging users in new business	Bankable smart cities solutions	Smart local sustainable businesses	V2grid monetization	Dynamic pricing of EV charging
New Economy						
Smart business models						
Engaging users in new business	New products /services: energy and flexibility					
Bankable smart cities solutions	Enables	Enables				
Smart local sustainable businesses	Enables	Enables	Enables			
V2grid monetization	Enables	Enables	Enables	Enables		
Dynamic pricing of EV charging	Enables	Enables	Enables	Enables	Enables	
Urban Innovation						
Cocreation for PEB developments	Enables	Enables	Enables	Enables	Enables	Enables
ICT						
ICT for PEB	Enables	Enables	Enables	Enables	Enables	Enables
VPP ICT	Enables	Enables	Enables	Enables	Enables	Enables
Virtual twins	Enables	Enables	Enables	Enables	Enables	Enables

Table 40. Target city cross effects (general) – table 05

	Cocreation for PEB developments	ICT for PEB	VPP - ICT	Virtual twins
ICT				
ICT for PEB	Enables Supports the operation			
VPP ICT	Enables			
Virtual twins	Enables	Enables	Enables	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Considering Maia's solutions with the highest unharvested potential (from Figure 4) and their cross effects (from Table 36 to Table 40), the expected impacts (cross-effects) for Maia city are presented in next table.

Table 41. Maia cross effects

Maia's solutions	Cross-effects
• For the Positive Energy blocks · Renewable energy - Wind · VPP · Demand response · Microgrids · Energy infrastructure planning	Reduction in electric generation and transport infrastructure Supply Electrical flexibility Energy supply
• E-mobility · V2grid · EV integration in VPP	Supply Energy and Electrical flexibility
• New Economy · Smart business models · Engaging users in new business · Bankable smart cities solutions · Smart local sustainable businesses · V2grid monetization · Dynamic pricing of EV charging	New products /services: trading energy, green energy, flexibility, emission certificates
• Urban Innovation · Co-creation for PEB developments	Enables most of the solutions.
• Digital Integration · ICT for PEB · Virtual power plants · Virtual twins	Improves performance Improves operation Enables the overall system integration- PED, VPP, microgrids

So, the methodology has allowed us to evaluate the solutions, prioritize them, choose the most adequate ones, recombine them and qualitatively assess their combined effect (see Table 41. Maia cross effects).

To conclude, the methodology presented enabled the replication of the SPARCS lighthouse cities solutions to any cities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

6. SCALABILITY

Scalability is the capacity of a system to cope with a given increase in size[14]. In the SPARCS project, we access the scalability of the Lighthouse solutions by evaluating their potential impact when implemented on a larger scale. A solution has scale-up potential when it has positive externalities associated with a wider implementation This analysis is presented on the next tables, in which the SPARCS solutions are ex-ante evaluated to identify their scale-up potential.

Table 42. Scalability – table 01

	Scaling up Impact
PEDs	
Renewable energy - PV	Network positive externalities[15] regarding suppliers, market, platforms, etc. R&D Spill overs[16] Complementarities[17] Increased demand for raw materials
Renewable energy - Wind	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Increased demand for raw materials
Renewable energy - Geothermal Low enthalpy	R&D Spill overs Complementarities
Renewable energy - Geothermal High enthalpy	R&D Spill overs Complementarities
Renewable energy - Heat Pump	R&D Spill overs Complementarities
VPP	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities
Energy storage	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Increased demand for environmentally sensible raw materials
Demand response	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities
Microgrids	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities

[14] Bondi, A., Characteristics of scalability and their impact on performance, AT&T Labs, New Jersey, DOI: 10.1145/350391.350432 · Source: DBLP.

[15] Varian, H. R., Intermediate Microeconomics A modern approach, 8th edition, Norton & Co., pag. 678, NY,2010.

[16] Mazzucato, M., The Entrepreneurial State Debunking Public VS. Private Sector Myths revised Edition, Pag. 208, Athem Press,USA, 2015.

[17] Varian, H. R., Intermediate Microeconomics A modern approach, 8th edition, Norton & Co., Pag. 668, NY,2010.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Energy infrastructure planning	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities
EMS (Energy Management Systems)	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities

Table 43. Scalability – table 02

	Scaling up Impact
Mobility	
E-mobility	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities
Mobility hubs	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities
V2grid	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Increased demand for environmentally sensible raw materials (batteries)
EV integration in VPP	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities
Last mile electrification	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities

Table 44. Scalability – table 03

	Scaling up Impact
New Economy	
Smart business models	Market expansion – Products and services, suppliers, clients and transactions volume
Smart governance models	Market expansion – Products and services, suppliers, clients and transactions volume
Engaging users in new business	Market expansion – Products and services, suppliers, clients and transactions volume
Co-creating new business models	Market expansion – Products and services, suppliers, clients and transactions volume
Bankable smart cities solutions	Market expansion – Products and services, suppliers, clients and transactions volume
Smart local sustainable businesses	Market expansion – Products and services, suppliers, clients and transactions volume
V2grid monetization	Market expansion – Products and services, suppliers, clients and transactions volume
Dynamic pricing of EV charging	Market expansion – Products and services, suppliers, clients and transactions volume

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 45. Scalability – table 04

	Scaling up Impact
Urban Innovation	
Engaging users	Market expansion – Clients and transactions volume
Sustainable lifestyle	Market expansion – Products and services
Cocreation for PEB developments	Market expansion – Products and services
Induce citizens behaviour towards energy positiveness	Market expansion – Products and services
Optimize people's flow	Market expansion – Products and services
City planning district development	Market expansion – Products and services, suppliers, clients and transactions volume
Promotion of soft mobility	Market expansion – Products and services, suppliers, clients and transactions volume

Table 46. Scalability – table 05

	Scaling up Impact
ICT	
ICT for PEB	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Market expansion – Products and services, suppliers, clients and transactions volume
Smart business models	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Market expansion – Products and services, suppliers, clients and transactions volume
Virtual power plants	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Market expansion – Products and services, suppliers, clients and transactions volume
Virtual twins	Network positive externalities regarding suppliers, market, platforms, etc. R&D Spill overs Complementarities Market expansion – Products and services, suppliers, clients and transactions volume

From Table 42 to Table 46, and recuperating Maia's most interesting solutions (obtained from the replication methodology), the expected scaling results for Maia city after implementing the solutions with the highest unharvested potential are presented in the next table.

Table 47. Maia's scale up results

Maia's solutions	Scale-up effects
• For the Positive Energy blocks · Renewable energy - Wind · VPP · Demand response	(+) Network positive externalities regarding suppliers, market, platforms, etc. (+) R&D Spill overs (+) Complementarities (-) Increased demand for raw materials

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

· Microgrids · Energy infrastructure planning	
• E-mobility · V2grid · EV integration in VPP	(+) Network positive externalities regarding suppliers, market, platforms, etc. (+) R&D Spill overs (+) Complementarities (-) Increased demand for environmentally sensible raw materials (batteries)
• New Economy · Smart business models · Engaging users in new business · Bankable smart cities solutions · Smart local sustainable businesses · V2grid monetization · Dynamic pricing of EV charging	(+) Market expansion – Products and services, suppliers, clients and transactions volume
• Urban Innovation · Co-creation for PEB developments	(+) Market expansion – Products and services
• Digital Integration · ICT for PEB · Virtual power plants · Virtual twins	(+) Network positive externalities regarding suppliers, market, platforms, etc. (+) R&D Spill overs (+) Complementarities (+) Market expansion – Products and services, suppliers, clients and transactions volume

From Table 41 one can conclude that most of the scale-up effects are positive. Nevertheless, there is a major negative scale-up effect related to the *increased demand for environmentally sensible raw materials (batteries).* This drawback does not affect all solutions, but mainly the ones related to batteries and wind turbines. Although, as of today, this is an important drawback, it is expected that in the near future new materials and new mining methods will contribute to overcome it.

The fact that most of the scale-up effects are positive supports the belief that most of the solutions considered in the SPARCS project are not yet mainstream because their economic model[18] and business model[19] are not yet mature.

The main player to support the development of enabling economic models is the Government, that is, the Government should use the tools at its disposal, such as fiscal incentives, investments, regulation and so on to support the solutions that as of today are not yet integrated into a sustained business model. At the moment when there are viable business models for the solutions, they will be adopted by firms, and network and scale effects will appear further reinforcing the development of the solutions.

[18] Economic model - *"...how **a society** functions to generate, deliver and capture value in all dimensions: economic, financial, social, cultural and environmental."* In Serra, L. "The fourth industrial revolution in the contexts of past industrial revolutions: A systematic analysis", IST, Master Thesis, 2019.

[19] Business Model – *"...how **firms** function to generate, deliver and capture value in all dimensions: economic, financial, social, cultural and environmental."* In Serra, L. "The fourth industrial revolution in the contexts of past industrial revolutions: A systematic analysis", IST, Master Thesis, 2019.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

7. Conclusions and Recommendations for Upscaling

This report presents a methodology to implement and evaluate the replication of holistic PED solutions. The report starts by presenting the typical challenges the cities are facing, the solutions that allow the cities to address those challenges, and the impact of the individual solutions. The second part of the report presents the replication methodology:

1. Separation of the integrated solutions in their components (detailed in Chapter 3)
2. Evaluation of the components of the integrated solutions:
    a. Technical characterisation (detailed in Chapter 3, in D3.1[20] and D4.1[21])
    b. Impact evaluation (see D2.1[22])
    c. Main stakeholders (see Chapter 4)
    d. Requirements for their implementation (see Chapter 3)
3. Characterization of the city (target city) – evaluation of the city needs, and potential regarding the components of the integrated solutions
4. Assessment of the applicability of the solutions- individually and holistically - in the city – as of today

The implementation of the methodology enabled the evaluation of the replication, potential of the SPARCS lighthouse cities solutions, as an example the methodology was applied to a real target city, Maia. The deliverable provided a significant advance in terms of prioritization of the solutions for PED implementation. Although it was applied only to a target city, it provides a methodology that allows the evaluation of different cities based on the city potential and the requirement of the solutions.

The report also allows to identifying major gaps and fields where cities should allocate more effort and invest more resources to bridge that gap.

Finally, the present guideline provides a tool (see Annex 01 – Requirements Methodology and Annex 02 – Excel Tool) for support of the stakeholders involved in the creation of PEDs and paves a way to the systematization of PED replication.

[20] **D3.1 Detailed plan of the Espoo smart city light house**
[21] **D4.1 Detailed plan of the Leipzig smart city light house**
[22] **D2.1 Definition of SPARCS Holistic Impact Assessment Methodology and kPIs**

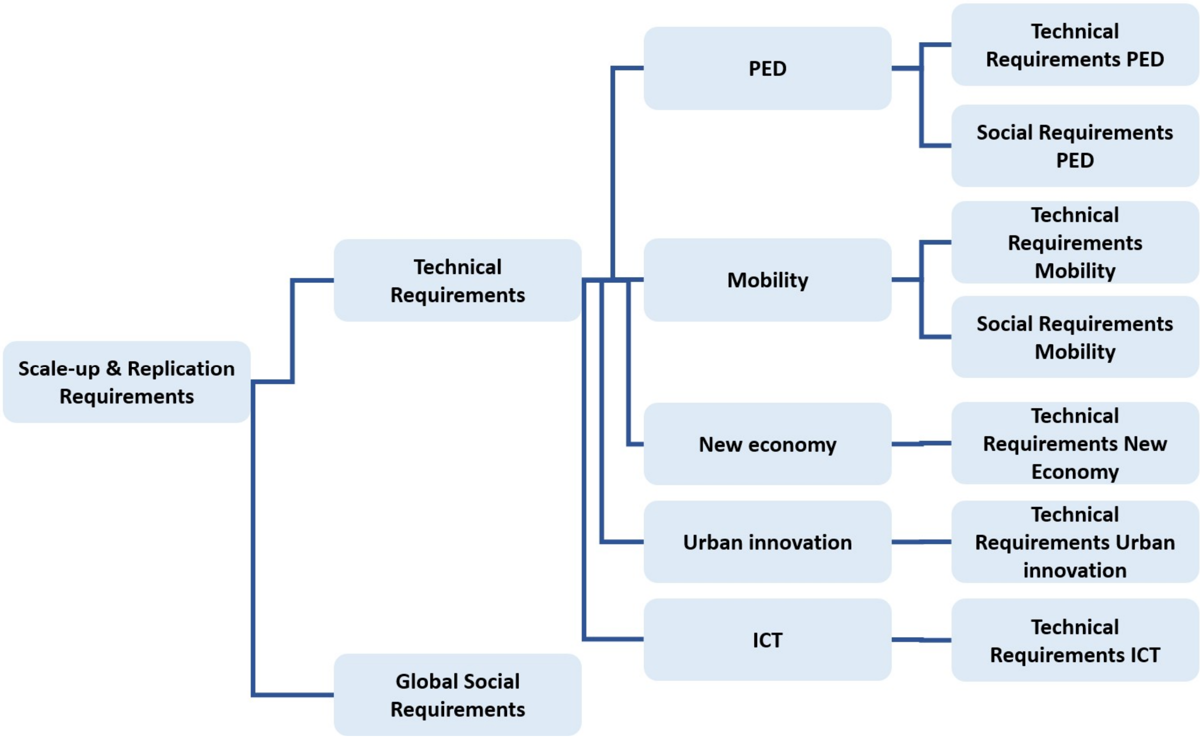
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

8. ANNEXES

8.1 Annex 01 – Requirements Methodology

The evaluation of the requirements must produce for each city two evaluation sets: one regarding the technical requirements and the other regarding the social requirements.

The requirements that were identified are:



Only the most complex solutions present *Technical* and *Social Specific Requirements*, such as PED and Mobility. The other solutions, New Economy, Urban Innovation and ICT, only present *Technical Solutions*. There is also a list of *Global Social Solutions* that address the global requirements that are crucial for the Positive Energy and Zero Emissions District implementation.

Each requirement is evaluated in a scale from 0 to 3. The result is produced either from qualitative scales, via a Likert conversion, or from an on/off scale via a conversion. To integrate the different components of each requirement, a methodology is provided for each one of them. In all requirements, the ON/OFF components are translated into an absorbing element (thus multiplicative), whereas the qualitative components are direct Likert conversions. The full methodology is explained in the next tables.

The methodology for evaluating the **technical requirements** for **PED** is presented on the next table:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 48. Technical requirement's evaluation for PED

<table>
<tr><th>Technology</th><th>Technical requirements Evaluation</th></tr>
<tr><td>Renewable energy – PV
[Var 1]</td><td>
PV:
1. Click on your city in the map (https://globalsolaratlas.info/map) and check for your city "Specific photovoltaic power output (SPO)"
<table>
<tr><td>Score</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>SPO [kWh/kWp]</td><td>< 1100</td><td>1100 -> 1350</td><td>1350 -> 1600</td><td>> 1600</td></tr>
</table>
2. Area of around 2 m^2 per panel available
<table>
<tr><td>Score</td><td>0</td><td>1</td></tr>
<tr><td>Yes/No</td><td>No</td><td>Yes</td></tr>
</table>
<hr>
Evaluation for PV should be the result of the multiplication of the two requisites.
For a PV located in a site with 4200hrs of sum per year:03
More than 2 m^2 of area available the RES PV potential: 01
RES PV= Req.1 * Req.2 = (03)*(01) = 3
</td></tr>
<tr><td>Renewable energy – Wind
[Var 2]</td><td>
Wind (Source: https://news.energysage.com/small-wind-turbines-overview/):
1. Average wind speed of more than 5 m/s – in this case small wind turbines can be a good alternative to PV panels
Click on your city in the map(https://globalwindatlas.info/) and check for your city "mean wind speed – 10% of windiest areas value"
<table>
<tr><td>Score</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>(m/s)</td><td>< 5</td><td>5 -> 6.5</td><td>6.5 -> 8</td><td>> 8</td></tr>
</table>
2. No obstacles nearby the turbine that may interfere with wind speed
<table>
<tr><td>Score</td><td>0</td><td>1</td></tr>
<tr><td>Yes/No</td><td>Yes</td><td>No</td></tr>
</table>
3. Availability of one acre of clear land, i.e. around 4000 m^2, recommend by most installers
<table>
<tr><td>Score</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>m^2</td><td><1000</td><td>1000 -> 2500</td><td>2500 -> 4000</td><td>> 4000</td></tr>
</table>
</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Evaluation for **RES wind** should be the result of the 3 requisites. Example: For a site with: Average wind speed of 7.5 m/s: 02 No obstacles nearby: Yes- 01 Availability of two acres of clear land – 03 RES wind = Req.2 * (Req.1 +Req.3)/2= (1)*[(2)+ (3)]/2 = 2.5
Renewable energy – Geothermal – Low enthalpy **[Var 3] for all RES Heat (the maximum of them all)**	Geothermal – Low-enthalpy: 1. Availability of temperatures in the range (20°C to 150°C) to provide **direct** heat for residential, industrial, and commercial uses Score: 0 / 1 / 2 / 3 °C: < 20 / 20 -> 90 / 90 -> 150 / > 150 Evaluation for **RES geothermal Low enthalpy.** For a site with: Available temperature of 100 Celsius degrees: 02 RES geothermal Low enthalpy = (Req.1) = 02
Renewable energy – Geothermal- high enthalpy	1. Availability of temperatures in the range (150°C to 370°C) to provide high enthalpy fluid for **geothermal electricity generation** Score: 0 / 1 / 2 / 3 °C: < 150 / 225 -> 300 / 300 -> 375 / > 375 2. Distance of the geothermal reservoirs below 3 km – since electricity production demands a close to the earth surface Score: 0 / 1 / 2 / 3 km: > 3 / 1,5 -> 3 / 0,5 -> 1,5 / < 0,5 Evaluation for **RES geothermal high enthalpy** should be the result of the 3 requisites. Example: For a site with: Available temperature of 320 Celsius degrees: 02 Distance of the geothermal reservoirs 1 km: 02 RES geothermal high enthalpy = (Req.1 + Req.2)/2= = [(2) +(2)]/2 = 1 .6

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Renewable energy – heat pump

1. For geothermal heat pumps existence of excavations of around 2 meters for the installation of the coiled pipes. Geothermal heat pumps take advantage of the soil moderate temperatures both in winter and summer to cool or heat houses. So, these systems do not require geothermal reservoirs, but will require excavations of around 2 meters for the installation of the coiled pipes.

Score	0	1	2	3
m	< 1	1 -> 1.5	1.5 -> 2	> 2

2. The more space available (m^2), the easier and more economical the installation.

Score	0	1	2	3
m^2	< 100	100 -> 250	250 -> 500	> 500

Evaluation for **RES heat pump** should be the result of the 2 requisites.
Example: For a site with:
Excavation for the heat pipes 3 m available: 03
Availability of 100 m^2 – 01

RES geothermal heat pump = (Req.1 + Req.2)/2=
= [(3) + (1)]/2 = 2

Virtual power plants

[Var 4]

1. Existence of EMS, sensors and actuators

Score	0	1
Yes/No	No	Yes

2. Existence of a VPP controller

Score	0	1
Yes/No	No	Yes

3. Existence of VPP regulation and contracts with prosumers

Score	0	1
Yes/No	No	Yes

4. Existence of a transparent, accountable, fair transaction ledger system

Score	0	1
Yes/No	No	Yes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr><td></td><td>Evaluation for Virtual power plant should be the result of the 3 requisites. Example: For a site with:

Existence of HEMS, sensors and actuators: Yes - 01
Existence of a VPP controller: Yes - 01
Existence of regulations and contracts: Yes – 01
Existence of transaction ledger: Yes - 01

VPP = (Req.1 * Req.2 * Req.3* Req.4) * 3=
= [(1)* (1)* (1)* (1)]*3 = 3</td></tr>
<tr><td>Energy storage
[Var 5]</td><td>1. Does the battery increase the PV self-consumption in about 50%?

Score | 0 | 1
Yes/No | No | Yes

2. Does the battery system represent less than 50% of the total investment cost (PV + battery)?

Score | 0 | 1
Yes/No | No | Yes

3. Available space: about 1 to 2 m^2 of wall area (batteries are usually placed on the wall)

Score | 0 | 1
Yes/No | No | Yes

Evaluation for Energy storage should be the result of the 2 requisites. Example: For a site with:

The battery increases the PV self-consumption in about 50%: Yes - 01
The battery system represents less than 50% of the total investment cost: Yes - 01
Available space of 3 m^2: Yes – 01

VPP = (Req.1 * Req.2 * Req.3) * 3=
= [(1) * (1) * (1)] *3 = 3</td></tr>
<tr><td>Demand response
[Var 6]</td><td>1. EMS and at least 3 kW of controllable loads (examples washing machine, dishwasher machine, water heater, heating/cooling devices, etc)

Score | 0 | 1 | 2 | 3</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>kW</td><td>< 2</td><td>2 -> 3</td><td>3 -> 5</td><td>> 5</td></tr>
</table>
<hr>
Evaluation for Demand response should be the result of the 2 requisites. Example: For a site with:

Controllable load 4 kW: 02

Demand response = 02
</td>
</tr>
<tr>
<td>Microgrids
[Var 7]</td>
<td>
1. Grid that allows independent grid operation
<table>
<tr><td>Score</td><td>0</td><td>1</td></tr>
<tr><td>Yes/No</td><td>No</td><td>Yes</td></tr>
</table>
2. Microgrid controller
<table>
<tr><td>Score</td><td>0</td><td>1</td></tr>
<tr><td>Yes/No</td><td>No</td><td>Yes</td></tr>
</table>
3. Existence of regulation and contracts
<table>
<tr><td>Score</td><td>0</td><td>1</td></tr>
<tr><td>Yes/No</td><td>No</td><td>Yes</td></tr>
</table>
<hr>
Evaluation for Microgrids should be the result of the 3 requisites. Example: For a site with:

Independent blocks operation Yes - 01
Microgrid controller: Yes - 01
Regulation and contracts in place: Yes – 01

Microgrids = (Req.1 * Req.2 * Req.3) * 3=
= [(1) * (1) * (1)] *3 = 3
</td>
</tr>
<tr>
<td>Energy infrastructure planning
[Var 8]</td>
<td>
1. Energy infrastructure planning developed with relevant stakeholders– Stakeholders identified, existing communication channels
<table>
<tr><td>Score</td><td>0</td><td>1</td></tr>
<tr><td>Yes/No</td><td>No</td><td>Yes</td></tr>
</table>
2. Integration of the outputs of the work with relevant stakeholders in the Energy infrastructure planning
</td>
</tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr><td></td><td>

0	1	2	3
None	Low integration	Well-developed integration	Advanced integration

Evaluation for **Energy infrastructure planning** should be the result of the 2 requisites. Example: For a site with:

Energy infrastructure planning developed with relevant stakeholders Yes - 01
Well-developed integration of the outputs of the work with relevant stakeholders: 02

Microgrids = (Req.1 * Req.2) =
= (01) * (02) = 02
</td></tr>
<tr><td>**EMS (Energy Management Systems)**

[Var 9]</td><td>

1. Existence of EMS, sensors, actuators

0	1	2	3
None	Low availability	High availability	Extremely high availability

Evaluation for **Energy Management Systems.** Example: For a site with:

Existence of EMS, sensors, actuators in a high number: Yes - 02

EMS = (Req.1) = 02
</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **social requirements** for **PED** is presented in the next table:

Table 49. Social requirement's evaluation for PED

<table>
<tr><th>Technology</th><th>Social Requirements Evaluation</th></tr>
<tr><td>[Var 43]</td><td>1. Policies and regulation frameworks to support PED conceptualization, implementation and stakeholder's engagement, including co-creation

Score: 0 = No; 1 = Yes

Policies and Regulations: yes: 01

Req.1 = 01</td></tr>
<tr><td>[Var 44]</td><td>1. Incorporation of innovative investment valuation methodologies such as dynamic evaluation[23], scenario analysis, or at least cost-benefits analysis, risk analysis and RoI (Return on Investment), all integrating social impacts.

Score: 0 = No; 1 = Yes

innovative investment valuation methodologies: yes: 01
Req.1 = 01</td></tr>
<tr><td>[Var 45]</td><td>1. Community energy initiatives led by citizens and households

Score: 0 = No; 1 = Yes

Community energy initiatives: yes: 01
Req.1 = 01</td></tr>
<tr><td>[Var 46]</td><td>1. Community energy initiatives funding

Score: 0 = No; 1 = Yes

Community energy funding: yes: 01
Req.1 = 01</td></tr>
</table>

Each Score / Yes/No sub-table:

Score	0	1
Yes/No	No	Yes

[23] Mazzucato, *Mission Economy A Moonshot Guide to Changing Capitalism*, page 179, Allen Lane, Dublin, 2021.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

[Var 47]

1. Transparency, openness and inclusiveness in the decision making process and procedures to guarantee trust/fairness in the technology implementation and in the decision makers/relevant stakeholder relation

0	1	2	3
None	Low transparency	High transparency	Extremely high transparency

Transparency, openness and inclusiveness in the decision making: High: 02
Req.1 = 02

[Var 48]

1. Existence of short, medium and long term strategies at the city level that involve the local community in planning PED projects.

0	1	2	3
None	Some strategies	Not many strategies	Many strategies

Existence long term strategies: 2
Req.1 = 02

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **technical requirements** for **Mobility** is presented in the next table:

Table 50. Technical requirement's evaluation for Mobility

<table>
<tr><th>Technology</th><th>Technical requirements Evaluation</th></tr>
<tr><td>E-mobility

[Var 10]</td><td>1. Existence of fast charging capabilities

<table><tr><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>0 – 10 [kW]</td><td>10 – 20 [kW]</td><td>20 – 50 [kW]</td><td>>50 [kW]</td></tr></table>

2. Existence of sufficient parking space for charging 2 to 4 vehicles and preferably near a transformer substation (less than 50 meters)

<table><tr><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>None</td><td>Between 1 and 2 (including 1 &2)</td><td>Between 3 and 4 (including 3 &4)</td><td>More than 4 parking places</td></tr></table>

3. Existence of EV charger equipment that is universal and compatible with most automobile brands

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>

4. Existence of Contract with energy retailer for the supply of the charging station

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
<hr>
Evaluation for E-mobility should be the result of the 6 requisites.
Example: For a site with:

Existence of fast charging capabilities: 15 kW- 01
Existence of 6 parking space: 03
Existence of EV charger equipment: Yes – 01
Existence of Contract with energy retailer: Yes - 01
E-mobility = (Req. 1 + Req.2)/2 * (Req.3 * Req.4) * =
= (1+3)/2 (1*1) = 2</td></tr>
<tr><td>Mobility hubs

[Var 11]</td><td>1. Identification of the spots where is more interesting to install EV charging stations, for example railway stations, light rail stations.

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table></td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

SPARCS

	2. The mobility infrastructure works in an integrated way in terms of connections between public transportation (light rail, boats, buses, etc) and their schedules Score | 0 | 1 Yes/No | No | Yes 3. Discounts for integrated passes of public transportation Score | 0 | 1 Yes/No | No | Yes 4. Management of the electric scooter's logistics to the places/stations with higher demand Score | 0 | 1 Yes/No | No | Yes Evaluation for **mobility-hubs** should be the result of the 5 requisites. Example: For a site with: Identification of spots: Yes - 01 Integrated mobility infrastructure: Yes - 01 Discounts for integrated passes: Yes – 01 Management of the scooter's logistics: Yes - 01 E-mobility = (Req.1 *Req.2* Req.3 * Req.4) * 3 = = (1*1*1*1)*3 = 3
V2grid **[Var 12]**	1. Cars equipped with V2G technology (bidirectional vehicles) Score | 0 | 1 Yes/No | No | Yes 2. Existence of V2G regulation and contracts Score | 0 | 1 Yes/No | No | Yes 3. System integration with VPP controller or DSO Score | 0 | 1 Yes/No | No | Yes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr><td></td><td>
4. Adequate V2grid infrastructures (charge points) at the city level

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>

Evaluation for V2G should be the result of the 4 requisites. Example: For a site with:

Cars equipped with V2G tech: Yes - 01
Existence of V2G regulation and contracts: Yes - 01
System integration with VPP controller: Yes – 01
Adequate V2grid infrastructures: Yes - 01

V2G = (Req.1 *Req.2* Req.3 * Req.4) * 3 =
= (1*1*1*1)*3 = 3
</td></tr>
<tr><td>EV integration in VPP

[Var 13]</td><td>
1. Cars equipped with V2G technology (bidirectional vehicles)

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>

2. Existence of V2G regulation and contracts

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>

3. System integration with VPP controller or DSO

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>

Evaluation for EV integration in VPP should be the result of the 3 requisites. Example: For a site with:
Cars equipped with V2G tech: Yes - 01
Existence of V2G regulation and contracts: Yes - 01
System integration with VPP controller: Yes – 01

EV integration in VPP = (Req.1 *Req.2* Req.3 * Req.4) * 3 =
= (1*1*1*1)*3 = 3
</td></tr>
<tr><td>Last-mile electrification

[Var 14]</td><td>
1. Availability of well-located charging points

<table><tr><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>None</td><td>Between 1 and 2 (including 1 &2)</td><td>Between 3 and 4 (including 3 &4)</td><td>More than 4 parking places</td></tr></table>
</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

2. Existence of safe roads and dedicated lanes for soft mobility

0	1	2	3
None	Some safe roads	Average number of safe roads	High number of safe roads

Evaluation for **Last-mile electrification** should be the result of the 2 requisites. Example: For a site with:

Availability of 5 well-located charging points: Yes - 03
High number of safe roads & dedicated lanes for soft mobility:03

Last mile electrification = (Req.1 +Req.2)/2 =
= (3+3)/2 = 3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **social** requirements for **Mobility** is presented in the next table:

Table 51. Social requirement's evaluation for Mobility

<table>
<tr><th>Technology</th><th>Social requirements Evaluation</th></tr>
<tr><td>Policy Framework e-mobility

[Var 49]</td><td>1. Policy frameworks and political commitment at the city level to directly promote e-mobility

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
Evaluation for Policies frameworks for e-mobility:

Policies frameworks for e-mobility: Yes - 01

Policy frameworks = (Req.1)*3 = 3</td></tr>
<tr><td>Policy Framework V2G

[Var 50]</td><td>1. Policy frameworks and political commitment at the city level to support the V2grid infrastructures

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
Evaluation for Policies frameworks for V2G:
For a site with:

Policies frameworks for V2G: Yes - 01

Policy frameworks = (Req.1)*3 = 3</td></tr>
<tr><td>User acceptance for e- vehicles

[Var 51]</td><td>1. Foster user acceptance for electric vehicles through engagement activities focused on advantages/benefits/positive externalities (environmental sustainability; cost-effectiveness, etc.)

<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
Evaluation for User acceptance:
For a site with:

Policies frameworks for V2G: Yes - 01

Policy frameworks = (Req.1)*3 = 3</td></tr>
<tr><td>Develop end-users profiling

[Var 52]</td><td>1. Develop end-users (citizens) profiling (e.g surveys; questionnaires) related to environmental/technology-friendly driving, behaviours and preferences to adequate the offer (complying with theGDPR).</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Score	0	1
Yes/No	No	Yes

Evaluation for **end-users profiling:**
For a site with:

Policies frameworks for V2G: Yes - 01

Policy frameworks = (Req.1)*3 = 3

Evaluation for **end-users profiling:**
For a site with:

End-users profiling: Yes - 01

Policy frameworks = (Req.1)*3 = 3

Orography

[Var 53]

1. Orography of the District (important for the e-bikes and e-scooters)

0	1	2	3
Not adequate	Highs and lows	Some ups and downs	Completely flat

Evaluation for **orography:**
For a site with:

Highs and lows : 01

Orography = (Req.1) = 1

Transport infrastructure Quality

[Var 54]

1. Transport infrastructure quality (equipment's quality, availability of bicycle lanes, between others....)

0	1	2	3
None	Low	High	extremely high

Evaluation for **transport infrastructure quality:**
For a site with:

Good transport infrastructure : 02

Transport infrastructure = (Req.1) = 02

Transport infrastructure availability

[Var 55]

1. Transport infrastructure availability (Public transportation lines, # of stops per km, frequency of services, between others)

0	1	2	3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>None</td><td>Low</td><td>Good</td><td>Extremely Good</td></tr>
</table>
<hr>
Evaluation for transport infrastructure availability:
For a site with:

Good Transport infrastructure : 002

Transport infrastructure = (Req.1) = 02
</td>
</tr>
<tr>
<td>Transport infrastructure Types

[Var 56]</td>
<td>
1. Transport types (Bus, Subway, Train, Suburban Rail)

<table>
<tr><th>0</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>None</td><td>1 to 2</td><td>2 to 3</td><td>Equal or greater than 4</td></tr>
</table>
<hr>
Evaluation for Stock of vehicles:
For a site with:

2transort types: 02

Stock of vehicles = 02
</td>
</tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **technical** requirements for **New economy** is presented in the next table:

Table 52. Technical requirement's evaluation for New Economy

<table>
<tr><th>Solution</th><th>Technical requirements</th></tr>
<tr><td>Smart business models

[Var 15]</td><td>1. Literacy regarding New Business

<table><tr><td>0
No literacy</td><td>1
Low developed literacy</td><td>2
Well-developed literacy</td><td>3
Advanced literacy</td></tr></table>

2. Users engaged – users identified, efficient and effective communication channels

<table><tr><td>0
No engagement</td><td>1
Low engagement</td><td>2
High engagement</td><td>3
Extreme high level</td></tr></table>

3. Regulation on New Business models

<table><tr><td>0
No regulation</td><td>1
Basic regulation</td><td>2
Good regulation</td><td>3
Extreme well designed and comprehensive</td></tr></table>

Evaluation for Smart Business models should be the result of the three requisites. Example: For a site with:

High level of literacy regarding New Business: 01
Users engaged: High level – 02
Regulations on New Business: Basic regulation - 01

Smart Business Models = Req.1 * (Req.2 +Req.3)/2 = (1)*[(2)+(1)]/2 = 1.5</td></tr>
<tr><td>Smart governance models

[Var 16]</td><td>1. Literacy regarding Urban transformation

<table><tr><td>0
No literacy</td><td>1
Low developed literacy</td><td>2
Well-developed literacy</td><td>3
Advanced literacy</td></tr></table>

2. Urban transformation co-creation – users identified, existing communication channels
<table><tr><td>0
No users engaged & no communication channels</td><td>1
Low users' engagement &/or not so good communication channels</td><td>2
High users' engagement &/or good communicationchannels</td><td>3
users highly engaged & good communication channels</td></tr></table></td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

3. Urban transformation financing models

0	1	2	3
No financing models	Low developed financing models	Well-developed financing models	Advanced financing models

4. Urban transformation governance models

0	1	2	3
No governance models	Low developed governance models	Well-developed governance models	Advanced governance models

5. Urban transformation procurement

0	1	2	3
No U.T. procurement	Low level of urban transformation procurement implemented	Well-developed urban transformation procurement	Advanced urban transformation procurement

6. Regulation on smart governance models

0	1	2	3
No regulation on smart gov. models	Low level of regulation on smart governance models	Well-developed regulation on smart governance models	Advanced regulation on smart governance models

7. Coordination mechanisms for networked urban development

0	1	2	3
None	Low level	Well-developed	Advanced

8. Promotion of direct social engagement activities involving local communities in planning, implementation of smart governance models

0	1	2	3
No social engagement activities	Low level of social engagement activities	Well-developed social engagement activities	Advanced social engagement activities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Evaluation for Smart Governance models should be the result of the 8 requisites. Example: For a site with: Literacy regarding urban transformation: Advanced - 01 Urban Transformation co-creation – high users' engagement: 02 Urban transformation financing model well developed – 02 Urban transformation governance model - Advanced – 03 Urban transformation procurement – low level – 01 Regulations on Smart governance models- well developed - 02 Coordination mechanisms for networked urban development – Advanced: 03 Promotion of direct social engagement… – well developed - 02 Smart Governance Models = (Req.1 + Req.2 +Req.3+ Req.4+ Req.5 +Req.6 + Req.7 + Req.8)/8= [(3)+(2)+(2)+ (3)+(1)+(2)+ (3)+(2)]/8 = 2.25
Engaging users in new business **[Var 17]**	1. Literacy regarding New Business models 0: No literacy; 1: Low developed literacy; 2: Well-developed literacy; 3: Advanced literacy 2. Existence of a Peer-to-peer energy marketplace 0: No; 1: Yes 3. Existence of personalized Informative billing using real-time energy prices 0: No; 1: Yes 4. Existence of a benchmarking informative system to compare user consumption. 0: No; 1: Yes Evaluation for Engaging users in new business should be the result of the 4 requisites. Example: For a site with: Literacy regarding new business: Yes - 01 Existence of a peer, to peer …–: Yes - 01 Existence of personalized Informative billing Yes – 01 Existence of a benchmarking informative system: Yes – 01 Engaging users = (Req.1 * Req.2 * Req.3* Req.4)*3 = (1*1*1*1)*3 = 3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr>
<td>

Co-creating new business models

[Var 18]

</td>
<td>

1. Literacy regarding New Business

0	1	2	3
No literacy	Low developed literacy	Well-developed literacy	Advanced literacy

2. Users engaged – users identified, efficient and effective communication channels

0	1	2	3
No users engaged	Low level of users engaged	Well-developed level of users engaged	Advanced level of users engaged

3. Regulation on New Business

0	1	2	3
No Regulation	Low developed Regulation	Well-developed Regulation	Advanced Regulation

4. Urban transformation co-creation – users identified, existing communication channels

0	1	2	3
No U.T. co-creation	Low level of urban transformation urban transformation co-creation	Well-developed level urban transformation co-creation	Advanced urban transformation co-creation

5. Develop new financing models through partnerships involving community cooperatives/public/private sector.

0	1	2	3
No financing	Low level of financing	Well-developed financing	Advanced financing

Evaluation for Co-creating new business modes should be the result of the 5 requisites. Example: For a site with:

Literacy regarding new business: Advanced - 03
Users engaged – well developed : 02
Regulation on new business: Advanced - 03
Urban transformation co-creation – Advanced -:03
Develop new financing models – Advanced:03

</td>
</tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

SPARCS

<table>
<tr><td></td><td>Co-creating new business models = (Req.1 +Req.2+ Req.3 + Req.4+ Req.5) = (03+02+03+03+03)/5 = 2.8</td></tr>
<tr><td>Bankable smart cities solutions

[Var 19]</td><td>1. Existence of a catalogue with bankable solutions encompassing user-centric, carbon-free buildings, smart technologies applied to the district and to mobility and all connected services

<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
2. Existence of an innovation ecosystem enabling the development of the bankable smart city solutions to be worldwide replicated

<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
3. Promote dissemination activities focused on bankable smart cities solutions reaching out to hard-to-reach group

<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
<hr>
Evaluation for Bankable smart cities solutions should be the result of the 3 requisites. Example: For a site with:

Catalogue with bankable solutions: Yes - 01
Existence of an innovation ecosystem: Yes - 01
Promote dissemination activities – 01
Bankable smart cities solutions = (Req.1 * Req.2 *Req.3)*3 = (1*1*1)*(3) = 3</td></tr>
<tr><td>Smart local sustainable businesses

[Var 20]</td><td>1. Existence of an ecosystem enabling the creation of smart local sustainable businesses: market potential, prospective businesses plans, municipal support, joint procurement

<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
<hr>
Evaluation for Smart local sustainable businesses:

Yes - 01
No – 0
Smart local sustainable businesses = (Req.1)*3 =
Yes (1)*(3) = 3
No (0)*(3) = 0</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

V2grid monetization

[Var 21]

1. Existence of grid connection points permitting the bidirectional charging of vehicles

0	1
No	Yes

2. Existence of a metering system enabling the electrical bidirectional flow quantification

0	1
No	Yes

3. Regulation allowing the electricity grid charging and monetization

0	1
No	Yes

4. Existence of a demand response system facilitating V2G flexibility use

0	1
No	Yes

5. Existence of a life cycle cost evaluation of the V2G operation

0	1
No	Yes

6. Clear definition of the V2G overall costs (OPEX, CAPEX) allocated

0	1
No	Yes

Evaluation for **V2grid monetization** should be the result of the 6 requisites for a site with:

Existence of bidirectional grid connection points: Yes – 01 // No - 0
Existence of a bidirectional metering system: Yes – 01 // No - 0
Regulation allowing electricity grid charging and monetization: Yes – 01 // No - 0
Existence of V2G demand response: Yes – 01 // No - 0
Existence of a life cycle cost evaluation: Yes – 01 // No - 0
Clear definition of the V2G overall costs: Yes – 01 // No - 0

V2grid monetization = (Req.1 * Req.2 *Req.3 * Req.4 * Req.5 *Req.6)*3

If all exist = (1*1*1*1*1*1)*(3) = 3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr><td></td><td>If one fails= (0*1*1*1*1*1)*(3) = 0</td></tr>
<tr><td>Dynamic pricing of EV charging

[Var 22]</td><td>
1. Existence of grid connection points permitting the bidirectional charging of vehicles
<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
2. Regulation allowing the electric vehicle charging and dynamic pricing
<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
3. Existence of a demand response system facilitating V2G flexibility use
<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
4. Existence and application of dynamic pricing models for electric vehicle charging and price of electricity depending on the flexibility resource the EV can bring.
<table><tr><td>0</td><td>1</td></tr><tr><td>No</td><td>Yes</td></tr></table>
<hr>
Evaluation for Dynamic pricing of EV charging should be the result of the 4 requisites for a site with:

Existence of bidirectional grid connection points: Yes – 01 // No - 0
Regulation allowing electricity grid charging and dynamic pricing: Yes – 01 // No - 0
Existence of V2G demand response: Yes – 01 // No - 0
Dynamic pricing models depending on flexibility: Yes – 01 // No – 0

Dynamic pricing of EV charging = (Req.1 * Req.2 *Req.3 * Req.4)*3

If all exist = (1*1*1*1)*(3) = 3
If one fails= (0*1*1*1)*(3) = 0
</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **technical** requirements for **Urban innovation** is presented on the next table:

Table 53. Technical requirement's evaluation for Urban innovation

<table>
<tr><th>Solution</th><th>Technical requirements</th></tr>
<tr><td>Engaging users
[Var 23]</td><td>
1. Literacy regarding Urban Innovation
<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>No literacy</td><td>Low developed literacy</td><td>Well-developed literacy</td><td>Advanced literacy</td></tr>
</table>
2. Urban innovation user involvement in co-creation– users identified, existing communication channels
<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>No engagement</td><td>Low engagement</td><td>High engagement</td><td>Extreme high level</td></tr>
</table>
<hr>
Evaluation for Engaging users should be the result of the 2 requisites.
Example: For a site with:

Advanced level of literacy regarding urban innovation: 03
Users involved: High level – 02

Engaging users = [(Req.1)+ (Req.2)]/2 = (3+2)/2 = 2.5
</td></tr>
<tr><td>Sustainable lifestyle
[Var 24]</td><td>
1. Definition by the municipality of a Sustainable lifestyle roadmap
<table>
<tr><td>0</td><td>1</td></tr>
<tr><td>No</td><td>Yes</td></tr>
</table>
2. Literacy regarding Sustainable lifestyle (includes the adoption by the municipality of a Sustainable definition)
<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>None literacy</td><td>Low literacy</td><td>High literacy</td><td>Extremely high literacy</td></tr>
</table>
3. User involvement in Sustainable lifestyle – users identified, existing communication channels (includes the implementation by the municipality of a Sustainable lifestyle paradigm)
<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>No involvement</td><td>Low involvement</td><td>High involvement</td><td>Extreme high involvement</td></tr>
</table>
</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

SPARCS

	4. The Sustainable lifestyle roadmap should include solutions for optimizing people's flow (urban) regarding energy and user experience, should identify benefits and the added value for citizen and other stakeholders in different district lifecycle phases 0: No Sustainable lifestyle roadmap; 1: Low developed Sustainable lifestyle roadmap; 2: Well-developed Sustainable lifestyle roadmap; 3: Advanced Sustainable lifestyle roadmap 5. Solution included in the Sustainable lifestyle roadmap (Mobility, construction and energy solutions, by offering teaching and education supporting a sustainable lifestyle, by providing culture, sports and social and health care services enhancing wellbeing and by maintaining comfortable nature and the nearby green areas) 0: Zero solutions included; 1: More than 1 and less than 3 solutions included; 2: More than 3 and less than 6 solutions included; 3: More than 6 solutions included Evaluation for Sustainable lifestyle should be the result of the 6 requisites. Example: For a site with: Literacy regarding urban transformation: Yes - 01 Literacy regarding Sustainable lifestyle – high: 02 User involvement in Sustainable lifestyle – extremely – 02 Sustainable lifestyle roadmap – Avanced - 03 Solution included in the Sustainable lifestyle roadmap – 5 solutions – 02 Smart Governance Models = Req.1 * (Req.2 +Req.3+ Req.4+ Req.5)/4= (1)*[(2)+(2)+ (3)+(2)]/4 = 2.25
Cocreation for PED developments **[Var 25]**	1. Existence of an established PEB/PED methodology 0: No; 1: Yes 2. Stakeholders involvement in PEB/PED co-creation 0: No involvement; 1: Low involvement; 2: High involvement; 3: Extreme high involvement Evaluation for Engaging users in new business should be the result of the 2 requisites. Example: For a site with: Existence of an established PEB/PED methodology: Yes - 01 High stakeholders involvement in PEB/PED co-creation: 02 Cocreation for PED= Req.1 * Req.2 = 1*2 = 2

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Induce citizens behaviour towards energy positiveness

[Var 26]

1. Literacy regarding Energy Positiveness

0	1	2	3
No literacy	Low developed literacy	Well-developed literacy	Advanced literacy

2. Stakeholders involvement in energy positiveness

0	1	2	3
No Stakeholders engaged	Low level of Stakeholders engaged	Well-developed level of Stakeholders engaged	Advanced level of Stakeholders engaged

3. Existence of a system to allow bi-directional communication between users and the municipality

0	1
No	Yes

4. End-users (citizens/owners) characterization (preferences/ expectations/ behaviour) in order to adapt the technology (e.g through surveys; questionnaires, etc.)

0	1	2	3
No characterization	Low level of characterization	Well-developed characterization	Advanced characterization

Evaluation for Co-creating new business modes should be the result of the 4 requisites. Example: For a site with:

Literacy regarding Energy Positiveness: Advanced - 03
Advanced level of Stakeholders involvement in energy positiveness: 03
Existence of a system to allow bi-directional communication – 01
-users (citizens/owners) characterization – Advanced - 03

Induce citizens behaviour towards PED = (Req.3)*(Req.1 + Req.2+ Req.4) = (1)*(03+03+03)/3 = 3

Optimize people's flow

[Var 27]

1. Existence of data regarding citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives

0	1	2	3
No data	Limited available data	Available data	Highly available data

2. Use of the data on people's mobility to optimize the people flow from energy and user experience perspectives

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

0	1	2	3
No use of data	Low use of data	Well-developed use of data	Advanced use of data

Evaluation for **Optimize people's flow** should be the result of the 2 requisites. Example: For a site with:

Highly available data: 03
Low use of data: 01
Optimize people's flow = (Req.1 + Req.2)/2 = (03+01)/2 = 2

City planning district development

[Var 28]

1. Existence of inclusive management, cooperation and planning models (includes the participation of companies, city planning departments, citizens and research organizations)

0	1	2	3
None	Low cooperation and planning	Average cooperation and planning	High cooperation and planning

2. Definition by the municipality of the smart city paradigm

0	1	2	3
No definition	The definition appears in a granular way	The definition is structured	Extremely clear and well-articulated

3. Stakeholders involvement in co-creation models for smart city planning, guaranteeing that their inputs are considered – users identified, existing communication channels orchestrated by the municipality or other governing institution

0	1	2	3
No Stakeholders involved	Low level of Stakeholders involved	Well-developed level of Stakeholders involved	Advanced level of Stakeholders involved

4. Clear political commitment with the local community

0	1	2	3
None commitment	Low commitment	High commitment	Extremely high commitment

5. Public accountability involving policy makers at different levels of governance/government

0	1	2	3
None accountability	Low accountability	High accountability	Extremely high accountability

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Evaluation for City planning district development should be the result of the 5 requisites for a site with:

Low cooperation: 01
Structured definition by the municipality of the smart city paradigm: 02
Stakeholders involvement - Advanced– 03
Clear political commitment – Extremely high - 03
Public accountability – Low– 01

City planning district development = (Req.1 + Req.2 + Req.3+ Req.4+ Req.5)/5= [1+2+3+ 3+1]/5 = 2

Promotion of soft mobility

[Var 29]

1. Existence of data regarding citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives

0	1	2	3
No data	Limited available data	Available data	Highly available data

2. Use of the data on people's mobility to optimize the people flow from energy and user experience perspectives

0	1	2	3
No use of data	Low use of data	Well-developed use of data	Advanced use of data

3. Existence of integrated sustainable strategies connecting Metro and e-bicycle modes, to boost e-mobility in the district

0	1
No	Yes

Evaluation for Promotion of soft mobility should be the result of the 3 requisites for a site with:

Available data regarding citizens' preferable future mobility: 02
Low use of the data on people's mobility ....: 01
Existence of integrated sustainable strategies connecting different mobility systems: Yes – 01 // No - 0

Promotion of soft mobility = [(Req.1 + Req.2) *Req.3]/2

Promotion of soft mobility = = (02+01)*1/2= 1.5

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **technical** requirements for **ICT** is presented on the next table:

Table 54. Technical requirement's evaluation for ICT

<table>
<tr><th>Technology</th><th>Technical requirements Evaluation</th></tr>
<tr><td>ICT for PEB
[Var 30]</td><td>
1. Digital platforms availability
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
2. Availability of historical data, consumption, generation , etc.
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
3. Availability of data streams
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
4. Data analysts
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
5. Internet connections and mobile phones
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
6. 5G infrastructure availability
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
7. Blockchain infrastructure availability
<table><tr><td>Score</td><td>0</td><td>1</td></tr><tr><td>Yes/No</td><td>No</td><td>Yes</td></tr></table>
<hr>
Evaluation for ICT for PEB should be the result of the 7 requisites.
Example: For a site with:

Digital Platforms availability: Yes - 01
Availability of historical data: Yes - 01
Availability of data streams: Yes – 01
Data analysis: Yes - 01
</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

	Internet connections and mobile phones: Yes - 01 5G infrastructure availability: Yes – 01 Blockchain infrastructure availability: Yes – 01 PED = (Req.1 *Req.2* Req.3 * Req.4* Req.5* Req.6* Req.7) * 3 = = (1*1*1*1*1*1*1)*3 = 3
Smart business models **[Var 31]**	1. Business model's creation expertise Score: 0 = No, 1 = Yes 2. Budget for engagement activities Score: 0 = No, 1 = Yes 3. Engagement tools Score: 0 = No, 1 = Yes 4. City wide ecosystem with local SME and start-ups Score: 0 = No, 1 = Yes 5. Regulatory incentives for new services and business models Score: 0 = No, 1 = Yes Evaluation for **ICT for PEB** should be the result of the 5 requisites. Example: For a site with: Business model's creation expertise: Yes - 01 Budget for engagement activities: Yes - 01 Engagement tooling: Yes – 01 City wide ecosystem with local SME and start-ups: Yes - 01 Regulatory incentives for new services and models: Yes – 01 PED = (Req.1 *Req.2* Req.3 * Req.4* Req.5) * 3 = = (1*1*1*1*1)*3 = 3

Score tables (each of requisites 1–5 above):

Score	0	1
Yes/No	No	Yes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Virtual power plants

[Var 32]

1. Availability of controllable flexible loads

Score	0	1
Yes/No	No	Yes

2. Minimum capacity of flexibility according to the national energy market rules

Score	0	1
Yes/No	No	Yes

3. Aggregator business model availability

Score	0	1
Yes/No	No	Yes

4. Historical data for controllable flexible assets

Score	0	1
Yes/No	No	Yes

5. Continuous data collection infrastructure

Score	0	1
Yes/No	No	Yes

Evaluation for **VPP** should be the result of the 5 requisites.
Example: For a site with:

Availability of controllable flexible loads : Yes - 01
Minimum capacity of flexibility: Yes - 01
Aggregator business model availability: Yes – 01
Historical data for controllable flexible assets: Yes - 01
Continuous data collection infrastructure: Yes – 01

$$PED = (Req.1 * Req.2 * Req.3 * Req.4 * Req.5) * 3 =$$
$$= (1*1*1*1*1)*3 = 3$$

Virtual twins

[Var 33]

1. Digital twin platform populated with city models to simulate complex real scenarios

Score	0	1
Yes/No	No	Yes

2. Historical data regarding city assets operation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Score	0	1
Yes/No	No	Yes

3. Detailed models for city evolution

Score	0	1
Yes/No	No	Yes

Evaluation for **Virtual Twins** should be the result of the 3 requisites. Example: For a site with:

Digital twin platform: Yes - 01
Historical data: Yes - 01
Detailed models for city evolution: Yes – 01

PED = (Req.1 *Req.2* Req.3) * 3 =

= (1*1*1*1*1)*3 = 3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

The methodology for evaluating the **overall social requirements** for **all solutions** is presented on the next table:

Table 55. Overall Social requirement's evaluation

<table>
<tr><th>Solution</th><th>Technical requirements</th></tr>
<tr><td>Density of population

[Var 34]</td><td>1. Density population – density population that enable the feasibility of the solutions

<table>
<tr><td>Score</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Density of population [inhab/km^2]</td><td>0 -> 100</td><td>100 -> 500</td><td>500 -> 1000</td><td>>1000</td></tr>
</table>

Evaluation for Density of population:
For a site with:

Population density of about 800 inhabitant per square km:02

Req.1 = 02</td></tr>
<tr><td>Socio economic level

[Var 35]</td><td>1. Social economic level of the population

<table>
<tr><td>Score</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>GDP/inhab [k€/inhab]</td><td>0 -> 5</td><td>5 -> 15</td><td>15 -> 25</td><td>> 25</td></tr>
</table>

Evaluation for Social economic development, for a site with:

GDP per capita 20k€

Req.1 = 02</td></tr>
<tr><td>Population literacy PED

[Var 36]</td><td>1. Population literacy on PED, e-mobility, New Economy, Urban innovation
<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Extremely low</td><td>Low</td><td>High</td><td>Extreme high level</td></tr>
</table>

Evaluation for Population literacy on PED for a site with:

High literacy: 02

Req. 1= 02</td></tr>
</table>

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Ethical requirements

[Var 37]

1. Inclusion of ethical requirements/social objectives & priorities (e.g improve health conditions; include hard-to-reach groups, etc.) in contracts with end-users (citizens/owners)

0	1	2	3
No inclusion	Low inclusion	Well-developed inclusion	Advanced inclusion

Evaluation for inclusion ethical requirements for a site with:

Low inclusion – 01

Req. 1= 01

Social acceptance

[Var 38]

1. Social acceptance (perception of advantages/positive externalities - in terms of environmental sustainability, cost effectiveness, risks) from technology implementation

0	1	2	3
No acceptance	Low acceptance	High acceptance	Extremely High acceptance

Evaluation for social acceptance requirements for a site with:

Low acceptance– 01

Req. 1= 01

Technology's flexibility

[Var 39]

1. Technology's flexibility to address user's (citizens) needs

0	1	2	3
No flexibility	Low flexibility	High flexibility	Extremely high flexibility

Evaluation for Technology flexibility requirements for a site with:

Low flexibility– 01

Req. 1= 01

Friendliness of ICT technologies

[Var40]

1. Friendliness of ICT technologies

0	1	2	3
None friendliness	Low friendliness	High friendliness	Extremely high friendliness

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

<table>
<tr><td></td><td>
<hr>
Evaluation for ICT technologies friendliness requirements for a site with:

Low friendliness – 01

Req. 1= 01
</td></tr>
<tr><td>Data privacy/security mechanisms

[Var 41]</td><td>
1. Integration of privacy/security mechanisms for end-user’s data treatment on energy consumption

<table>
<tr><th>0</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>No integration</td><td>Low integration</td><td>High integration</td><td>Extremely high integration</td></tr>
</table>
<hr>
Evaluation for integration of privacy/security mechanisms requirements for a site with:

Low integration – 01

Req. 1= 01
</td></tr>
<tr><td>Solutions life-ling technical support

[Var 42]</td><td>
1. Existence of technical support for the solution/product through its life

<table>
<tr><th>0</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>None</td><td>Low support</td><td>High support</td><td>Extremely high support</td></tr>
</table>
<hr>
Evaluation for technical support for the solution for a site with:

Low support – 01

Req. 1= 01
</td></tr>
</table>

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 864242

8.2 Annex 02 – Excel Tool

We have built an excel tool that processes the 142 answers to the questions according with the Annex 01 methodology. In Maia's case the results are shown in the next tables:

Table 56 – Technical requirements evaluation SPARCS solutions in Maia

PEDs	Value	1	2	3	4	5	6	7	8	9
Renewable energy - PV	2,0	2	1							
Renewable energy - Wind	0,0	1	0	0						
Renewable energy - Geothermal Low entalphy	0,0	0								
Renewable energy - Geothermal High entalphy	0,0	0	0							
Renewable energy - Heat Pump	3,0	3	3							
VPP	0,0	1	0	0	0					
Energy storage	3,0	1	1	1						
Demand response	0,0	0								
Microgrids	0,0	0	0	0						
Energy infrastructure planning	0,0	0	0							
EMS (Energy Management Systems)	1,0	1								

Mobility	Value	1	2	3	4	5	6	7	8	9
E-mobility	3,0	3	3	1	1					
Mobility hubs	1,0	1	1	1	1	1				
V2grid	0,0	0	0	0	0					
EV integration in VPP	0,0	0	0	0						
Last mile electrification	1,0	1	1							

New Economy	Value	1	2	3	4	5	6	7	8	9
Smart business models	0,0	0	0	0						
Smart governance models	1,3	2	1	1	1	1	1	2	1	
Engaging users in new business	0,0	1	0	0	0					
Co creating new business models	1,2	1	2	1	1	1				
Bankable smart cities solutions	0,0	0	0	0						
Smart local sustainable businesses	0,0	0								
V2grid monetization	0,0	0	0	0	0	0	0			
Dynamic pricing of EV charging	0,0	0	0	0	0					

Urban Innovation	Value	1	2	3	4	5	6	7	8	9
Engaging users	1,3	1	1,5							
Sustainable lifestyle	2,0	1	2	2	1	3				
Cocreation for PEB developments	0,0	0	0							
Induce citizens behaviour towards energy positivenes	1,0	1	1	1	1					
Optimize people's flow	1,5	2	1							
City planning district development	1,8	3	1	2	2	1				
Promotion of soft mobility	2,0	1	1	1						

ICT	Value	1	2	3	4	5	6	7	8	9
ICT for PEB	0,0	1	1	1	1	1	0	0		
Smart business models	3,0	1	1	1	1	1				
Virtual power plants	0,0	1	0	0	1	0				
Virtual twins	0,0	0	1	0						

		Overall Social requirements								
Overall Social	Value	1	2	3	4	5	6	7	8	9
Population – number of people	2,0	2								
Social economic level of the population	2,0	2								
Population literacy on the technical solutions	1,0	1								
Ethical requirements/social objectives	1,0	1								
Social acceptance	2,0	2								
Technology's flexibility to user's/citizens needs	2,0	2								
Friendliness of ICT technologies	2,0	2								
Integration of privacy/security mechanisms	3,0	3								
Support for the solution/product through its life	1,0	1								

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242

Table 57 – Overall Social requirements evaluation for SPARCS solutions in Maia

Overall Social	Value
Population – number of people	2,0
Social economic level of the population	2,0
Population literacy on the technical solutions	1,0
Ethical requirements/social objectives	1,0
Social acceptance	2,0
Technology's flexibility to user's/citizens needs	2,0
Friendliness of ICT technologies	2,0
Integration of privacy/security mechanisms	3,0
Support for the solution/product through its life	1,0

Table 58 – Social requirements for PED evaluation

Social PED	Value
Policy framework PED	0
Innovative investment evaluation meth.	0
Community energy initiatives led by citizens	0
Community energy initiatives funding	3
Transparency, openess and inclusiveness in decision making	2
Short, medium and long term strategies planning PED	1

Table 59 – Social requirements for mobility evaluation

Social mobility	Value
Policy framework mobility	3
Policy framework V2G	0
User acceptance e-vehicles	3
Develop end-user profiling	3
Orography	1
Transport infrastructure quality	1
Transport infrastructure availabiity	1
Transport infrastructure types	1

From these results, we have built the resulting graphs: Figure 4, Figure 5, Figure 6 and Figure 7 presented in the Chapter 5.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242