D6.6 Recommendations on cross-cutting issues

30/09/2023

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Deliverable administration

No & name	**D6.6 Recommendations on cross-cutting issues**				
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Description of the related task and the deliverable. Extract from DoA	**T6.2 Building recommendations on cross-cutting issues (VTT) [M1-M60]** T6.2 will build recommendations on agreed crosscutting issues using project knowledge to contribute to on-going work and filling the existing gaps. In particular, activities should be organized with the 2018 financed projects in order to build on call specificities. The activities for the exchange and consolidation of knowledge, to issue the recommendations will be synchronized with the correspondent project meetings and workshops, adding a dedicated agenda. Each crosscutting issue will have a responsible SPARCs partner who will also manage the cooperation activities with the SCC1 cluster on these issues. Issues and task responsibilities in SPARCs: Impact monitoring (MOH), Effective business models for sustainable solutions (FHG), Regulatory and legal aspects (VTT), Data security/protection (SUITE5), Gender and Socioeconomics (Social Sciences and Humanities) (SPI), Storage solutions (from short-term to seasonal) (VTT), Big data, Data management and Digitalisation (SUITE5), Electro-mobility: i) its impact on energy system and ii) appropriate city planning measures to support large scale roll-out (VTT), Positive blocks (VTT), Citizens engagement (SPI) **D6.6 Recommendations on cross-cutting issues (VTT)** Report on preliminary recommendations on crosscutting issues using project knowledge to contribute to ongoing work and filling the existing gaps. Issues and task responsibilities in SPARCs: Impact monitoring (MOH), Effective business models for sustainable solutions (FHG), Regulatory and legal aspects (VTT), Data security/protection (SUITE5), Gender and Socioeconomics (Social Sciences and Humanities) (SPI), Storage solutions (from short-term to seasonal) (VTT), Big data, Data management and Digitalisation (SUITE5), Electro-mobility: i) its impact on energy system and ii) appropriate city planning measures to support large scale roll-out (VTT), Positive blocks (VTT), Citizens engagement (SPI). The deliverable is generated by task T6.2. (R/PU; M48,)				
Participants	ESP, LPZ, CMM, RVK, KLD, KFS, LVIV, KONE, SIE, PIT, CIT, RIL, ADV, FHG, WSL, LSW, CEN, ULEI, SPI, NEW, CVUT, MOH, NECU, LCE, CiviESCo, GOPA				
Comments					

VP	Date	Authors	Description
0.1	30/10/2022	WP Lead	Draft and discussion with partners
0.2	30/04/2023	All	Draft and discussion with partners

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0.3	10/08/2023	All	Revised and adding missing inputs
0.4	29/09/2023	WP leader	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1.0	29/09/2023	VTT	Coordinator submits the deliverable to the EC

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

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About SPARCS

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

Partners

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1 EXECUTIVE SUMMARY

SPARCS is one of the ongoing H2020 projects focusing on implementing and replicating Positive Energy Districts (PEDs) across seven European cities (two Lighthouses: Espoo, Leipzig; Five Fellow Cities: Maia, Reykjavik, Kladno, Kifissia and Lviv). The seven cities have planned 100+ actions that will turn the buildings, blocks, and districts into energy prosumers.

This deliverable provides practical recommendations on 10 cross-cutting issues. Cross-cutting issues are priority areas, which were identified and agreed upon by the SCC1 clusters during 2018 when new PED projects were to be financed (the clusters have now merged with the Smart city Marketplace).

The document targets several actors in order to support them in their PED implementation and replication journey: Enablers, Decision makers, Implementers and Multipliers.

Figure 1 illustrates the 10 cross-cutting issues, each having challenges relevant to the SPARCS cities. The recommendations are based on the SPARCS partners' experiences during the past 48 months, which has included a variety of PED demonstration actions such as installation of renewables, smart mobility services and joint procurement.

Some recommendations appear relevant for many of the cross-cutting issues:

- Introduce and align the regulations at least nationally, and preferably also at EU-level, learning from those countries where they are already applied. (Enablers)
- Lobby for the regulations that are needed for the efficient implementation and operation of PEDs, giving the regulators professional insights on what is needed. (Decision makers, Implementers and Multipliers)
- Engage/ communicate with the stakeholders early on in the project, especially the final users of the buildings and equipment. Provide information in a format suitable for the target group. Continue the communication and education of the users and stakeholders during the operational phase. (Decision makers, Implementers)
- Pilot and test the solutions in smaller scale. Share the learnings with other similar actors. (Implementers, Multipliers)

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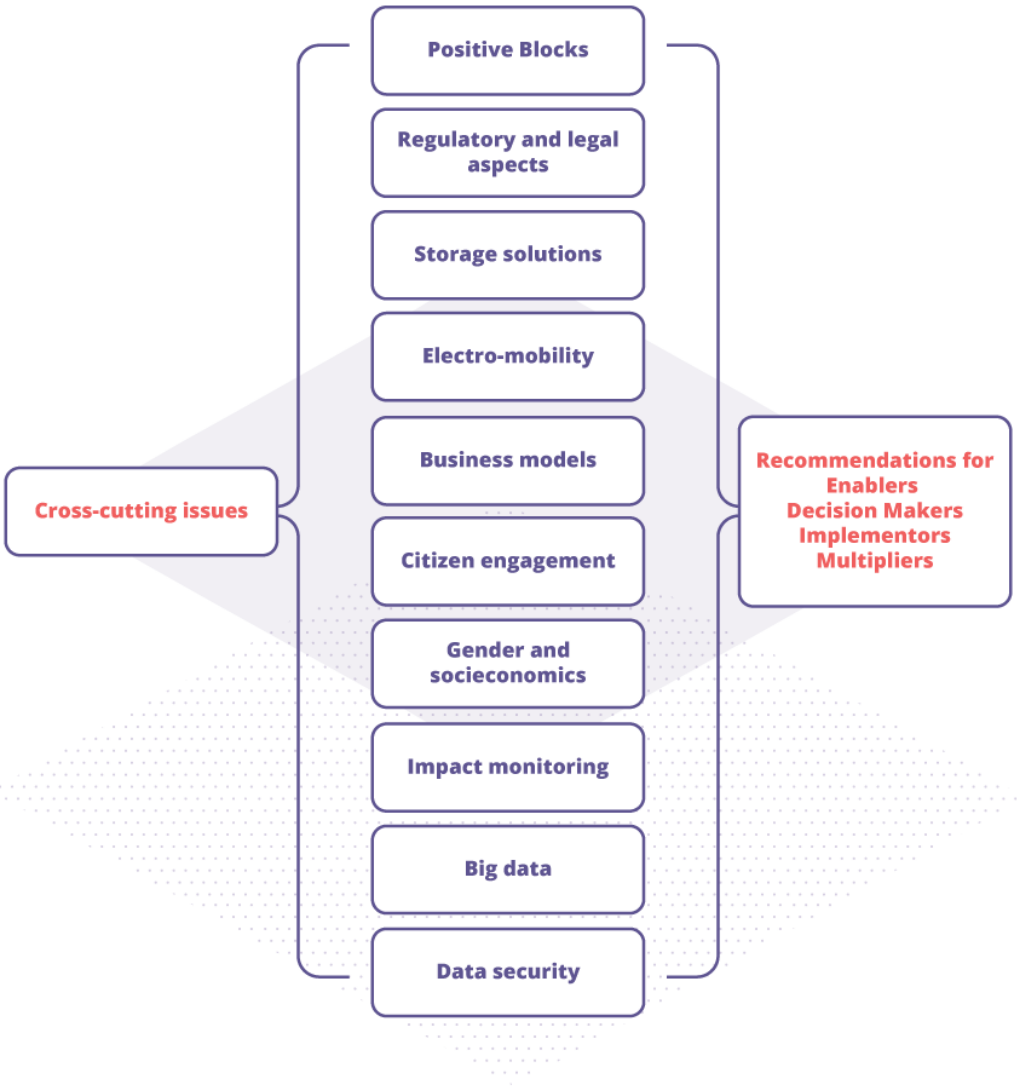

Figure 1: The 10 cross-cutting issues for SPARCS

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1 INTRODUCTION

This deliverable addresses the task *T6.2 Building recommendations on cross-cutting issues* to describe the ongoing work and fill in the existing knowledge gaps.

Positive Energy District (PED) is a specific type of project that very well represents the complexity of smart city implementation. The growing body of evidence on PED implementation in SPARCS cities and beyond is therefore helpful to frame and map the cross-cutting issues that cities are facing in complex smart city projects focusing on energy, mobility and data.

The PED-EU-NET[1] database is a growing repository where around 20 European cities aggregated their experiences into one location. The database identified a plethora of barriers common across several cities such as lack of internal capacities to support energy transition, lacking or fragmented local political commitment and support in the long term, building code and land-use planning hindering innovative technologies amongst many others. This shows that in many cases, non-energy issues are more important and require attention. Barriers related to social aspects, ICT, finance and market situations have also been provided within the database.

A study by Zhang et al. (2021) analyses 60 PED projects in Europe collecting a larger set of data from cities such as geographical information, energy concepts, building archetypes and finance models to construct an even more comprehensive database. The most common renewable energy systems include solar energy, district heating/cooling, wind and geothermal energy.

The EXCESS[2] project examined development of Positive Energy Buildings (PEBs) in European cities by interviewing several actors (Hukkalainen et al. 2020). The conclusion is that all levels of governance have an important role to play in the roll-out of PEBs and the coordination between the different levels of administration is crucial for success. Stakeholder engagement is also one key element. Other influencing factors for planning of NZEB (net-zero-energy building) and PEBs were found to be the cost, communication with investors about the importance of NZEB/PEB, feasible financial models, open discussion and tackling legal barriers.

1.1 Purpose and target group

This report provides a thorough overview of the knowledge gained in the SPARCS Lighthouse cities (LHCs) and Fellow cities (FCs) regarding the ten cross-cutting issues. This report produces recommendations that may be pursued further by not only cities and policy makers but also researchers working in similar projects, decision makers across governmental levels, and experts on the EU level amongst several others. The purpose of this collection of recommendations is to highlight and bring closer to the target groups selected learnings that can help with the implementation of ongoing and future PED and smart city projects.

[1] https://pedeu.net/

[2] https://positive-energy-buildings.eu/

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The cumulated experience of SPARCS that is implementing PED and smart city interventions allows process learning across the whole value chain of practitioners, starting with **Enablers** (regulatory and policy making authorities, typically on national or EU level), **Decision makers** (both city leaders and strategic planners as well as private investors such as real estate developers), **Implementers** (operative teams that ensure project design, management and implementation activities) and last, but not least, **Multipliers** (in this case researchers who analyse and support the implementation processes according to scientific standards). Figure 2 summarises main target audience categories of the SPARCS recommendations.

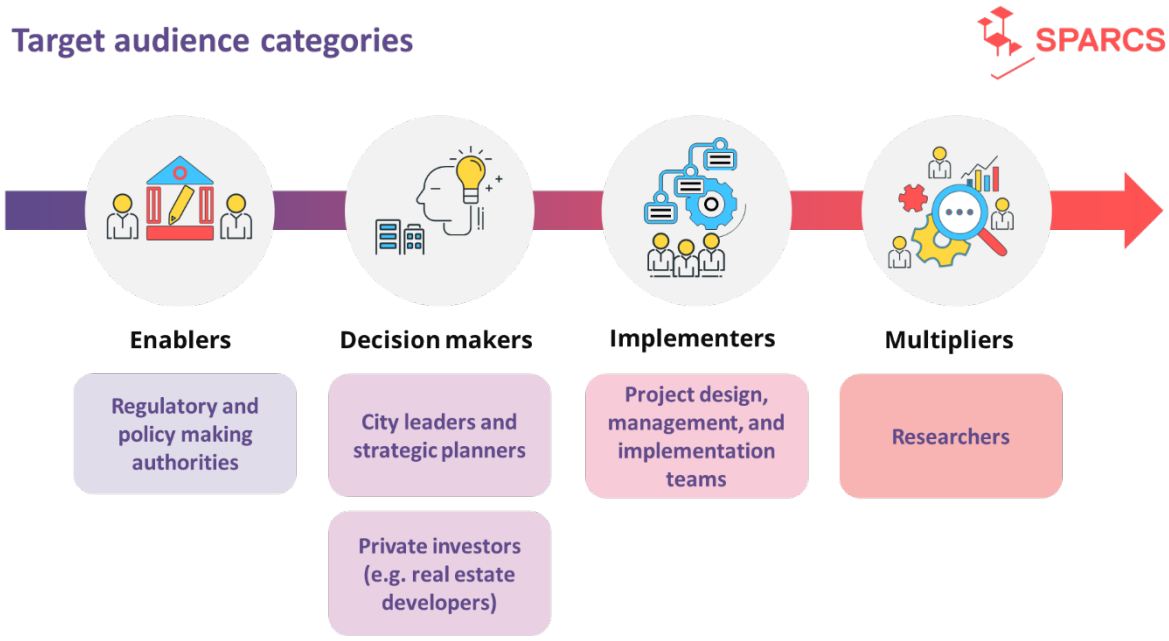

Figure 2: Target audience categories of SPARCS recommendations

The term **process learning** describes the kind of learning that takes place in demonstration projects and urban innovation projects, and represents a combination of social and organisational learning generated by the interaction of local actors with innovative solutions which results in an increased capacity of individuals, organisations and complex stakeholder ecosystems to transform and utilise innovative approaches. Process learning results in better understanding of how to design and implement urban innovation and urban transformation projects. It is learning that relates to and strengthens the processes that enable innovation. Process learning results in changes at individual level as well as in structural changes. (Vácha et al., p. 16)

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1.2 Contribution of partners

Table 1 depicts the main contributions from partners in this deliverable.

Table 1: Contributions of partners

Partner	Contributions
VTT	Editor of the deliverable. Content planning, allocation of writing responsibilities.
CVUT	Co-editor of the deliverable
MOH	Chapter 9
FHG	Chapter 6
BABLE	Chapter 6
SUITE5	Chapter 10, 11
SPI	Chapter 7, 8

1.3 Relation to other activities

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

Table 2. Relation to other activities in the project

Deliverable / Milestone	Contributions
D3.3	Implemented demonstrations of solutions for energy positive blocks in Espoo
D3.6	People flow and user experience
D4.3	Leipzig mid term review update
D4.4	Interoperability of holistic energy systems in Leipzig
D4.5	E-mobility integration and its impacts in Leipzig
D4.6	Citizens and stakeholders in Leipzig's energy transition
D6.3	The relevance of challenges was cross-checked again with PED-EU-NET database
D7.3	Solutions descriptions feed into the Massive Open Online Course (MOOC)

1.4 Methodology

The recommendations on the ten cross-cutting issues (or topics) are based on the partners' experiences within the seven SPARCS cities during the past 48 months. They were selected for their relevance across different disciplines and interconnectedness with each other (hence the cross-cutting nature) as well as for their importance for the success of complex PED and smart city projects. Considering this fact, there is no single method that can be applied to explore each cross-cutting issue. Each city has had a unique experience during the past 48 months with regard to each cross-cutting

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issue, which also means that there are varying scales of learnings and recommendations from different partners.

VTT coordinated regular group meetings with the 10 topic leaders since October 2022 onwards to understand the cross-cutting issues at hand and identify relevant challenges for each cross-cutting issue (Figure 3). The topic leaders were requested to describe their method of data collection during the meetings and contact relevant individuals for further information as needed (Table 3). During the physical Extended Executive Board meeting in March 2023 held in Kladno, the topic leaders had the opportunity to present the first set of challenges to the partners, get feedback and identify any missing challenges. This list was further analysed during the following months where topic leaders selected high priority challenges. The final draft and list of recommendations was reviewed by the City Coordinators before publication as they are one of the main users of the final recommendations. “Capturing the insights of this group is significant to understand how urban experimentation links to transformation, as they play a key role in testing and scaling up innovations across the energy, ICT, transport, and green infrastructure sectors" (Evans et al. 2021, p. 172).

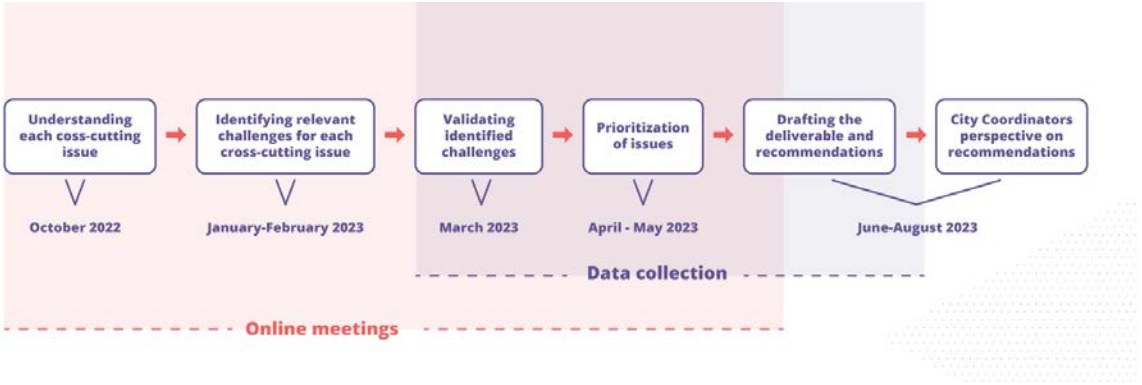

Figure 3: Process and timeline

Table 3: Data collection for each cross-cutting issue

Cross-cutting issue	Approach
Positive blocks	Interviews with City of Espoo, Cenero, University of Leipzig, LSW, City of Maia, EDP, City of Lviv, City of Kladno, CVUT, Municipality of Kifissia
Regulatory and legal aspects	Interviews with City of Espoo, Cenero, University of Leipzig, LSW, City of Maia, EDP, City of Lviv, City of Kladno, CVUT, Municipality of Kifissia
Storage solutions	Interviews with Citycon, CENERO, Siemens, Adven
Electro-mobility	Interviews with City of Reykjavik, OR
Effective business models	SPARCS deliverables D7.4, D5.16, SPARCS grant agreement, information from LPZ and KONE, desktop review.
Citizen engagement	Data collected from deliverables, QAT forms, SPARCS newsletters and information published in German by FHG IMW (direct link to German article)

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Gender and socio-economics	Data collected from deliverables and QAT forms, discussions with Seecon and Leipzig
Impact monitoring	Recurrent telcos, workshops and meetings with Lighthouse cities' consortia and technical experts
Big Data and management	Input collected during the implementation and the operation phase from technical partners and cities' consortia.
Data security/protection	Input collected during the implementation and the operation phase from technical partners and cities' consortia.

2 POSITIVE BLOCKS

2.1 Introduction

Positive Blocks are key development areas when discussing the present and future sustainability of cities (JPI Urban Europe, 2020). The term 'Positive Blocks' is one of the latest steps in the series of development from Passive Houses through different zero energy (or emission) concepts towards positive energy concepts, varying from building to district level. Brozovsky et al. (2021) include the concept as one of the Climate Friendly Neighbourhoods, highlighting more than 35 different terms used to describe such solutions for example, 'zero emission neighbourhood', 'zero energy community', 'energy positive neighbourhood' or 'plus energy district'.

No commonly agreed definition of the concept exists, but in SPARCS, Positive Blocks refer mainly to the concept used by European Commission in their definition for the Horizon 2020 Work Programme 2018–2020 (European Commission, 2020). There, the concepts PEB (Positive Energy Block) and PED (Positive Energy District) are used interchangeably (European Commission, 2020). Similar to the SET Plan Action 3.2 definition of a PED (JPI Urban Europe, 2020), local renewable energy production and storage, as well as advanced materials, smart energy grids, demand-response, energy management and user interaction/involvement are the basis for PEB/PED (European Commission, 2020). The SET Plan Action 3.2, JPI Urban Europe and the EERA Joint Program on Smart Cities describes Positive Energy Districts (PEDs) as follows:

"*Energy-efficient and energy-flexible urban areas or groups of connected buildings 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 securing the energy supply and a good life for all in line with social, economic and environmental sustainability*" (JPI, 2020).

Furthermore, in that context, PEDs are classified into three categories (Wyckmans et al. 2019), which are also used in SPARCS to categorise the different demo areas:

- PED autonomous: a district having clear geographical boundaries that is completely self-sufficient energy wise. This means the energy demand is covered by renewable energy produced within the district internally. The district

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is thus not allowed to import any energy from the external electricity grid or district heating/gas network. Energy generated in excess may be exported.

- PED dynamic: a district having clear geographical boundaries with annual onsite renewable energy generation higher than its annual energy demand. The district may also openly interact with other PEDs as well as the external electricity grid and district heating/gas network.
- PED virtual: a district that makes use of virtual renewable energy systems and energy storage located outside its geographical boundaries. The combined annual energy production of the virtual renewable energy systems and the onsite renewable energy systems must, however, be greater than the annual energy demand of the district.

Regarding replication, the Smart city Information System (SCIS) defines replication of PEDs as the possibility of transporting or 'copying' results from a pilot case to other geographical areas with potentially different boundary conditions (Ferrer et al. 2017). This suggests that if a pilot PED was proven to work in one community or region, it could be exported to other communities or regions (indigenously or abroad) but taking into account that the boundary conditions could differ from those in the piloted community or region. Replication may also involve the management process that was used in the pilot scheme or the cooperation structure between critical stakeholders.

SPARCS agreement describes the Positive Blocks as follows: "In the call, Positive Energy Blocks/Districts (…) have an annual positive energy balance, are designed to be integral part of the district/city energy system, and they are well embedded in the spatial, economic, technical, environmental and social context of the project site." In the project, the seven cities of Espoo, Leipzig, Maia, Reykjavik, Kladno, Kifissia and Lviv have planned 100+ actions that will turn the buildings, blocks, and districts into energy prosumers. SPARCS work packages aim at urban transformation through City Vision 2050 and social empowerment (WP1), joint procurement, feasibility studies and bankable solutions in Fellow Cities (WP5) and establishing new business models (WP7). Co-creation is also a critical element in the project and has been implemented through several actions in the Lighthouse cities (WP3 & WP4).

It has to be noted, however, that there is no strict definition of the PED concept in SPARCS, but it is rather the aim to study how far towards the concept it is possible to arrive with the solutions developed and demonstrated in the project.

2.2 Challenge of Significance for SPARCS cities: Detailed interpretation of the PED concept in SPARCS cities

Although many European cities are leading transitions to low-carbon energy, there is no common definition, roadmap and guideline to ensure the actual feasibility of PED designs (Bossi et al. 2020). A precise concept of PED does not exist in literature either (Brozovsky et al. 2021) nor has it been described in the revised European Building Directive (EPBD, 2023) mainly because cities are in the planning or early implementation stages with PEDs. As a consequence, the PED has not been included in the national legislation. It is difficult to define what Positive Blocks consist of: e.g. do they only include buildings or do they also include electric mobility? The municipality and city require a clear understanding of Positive Block to convince citizens and stakeholders about the need. Moreover, when discussing districts and blocks, the

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boundary issues are inevitable. This raises the question: how can PED boundaries be accurately marked as this also means defining the road boundaries? In general, defining boundaries on a city level has proven to be a tedious task and inclusion of transportation boundaries could make it more difficult for the municipalities.

Now, in the JPI booklet (Gollner et al. 2020) and the PED-EU-NET database co-developed by SPARCS there are more than 60 project entries altogether. Out of these around 50% are at least in the implementation phase. The mapped case studies include also those that are not fully PEDs but have interesting features for moving 'Towards PEDs' (also marked as 'PED-relevant' in the database). The number of PED and PED-relevant projects is increasing the chance of reaching the goal of 100 PEDs by 2025.

2.2.1 Solutions developed in SPARCS

SPARCS **Lighthouse Cities applied the definition that is aligned with 'PED virtual' concept while the Fellow Cities had more flexibility and focused on other types of PEDs**.

In SPARCS, *the City of Espoo* has examined the urban planning requirements, current state, and drivers and barriers related to PED development. Taking Kera area as a concrete, geographically defined, development area, the possibilities of incorporating PED solutions to the new, upcoming city district have been examined and studied. The concept of the PED here leans mostly to 'virtual' and 'dynamic' PEDs, where the positive energy district, or the related individual solutions, interact with the system as a whole. The key learnings of Espoo in PED development are related to the acknowledged requirement of co-creation and collaboration on the topic with diverse local stakeholders, including landowners, companies, and citizens. The key learnings of the PED development from a city's urban planning perspective have been collected into a *Co-creation model for sustainable and smart urban areas* – toolkit (see Section 2.3 for more details).

In the *City of Leipzig*, the PED approach was tested in existing neighbourhoods where Leipzig pursued a virtual and dynamic approach. This approach was implemented in two demo districts, where various monitoring, energy and load management systems were tested. The primary objective was to enhance energy efficiency and increase the proportion of renewable energy by effectively controlling energy demand and consumption based on specific requirements. The two demo districts are typical of Leipzig's urban structure: the monument protected Baumwollspinnerei, a former cotton mill built at the end of the 19th century, and the Dunckerviertel (part of Leipzig-West demo district), a residential neighbourhood representing a typical German Democratic State (GDR) dwelling type WBS70 – an architecture type from the GDR period when all wall, roof, and floor elements were industrially prefabricated. Additionally, a virtual neighbourhood was established, where a virtual power plant was developed and implemented to efficiently manage renewable energy sources.

Leipzig also believes it is of paramount importance to provide tenants with the necessary tools to actively participate in the energy transition. A significant outcome of this project is the realization from a technical perspective that almost anything is achievable; however, numerous regulatory barriers exist in Germany. As part of the SPARCS initiative, the city of Leipzig explored new processes within the city

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administration to expedite the further roll-out of PEDs (in Germany often declared as "climate-neutral districts") and to visually represent the expansion of renewable energy through the Energy Atlas, representing energy and climate data as a prerequisite to the development of a digital twin, thus making the energy transition more visible.

Maia municipality's approach is closely aligned with the concept of the 'PED virtual'. One key aspect is the absence of a clear geographical boundary, as the project considers multiple municipal buildings spread throughout the city. The main typologies addressed were residential (Sobreiro Social Housing), industrial (Tecmaia), and service buildings, highlighting that mobility was not considered in the analysis. The project involves onsite production of renewable energy, both electric (through distributed photovoltaics plants) and thermal (via small-scale solar thermal plants), however, the local PED still relies on the national electric and gas grids as the main contributors for the energy supply. Therefore, the road to positivity implies the decarbonization of the 'virtual renewable energy systems', that was not achieved during the timeline of the project. Nonetheless, there are several positive aspects to consider, since these projects have provided an opportunity to showcase the complete process, starting from the baseline and illustrating the path that needs to be taken to achieve energy positivity and the carbon neutrality goals of Maia for 2050. This also highlights the importance of adopting this approach as the way forward in designing new urban areas, infrastructures, buildings, or their rehabilitation.

The city of Kladno adopted for the design that is more aligned with 'PED dynamic' with emphasis on the onsite renewable energy production. That decision proved to be very limiting in terms of scope as the high energy consuming buildings within the locality had to be left out from the balance to reach the annual positive balance. The main heat source was the excess heat from the Winter Stadium combined with photovoltaics. In the end, the city decided to further pursue 'Towards PED'/'PED relevant' alternative with a more favourable annual mismatch ratio (higher self-consumption), but without achieving the annual positive balance calculated with the onsite energy ratio (OER) indicator.

Due to the existing challenges of the built environment, lack of available space, technical and regulatory difficulties for installing RES, *Municipality of Kifissia* is working on PEDs via the formation of a pilot energy community. The solution includes the installation of a PV park on the terrace of a municipal building. In this way, citizens of Kifissia and members of the community will benefit from the energy produced via virtual net metering without the need of clear boundaries or proximity to the installation. The initial (and pilot) phase will not cover all energy needs of the buildings connected but instead it will be the beginning towards a PED through a collective action that could expand in the future, adding more renewables and achieving net zero greenhouse gas emissions.

The *City of Lviv* has planned to integrate solutions developed within the SPARCS project and implement them through municipal programs and large investment projects funded by European financial institutions (EBRD, EIB). However, due to the current circumstances in Ukraine, a full-scale war with Russia, the use of public costs and loans for PED, development is not possible. Thus, Lviv is developing instruments that will enable better justification of a PED, in particular by engaging businesses and attracting private funds for development.

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The *City of Reykjavik* has an abundance of renewables, particularly hydropower and geothermal energy and so the heating and power system rely more on R&D than developing efficient networks. Nonetheless, Reykjavik still considers the energy system as 'virtual PEDs', where the district itself is energy positive. This added advantage allow them to tackle the climate mitigation agenda through other innovative measures.

SPARCS researchers have contributed to various efforts to define PEDs in Europe, including taking part in the mapping and publicizing the different aspects and implications of the varying PED definitions. In this manner, together with peer projects such as MakingCity, SPARCS contributed to a more structured and differentiated approach to defining PEDs (Albert-Seifried et al. 2022).

2.2.2 Impact of the solution in SPARCS

Introducing the PED concept into city planning proved to be a test for the perception of the PED concept itself. Much effort was invested into educating the decision makers in the SPARCS cities about what constitutes the PED and what are the benefits of creating one. Throughout the process, many individual effects in terms of process learning were generated. The awareness among the stakeholders was increased about RES opportunities, self-sufficiency limitations, grid interaction and many other elements of PEDs. The PED planning process was coupled with the rise of energy community concept and both approaches have been intertwined ever since in the SPARCS cities.

As **Espoo** began its journey, soon it was realized that bringing stakeholders together and convincing them to agree on the common needs of the city was of crucial importance instead of reaching out to various stakeholders individually. This led to the formation of the *Co-creation model* that focuses on the themes of energy and mobility, which account for more than 90% of Espoo's climate emissions. By promoting the development and introduction of innovative and sustainable solutions in these themes, the model supports the City's objective of being carbon-neutral by 2030 and answers how new innovative operational and technological solutions can be introduced into the region. The model provides a toolbox that contains practical methods and descriptions of processes, operator roles and various steps in general development work (see Section 2.3).

The implemented solutions in **Leipzig** led to an increase of renewable energy sources in the physical demo districts. Due to the data-oriented approaches of the energy and load management, the amount of consumed energy and heat could be reduced. Further analysis of energy demand and provision (e.g. PV) etc. will continuously help to provide the exact amount of needed energy to reduce peak loads. Also, the benefits of energy storages was explored in both physical demo districts. One of the most significant findings are the substantial amount of existing regulatory barriers, in addition to the delays in supply chains and the lack of skilled personal to plan and build e.g. PV installations. At the federal level, regulatory requirements are restrictive and hinder the implementation of some approaches developed within the SPARCS project as they do not yet reflect the changing landscape of technologies, different stakeholders and cooperation modes in energy transition to its full extent. Furthermore, laws and regulations are subject to frequent changes, especially after the start of the energy crisis in 02/2022, making it challenging to implement technical solutions as

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adjustments are required regularly to align with these legal changes. The local consortium is discussing and evaluating the impacts of those challenges especially on Federal level for the German energy transition which results will then be incorporated in a policy paper.

Furthermore within the framework of the SPARCS project, smart solutions (e.g. applications) for citizens were also developed to enable their active participation in the energy transition in Leipzig. However, it emerged that these solutions garnered only limited interest. Emphasizing energy savings alone is insufficient to motivate citizens to participate. Instead, when developing products, attention should be paid to ensuring they offer tangible added value. In addition to energy savings, approaches incorporating gamification elements and reward systems are preferred. This means that solutions should be designed to not only encourage citizens to save energy but also provide them with immediate benefits and rewards to enhance their motivation (see Section 8.3).

From **Maia's** context, several infrastructural improvements were foreseen to be implemented since the beginning of SPARCS project, particularly in the field of energy efficiency and building retrofitting. For these types of interventions, the Portuguese public administration is highly dependent on public funding, involving a substantial portion of non-repayable funds, this being the most conventional financing mechanism. When public funding for the energy field was scarce, most likely due to the restructuring of these schemes to more urgent matters, such as the COVID pandemic, various interventions had to be continuously postponed due to the lack of financial support to its implementation. Even when such opportunities were available (e.g., for renewable energy communities), municipalities seemed to be unprepared. This may be attributed to the disruptive concept, which diverges from the historical organization of the national electricity production and distribution system. The Portuguese electrical system was under a concessionary arrangement for several years, leading municipalities to view these functions as a third-party responsibility. This new paradigm demands a revaluation of responsibilities, a transition that does not seem to have been yet fully embraced by local authorities. Facing these challenges, the involvement of Maia municipality in SPARCS and other R&D projects created additional pressure on accelerating these initiatives, meaning that local authorities cannot be dependent on available public funding, highlighting the need to design new strategies and find new financing mechanisms.

Kladno leveraged the work on the PED concept to start and strengthen new and ongoing innovation processes within the municipality. Namely, this includes: 1) integrated planning of municipal building retrofits, scouting for synergetic energy solutions for previously energy non-integrated buildings (e.g. winter stadium, aquapark, other sports facilities, and residential housing), 2) introducing "city as a prosumer" business model for the RES production, 3) mapping potential for e-charging infrastructure and many others. The work on PED also initiated a close working group of several key city companies, university, and private partners, strengthening the local ecosystem collaboration.

In **Lviv**, the Spatial Energy Plan will define areas where the PED is most feasible. Concrete energy efficiency and RES integration measures need to be implemented so that the city of Lviv can invest its own funds and loans acquired from international financial organizations. The mobility aspect will be implemented through small-scale

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improvements of street infrastructure in the city and a data-driven transport network development. Furthermore, the justification of large-scale interventions in mobility development will include the information about reduction of CO_2 emissions that will improve the project development and cooperation with EBRD and EIB as potential investors.

In **Reykjavik's** Green Housing for the Future project, the innovation lies in the methodology of the whole tendering process, where the City of Reykjavík has launched a worldwide call for developers and offers more than 40% discount on 5 prime plots. The developers must be willing to build sustainable housing and be committed to reducing climate impact throughout the whole building cycle. Reykjavik's second project in SPARCS, the Hlemmur mobility hub project is unique in the way that the site will be the first mobility hub in Reykjavík and shall serve as a testbed for current and future innovative solutions, such as new EV charging service and the implementation of fresh produce pick-up service initiated by a local start-up. It will also connect complex projects of different scales, timelines and ownerships under the same umbrella, a few examples include the Re-design City Streets project managed the Environmental and Planning Division of the City of Reykjavík, new infrastructure and pipework by Veitur (power and water distribution company owned by Reykjavík Energy) and the new City Line Borgarlínan which is a joint project by the Icelandic state government, municipalities in the Capital Region and the Icelandic Road Administration.

2.2.3 Recommendations

The unclarity of the PED concept has led to different interpretations in the SPARCS cities, which also revealed the need to create the definition on National or European level, including different levels for PED development. There are some guidelines available in the literature which will help in designing the PED for local context. Based on the learnings from SPARCS cities and the literature, the following recommendations can be given to make the process smoother:

- Before the PED definition is clearly standardized it is up to individual project owners to decide which definition they apply. To avoid comparing apples with pears, SPARCS recommends **to consciously declare the relevant aspects (especially the system boundary and calculation method) for each PED, already in the prefeasibility design stage**. Clarity of definition is a necessary starting point for explaining the benefits of PEDs to the main stakeholders.
- It will help to **have the PED defined on the EU and national level**. The definition should include the overall aim of the PED, the components of the energy balance (energy demand & supply, inclusion of e-mobility, etc.) and the physical and operational boundaries (Figure 4). These could include e.g. the life-cycle phases to be included in the balance and the potential requirement for flexibility or environmental and economic viability. A useful approach could be to also have basic PED concepts such as Level 1: Basic PED, Level 2: PED+, Level 3: PED Advanced. This will support the municipality in moving forward in small steps rather than planning a very large project and facing too many obstacles. In addition, this will acknowledge the different layers of complexity. Since each city has a different starting point, maybe having one concept and one way to achieve PED could be discouraging.

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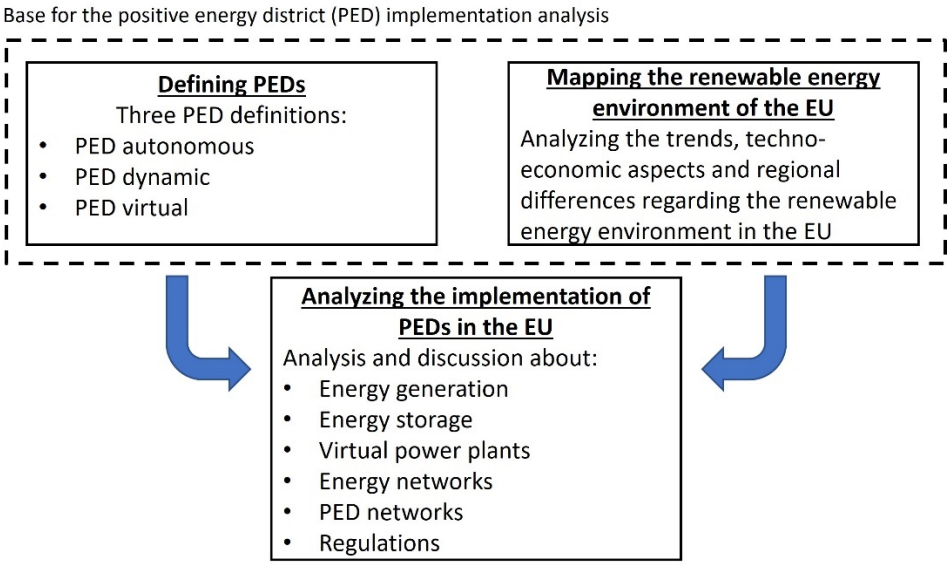

Figure 4: PED design approach by Lindholm et al. (2021) (original figure remade with permission)

- When designing the PED for local context, it is important to **identify the energy market situation, population, economy, climate, and availability of the resources**. For example, the renewable sources such as solar, wind and hydro are location dependent. Similarly, some energy storage systems such as pumped hydro, boreholes or compressed air energy storage (CAES) could be more beneficial in certain geographical conditions.
- By **utilizing the Virtual Power Plant (VPP) concept**, a PED could own and operate renewable energy systems and energy storage outside its geographical boundaries. Examples of technologies that are best suited as VPPs are wind power and hydropower as well as large-scale energy storages, such as pumped hydro and CAES. Solar PV and batteries, on the other hand, are more suitable for an urban environment and are thus possible to install in all types of PEDs (Lindholm et al. 2021). The utilization of VPPs could also be implemented through agreements with other energy market actors instead of the ownership of the renewable energy systems and energy storage (Briink, 2020).
- An **'onion model' could be beneficial for constructing PED networks.** Based on this model, the majority of the PEDs could be placed in the outskirts of the city, and the excess energy generated from these PEDs is exported to the more central areas in the city, where the renewable energy installations are not able to fulfil the energy demand. This way, it would be possible to increase the renewable energy share of the whole city (Lindholm et al. 2021).
- Diversification of intermittent renewable energy technologies helps to increase the demand coverage and reduce life cycle costs (Heidi et al. 2010; Liu et al. 2018). Intermittent renewable energy technologies, such as wind and solar energy, are often able to compensate each other, as windy and sunny periods are not synchronized. As the price of energy export is often lower than the price of energy import for small-scale energy producers (Lindholm 2019), it might be

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beneficial for a PED to minimize the external grid interaction. By **diversifying the intermittent renewable energy generation**, it would be possible to achieve a positive annual energy balance with a lower export rate (Rehman et al. 2019).

- The different RES (and other technology) options have several benefits, but also some limitations that **need to be considered when designing the local PED solution**:
    - Solar energy can be used widely in many locations, and it can be used in different formats. **The cost of solar electricity has reduced significantly and it will continue to decrease** (IRENA, 2022)**. Solar thermal collectors can be integrated and installed with heat storage** tanks, and this can assist in district heating allowing districts to import and export heat energy.
    - Solar PV panels on roofs should be prioritized in PEDs, while **façade integrated solar PV panels can be considered** if the solar radiation on a particular façade is sufficient (Fath et al. 2015, Lindholm 2019). Overall, city-integrated solar PVs have a great potential and can satisfy over 60% of the electricity demand in some smaller cities in Europe (Amado & Poggi 2014; Hofierka & Kanuk 2009).
    - **Vertical axis wind turbines (VAWTs) are a popular alternative among small-scale wind turbines**. These wind turbines can handle the higher turbulence and varied wind speeds associated with urban environments (Kammen, 2016). The hub height of small-scale urban wind turbines is, however, not high enough to access the same wind speeds as large-scale wind turbines (Wagner et al. 2009).
    - Due to the limited space in urban areas, wind power is best suited for virtual power plants. The **distance between the district and the virtual wind power farm could**, however, **be relatively short and thereby ease the power transmission to the district**. Wind farms could, for instance, be installed in nearby rural areas or even offshore if the district is in a coastal area. Hydropower could also be suitable for virtual PEDs (Lindholm et al. 2021).
    - **Bioenergy and hydropower can be used to provide PEDs with flexible power** when the intermittent energy generation is lower than the electricity demand (Graabak et al. 2019; Haakana et al. 2016). Bioenergy generation does, however, produce emissions, which contradicts the PED's aim to provide a carbon-free energy environment and better life quality in residential areas (Lindholm et al. 2021).
    - **Heat pumps can be used** to recover low temperature heat from the ground and the ambient air as well as low temperature waste heat from sewage systems, ventilation air and other waste heat flows, thus they are able to increase the total energy efficiency of PEDs and minimize the import of externally generated thermal energy. Moreover, heat pumps provide additional flexibility to PEDs, as they can be used to transform

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electrical energy into heat that can be stored in Thermal Energy Storages (TES) (Lindholm, 2019).

- It is **more cost-effective for dynamic PEDs to interact with the electricity grid than to use batteries** as bidirectional interaction between the district and its surroundings is allowed (Lindholm et al. 2019). Batteries have a significantly shorter reaction time, add more flexibility to the district energy system and increase the utilization of onsite intermittent renewable energy (Haas et al. 2018). Batteries could be more useful in autonomous PEDs.
- Both **4GDH and district cooling can be implemented as local networks** (to which all energy consumers and producers are connected) in the PED with connections to the external district heating and cooling networks. This way, PEDs can balance their internal heating and cooling demands before exporting or importing energy from the external network (Lindholm et al. 2021)

2.3 Challenge of Significance for SPARCS cities: How to co-create PED solutions in the old and new city districts (Espoo)

Identifying the various actors in society and bringing on them onboard to design and implement PEDs is a tedious task and requires several questions to be answered (Tartia, 2023):

- WHO – What kinds of individuals/groups?
- HOW – What kind of platforms, methods and processes of participation should be used?
- WHY – Why they would like to participate? Why is it important that they participate?
- WHEN / TIMING – When should different citizens participate, how and why?

The co-creation model fills the gap for developing sustainable and smart city districts in collaboration with the city organization, private companies, educational institutions, research organizations, associations, and citizens. The co-creation model, or toolbox, for sustainable and smart urban areas was influenced by the lessons learned from the development of the City of Espoo's Kera area and the views of a wide network of actors. Case studies of the Kera area and the Soukka area were used as examples of how the model can be applied, after which the model was generalised to include a wider range of urban areas.

Kera is to be redeveloped from a current brownfield area to a new urban district and will stand as an international example of circular economy solutions through active collaboration with different stakeholders. Kera will be transformed into an urban centre for approximately 14,000 residents and will offer employment opportunities for 10,000 people, thus providing a unique opportunity to test and implement tailor-made solutions addressing local needs.

The co-creation model is applicable to all urban areas and urban systems identified for development**Error! Bookmark not defined.**. The purpose is to cover the whole life

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cycle of the area starting from the initial planning and moving to the in-depth design, construction, use and operation phases.

2.3.1 Solutions developed in SPARCS

The **co-creation model for smart and sustainable urban areas** has been developed through a service design process comprising of a series of case project reviews, benchmarking (national, European level), Design Sprint workshops, questionnaires, interactive webinars, and other activities that have been directed to different stakeholders at different stages to co-create the model. The stakeholders in question are city departments, companies, organizations, research institutions, other Finnish cities, landowners, and citizens. Development of the co-creation model began in December 2021 after a subcontractor was chosen through the tendering process to lead the model's development. The model was completed in December 2022 and it is publicly available as an online toolbox (www.co-creatingsparcs.fi/en). See Figure 5.

The aim of creating a co-creation model was to provide insight for the (re)development process of urban areas and incorporate new innovative smart and sustainable solutions in the energy and mobility sectors with different stakeholders. Many technological and practical solutions exist today on these topics but the process of how these new solutions materialize in the planning and design processes is still less clearly defined. The model also took a system-thinking approach to the developed area, examining the developed area as a system of interlinking connections, practices, technologies and flows, which affect the development of the area and, for example, the optimization of different sustainable and smart solutions in the area.

It is also essential to highlight here that the development of the co-creation model promoted 'co-creation' with the participating stakeholders by **1.** Defining shared objectives and **2.** Encouraging open communication. The model focused on the themes of energy, mobility and green-blue infrastructure (including land use development) all of which are critical to Espoo's goal of becoming carbon neutral by 2030.

The City of Espoo also formed a steering and sparring group consisting of the SPARCS project team, Kera area development team and the city's urban planning department to lead the development of the model and arranged regular meetings. In addition, to improve communication with the city departments, regular coffee mornings were held initially between January – March 2022 with the Centre of Excellence for Sustainable Development (city department) that is responsible for city level sustainable development and climate work. In total, 15 thematic experts (energy, mobility, construction, green and blue infrastructure, smart cities) were interviewed in the first stages of the process to provide up-to-date insight to the matter.

The co-creation model utilized the method of Design Sprints (January 2022 – September 2022). The definition of Design Sprint is rooted within the concept of Design Thinking that consists of: Understanding, Reframing, Ideating, Prototyping and Testing. This is an iterative processes and steps can be repeated to obtain the desired product based on the needs, wants and likes. The goal of prototyping is not to finish but to see the strengths and weaknesses and identify new directions to make the product even better (Brown, 2008). Design Sprints are intense 4 – 5 days of

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participants working together with the aim to create and test solutions within the short timeframe.

Online Design Sprint workshops were held between January – September 2022; three of the sprints arranged as two half-day events and the last sprint as a shorter event. The participants were employees of different organizations, policy makers, and also employees of the City of Espoo from various departments. The potential participants were approached through direct invites and also open calls for participation were distributed to organizations. Many of the invited partners were the ones already actively participating in the development groups of Kera area. The Kera area is also a replication area within the project and provided a ground to test findings/results from the Design Sprints.

- Design Sprint 1 (February 2022): Two half day online workshops to share information with all participants, get familiar with case studies, share previous experiences and good examples, and inform about critical steps. In total, 23 people from different organizations participated.
- Design Sprint 2 (March 2022): Two half day online workshops to develop a new concept of co-creation and build on the findings from the first sprint. In total, 17 people from different organizations participated.
- Design Sprint 3 (April 2022): Two half day online workshops to apply the preliminary results in the context of Kera. This helped collect feedback on improvements to the model. In total, 15 people from different organizations participated.
- Design Sprint 4 (September 2022): A half-day workshop to further identify and fit the model to different areas with different urban typologies (e.g. existing district heating infrastructure, public/private landownership, possibilities for RES integration). Ideas regarding application of the model to new, redeveloped, and infill development areas were also discussed. In total, 12 people from different departments of City of Espoo participated in this city's internal workshop.

The final model includes various steps and tools that support the co-creation of an area incorporating sustainable and smart urban solutions from the first *Initial (strategic) planning and visioning phase* to more *Detailed planning and the construction phase(s)*, *Utilization and maintenance phase(s)*, and the *Re-development of the area (as a continuous process)*. The Design Sprints generated the insight and knowledge that form the basis of the identified tools and steps (Santala et al. D3.6, 2022). Six interactive webinars were also held during the active working process to present the interim and final results to the participants. The total number of unique participants to one or more event(s) in the co-creation process was around 140 from around 40 different organizations.

Citizens were reached by conducting an online survey during February-March 2022. The survey was shared via the social media network (Facebook page) of the City of Espoo and received 118 responses. The presented questions were mostly open-ended and provided valuable information about the citizens' perspectives on current smart city and sustainable city development and their views on the possibilities for participation in different stages of urban development processes. Several responses claimed that the possibilities for participation still require improvement, an issue that has been commonly identified as a challenge for cities. A separate online event was also organized to present and further discuss these results with the citizens in March

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2022. A workshop on the results of questionnaire was also planned and scheduled for May 2022 to further work on the themes with citizens directly, but unfortunately due to low interest the event was cancelled. The Covid-19 situation might have also played part in the low interest for the participation in a face-to-face event. Municipal worker's strike also had an effect on the workshop as the chosen venue closed due to strike. Another workshop for citizens was organized in September 2022 in collaboration with City of Espoo's TUPA project, which utilized the pre-selected citizen group to co-develop topics related to sustainable development. 17 citizens participated in the live workshop. (Santala et al. D3.6, 2022)

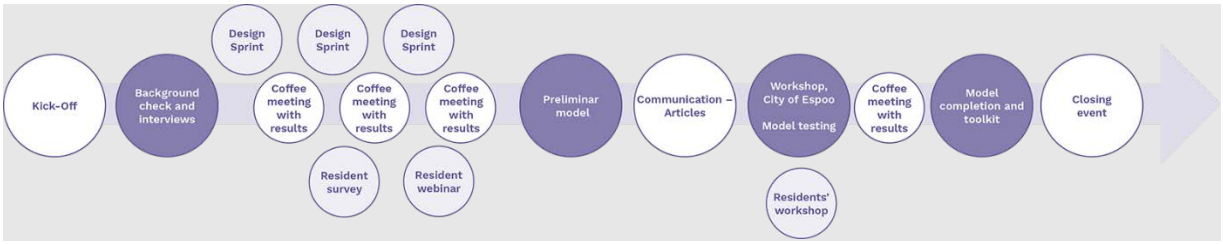

Figure 5: Co-creation model development timeline January 2022 – December 2022. Source: Co-creatingsparcs (Link)

The co-creation toolkit has six themes that are key to the regional co-creation process.

1. *Prerequisites* (for example understanding the benefits of the project and knowing available skills and resources).
2. *Identification of starting points* (for example, understanding the area and operators)
3. *Solutions development* (energy, mobility, green-blue infrastructure and previous development experiences)
4. *Co-creation methods* (recommended methods for different stages of the process such as interviews and gamification)
5. *Roles* (for example, importance of city officials, landowners and residents)
6. *Thinking about the future* (explore opportunities to co-create further)

2.3.2 Impact of the solution in SPARCS

The work on the co-creation model brought together the SPARCS technical partners, various units within the City of Espoo, local companies, other Finnish cities, organizations and citizens. However, keeping the actors engaged throughout the process was a key challenge. Design Sprints require large time-resource investments from the participants but can provide valuable and 'deep' insights required for the development of a complex topic as this. The interactive intermittent 'coffee meeting' webinars after each Design Sprint on the current stage of the process proved popular and good places for gathering more (though less 'deep') insight for the next phases. From the citizen engagement perspective, the topic is a bit conceptual and theoretical, which created some challenges for how to provide places for participation that are accessible and open to all. The questionnaire and the workshop for a pre-selected group proved to be the best ways to gather invaluable citizen perspectives on urban sustainable development. (Santala et al. D3.6, 2022)

The toolkit describes a general model for urban co-creation, taking into account the conditions and different starting points. The steps also form a continuous improvement

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cycle which means that once the solution is in operation and monitored, a new cycle can begin, for example, when the solution is re-examined and further developed in the context of the dynamic and transforming operational environment.

Participants gave positive feedback upon completion of the co-creation model. Participants believed that the model could help in proper identification of actors, designation of roles, planning both small and large-scale regional projects, and understanding what information is available, what is missing and what skills are needed. The toolbox is readily available online so that it can be picked up by any stakeholder for urban development purposes (Link to toolbox). The toolbox has had 2800 visitors (calculated monthly) since its launch in February 2022.

2.3.3 Recommendations

Co-creation means working together on equal footing with a network to achieve a common goal. Commitment may be ensured through letters of intent and binding agreement at various stages of the process. A well-organized co-creation process can also speed up implementation and still be democratic and transparent. It is also helpful to not be anchored to a particular result but rather to focus on continuous improvement. The co-creation process can be initiated by anyone with a serious interest in implementation (city, business, landowners, residents). Resident participation must be ensured in the initial mapping, setting of objectives, and evaluation of solutions. Moreover, having a common understanding of the objectives and ensuring feasibility of new ideas is also key.

Figure 6 shows the six recommended steps of the co-creation model that can be applied to any urban development project.

1. **Identify and define the changes/transformations needed and desired**: Identify drivers behind the needed or desired change; identify and bring together the key actors.
2. **Identify the current state of affairs related to the developed topic(s)**: Identify specific areas or locations; identify opportunities or actions for the needed/desired change.
3. **Create a vision for the desired change and for the intended future state of the district**: Identify the measures needed to achieve the objectives, identify or form necessary cooperation groups/networks; identify key issues/actions/targets that need to be agreed on or committed to.
4. **Identify the measures and actions that can be promoted jointly with different stakeholders**: identify and define the roles and responsibilities of the different actors; plan the selected solutions in cooperation networks; plan the coordination of individual solutions with other solutions being implemented simultaneously.
5. **Create an action plan**: Setup a suitable monitoring model based on the objectives; plan the implementation schedule and progress; establish a local/district level commitment agreement.
6. **Pilot and test the selected actions**: Monitor the developed actions; Update the targets and measures if necessary; share the lessons learned.

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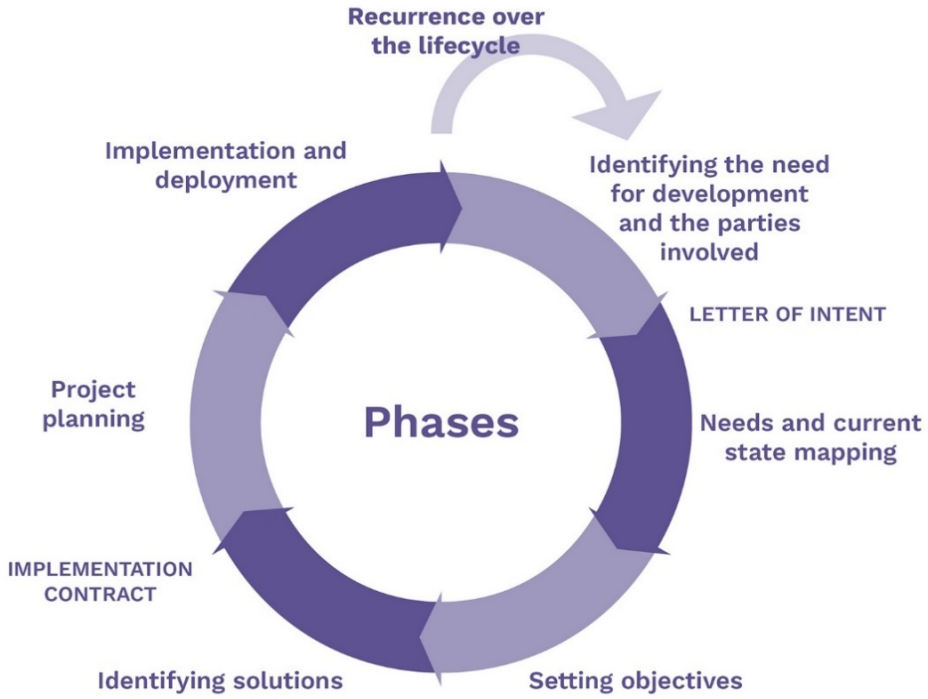

Figure 6: Co-creation model developed by Espoo together with stakeholders

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3 REGULATORY AND LEGAL ASPECTS

3.1 Introduction

Local administrations face a plethora of challenges to develop smart and sustainable cities. While some may lack the necessary policies, others are unable to access fiscal incentives or are not responsible for the key local issues, for example, the responsibility of the road infrastructure may not be in the hands of the local municipality but might instead be a responsibility of the regional authorities. Moreover, in cases where public administration is very centralized, this may lead to delays in negotiations, highlighting that the power of the local authorities in Europe is very heterogeneous (Ferrer et al. 2021).

Stability of the regulatory environment is also of vital importance as without a stable policy framework, investors may start to look at other possible markets. The processing of permits may involve numerous state agencies and in certain cases, the project developer may be required to acquire noise, visual, spatial, ecological, heritage and drilling approvals which can cause significant delays in implementation if the administrations are fragmented (Ferrer et al. 2021). In addition, there may be restrictions imposed by the grid operator, such as types of renewables that can be connected to the grid, a fee for selling surplus energy or high taxation on certain renewables (in Finland, property tax for off-shore wind power turbines is three times higher compared to on-shore wind turbines) (Bartel, 2021).

Within the project, the five Fellow Cities have claimed that lack of leadership in the energy sector, weak cooperation between the municipality and private service providers, lack of communication between departments and sectors, high individualism and most importantly, bureaucracy cause immense difficulties for local administrations to achieve and suggest changes (Fatima et al. 2022).

Although knowledge of regulations and legal aspects is vital throughout the project, this becomes more critical in certain project tasks. The topic, for example, is strongly connected to Task 1.2 Urban Transformation, in particular *D1.5 Recommendations for integrating Positive Energy Blocks in strategic and political city instruments including recommendations for the national and supra-national legislation* (due in September 2024). The deliverable will focus on providing recommendations on how to integrate Positive Energy Blocks in the cities', national and supranational existing legislation, namely via policies & regulations, masterplans, infrastructure plans, budget, among other possible tools. For example, in Espoo, policy and regulations are necessary when working with blockchain enabled business cases and control strategies. Additionally, work related to battery storage, use of Virtual Power Plant and integration of renewables into district heating are some of the instances where regulations and legal are prominent.

3.2 Challenge of significance: Overcoming regulatory barriers for integrating RES in existing buildings (Lviv & Kladno)

Construction and refurbishment of old buildings has been on the European agenda for quite some time as well as construction of more energy efficient buildings that follow

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the updated building codes in Member States. However, the recent changes in the political environment within Europe (mainly the War in Ukraine) has led to drastic measures being taken across countries, and to the prioritization of Energy Efficiency First and REPowerEU policies.

Already in 2021, Lviv introduced new building regulations for thermal insulation and energy efficiency of buildings. According to the new updates, all new buildings in Lviv now have the requirement to have alternative sources of energy (mostly from renewables) and to also have electric charging. This has been supported by the local and national authorities. However, the efforts to achieve the goal stretched over several months as the idea first had to be accepted by the local council and now due to the current political situation, this idea became a local and national strategy.

The situation in the City of Kladno shows that the national level of legislation does not guarantee smooth application on the ground. Kladno pursues its Sustainable Energy and Climate Action Plan with the planned increase in RES installations by 30 % until 2030. However, it is the grid operator that determines the conditions for selling of production surplus and respective prices. Also, it is necessary to check and obtain permission from the grid operator before installing RES facilities and permission is required to sell to the grid. Installation on the roof requires a different type of approval and installation on the ground requires another type of approval, the latter being much more difficult because of associated problems such as limited space and land ownerships. Moreover, a separate agreement with the grid operator is needed for each building where the renewables will be installed, therefore in the case of powerplants, it is much more difficult to do. In terms of prices, there is no regulation in place that would favor selling the surplus to the nearby points of consumption. Increasingly, due to technical limitations the grid also does not favor large scale installations of renewables. The negotiations with the grid operator can be time consuming and they require good preparation to avoid risks of asymmetric information. Even if the regulation says that the operator is required to connect new PV plants, in practice this can be delayed by years due to extra investment on the side of the grid that needs to be organized and jointly covered by the newly connected energy producer and the grid operator.

3.2.1 Solutions developed in SPARCS

Based on the discussion with City of Lviv, obtaining a license to install RES facilities in the building is mandatory and it is a lengthy process where the time period may stretch from two months to one year, depending on who owns the land (private individuals or the government). Once the building begins to operate and produce energy, the grid operator (who has a monopoly in Ukraine) will determine how much surplus energy the producer is able to sell and requires the producer to have a license to sell energy. Being a partner in the SPARCS project provided inspiration, support and enthusiasm needed to initiate use of renewables in new buildings and bring in knowledge from other SPARCS cities about how to integrate the technical solutions successfully.

In anticipation of potential barriers during the implementation phase of PVs on individual buildings, Kladno decided to go for a “wholesale” approach, preparing the ground for maximizing the renewable production by assessing potential of all city owned roofs, while avoiding (at least for now) any ground installations. In the first phase, the priority list of “low hanging” fruit was identified to highlight opportunities that require low investment but provide a high yield. Out of over 100 buildings, 10 buildings

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were selected. The municipal district heating operator was given the task of obtaining the license for production (required for installations over 50 kWp) and license for trading. This organizational change was no small achievement in an institutional environment where no one had previous experience with large scale PV installations.

3.2.2 Impact of the Solution

Having alternate sources of energy supply for the buildings ensures tenant safety, energy security, and well-being. The new regulation in Lviv aims to maintain citizen safety despite the uncertain situation within the country. It is hoped that Lviv could lead the way for other cities in Ukraine by setting an example regarding how to implement energy efficient solutions and networking with other European cities and companies that could support the implementation process.

In Kladno the city managed to send a powerful signal to the grid operator that the city had a long-term plan it wanted to gradually fulfill. The grid operator can now adjust both its technical infrastructure re-investment plan and its local processes with application procedures to accommodate to Kladno's plan. However, continuous engagement by the city energy company is instrumental to successful implementation.

At the same time, Kladno started discussion with the central power plant owner (providing both power to the grid and heat to the city's district heating) about how to find better (more sustainable) solutions for the future. The power plant owner is also a part of the city energy platform (a coordination group of key stakeholders in energy sector). They are aware of the restrictions on fossil fuels, and are considering diversifying their energy production, for example by adding biomass. However, the issue remains how to build the new infrastructure and the level of motivation behind it. The heat distributor has requested the city to verify the feasibility plan for waste-to-energy and involve all relevant partners, which signals a possible but slow change towards a diversified energy mix in the future.

3.2.3 Recommendations

- While energy efficient buildings are now part of the national strategy in Ukraine, to better resolve the energy instability and promote a more sustainable lifestyle, **removal of the license requirement to sell surplus energy to the grid** would make installation and use of renewables much more attractive than it is now. Instead, the license requirement could be applied to larger installations that produce electricity above a certain limit. In addition, **having low interest rate credit for energy efficiency projects** can also be an appealing incentive for the local companies in Ukraine.
- Cities are in unique position towards grid operators. Their negotiation starting point is stronger with clearly stated long-term plans for RES implementation in municipal buildings that are specific enough to allow grid operators to adjust their local processes and infrastructure re-investment plans. Therefore, SPARCS recommends **developing clear and phased RES (or just PV) development plans** and speaking to the distributors early on to engage them in a common strategy. Among other important aspects, this will allow the grid operators to prioritize the refurbishment of local transformers according to the need of the newly installed capacity.

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- The environmental impacts are largely still not reflected in the energy prices (OECD, 2019). To increase the motivation for switching from large, centralized fossil sources to decentralized clean sources of energy, taxes increasing the end price per unit of fossil fuel energy (**"carbon taxes"**) proved to be a powerful solution. These taxes work in addition to the EU Emissions Trading System (EU ETS) and they directly affect the price competitiveness of clean energy. SPARCS recommends **watching closely the positive effects of the carbon taxes on RES uptake in countries that introduced them already** (e.g. Finland, Netherlands, and many more) and introduce the appropriate levels across all European countries. Indeed, in times of energy crisis of (such as the one in 2022 to 2023) the tax buffer can provide a fiscal check to balance the spikes in market prices, safeguarding the social stability ("soft landing" opportunity).
- Removing fossil fuels completely is theoretically easy from the technical perspective, but to provide the residents with a better, cost-friendly, and a resilient alternative is much more difficult. SPARCS recommends **introducing regulations and support mechanisms to allow faster transfer of new RES technologies and solutions to the market** and support their competitiveness.

3.3 Challenge of significance: PV panels vs Protected buildings and areas (Leipzig & Kifissia)

In many areas, regulations limit the shape, size and materials to be used for new buildings to keep the esthetical value of an area. While it is agreed that monuments must be preserved, many of the rules may be out of date and too restrictive, such as on the use of modern materials for energy efficiency or solar production (Ferrer et al., 2021).

Leipzig

The city of Leipzig comprises of an outstanding number of cultural monuments. The 'Department for the Preservation of Historic Monuments and Buildings' is responsible for the protection and preservation of cultural monuments within the district of Leipzig. This department provides advice on this topic to owners, developers, craftsmen, architects and citizens and deals with any enquiries about the protection and preservation of historic monuments and buildings. The protection of cultural monuments is approved in the Law and Ordinance Gazette of Saxony. All actions taken by the 'Department for the Preservation of Historic Monuments and Buildings' are based on the Saxon Monument Protection Act. (City of Leipzig, 2023)

Any work to be done in or on a cultural monument requires an authorisation permit in accordance with the Saxon Monument Protection Act. The obligation to obtain a permit applies to basic work as well, such as restoration or painting. Before the work commences, an informal written request is to be placed with the local authority responsible for the protection and preservation of cultural monuments. (City of Leipzig, 2023). Despite the strict regulations for monument protected buildings there are already good examples where PV installations were feasible on such buildings. Especially large roofs of former industrial halls, where also a significant amount of energy can be produced, are favoured by the monument protection department despite small scale interventions. One should not forget that also the physical precondition of

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roofs of older buildings, especially statics and the existing technical equipment within in the building, might limit the use of solar potential.

Within SPARCS, the City of Leipzig aims to enhance self-consumption of renewables and virtually connect all building assets to balance energy consumption & production and enable new services for reducing CO_2 emissions. The strategy focuses on multiple aspects, from integrating RES into an existing and historic building stock to the integration of into newly constructed buildings, all connected to one smart energy grid. Leipzig has three demo areas within the project: 1. former industrial area (Baumwollspinnerei premises/historical); 2. a housing district from the 1970s (Duncker Neighbourhood in the Leipzig West district) and a 3. Virtual Positive Energy community.

Kifissia

A similar situation to Leipzig occurs in the municipality of Kifissia where many buildings are protected, and it is extremely difficult to obtain approval to install renewables on the roof. Although rooftop solar panels are very common in Greece due to the ongoing energy crisis and the fact that the weather conditions also provide a favourable environment, finding a suitable available area for PV installation in Kifissia is not an easy task.

The municipality of Kifissia is a green suburb located about 12km away from the Athens city center. The green areas in Kifissia are protected as the trees are over a hundred years old. However, the trees obstruct the sunlight and reduce the solar power production capacity. Preservation of green space is without a doubt a must; however, the presence of tall trees is not compatible with the installation of PV panels for low height buildings (local building regulations do not allow the construction of high buildings, the usual height is 8 – 11m).

According to the urban and architectural regulations in Greece, majority of the buildings are required to have an inclined rooftop with ceramic tiles, and this creates technical problems in the installation of PV panels. Additionally, this increases the cost and reduces the available area. Kifissia also has many historic buildings that prohibit any type of roof installation or modification, thus this also reduces the total solar power capacity that can be harnessed across the city.

The municipality does indeed own many buildings that include horizontal terraces that create an ideal scenario for PV panels. However, the process for acquiring permits to install the panels is time consuming and requires approval from the city council and from other public authorities, depending on the type of property and the status of ownership.

Moreover, once the panels are installed, it is another lengthy process to apply for a permit to connect to the grid. The type of permit that is needed depends on the PV panel size. Photovoltaics that are under 100kW of installed power are easier and faster to implement with lower cost. These panels require a smaller installation area and they do not have to be connected to a substation, which would otherwise increase the cost and time for issuing the needed permit.

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3.3.1 Solutions developed in SPARCS

Leipzig

The Baumwollspinnerei (acronym Spinnerei) is a former cotton mill and a protected heritage site. The building was originally constructed in 1884 with a floor area of 17,000m^2. Over the years, it has been partly renovated. It is currently used as an office space for startups and also as an event location for cultural activities.

Energy demand for the demo site will be covered through a bio-CHP, Solar Thermal plant and also through photovoltaics (PVs) located onsite. Air quality will also be monitored, and batteries will be used as a buffer to store energy from PVs. The local electricity network will be upgraded to the microgrid, which will interact with the Leipzig city virtual power plant (VPP).

However, as Spinnerei is a protected site, approval was required from the local department to install PV panels on the roof. In addition, there are challenges in the actual installation of PV panels as the panels must be installed in such a way that they are not visible from any point on the street. Moreover, the local department has not identified a standard procedure for the assessment of buildings where renewable solutions are to be installed. Instead, the assessment process is conducted in an informal manner and the installation plan could be easily rejected by the department without detailed reasoning.

To support the project work and also resolve the approval process, the SPARCS team in Leipzig developed a **renewable energy map** (“Energie Atlas Leipzig”) to illustrate the potential of renewable energy production on all buildings and the current expansion status of renewable energy plants in Leipzig. All information is shown in a geographic information system (GIS). In addition to the maps, a dashboard was also developed. The dashboard shows the current expansion status of photovoltaic plants in Leipzig and their historical expansion of the last years and also some ideas for the future. The map and the dashboard are currently in process, and it will be shown to the local department till the end of 2023. The map is only available for the City of Leipzig’s internal use at the moment.

For developing the renewable energy map, a large-scale engagement process with all relevant departments was started (e.g., department of monument protection, environmental protection, climate neutrality, traffic, economic development, green spaces and waters, housing subsidies and urban restructuring). Through the workshops, it was realized that the departments need the renewable energy map for their daily work and the map can also be used for citizen engagement purposes, which will allow residents to see the renewable energy potential for their own houses.

Kifissia

In order to increase the renewable energy production in the city, the municipality of Kifissia together with the local SPARCS team is preparing the **formation of an energy community** that will be a collaboration between the municipality and citizens. The plan consists of an open call to the citizens to join the energy community. The proposal includes the construction of a photovoltaic park on a terrace of a municipal building.

The installation of the PV park on a municipal building will give the opportunity to all the citizens/members of the energy community to profit from the production of green

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energy via virtual net metering. The citizens/members of the energy community can also benefit from the new law that enables them to join more than one community.

The local SPARCS team considered many municipal buildings in Kifissia, examining the building structure, orientation and surrounding area. Finally, a municipal school building was considered suitable for PV installation. The selected building has a horizontal terrace of about 800m^2. The total installed power of the PV system will be 99kW and according to the initial feasibility study, the system will produce around 150,000 kWh per year. The proposal for the formation of the energy community and its goals was presented to the city council and has received the approval.

3.3.2 Impact of the solution in SPARCS

In Leipzig, the SPARCS project activities provided a very strong basis to discuss the obstacles associated with protected buildings and installation of renewables on the roof. With the help of SPARCS, the Leipzig project team has built a strong case that will help fasten the approval process. More importantly, work done so far in Leipzig has helped the local administration and the project partners become more aware of regulations and legal aspects since the project requires implementation and monitoring, which means the 'actual effect' of the regulation on specific demo activities were not known before. It is hoped that the knowledge and momentum gained from SPARCS supports future work on the heritage buildings as the city has an abundance of monument-protected buildings, which will need to be retrofitted for energy efficiency in the near future and thus the existing regulations must be able to support the efforts.

In Kifissia, different experts and members of the municipality are now collaborating to address the numerous challenges that the project has raised. The goal is to increase the energy produced by RES and at the same time to raise awareness by engaging citizens and to help promote energy transition. This work will also subsequently support the creation of the energy community. Moreover, work done through SPARCS helped realize that there is a need in promoting RES within the municipality.

3.3.3 Recommendations

- SPARCS recommends that **State/local administration revise their procedure to assess the protected buildings** in a way so that the process is more standardized. The procedure should clearly highlight the minimum requirements and conditions that need to be met (if any) and also allow a certain level of flexibility which will support the installation of renewables on the roofs. Bureaucratic procedures for awarding permits should also be improved and simplified.
- **Enabling tools such as a solar power map** could support the decision-making process to assess gains and avoid unnecessary delays. Such tools represent a sustainable data base that combines information on the solar potential and highlights monument protected buildings.
- **More incentives and funding options for net metering** will also promote energy transition.
- According to a recent law in Greece, the minimum number of members required to set up an Energy Community is sixty (60). This number is too high and, in most cases, not applicable. This regulation also causes difficulties for citizens of remote areas to participate in such communities. SPARCS recommends

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reducing the minimum number of energy community participants as a citizen group usually starts from 10 - 20 initial members.

- There is a need for funding programs especially to enable energy communities and support municipalities. SPARCS recommends **providing financial instruments to implement RES projects and energy communities** to be provided with easy-to-join financing programs with favorable terms.
- SPARCS recommends **establishing a help desk through which the ministry (or relevant public authority) could give valid information and recommendations**. Citizens, municipalities or other legal entities could refer for information and clarifications of the needed procedures to establish energy communities and implementation of RES, thereby saving valuable time and resources.

3.4 Challenge of Significance for SPARCS cities: Blockchain solutions for P2P trade within Virtual Power Plant (Leipzig)

The different showcases of the Leipzig virtual power plant were originally designed to heavily rely on blockchain-based systems. After developing blockchain prototypes to demonstrate energy transactions on live systems, the replication into real market areas posed substantial challenge in the central European and particular German regulatory environment. These challenges matter as blockchain was originally planned to support the tracking of energy amounts, individualized CO_2 certificates and bonus tokens for private users.

In this context the Leipzig virtual power plant has been subject to numerous challenges and barriers. Among the conventional and known issues (e.g., standardisation of interfaces, legacy system, data access rights, limitations of throughput), the use cases involving peer-to-peer energy (P2P) trade and blockchain were of specific concern.

Peer-to-peer (P2P) energy trade is highly relevant for the future due to its potential to contribute to environmental sustainability, CO_2 reduction, and enhanced energy flexibility. By directly connecting energy producers and consumers within local communities, P2P trading enables the integration of decentralized renewable energy sources, reduces reliance on fossil fuels, and minimizes greenhouse gas emissions. It promotes energy flexibility, allowing real-time balancing of supply and demand, optimizing the utilization of renewable resources. P2P trading empowers energy prosumers, fosters resilient and efficient energy systems, and plays a vital role in accelerating the transition towards a sustainable and low-carbon future.

Sub-challenge 1: From the perspective of owners of small assets: Article 5 of the German Energy Industry Act (EnWG) sets out the requirement for energy trading to be conducted by authorised companies. This requirement can be seen as a barrier to P2P energy trading and blockchain use cases as it limits the ability of individuals to engage in direct energy transactions without intermediaries.

Sub-challenge 2: For the context of energy taxation: Article 9 of the German Electricity Tax Act (StromStG) imposes a tax on the generation, transmission, and distribution of electricity. This tax applies to all electricity transactions, including local P2P energy trades.

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Sub-challenge 3: Regarding different balancing groups. Article 26 of the German Electricity Market Regulation (StromNZV) sets out the rules for the balancing of electricity supply and demand in the German electricity market. One issue with regard to P2P energy trading concerns the lack of clarity in how P2P transactions should be treated in different balancing groups. Balancing groups are responsible for ensuring that the electricity supply and demand in their respective areas are balanced in real time. However, the legal status of P2P energy trades with regard to different balancing groups is unclear, as the current regulations were not designed with P2P transactions in mind.

Sub-challenge 4: Article 80 of the German Renewable Energy Sources Act (EEG) sets out the rules for the feed-in and priority dispatch of electricity generated from renewable sources. One aspect of this section concerns the prohibition of double selling, which prevents small, distributed energy resources (DERs) from participating in local markets. The prohibition of double selling means that electricity generated by small DERs, such as rooftop photovoltaic (PV) systems, cannot be sold twice to different parties. This restriction makes it difficult for small DERs to participate in local energy markets, as it limits their ability to sell surplus energy to others. The electricity must be supported by the EEG and fed into the grid. The prohibition of double selling can be seen as a barrier for small DERs to participate in local energy markets, as it restricts the potential revenue streams for these systems. This, in turn, may discourage investment in small DERs and limit the growth of decentralised energy production.

Sub-challenge 5: The issue of immutability of many blockchain systems: Article 20 of the General Data Protection Regulation (GDPR) sets out the rights of individuals regarding their personal data. One issue regarding the use of blockchain technology for P2P energy trading is the lack of user data portability due to the immutability of the blockchain. The immutability of the blockchain means that, once data has been written to the blockchain, it cannot be altered or deleted. This is a key feature of blockchain technology which provides security and reliability, but it also creates challenges for data portability. Under the GDPR, individuals have the right to data portability, which means that they have the right to receive their personal data in a structured, commonly used, and machine-readable format, and to transmit such data to another controller without hindrance. However, the immutability of the blockchain makes it difficult to meet this requirement, as it is not possible to alter or delete personal data once it has been written to the blockchain.

3.4.1 Solutions developed in SPARCS

Due to the challenges and barriers faced by the VPP, LSW made several strategic decisions to navigate these obstacles and ensure progress:

Adoption of Centralized Information Systems: Recognizing the limitations imposed by regulatory requirements, LSW temporarily put purely blockchain-based systems on hold. Instead, they focused on further developing the VPP using centralized information systems. This approach allowed them to continue making advancements in the VPP's functionality and performance without being hindered by the regulatory challenges associated with blockchain technology.

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Collaboration with researchers and policy makers: LSW and the other SPARCS project members actively engaged in discussions with researchers and policy makers to address the regulatory issues encountered. By sharing their experiences and challenges, they contributed valuable insights that could help shape future regulations and policies. They identified potential ways to circumvent specific issues, such as exploring possible exemptions or modifications to regulatory requirements like §9 StromStG[3], which imposes restrictions on energy assets below 2 MW. Through these discussions, they aimed to influence regulatory reforms that would create a more favorable environment for their project and similar initiatives.

Monitoring the development of future blockchains: Understanding that existing blockchain networks presented regulatory challenges, LSW disengaged from these networks. Instead, they decided to closely monitor the development of future blockchain technologies that could address the specific reasons behind these regulatory issues. By staying updated on the progress of different blockchains, they aimed to identify potential solutions that would allow for the integration of blockchain technology in their project while complying with regulatory frameworks.

To provide a user experience that emulates the benefits of peer-to-peer energy trading without relying on blockchain technology, two project partners **LSW and Cenero opted to simulate live P2P trade**. Through advanced algorithms and sophisticated software, they created a simulated environment that mimicked the real-time dynamics of P2P energy transactions. This approach allowed them to showcase the advantages of decentralized energy trading to users and stakeholders while circumventing the regulatory challenges associated with blockchain-based P2P trading.

3.4.2 Impact of the solution in SPARCS

The requirement for authorisation may limit the potential for P2P energy trading, as it creates a barrier for individuals to participate in these types of transactions. Additionally, blockchain technology offers new possibilities for secure and transparent energy trading, but these opportunities may be limited by the need for authorised companies to participate in such transactions.

The taxation of local P2P energy trading might reduce incentives for individuals to engage in these transactions, as it increases the cost of energy for both the buyer and the seller. This increase in cost can make P2P energy trading less attractive, as it reduces the potential financial benefits of such transactions. Additionally, the tax on local P2P energy trading can limit the growth of decentralised energy systems, as it discourages investment in small-scale renewable energy production and energy efficiency measures. This is because the tax reduces the potential financial returns from such investments, making them less attractive for individuals and companies.

Regarding the different balancing groups, the lack of clarity in the legal status of P2P energy trades can create uncertainties for participants as it is not clear which balancing group is responsible for ensuring the balancing of electricity supply and demand in P2P

[3] https://www.gesetze-im-internet.de/stromstg/__9.html

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transactions. This can make it difficult for P2P energy trading to be implemented in practice and limit the growth of decentralised energy systems.

LSW is actively developing and conceptualizing business models based on P2P trade. They plan to collaborate with residential homeowners who have renewable energy assets, such as solar panels. This models are aimed to empower homeowners by allowing them to sell their excess energy directly to their neighbors or nearby businesses, fostering a sense of energy self-sufficiency and reducing dependence on centralized grids.

To support community-based renewable energy projects, LSW explored the idea of facilitating energy trading within specific communities. By developing the "Bürgerbeteiligung" platform, they aimed to connect residents who collectively owned and operated renewable energy assets. This localized energy marketplace would enable community members to buy and sell energy among themselves, enhancing energy resilience and promoting sustainable practices at a grassroots level.

Looking ahead, LSW also prepares the launch of partnership programs with electric vehicle (EV) owners to integrate their flexibility into the VPP. By leveraging the growing EV market, LSW sought to optimize the utilization of renewable energy resources and support the transition towards electric mobility.

Additionally, LSW is actively working on developing a robust and extensive VPP that integrates various assets and devices capable of participating in multiple energy markets. However, the implementation of live peer-to-peer energy trade faces several barriers, as the existing market infrastructure is not designed to accommodate such transactions. Nevertheless, LSW is committed to overcoming these regulatory challenges by exploring alternative solutions, such as making strategic technology decisions to ensure privacy protection and compliance. The applicability of the envisioned business models will be a key focus, with particular emphasis on understanding user acceptance. LSW recognizes that user engagement and acceptance play vital roles in the success of P2P energy trading initiatives. Through continuous evaluation, feedback, and adaptation, LSW aims to refine and optimize these business models to create a sustainable and user-centric energy ecosystem for the future.

3.4.3 Recommendations

- One approach is to **lobby for changes in German and EU legislation that would enable P2P energy trading and blockchain use cases**. This could involve engaging with lawmakers and industry stakeholders to raise awareness of the benefits of these technologies and to encourage the development of more supportive regulatory frameworks.
- Another strategy is to **identify and collaborate with companies that are willing to participate in specific P2P energy trading and blockchain use cases**. This could involve negotiating clear agreements that would enable such transactions to take place within the existing legal framework. It may also be worth exploring alternative business models that do not rely on P2P energy

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trading or blockchain technology. For example, this could involve developing solutions that leverage existing authorized companies, such as LSW, or adopting a more centralized approach to energy trading.

- In addition, there is potential for **developing new technologies that could help overcome some of the legal barriers**. For instance, a blockchain-based system that is specifically designed to comply with regulations and address data portability issues could be developed.
- Finally, **working with legal experts who specialize in blockchain energy trade** in the German jurisdiction may be helpful as they can provide guidance on how to mitigate the legal barriers. Their expertise could prove invaluable in navigating the complex legal landscape and identifying ways to achieve compliance with relevant regulations.

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4 STORAGE SOLUTIONS (FROM SHORT-TERM TO SEASONAL)

4.1 Introduction

Storages are an essential element in facilitating flexibility in the energy system, helping to balance the energy demand and supply on the area. A plethora of solutions exist, both for short- and long-term application. Energy storage enables PEDs to store excess energy instead of exporting it and increase the onsite utilization of intermittent energy sources, such as solar and wind. This is particularly important for self-sufficient PEDs, so-called autonomous PEDs, as they are not allowed to import energy from the external grid. For dynamic PEDs, energy storage is not as crucial since they allow bidirectional interaction between the district and its surroundings and can thereby use the external grid to balance the energy demand during periods of low onsite energy generation (Lindholm et al. 2021).
The heat energy can also be stored in PEDs and it can also interact with the district heating network of the city. The heat can be stored for both short and long term. In the urban environment, the use of heat tanks is very common for short term storage. For long term storage, heat can be stored e.g., in pit storage, sand storage and boreholes thermal energy storage. However, the losses from these storages can be high so the efficiency of the storage is low compared to battery storage.

In SPARCS, two types of storage solutions are mainly used:

- In Espoo - in Sello and Lippulaiva shopping centres - batteries are used for facilitating flexibility and participation in the electricity market. They work as part of the virtual power plant on these sites.
- In Leipzig, a thermal energy storage supports the district heating system. In addition, the use of a battery energy storage in the citywide virtual power plant is simulated.

4.2 Challenge of Significance for SPARCS cities: How to avoid major challenges in storage implementation?

In SPARCS, there were mostly minor challenges related to storages, and the storages had only been operational for relatively short time during the interviews or even not started yet.

In most of the BESS (Battery Energy Storage System) cases in SPARCS, there were challenges related to fire safety during the planning or installation phase. This was however quite easily solved in most cases. Also, the weight of the batteries caused some limitations for the placement of the system in several cases, which was not always anticipated by the actors involved. A typical offering for BESS is in a container, but this is not so easy to place e.g., in shopping malls.

In several cases there have been challenges with the limitations of the IT systems: they were either not meant for the particular use, they were not interoperable, or some key functionalities were missing. In one case, the metering system was not compatible with the network operator's system, which delayed getting the required permission from the local network operator for connecting the BESS to the grid. It also turned out

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that these requirements can vary from network operator to other. In new buildings the metering is usually easier to connect to the network operator's system, but in older systems the two-way energy flows (electricity or heat) are usually not taken into account, requiring some additional installations or programming.

The delivery times for batteries have been quite long. This is partly a challenge, but it also has given a lot of time to solve the other challenges.

In case of the thermal storage in Lippulaiva, the ongoing work for the new metro line in the area caused some changes to the original plans as the distance to the metro tunnel had to be kept at 10 meters minimum. This, however, caused only minor delays in the process.

The most serious effects of the different challenges were the additional delays, which then caused financial damage in some cases as the investments were already made, but the system was not in operation, so it did not produce incomes.

4.2.1 Solutions developed in SPARCS

For the fire safety issues, there were several solutions, e.g., early communication and **co-operation with the local fire department** and clear signs to mark the spaces where BESS was located. It is essential to make sure that the fire fighters know how to address the battery fires, which require slightly different protocols than normal fire incidents due to the materials included in the batteries.

In some cases, the original plan was to place the BESS on the roof of the building, but the weight of the system would have caused additional requirements for the structures and challenges for the installation, so the best solution was to place it on the ground floor.

For the IT system challenges, the best solution for some partners was to do some of the programming tasks themselves. This is of course not possible for all actors in the same position.

4.2.2 Impact of the solution in SPARCS

The co-operation with the fire department was found fruitful, as it will be beneficial also for the fire department in the future, when there will be more and more BESSs around.

Taking the initiative for the programming in own hands also gives more power to make changes, and also most often reduces the time for getting them done. One of the partners even managed to develop an IT product for BESS management and sold it to several customers already.

4.2.3 Recommendations

As there were no serious challenges related to the storages, we asked the interviewees' views on the potential reasons for this success. These are their answers:

- Starting from the planning phase, it is important to not only concentrate on the technical part, also on the rules of e.g., net operators regarding the exchange with the grid, and general rules and regulations.
- In SPARCS demos, the storages are used both for increasing the self-sufficiency and for providing flexibility services for grid operators and district

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heating company. With such a complex system integration, the choice of the project team is very important as it has to be highly competent and documentation needs to be up to date and correct. It is also important for a smooth transfer to operational phase that the **users are included already in the planning phase**. It could be beneficial if the owner is the same as the constructor.

- It will help mitigate the problems in implementation if the **(building/ fire safety) inspectors are of high quality and involved early on in the process** to point out the shortcomings already in the construction or even planning phase. In one case, it was a good solution to involve the inspector in the planning phase, when it was clear that some exceptions need to be done related to standards.
- The anticipation of potential problems is important, and related provisions should be added in the contract, e.g., related to the availability of maintenance. This is relatively easy for an established actor but might be more challenging for a new actor in the field.
- **Simulations are highly recommended to support the dimensioning of the (storage) system**.

4.3 Challenge of Significance for SPARCS cities: Lack of regulations to install storage solutions

One of the most significant challenges was related to unclarity or lacking regulations, which caused some extra work and need of active contacting with the authorities. This is a truly cross-cutting issue, related to the regulations. The regulations are not built for storage solutions everywhere, and in some cases they simply don't exist. This might partly be due to the missing information of the specific features and requirements related to storage systems on the regulators' side.

4.3.1 Solutions developed in SPARCS

The main way to address the lack of regulations was to first study if they existed on European or global level, or in another European country, and then contact the regulatory instances to ask how to proceed.

4.3.2 Impact of the solution in SPARCS

Contacting the regulators helped in ensuring that the storage solutions would be aligned with the upcoming regulations as far as possible. It also gave a chance to give the actors' own view on how the regulations should be formulated and why, and to give relevant information to the regulators about the specific features of the energy storages and their operation.

4.3.3 Recommendations

- As the regulations related to storage systems are largely missing, this would be a good opportunity to **align them around Europe**, as far as possible, **when formulating them**.
- **Keep regulators informed about the specific needs for the regulations regarding storage systems.**

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5 ELECTRO-MOBILITY

5.1 Introduction

Within the EU, the transportation volume has been steadily increasing from the year 2000 to 2019 both in the passenger sector as well as in the freight sector. A significant decrease was observed in 2020 due to the COVID-19 pandemic, but the growth is expected to continue after recovering from the pandemic. While the greenhouse gas emissions of other sectors have decreased from the reference year 1990, the emissions originating from transportation are still growing. Hence, the relative importance of the transportation sector is increasing in the attempts to combat climate change. Existing policies will probably not be enough to meet the emission reduction targets of 90% compared to 1990 as projections show that the reduction will only be 22% in the transportation sector.

E-mobility solutions in combination with renewable electricity generation can greatly reduce the impact of transportation on global warming (Hung et al. 2021). Nitrogen oxides originating from burning fossil fuels can also be avoided by transitioning to e-mobility. However, as battery-electric vehicles tend to be heavier than conventional vehicles, this may affect the air quality as the tires on EVs undergo more wear and tear and will thus release more particulate matter into the air. Hence, public transport and light mobility are of great importance in improving the air quality in cities.

Battery-electric vehicles can conveniently be recharged while being parked as long as appropriate charging infrastructure is provided. Private cars are parked for approximately 95% of the time. Commercial vehicles are utilized more, particularly during daytime and the time required for recharging is short. Due to this, private cars can often rely on a lower charging power, and they can be rather flexible in the matter of where and when to charge. Commercial vehicles have much stricter schedules, and the optimal solution from an operational point of view would be to use the short natural breaks during loading and unloading of the vehicles for recharging. Hence, charging possibilities for commercial vehicles should be provided based on these constraints.

The SPARCS Lighthouse City demonstrations have included the integration of EVs in the local energy systems, peak load monitoring and control, smart charging and bi-directional charging and implementation of charging infrastructure for public transportation purposes. Furthermore, the needs of EVs have been taken into consideration when planning new urban areas. With regard to the Fellow Cities, the City of Reykjavik is constructing its first mobility hub, municipality of Kifissia is implementing its first bike sharing system and smart sensors and City of Lviv will be creating a digital Data-Driven Sustainable Mobility Plan.

5.2 Challenges of Significance for SPARCS cities: Provision of charging infrastructure

In Europe, more than 20% of cars sold during 2022 were electric and the sales of EVs increased by 15% from the year before. The increase of EVs is expected to continue during the upcoming years supported by new stricter rules for emission levels (Global EV Outlook 2023). The steadily growing number of electric vehicles naturally needs

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continuous investments in charging infrastructure to ensure charging availability for all users.

In some cities, EV owners face challenges due to scarcity of charging points; there is nowhere to charge the vehicle outside home. The scarcity of the charger network might be a barrier to invest in an electric vehicle. On the other hand, charging service providers cannot invest in cases where there are not enough customers to utilize the service. Urban areas that are already densely populated often lack space for parking and residents do not have their own dedicated parking space, making it impossible to install their own charger. Architectural requirements and lack of space might also be a problem when implementing charging infrastructure for heavy-duty vehicles, as high-power charging equipment requires a substantial amount of space.

The physical implementation of charging infrastructure is only one part of the issue, though. To fully utilize the possibilities that EVs could bring, smart charging and even bi-directional charging should be enabled. Uncontrolled charging of EVs might lead to high power peaks and undesired stress on the grid. So far, as the number of electric vehicles is low, this has not been an issue in most cities, but as the number of vehicles and charging stations increase, the impact on the grid should be considered. Smart charging services, and even more bi-directional charging services, require specially designed software to control the charging process. The smart charging software can provide a link between the user and the electric grid so that the energy usage is optimized without jeopardizing the true needs of the vehicle owner.

Physical interventions in an urban environment easily becomes a long and tedious project. Multiple issues and stakeholders have to be involved in the process, and regulations and requirements from the city have to be met. The interlinkage between energy production and mobility introduces a new level of complexity when it comes to e-mobility. It is not sufficient to simply install chargers and wait for the customer to appear, instead, development of software for smart charging services and implementation of new business models have to run in parallel.

While implementation of charging infrastructure is crucial in order to support the decarbonization of transportation, one should keep in mind the simple technical solution, which is light mobility in combination with public transportation. Private vehicles provide a high level of comfort, and the challenge in all cities is how to convince people to switch to alternative mobility modes. This is not an easy task, and people should, of course, always have freedom of choice. However, successfully addressing this challenge could bring additional benefits in the form of improved health and wellbeing. Therefore, these technically simple, but socially challenging solutions should not be overlooked.

5.2.1 Solutions developed in SPARCS

Several actions to address the challenges related to infrastructure have been undertaken within the SPARCS project. In Leipzig, one of the main focuses has been **intelligent charging** and preparations for **bidirectional charging**. In both Leipzig and Espoo, load management and integration of bus charging in the energy system have been targeted.

In Leipzig, a mobile application enabling intelligent charging of cars has been developed. The software, including the back-end for controlling the charging and a

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user-friendly front-end has been developed in cooperation with private companies. The development work has required substantial knowledge related to multiple aspects, such as technical issues, tax regulations, charging protocols, and practical issues related to charging of vehicles.

The aim of the e-mobility activities within SPARCS was also to integrate bus charging with the energy management system in both Leipzig and Espoo and to optimize the charging and manage peak load of the electric grid. The optimization of charging of buses was mainly carried out by means of data analysis and simulations. There is potential for improving the bus charging through optimization in both Leipzig and Espoo even though the possibility is not taken into use currently. The data analysis of bus charging in Leipzig showed a potential to reduce the charging capacity at the terminal, and the simulations of charging in Espoo revealed the possibility to minimize the peak power fee by altering the charging behaviour of the buses. However, the practical implementation of these applications has not been possible due to contractual issues. This highlights the need to involve all parties from the very beginning and to create business models that can incorporate new kinds of smart usage of energy. Optimized charging would be beneficial for both the transport operator and charging service provider in form of lower energy prices, but a mutual understanding of the targets and agreement on practical issues are required in order for the optimization to become reality.

5.2.2 Impact of the solution in SPARCS

The work carried out in SPARCS has created a basis for further development. The smart charging software provided in Leipzig has mostly received positive feedback as it has streamlined the charging service and improved the user experience. The potential to intervene in the charging session and optimize the energy usage has not fully been taken into use, hence, no negative feedback for example, interrupted charging has been received. However, the building blocks are there, and as soon as improved business models are created and there are good incentives for the user to participate in smart services, the capabilities of the developed software can be taken into full use. The electricity mix and the electricity price volatility vary greatly from region to region. As a consequence, the value of for example, bidirectional charging and participation in ancillary services will depend on the region. Hence, further work is needed to set the correct prices for smart charging services.

Although the simulations for public transport needs have not yet led to concrete actions related to the provided service, the analysis itself has increased the understanding for optimized charging services. The highest potential of simulation methodologies is to use them prior to implementing charging services in practice. The simulation approaches developed in combination with transportation data and vehicle data can be used as support in the decision making to avoid over or underestimation of the required charging need.

5.2.3 Recommendations

- **Utilize private companies efficiently:** While the coordination and certain mobility solutions can be handled by the municipality, involvement of private services is often preferred. Private companies can be agile by nature, and rapidly scale up as the uptake of the provided solutions increases.

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- **Prepare in advance for upcoming phases:** The transition to e-mobility solutions is very fast and the need for new charging infrastructure is constantly growing. The municipality should consider the needs of transportation that traditionally have been handled by private companies. For instance, early preparations for the needs of electric heavy-duty vehicles should be undertaken in order to ensure that they can be introduced in the urban environment as soon as possible.
- **Promote light mobility and public transportation**: Prioritize traditional light mobility, such as walking and biking, in all stages of city planning. This includes infrastructure, parking, street maintenance, placement of schools and day care centers etc. Improve the service level of public transportation and make sure that the mobility needs of the majority of residents can be fulfilled.

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6 EFFECTIVE BUSINESS MODELS FOR SUSTAINABLE SOLUTIONS

6.1 Introduction

Timeus et al. (2020) describes the 'smart city business model' as the way in which a city government organizes its services to create and deliver value for its citizens that is economically viable, socially inclusive and environmentally sustainable.

Business models are necessary for sustainable/smart city solutions to ensure financial viability and long-term sustainability (Timeus et al., 2020). Effective business models allow cities to understand and visualise how changes in one or more elements would open new business opportunities and bring about new ways of creating and delivering value (Teece, 2010). Since sustainable/smart city solutions sometimes have high upfront costs, significant technological risks and a long-term payback horizon making it difficult to attract investment (Rivada et al., 2016), the goal for cities is to identify ways to finance them without prioritizing large-business goals over social goals which could lead to inequality (Grossi & Pianezzi, 2017).

Within SPARCS, one of the objectives is to identify, analyse and adopt innovative and effective business models, so that the developed tools and solutions can be scaled up to the city level and replicated in Fellow Cities and other European and Worldwide cites. Figure 7 shows the project development process led by BABLE.

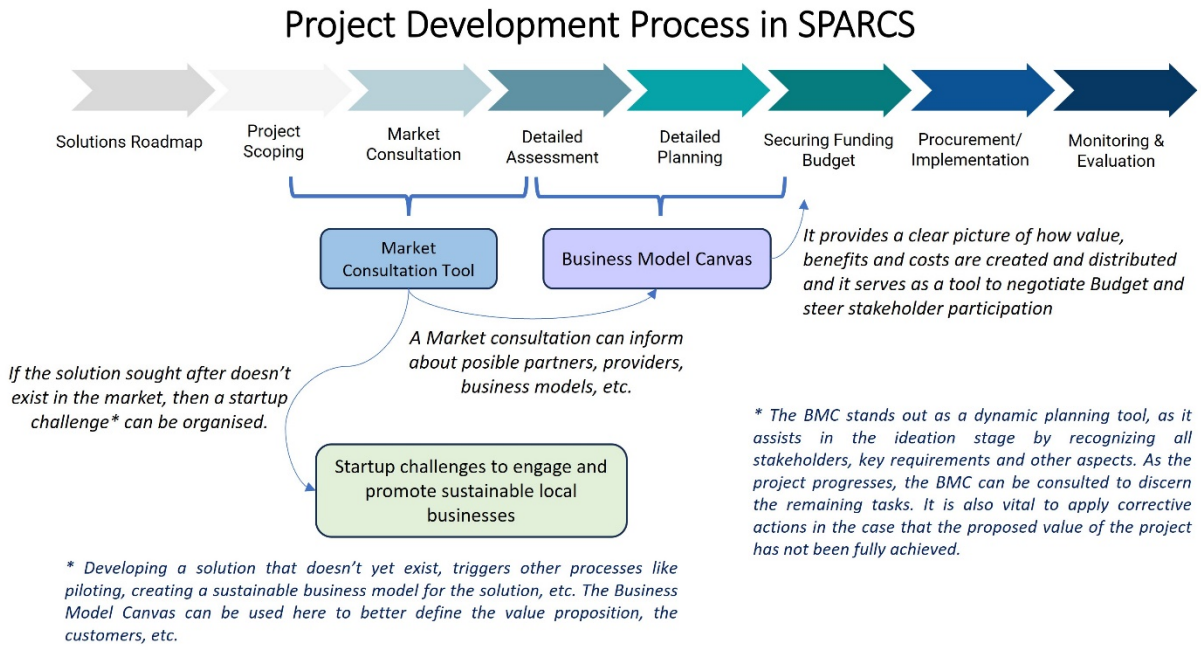

Figure 7: Connection of the three SPARCS challenges regarding Business Models as described in the following sections

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6.2 Challenge of significance to SPARCS Cities: Developing and finding financially viable business models for the projects

Cities aim to identify financing methods that avoid prioritizing large-business goals over social goals, as the former approach ultimately leads to inequality (Grossi & Pianezzi, 2017). Therefore, it is critical to find a balance between generating economic benefits and addressing social needs when developing sustainable/smart city solutions. By establishing effective business models, cities can overcome these obstacles and ensure the financial viability and long-term success of their initiatives.

Evaluation approaches for smart city business models vary depending on the context, objectives, types of solutions/technologies/business sectors involved, and the intended users of the evaluation results. These approaches consider not only the financial aspects but also the public value and societal benefits derived from implementing smart city solutions. Additionally, the city government has a unique role in the value-creation process. (MAtchUP project, 2019)

City council managers face several challenges during the implementation of smart city projects: (1) Unclear local system: there is a need for a transparent and well-defined local framework that allows for improved planning and mapping of various activities throughout the project's stages; (2) Non-financial impacts: emphasis on non-financial aspects requires city council managers to weigh the costs against the benefits of smart services meticulously which ensures that the broader implications of such projects are considered; and (3) Stakeholder identification: understanding and aligning with key partners, customers, and beneficiaries and recognizing their unique views on the project's risks and rewards could be complex (Timeus et al., 2020).

Various business model evaluation frameworks exist but the Business Model Canvas by Osterwalder and Pigneur (2010) stands out as the most well-recognized. This tool provides a holistic view of a business model, and it can be applied to different private and public organizations allowing them to assess, redefine their strategies and explore new improvement opportunities in their processes (Osterwalder and Pigneur, 2010). The city model canvas developed by Timeus et al. (2020) is also a useful reference. It has been tested in Bristol (Lighthouse City in H2020 REPLICATE Project) to plan and design the city's ICT platform.

The Business Model Canvas developed in SPARCS targets all the organizations that want to have a view of how a Positive Energy District Solution can create, deliver, and capture value. Within SPARCS, the targets on one hand are the cities and their municipal authorities who are responsible for managing the smart city solutions from product suppliers, service providers and investors and on the other hand, the companies owning and/or developing the smart city solutions.

6.2.1 Solution developed in SPARCS: the SPARCS Business Model Canvas Template

To build a Business Model Canvas in SPARCS, the following references were taken into consideration:

- Social Business Model Canvas: Derived from the original Business Model Canvas, the Social Business Model Canvas specifically caters to the unique needs and goals of social enterprises. This tool helps in structuring and

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organizing key components of a business model, creating a comprehensive and well-designed approach to deliver both social impact and financial sustainability.

- MAtchUP Project: EU-funded Smart city project involving three lighthouse cities and four follower cities. The seven cities have developed and deployed innovative solutions in the fields of energy, mobility, and ICT. The deliverable D6.1 "Review of business models and financial instruments" provides an extensive literature review on smart city business models and introduces an assessment framework. This framework is designed to analyze smart city business models and can be used to assess their effectiveness from both a private and broader public standpoint.
- MOVE2CCAM Project**:** An EU-funded project, consortium of 10 participants, seeks to establish a wide 'Satellite' network for CCAM (Cooperative, connected, and automated mobility) stakeholders. Additionally, this project aims to develop a tool for modelling scenarios and evaluating the effects of upcoming CCAM measures.

A meticulous selection was made to identify the segments that hold utmost significance and necessity for the work within SPARCS. The 12 segments are presented in Table 4 and the canvas is shown in Figure 8.

Table 4: Elements of SPARCS Business Model Canvas

SPARCS Canvas Segments	Explanation
City Government role	Overview of the control that the city government has on the different actions: Design/Management/ Performance and collaboration with the private partners/ Finance and funding/ Necessary policy and regulatory framework/ Taxes and economic incentives/ Engaging with the citizens.
Asset Ownership	Indication of actors that own or possess the assets used by the different actions (if assets are present). Asset ownership can be held by different types of organizations such as companies (physical assets like lands, buildings, and intangible assets like patents or intellectual property) and governments (infrastructure, lands, buildings).
Business Model Typology	Main Business Model typologies which support the action bundle: Public own/operate, Energy performance Contracting (EPC), Public Private Partnership (PPP), Concession, Crowdfunding and Outcome-based Contracting
Value proposition (Customer, Impact Measures and Beneficiary)	Description of the real value that this action intends to create for the citizens/city-users/local government/other stakeholders.
Funding/Financing	Determination, identification, and measurement of resources needed to implement and execute the project (National funding, regional/state funding, EU funding, loans, etc.)
Cost Structure	Divided in Capital expenses of the action bundle, expenses that a business requires to improve and preserve long-term assets (property, buildings, equipment) and Operational expenses, expenses that a business requires to maintain its operations (rent and utilities, salaries, marketing, professional services, etc.)
Revenue Streams	Identification and measurement of the different sources of incomes or revenue streams associated with the action bundle (economic

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	efficiencies in terms of cost savings, payments/fees for the use of the services, asset transfer, other).
Social & Environmental Costs	Non-financial aspects of the business model that are detrimental to the city. Social costs such as mental health impacts, concerns about privacy and data security, reduced human interaction due to over-dependence on technology, job losses, etc. Environmental costs such as Increase of energy consumption and greenhouse gas emissions, natural resource depletion, electronic waste, loss of biodiversity, etc.
Social & Environmental Benefits	Non-financial aspects of the business model that are beneficial to the city. Social benefits such as Job creation, social inclusion, efficient and convenient services, citizen engagement, increased safety and security, sustainable practices, etc. Environmental benefits such as Increase of energy efficiency, green infrastructures, sustainable transportation, reducing greenhouse gas emissions, smart waste management, etc
Partners and Key Stakeholders	Besides partners, it should be included the key stakeholders that are/ should be involved in the project. Key stakeholders are the organizations that have a particular and special interest in the project and could have the ability to influence in its success or failure. It's not being considered the customers and beneficiaries as part of this segment.
Target users/Customer Segments (Customer and Beneficiary)	Description of key target users or customers of the product or service. There are two relevant groups: the customer and the beneficiary. Customer is an individual or organization that purchases goods or services in exchange for payment. Beneficiary is a person or organization who benefits from the value created by your product or service, though they might not be the one to pay for it.
Surplus (Reinvested in other services for the citizens)	Description of where and how you plan to reinvest the profits in support or give more benefits to the communities; for example, other activities or services to benefit the citizens such as educational workshops.

The segments that add differential value to the SPARCS Business Model Canvas are: (1) Customer segment, (2) Surplus segment, (3) Social & Environmental costs, and (4) Social & Environmental benefits. These four segments give a better approach to how this framework could assist City Council managers and Use Cases owners in outlining the ways they can generate and provide public value via their smart city initiatives and have better acceptance and participation by citizens, which is also considered one of the bottlenecks at the time of implementation.

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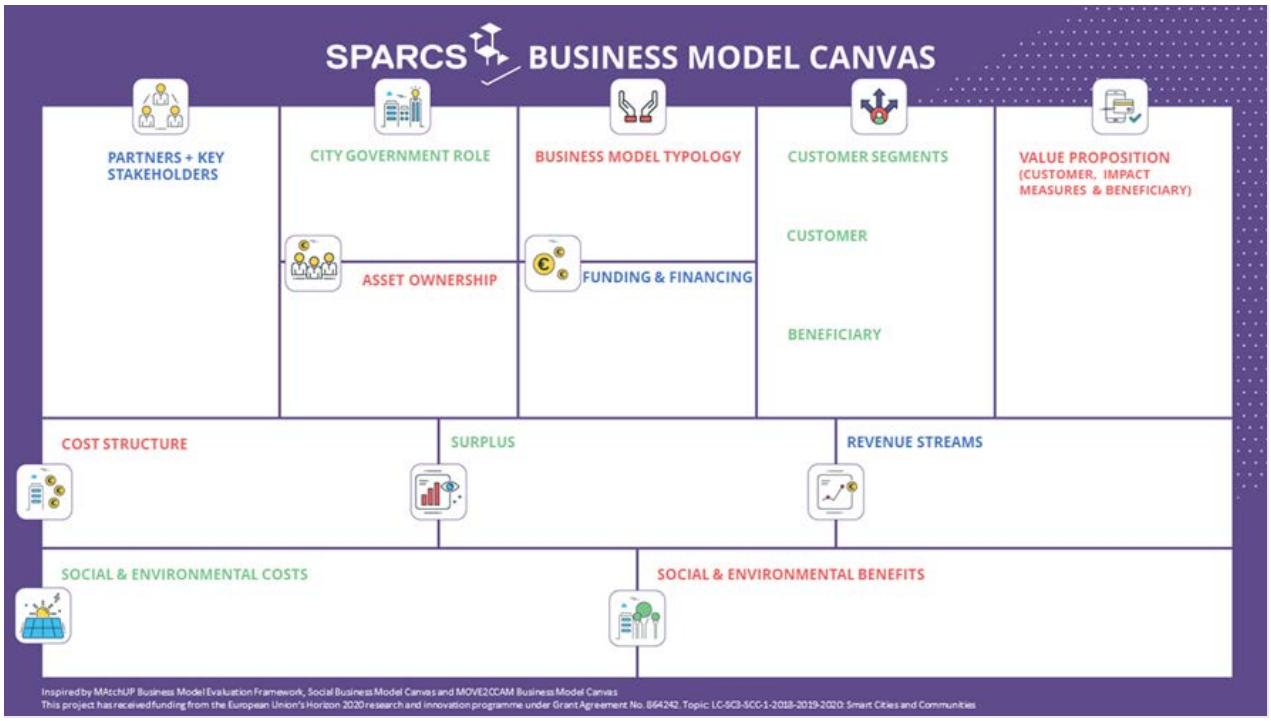

Figure 8: SPARCS Business Model Canvas (BABLE Smart Cities, 2023)

6.2.2 Impact of the solution in SPARCS

The SPARCS Business Model Canvas was developed during spring 2023 and it was tested with the partners in a 3-hour workshop during the consortium meeting in June 2023. The focus was on the Use Case Owners, which can either be the Lighthouse City, Fellow City or the technical partner.

A Use Case is an application of technology to reach a specific goal in a specific context and whose impacts can be measured independently and also replicated. Each Use Case has various supporting factors such as lessons learned, financial details, providers, end users, results, and additional benefits that enable its implementation in a specific setting. For Lighthouse Cities, the Use Cases explain information about the planning, implementation and monitoring of each demonstration action.

An example of a Use Case is the "Charging options at new mobility hub" being built by the City of Reykjavik together with the technical partner OR. This will serve as a prototype for future mobility hubs and improve availability of services. This pioneering approach to neighbourhood planning will be illustrated by using one of two main bus terminals at Strætó bs in Reykjavík. This Use Case was inspirational and relevant for the City of Kladno as they are also implementing a project related to EV charging infrastructure.

Prior to the workshop, the Use Case owners were requested to pre-fill the template based on the assigned Use case. During the workshop, the participants had more time to discuss and reflect on the challenges of each use case.

It was observed that as the cities are between the planning and implementation stages of their projects, the full benefit of using the Business Model Canvas would have been

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more visible had it been done at an earlier stage in the project. Nonetheless, the canvas serves as a planning tool for cities as it allows to review the Use Case before, during and after implementation, thereby allowing corrective and complementary actions to be taken when needed.

The aim of the SPARCS canvas is to help all cities in building the most fitting technical solutions that yield social, environmental, and economic outcomes backed by a validated business plan. At the same time, it is important to support the Fellow Cities in identifying crucial actions and partners to further their project development. This canvas offers a holistic and practical view of the main actions that municipalities and supporting partners should consider for the implementation of these smart city initiatives. Best practices set by Use Case owners and respective city representatives will be selected after further analysis. Additionally, any gaps that need to be addressed and reformulated in the canvases will also be addressed.

A typical understanding by Business Model is oriented to economic impacts (costs and benefits). In other words, when people think of a Business Model, they mostly think about costs (how much money is required to launch and run an initiative) and benefits (how much profit or revenue an initiative can bring in). But this approach is limiting, especially for Smart city initiatives. The implementation of these projects should be truly effective and sustainable in a way where the initiatives are balanced and benefit the city and its residents in multiple dimensions. The canvas is an iterative tool whereby the canvas owner (typically the city or a solution provider) refines the level of detail in each iteration.

6.2.3 Recommendations

- **Use of the SPARCS Business Model canvas** allows thinking from multiple perspectives and avoids the typical ‘profit and loss’ approach.
- The canvas allows continuous iteration and integrates the co-creation approach. SPARCS recommends **collaborating with internal and external representatives from different sectors and to also invite citizens** to give their input before, during and after implementation of the project (Timeus et al. 2020).
- To complete the Business Model Canvas successfully, **all cities and technical partners must understand the different segments**. Start with the Customer Segment by identifying potential customers and understanding their demographic, economic, and social characteristics to help direct the implementation of the project. Continue with the segment for Value Proposition by identifying the problem that will be solved and the opportunity for improvement. The order of these two segments may vary according to the stage of the project. However, once these two segments are identified, the remaining segments may be completed more easily.
- **Use of the canvas from the very start of the project and assigning the role of the ‘canvas owner’** will result in better input during the various phases of the project (planning, implementation, monitoring and maintenance). The canvas owner will oversee the final completion of the canvas and will continuously need to interact with the project design team to complete all technical and non-technical segments of the canvas.

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6.3 Challenge of Significance to SPARCS cities: Inefficient procurement processes in cities

The 2014 Procurement Directive was designed in response to the procurement challenges faced by authorities within the European Union. Use of different national procurement portals by cities has led to insufficient knowledge exchange among cities concerning procurement plans. In addition, the procurement processes were observed to consume more resources than necessary. The effort and work required to complete each procurement had to be repeated by authorities in other cities (i.e., cities did double-work), even though they were purchasing similar products but because each member state had very different regulations, the extra work was unavoidable. In an attempt to join efforts and find more efficient ways to carry out these needed processes in the cities, the idea of joint cross-border procurement processes emerged.

The joint cross-border procurement process (JCBP) targets the contracting authorities within the EU. These contracting authorities include but are not limited to municipalities, government offices and their representatives.

6.3.1 Solution developed in SPARCS: the market consultation tool

The joint cross-border procurement process (JCBP) was enabled in the 2014 Procurement Directive to allow contracting authorities from EU member states to collaborate in procurement. The JCBP allows contracting officers in one country to use public contracts already awarded by another member state in their procurement procedure. Member states can also set up joint entities for procurement purposes under EU or national laws (Ponzio, 2017)

According to BABLE, the experiences of JCBP are mainly limited to processes between countries sharing borders, health sector procurements and partnerships between national governments. Furthermore, there is no expert consensus whether the benefits outweigh the costs.

While this solution produced limited success, it faced several challenges when trying to implement it as seen within SPARCS below:

1. The countries had different existing procurement processes.
2. Language and cultural barriers exist.
3. Need for substantial coordination and agreement is required.
4. Defining standard technical requirements is a highly complex task when very diverse cities are involved.

Consequently, research by BABLE found that most of the expected benefits of the JCBP could be achieved through a formal joint market consultation. Market consultation serves the dual function of informing a tender preparation process and notifying suppliers and service providers about the procurement plans by the city or other public authority.

A new tool was then created by BABLE, to simplify the process for cities to reach a wider market early on in the project. The BABLE **market consultation tool** informs public sector representatives about the smart city solutions they intend to procure and then automatically alerts suppliers in such fields about this intention (See Figure 9, Figure 10 and Figure 11). It allows cities to reach suppliers/service providers from markets they might not have explored. This mechanism is particularly beneficial for

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pre-commercial procurement (PCP) and public procurement of innovation (PPI). Table 5 shows the details to be filled.

Figure 9: Benefits of the Market Consultation Tool

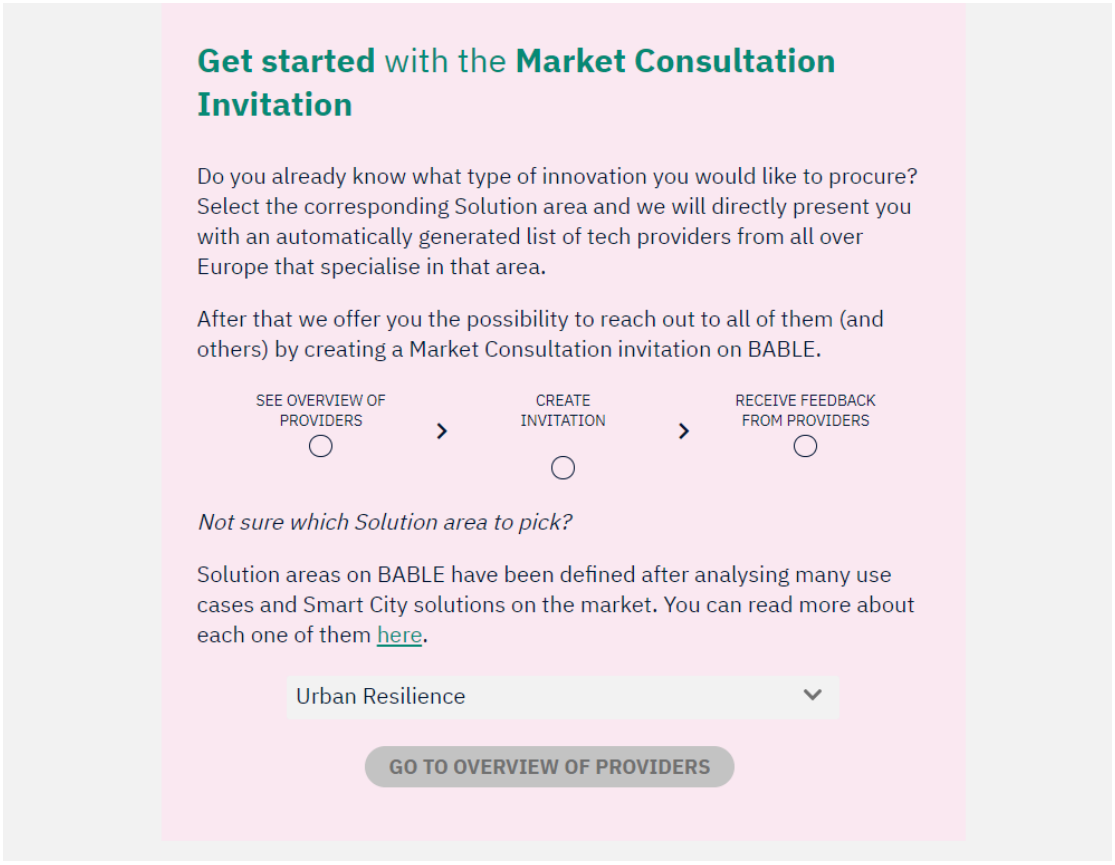

Figure 10: Getting started with the Market Consultation Tool (1)

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Figure 11: Getting started with the Market Consultation Tool (2)

Table 5: Fields to be filled in to create a Market Consultation invitation

Fields to be filled
City/Region
Title
Description
Link to existing page for Market Consultation with more information
Link to event (sign-up) on external page
Link to survey on external page
Deadline
Deadline for responses
Event date
Other details
Estimated value of contract
Is it divided into lots?
Expected duration of Project
Expected Start Date of Delivery
Expected Date of Tender Publication
I am running this consultation with these other organisations:
Media
Images (Upload a file)
Video
Attachments (Upload a file)

6.3.2 Impact of the solution in SPARCS

The BABLE market consultation tool was developed and released in the BABLE platform at no cost for all cities. The tool was piloted by Maia (Portugal) to implement building-integrated photo voltaic (BIPV) in a demo site. Using the tool, Maia provided a detailed description of the required solutions, describing a clear goal of the project,

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system specifications, mandatory requirements, architectural plans, and pictures to help prospective providers understand the city's needs and minimum expectations. These details were published on the BABLE platform where a large community of providers had access. This way, only providers who met all the listed requirements would register to participate in the market consultation.

The municipality of Maia, one of the most industrialised municipalities in Portugal and an important transportation hub, intends to implement a Building Integrated PV (BIPV) demo-site in Maia City Hall within the scope of the SPARCS project. The work is coordinated with Porto Energy Agency (AdEPorto).

The purpose is to study the viability of BIPV technology in existing buildings, creating the possibility to replicate the solution at a large scale. The aim of this project was to install PV films on the existing windows without having to replace any elements on its facade structure.

According to feedback from the Maia team, using the tool ensured significant time saving as they did not need to contact possible suppliers/service providers individually for their smart city solution. Instead, interested parties who had a perfect fit with the needed products registered to participate in a joint event with the procurement team.

Using the Market Consultation tool for Maia:

"Before using the Market Consultation, we identified possible technology providers and contacted them individually ourselves. By using the Market Consultation tool, the process became easier and only the organizations who were interested would register to participate at the event. We then did only one event with all the interested parties which saved us a lot of time as well. Additionally, BABLE has a large community, so they were able to go further and identify different companies from the ones we originally targeted. However, we couldn't find a Photovoltaic (PV) film technology provider immediately as the most of the available technologies were not mature enough to test in real environment."

6.3.3 Recommendations

1. If your city wishes to start a procurement process to implement their smart city initiatives, the best way to optimize this process is with a **Preliminary Market Consultation** in order to interact with the market in the early stages of procurement.
2. This tool does not replace any official tendering process but rather exists as a complement that will increase the number of suppliers that respond on the cities' tendering portal. **Think about how you can improve your tendering process through the Preliminary Market Consultation**.
3. The starting point to use the tool should be based on **an evaluation of a number of factors including the complexity of the solution** to be procured, your own team's expertise, the market complexity and maturity, the goals of the procurement procedure such as policy or innovation objectives, and the expected value of the contract.
4. Through the Market Consultation tool, cities can initiate this preliminary process where relevant smart city companies in BABLE's community will be informed

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about the city's intention of procurement. It is recommended to **provide as much information as possible** because in this way the tool can help to match with suppliers/service providers that meet these requirements.

5. A representative of the **BABLE team will be in charge of guiding the city during this process** that starts with the registration of the city on the BABLE platform followed by the creation of the Market Consultation Invitation that consist of three steps: (1) See overview of providers according to the Solution area, (2) Create Market Consultation post on the platform, filling out the necessary fields about the solution you require, and (3) Receive feedback from providers or request for more information from providers as well as promote it on the BABLE platform publicly to other providers. This process should be around 3 weeks.
6. To maximize success in the consultation invitation, **cities should take into consideration**: (1) Clarity: ask clear and concise questions, (2) Call for action: define clearly how collaboration will be done (3) Language: specify the language(s) of the consultation, (4) Context: provide any supporting materials, and (5) Expertise: invite suppliers/service providers to involve relevant staff.

6.4 Challenge of significance to SPARCS Cities: How to engage local businesses in sustainable solutions?

Smart city solutions are complex and require the input of a variety of stakeholders, including businesses, government, academia, and civil society. Implementing these solutions can help to expand the economy, attract investment, and boost productivity. Businesses are often at the forefront of innovation, and by collaborating with businesses, cities can gain access to new technologies and ideas that can help to create a more vibrant and prosperous economy.

The challenge exists for cities to create a more open and collaborative environment for businesses and researchers. When businesses and researchers are able to share data and ideas, they can develop new solutions that can address the challenges cities face. By collaborating with businesses, cities can leverage the expertise and resources of the private sector to develop and implement solutions that are both effective and sustainable. Engaging with local businesses is essential for the successful implementation of smart city solutions as they are often the ones who will be responsible for implementing and operating smart city solutions and can ensure that smart city solutions are tailored to the needs of the local community.

The SPARCS Lighthouse cities organized two startup smart city challenges during 2021: The Sustainable Mobility Challenge, implemented by KONE and Gaia Consulting, and supported by the city administration in Espoo; and the Smart city Challenge, implemented by the Digital City Unit and the city administration, and supported by the Smart Infrastructure Hub in Leipzig. Both competitions were inspired by traditional pre-commercial procurement processes, based on stages of development and implementation of services. However, both competitions opted for more flexible organizational programs. (Villegas de la Ossa et al. D7.4, 2022)

The SPARCS project provided the thematic framework, geographic focus, and support in linking and comparing the process of the start-up competition in the two Lighthouse Cities.

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6.4.1 Solution developed in SPARCS

Sustainable mobility challenge Espoo

The goal was to seek innovative solutions for sustainable urban flow and future mobility. The project partner KONE subcontracted Gaia Consulting to facilitate the startup competition (See Figure 12). The topics included *micro-mobility, shared mobility, and multimodal navigation*. KONE also established a list of already identified specific user challenges based on the user research done in Espoo that should be addressed for example, lack of safe and trusted parking, big barriers for giving up cars, citizens' mobility needs and desires vary depending on the day, and lack of knowledge about different mobility modes. (Villegas de la Ossa et al. D7.4, 2022).

The criteria evaluated were 1. Sustainability, 2. Differentiation, 3. Scalability, 4. Customer value, 5. Trustworthiness, 6. Inclusiveness, and 7. Implementation effort (Table 6). The evaluation was done in collaboration with KONE and City of Espoo to bring the city perspective and the already identified challenges in the city environment into the review criteria.

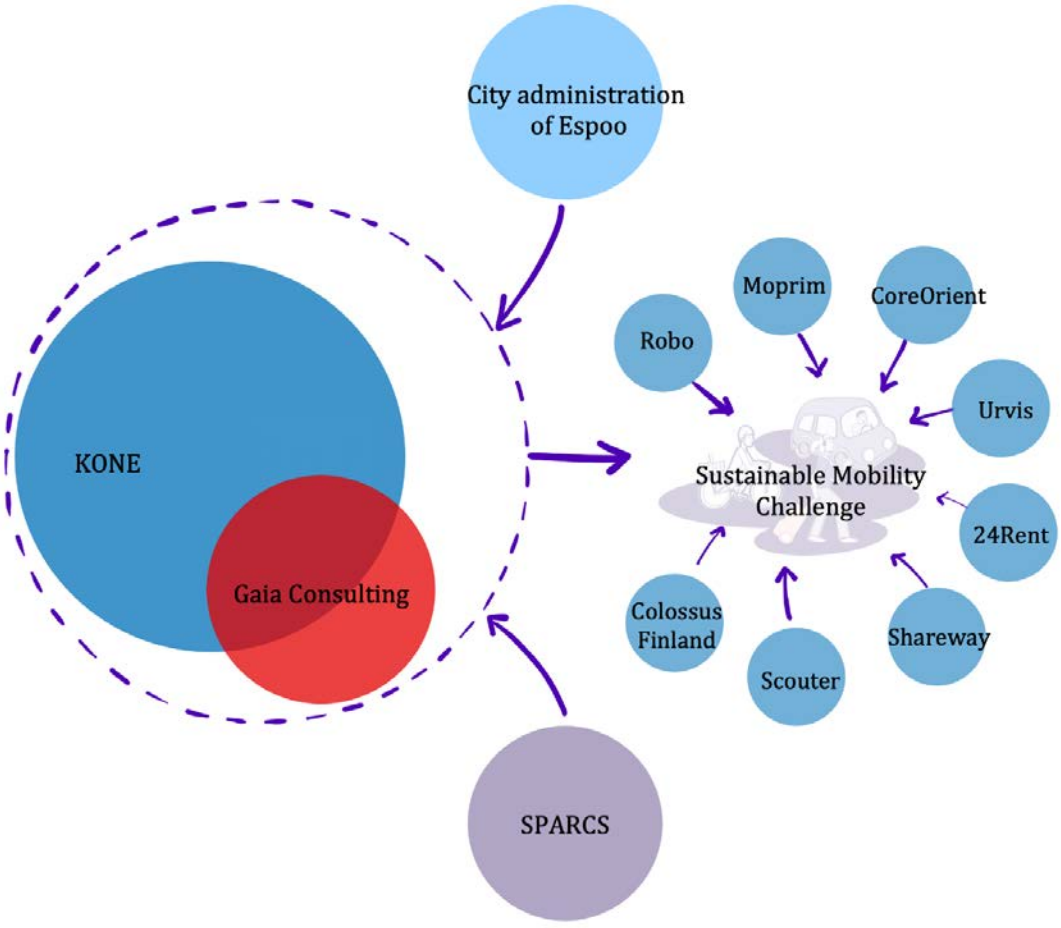

Figure 12: Sustainable Mobility Challenge, stakeholders & partners (Source: Villegas de la Ossa et al. 2022, D7.4)

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Table 6: The four phases of Sustainable Mobility Challenge (Villegas de la Ossa et al. 2022, D7.4)

Phase 1	Phase 2	Phase 3	Phase 4
Game plan (setting rules, contacting and recruiting etc.)	Pitchings and Matchmaking (briefing session with jury, first pitching event etc.)	Mentoring and selection (mentoring, second round of pitches etc.)	Piloting

In total, 140 startups were contacted via communication channels and directly by Gaia and KONE out of which ten submitted successful applications. Finally, eight startups were selected to continue to the Phase 2 Pitching and Matchmaking after which four teams qualified for the Phase 3: (MOPRIM: Smart mobility app; URVIS: e-cargo bikes; SHAREWAY: renting and sharing parking spaces; COLOSSUS FINLAND: cargo bikes as a public service). Eventually the jurors selected MOPRIM as the chosen pilot project. MOPRIM is a software developing company that proposed a community-based platform with an application to track the sequence of trips that a user makes on a given day i.e., travel chains.

Annual Smart city Challenge Leipzig

Every year City of Leipzig organizes the annual innovation competition "Smart city Challenge Leipzig". The competition invites founders, startups, students, and established ventures to come up with innovative digital solutions for predetermined questions and challenges in the areas of civil society and municipal administration. The Smart Infrastructure Hub collaborates with the city to run the competition. (Stadt Leipzig, 2023). The competition helps the municipality to consult the market for innovative solutions and to adopt them to their real needs within prototypes and pilot development. Furthermore, the local startup system benefits from the close collaboration process with the municipality to further develop their products and services (Figure 13).

The Smart city Challenge Leipzig has three phases: Idea collection, Development phase and the Implementation phase.

- Phase 1: During the idea collection, a challenge description coming from the city departments is published and companies, startups but also NGO or NPOs are encouraged to turn in a short description of their service or solution that would help to solve the challenge.
- Phase 2: In the development phase, the three best ideas for each challenge are further developed over a period of two months. Each of the three selected applicants per challenge receives 2000 EUR (gross price) for the qualification and further development of the proposed solution. In this phase, the solutions are developed together with the city administration, and the further developed solutions will be presented and evaluated in a pitch event.
- Phase 3: In the implementation phase, depending on the maturity level, complexity, probability of implementation, expected follow-up costs, and verification potential of the presented solution, there is the option of implementing one pilot project per challenge. A period of 6 months and a

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maximum budget of 25000 EUR (gross price) is available for the pilot project. External experts from Leipzig's startup ecosystem and the Smart city Infrastructure Hub Initiative cooperation partner are also involved in both phases.

Table 7 shows the three categories for the Leipzig competition in 2021 were as follows:

Table 7: Leipzig competition categories

Digital urban tourism
• Digitalisation in the form of apps; • Create new onsite experiences; • In combination with gamification, edutainment and storytelling; • Attract families to Leipzig's city centre; • Interactive and child- and adult-friendly; • Considering the central tourism data base of the Tourismus Marketing Gesellschaft Sachsen.
Urban environmental data
• Innovative and interactive way to convey invisible urban data to the public; • Citizen-oriented administration; • Barrier-free digital solutions and strategies for digital communication for the public; • User-oriented; • Expandability to include additional environmental topics; • Spatio-temporal data, sensor data or modelled data; • Focus on air quality or urban climate as test example; • Development of low-threshold, media-didactic tools (e.g.: app, portal.); • Consideration of sustainable data structure; • Integration with municipal geodata infrastructure; • Low maintenance; • Linkage with website of the City of Leipzig.
Civil society and participation models
• Innovative and inclusive digital tools that enable participation "bottom-up" processes; • In the interface between urban actors such as business and science; • In cooperation with local democracy and city administration; • Testing new forms of democratic processes; • Obtain a market overview of digital-analogue solutions for strengthening civil society exchange, engagement and co-production in the context of bottom-up processes in urban development and discuss possible interfaces for expanding the city's own participation infrastructures; • Models to be tested in two specific areas in Leipzig; • Motivation of communities; • Intuitive usability; • Online and offline participation; • Open-source solutions preferred; • Presentation of costs, follow-up costs as well as technical knowledge for operation, transfer of knowledge about the tool in organisations.

The criteria evaluated were: 1. Idea; 2. Degree of innovation; 3. Realization potential; 4. Overall understanding of the challenge; 5. Team behind the startup; 6. Overall impression of the pitch; 7. Progress from the development phase (only applied in Round 2); 8. Were the conditions and tasks addressed (only applied in Round 2); 9.

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Realist/feasibility (only applied in Round 2); and 10. Scalability (only applied in Round 2).

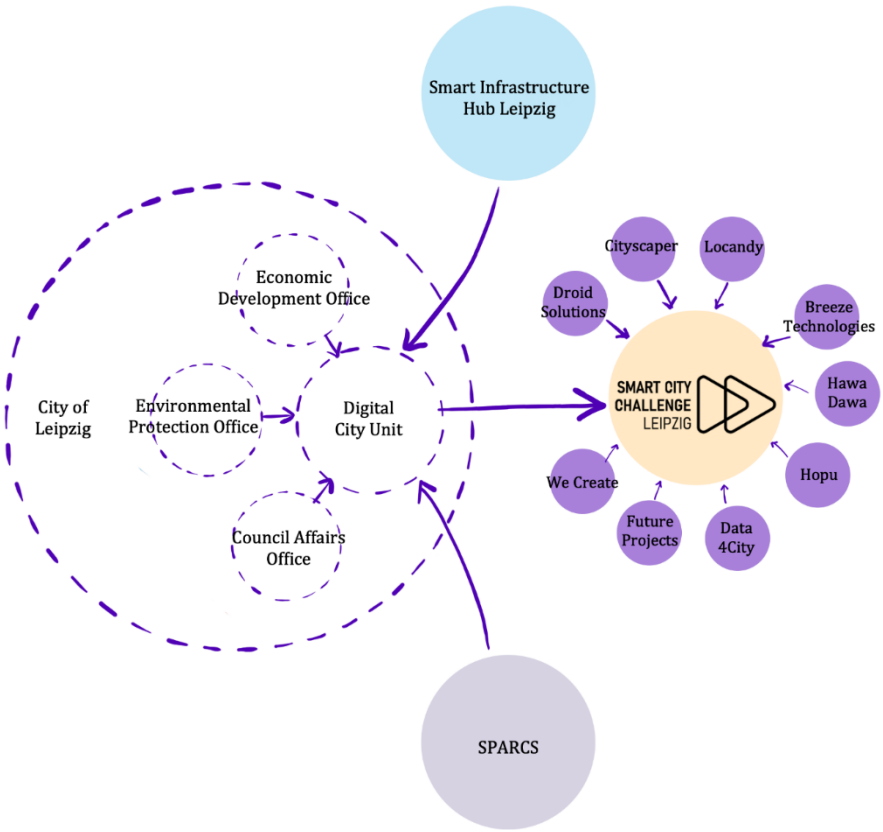

Figure 13: Smart city Challenge, stakeholders & partners (Source: Villegas de la Ossa et al. 2022, D7.4)

The challenge providers were the different administrative departments of the City of Leipzig that supervised each topic. Thirty-two participants submitted proposals for the Smart city Challenge 2021. Three proposals were selected for each category, therefore there were nine proposals altogether.

- DroidSolutions, a Leipzig-based company specializing in augmented and virtual reality, qualified for the challenge with their "Sticker Safari Leipzig" app. This app guides users through Leipzig, enabling them to discover escaped zoo animals while providing quizzes, texts, audio, images, augmented reality elements, and selfie points to enrich the experience and promote exploration of the city (Digital Campus Leipzig & Stadt Leipzig, 2023).
- Hawa Dawa, a specialized team, qualified for the challenge, employing various data sources including satellites and stationary measurements to produce comprehensive environmental insights. They intend to present easily comprehensible air quality, weather, health, and pollen data through a city website and app, offering recommendations to avoid high-emission areas, alternative routes, and background information about emissions and city measures. The goal is to cater environmental information to all user groups' individual needs (Digital Campus Leipzig & Stadt Leipzig, 2023).
- The startup Cityscaper from Aachen qualified with their augmented reality (AR) app, allowing citizens to experience and discuss project ideas in real-time,

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enabling informed opinions and active engagement in city design. The app's playful AR visualization and concise explanations enhance participation and involvement in developing project proposals for district budgets, fostering transparency and democratic urban development (Digital Campus Leipzig & Stadt Leipzig, 2023).

6.4.2 Impact of the solution in SPARCS

The startup competition offered the opportunity to move away from conventional commercial procurement procedures. Furthermore, it offered a larger scope for creativity and also gave the startups an opportunity to gain visibility.

The competition has proven to be a significant catalyst for the cities' growth and innovation ecosystem.

The competition ignited a surge of economic activity by fostering the creation of new businesses and opportunities. The influx of innovative startups also leads to job creation and enhanced economic vitality.

The event served also as a dynamic platform for networking and collaboration. It is a platform that allows for cross-pollination of ideas and partnerships that extend beyond the competition's scope. In essence, startup competitions unleash a wave of positive transformation and contribute to the creation of an evolving landscape of innovation and entrepreneurship.

The winner from Espoo's Sustainable Mobility Challenge Moprim was implemented as a pilot for two basketball teams in Espoo where the aim was to study the mobility footprint of the sports teams by collecting location-based mobility data and understanding the effect of the individuals' mobility behaviours together. The app enabled the team members to register data on their daily journeys and mobility choices and calculate the carbon emissions. The study last two months. (Santala et al. 2022)

Leipzig has also continued to collaborate with the three winners on new projects.

6.4.3 Recommendations

- **SPARCS recommends integration of startup competitions in the overall urban planning**: The regular use of these processes is a successful way for bringing different actors and contributing to the development of new solutions for the city, increasing community engagement and fostering a sense of ownership over the city progress. A successful startup challenge will evaluate four topics: organisation; criteria and coefficients; maturity of the startup; and sustainability within the challenge.
    - **Organisation**: The design of an entire **work plan early in the project** will allow participants to understand expectations better. Timeframes, schedules, and programs must be created at the beginning of the process to limit unforeseen situations to a minimum.
    - **Criteria and coefficients**: When defining the evaluation criteria for selecting successful proposals, it is recommended to **consider the use of weighted criteria** and make the criteria clear from the beginning. Weighted coefficients allow for more differentiated judgements of different project aspects.

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    - **Maturity of the startups**: A first round of qualification prize money is recommended to **keep small companies interested**. Otherwise, the participants can be separated according to their capacity to ensure fairness and tailored support.
    - **Secure enough internal resources for the co-creation process:** This may happen when it comes to a joint development of a prototype between the municipality and the startup, therefore additional resource need to be blocked and commitment is needed from the municipality in this time-consuming process.
- **Secure municipal budget**: Within the municipalities, startup competitions can be financed by the overall municipal budget as in the case of Leipzig. The budget can be allocated on a yearly basis for these activities.
- **Additional support for the process:** As city units are usually deeply engaged in their daily labour, they lack resources and competences to successfully carry out such smart city competitions. It is useful to have one unit from the city or an external service provider to take care of the management process of the competition and also guide the participating departments through the process.
- **Secure follow-up**: The startup competition is only the starting point for integrating new solutions or services into the municipality. As the competition is only financing this initial phase, it is necessary that by the end of the pilot phase the city creates a plan regarding how to continue the cooperation and provide further financing to the pilot.
- **Outreach strategy:** The outreach strategy for contacting the ideal startups should involve the **efficient use of social media and online search engines**, **engaging accelerators and incubators, and leveraging the platform provided by startup events**. Once potential startups have been identified, take some time to research their goal and objectives, strengths, and track records. Better information collection about the startups improves the chances of successful contact. Furthermore, highlight the benefits of your competition. This could include prize money, access to mentors or investors, or the opportunity to showcase their product or service to a wider audience.

Further guidelines on startup competitions will be provided in D7.13 *How to Implement a Startup Competition – Toolkit of Guidelines and Recommendation* (due in March 2024) to guide cities in approaching local businesses and working with them in various during the length of a project.

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7 CITIZEN ENGAGEMENT

7.1 Introduction

Citizen engagement, also known as public participation, is a process that seeks to secure direct and active involvement of citizens in decision-making. It ranges from consultation where citizens' opinions are sought to empowering citizens for influencing decision-making. This process not only aids in enhancing democratic legitimacy but also improves public trust and ensures that decision-making processes are inclusive and reflective of the diversity of interests within the community (Anrstein, S.R, 1969).

In the context of sustainable urban development, it has become essential to incorporate the voices of the public given the socio-economic and environmental complexities of urban environments. In this sense, citizen engagement is particularly important as it has the potential to foster collective problem-solving, contribute to the development of sustainable urban policies, and build resilient cities. It is a mechanism that allows citizens to be part of designing and implementing solutions for the urban problems they face, resulting in policies that are more effective, more accepted, and more likely to lead to sustainable outcomes (Fung, A, 2006).

One of the main objectives of SPARCS is to have a community engagement strategy that involves and empowers citizens by involving them directly in urban management, providing open access to data, and engaging them in the design and implementation of solutions for sustainable living and energy use. Furthermore, the project aims at promoting a "citizen-centric approach for enabling inclusive, integrated, and sustainable urban development, planning and management practices and governance models."

7.1.1 Challenge of Significance for SPARCS cities: Where and how to start with citizen engagement?

Involving citizens and stakeholders in the process of developing smart city solutions is part of good practice in this field and is a key element for the EU Missions in Horizon Europe. In this sense, there is a high variety of tools, techniques and recommendations for engagement activities which are more or less adequate depending on the context, conditions and purpose for which they are used.

In the SPARCS project, social and community engagement activities should be conducted across all the project tasks in order to promote co-ownership by the citizens and stakeholders. These tasks focus on different levels of intervention and scales, varying from specific sustainable energy or mobility solutions, all the way to a co-creation model for smart city planning for a carbon neutral future.

Considering the diversity of scope and scale of these tasks, it is necessary to provide cities with access to the right engagement tools and techniques and to also support cities to assess the quality and outcome of each interaction and/or activity conducted.

As some of the engagement activities occurred during COVID-19 pandemic-associated restrictions, the cities and partners faced the challenge to find alternative approaches to the traditional face-to-face participation and engagement methods. The

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subsequent increase of online activities required new ways of reaching people and the need to adapt to new techniques and tools.

7.1.2 Solutions developed in SPARCS

The **Citizen Engagement Database** was designed by the Fraunhofer Center for International Management and Knowledge Economy (IMW) as part of the SPARCS project (Figure 14). It was intended to assist cities participating in the project, including Leipzig, in promoting citizen and relevant interest group engagement in the energy transition process. The impetus for its design came from the ambitious 2030 climate and energy targets set by the EU, the recognition of the critical role of citizen involvement in achieving these targets, and the need to prevent delays or failures in urban development projects due to insufficient public participation. Hence, the toolbox serves as a guide to bolster social participation and foster the successful implementation of energy system transformation.

The database describes over 90 different participation formats derived from the analysis of past and on-going SCC1 projects and their citizen engagement activities as well as other projects outside of this scope considered relevant for the purpose. SPARCS also held internal discussions with the seven project cities to understand their experiences and gather ideas.

The database allows to filter the information using a set of criteria: target group, number of participants, duration, budget and implementation (live, virtual, hybrid events). A short summary and further links are provided for the selected formats.

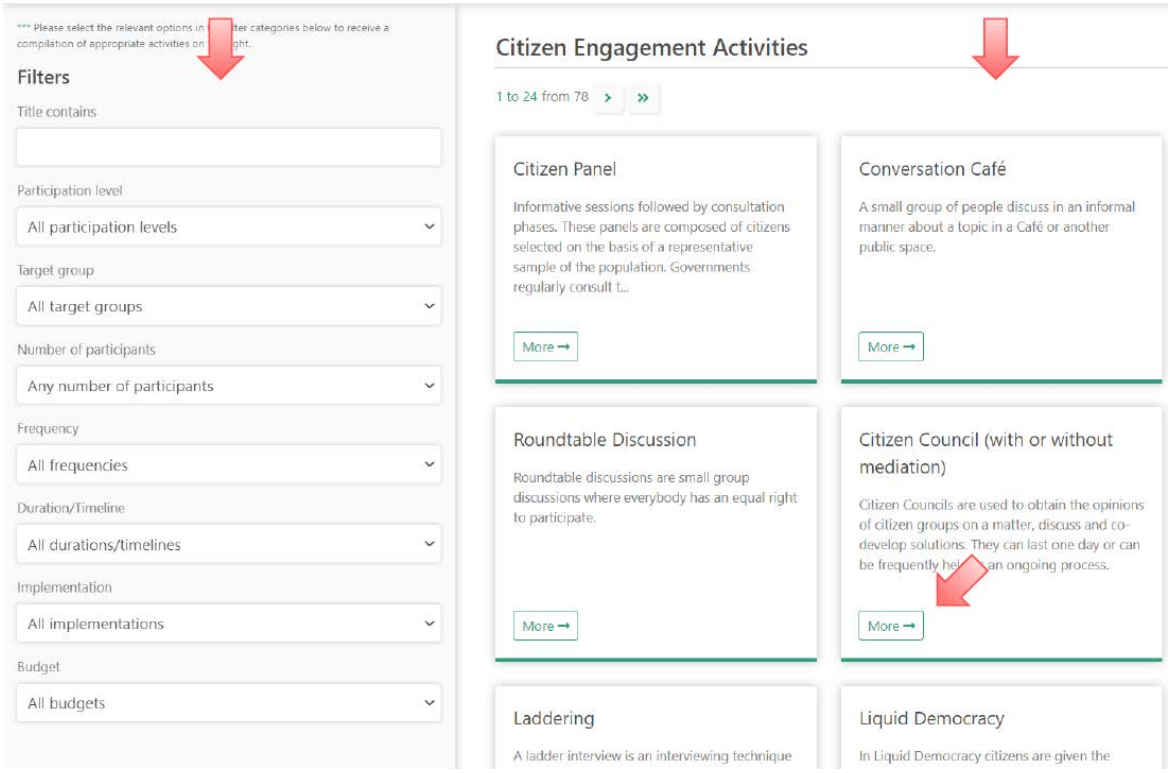

Figure 14: Citizen Engagement Toolbox (Source: Pollmer, 2021)

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The tool is intended for all interested municipalities and supporting partners who aim at a stronger citizen engagement and are in search for suggestions for the implementation. With the help of the filter function and the short description, a pre-selection of engagement activities can be made, which can be narrowed down with the help of further links to find the appropriate format (Pollmer, 2021).
The database was launched in 2020 together with the **Quality Assessment Template** (QAT), which supports in assessing the quality of the engagement activity. The QAT consisted of several feedback questions that the activity host should answer, for example:

- What was the main purpose of the activity?
- What participatory process did you use? (World café, Focus group, Walking tour etc.)
- How many sessions of activity did you arrange? (Two half-day workshops, 3 world cafes etc.)
- Who was the main participant? (Citizens, EU policy makers, NGOs etc.)
- Was the engagement activity gender balanced?
- How was diversity taken into account?

7.1.3 Impact of the solution in SPARCS

By September 2023, over 40 engagement activities were reported by the project partners through the use of the QAT, showcasing a wide variety of tools and techniques utilized. Figure 15 showcases the types of engagement activities held.

Figure 15: Types of engagement activities held by the project partners

During the three project years, citizens and citizen organization representatives were involved in 40% of the engagement activities focusing on city-wide topics (spatial and strategic dimension). Additionally, discussions on city-wide topics were the focus of 72% of the engagement activities. A large number of workshops were held with regard to the City Vision 2050, which was one of the key project tasks. The City Vision 2050 asked citizens how the city should look like in the future. It was mandatory for all cities to arrange these workshops.

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In the case of Kifissia's City Vision process, in order to have a better understanding of the citizen views, the city invited citizen representatives to a virtual open discussion prior to the workshop. For the actual workshop, the city also invited students from local elementary schools to draw their vision of the city for 2050 and display these drawings during the workshops.

One of the main challenges of the database is there is a wide variety of formats to choose according to purpose and target groups. The framework conditions for each project are very different, so the planning requires a high degree of flexibility and a certain willingness to experiment (Pollmer, 2021).

7.1.4 Recommendations

- To successfully conduct online participation activities, it is crucial to develop specific skills such as the ability to **clearly articulate ideas via virtual platforms**, use digital tools such as polling features or shared documents for interactive engagement, and effectively moderate online discussions to ensure everyone's voice is heard.
- The online engagement activities can be easy, effortless, and fun, but they require good preparation and prior sharing of information or small tasks. **Asking the participants to share their interests before the activities** can be useful to find a common denominator and to be able to plan the discussion. The resulting suggestions and ideas can serve as a reference and be used in follow up workshops.
- When preparing online activities, it is important to **take into consideration that online format can make it harder to build long-term engagement relationships** with the participants.
- When promoting citizen-driven research and co-design processes, **diverse channels, platforms and networks for reaching citizens and participants should be used**;
- In order to encourage participation, it's important to not only **offer some form of compensation for participants' time**, but also to consider other potential benefits that could be attractive to them. These benefits could include opportunities for learning or gaining deeper knowledge about the topic at hand, the chance to connect and network with others, or the possibility to influence issues that are of personal importance to them such as buddy class activities.

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8 GENDER AND SOCIOECONOMICS

8.1 Introduction

In order to face the growing urbanization challenges and promote social sustainability in urban planning, it is essential to ensure thorough engagement of local governments, stakeholders, communities, and citizens. In this sense, the solutions should be co-created with the public and end-users based on a collaborative approach that caters to their specificities, needs and aspirations, reflecting these into the attributes of future urban landscapes.

SPARCS cities are committed to be "fair – open, just equal, humane and tolerant – and aim for a socially, ecologically, and economically sustainable development" (SPARCS Grant Agreement). To achieve this premise, the SPARCS project takes into consideration aspects such as gender and diversity as well as socio-economic perspectives in all dimensions and phases of the project.

The subject of gender and socioeconomics cannot be approached without taking into consideration the social engagement aspect, which is fundamental to co-creating and co-developing solutions with and for the public. In this respect the present chapter focuses on the challenges of promoting representativeness and behavioural change through public engagement activities and provides examples and recommendations which are complementary to the ones presented in the chapter on "Citizen Engagement" (See section 7).

8.2 Challenge of Significance for SPARCS cities: Ensuring diversity of end users (Espoo)

It is critical to not only focus on groups who may already have access to services, benefits and a good quality of life. It is essential to promote an engagement strategy that reaches a variety of citizens segments and engages them in the co-development of the solutions.

8.2.1 Solutions developed in SPARCS

With the aim of understanding Espoo citizens' current mobility needs and experiences, an eight-week **mobility ethnographic study** was conducted with ten citizens from Leppävaara and Espoonlahti (project demo areas in Espoo, Finland). The recruitment process focused on diversity, namely in terms of age, mobility behaviors and attitude towards sustainability. The recruitment for the micro mobility study conducted by KONE and Citycon in Espoonlahti and Leppävaara districts in Spring 2021 was carried out through online surveys distributed via social media channels. Specifically, the surveys were posted in the city Facebook groups for Espoonlahti, Greater Espoonlahti areas, and Leppävaara areas. In total, they received responses from 79 residents in Espoonlahti and 41 residents in Leppävaara. The survey questions covered various aspects, including demographic information, daily distances and mobility modes to

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school/work, experiences with existing micro mobility vehicles, motivations, hindering aspects, and suggestions for improvements. After the initial survey phase, four qualitative online interviews were conducted with residents from Espoonlahti. The participants in these interviews were chosen to represent varying life situations and different age groups to understand the diverse needs of the area's residents. The selected participants were both men and women, and the study also included families in the final group. The decision to utilize the city Facebook groups as the primary platform for distributing the survey information might have been due to its wide reach and ability to engage a larger audience within the target areas. The mobile probing method used allowed citizens to actively generate information by documenting their everyday life. Together with the subsequent interviews and co-design workshop, this method provided extensive insights into Espoo citizens' behaviors and needs concerning mobility in the city.

Besides mobile probing, **Buddy class activities** promoted in Espoo sought to actively involve young people in the city's activities and thus get the youngsters to think about sustainability and how they can influence their city's future. Buddy class activities involved two classes during their upper secondary school. The classes and students were the same during the whole period; one class from Maininki school and one from Espoonlahti school (both located in Espoonlahti area near Lippulaiva demo site). Altogether there were 40 students involved about 4 times a year for 3 years. The City of Espoo was responsible for one class and Citycon was responsible for another class. The main themes were sustainable lifestyle, city visioning and engagement. The students belonged to age groups between 13 – 16 year old and participated in the engagement activities between 2020 and 2023. A variety of workshops and discussions promoting sustainable lifestyle were organized, for example, an art lesson for designing waste bins and an energy lesson concerning renewable energy and how to save energy at home. It is important to acknowledge that when conducting research involving young, underage individuals as part of educational activities, a research permit is necessary. The application for this permit was jointly prepared by Espoo and Citycon with assistance from VTT to ensure compliance with ethical guidelines and GDPR regulations, particularly regarding anonymity in the creation of visual material from the events. Prior to commencing the Buddy Class activities, the students' parents were notified about the upcoming events, and appropriate permits were obtained to secure the students' participation.

8.2.2 Impact of the solution in SPARCS

The mobility ethnographic study conducted in Espoo provided a solid foundation for shaping mobility related solutions that address the needs and challenges identified by the recruited citizens. Together with the subsequent workshops and design sprints, the study contributed to the identification and development of specific mobility concepts, reflecting the needs and current difficulties of Espoo citizens. Furthermore, 8 mobility concept solutions were formed and developed in a co-design process involving diverse stakeholders, to provide answers to the identified end-user challenges and identify potential direction for the future smart and sustainable cities under the themes of micro

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mobility, shared mobility, navigation & hybrid travel chains, and autonomous mobility (Figure 16). (Santala et al. D3.6, 2022)

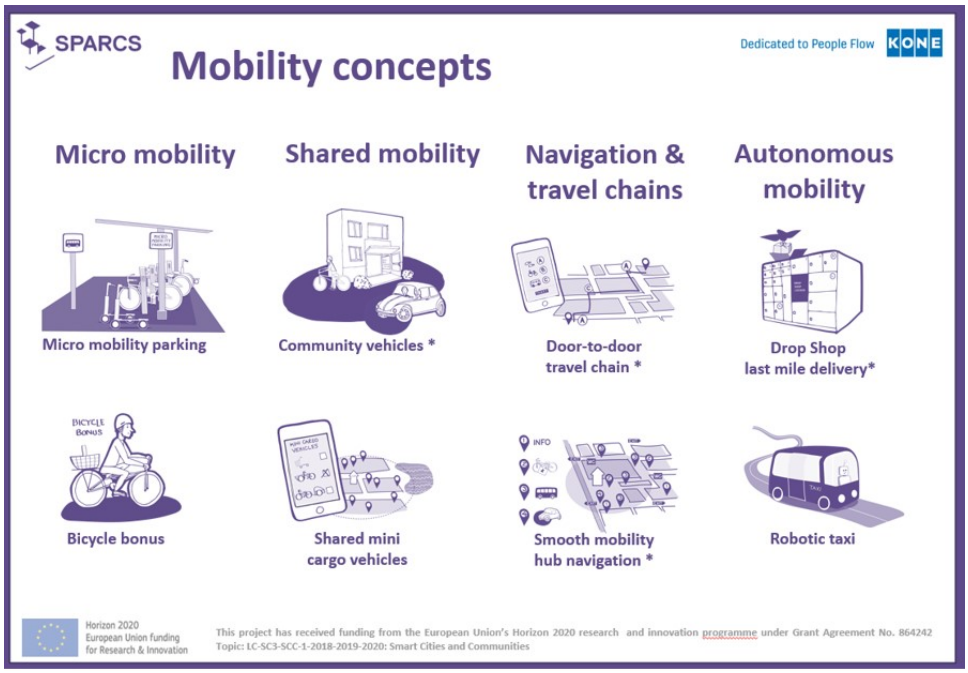

Figure 16: Co-designed eight final sustainable mobility concepts. (Source: KONE)

Furthermore, the insights gained from this study were extremely relevant as they formed a basis for the development of the co-creation model (for more information see Challenge of Significance for SPARCS cities: How to co-create PED solutions in the old and new city districts (Espoo).

The Buddy Class activities also yielded positive feedback and engagement from participants. The students reported feeling a sense of contribution and being heard during the activities. The Buddy Class experience shows that listening to the students with a sensitive ear and let them influence the choice of the topic is essential as a way of raising commitment and active participation on the young person's part.

8.2.3 Recommendations

As a result of Espoo community engagement activities performed under SPARCS, the following recommendations stand out as references for further activities:

- **Communication** is an essential aspect for the success of engagement activities and should be **addressed before, during and after the activities**. Participants need to know that their participation was useful and beneficial for the development of the work to fulfil their participation experience.
- To reduce the risk of not reaching the desired target groups, **recruiting extra participants and those outside the specific scope is recommended**.
- For activities such as the Buddy Class to succeed, the **work requires persistency and long-term commitment both from the organizer and the participating school and pupils**.
- Tone of voice and **communication** channels used needs to be moulded to **match the citizen segment reached**

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- In order to promote commitment and a more active engagement in the activity on the part of the participant it is important to **tailor the message according to the specific needs and concerns of the audience**. The message can be more effective if it resonates with the person's life. This is especially relevant when dealing with young people

The fact that the participants in the community engagement activities in Espoo were not always part of relevant citizen groups in terms of diversity was justified in some cases, but in other cases it was considered that a wider demographic sample would have been beneficial to represent a greater variety of people with different demographic characteristics. In the case of the mobile ethnographic study conducted, one of the participants pointed out:

"Now the participants were educated adults from the local population, unlike the future urban dwellers, who are young adults from a migrant background. They should be studied and involved more instead of us."

(Mobile ethnographic user study participant)

Regarding this issue, the city and partners reflect that there should always be an understanding of who has been included and who has not been represented in an engagement activity, and what impact this has on the outcome. (Santala et al. D3.6, 2022)

8.3 Challenge of significance for SPARCS cities: How to support behavioural change? (Leipzig)

For the effective implementation of smart city solutions, especially in cases where active participation of the end users is required, it is essential to involve and engage the people affected by the solutions. This effort proves especially challenging when the solution requires the use of modern technical tools and the target groups consist of citizen groups facing difficulties or barriers in the use of these technologies, such as elderly people, refugees, and asylum seekers, or people whose interest is not primarily on the subject in question.

In the Duncker district demo site in Leipzig, in order to engage communities and individuals in energy saving behaviours and data collection, the local consortium designed and distributed two Apps (MeineLWB App and SPARCS App). In the case of **MeineLWB App**, the target users were residents of a block of houses in Duncker district, containing social housing with inhabitants with socially critical solutions and migration history whose personal focus is typically not on climate related issues. Furthermore, in some cases, the heating bills of the residents are covered by the social system, lowering the incentive to reduce consumption and consequently the leverage to use the apps.

8.3.1 Solutions developed in SPARCS

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Having understood the difficulty in reaching the target groups and engaging them in the use of the developed Apps, the Leipzig consortium realized the need to change its approach by focusing on reaching the population and gaining their trust and interest first, and afterwards introducing the topic of the Apps and its benefits.

In this respect, the city promoted live events to provide further opportunities for the residents of Duncker district to engage with the **SPARCS App** and to learn about energy saving tips, and also to engage children from the neighbourhood in learning about climate change and other challenges for which SPARCS is seeking solutions. These events were combined with engaging activities such as an interactive table (DIPAS) in which the participants could input ideas and suggestions for their neighbourhood sustainable development or a drawing competition for children, where the awards, which were based on age-group, were made from recycled materials and related to ecological and environmental topics.

The Children Cinema was also a solution for approaching SPARCS related subjects with the Duncker district population as it consisted of inviting families for the screening of a movie promoting environmental topics and afterwards promoting a discussion about the subject with the children.

To enhance the engagement and support for residents in the Duncker neighbourhood, a dedicated "**Energy Advisor**" was introduced facilitated by a local partner, Seecon. This Energy Advisor played a pivotal role in offering free desk support and advice to residents, guiding them on a myriad of topics including energy efficiency, renewable energy sources, integration into the Positive Energy Community, and the adoption of energy-conserving habits. Not only was the Advisor's role informational, but it also encompassed showcasing the innovative technological solutions developed by SPARCS such as the MeineLWB-App and the SPARCs-App. As an extension of this initiative and to ensure residents had a consistent touchpoint, Seecon made sure to include direct contact details in every communication medium from flyers to published articles, with a dedicated email address, sparcs@seecon.de, for more streamlined communication. The SPARCS initiative is further bolstered by its dedicated manager who is omnipresent at every event, handling an array of responsibilities from event organization to report writing. This manager, in collaboration with a robust team of SPARCS energy experts, ensures that all technical and non-technical inquiries are addressed promptly. It is worth noting that while Seecon employees actively participated during events, their commitment extended beyond making themselves available for regular interactions even outside these scheduled occasions. (SPARCS, D4.3, D4.6).

8.3.2 Impact of the solutions in SPARCS

Although the challenge of behavioural change is difficult to measure over short timespans, the preliminary results concerning Leipzig interventions, including data collected between September 2022 to February 2023 show that 80% of participants in the events promoted in the Duncker district became aware of the presented solutions and 130 participants reported feeling that they were able to affect and participate in the ideation of future directions. On the other hand, the full target of including the hard-to-

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reach group (young families with low income, older people, minority groups, socially excluded groups) was not fully reached (only 25 out of 50 people, refer to Ntafalias et al. D2.6). The decision to set a target of reaching 50 individuals was born out of the estimation that a minimum of 300 individuals resided in the SPARCS demo district apartments. Given the nature of the target group, the goal was set at a plausible 50 people per year, accounting for potential attendance constraints at meetings. To ensure these groups were effectively reached, a participation concept was devised which distinguished between communication and active participation. Communication aimed at informing and raising awareness, serving as a foundational platform for more involved activities. The participation strategy was further segmented into various co-involvement approaches, which spanned informational and awareness levels (both under communication) and an engagement level (under participation).

In the case of the cinema for children, over 40 visitors attended the event, having displayed their interest in participating in future events of the same nature. This was also an opportunity to share informational material about SPARCS as well as a film on the subject of climate change for subsequent use and awareness raising in children (SPARCS, 4.6).

8.3.3 Recommendations

- In cases where the level of commitment and participation of the target groups are lower, promoting an in-depth engagement of the citizens, **focusing on the energy monitoring activities**, *per se*, or to **providing incentives or rewards** for their participation can prove beneficial.
- Raising awareness concerning climate issues or the change of behaviour are also investments in the future, thus it is important for the entities promoting the activity to **avoid focusing only on the data collecting part**, and also **aim for the bigger picture**.

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9 IMPACT MONITORING

9.1 Introduction

Impact monitoring in the field of smart city interventions involves the systematic evaluation and measurement of the impacts and results of various initiatives and projects implemented in the context of the smart city. It involves carefully monitoring and evaluating how these interventions affect various aspects of urban life, including the environment, the economy, social equity, governance, and the overall well-being of residents (Ntafalias et al. 2022).

The primary objective of impact monitoring is to collect valuable data and information that can be used to assess the effectiveness, efficiency, and sustainability of smart city interventions. It is important to note that data collection alone is insufficient – it must be used effectively in project management for mitigation and compensation or as a predictive tool in the impact assessment process for improvement and better outcomes (Carley, 2012). By leveraging impact monitoring data, decision makers can make informed decisions, implement the necessary measures to mitigate negative impacts, and enhance future interventions to benefit the city and its residents.

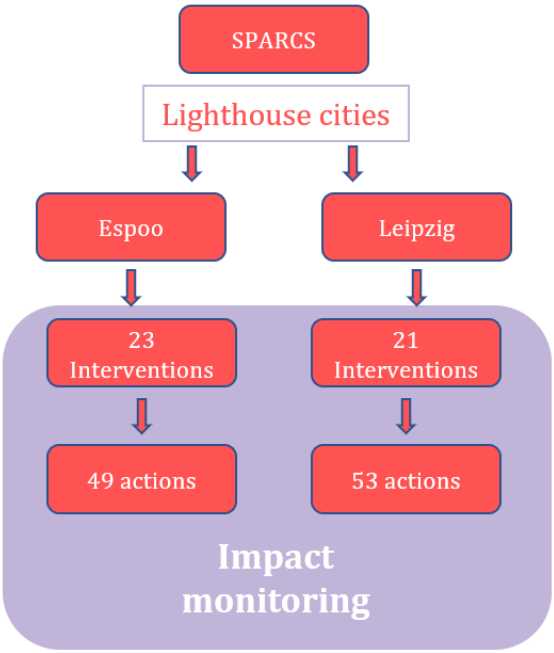

Figure 17: Interventions mapping

Espoo and Leipzig, as the Lighthouse cities in the SPARCS project, have set ambitious goals to become leading examples in the smart city transition, aiming to inspire other cities worldwide. Through the project, they have implemented over 40 interventions together with their local technical partners, focusing on various aspects such as building and district interconnection, efficient management of renewable energy, energy storage, electromobility, business model development, and Positive Energy Districts urban planning (Figure 17) (Ntafalias et al., 2021 – D2.2).

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To evaluate the effectiveness of these interventions and track progress towards the project's sustainable objectives, an impact monitoring and assessment framework is crucial. This framework allows decision-makers to gather data, analyse impacts, and make informed decisions, thereby refining strategies and allocating resources more effectively. Impact monitoring involves systematically assessing and measuring the effects and outcomes of smart city interventions, encompassing various dimensions of urban life such as the environment, economy, social equity, governance, and overall quality of life for residents.

However, several challenges are associated with impact monitoring in smart cities interventions. Firstly, defining appropriate indicators that accurately capture the desired outcomes can be complex. Secondly, ensuring data availability and proper collection from diverse sources pose challenges in creating a comprehensive monitoring system. Additionally, establishing baseline conditions and tangible targets to measure progress can be demanding. Lastly, effective stakeholder coordination and collaboration are essential for successful impact monitoring efforts.

9.2 Challenge of Significance for SPARCS cities: Defining appropriate indicators with Lighthouse City partners

Indicators should be defined in such a way that they provide critical and valuable information about the areas under consideration. However, the multifaceted nature of impact analysis as well as the balancing of simplicity and complexity are perspectives that must be considered in defining KPI lists.

On the one hand, having a simple and concise set of indicators allows easy communication, understanding and monitoring of progress. It allows stakeholders to understand the essence of the impact being measured without overwhelming them with too many metrics.

On the other hand, capturing the complexity of impact requires considering multiple dimensions, outcomes, and indicators. The impact is often interconnected and can have both intended and unintended consequences. Failure to account for these complexities can lead to oversimplification and loss of valuable information.

9.2.1 Solution developed in SPARCS

To strike the right balance, it is crucial to identify a core set of key indicators (Ntafalias, et al. 2021 – D2.2) that capture the most essential aspects of impact while still acknowledging the interconnectedness of the desired outcomes. This involves carefully selecting indicators that are representative of the broader impact framework and provide a comprehensive view without overwhelming stakeholders with an excessive number of metrics.

Impact monitoring should consider the perspectives and needs of various stakeholders, including city councillors, energy experts, and technical departments. Balancing these diverse perspectives and ensuring that KPIs reflect the expectations and interests of different stakeholders is important.

One approach is to have a combination of both high-level indicators that provide an overview of impact across different dimensions and specific indicators that delve into the details of each dimension. This allows for a simplified representation of impact

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while ensuring that the most critical aspects are captured. For example "Greenhouse gas emissions per year" (i.e. the total amount of greenhouse gases emitted by the city) can be considered as high-level indicator while "Total emissions reduced since baseline year" (i.e. the absolute decrease in emissions since a designated starting point) can be considered as specific KPI.

Regular review and refinement of the chosen indicators is essential to ensure that they remain relevant and aligned with the evolving goals and context. It is also important to consider the capacity and resources available for data collection, analysis, and reporting when striking the balance between simplicity and complexity.

9.2.2 Impact of the solution in SPARCS

The approaches used to define KPIs in SPARCS proved to be useful in introducing a holistic impact assessment framework. The top-down analysis of the interventions provided the first understanding of the city's needs, the metrics to be collected, and laid the foundations on which the evaluation framework would be based.

Subsequently, the detailed bottom-up analysis of their explicit actions carried out gave the opportunity for stakeholders, partners, and energy experts of the city to examine in detail each action and intervention in order to document the expected impact of each activity.

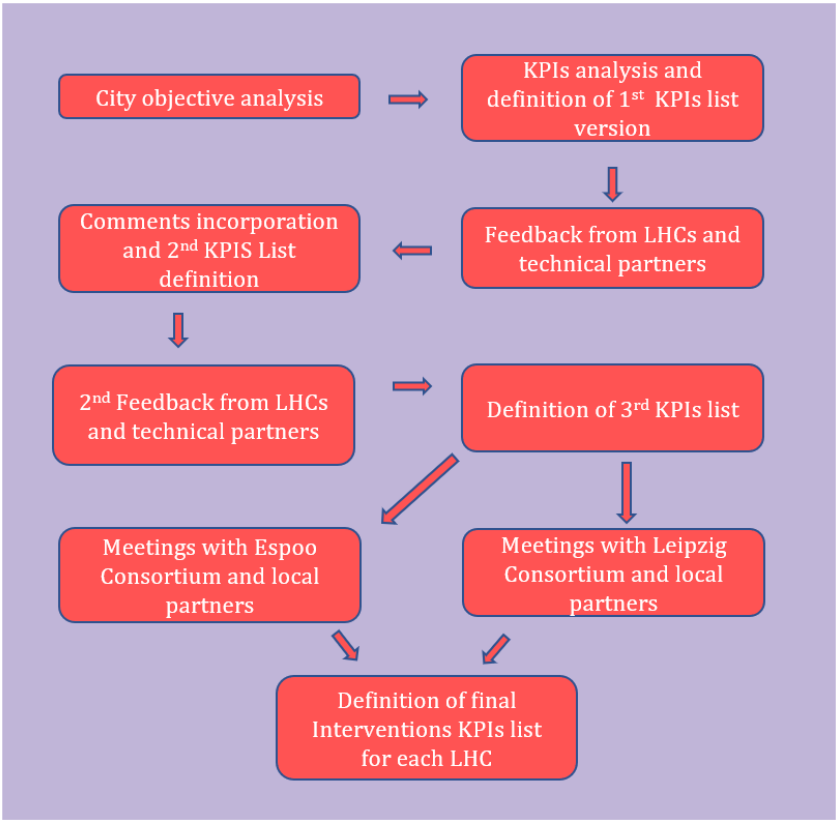

Figure 18 Involvement of Lighthouse partners on KPIs definition

As Figure 18 presents, initially the KPIs were defined from city objectives, and after incorporating feedback from city representatives and experts, second and third

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versions of the KPI lists were created. Individual calls were held with partners to finalize the KPIs based on data availability and responsibilities. These interactions facilitated knowledge sharing and collaborations among partners. The meetings also sparked discussions on measuring citizens' awareness and involvement in the interventions.

In this way we managed to capture all aspects of the needs of the smart city and more specifically the needs of the SPARCS project by addressing several categories of the multifaceted nature of impact assessment. Energy, economic, social and technological dimensions were defined and examined, as well as environmental, governance, citizen engagement and mobility. Furthermore, a comprehensive assessment of impacts was conducted by considering both qualitative and quantitative perspectives, ensuring a well-rounded evaluation.

9.2.3 Recommendations

Considering the importance of defining the proper KPIs to assess the impact of interventions in smart cities projects the following key-suggestions are summarised:

- **Engage stakeholders**: Involve relevant stakeholders, including beneficiaries, experts, and community representatives, right from the outset of the process to define KPIs. Their insights and perspectives can help identify the most critical aspects of impact and ensure that the chosen indicators are meaningful and relevant to all. In addition, stakeholders may provide the data needed for indicator development and calculation, therefore, involving them in the process from the beginning ensures that they are kept informed and engaged.
- **Prioritize impact framework**: Develop a clear impact framework that outlines the desired outcomes. This framework serves as a guide for selecting indicators that capture the core aspects of impact. It should be aligned with the mission and goals of the city/project and provide a comprehensive view of the intended change.
- **Balance high-level and specific indicators**: Use a combination of high-level indicators that provide an overview of impact across different dimensions and specific indicators that delve into the details of each dimension. This approach allows for a simplified representation of impact while ensuring that the most critical aspects are captured. The high-level indicators can serve as key summary measures, while specific indicators provide more granular insights. Additionally, it is important to check for existing KPIs or monitoring processes that cities may already have in place. This is crucial to avoid overlaps and to identify potential synergies.
- **Continuously review and refine the chosen indicators** to ensure their relevance and alignment with evolving goals and context. Regularly assess whether the indicators are capturing the desired outcomes and whether any adjustments or additions are necessary to improve monitoring and evaluation efforts.

In the process of defining KPIs, more than 35 meetings were held with city representatives. These discussions focused on strategizing effective metrics for evaluation, and on capturing citizens' awareness and involvement in SPARCS interventions. The aim was to create valuable pipelines to meet the project's needs and benefit the stakeholders of the cities involved.

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9.3 Challenge of Significance for SPARCS cities: Target setting and data availability in Lighthouse Cities

An important aspect of impact assessment in smart cities is target setting because it provides focus, measurement, and direction for achieving specific goals. Targets enable cities to assess progress, allocate resources effectively, engage stakeholders, and promote accountability. They guide decision-making processes and help cities prioritize actions that drive sustainable and inclusive urban development. By setting targets, cities can track their performance, collaborate with stakeholders, and continuously improve their smart city initiatives, leading to positive impacts and enhanced quality of life for residents.

Figure 19 Challenges on target setting and monitoring

However, setting targets for smart city interventions can present several challenges as illustrated in Figure 19. One of the main challenges is the complexity and diversity of smart city initiatives. Each city has its unique context, priorities, and challenges, making it challenging to establish standardized targets that can be applicable in other cases. Moreover, smart city initiatives involve multiple stakeholders, including government agencies, private sector organizations, community groups, academia, and citizens. Each stakeholder has their own interests, goals, and expertise, which adds complexity to the decision-making and implementation processes. Effective collaboration and alignment of diverse stakeholders' interests are crucial for successful smart city initiatives.

Data availability, quality and collection can also pose challenges, as obtaining accurate and timely data for monitoring and evaluation purposes may be challenging. Through the proper collection and analysis of data, objective and reliable information about performed actions are gathered and potential inefficiencies and misguided strategies are avoided. In addition, ensuring the quality, relevance, and timeliness of data is crucial for reliable impact monitoring. While KPIs are defined during the initial stages, it is common for cities to face difficulties in obtaining the necessary data or discovering that the available data lacks the required level of detail. Moreover, in some cases, usually in big cities, data is often scattered across different tools and departments, which leads to data silos and a lack of communication between stakeholders. This can make it difficult to access and use data effectively, which can hinder efforts to achieve sustainability goals.

Lastly, balancing the ambition of targets with the feasibility of implementation and resource constraints can be a delicate task. On one hand, cities strive to set ambitious targets that drive transformative change and address pressing urban challenges. Ambitious targets can inspire innovation, mobilize resources, and push cities to reach new levels of sustainability, efficiency, and liveability. Nevertheless, it is equally important to consider the feasibility of implementing these targets and the resource constraints that cities face. Implementing smart city initiatives often requires significant financial investments, technological capabilities, infrastructure development, and human resources. Cities need to assess whether they have the necessary capacity,

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expertise, and funding to undertake the initiatives required to achieve the ambitious targets.

9.3.1 Solution developed in SPARCS

Facing the challenges of target setting in Lighthouses requires a proactive and systematic approach. First and foremost, it is crucial to engage diverse stakeholders in the process. This collaborative approach ensures that different perspectives and expertise are considered, fostering ownership and alignment among stakeholders.

Additionally, cities are encouraged to invest in robust data collection and management systems to overcome data availability and quality challenges. This involves establishing data protocols, leveraging technology and innovation, and engaging in partnerships to access relevant data sources.

Regular review and refinement of targets are essential to account for changing contexts and emerging challenges. Flexibility and adaptability in target setting allow cities to respond to evolving needs and opportunities.

Finally, cities are urged to learn from best practices and experiences of other smart city initiatives in relevant projects, leveraging knowledge sharing platforms and networks to gain insights and guidance in addressing target-setting challenges.

9.3.2 Impact of the solution in SPARCS

During the implementation phase of the SPARCS project, the challenge of setting targets emerged as part of the impact assessment process. Lighthouse city stakeholders and partners, with their expertise and deep understanding of the local context, actively collaborated to establish feasible targets that accounted for the technical specifications of the installed systems and the unique characteristics of the implementation areas.

However, this endeavour was not without obstacles. Data availability and resource constraints presented significant challenges throughout the target-setting process. Data collection proved to be a particularly intricate task with issues encompassing the definition of data parameters, determining capturing intervals, undertaking extensive data collection efforts, and ensuring data accessibility, standardization, and consistency.

The diverse and dynamic nature of large cities like Espoo and Leipzig posed additional difficulties in attributing specific effects to the SPARCS project amidst the broader variations at the city level. Justifying the monitoring of certain indicators became a demanding task, especially when the project's impact was not readily discernible from the available data.

Moreover, it was observed that some city-level KPIs could only be reliably measured at the demonstration district level, creating a misalignment with the targets set for the entire city. Additionally, the pressure to showcase positive outcomes externally sometimes led to a preference for focusing on internal improvements rather than openly addressing weaker interventions.

It is evident that further efforts are necessary to enhance monitoring mechanisms and refine target-setting approaches, encompassing improved data collection processes,

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robust data standardization and accessibility measures, and a more comprehensive alignment of project impact with the broader sustainability objectives set by the city.

Such advancements will ultimately contribute to a more comprehensive understanding of the SPARCS project's effects and its integration within the overall development framework of all cities.

9.3.3 Recommendations

In order to guide SPARCS stakeholders and technical partners to more effectively monitor and evaluate its impact and align it with broader sustainability goals, the following recommendations could be pursued:

- **Strengthen data partnerships**: Identify key stakeholders and initiate early discussions to build collaborative data partnerships and regularly engage with partners to maintain a healthy and productive data-sharing relationship. Data is a critical asset for cities and stakeholders to collaborate effectively and bring numerous benefits to the monitoring and evaluation of sustainable targets. For example, it can help to improve the precision of monitoring and reporting of sustainability indicators and make it easier to identify best practices for achieving sustainability objectives. Partnership agreements should explicitly mention data collection, use, and sharing practices to ensure transparency, trust, and accountability. Strategic agreements should also include provisions for data sharing to facilitate innovation and joint problem-solving.
- **Improve data collection processes**: Streamline data collection efforts by leveraging automation, sensor technologies, and digital tools. Invest in advanced sensor technologies and digital tools to automate data collection wherever feasible and ensure that data collection tools and methods are standardized to maintain consistency. This can reduce manual data collection efforts, minimize delays, and ensure real-time data availability.
- **Foster collaboration and knowledge sharing**: Establish platforms for collaboration and knowledge sharing among cities and projects working on similar smart city initiatives. Organize regular workshops and webinars to facilitate in-person knowledge exchange and networking. This can facilitate the exchange of best practices, lessons learned, and innovative approaches to target setting, data collection, and monitoring. Encourage the documentation of successful case studies and best practices to be shared with others.

SPARCS developed a powerful data management platform to collect data, visualize, and track the specific KPIs defined in the project (more than 20 KPIs already incorporated). By streamlining in many KPIs automatic data collection processes, SPARCS is able to provide real-time data availability enabling stakeholders to make informed decisions and drive sustainable progress.

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10 BIG DATA, DATA MANAGEMENT AND DIGITALISATION

10.1 Introduction

In the rapidly evolving landscape of smart cities, the proliferation of big data, data management and digitalisation have become significant challenges. The rapid advancements in technology have led to the utilisation of numerous devices that offer data streams in different formats and models, which must be effectively handled. These devices include sensors, Internet of Things (IoT) devices, and various other sources that generate vast amounts of data. However, managing and collecting this diverse range of data streams poses several issues for smart cities such as in the case of the SPARCS cities with key challenges dealing with inconsistent and incorrect data that is ingested into a platform.

For instance, sensor readings may be affected by environmental factors or malfunctioning equipment, leading to erroneous or missing data. Furthermore, data from different devices might follow different formats or models, making it difficult to integrate and analyse them effectively.

Another crucial issue in the context of big data, data management, and digitalisation for smart cities is the storage and retrieval of huge amounts of real-time data streams. In the case of smart cities enormous volume of data is generated in real-time; as a consequence, storing and efficiently accessing this massive volume of data is a major technical challenge.

Traditional data management approaches may struggle to handle such high-velocity data streams and may lead to performance issues or data loss. Addressing these issues requires robust strategies and technologies. Data governance frameworks need to be established to ensure the quality, integrity, and consistency of the ingested data. This includes data validation processes, data cleaning techniques, and error detection mechanisms to identify and rectify inconsistencies or incorrect data.

Additionally, cities must adopt advanced data management techniques to handle the storage and retrieval of real-time data streams. This involves leveraging scalable and distributed storage systems, such as cloud-based architectures or edge computing infrastructures. These technologies can provide the necessary computational resources and flexibility to handle the high data volumes and velocity associated with smart city environments mentioned above, various research studies and industry initiatives have been conducted. Overall, researchers and practitioners are actively exploring innovative approaches, such as data fusion techniques, data cleaning algorithms, scalable storage solutions, etc. Altogether, these approaches aim to enhance the efficiency, reliability, and usability of big data, data management, and digitalisation in the context of smart cities.

The various issues and challenges arising in the data management (including big data) and digitalisation process of the project's Lighthouse cities are addressed through the development of the **SPARCS Data Management Platform**; specifically designed and developed to cover the cities' requirements and needs for collecting, storing and managing data from various sources, including diverse devices and sensors, by providing mechanisms for data validation, cleansing, and integration. It leverages

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advanced technologies and techniques for scalable data storage and retrieval, enabling the processing of massive volumes of real-time data streams from the demonstration activities in the Lighthouse cities allowing for the continuous monitoring of the project activities' progress and, subsequently, the assessment of the impact achieved by the project interventions in the lighthouse cities.

10.2 Challenge of Significance for SPARCS cities: How to deliver data to the Data Management Platform?

One of the prominent challenges encountered in the context of SPARCS was to efficiently provide data to the platform from the Lighthouse Cities. SPARCS Lighthouses generate data from a wide range of sensors, devices, systems, and applications, each with its own format, structure, and interface. Ensuring seamless data collection, integration, harmonisation, and standardisation becomes crucial for efficient analysis and decision-making.

Consequently, connected challenges are related to:

- ***Data Quality and Consistency***: The data collected from the diverse the city sources varies in quality, accuracy, and consistency. Discrepancies in data formats, missing values, and inconsistencies can hinder the reliability and effectiveness of data analysis, impacting the accuracy and reliability of the insights derived from the data. Thus, data validation and data cleansing processes are necessary to ensure the accuracy and reliability of the collected data and provide high quality and integrity data that can be used for analysis and decision-making.
- ***Scalability and Performance***: The Lighthouses generate big volumes of data also in real-time, which can strain the capabilities of any data management platform. Thus, ensuring scalability and high-performance data processing becomes essential to handle the ever-growing influx of data. This includes optimising both storage and processing resources, along with retrieval mechanisms to support the increasing demands of data collection.
- ***Interoperability and Compatibility***: Smart city ecosystems comprise of multiple stakeholders, each employing different technologies, systems, and protocols. Ensuring interoperability and compatibility between these systems and the data management platform can be a complex challenge; thus standards, protocols, and APIs need to be established to facilitate seamless data exchange and integration among the diverse smart city sources.
- **Data Storage and retrieval:** The sheer volume of real-time data streams generated by smart city systems presents a significant data storage and retrieval challenge. As the data flows into the platform continuously, there is a need for robust infrastructure and efficient data storage mechanisms. The platform should be capable of handling large-scale data storage, retrieval, and processing in real-time to enable timely decision-making and response to the dynamic nature of smart city operations.
- **End-user adoption, user experience:** As with any software system addressed to end-users, a very important challenge is to ensure the success and adoption of the data management platform from its end-users. Thus, it is essential to offer

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a user interface (UI) that is tailored to the needs of its users, intuitive to navigate, and provides the necessary functionalities for effective data management.

The importance of effectively using and adopting the SPARCS data management platform for collecting data from diverse sources from the project's Lighthouse cities (and any city in general) and their efficient management, lies in several key reasons:

- Informed Decision-Making: Overall cities rely on data-driven decision-making processes to address urban challenges, improve services, and enhance the quality of life for citizens. By collecting and integrating data from various sources, the SPARCS data management platform enables comprehensive and holistic insights into urban operations, enabling informed decision-making by city administrators, policymakers, and stakeholders.
- Improved Efficiency and Resource Allocation: The integration of data from diverse sources allows cities to optimise resource allocation and improve operational efficiency. By analysing data related to e.g., energy consumption, traffic patterns, waste management, and other aspects, cities can identify areas of improvement, implement targeted interventions, and allocate resources more effectively to enhance sustainability and optimize service delivery.
- Enhanced Urban Planning and Development: Data collected from city sources provides valuable insights for urban planning and development initiatives. By analysing data on population demographics, transportation patterns, and infrastructure utilization, city planners can make informed decisions about transportation infrastructure, public services, urban design, etc., leading to more sustainable and liveable cities.
- Mitigation of Urban Challenges: Presently cities face various challenges, such as congestion, pollution, increased energy consumption, and public safety. The collection and analysis of data from diverse sources enable proactive identification and mitigation of these challenges; for example, real-time data on traffic patterns can be used to optimise transportation routes, while reducing congestion and improving air quality.
- Continuous Improvement and Innovation: A data management platform facilitates continuous improvement and innovation when efficiently utilised in cities. By analysing data, identifying patterns, and evaluating the effectiveness of implemented interventions, cities can learn from past experiences and make data-driven decisions for future enhancements. This iterative process fosters innovation, leading to the development of new technologies, services, and solutions that address emerging urban challenges.

Overall, effectively utilising a data management platform for collecting data from diverse city sources is crucial for evidence-based decision-making, efficient resource allocation, sustainable urban planning, enhanced service delivery, and continuous improvement. It empowers cities to address challenges, meet citizens' expectations, and create more liveable, resilient, and intelligent urban environments.

The target audience would likely include professionals, researchers, policymakers, and stakeholders involved in the development, implementation, and management of smart city projects. Specifically, individuals who are interested in the cross-cutting issues related to big data, data management, and digitalisation in the context of smart cities would find all this information relevant, as it aims to inform and guide professionals and

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stakeholders engaged in the planning, development, and management of smart city projects, focusing on effective data handling and digitalisation strategies to optimise the benefits and impact of smart city initiatives.

This audience may consist of:

- Smart city Planners and administrators, who typically are responsible for conceptualising, designing, and overseeing the implementation of smart city initiatives; and who would benefit from understanding the challenges and best practices related to big data, data management and digitalisation in smart cities.
- Data scientists and analysts, involved in smart city projects need to be aware of the challenges related to data collection, harmonisation, and data quality assurance to effectively analyse and extract insights from the vast amounts of generated data.
- Technologists and software developers, and in general professionals engaged in building smart city platforms and applications would find the recommendations on user interface design, agile development, and data storage solutions relevant for creating efficient and user-friendly systems.
- Researchers and academics researching topics related to smart cities, big data, and digitalisation can benefit from the insights and references provided to enhance their understanding of the challenges and solutions in this domain.
- Policymakers and Government officials, who are involved in shaping regulations and governance frameworks for smart city data management would gain valuable insights into addressing data privacy, security, and data sharing concerns.
- Private Sector Entities, such as private companies and organisations involved in providing smart city solutions, data analytics, and IoT technologies may also find relevant information on data management challenges and best practices.

10.2.1 Solutions developed in SPARCS

As mentioned previously, to address the SPARCS Lighthouse data collection, data management, storage and retrieval needs, the **SPARCS Data management platform** has been developed addressing as practicable as possible many of the challenges and which are described below with the key ones focusing on:

- ***Data Quality and preparation:*** The SPARCS Data Management Platform has successfully addressed the challenge of data quality and data preparation by encompassing all required data collection mechanisms (such as file upload, upload through REST APIs, provision of KAFKA mechanism for streaming data collection) and putting emphasis in identifying problematic patterns of data streams. In addition, the platform provides data validation and cleaning mechanisms enabling data owners to clean and correct their available data.
- ***Data Integration and Interoperability***: The SPARCS Data Management Platform has successfully addressed the challenge of integrating data from heterogeneous sources by developing mechanisms for data harvesting, harmonisation and standardisation. Through the use of established protocols, a common information model (namely the SPARCS CIM), aligned with different relevant standards, and the provision of REST APIs for data retrieval, the platform ensures interoperability and compatibility between various Lighthouse

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sources, facilitates seamless data integration, enabling subsequent usage of the collected data for comprehensive analysis and insights.

- **End-user adoption, increased User experience***:* The SPARCS Data Management Platform has been tailored to the specific Lighthouse requirements; during its design phase, user research and analysis was carried out to understand the requirements, preferences, and expectations of the platform users. Engagement with the cities' stakeholders took place gathering the functional requirements that reflect their identified needs. Mock-ups of the platform's interface were also created to collect feedback of the early UI, while iterative design cycles took place to refine the final design based on the feedback received, incorporating usability principles and best practices. Agile development practices were also followed, along with quality assurance processes to ensure the platform's reliability, stability, and usability of the UI. This involved also comprehensive testing, including functional testing, usability testing, and performance testing, to identify and resolve any issues or bugs.

All this knowledge was applied within the SPARCS data management platform towards:

- *Addressing Data Collection Challenges*: During its design phase, the SPARCS data management platform considered the challenges related to data volume, variety, and quality. Thus, it implements a scalable infrastructure and different collection mechanisms capable of handling the high-velocity data streams from various sources.
- *Data Harmonization:* As the SPARCS project involves collection of data from diverse city sources from the two Lighthouses, each with its own data sources and systems. Thus, establishing a common information model and harmonising data is crucial. In this direction, a standardized data scheme is developed (namely the SPARCS CIM) utilised within the platform which also provides functionalities for mapping concepts and fields across different devices and sensors thus supporting data integration and harmonisation.
- *Data Cleaning and Preparation:* The SPARCS data management platform incorporates data cleaning and data preparation functionalities towards ensuring the accuracy and reliability of the collected data. Through these mechanisms users can identify and address problematic data patterns, such as missing values, outliers, and inconsistencies,
- *User-Friendly UI (user interface):* Creating a user-friendly and intuitive user interface for the SPARCS data management platform was a priority during its design phase to enhance its usability and adoption from the cities' stakeholders. User research, creation of mock-ups, feedback gathering, and incorporation of iterative design processes assisted in ensuring that the platform provides the necessary functionalities in an easily accessible manner.

10.2.2 Impact of the solution in SPARCS

The SPARCS Data Management platform is currently being utilised in the context of the project by the cities of Espoo and Leipzig with the purpose to gather diverse data from these cities' various sources into a single, secure, and privacy-preserving location.

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Both cities are using the platform for data collection and as a secure repository for assessing the impact of key performance indicator (KPI)-relevant data streams; also aiming to enhance the cities' capacity for publishing open data. User accounts have been established for each city's organisation, allowing members to access and view the data assets specific to their respective organisations; upon successful authentication, while ensuring that their data is protected according to the established access policies. In addition, users can also utilise the platform's data cleaning mechanisms, to harmonise and enhance the quality of their data once these are uploaded to the platform.

Through the correct and efficient utilisation of the SPARCS Data Management Platform the following impacts are foreseen for the Lighthouses:

- Informed Decision-Making: Through the platform, the SPARCS Data Visualisation framework (as described in D1.6) obtains input and the analytics provides cities with comprehensive and accurate data insights. This enables informed decision-making in various domains, including urban planning, resource allocation, service optimization, and policy development. By leveraging high-quality data, cities can make evidence-based decisions that lead to improved efficiency and sustainability.
- Continuous Improvement and Innovation: The use of a data management platform encourages cities to adopt a continuous improvement mindset. By monitoring data, analysing outcomes, and measuring performance indicators, cities can identify areas for improvement and drive innovation. This iterative process leads to the development of smarter, more efficient solutions, and enables cities to stay at the forefront of technological advancements.
- Targeted Interventions: Data collected and managed through the platform will allow all seven cities to identify specific areas or segments that require targeted interventions; by analysing patterns and trends, which can lead to the implementation of precise measures to address their challenges. This targeted approach optimises resource allocation and enhances the effectiveness of interventions.
- Engagement and Empowerment: In the context of SPARCS, the developed data management platform facilitates the cities' engagement by providing opportunities for data sharing, feedback, and participation. In the event such a platform becomes publicly open, (as with any public platform) it is anticipated that even citizens can contribute their data, insights, and concerns, allowing their cities to create more citizen-centric solutions and services. This engagement empowers citizens to actively participate in shaping their urban environment and fosters a sense of ownership and collaboration.

10.2.3 Recommendations

Based on the challenges associated with big data, data management, and digitalization in smart cities context, fostering efficient and effective data management platform is key in meaningfully utilise cities 'data for improving urban services, sustainability, and citizen well-being. A non-exhausting list of recommendations can include the following:

- **Embrace scalable and distributed storage solutions**, such as cloud-based architectures or distributed databases, to handle the vast amounts of real-time data streams generated by smart city applications. These technologies can

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provide the necessary computational resources and flexibility to store, process, and retrieve data efficiently.

- **Align with data harmonisation standards** by adopting common information data models and standards to facilitate data harmonisation across different devices, sensors, and systems used in cities. Establishing standardized data formats, protocols, and ontologies will enhance interoperability, integration, and analysis capabilities.
- **Prioritise data quality and cleaning processes**: Implement robust data validation, cleaning, and preparation processes to address inconsistencies, errors, and inaccuracies in the ingested data. Develop automated algorithms and tools for identifying and rectifying problematic patterns in the data streams, ensuring high-quality and reliable data for analysis.
- **Enhance user interface (UI) and user experience (UX)**, by focusing on developing user-friendly interfaces for data management platforms; conduct thorough user research, early design mock-ups, and usability testing to gather feedback and iterate on the UI design.

Finally, cities' stakeholders shall continuously aim to monitor and embrace the various technological advancements in the field of big data, data management, and digitalization; staying informed about emerging technologies, tools, and frameworks that can enhance data collection, storage, processing, and analysis capabilities in smart city contexts.

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11 DATA SECURITY/PROTECTION

11.1 Introduction

Smart cities leverage advanced technologies to improve the efficiency, sustainability, and quality of life for their citizens. However, alongside the numerous benefits that smart cities bring, data security emerges as a paramount concern. With the vast amount of data collected from various sources such as sensors, and IoT devices, safeguarding this information becomes imperative. The implementation of robust data security measures is crucial to ensure the privacy, integrity, and confidentiality of the data generated within smart cities. Encryption, authentication protocols, and secure data storage are some of the key elements in fortifying the digital infrastructure of smart cities. Moreover, strict regulations and policies must be in place to govern data handling, access, and sharing practices. By prioritising data security, smart cities can foster trust among their residents, businesses, and government bodies, enabling them to fully embrace the potential of technology while minimising the risks associated with data breaches or misuse.

Notably, the development of the SPARCS Data Management platform (developed to serve the project's data, storage and data availability needs) is strongly connected with the aspects of data security and protection in the context of smart cities. As a result, the design, development and ultimately the utilisation of the data platform for the project's Lighthouse Cities and Fellow Cities brought crucial points that needed to be considered:

- Secure Data Transfer, Storage, and Retrieval: Ensuring the secure transfer of data between the various cities' sources and the SPARCS Data Management platform is of utmost importance. Encryption protocols, secure communication channels, and robust authentication mechanisms are implemented to safeguard data during transit. Similarly, the storage and retrieval of the Lighthouse and Fellow Cities data within the platform are protected through access controls, private tokens and regular security audits.
- Data Privacy and End User-Related Concerns: Smart cities rely on the data shared by organisations and citizens for analysis and decision-making. However, it is essential to address user concerns regarding data privacy. Thus, the SPARCS Data Management platform implements transparent data usage policies, providing clear opt-in and opt-out mechanisms.

SPARCS project acknowledges the importance of data security and protection, ensuring compliance with national regulations, privacy laws, and the General Data Protection Regulation (GDPR). To this end, the project provides a regularly updated data management plan (internal project deliverables D9.8 – D9.1; Kousouris & Papadopoulos 2020, Tsitsanis 2022 and Papadopoulos 2023) and an internal ethics guideline (D9.6; Ikonen 2020) to guide the overall approach followed. Additionally, the project emphasises the need for practical solutions enabling data interoperability, big data management, and addressing issues related to data security and protection, which are (as practically as possible) covered by the SPARCS Data Management platform.

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Overall, data security and privacy concerns are addressed throughout the project's activities, particularly in terms of accurate monitoring, calculation of indicators (KPIs), and decision-making processes. Safeguarding data protection, security, and privacy is an integral part of the project's integrated security and ethics management policy, encompassing technology and data management practices. To this end, the SPARCS Data Management platform is shaped based on functional requirements addressing the high concerns about data privacy and security, also adhering to all relevant data protection recommendations e.g., 'data protection by design and by default' (Art. 23 GDPR) or 'security of processing' (Art. 30 GDPR); also adopting existing standards (within the SPARCS CIM) to ensure the scalability and replicability of the platform.

11.2 Challenge of Significance for SPARCS cities: How to ensure secure transfer, storage and retrieval of data?

The use and adaptation of the SPARCS Data management platform for collecting data from diverse smart city sources present challenges related to:

Data Privacy and Security: Collecting data from diverse smart city sources brings forth concerns about data privacy and security. The data management platform must adhere to stringent data protection regulations and implement robust security measures to safeguard sensitive information. Where applicable, user authorisation techniques, access controls, encryption, and secure communication channels are vital to protect data privacy and prevent unauthorized access or breaches.

Governance and Data Ownership: The diverse sources of data in smart cities involve multiple stakeholders, including government entities, private organizations, and citizens. Establishing clear governance frameworks and data ownership models becomes crucial to address legal, ethical, and privacy concerns. Transparent policies and consent mechanisms should be in place to define the rights and responsibilities of data owners, data users, and citizens.

The importance of effectively using and adopting the SPARCS data management platform for the secure transfer, storage and retrieval of data deriving from diverse sources of the project's cities lies in several key reasons:

- Informed Decision-Making: Smart cities rely on data-driven decision-making processes to address urban challenges, improve services, and enhance the quality of life for citizens. By collecting and integrating data from various sources, the SPARCS data management platform enables comprehensive and holistic insights into urban operations, enabling informed decision-making by city administrators, policymakers, and stakeholders.
- Improved Efficiency and Resource Allocation: The integration of data from diverse sources allows smart cities to optimise resource allocation and improve operational efficiency. By analysing data related to energy consumption, traffic patterns, waste management, and other aspects, cities can identify areas of improvement, implement targeted interventions, and allocate resources more effectively to enhance sustainability and optimize service delivery.
- Enhanced Urban Planning and Development: Data collected from smart city sources provides valuable insights for urban planning and development

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initiatives. By analysing data on population demographics, transportation patterns, land use, and infrastructure utilization, city planners can make informed decisions about zoning, transportation infrastructure, public services, and urban design, leading to more sustainable and liveable cities.

- Mitigation of Urban Challenges: Smart cities face various challenges, such as congestion, pollution, energy consumption, and public safety. The collection and analysis of data from diverse sources enable proactive identification and mitigation of these challenges; for example, real-time data on traffic patterns can be used to optimise transportation routes, reducing congestion, and improving air quality.
- Continuous Improvement and Innovation: A data management platform facilitates continuous improvement and innovation in smart cities. By analysing data, identifying patterns, and evaluating the effectiveness of implemented interventions, cities can learn from past experiences and make data-driven decisions for future enhancements. This iterative process fosters innovation, leading to the development of new technologies, services, and solutions that address emerging urban challenges.

Overall, effectively utilising a data management platform for collecting data from diverse smart city sources is crucial for evidence-based decision-making, efficient resource allocation, sustainable urban planning, enhanced service delivery, and continuous improvement. It empowers cities to address challenges, meet citizens' expectations, and create more liveable, resilient, and intelligent urban environments.

The target audience for utilising and adopting the SPARCS data management platform can include:

- City Administrators and Government Officials: These stakeholders, play a crucial role in decision-making processes related to urban planning, policy development, and resource allocation; and can benefit from the insights derived from a data management platform to make informed decisions, optimise services, and enhance the overall functioning of their cities.
- Policymakers and Regulators: Policymakers and regulators shape the legal and regulatory frameworks governing smart cities. They can benefit from data collected through a data management platform to identify areas that require policy interventions, assess the impact of existing regulations, and ensure compliance with data privacy and security standards.
- Technology Providers and Solution Integrators: These stakeholders, play a critical role in developing and implementing data management platforms and associated technologies used in smart cities. They can leverage insights from diverse data sources to improve their solutions, develop innovative applications, and address specific challenges faced by cities.
- Researchers and Academics: Researchers and academics studying smart cities, urban planning, and data science can utilise the data collected from diverse sources to conduct research, develop models, and gain insights into

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urban dynamics; contributing to advancements in the field and support evidence-based policymaking.

- Citizens and Community stakeholders: Ultimately, the benefits of utilising a data management platform extend to the citizens and community stakeholders of smart cities. By leveraging data to enhance services, optimise resource allocation, and improve quality of life, citizens can enjoy an overall enhanced urban experience, better access to public services, reduced environmental impact, etc.

11.2.1 Solutions developed in SPARCS

Based on existing best practices and relevant standards, the project leveraged the consortium's knowledge to design and develop the SPARCS Data Management platform specifically tailored to the needs of project, which enabled the collection and integration of data from the cities and fulfilling the objectives of secure data transfer, storage and data privacy. The knowledge of data security and protection was applied to ensure the secure handling of data within the SPARCS data management platform. Advanced security mechanisms, such as access controls, secure communication channels, and private tokens were implemented to safeguard the data during transfer, storage, and retrieval. Also, by incorporating industry-standard user authorisation/authentication and security protocols and practices, the platform ensures the confidentiality and integrity of the collected data.

Moreover, considering the importance of data privacy, particularly in the context of smart cities, the project team applied their knowledge of privacy regulations, such as the General Data Protection Regulation (GDPR), to ensure compliance. Data handling practices, consent mechanisms, and privacy policies were also developed and implemented to address user-related concerns and protect the privacy rights of individuals whose data was collected and processed within the project.

11.2.2 Impact of the solution in SPARCS

Currently the SPARCS data management platform is used in the context of the project's demonstration and evaluation phases from the cities of Espoo and Leipzig to gather into one secure and privacy preserving location the various data deriving from the cities' diverse sources. Both cities are utilising the platform as a secure data repository for impact assessment of KPI-relevant data streams, improving both cities' open data publication capacity. Appropriate user accounts have been created from both cities' organisations, where the members of each organisation can see and retrieve the various data assets from their organisation that are stored in the platform and protected from the respective access policies.

Overall, cities that adopt a data management platform to address security and data privacy impacts can anticipate positive outcomes such as:

- Enhanced data security since adopting a robust data management platform will strengthen data security measures, reducing the risk of unauthorized access, data breaches, and cyber threats. By adopting appropriate access controls, cities can protect sensitive information and maintain the integrity and confidentiality of their data.

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- Improved Data Privacy as the adoption of a data management platform enables cities to establish transparent data privacy practices. By implementing mechanisms for user consent, and data protection by design, cities can address privacy concerns and ensure compliance with privacy regulations. Also fostering trust among citizens and stakeholders, encouraging them to upload their data for the benefit of the city while respecting individuals' privacy rights.

11.2.3 Recommendations

Based on the gathered knowledge we list below a non-exhausting list of recommendations which can be followed towards ensuring a robust and privacy-preserving data management approach within organisations.

- **Incorporate privacy considerations from the early stages** of a data management platform development, addressing these needs through the platform's functional requirements. Implement privacy-enhancing technologies and access control mechanisms to protect individual privacy rights and ensure compliance with privacy regulations.
- **Establish a robust data governance framework** that clearly define roles, responsibilities, and guidelines for data management, security, and privacy. This will ensure consistent and compliant practices throughout the organisation and promote trust among stakeholders.
- **Conduct regular security audits and assessments** to identify vulnerabilities, address gaps, and ensure that the data management platform's security remains robust. Stay updated with the latest security best practices and technologies to proactively mitigate emerging threats.
- **Provide ongoing training and awareness programs for employees and stakeholders** involved in data management. Educate them about data security, privacy regulations, and best practices to ensure responsible data handling and foster a culture of data protection.
- In the future, advancements in technologies such as artificial intelligence (AI), machine learning (ML) and blockchain will play a significant role in enhancing data security, privacy, and management. Thus, embracing these emerging technologies and exploring their potential applications is crucial for strengthening data protection privacy. Additionally, ongoing monitoring of regulatory developments (e.g., updates to privacy laws and regulations), can ensure compliance and early adaptation of data management practices accordingly. Lastly it is important for organisations to **stay informed about evolving industry standards, guidelines, and frameworks** related to data security and privacy to maintain a proactive and up-to-date approach.

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12 SUMMARY

The deliverable has discussed the challenges encountered during the first 48 months of the project and presented recommendations on 10 cross-cutting issues. The developed recommendations have been reviewed by the seven SPARCS cities and their respective coordinators in order to be as clear and practical as possible so that they can be applied in local contexts and shared across the city administrations and other relevant stakeholders. It is envisioned that the recommendations also guide and inspire the ongoing sister projects in their efforts to also develop recommendations based on their own project experiences. Table 8 illustrates the recommendations for each cross-cutting issue and the most relevant target groups for those. The detailed descriptions for the challenges and recommendations can be found in the chapters referred to in the table with the CoS (Challenge of significance) numbering. Some recommendations appear relevant for many of the cross-cutting issues:

- Introduce and align the regulations at least nationally, and preferably on EU-level, as far as possible. At least learn from those countries where they are already applied. (Enablers)
- Lobby for the regulations that are needed for the efficient implementation and operation of PEDs, giving the regulators professional insights on what is needed. (Decision makers, Implementers and Multipliers)
- Engage/ communicate with the stakeholders early on in the project, especially the final users of the buildings and equipment. Provide information in a format suitable for the target group. Continue the communication and education of the users and stakeholders during the operational phase. (Decision makers, Implementers)
- Pilot and test the solutions in smaller scale. Share the learnings with other similar actors. (Implementers, Multipliers)

Table 8: Summary of recommendations (CoS=Challenge of significance, ER=Enablers; Regulatory and policy making authorities; DC/DI=Decision makers; City leaders and strategic planners/Private investors, IP=Implementers; Project management and implementation teams; MR=Multipliers; Researchers; see Figure 2)

Positive Blocks		**Target group**				
CoS 2.2: Detailed interpretation of PED concept in SPARCS cities (ch2.2)						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R2.2.1	Consciously declare the relevant aspects of each PED, already in the prefeasibility design stage		✓		✓	
R2.2.2	Define PED on the EU and national level	✓	✓		✓	✓
R2.2.3	Identify the energy market situation, population, economy, climate, and availability of the resources		✓		✓	
R2.2.4	Use the VPP concept for PEDs		✓		✓	
R2.2.5	Use the 'onion model' to construct PED networks		✓		✓	

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R2.2.6	Diversify the intermittent renewable energy generation		✓		✓	
R2.2.7	Consider the benefits and limitations of the RES options when designing the local PED solution (details in ch 2.2)		✓		✓	✓
CoS 2.3: How to co-create PED solutions in the old and new city districts (Espoo)						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R2.3.1	Identify and define the changes/transformations needed and desired		✓		✓	
R2.3.2	Identify the current state of affairs related to the developed topic(s)		✓		✓	
R2.3.3	Create a vision for the desired change and for the intended future state of the district		✓		✓	
R2.3.4	Identify the measures and actions that can be promoted jointly with different stakeholders		✓		✓	
R2.3.5	Create an action plan		✓		✓	
R2.3.6	Pilot and test the selected actions		✓		✓	

Regulatory and legal aspects		**Target group**				
CoS 4.2: Overcoming regulatory barriers for integrating RES in existing buildings						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R3.2.1	Remove the license requirement to sell surplus energy to the grid	✓				
R3.2.2	Develop clear and phased RES development plans		✓	✓	✓	
R3.2.3	Reproduce the positive effects of the carbon taxes on RES uptake in countries that introduced them already	✓	✓	✓	✓	
R3.2.4	Introduce regulations and support mechanisms to allow faster transfer of new RES solutions to the market	✓	✓	✓	✓	
CoS 4.3: PV panels vs Protected buildings and areas						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R3.3.1	Local administration should revise their procedure to assess the protected buildings		✓	✓		
R3.3.2	Develop of enabling tools such as a solar power map	✓	✓	✓	✓	
R3.3.3	More incentives and funding options for net metering	✓		✓		
R3.3.4	Limit the minimum number of energy community participants to 10 - 20 initial members	✓		✓		

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R3.3.5	Provision of financial instruments to implement RES projects and energy communities	✓		✓		
R3.3.6	Establish a help desk through which the public authority can give valid information and recommendations	✓		✓		
CoS 4.4: Blockchain solutions for P2P trade within the Virtual Power Plant						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R3.4.1	Lobby for changes in local and EU legislation that enable P2P energy trading and blockchain use cases	✓	✓	✓	✓	✓
R3.4.2	Identify and collaborate with companies that are willing to participate in specific P2P energy trading and blockchain use cases		✓	✓		
R3.4.3	Develop new technologies that could help overcome some of the legal barriers		✓	✓		
R3.4.4	Work with legal experts who specialize in blockchain energy trade		✓	✓	✓	

Storage solutions		**Target group**				
CoS 4.2: How to avoid major challenges in storage implementation?						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R4.2.1	Starting from the planning phase, it is important to not only concentrate on the technical part		✓	✓		
R4.2.2	Include users already in the planning phase		✓	✓	✓	
R4.2.3	Try to involve high quality building and fire safety inspectors, preferably early on in the process		✓	✓	✓	
R4.2.4	Use simulations to support the dimensioning of the (storage) system		✓	✓	✓	
CoS 4.3: Lacking or missing regulations						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R4.3.1	Set and align regulations for storage systems	✓				
R4.3.2	Keep regulators informed about the specific needs for the regulations regarding storage systems		✓	✓	✓	✓

Electro-mobility		**Target group**				
CoS 5.2: Introduction of smart mobility services						
SPARCS Recommendations:		ER	DC	DI	IP	MR

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R5.2.1	Utilize private companies efficiently		✓	✓	✓	
R5.2.2	Prepare in advance for upcoming phases		✓	✓	✓	
R5.2.3	Promote light mobility and public transportation		✓	✓	✓	

Effective Business Models for sustainable solutions		**Target group**				
CoS 6.2: Developing and finding financially viable business models for the projects						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R6.2.1	Use of the SPARCS Business Model canvas		✓	✓	✓	
R6.2.2	Collaborate with internal and external representatives from different sectors including citizens		✓	✓	✓	
R6.2.3	All cities and technical partners must understand the different segments of the canvas		✓	✓	✓	
R6.2.4	Use of the canvas from the very start of the project and assign the role of the 'canvas owner'		✓	✓	✓	
CoS 6.3: Lengthy procurement process in cities						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R.6.3.1	Use Preliminary Market Consultation (PMC) tool in the early stages of procurement.		✓		✓	
R6.3.2	Think about how you can improve your tendering process through the PMC		✓		✓	
R6.3.3	Evaluate a number of factors including the complexity of the solution		✓		✓	
R6.3.4	Provide as much information as possible				✓	
R6.3.5	BABLE team to guide the city				✓	
R6.3.6	Cities should take clarify as much as possible				✓	
CoS 6.4: How to engage local businesses in sustainable solutions?						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R6.4.1	Organisation: design the work plan early in the project				✓	
R6.4.2	Integration in the overall urban planning		✓			
R6.4.3	Outreach strategy: efficient use of social media and online search engines				✓	
R6.4.4	Criteria and coefficients: consider the use of weighted criteria				✓	

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R6.4.5	Maturity of the start-ups: keep small companies interested				✓	
R6.4.6	Secure enough internal resources for co-creation process		✓		✓	
R6.4.7	Ensure additional support for the process		✓		✓	
R6.4.8	Secure follow-up		✓		✓	
R6.4.9	Secure municipal budget		✓			

Citizen Engagement		**Target group**				
CoS 7.2: Where and how to start with citizen engagement?						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R7.2.1	Clearly articulate ideas via virtual platforms		✓		✓	
R7.2.2	Ask the participants to share their interests before the activities		✓		✓	
R7.2.3	Online format can make it harder to build long-term engagement relationships		✓		✓	
R7.2.4	Use diverse channels, platforms and networks for reaching citizens and participants		✓		✓	
R7.2.5	Offer some form of compensation for participants' time		✓		✓	

Gender and socioeconomics		**Target group**				
CoS 8.2: How to ensure diversity of end users?						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R8.2.1	Address communication before, after and during the activities		✓	✓	✓	
R8.2.2	Recruit extra participants and those outside the specific scope		✓	✓	✓	
R8.2.3	Buddy Class: persistency and long-term commitment is required from both sides		✓	✓	✓	
R8.2.4	Match communication with the citizen segment reached		✓	✓	✓	
R8.2.5	Tailor the message according to the specific needs and concerns of the audience		✓	✓	✓	
CoS 8.3: How to support behavioral change?						
SPARCS Recommendations:		ER	DC	DI	IP	MR

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R8.3.1	Focus on the energy monitoring activities, provide incentives or rewards		✓	✓		
R8.3.2	Avoid focusing only on the data collecting part, aim for the bigger picture		✓	✓		

Impact Monitoring		**Target group**				
CoS 9.2: Defining appropriate indicators with Lighthouse City partners						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R9.2.1	Engage stakeholders		✓	✓	✓	
R9.2.2	Prioritize impact framework		✓	✓	✓	✓
R9.2.3	Balance high-level and specific indicators		✓	✓	✓	✓
R9.2.4	Continuously review and refine the indicators				✓	✓
CoS 9.3: Target setting and data availability in Lighthouse Cities						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R9.3.1	Strengthen data partnerships				✓	
R9.3.2	Improve data collection processes				✓	
R9.3.3	Foster collaboration and knowledge sharing				✓	✓

Big Data, data management and digitalization		**Target group**				
CoS 10.2: How to deliver data to the Data Management Platform?						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R10.2.1	Embrace scalable and distributed data storage solutions		✓	✓	✓	✓
R10.2.2	Align with data harmonisation standards		✓	✓	✓	✓
R10.2.3	Prioritise data quality and cleaning processes		✓	✓	✓	✓
R10.2.4	Enhance user interface and user experience		✓	✓	✓	

Data security/protection		**Target group**				
CoS 11.2: How to ensure secure transfer, storage and retrieval of data?						
SPARCS Recommendations:		ER	DC	DI	IP	MR
R11.2.1	Incorporate privacy considerations from the early stages		✓	✓	✓	
R11.2.2	Establish a robust data governance framework		✓	✓	✓	

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R11.2.3	Conduct regular security audits and assessments		✓	✓	✓	
R11.2.4	Provide ongoing training and awareness programs for employees and stakeholders		✓	✓	✓	
R11.2.5	Stay informed about evolving industry standards, guidelines, and frameworks		✓	✓	✓	

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

13 REFERENCES

Albert-Seifried, Vicky & Murauskaite, Lina & Massa, Gilda & Aelenei, Laura & Baer, Daniela & Krangsås, Savis & Alpagut, Beril & Mutule, Anna & Pokorný, Nikola & Vandevyvere, Han. 2022. Definitions of Positive Energy Districts: A Review of the Status Quo and Challenges. 10.1007/978-981-16-6269-0_41.

Amado, M.; Poggi, F. 2014. Solar urban planning: A parametric approach. Energy Procedia 2014, 48, 1539–1548

Bartel, Angela. 2021. *Technical, Economic and Regulatory Barriers for PEDs*. City of Espoo. Internal project report.

Briink, Päivi. Sector integration will help to manage the power balance. 2020. Available at https://www.fingridlehti.fi/en/sector-integration/#51f50260

Brozovsky, J., Gustavsen, A. and Gaitani, N. 2021. Zero emission neighbourhoods and positive energy districts – A state-of-the-art review. Sustainable Cities and Society.

City of Leipzig. 2023. Protection and preservation of monuments and historic buildings. Website link: https://english.leipzig.de/construction-and-residence/building/protection-and-preservation-of-monuments-and-historic-buildings

Digital Campus Leipzig, & Stadt Leipzig. (2023, July 21). SCCL – Digital Campus Leipzig. Digital Campus Leipzig; Stadt Leipzig. https://digitalcampus.leipzig.de/sccl/

E. Derkenbaeva, S. Halleck Vega, G. J. Hofstede, and E. van Leeuwen. 2022. Positive energy districts: Mainstreaming energy transition in urban areas, *Renewable and Sustainable Energy Reviews*, vol. 153. Elsevier Ltd, Jan. 01, 2022, doi: 10.1016/j.rser.2021.121782.

EPBD, Energy performance of buildings (recast). 2023. Available at https://www.europarl.europa.eu/doceo/document/TA-9-2023-0068_EN.pdf

European Commission Horizon 2020 Work Programme 2018-2020: 10. Secure, clean and efficient energy European Commission (2020)

Evans, J., Vácha, T., Kok, H., & Watson, K. (2021). How Cities Learn: From Experimentation to Transformation. Urban Planning, 6 (1), 171-182. doi:https://doi.org/10.17645/up.v6i1.3545

EXCESS - FleXible user-CEntric Energy poSitive houseS. H2020 Project. 2019. Available at https://positive-energy-buildings.eu/

Fath, K.; Stengel, J.; Sprenger, W.; Wilson, H.R.; Schultmann, F.; Kuhn, T.E. 2015. A method for predicting the economic potential of (building-integrated) photovoltaics in urban areas based on hourly Radiance simulations. Sol. Energy 2015, 126, 357–370

Fatima, Z.; Pollmer, U.; Santala, S.-S.; Kontu, K.; Ticklen, M. 2021. Citizens and Positive Energy Districts: Are Espoo and Leipzig Ready for PEDs? Buildings 2021, 12, 102. https://doi.org/10.3390/buildings12030102JPI Urban Europe, "Positive Energy Districts (PED)," 2020. Available at https://jpi-urbaneurope.eu/ped/

Fatima, Zarrin; Tomas Vacha; Kavyashree Swamygowda and Reef Qubailat. 2022. "Getting Started with Positive Energy Districts: Experience until Now from Maia, Reykjavik,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Kifissia, Kladno and Lviv" Sustainability 14, no. 10: 5799. https://doi.org/10.3390/su14105799

Ferrer, Jorge Nunez; Taranic, Igor; Veum, Karina; van den Oosterkamp, Paul & Wilson, Cordelia. 2021. *The making of a smart city: policy recommendations*.

Fung, A. 2006. Varieties of Participation in Complex Governance. Public Administration Review, 66, 66–75. http://www.jstor.org/stable/4096571

Gollner C.; Robert Hinterberger, R.; Bossi, S.; Theierling, S.; Noll, M.; Meyer, S. and Schwarz, H.-G. 2020. Europe Towards Positive Energy Districts; First Update; February 2020 A compilation of projects towards sustainable urbanization and the energy transition.

Graabak, I.; Korpås, M.; Jaehnert, S.; Belsnes, M. 2019. Balancing future variable wind and solar power production in Central-West Europe with Norwegian hydropower. Energy 2019, 168, 870–882.

Grossi, G., & Pianezzi, D. 2017. Smart cities: Utopia or neoliberal ideology? Cities, 69, 79–85. https://doi.org/10.1016/j.cities.2017.07.012

Haakana, J.; Tikka, V.; Lassila, J.; Partanen, J.; Rinne, S. 2016. Opportunities of bioenergy-based CHP production in balancing renewable power production. In Proceedings of the International Conference on the European Energy Market, Porto, Portugal, 6–9 June 2016.

Haas, J.; Cebulla, F.; Nowak, W.; Rahmann, C. Palma-Behnke, R. 2018. A multi-service approach for planning the optimal mix of energy storage technologies in a fully-renewable power supply. Energy Convers. Manag. 2018, 178, 355–368

Heide, D.; von Bremen, L.; Greiner, M.; Hoffmann, C.; Speckmann, M.; Bofinger, S. 2010. Seasonal optimal mix of wind and solar power in a future, highly renewable Europe. Renew. Energy 2010, 35, 2483–2489.

Hofierka, J.; Kaňuk, J. 2009. Assessment of photovoltaic potential in urban areas using open-source solar radiation tools. Renew. Energy 2009, 34, 2206–2214.

Hukkalainen, Mari, Andreas Jaeger; Mia Ala-Juusela; Javier Llorente; Joaquin Villar; Hassam ur Rehman, Dimitri Weibel. 2020. Deliverable 1.3: Report on making PEB concepts part of local authorities planning instruments. EXCESS project. Available at https://positive-energy-buildings.eu/resource?t=Report%20on%20making%20PEB%20concepts%20part%20of%20local%20authorities%20planning%20instruments

Hung, C. R.; Völler, S.; Agez, M.; Majeau-Bettez, G.; Strømman, A. H.; 2021. Regionalized climate footprints of battery electric vehicles in Europe, Journal of Cleaner Production, https://doi.org/10.1016/j.jclepro.2021.129052

IEA, Global EV Outlook, 2023, Available at https://www.iea.org/reports/global-ev-outlook-2023

Ikonen, Veikko. 2020. D9.6 Internal Ethics Guideline. SPARCS H2020 project.

IRENA, Renewable Power Generation Costs in 2022. Available at https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

J. N. Ferrer, I. Taranic, K. Veum, P. van den Oosterkamp, and C. Wilson, "The making of a smart city: replication and scale-up of innovation in Europe," 2017. [Online]. Available: https://smart-cities-marketplace.ec.europa.eu/insights/publications/making-smart-city-replication-and-scale-innovation-europe.

JPI Urban Europe/SET-Plan Action 3.2, "White paper on PED Reference Framework White Paper on Reference Framework for Positive Energy Districts and Neighbourhoods," *JPI-Urban Eur.*, no. March, pp. 1–22, 2020, [Online]. Available: https://jpi-urbaneurope.eu/wp-content/uploads/2020/04/White-Paper-PED-Framework-Definition-2020323-final.pdf

Kammen, D.M.; Sunter, D.A. 2016. City-integrated renewable energy for urban sustainability. Science 2016, 352, 922–928. DOI: 10.1126/science.aad9302

Kousouris, S; Papadopoulos, G. 2020. D9.8 Data Management Plan – updated version 1 – updated version 1. SPARCS H2020 project.

Lindholm, O. 2019. Techno-Economic Analysis of a Reversible Solid Oxide Cell and Hydrogen Gas Storage System. Master's Thesis, Åbo Akademi University, Turku, Finland, October 2019.

Lindholm, O.; Rehman, H; Reda, F. 2021. Positioning Positive Energy Districts in European Cities. Buildings 2021, 12, 19. https://doi.org/10.3390/buildings12010019

Liu, H.; Andresen, G.B.; Greiner, M. Cost-optimal design of a simplified highly renewable Chinese electricity network. Energy 2018, 147, 534–546.

MAtchUP Project (2019). D6.1: Review of business models and financial instrument. Available at https://www.matchup-project.eu/wp-content/uploads/2021/07/MATCHUP_D6.1_Review-of-business-models-and-financial-instruments.pdf

Ntafalias, A.; Papadopoulos, G.; Papadopoulos, P.; Huovila, A. 2022. A Comprehensive Methodology for Assessing the Impact of Smart city Interventions: Evidence from Espoo Transformation Process. Smart Cities 2022, 5, 90-107. https://doi.org/10.3390/smartcities5010006

Ntafalias, A.; Papadopoulos, P.; Menyktas, K.; Tountas, I.; Papadopoulos, G.; Kousouris, S. and Tsitsanis, A. 2021. D2.2 Definition of SPARCS Holistic Impact Assessment Methodology and Key Performance Indicators (updated version)., 2021. SPARCS Project.

Ntafalias, Aristotelis; Panagiotis Papadopoulos, Kyriakos Kentzoglanakis- VERD, MOH, Giorgos Papadopoulos, Katerina Vagena- Suite5, Jani Tartia, Joni Mäkinen, Aapo Huovila, Kalevi Piira, Tiina Vainio-Kaila, Mikaela Ranta, Petr Hajduk, Elina Ekelund, Joona Töyräs, Saga-Sofia Santala, Merja Honkanen, Toni Tukia, Sami Laakso, Daniel Boldt, Timo Koljonen, Irene Müller, Nadja Riedel, Simon Baum, Sandra von Schirp, Patrizia Bolognesi, Heidi Marschner, Hendrik Kondziella, Erik Jelinek , Simon Albrecht, Alexander Peitz. 2023. D2.6 Holistic Impact Assessment of Demonstration Activities. SPARCS H2020 project.

OECD, 2019. *Taxes on polluting fuels are too low to encourage a shift to low-carbon alternatives.* Available at https://www.oecd.org/tax/taxes-on-polluting-fuels-are-too-low-to-encourage-a-shift-to-low-carbon-alternatives.htm

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A handbook for visionaries, game changers and challengers. African Journal of Business Management, 5, 1-5.

Papadopoulos, G. 2023. D9.10 Data Management Plan – updated version 3. SPARCS H2020 project.

Poller, Uta. 2021. *WP1 Feedback Workshop Citizen Engagement Database*.

Ponzio, S. (2017). Joint procurement and innovation in the new EU Directive and in some EU-Funded projects. IUS Publicum.

Rehman, H.; Reda, F.; Paiho, S.; Hasan, A. Towards positive energy communities at high latitudes. Energy Convers. Manag. 2019, 196, 175–195.

Rivada, A., Hoyos, E., Demir, E., Aksu, M., Stacey, A., Yorton, B., & Nagy, I. (2016). Report on Non-technical Barriers and Legal and Normative Issues (No. D1. 13). Valladolid, Spain: Fundación CARTTF.

Santala, Saga-Sofia; Ryöppy, Merja; Takala, Lotta; Tartia, Jani; Kaurila, Mia; Juslin, Angela; Ekelund, Elina and Fatima, Zarrin. 2022. *D3.6 Optimizing People Flow and User Experience for Energy Positive Districts.* SPARCS Project.

Sherry R. Arnstein (1969) A Ladder Of Citizen Participation, Journal of the American Institute of Planners, 35:4, 216-224, DOI: 10.1080/01944366908977225

Stadt Leipzig. (2023, July 21). SmartCity Challenge Leipzig 2022 – Digital Campus Leipzig. Digital Campus Leipzig; Stadt Leipzig. https://digitalcampus.leipzig.de/en/sccl-en/sccl-2022-en/

Tartia, Jani. 2023. Consortium meeting presentation in Reykjavik 'WP3 Workshop: Citizen Engagement in PED development'. SPARCS H2020 project.

Teece, D. J. (2010). Business Models, Business Strategy and Innovation. Long Range Planning, 43(2), 172–194. https://doi.org/10.1016/j.lrp.2009.07.003

Timeus, K., Vinaixa, J., & Pardo-Bosch, F. (2020). Creating business models for smart cities: a practical framework. Public Management Review, 22(5), 726–745. https://doi.org/10.1080/14719037.2020.1718187

Torcellini, P.; Shanti, P.; Deru, M.; Crawley, D. Zero Energy Buildings: A Critical Look at the Definition; ACEEE Summer Study: Pacific Grove, CA, USA, 2006

Tsitsanis, Tasos. 2022. D9.9 Data Management Plan – updated version 2. SPARCS H2020 project.

Vácha, Tomáš; Dvořáková, Klára; Kuzmič, Michal; Wyckmans, Annemie; Ahlers, Dirk; de Andrade, Elisa Junqueira; Hansen, Maria; Garofalo, Irene; Beurden, Judith Borsboom-van; Cremer, Marjolein; Rodriguez, José & Evans, James. 2022. CrAFt – Creating Actionable Futures. Available at https://craft-cities.eu/wp-content/uploads/2023/01/D4.1-NEB-inspired-learning-framework.pdf

Villegas de la Ossa, Gabriel; Frieling, Hendrik; Effenberger, Niklas; Ryöppy, Merja; Riedel, Nadja; Graetz, Sebastian. 2022. D7.4 Lighthouse Cities Start-Up Smart city Challenge Report and Lessons Learned. SPARCS H2020 project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Wagner, R.; Antoniou, I.; Pedersen, S.M.; Courtney, M.S.; Jørgensen, H.E. The influence of the wind speed profile on wind turbine performance measurements. Wind Energy 2009, 12, 348–362.

Wyckmans, A.; Karatzoudi, K. and Brigg, D. 2018. +CityxChange. D9.5: Report on attendance at events held by other SCC-01 co-ordinators 2, no. 824260, 2018.

Zhang, X.; Penaka, S.R.; Giriraj, S.; Sánchez, M.N.; Civiero, P.; Vandevyvere, H. Characterizing Positive Energy District (PED) through a Preliminary Review of 60 Existing Projects in Europe. Buildings 2021, 11, 318. https://doi.org/10.3390/buildings11080318

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities