D4.7 Replicating the smart city lighthouse learnings in Leipzig: technical, social and economic solutions with validated business plans

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Description of the related task and the deliverable. Extract from DoA	**T4.7 Replication and exploitation preparation (LPZ)** All work in the Lighthouse Demonstration City Leipzig aims at developing solutions and services for future energy positive blocks (EPB) and districts to reach the development goals of sustainable Leipzig. Replication and exploitation opportunities is the driver for the actions. SPARCs offers a platform for demonstrating, analysing, evaluating and optimising the solutions as well as collaboration means and community engagement models. The task will: • deliver a Post-SCC01 Monitoring Strategy (M48), • prepare for immediate replication in selected energy districts including LWB stock and Virtual Energy district, • develop future tools for city planning, • evaluate governance models, • further the creation of local business models. Replication is additionally supported by collaboration with existing networks, such as NEU e.V. and Metropolregion Mitteldeutschland, which bring together more than 75 actors in the field of renewable energy solutions and SMEs.
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0.9	30.7.2024	VTT	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	30.9.2024	VTT	Coordinator submits to EC

About SPARCS

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

Partners

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1. Executive Summary

The following report presents the method for a replication strategy that was developed and implemented by the city of Leipzig. In close cooperation with the Leipzig consortium, the city of Leipzig organised joint workshops and bilateral discussions to design a common strategy.

This deliverable presents the project results and their challenges as well as the possibilities for replicating the individual solutions.

The second chapter presents the city-wide strategies on how the city of Leipzig can achieve climate neutrality and develop smart city governance.

The third chapter describes how the replication plan in Leipzig was developed together with the partners and how use cases with high replication potential were identified.

Chapters 4 and 5 describe the challenges, findings and replication strategy of the partners' various use cases. This is intended to help other municipalities learn from the experiences of the SPARCS use cases. The use cases are divided into two chapters, as there are two replication districts. The use cases are presented for each replication district.

The following information is provided in tabular form for each use case in this replication process:

Project results:

- Key results during the project life cycle
- challenges
- Findings and insights

Replication:

- Status of replication
- Replication potential
- Plans for replication - outlook
- Evaluation of the replication potential
- Business Model Canvas (BMC)

The final section summarises the replication plans.

2. INTRODUCTION

2.1 Contributions of partners

The city of Leipzig has developed a replication plan in close cooperation with the Leipzig Consortium. The strategy was developed during joint workshops and bilateral discussions and the plan was implemented by the city of Leipzig.

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

Partner	Contributions
LEI	Editor of the deliverable. Content planning, allocation of writing responsibilities. Chapter 1, 2, 3, 6.2; 6.3; 7
LSW	Chapter 5.1, 5.2, 5.3
WSL	Chapter 4.1, 4.2, 4.3, 4.4, 4.5
CEN	Chapter 5.1, 5.2, 5.3
SEE	Chapter 4.6
ULEI	Chapter 6.1

Table 1: Contributions of partners

2.2 Relations to other activities

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

Deliverable/ Milestone	Contributions
L4-6	**Leipzig Model to integrate PV electricity into the general power supply**
L20	**Standard model for smart cities**
D5.14	**Upscaling Plan**
D6.6	**Recommendations on cross-cutting issues**
	Challenges of the Energy Transition and their Solutions - **Field report from SPARCS Leipzig**

Table 2: Relation to other activities in the project

3. City-wide strategies on the path to climate neutrality and smart city governance

In Leipzig, the following city-wide strategies are in place to achieve the goal of climate neutrality. These Leipzig strategies also have a positive impact on the SPARCS replication strategy, as they share common goals and there are good synergies between the replication process and the strategies. This chapter describes these strategies:

Energy and Climate Action Programme 2030 (SECAP) and **EU 100 Climate Neutral and Smart Cities Mission**: These two programmes aim at a massive expansion of renewable energy systems as a measure to achieve climate neutrality. This also applies to LWB buildings. In addition, the stabilisation of a virtual power plant (VPP) from SPARCS is described as a measure.

Digital agenda - smart city strategy: The Digital Agenda aims to centralise data and develop tools for the city administration. The "Energy Map Leipzig" tool developed as part of SPARCS will be integrated and further developed as part of the Digital Agenda.

Municipal heat planning: As part of municipal heating planning, numerous heat-generating renewable energy plants are to be built and connected to the district heating network. This also includes additional solar thermal systems, such as the SPARCS solar thermal system. Tools such as the University of Leipzig (ULEI) tool developed as part of SPARCS are to be further utilised and developed for the simulation of district heating networks.

3.1 SECAP and EU Mission on 100 Climate Neutral and Smart Cities

Since joining the European Energy Award in 2009, the city of Leipzig has been engaged in an expanding process of climate protection. This includes establishing structures within the administration to develop and implement measures, as well as broad civic engagement in the areas of climate and environmental protection. With the Leipzig City Council's decision to declare a climate emergency 2019, ambitious goals were expressed as political will: by 2035, the city administration and by 2040 at the latest, the entire city should be climate neutral. Thus, the city of Leipzig aims for climate neutrality well before the deadline of the German Federal Government of 2045. Additionally, in 2020, an immediate action program with over 24 urgently implementable measures was adopted.

With the SECAP, the city of Leipzig has presented an ambitious framework. Through ten success factors, Leipzig aims to have implemented 100 measures by 2030 across its seven action areas. With the endorsement of the SECAP by the city council in 2022, the city council has also committed to increase efforts to reach climate neutrality by 2030 within the 100 Cities Mission. The SECAP is supported by biennial implementation programmes which are also endorsed by city council.

Leipzig's climate protection efforts and commitments were appreciated by the European Commission by selecting Leipzig as a Mission City of the EU mission "100 climate-neutral and smart cities". While the city administration is playing a pioneering role in the transition process to a climate-neutral city, climate neutrality requires the cooperation of the entire urban society, including businesses and civil society. Therefore, in a broad participation process for the creation of a Climate City Contract, further climate protection measures are currently solicited, aligned with and supported by ongoing and future Smart City solutions.

In order to achieve climate neutrality and to continue to maintain the city as a place worth living in, a wide variety of measures are necessary, ranging from a change in transportation to the decarbonisation of energy and heat supply to sustainable land use planning. All of these measures are part of the solution that pave the City of Leipzig's way to climate neutrality.

3.2 Digital Agenda – Smart City Strategy

The Digital Agenda applies to the municipal administration, municipal enterprises and associated companies. It defines guiding principles and fields of action together with targets and projects up to 2026. It regulates responsibilities, decision-making processes and further steps for implementation. The agenda is an important basis for cooperation with business, science, urban society and other municipalities as well as for mobilising public and private resources such as funding.

The Digital Agenda builds on existing strategies at European, national and municipal level. These include the Sustainable Development Goals of the United Nations' 2030 Agenda and the New Urban Agenda of 2016. The European Union's Green Deal recognises digital technologies as a key prerequisite for achieving the UN Sustainable Development Goals and aims to provide concrete support in line with the European Union's digital strategy with the EU's Digital Compass.

The city of Leipzig is committed to the principles of the international network Cities Coalition for Digital Rights and is involved as a member of the network with its findings. Germany has developed its own digital strategy, in which the city of Leipzig is involved in nationwide committees and lighthouse projects. On a regional level, the federal state of Saxony has an own digitalisation strategy as well, the key messages of which are incorporated into the Digital Agenda.

Cooperation with other cities and organisations in the Central German region are particularly important. The goals and fields of action of the Digital Agenda are also part of the Integrated Urban Development Concept INSEK 2030.

The following are the Guiding Principles of the Digital Agenda

- GP 1: Digitalisation should serve the people.
- GP 2: We use digitalisation to develop our city sustainably together.
- GP 3: We act in a self-determined, transparent and responsible manner.
- GP 4: We empower people to participate in digital life.
- GP 5: We support pioneers of digital development.
- GP 6: We collect, connect and share data for the benefit of the community.
- GP 7: We offer our services online, securely and barrier-free.

3.3 Municipal heating planning

Germany’s responsibility at national level to implement the internationally and in particular the EU-wide agreed climate neutrality targets, is reflected in the Federal Climate Protection Act, establishing a binding commitment for the overall target to reduce - compared to 1990 levels - greenhouse gas emissions by at least 65 % by 2030 and by at least 88 % by 2040. Net emissions nationwide are to be zero by 2045. Further important legislation is enacted through the Gebäudeenergiegesetz [Building Energy Act] regulating specifications for the energy quality of buildings, creation and use of energy certificates, the use of renewable energies in buildings and for local authorities, the use of renewable energies in new buildings and renovations. Furthermore, the act for heat planning and the decarbonisation of heating networks stipulates that the federal states implement municipal heat planning, including heat plans, in municipalities with more than 100,000 inhabitants by 30 June 2026 (i.e. mandatory for Leipzig). In the Free State of Saxony, the strategic direction of energy and climate policy up to 2030 is also set out in the Saxony Energy and Climate Programme. Although this programme does not formulate its own reduction targets, it does refer to the national target, which serves as the most important orientation.

As part of its municipal services of general interest, the city of Leipzig is therefore tasked with finding solutions in the heating sector that ensure a sustainable, secure and affordable energy supply for its citizens. Strategic municipal heating planning forms the essential basis for initiating targeted measures to achieve this. This is currently being drawn up in the City of Leipzig.

The aim of the heat planning is to show the path to a climate-neutral heat supply by 2038 for every building and therefore for every citizen of the city. The heating plan serves the city and its municipal companies, as well as the property industry, owners, energy suppliers and citizens, as a guide for designing, controlling and investing to save heating energy and gradually decarbonise heating consumption.

The municipal heating plan is a central instrument for shaping a climate-neutral heat supply within sustainable integrated urban development and is also a key component of the city of Leipzig's Energy and Climate Protection Programme 2030. The heating plan in Leipzig is being developed by the city administration, in particular in cooperation with Leipziger Stadtwerke (LSW) and Leipziger Wohnungs- und Baugesellschaft (LWB).

The aim of the heating plan is to set the decisive course for a climate-neutral heat supply by 2038 to enable the necessary intensification of climate protection efforts in light of current climate-relevant developments. For this reason, the preparation of the heating plan will examine whether and under what conditions a climate-neutral heat supply for the city of Leipzig can be achieved by 2035.

4. Replication Process in Leipzig

A multi-stage workshop concept was developed for a replication plan and the identification of replication potential in order to work out the best solutions and use cases during ongoing operations and then pursue these strategically for the Leipzig solutions.

The aim of this process was to evaluate together with the Lighthouse City (LHC) Leipzig partners which use cases of SPARCS have a high replication potential. Replication was defined here as the implementation at new locations and in different environments.

The target group of the process included the project partners in the Leipzig consortium of the SPARCS project and the Digital City Unit as the coordinator. The Digital City Unit evaluated the project and developed their own topics and products.

The process involved three workshops, each lasting two hours, as well as bilateral discussions with the project partners. The workshops took place once per year, with the first workshop being held online and all subsequent workshops taking place in person.

The described process is shown schematically in the diagram below.

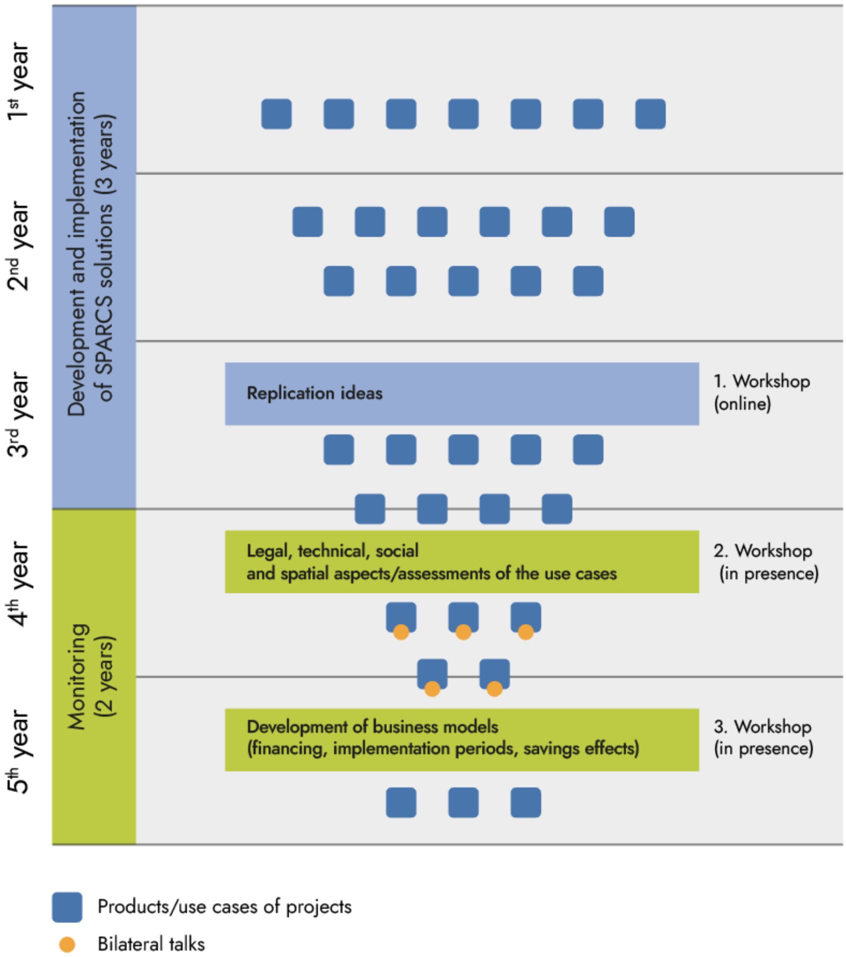


Figure 1: Graphic of the replication process (Source: LEI)

The first workshop focused on determining which of the SPARCS solutions and approaches could potentially be replicated. In the second workshop, the requirements for replicability and potential locations in Leipzig were discussed. The following questions were asked:

- Which legal, technical and spatial requirements are necessary for the solutions to be replicated?
- How high is the replication potential? (low, medium, high)
- Can the product be applied to individual buildings or to an entire neighbourhood?
- Which stakeholders need to be involved for replication?
- Who is the target group?

As a result of the workshop, a graphic was created that evaluates all use cases in terms of their replication potential and shows possible further developments. The use cases are described in detail in the following chapters on the replication districts.

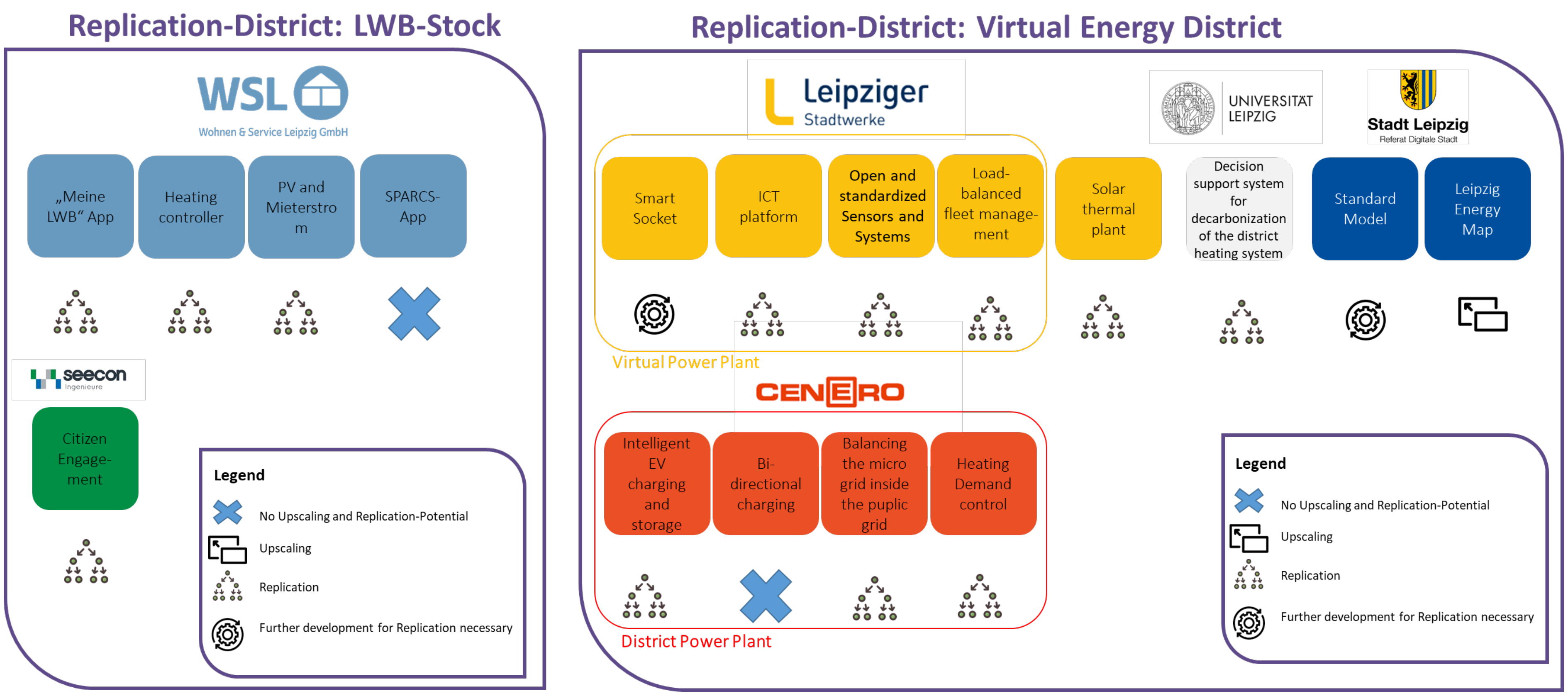


Figure 2: Overview of the use cases and their replication potential (Source: LEI)

The meaning of the legend is described as follows:

No upscaling and replication potential	The development process revealed that there is neither replication nor upscaling potential for the use case
Upscaling	There is an upscaling plan for this use case (see D5.14)
Replication	This use case has replication potential
Further development for replication necessary	Further development potential was recognised in the process to enable better replication

In the last workshop, business model canvases were developed for the use cases. In-depth discussions after the workshop were held in bilateral talks in order to address the characteristics of the use cases and the individual partners. The SPARCS solutions developed were then presented to the entire consortium during a meeting in Leipzig in December 2023 during a poster session to facilitate the knowledge transfer and identify potential synergies.

Five **insights and learnings** were gained from this process:

1. The replicability and further development of products should be considered early in the project.
2. Continuation and replication are iterative processes, therefore a continuous work process should be established.
3. When examining replicability, not only technical and legal aspects, but also social and spatial aspects should be included.
4. In preparation for the workshop concept: Develop profiles for sub-projects/sub-products and compare them in a short online session.
5. The actual discussion on replicability should take place in face-to-face workshops in order to promote exchange, knowledge transfer and synergy potential between the participants.

In order to present the content of the chapters 4 and 5 in an easily understandable way, all use cases are presented in a tabular overview as follows:

Partners involved		CO_2 reduction potential of future replication	*low, medium, high*
Replication potential	*None, low, medium, high*	Status of replication	*Replication in planning, replication in progress*
Use case description			
Key results during the project lifecycle			
Challenges			
Learnings and insights			
Evaluation of the replication potential	*Explain and describe why it is going to be replicated and why not*		
Plans for replication - Outlook			
Realisation horizon for replication	Short term 0-3 years	Medium term 3-5 years	Long term 5-10 years
Business Model Canvas	*Complete BMC in Annex*		

Table 3 Tabular overview

5. Use Cases in Replication District LWB Stock

For the replication district of the LWB Stock, the following SPARCS solutions were evaluated regarding their replication potential:

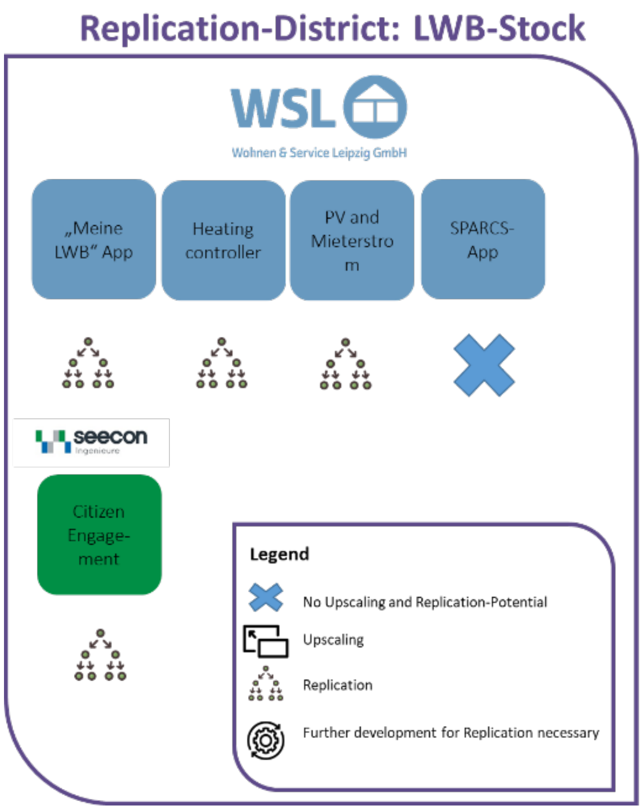


Figure 3: Replication District LWB Stock (Source: LEI)

5.1 Description of the replication district

The replication strategy focusses on the objects of the building type WBS 70. The WBS 70 building type was a significant construction project in the former German Democratic Republic (GDR), initiated in the 1970s. The abbreviation WBS stands for "Wohnungsbauserie," which translates to "residential building series" in English. Following World War II and the division of Germany, there was a substantial demand in the GDR for affordable and quickly available housing. To meet this demand, the GDR government began developing standardised construction concepts and techniques enabling efficient mass production of residential buildings. The WBS 70 series was one such initiative.

The WBS 70 construction method primarily relied on prefabricated concrete panels assembled at construction sites. This allowed for the rapid construction of large residential complexes at relatively low costs. The apartments were often small and offered little variation in terms of layout or architectural design. These buildings were frequently situated in what are known as prefabricated building settlements, often constructed on the outskirts of cities or in suburbs. While the WBS 70 buildings provided a solution to the acute housing shortage in the GDR, they were later criticised for their uniform and simplistic aesthetics.

Following the reunification of Germany in 1990, many of these apartments of the prefabricated building were renovated or demolished. Some were modernised and continued to be used as residential space, while others were replaced by new construction projects. Nevertheless, WBS 70 buildings are still present in various cities in Germany today, often serving as a testament to the architecture and history of the GDR.

Figure 4: Prefabricated buildings in Dunckerviertel (Source:WSL)

This building type covers a third of the whole apartments of WSL / LWB (including 127 buildings with 11,750 apartments). The whole stock is connected to the district heating grid of LSW and often centred in residential areas of several buildings – for example Leipzig Paunsdorf.

The replications focus on three main areas: (1) expanding the use of renewable energies, (2) digitising buildings and technical facilities, and (3) continuously monitoring and optimising energy consumption using suitable energy management systems.

5.2 PV plants and tenant electricity ("Mieterstrom")

Partners involved	WSL	CO_2 reduction potential of future replication	high
Replication potential	medium	Status of replication	Replication in planning and in progress
Use case description	The roofs of the described buildings show a big potential for the installation of photovoltaic (PV) systems. This presents a significant opportunity to boost renewable energy production directly within urban areas. As part of WSL initiative, we are conducting analyses of various business models to effectively utilise PV plants. WSL involves the installation of PV plants across selected sites to boost renewable energy generation. Additionally, WSL aims at implementing and evaluating energy storage solutions to optimise self-consumption of generated energy. This integrated approach aligns with WSLs commitment to sustainability and reducing reliance on non-renewable energy sources.		
Key results during the project lifecycle	Since the inception of the project, we have successfully installed 3.5 MWp of new PV plants. These systems generate around 3,750,000 kWh of renewable electricity annually, leading to a reduction of 1,570 tons of CO2 per year. The focus extends beyond mere installation; we meticulously analyse various business models to ensure optimal utilisation of these resources. Within the demonstration district, two main components were implemented: - Two PV plants directly feed into the public grid, contributing to the local energy supply and promoting sustainability. - A single PV plant, complemented by a storage system, facilitates self-consumption optimisation. This setup allows for efficient use of generated energy, reducing reliance on external sources. As part of our efforts, we are conducting a thorough "Mieterstrom" [tenant electricity] study. This study aims to evaluate the feasibility and benefits of tenant-based energy supply models, ensuring affordability and accessibility while promoting renewable energy adoption.		

Challenges	The challenge is the complexity of finding the right business model to face the individual requirements of the economic, political and local conditions. Recognising the complexities of "Mieterstrom" and the rapidly changing regulatory landscape, we are exploring alternative business models to ensure sustainable energy solutions. Our focus lies in innovation and adaptability to navigate these challenges effectively. One approach involves leveraging the flexibility of energy markets through dynamic pricing models. By dynamically adjusting prices based on market conditions and energy demand, we can optimise revenue streams while offering competitive rates to consumers. Furthermore, we are exploring the concept of energy-as-a-service (EaaS), wherein customers pay for energy services rather than owning the infrastructure outright. This model promotes efficiency and allows for greater scalability, catering to evolving consumer preferences and regulatory requirements. Additionally, community-based energy initiatives, such as peer-to-peer energy trading platforms, offer exciting opportunities for decentralised energy generation and consumption. By empowering local communities to participate in energy production and distribution, we foster a sense of ownership and sustainability while adapting to regulatory changes. In essence, our approach prioritises flexibility, innovation, and collaboration to create resilient business models that thrive amidst regulatory uncertainties.
Learnings and insights	When considering business models and options for utilising PV plants and renewable energy, simplicity and ease of implementation are key factors. Here are several straightforward approaches: • **Direct Ownership Model:** Under this model, individuals or businesses own and operate PV plants installed on their properties. They benefit from reduced energy costs through self-consumption of generated electricity and potentially selling excess energy back to the grid. • **Third-Party Ownership:** This model involves a third-party entity owning and operating PV plants on behalf of property owners. Property owners typically enter into long-term agreements, such as power purchase agreements, to purchase electricity generated by the PV system at predetermined rates, often lower than traditional utility rates. • **Solar Energy Communities:** Community solar projects allow multiple individuals or businesses within a community to collectively own or subscribe to a shared PV system. Participants receive credits on their electricity bills for their share of the energy generated by the system, providing access to solar energy benefits for those unable to install PV systems on their own properties. • **Solar Leasing:** Similar to third-party ownership, solar leasing involves leasing PV systems from a provider for a fixed

	monthly fee. The provider handles installation, maintenance, and operation of the system, while the lessee benefits from reduced energy costs. • **Energy Service Agreements:** Energy service agreements involve outsourcing energy services, including the installation and operation of renewable energy systems, to a third-party provider. The provider guarantees energy savings or performance outcomes, allowing customers to benefit from renewable energy without upfront capital investment. • **Feed-in Tariffs:** These programmes offer fixed, long-term contracts to PV system owners for the electricity they generate and feed into the grid. Feed-in tariff rates are typically set higher than retail electricity rates to incentivise renewable energy adoption and provide a stable revenue stream for PV system owners. • **Net Metering:** Net metering policies allow PV system owners to offset their electricity consumption with the electricity generated by their PV systems. Excess electricity generated is fed back into the grid, and owners receive credits on their electricity bills for the surplus energy exported. By focusing on these straightforward business models and options, stakeholders can easily navigate the process of installing and utilising PV plants and renewable energy, promoting broader adoption and sustainability.
Evaluation of the replication potential	This use case shows a medium replication potential depending on the condition of the roof renovation and electrical system. In terms of reducing CO2 emissions and increase renewable energy production in the city however, the replication potential is high.
Plans for replication - Outlook	The total potential for utilising WBS 70 properties for the installation of pv systems is approximately 9,000 kWp. This could generate around 8,150,000 kWh of electricity per year, resulting in an annual reduction of about 3,500 tons of CO2. The estimated budget required for installing the additional systems would be around EUR 8 million net. • Rollout PV plant installation • per year 1 MWp new PV plants planed • focus on an easy business model
Realisation horizon for replication	Long term 5-10 years
Business Model Canvas	Complete BMC in Appendices

Table 4 PV plants and tenant electricity ("Mieterstrom")

5.3 "Meine LWB"-App

Partners involved	WSL	CO_2 reduction potential of future replication	low
Replication potential	high	Status of replication	replication in progress
Use case description	Providing information to tenants about their heating consumption is crucial for promoting energy awareness and encouraging efficient usage. The digitisation of buildings and technical systems aims to cover two main aspects: The first part includes consumption-related matters pertinent to housing, such as heating energy and general electricity usage. Also, it addresses the issue of housing through submetering for the utilisation of the "Meine LWB" application. This application is designed to provide tenants with monthly breakdowns of their apartment's heat consumption, along with suitable comparison tools to contribute to energy conservation efforts. By implementing these strategies, landlords and property managers can effectively inform tenants about their heating consumption, promote energy awareness, and foster a culture of sustainability within residential communities.		
Key results during the project lifecycle	At the project's outset, digitisation in submetering was limited to annual readings via the walk-by system. At the beginning of the project, the number of installed gateways was 0. Throughout the project's duration, the system was extensively upgraded, incorporating numerous gateways and corresponding measuring devices. As of January 1, 2024, 33,800 out of the 36,000 apartments are capable of monthly data retrieval without physical presence, thereby enabling these units to utilize the "Meine LWB" application for heating consumption information. This was achieved through the installation of approximately 1,180 gateways across the entire inventory.		
Challenges	To ensure the successful digitalisation of buildings and apartments and the development of a functional application, one should consider the following steps: • **Assessment of Needs:** Conduct a thorough assessment of the buildings and apartments to determine the necessary equipment and technologies required for digitalisation. Identify key areas for improvement, such as energy management systems, smart meters, and Internet of Things (IoT) devices. • **Selection of Equipment:** Choose appropriate equipment and technology solutions that align with the goals of digitalisation. Consider factors such as scalability, compatibility with existing infrastructure, and ease of integration. • **Installation Process:** Coordinate the installation of necessary equipment, ensuring compliance with safety regulations and building codes. Engage qualified technicians or contractors to handle the installation process efficiently and effectively. • **Digitalisation Strategy:** Develop a comprehensive digitalisation strategy outlining the steps and timelines for implementation. Define clear objectives and key performance indicators to measure the success of the digitalisation efforts.		

	• **Application Development:** Collaborate with software developers or technology partners to design and develop a user-friendly application tailored to the needs of building occupants. Ensure that the application integrates seamlessly with the installed equipment and provides relevant information and functionalities. • **Testing and Optimisation:** Conduct rigorous testing of the equipment and application to identify any issues or bugs. Solicit feedback from users and stakeholders to refine and optimise the functionality and user experience. • **Training and Education:** Provide training and education sessions for building managers, maintenance staff, and occupants on how to use the digitalised equipment and application effectively. Empower users with the knowledge and skills needed to maximise the benefits of digitalisation. • **Continuous Improvement:** Establish mechanisms for ongoing monitoring and maintenance of the digitalised systems. Regularly evaluate performance metrics and user feedback to identify areas for improvement and implement updates or enhancements as needed. By following these steps, the digitalisation of buildings and apartments can be executed smoothly, resulting in improved efficiency, sustainability, and occupant satisfaction.
Learnings and insights	• **Identify Core Needs:** Determine the primary objectives of digitalisation, such as energy management, security, or tenant comfort. Focus on addressing these core needs to prioritise resources effectively. • **Information Requirements:** Clearly define the type of information needed to support these objectives. This may include real-time energy consumption data, occupancy patterns, environmental conditions, maintenance alerts, or tenant feedback. • **Equipment Selection:** Choose equipment and sensors that can capture the necessary information effectively. For example, smart meters for energy monitoring, occupancy sensors for space utilisation insights, or temperature sensors for climate control optimisation. • **Data Security and Privacy:** Implement robust security measures to protect sensitive information collected by the digitalised systems and application. Comply with relevant data privacy regulations and industry standards to safeguard user data. • **Application Functionality:** Design the application to provide access to relevant information based on user roles and needs. Ensure that users can easily access and interpret data related to their specific areas of responsibility or interest.
Evaluation of the replication potential	High replication, because the benefits for the tenants are very high and the new laws require transparent monthly billing, which is guaranteed by this system.
Plans for replication - Outlook	Rollout to every apartment of LWB (37,000) until 2025. LWB is the landlord and owner of the application.

Realisation horizon for replication	Short term 0-3 years
Business Model Canvas	no business Modell behind application – just a service for free offered by the landlord to their tenants

Table 5 "Meine LWB" -App

5.4 SPARCS-App

Partners involved	WSL, Suite5	CO_2 reduction potential of future replication	low
Replication potential	None to low	Status of replication	no replication planned
Use case description	Similar to 4.3 "Meine LWB App" plus • additional information for heating and • additional information for electricity • 24/7 offered detailed information about consumption and profile		
Key results during the project lifecycle	Simular to 4.3 "Meine LWB App" plus • the more detailed the information to be recorded, evaluated and displayed, the more complex the system becomes • Detailed information are sometimes hard to understand for users • Application hosted by a third party (unknown for users) makes it difficult to acquire users.		
Challenges	Simular to 4.3 "Meine LWB App" plus • Finding users (unknown host, data protection, detailed information – sometimes hard for different people without technical or energetic background to understand)		
Learnings and insights	Simular to 4.3 "Meine LWB App" plus • Application must be simple but also informative, helpful and interesting to be used		
Evaluation of the replication potential	The application and its necessary hardware and sensor technology is so unique that it is not to be replicated one-to-one in our stock. On the one hand, this depends on the framework agreements for the supply and equipping of the apartments with metering devices and, on the other hand, the necessary infrastructure for 24/7 data transmission generates high costs that cannot be allocated. But it is to be checked if details like the electricity consumption can be integrated into the "Meine LWB App".		

Plans for replication - Outlook	Integrate parts of the application into ”Meine LWB App”
Realisation horizon for replication	none
Business Model Canvas	*No Business Canvas*

Table 6 SPARCS-App

5.5 Intelligent heating control

<table>
<tr><td colspan="4"></td></tr>
<tr><td>Partners involved</td><td>WSL</td><td>CO_2 reduction potential of future replication</td><td>high</td></tr>
<tr><td>Replication potential</td><td>medium to high</td><td>Status of replication</td><td>Replication in planning and in progress</td></tr>
<tr><td>Use case description</td><td colspan="3">Optimising heating stations is not commonly practiced, yet it presents a significant opportunity to save energy and reduce CO2 emissions. To capitalise on this potential, we propose the development of an intelligent heating controller unit. This unit will optimise the heating station in real-time by dynamically adjusting key parameters based on fluctuating values. Here's how we can approach this:

• Data Collection: Implement sensors and meters to collect real-time data on factors influencing heating demand, such as outdoor temperature, indoor temperature, occupancy levels, and heating system performance.
• Dynamic Optimisation Algorithm: Develop an advanced optimisation algorithm that analyses incoming data streams and dynamically adjusts heating system parameters, such as flow rates, set points, and boiler operation schedules, to maximise efficiency and comfort.
• Predictive Modelling: Incorporate predictive modelling techniques to anticipate future heating demand based on historical data patterns and external factors, enabling proactive adjustments to heating system settings.
• Integration with Building Management Systems: Ensure seamless integration with existing building management systems to exchange data and coordinate heating optimisation strategies with other building functions, such as ventilation and cooling.
• Adaptive Learning: Implement machine learning algorithms to continuously adapt and refine optimisation strategies based on observed system behaviour and feedback from building occupants and operators.
• Remote Access and Control: Enable remote access and control capabilities, allowing operators to adjust heating settings and monitor system performance from anywhere via web-based or mobile interfaces.</td></tr>
</table>

	• **Performance Monitoring and Reporting:** Implement comprehensive performance monitoring and reporting features to track energy savings, CO_2 emissions reductions, and other key metrics, providing stakeholders with transparent insights into the impact of heating optimisation efforts. By developing an intelligent heating controller unit with these capabilities, we can unlock substantial energy savings potential and contribute to meaningful reductions in CO_2 emissions while enhancing comfort and efficiency in buildings.
Key results during the project lifecycle	The energy management system aims to automatically and continuously optimise heating systems in line with the pilot project for dynamic heating control at Beckerstrasse 52, thereby conserving energy. The 127 properties possess an equal number of heating systems. To equip these with the system, installation costs of approximately EUR 127,000 net would be incurred, along with an annual service fee of around EUR 115,000 net for the equipment. Since the beginning of the project, 50 controller units and 10 dynamic heating control systems have been installed.
Challenges	Addressing the compatibility issues between sensors and communication protocols, as well as establishing a clear and viable business model, are crucial aspects of optimising the heating station. The following paragraphs provide information on how to tackle these challenges: **Compatibility Solutions:** • **Standardisation Efforts:** Advocate for industry-wide standardisation of sensor interfaces and communication protocols to ensure interoperability among different devices and systems. • **Gateway Integration:** Implement gateway devices or middleware solutions that can translate between incompatible protocols, allowing sensors to communicate seamlessly with the central heating control system. • **Flexible Connectivity Options:** Choose sensors and devices that support multiple communication protocols or offer flexible connectivity options, such as Wi-Fi, Bluetooth, Zigbee, or Modbus, to accommodate diverse infrastructure requirements. **Regulatory and Policy Considerations:** • **Incentive Programs:** Advocate for government incentives, subsidies, or grants to support the adoption of energy-efficient technologies and promote sustainable heating practices. • **Regulatory Compliance:** Ensure compliance with relevant regulations, standards, and guidelines governing building energy efficiency, data privacy, and cybersecurity to build trust and confidence among stakeholders and mitigate legal risks. By addressing these challenges through a combination of technical innovation, business model development, and regulatory engagement, we can overcome barriers to optimise the heating station and create a sustainable and cost-effective solution that benefits both building operators and occupants.

Learnings and insights	Indeed, digitalisation holds the key to unlocking significant benefits in optimising heating systems. To leverage this potential effectively, we should focus on collecting and controlling the main values essential for efficient operation while prioritising ease of implementation. Here's a streamlined approach: • **Identify Key Values:** Determine the critical parameters and data points necessary for optimising heating systems. This may include temperature levels, humidity levels, occupancy patterns, energy consumption, equipment status, and environmental conditions. • **Simplified Sensor Deployment:** Opt for easy-to-install sensors and devices that require minimal wiring and configuration, facilitating rapid deployment and reducing installation complexities. Choose wireless or plug-and-play solutions whenever possible to expedite implementation. • **Integration-Friendly Solutions:** Select digitalisation solutions that seamlessly integrate with existing heating infrastructure and building management systems. Compatibility with common protocols and communication standards ensures smooth interoperability and avoids compatibility issues. • **User-Friendly Interfaces:** Design intuitive and user-friendly interfaces for controlling and monitoring heating systems. Provide building managers and occupants with straightforward dashboards and controls accessible via web or mobile applications for convenient management. • **Automated Optimisation Algorithms:** Implement intelligent algorithms and automation mechanisms to optimise heating system operation based on real-time data and predefined performance parameters. This reduces manual intervention and enhances system efficiency. • **Remote Monitoring and Management:** Enable remote monitoring and management capabilities, allowing stakeholders to oversee heating system performance and make adjustments from anywhere with an internet connection. This enhances convenience and facilitates proactive maintenance. • **Scalable Solutions:** Choose scalable digitalisation solutions that can accommodate future expansion and evolving needs. Ensure flexibility to add additional sensors, devices, or functionalities as required without significant disruption to existing operations. • **Data Analytics for Insights:** Leverage data analytics tools to analyse collected data and derive actionable insights for continuous improvement. Identify trends, anomalies, and optimisation opportunities to maximise energy efficiency and operational performance. By focusing on these main values, emphasising ease of implementation, and harnessing the power of digitalisation, we can unlock the potential for optimising heating systems and realise significant benefits in energy savings, cost reduction, and sustainability.

Evaluation of the replication potential	Replication and development of the intelligent heating control to an energy management service and integrate this as a new business to WSL: To fulfil this, a new employee is to be hired in July 2024.
Plans for replication - Outlook	Replication as an energy management service to all LWB houses/heating stations (700). Regarding the WBS 70 building type, the digitisation of apartment consumption data has already been fully implemented. These properties collectively consume approximately 75,000 MWh of heat energy. With a potential average saving of 10 %, this equates to energy savings of 7,500 MWh, corresponding to a reduction in CO2 emissions of around 1,500 tons. Financially, given current district heating prices, this would lead to a relief of almost EUR 1 million per year.
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	Complete BMC in Annex

Table 7 Intelligent heating controll

5.6 Citizen engagement

Partners involved	SPARCS partner: SEE, LWB, WSL, Municipality of Leipzig, External partners: Caritas, Verbraucherzentrale, Landesfilmdienst Sachsen e. V., Mosaik e. V	CO_2 reduction potential of future replication	Low
Replication potential	High	Status of replication	Replication in progress
Use case description	Citizens' engagement has been actively fostered at the **"Nachbarschaftstreff" (LWB-Kiosk**) in the demo district Dunckerviertel. Positioned in the heart of the Duncker district, the LWB-Kiosk serves as a central meeting point for residents to gather and participate in various activities. The LWB-Kiosk is not only a **comfortable building** with spacious rooms, a kitchen, and a bathroom; it is a neighbourhood meeting point model which involves building a robust network among local partners and collaborating to organise events for citizens. It serves as a **convenient venue** for coordinating neighbourhood activities, promoting local initiatives, and enhancing social connections within the community. This model is not only effective in the Duncker district but also holds the **potential for replication** in other neighbourhoods, particularly those that are socially disadvantaged, offering significant opportunities for expansion and adoption.		
Key results during the project lifecycle	A new collaboration has emerged in **networking**, involving LWB's own social management, seecon, WSL, the City of Leipzig and local NGOs. This collaboration has paved the way for a comprehensive range of communication and information activities. The establishment of the **LWB-Kiosk as a meeting place** for residents has not only served as a hub for meetings, communication, information, leisure activities, and social participation but has also offered seecon the possibility **to combine and propose a wide range of communication and information activities**. For seecon, this experience has provided an opportunity to develop **various formats of citizen engagement**, which can be replicated in the future by similar activities, adding value to seecon's initiatives.		

Challenges	Challenges in this initiative encompassed the presence of different **priorities** and **limited resources** within the target group, which often led to **scepticism or resistance** towards the project. This scepticism poses a significant hurdle in effectively reaching and involving the target audience. Over the past few years, it has proven difficult to motivate people to participate in the SPARCS project or events, which has been exacerbated by the hardships of the COVID pandemic and the associated social distancing rules. However, this challenge aligns with existing research literature indicating that initiatives primarily driven by municipalities or top-down approaches may be less successful compared to projects that actively involve citizens and adopt a bottom-up approach. Moreover, motivating the target audience requires the development of **individually tailored formats**. Additionally, the use of **appropriate language and communication** channels tailored to their specific needs is crucial to overcome these challenges. Detailed information can be found in deliverable D4.6 - Citizens and stakeholders in Leipzig's energy transition.
Learnings and insights	Learnings and insights from the project emphasise the significance of defining the **right target group** and utilising **appropriate language** and **communication channels**. The communication of the project results in form of **simple videos** was implemented towards the end of the project and proved effective in creating understanding amongst citizens as well as causing further discussion about the project. This approach could have been implemented earlier in the citizen engagement process to better equip citizens for engaging with the project. Diverse **marketing strategies**, the establishment of strong networking connections, and the creation of **eye-catching elements**, including incentives and the opportunity to **win prizes**, are essential to effectively capture attention. **Setting good examples** and presenting successful case studies play a crucial role in inspiring and motivating participants. Additionally, allocating adequate resources is crucial for the success of such initiatives. In general, a **bottom-up approach** is recommended to further intensify collaboration with affected residents and actively incorporate their perspectives into the project's design and implementation. This **inclusive approach** holds the potential to foster a sense of ownership among residents and enhance their willingness to participate, ultimately contributing to the project's overall success.

Evaluation of the replication potential	In general, it can be asserted that the development of citizen engagement strategies and activities is a crucial element for instigating changes in neighbourhoods and cities. Citizen engagement stands out as one of the most effective ways to establish transparent, democratic, and participatory decision-making processes, providing citizens with a sense of involvement and information. In specific instances, a robust engagement process becomes fundamental in averting crises during the implementation phase of local processes or project realisations. For these reasons, it is crucial to incorporate citizen engagement in various processes. The establishment of **additional LWB-Kiosks** in other socially disadvantaged neighbourhoods is being considered for the upcoming years. This initiative is geared towards implementing **long-term measures** to improve the living environment, representing significant replication potential. Since LWB functions as a multiplier, experiences gained from SPARCS can be integrated into other "Nachbarschaftstreff" [neighbourhood meeting] locations. This integration enables the addressing of topics such as sustainability, energy conservation, climate protection, and the promotion of renewable energies in those areas as well. Particularly concerning seecon, these experiences have provided them with the opportunity to found and structure **seecon's stakeholder engagement team** more effectively. Seecon has developed citizen participation formats that will be reused in the future when working with other local authorities. Specifically, the experiences gained in SPARCS is being incorporated into their **standardisation processes** for the development of climate protection and district concepts, **as has already occurred** in the development of three Leipzig districts and in the creation of informative posters in Neukölln (Berlin).
Plans for replication - Outlook	• The creation of additional LWB-Kiosk locations in other socially disadvantaged neighbourhoods is being planned for the coming years to develop long-term measures to improve the living environment. • Seecon serves as a multiplier in other cities.
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	Complete business model canvas in appendices.

Table 8 Citizen engagement

6. Use Cases in Replication-District "Virtual Energy District"

The following SPARCS solutions were evaluated regarding their replication potential:

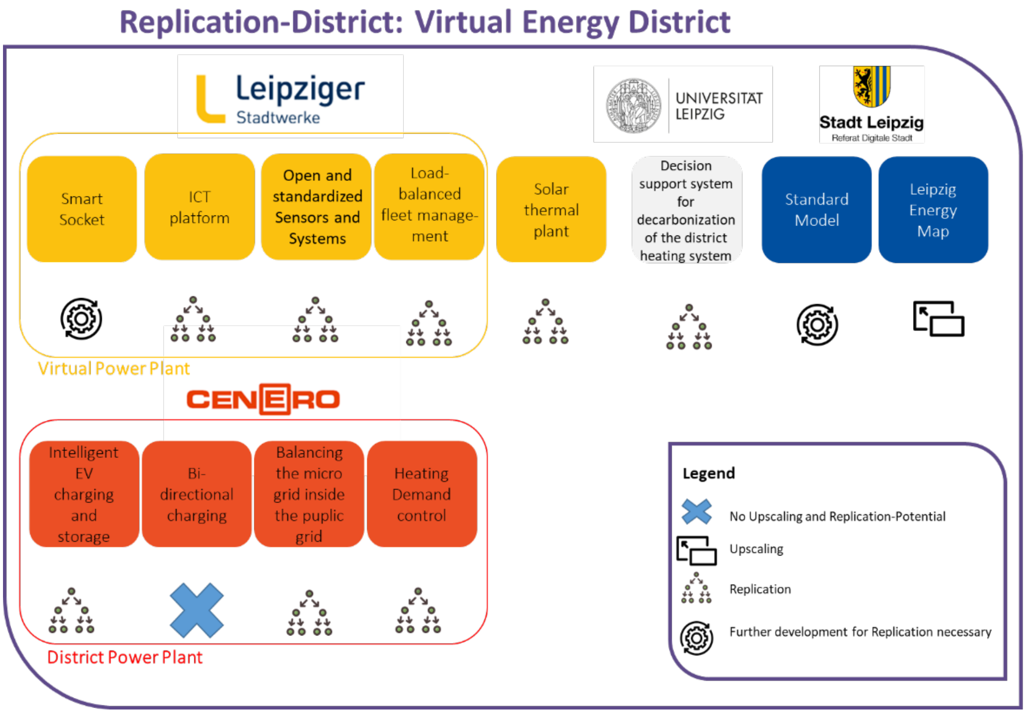


Figure 5: SPARCS solutions and their replication potential (Source:LEI)

6.1 Description of the replication district

The basis for a virtual district is the connection of many different assets on a digital platform as a compound. LSW has built such a digital platform as a cornerstone on which all its applications and services run. The use cases developed as part of SPARCS have also been integrated into this platform. The VPP forms the bracket and the centre of the virtual district. This is where data, assets and interactions come together.

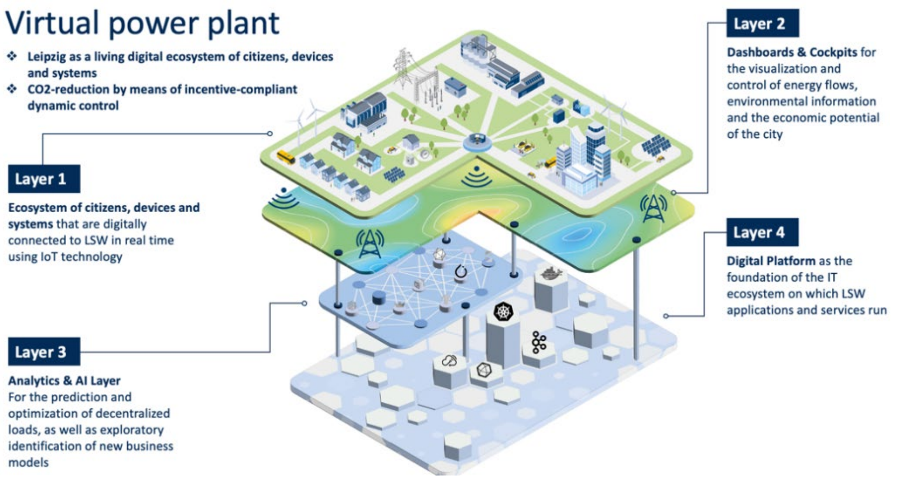
This is essentially made possible by an underlying advanced digital platform: the information and communication technologies (ICT) platform, which serves as a cornerstone for digital transformation in smart city operations. The aim of SPARCS was to improve the management of operational processes like telemetry, EV charging and energy trading, and to enable scalable and flexible service deployment that is essential for the dynamic smart city landscape.

To feed different data into the VPP, various use cases have been developed. To integrate third party sensoring data, e.g. from citizens or other organisations, LSW used open and standardised sensors and systems. Smart sockets and an application for users have also been developed. Intelligent charging points with own charging back-ends were installed and integrated.

As various use cases with different approaches have been planned, developed and implemented, all of which run on the digital platform, the VPP cannot be seen as a single product, but rather as a combination of different assets, technologies and data exchange, with the aim of standardised, centralised control.

6.2 Virtual power plant

Partners involved	LSW	CO_2 reduction potential of future replication	high
Replication potential	high	Status of replication	replication in planning
Use case description	A VPP is a group of decentralised energy assets which can be controlled remotely as one entity. These assets can include a variety of energy resources such as electric vehicles (EVs), solar panels and battery systems. LSW's VPP is based on the following key features: **Demand Response:** Demand response involves adjusting the demand for power instead of the supply. For example, during peak hours when the demand for electricity is high, a VPP can reduce the demand by instructing connected devices to reduce their power consumption. **Grid Balancing**: VPPs can help balance the power grid through connected IoT devices which detect peaks in the power grid and react to it. Another example is to connect a fleet of vehicles to operate as one large battery to balance the grid constantly. **Integration of Various Power Sources**: The VPP integrates several types of power sources to give a reliable overall power supply. The sources often form a cluster of different types of dispatchable and non-dispatchable, controllable or flexible load distributed generation systems. **Participation in the Energy Market**: The VPP is used to participate in the energy market by trading or selling power. As part of SPARCS, other key aspects were investigated and further developed in order to raise the LSW VPP to a new level. In order to prepare the LSW VPP for the future, e.g. for the increased use of renewable energies or heat pumps, LSW follows innovative approaches and focuses on the following three aspects: 1) **Interaction with people:** Our approach: interaction between LSW VPP, generation plants, e-mobilists and users at home. This includes not only connecting devices, but also people with their preferences and incentives,		

	which are an integral part of the VPP. Here, the information flow is bi-directional, meaning the VPP is learning about user behavior while consumers are incentivized to change behavior. 2) **Use of external data:** In addition, a lot of secondary data is collected from devices and data sources. This means that even the assets that are not switched directly are used by simulations to increase the efficiency level in the overall system (BMW, Baumwollspinnerei, WSL, environmental sensors). 3) **Holistic Integrated Energy:** We use the same digital platform to optimise electricity, mobility and the heating sector. This will become increasingly important in the future due to the electrification of mobility (electric cars) and heat (heat pumps). The different grids need to be considered together. The planning and optimisation of heat should therefore be carried out in a holistic VPP in the same way as electricity optimisation.  *Figure 6: VPP Layers – Overview*
Key results during the project lifecycle	We developed a modern, extensible ecosystem of microservices that serves as the backbone for efficient energy resource management. In our efforts to prepare the energy system for dynamic use, we tested dynamic interactions with users in sockets and vehicles. To further enhance our capabilities, we implemented digital tools and AI-based methods within the organization and provided comprehensive training to employees on these technologies. At LSW, AI was utilized for district heating, significantly improving the system's readiness for integrating a solar thermal plant. Additionally, we visualized the outcomes using dashboards, which facilitated the development of new IoT business models and direct marketing strategies for renewable energies, optimized based on market prices. By integrating a wide variety of components into the VPP as part of SPARCS, we were able to gain important results.

	- We now have a better understanding of the Incentives to provide flexibility on the household side through smart sockets and an app - Intelligent EV-charging: remote stopping of the charging process in the event of grid congestion has proven to be a feasible measure - The development and integraton of the live visualisation and forecast of the generation of PV systems of the LWB (WSL) serves as a role model for other sensoring and visualization projects - The Live trade simulation of energy quantities at Baumwollspinnerei serves as an experiment for future local market design - The Virtual integration of the BMW storage farm for resilience analysis has proven as a effective tool for grid resilience
Challenges	A VPP is associated with various challenges. In Germany in particular, data governance is a complex issue. It must be precisely defined which stakeholders are authorised to share and receive data. The data protection requirements are strict and extensive. Further challenges were: • Special interfaces had to be developed to close the gap between proprietary legacy systems and new open-source solutions. • Finding buildings and devices for testing purposes outside of productive operations • Big data integration: e.g. transmitting and analysing highly granular telemetry data from generating assets or heating stations
Learnings and insights	• Integrate large heterogeneous data streams onto buildings for future planning by utilizing IoT and big data technologies • Build a holistic general purpose digital platform to connect thousands of assets, devices, users and vehicles by utilising a distributed Kubernetes platform • Utilise AI for industry optimisation and for organisational processes through implementing open source AI models into legacy systems • Train employees for the use of digital services for business processes in cooperation with universities and research institutions
Evaluation of the replication potential	• The digital platform and AI-based optimisation tools developed by LSW offer a modular and scalable solution that can be tailored to various energy ecosystems, making the VPP model highly replicable for utilities aiming to digitalise and optimise their operations. • The complexity of data governance and stringent privacy requirements, especially notable in Germany, could limit the model's replication potential in jurisdictions with less rigorous data protection laws or in regions where stakeholders are hesitant to share data. • The need for substantial investment in technology, training, and the development of new business models may constrain replication among smaller utilities or those in developing regions. However, larger organisations or those with a strong

	commitment to innovation may find the model highly feasible and beneficial.
Plans for replication - Outlook	• Digital platform as a product that can be utilised by other electric utilities • AI-based services as a business model • IoT developments (L-Box light) as a product • Fleet Management: dynamic marketing of flexibility for vehicle fleet owners
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	-

Table 9 Virtual Power Plant

6.2.1 ICT platform

Partners involved	LSW	CO_2 reduction potential of future replication	medium
Replication potential	high	Status of replication	Replication in planning
Use case description	LSW has established an advanced digital platform that serves as a cornerstone for digital transformation in smart city operations. This platform is integral to managing diverse applications such as telemetry data processing, EV charging management, energy demand forecasting, power plant scheduling, and energy exchange trading strategies. At its core, the platform is built on a Kubernetes system that provides robust orchestration capabilities that are essential for smart city operations requiring scalability and high availability. Kubernetes facilitates the automated deployment, scaling, and operational management of containerised applications, accommodating the dynamic and fluctuating needs of the assets connected in SPARCS. Docker is employed to containerise these applications, ensuring that each service and its dependencies are encapsulated in a consistent and isolated environment. This standardisation is beneficial for a varied technological landscape, guaranteeing reliability across development, testing, and production environments without the risk of discrepancies. The platform's architecture, leveraging Kubernetes and Docker, provides a versatile and secure framework that enables LSW to offer centralised functionalities. These functionalities allow efficient data access and process execution across diverse systems and services, which is vital in its interconnected ecosystem. The digital platform not only simplifies internal operational processes but also sets the stage for broader integration with external systems, offering published data for use by other systems and facilitating complex processes that span across multiple domains. The resulting system is a comprehensive collection of services, frontends, ETLs, and integration tools, all deployed as Docker containers within the Kubernetes environment. Each component is defined by clear functionality and responsibility, adhering to the technical and organisational rules required for successful integration into the smart city digital infrastructure.		
Key results during the project lifecycle	• Successful deployment and integration of an internal digital platform using Kubernetes and Docker • Enhanced management of operational processes like telemetry, EV charging, and energy trading • Enabled scalable and flexible service deployment, essential for the dynamic smart city landscape		

Challenges	• Achieving seamless integration of various back-end systems with the digital platform • Maintaining high security and compliance with data protection regulations within the platform • Continuous education and upskilling of staff in Kubernetes and Docker technologies
Learnings and insights	• The initial steep learning curve of Kubernetes and Docker highlighted the need for specialised training and practice. By investing the time and resources for these training measures, the team gained proficiency in container orchestration, deployment, and scaling, significantly improving the platform's resilience and scalability. • Adapting to rigorous data protection regulations required a deep dive into security practices. Implementing secrets management, network policies and conducting regular audits taught the team effective strategies for maintaining the platform's integrity and compliance with laws such as the GDPR. • The transition towards a continuous integration/continuous deployment model was challenging due to the need for a cultural shift within the organisation. Lessons learned from integrating DevOps practices, including building automated pipelines and promoting closer collaboration between development and operations teams were crucial in enhancing the platform's agility and efficiency.
Evaluation of the replication potential	The ICT platform's use of Kubernetes and Docker has demonstrated strong potential for replication in similar urban settings due to its scalable architecture and the modular nature of its services. The platform's ability to streamline complex operational processes and enable a unified approach to data and process management makes it an exemplary model for other cities seeking to embrace digital transformation.
Plans for replication - Outlook	• Develop detailed documentation and case studies showcasing the platform's implementation and operational efficiency. Initiate knowledge sharing programs for cities interested in adopting similar technologies • Establish pilot replication projects with other municipalities, adapting the platform to different urban scales and operational requirements. Gather feedback and refine the replication strategy accordingly • Aim for widespread adoption of the platform in the smart city sector, while continually incorporating the latest advances in containerisation and orchestration technology to maintain state-of-the-art service delivery
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	Not a use case, but a basic requirement for VPP

Table 10 ICT-Plattform

6.2.2 Open and standardised sensors and systems

Partners involved	LSW	CO_2 reduction potential of future replication	low
Replication potential	high	Status of replication	Replication in planning
Use case description	LSW undertook efforts to install a city-wide network of environmental sensors, leveraging Long Range Wide Area Networks (LoRaWAN) and 5G technologies. This expansive network was designed to capture and interpret detailed environmental data, including factors such as temperature, humidity, air quality, and radiation levels. The scope of the task covered the entire city, but focussed on the western area, placing a special emphasis on difficult-to-reach areas like underground cellars (e.g. in the case of heat monitoring) and tightly packed urban districts that are typically challenging for standard connectivity solutions. This initiative brought together municipal authorities, private individuals, and educational bodies in a collective effort to enhance urban environmental governance. By deploying standardised sensors and establishing a network characterised by low-frequency, low-energy communication, Leipzig significantly boosted its environmental surveillance and energy efficiency management capabilities. This led to supporting capabilities for better informed decision-making for a greener, more sustainable urban living space. Additionally, the private sector was engaged (e.g. Cenero), adding value to the fundamental sensor infrastructure.		
Key results during the project lifecycle	• Deployment of 14 sensors throughout the city • Establishment of a LoRaWAN network for seamless device connectivity • Setup of inbound services to integrate third party sensoring data, e.g. from citizens or other organisations		
Challenges	• Ensuring sensor compatibility and effective data integration • Legal and privacy considerations when installing public sensors • Technical difficulties with sensor installation in remote areas		
Learnings and insights	• Strategic sensor placement and the importance of incentivising participation • Utility of ChirpStack open-source LoRaWAN network server for network setup		
Evaluation of the replication potential	The sensoring strategy pursued by LSW is a scalable model for smart city development. It has shown the ability to enhance urban planning and environmental monitoring, making it a strong candidate for replication in other cities that aim to improve sustainability and citizen engagement. LSW plans to incorporate it as a potential new service offered to municipalities.		
Plans for replication - Outlook	• Expand network coverage within Leipzig, refine data integration and analysis processes		

	• Begin replication as a service for other cities, adapt model based on regional requirements • Establish model as a standard for smart city deployments; continual innovation and network expansion
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	Not a use case, but a basic requirement for VPP

Table 11 Open and standardised sensors and systems

6.2.3 Smart socket

Partners involved	LSW	CO_2 reduction potential of future replication	low
Replication potential	low	Status of replication	Replication in planning
Use case description	**Enhancing Energy Efficiency with Smart Sockets** In an effort to promote energy efficiency and raise awareness about individual power consumption, a digital eco-platform was developed on which the smart socket was mapped as the first service including the following features and ideas: **Smart Socket Integration**: The digital eco-platform integrates smart sockets, allowing users to monitor and control their electricity usage. These sockets are placed within households to optimise energy distribution. **Visualising Consumption**: The platform's dashboard provides real-time visualisation of electricity consumption. Users can track their usage patterns, identify peak hours, and make informed decisions to reduce energy. **User-Side Dashboard**: LSW has developed a dedicated user-side dashboard. This dashboard, accessible via a mobile app, offers several functionalities: ○ **Incentivising Push Messages**: Users receive timely notifications encouraging energy-saving behaviours. These messages serve as gentle nudges, motivating individuals to be mindful of their consumption. ○ **Direct Plug Control**: Need to turn off a specific plug remotely? The user-side dashboard allows users to do just that whether it is an unused appliance or a power-hungry device. **Energy market utilisation**: User behaviour is being used to improve the pattern detection of customers. This way, the short-term market procurement (day-ahead and intraday) can be planned better. **Gamification Approach**: To foster active participation, LSW follows a gamification approach which is to be expanded in the future. The idea: Regular push notifications challenge users to respond to power grid load		

	dynamically. Achievements, rewards, and friendly competitions create a sense of community and encourage sustainable practices.
Key results during the project lifecycle	The development of smart sockets has reached significant milestones in the process: **Smart Socket Deployment**: LSW successfully developed the smart sockets. The smart sockets were provided as hardware. However, tests have shown that performance problems occur (coupling between app and hardware (router)). **Operator Dashboard and App**: The implementation phase is completed and both an operator dashboard and an app are fully functional. Operators can monitor and manage the smart sockets. The dashboard offers real-time data visualisation and remote-control capabilities. **Individual Device Consumption Visualisation**: Users can access energy usage information through the app. Consumption data for each connected device is visualised. **Feedback Loop**: Feedback is actively collected and analysed. This input informs ongoing development, ensuring that future iterations of the smart socket ecosystem align with user needs and preferences. **Remote Control:** It is possible to deactivate devices remotely via the smart socket if the desired setting is selected. This use case can be used to react to loads in the network. In summary, the focus remains on practical energy efficiency, driven by technology and user engagement. Many milestones have been reached over the last years. From the design and production of the hardware to the development of the application for pairing with devices in households. The smart socket aims to empower individuals to be conscious energy consumers but need further investigation in current connectivity issue.
Challenges	There were various challenges on the way from conception to planning and implementation to the use of smart sockets in private households. The following list of the challenges LSW have encountered is intended to benefit future approaches and describes the lessons learned from the perspective of LSW: **Legal Framework Clarification**: Understanding legal requirements is crucial. Compliance with safety standards, certifications, and local regulations ensures responsible deployment. **Logistics Process Implementation**: Integrating smart sockets into logistics processes requires efficient supply chain management, distribution, and maintenance procedures. **Challenges in Finding Demand Response Devices**: Identifying suitable devices for demand response (load management during peak times) can be difficult. Compatibility and functionality are key considerations. **High Complexity in Smart Socket Setup**: Configuring smart sockets involves intricate technical details, including compatibility, network settings, and integration with existing infrastructure.

	Technical Workarounds (e.g., 2.4 GHz Networks): Overcoming technical hurdles, such as configuring 2.4 GHz networks, ensures seamless smart socket operation. This is one main issue and is currently being processed. A smooth integration is essential for user acceptance. **User Willingness to Adopt Smart Sockets**: Encouraging user acceptance through education and awareness is essential for a successful implementation. Nevertheless, there is currently a lack of incentives and use cases for the sockets to address a large number of users and needs further investigation. **Legal Risks and Liability**: Determining liability for potential damage caused by smart sockets is a critical legal consideration. **Financial Risk vs. Benefits**: It is necessary to assess the costs and benefits as costs may outweigh the benefits. **Impact on Grid-Friendly Behaviour**: Smart sockets can play a role in promoting energy efficiency and grid stability but their actual impact depends on user behaviour and system integration.
Learnings and insights	Over the course of the project, LSW has learned a lot about planning, implementing and putting the smart socket project into operation. In addition to technical and procedural learnings, there were also findings about the needs of customers and potential users. The learnings can be divided into different categories: **Motivating Citizens to Save Energy**: • Awareness Campaigns: Educating citizens about the benefits of energy conservation is essential. Public awareness campaigns can highlight how smart sockets could contribute to reducing energy waste. • Incentives: Offering incentives such as tax breaks or rebates for adopting smart sockets can encourage citizens to use them. **Effective Measures for Energy Savings**: • Schedules and Timers: Smart sockets allow users to create schedules for devices. For instance, scheduling lights to turn off automatically during daylight hours reduces unnecessary energy consumption. • Energy Monitoring: Smart sockets equipped with energy monitoring features provide real-time data on power usage. Users can identify energy-hungry devices and take corrective actions. • Vampire Draw Prevention: Appliances often draw energy even when idle. Smart sockets can help combat this by remotely turning off devices when not in use. **Overcoming IoT Connectivity Barriers**: • Interoperability: Ensuring compatibility between different smart devices and platforms is crucial. Standardisation efforts can enhance connectivity. • Network Stability: Reliable Wi-Fi connectivity is essential for smart sockets. Addressing network issues ensures uninterrupted operation. **Designing Hardware Products from Scratch**: • Form Factor: Smart sockets should be compact, unobtrusive, and easy to install. Design considerations impact user acceptance.

	• Safety Features: Robust safety mechanisms (e.g., surge protection, fire resistance) are vital for user confidence. • Materials and Manufacturing: Sustainable materials and efficient manufacturing processes contribute to overall product quality. **Testing and Troubleshooting New Products**: • Quality Assurance: Rigorous testing ensures smart sockets meet safety standards and perform as expected. • User-Friendly Setup: Simplified setup procedures reduce user frustration.
Evaluation of the replication potential	400 smart sockets were distributed in an internal rollout. Of these, 100 are available to ULEI for testing, research and further development purposes. LSW is actively working on the resulting feedback and technical problems. Nevertheless, the difficulty with connectivity to WiFi and thus linking to end devices has proven to be a major obstacle for users. Monitoring is possible through the operator dashboard, but the data basis for further analyses is currently not significant due to the low usage and the resulting lack of information content. For this reason, smart sockets are unlikely to be replicated in the near future until all technical hurdles have been overcome and further distribution of sockets to customers has been halted for the time being. Further development potential has emerged parallel to the development, which is to be pursued further under the so-called L-Zero campaign (see also “Plans for replication - Outlook”). With the support of ULEI, further use cases and incentive options are also being tested with the smart socket in order to be able to replicate it in a new expansion stage beyond the SPARCS horizon if necessary. In summary: Before the smart sockets can be replicated, the technical problems must be resolved and it is necessary to develop new use cases and, if necessary, incentive systems in order to increase acceptance to a large extent. In addition, it is being examined how the smart socket can be part of green power contracts, communities or citizen participation. A further outlook beyond SPARCS is conceivable, such as the addition of features or the expansion of the gamification approach. We have learned that the user must be motivated in order to take advantage of savings potential and to be part of the energy transition. Even if the savings of the individual are rather small, we want to continue to focus on the customer and enable a green future together.
Plans for replication - Outlook	Even if the smart socket cannot initially be replicated, some ideas have nevertheless emerged from its development, which LSW is continuing to pursue with L-Zero. The L-Zero eco-platform was initialised through the development of the smart socket. Synergies and replication approaches to other products such as green electricity contracts and communities were investigated and are being pursued further. The smart socket is currently being examined as a permanent component of L-Zero.

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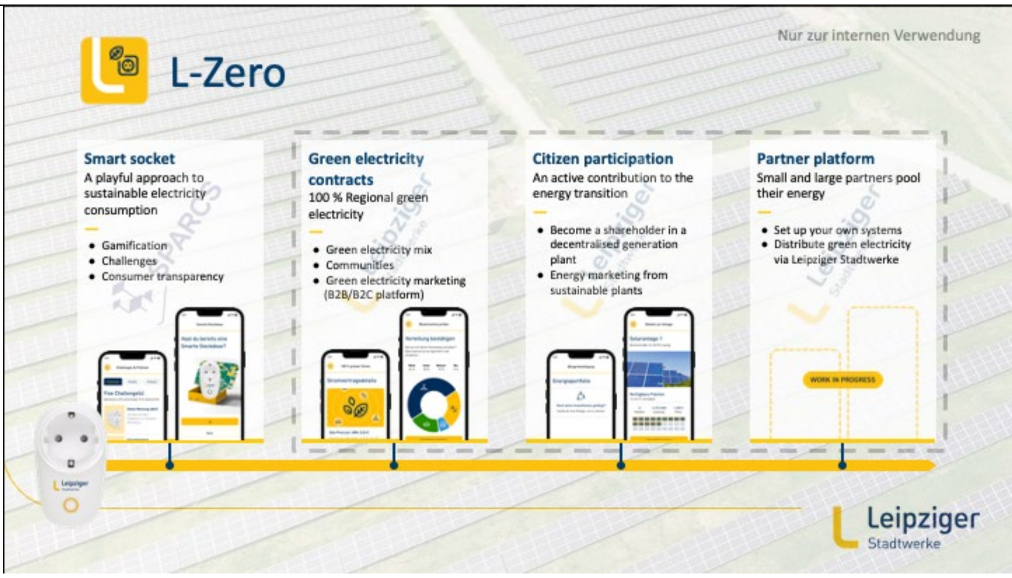
<tr><td></td><td>

Figure 7: L-Zero Strategy of the Leipziger Stadtwerke (Source:LSW)</td></tr>
<tr><td>Realisation horizon for replication</td><td>Long term
5-10 years</td></tr>
<tr><td>Business Model Canvas</td><td>Complete business model canvas in appendices</td></tr>
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Table 12 Smart Socket

6.2.4 Load-balanced fleet management

Partners involved	LSW	CO_2 reduction potential of future replication	*low*
Replication potential	*high*	Status of replication	*Replication in planning*
Use case description	The fleet management use case aimed to improve Leipzig's charging infrastructure by switching to intelligent charging systems. This involved enhancing the existing network of public charging stations with intelligent capabilities to meet the increasing demand for electric mobility. The initiative focused on the development of a process for the intelligent design of charging stations and their integration into the existing technical framework to enable optimised utilisation of the charging infrastructure, e.g. through fleet management and grid-resilient charging. The implementation of intelligent charging involved developing use cases in coordination with IT operations and market departments and analysing information from the charging infrastructure. Specifications for charging stations were designed, and collaboration with charging station manufacturers and e-mobility IT service providers was initiated. LSW developed their own back-end based on the Open Charge Point Protocol (OCPP), facilitating remote management and monitoring of charging stations and balancing the load on the power grid. Charging stations compatible with OCPP 1.6 were procured and installed at strategic locations to increase infrastructure utilisation. A Central Management System (CMS) was integrated for managing and monitoring the stations, enabling dynamic management of the infrastructure's electricity demand. A mobile application was developed to connect end-users directly with the CMS, providing easy access to intelligent charging functions in a user-friendly manner. This app allows users to remotely monitor and manage their EV charging sessions, view charging history, check the status of charging sessions, and receive notifications. It also enables users to schedule charging sessions and receive alerts about station availability, significantly enhancing the user experience of e-mobility in Leipzig. The CMS was used to develop a demonstration for intelligent fleet management, featuring a dashboard that integrates all charging functions into the fleet management context. This allows the OCPP functions to be controlled across all charging stations managed by LSW, and to stop charging processes based on the status of the distribution grid and potential threats to its resilience. This test case currently involves vehicles owned by LSW, but the functionality is designed to be extended to all customers.		

Key results during the project lifecycle	• LSW reached their goals by installing, integrating or activating 455 intelligent charging points. • LSW developed their own charging back-end using the CPP • LSW successfully demonstrated dynamic charging using their own vehicle fleet
Challenges	• Finding employees and stations for system testing • Difficulties in original plan of bidirectional charging due to lack of available vehicles and infrastructure • Product development and incentive setting for large-scale replication • Correct implementation of taxation and billing logic in the case of test customers
Learnings and insights	• LSW encountered a significant challenge with the initial proposal to use bidirectional charging for demand side management. The scarcity of EVs supporting bidirectional charging led to a pivot towards intelligent charging solutions. • The successful implementation of intelligent charging underscored the critical role of robust backend architecture. This includes the development of a CMS based on the OCPP, enabling remote management, monitoring, and dynamic load balancing of the charging infrastructure. This foundation is essential for scaling up the integration of EVs into the energy system and facilitating future business models. • This task laid the groundwork for managing a future increase in EV adoption. This proactive approach emphasises the importance of preparing infrastructure and business models for scalability.
Evaluation of the replication potential	• For replication, other cities need to consider the prevailing technological standards and readiness of the market, recognising that certain innovative approaches might still be at a prototype level and not yet suitable for widespread implementation (see bidirectional charging). • The development of a product based on the intelligent charging project, leveraging an OCPP-based CMS and fleet management dashboard, shows innovative solutions for grid resilience and efficient charging infrastructure management. These systems' scalability is crucial for replication, indicating that while current deployment may be limited and the impact on grid resilience minimal due to the low number of EVs, the foundational systems established are critical for future scalability and the integration of more EVs into the grid. • The importance of preparing at city level for future circumstances, including a more robust approach to grid resilience and charging infrastructure management, is emphasised. As EV adoption grows, cities replicating Leipzig's approach by developing information systems as a foundation for smart charging business models can better position themselves for future growth and take advantage of emerging opportunities in the EV market. The continuous monitoring of the market and collaboration with stakeholders to evaluate the feasibility of business models

	focused on intelligent fleet management are recommended steps for cities considering replication.
Plans for replication - Outlook	LSW is advancing its prototype for intelligent charging into a market-ready product through strategic measures: • LSW's product department is crafting innovative business models aimed at rewarding vehicle owners for participating in their system. These models are designed to financially incentivise both individual and fleet owners by compensating them for aiding in grid balance and efficiency through smart charging practices. • Engaging with companies that manage their own vehicle fleets, LSW is exploring the integration of its intelligent charging solutions into these operations. The discussions revolve around how these systems can be monetised, offering fleet operators not just advanced management tools but also financial benefits for optimising their charging processes in line with grid demands. • LSW ensures that its product evolution, from prototype to full-scale solution, is based on thorough market analysis and cooperation with key stakeholders. This includes refining the back-end architecture, enhancing the user experience, and guaranteeing scalability, security, and ease of use. The goal is to deliver a product that not only bolsters grid resilience but also provides clear advantages to users, fostering a wider adoption of EVs and smart charging infrastructure.
Realisation horizon for replication	Long term 5-10 years
Business Model Canvas	Complete business model canvas in appendices

Table 13 Load-balanced fleet management

6.3 Solarthermal plant and heat storage

Partners involved	LSW	CO_2 reduction potential of future replication	*high*
Replication potential	*high*	Status of replication	*Replication in planning*
Use case description	Construction of a solar thermal plant for renewable heat generation for a district heat grid.		
Key results during the project lifecycle	The project is under construction. Therefore, key results so far concern the planning stages and building start: - Finding and securing a suitable project location - Completing detail engineering of the plant and solving technical challenges regarding the integration of the plant into the district heating grid - Approval planning (development plan) with the responsible authorities (City of Leipzig) and securing the final permit - Successful public participation and resident events (ongoing including the project website) - Successful completion of EU-wide tendering process and awarding of construction contracts - Official build started on 08 January 2024		
Challenges	**a) Finding and securing a project site** Finding a suitable site that was large enough and close to the district heating network and securing a permit with regard to lengthy processing were the biggest challenges. **b) Authorisations/permits** This aspect is closely linked to the search for a site and varies from state to state and from municipality to municipality (in Germany). Depending on the site, different approval procedures may apply, ranging from “simple” building permit applications and the drawing up of development plans to deviation procedures regarding regional plans. This can be very time-consuming and resource-intensive until receiving the final permit. **c) Current scarcity of resources and skilled labour, uncertain market conditions and delivery times** This implies several points: On the one hand, various cities and municipalities as well as energy suppliers currently work intensively on decarbonisation and the renewable heating transition (German keyword: “municipal heating planning”). This requires a lot of resources in planning and implementation. On the other hand, there are still consequences of the global events of recent years, which have		

	created certain uncertainties regarding supply chains and prices as well as the regulatory framework. This is reflected in the fact that, despite extensive invitations to tender, often none or only a few bids are received as companies lack the capacity to take on more work or draft complete offers. The significant price increases in recent years must also be considered in the planning and economic evaluation of projects (especially with soaring inflation and interest rates). The delivery times for certain components are also currently rather unreliable and, in some cases, unexpectedly long (e.g. electrotechnical components or prefabricated concrete parts). **d) Technical integration in district heating grid and integration of operation in the heat-generation portfolio** The weather- and season-dependent heat supply of solar thermal systems must be considered both in system planning and in strategic district heating grid and generation portfolio planning. Due to the high flow and return temperatures of existing grids, even in the summer months, the operating times and efficiencies are correspondingly limited, depending on the chosen technology.
Learnings and insights	**a) & b) Searching for and securing a project site and securing the construction permit** To find and secure a project site went without any difficulties. The extensive activities in and around Leipzig enabled the dialogue and contact with the owners of the agricultural land on which the plant is being built. Its features fit the project perfectly as it is not only large enough but also located directly next to an existing district heating transport pipeline. Due to LSW's strong and reliable reputation in the region, we were able to secure the site on a long-term contractual basis. Cooperation and support from the authorities is crucial to successfully managing complex approval procedures for renewable energy projects. Despite initial difficulties in obtaining planning permission, close cooperation and recognition of the urgency of the project enabled the necessary approvals to be obtained quickly. To improve and speed up the project realisation, it should be possible to gain a construction permit for ground-mounted solar (thermal) systems via a simple building permit application (as described above) without restrictions (e.g. only on the edge of railway lines or motorways). Ideally, priority areas for solar thermal energy should already be designated in urban and regional planning. This would make both the search for sites and the authorisation process much easier. The focus here can also be on solar thermal energy, as these systems depend on proximity to the district heating grid (constructing long district heating pipelines to connect far away solar thermal plants to the grid reduces economic feasibility significantly and reduces efficiency through increased heat losses).

	c) Current scarcity of resources and skilled labour, uncertain market conditions and delivery times The rapidly changing conditions have caused major challenges. For example, the tender for the plant construction has been launched the day before the start of the war in Ukraine. This had a significant impact on profitability, but also on the project plans. Nevertheless, we were ultimately able to find a compromise for all sides and move the project forward. The scarce resources, however, still raise a lot of concerns about suppliers and service providers, and the longer delivery times for critical components. These can still be considered important hurdles to be overcome. Another lesson learned is the availability of engineering planning offices that are experienced in ground based solar thermal plants with connections to district heating grids. In Germany and Europe there are only a handful of engineering companies capable of doing the required detail engineering to certain standards. Usually, the plant manufacturers will provide the necessary planning and engineering work to fill this gap. This must be considered regarding the approval planning and tendering. It must be noted that the solar thermal plant usually needs to be specifically adapted to the conditions of the individual project. **d) Technical grid integration/operation in the heat generation portfolio** The transformation of our district heating grid is an ongoing process that is very complex due to the change from a centrally supplied existing system to an increasingly decentralised supply. However, together with our colleagues from district heating grid operations and our plant constructor, we were able to find a technical solution that gives us more flexibility in operation despite the special characteristics of solar thermal energy. Depending on the heat grid and overall system, a hydraulic compensator or heat storage may be used. The next steps are the installation and commissioning of the system. At the same time, we will also be dealing with the topic of weather forecasts and predicting solar radiation and solar heat generation to further optimise our district heating grid operation. By using efficient high-temperature collectors, we ensure that we maximise the yield from the available area even at high district heating temperatures. Solar thermal energy can be operated well in an energy system combination with heat pumps, near-surface geothermal energy and biomass. Considering this combinability regarding funding and framework conditions can pave the road towards a renewable tool kit for heat generation.
Evaluation of the replication potential	The replication potential exists mainly for hot water, heating (domestic) and industrial applications. For households, whether connected to the district heating grid or not, solar thermal energy will

	supply almost all of the hot water during summer half of the year and can also contribute to the heating season, depending on the technology. Especially for industrial applications requiring low temperature heat between 60-150°C (e.g. drying processes), the application of solar thermal technology can save a significant number of CO2-emissions. As mentioned above, solar thermal technology can be easily combined with other renewable technologies (e.g. heat pumps, geothermal, PV, etc.) to supply renewable heat year-round. Another big advantage is the independence on fuel imports due to the local availability of solar radiation. It comes with an initial investment which can be significant but due to almost no operating expenditures, solar will almost always be competitive in the long run. The lessons learned were used for a new solar thermal plant ("Solarthermie Leipzig Süd") which is currently in an early planning phase.
Plans for replication - Outlook	The immediate plans for replication concern a new solar thermal plant at the location of a cogeneration plant ("Heizkraftwerk Leipzig Süd") in the south of the city. There, an area of approximately 3 hectares, which was used as a coal storage and is currently fallow, is available for development. It is planned to build a new solar thermal plant to supply a newly built, secondary district heating grid, with a connection to the main district heating grid in case of little to no heat demand (currently at basic engineering level). Plant operation could begin as early as 2026/2027 depending on permits and investment decisions. In addition, LSW and the city of Leipzig have identified possible "high potential" areas around the city for further solar thermal projects, which could either be integrated in the district heating grid or used to supply smaller and separate "mini grids" in areas where a connection to the main district heating grid is not economically feasible. Several projects like this are currently being investigated for technical feasibility. Due to the relatively short supply of available land for housing and industry, future solar thermal plants will most likely be smaller and not necessarily close to the city centre. Therefore, new plants in the foreseeable future will most likely be built around new mini district heating grids for neighbourhood development projects in addition to heat pumps and near-surface geothermal energy.
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	Complete BMC in Appendices -

Table 14 Solarthermal plant and heat storage

6.4 District power plant (monument protected positive energy districts in industrial area)

The Baumwollspinnerei in Leipzig, a former industrial site and a protected monument, represents a fusion of historical infrastructure and cutting-edge digital innovation. In a unique blend of the old and the digital, this site stands as a testament to the energy transition.

Through a close collaboration with LSW, CENERO Energy has realised the District Power Plant at this site, which stands on its own but also forms part of the VPP designed by LSW. The District Power Plant, a decentralised energy system that can operate independently or in cooperation with the public grid, offers advantages such as increased self-sufficiency, greater energy efficiency, and the integration of various renewable energy sources. On-site, Cenero has integrated solar energy in conjunction with storage and intelligent e-mobility, a demand-oriented heating concept, and highly efficient Combined heat and power plants (CHPs).

To piece all the puzzle pieces together, an extensive digital network of meters and sensors, combined with energy monitoring and load management software, allows effective control and management of generation and consumption on the site. The Konsumzentrale serves as a replication site, breathing new life into obsolete structures through innovative approaches.

The following SPARCS solutions were evaluated regarding their replication potential:

1. Heating demand control
2. Intelligent EV charging and storage
3. Bidirectional charging
4. Energy and load management
5. Balancing the microgrid inside the public grid

6.4.1 Heating demand control

Partners involved	CENERO Energy Seecon Ingenieure GmbH	CO_2 reduction potential of future replication	medium
Replication potential	high	Status of replication	Replication in planning with augmentation to current concept.
Use case description	This is a demand response concept. In one of the tenanted areas in Hall 14 of the Baumwollspinnerei, Cenero Energy has implemented an intelligent heating demand control system. The system utilises smart thermostats to detect the need for heating. This information is then relayed through the energy management tool cenero.one to the valve within the corresponding heating circuit, which, in turn, regulates the flow of hot water in accordance with the demand. The innovation lies in the digital communication and precise control combined with a software-based energy monitoring. The smart home thermostats communicate through a central control unit (CCU). To make this information accessible to cenero.one, specific software is installed onto the CCU. This software serves as a bridge, passing on information without making any changes. Once cenero.one receives the data, the demand in the selected area is evaluated and the valve is regulated accordingly. The valve is equipped with a sensor specially programmed to receive information from cenero.one. The radio communication is also innovative, which is implemented through a LoRaWAN. In a LoRaWAN, data packets are transmitted via radio with a very long wavelength and therefore cover a large range. Because of that, it is an essential technology for large building complexes and their associated energy networks, where a variety of components are interconnected and centrally monitored. cenero.one and its ability to integrate several components into one platform is the central data processing platform of the system and enables a variety of evaluation and visualisation options. This makes it the central point of the system where the information from the heat distribution is collected and controlled and from where aggregated consumption data is distributed to the users. The system reduces heat loss associated with transportation by preventing the unnecessary circulation of heat in areas where it is not required. There is usually a delay before the pumps switch off, which is eliminated by the demand response concept. Furthermore, it conserves electrical energy that would otherwise be used to circulate the hot water. An even bigger energy saving potential comes with the smart thermostats which encourage the consumer-side to set up heating timetables and temperature levels. This avoids unnecessary and abrupt heating. Depending on this involvement of the user side, savings can reach up to 30 % of the heating energy demand. Due to the old and monument protected buildings at the Baumwollspinnerei, the actual potential of the savings within the concept in Hall 14 might not reach this level but can nonetheless be significant.		

	In alignment with lowering energy consumption, this intervention contributes positively to the site's carbon footprint, demonstrating a more efficient and sustainable energy solution for privately or commercially used rental space. To further enhance this intervention, Cenero plans to combine it with thermal precision profiling of buildings. Our approach involves assessing the building's capacity to retain heat using temperature sensors. Once determined, we can leverage this information to optimise heat generation, and efficiently allocate, schedule, and control distribution among tenants. This approach aims to reduce overall heating demand and mitigate heating peaks.
Key results during the project lifecycle	In the course of implementing the heat demand control intervention, a tenanted area within the Baumwollspinnerei underwent installation of Homematic smart thermostats. A software was integrated to the Homematic CCU, facilitating the transmission of the heating demand information to the cenero.one energy management platform. The cenero.one software underwent programming enhancements to allow it to automatically accept, analyse and relay the information. Within the heating circuit of the specific area, a valve was installed. Connected to the valve is a sensor specifically programmed to receive a signal from cenero.one. The sensor, triggered by the command received from cenero.one, in turn governs the operation of the valve in the heating circuit, determining whether it should open or close based on the specific signal received. While the primary goal of this intervention may not lead to a substantial reduction in heating demand, the pivotal achievement lies in the newfound capacity for precise control and management. Successfully establishing intricate communication pathways among various devices and software marks a significant milestone. These implemented tools lay a foundational framework, providing the flexibility to build upon and enabling us to realise more significant energy savings through future enhancements. This marks a key milestone in our continuous efforts to optimise heating systems and enhance overall energy efficiency within the Baumwollspinnerei.
Challenges	Interoperability of devices and software can pose a challenge. Integrating smart thermostats, the CCU, cenero.one and the sensor at the valve requires seamless interoperability. Ensuring compatibility and smooth communication among these diverse components requires initial programming, set-up, and installation. Any minor input error (human error) during these processes could potentially disrupt the entire concept. If errors occur, these are often a challenge to identify, and it may be necessary to review the entire process from start to finish. This challenge was faced in the implementation phase of this project and led to significant delays in the operation. Managing the complexity of software integration is a critical aspect of the system's performance. The software bridge between the smart thermostats and cenero.one must be intricately designed to relay information accurately without introducing errors or delays. The hardware devices, such as thermostats, valves, or CCU, might have technical faults, therefore potentially causing a disruption to the entire concept. Similar to software and communication issues,

	identifying these faults may pose a challenge and should not be excluded from troubleshooting efforts if problems occur. Although LoRaWAN presents significantly lower transmission losses and better penetration through obstacles such as building walls, the use of radio communication may in individual cases introduce challenges related to the reliability and stability of data transmission. Ensuring a consistent and secure connection is crucial for the successful implementation of the system. Consideration must also be given to the fact that frequent data transmission is required to ensure the efficient functionality of the concept. However, increasing the frequency of data transmission can lead to a reduction in battery life, necessitating more frequent battery replacements. Handling sensitive data related to heating demand and building occupancy requires security measures. Addressing potential privacy concerns regarding the collection and processing of user data is essential to build trust among tenants. Introducing intelligent heating control systems to tenants may cause resistance or scepticism. If concepts like this get introduced within a corporate environment, IT-security measures might also cause challenges within coordinating data-networks. Providing adequate training and ensuring user-friendly interfaces are crucial for user acceptance and the system's effective utilisation. The heat demand control relies on the active cooperation by the tenants, as the valve will only shut if the heating is turned down all the way at all heat cost allocators when no heat is required. Keeping tenants informed about the benefits, functionalities, and environmental impact of the system is crucial. Effective communication strategies and tenant engagement initiatives are essential for the successful adoption of the technology. Furthermore, this concept requires access to tenanted areas for the installation of the thermostats and the CCU. It may also require further access for troubleshooting efforts and maintenance.
Learnings and insights	The most significant learning we have taken from this concept is to better understand the complexity of the communication between different device components. Our learnings in this sector are of great value, as we have set the groundwork for automated steering technology in our software cenero.one. The next step is to enhance this concept by integrating the temperature mapping of the building itself and then optimise the control of the heat generation and distribution for greater savings.
Evaluation of the replication potential	The replication of this intervention is relatively straightforward. The initial work for communication between the different devices has been completed. The required hardware is relatively inexpensive and easy to install. Additionally, the software-as-a-service fee is negligible. However, the true value of this concept emerges when combined with thermal precision profiling of the building, which is still in the process of development and testing. Thermal precision profiling provides detailed insights into the thermal characteristics and behaviour of rooms or areas in a building. This can help identify potential issues such as overheating or inefficient heat distribution, allowing for better design,

	quality control, and optimisation of thermal management solutions such as the heat demand control solution. Learning how well an area can maitain a specific temperature can enhance the efficiency of demand orientated heating supply and favour heating during low peak periods to reduce the overall demand on the heating grid.
Plans for replication - Outlook	We intend to replicate this concept in several of our other sites, but we plan to implement it in conjunction with thermal precision profiling. The rollout of temperature sensors has already commenced in various buildings, such as the Konsumzentrale in Leipzig. We are currently collecting temperature data and will soon be able to optimise heating supply and generation through automated steering.
Realisation horizon for replication	Short term 0-3 years
Business Model Canvas	Complete business model canvas in appendices

Table 15 Heat demand control

6.4.2 Intelligent EV charging and storage

Partners involved	CENERO Energy Kostal	CO_2 reduction potential of future replication	*medium*
Replication potential	*High*	Status of replication	*Replication in Progress*
Use case description	This intervention relies on the use of intelligent EV charging, bidirectional charging stations, an electrical battery storage system, and solar PV cells in conjunction with a load management system to optimise the use of the renewable energy source, flatten the peak loads, and increase the rate at which decentralised renewable energy producers can be used directly on-site. With the increasing number and complexity of both producers and consumers, the control of grid stability is more important than ever before. By implementing a load management system into the grid, various producers, and consumers, such as intelligent EVs, can automatically be down- or upregulated depending on the relationship between demand and supply at the given time. In the case of storage and bidirectional EVs, energy flows can also be reversed. Not only does the load management enhance the stability of the grid, but it also increases the rate at which renewable energy produced on-site can be consumed directly on-site. When the demand is low and generation capacity high, solar electricity is directed to the EVs and storage. In turn, when the demand is high, the stored solar energy can be retrieved and directed to other consumers. The combination of load management with storage and smart EVs has additional potential to reduce load peaks and thereby saving costs.		
Key results during the project lifecycle	The intelligent EV charging columns from Walther-Werke were successfully installed and integrated into the load management system. Parameters for automatic steering based on the grid load		

	were configured in the load management software. The priority or hierarchy of consumers was established and configured in the load management software. The steering functionality was successfully tested and implemented. Unfortunately, discharging power into the local grid from the bidirectional Kostal box could not be tested. We have taken various measures to get the wallbox running, but without success. This is discussed in further detail in a subsequent section of this report, specifically addressing bidirectional charging. Consequently, the optimal utilisation of renewable PV electricity during periods of low or no generation capacity relies on the conventional lithium-ion battery storage. In theory, the concept of the conventional battery and the bidirectional EV battery is the same; however, with a bidirectional EV, one has the added value of sustainable mobility, making the most of a vehicle's battery storage capacity when parked and connected to a charging column.
Challenges	Ensuring the seamless integration and technical compatibility of intelligent EV charging stations, bidirectional charging stations, battery storage systems, solar PV cells, and the load management system may present challenges. Each component needs to communicate effectively and respond to commands accurately. Bidirectional EVs are a relatively new concept in Europe and are only available in prototype form. As the technology is not yet mature, errors may occur with the hardware or software communication, which, due to the novelty, may be difficult to identify and rectify. The adherence to and navigation through various regulatory requirements concerning bidirectional charging, grid interaction, and renewable energy integration with storage may present challenges. It is essential to carefully consider and comply with regulations that vary across regions and jurisdictions. In Germany, particularly, establishing multiple energy-generating plants along with storage and load management in a microgrid environment connected to the public grid is challenging. Regulations are unclear and change regularly. Tracing the origin of each kilowatt of energy fed into the public grid back to the specific generation plant is necessary to ensure accurate reimbursement and subsidies. This is particularly complicated when integrating storage, PV systems, and CHP simultaneously. It demands a detailed and complex digital metering structure and close cooperation with the grid operator. Furthermore, developing a suitable billing structure also poses a challenge. The reimbursement for electricity discharged from the vehicle battery must be agreed upon and legally documented. The wear and tear on the battery of the bidirectional EV through frequent charging and discharging must be considered in this calculation. Another concern is the range of travel for the vehicles. It is crucial for vehicle users to have sufficient battery capacity to reach their destination. For the bidirectional vehicle, a discharge limit needs to be established. The maximum distance achievable within this limit needs

	to be determined (taking into account traffic, potential rerouting, and some buffer capacity). A vehicle register must be created to document all trips exceeding the determined maximum distance achievable within the discharge limit. The vehicle register should include distance and departure time to ensure the charging station is instructed to ensure the required amount of charge to comfortable complete the trip. This information therefore needs to be integrated into the load management software to ensure that charging is, for instance, not downregulated or discharged if a vehicle is needed for a long trip in the near future. The cooperation of the vehicle user is therefore critical. Communication and transparency towards the users is important.
Learnings and insights	Implementing a load management system significantly contributes to the stability of the grid and the efficient use of renewable energy sources directly on-site. The potential benefits of bidirectional EV charging and intelligent e-mobility are far greater when upscaled. With a larger fleet, it is possible to increase the minimum discharging limit, thereby giving the users a larger guaranteed range of travel, while still achieving the same degree of flexibility for the grid. In other words, 10 % of one battery could be equal to 1 % of ten batteries. Scalability of this intervention, therefore, makes sense. The greater the fleet, the higher one can set the minimum discharging limit, guaranteeing vehicle users reach their destination with ease. The combination of load management, storage, and smart EVs demonstrates the potential to effectively reduce load peaks, leading to optimised energy consumption and potential cost savings. Establishing a comprehensive vehicle register and integrating trip data into the load management software is essential for effective planning and coordination of charging and discharging, or downregulating activities. The intervention emphasises the need for continuous monitoring, evaluation, and potential adaptation to ensure ongoing efficiency and alignment with evolving energy demands and technologies. Standardisation and interoperability among vehicles, charging stations, and load management software could facilitate a smoother implementation process.
Evaluation of the replication potential	There is great potential for the replication of intelligent e-mobility. Although the concept of bidirectional charging is not fully mature yet, we are confident that, once properly established and refined, it will hold significant potential for replication as well. The generation of solar power and wind power is volatile. This means that in the future, there is a demand for increased energy storage, even in public spaces. Here, technologies need to be sought that go beyond conventional, centralised lithium-ion storage.
Plans for replication - Outlook	Intelligent e-mobility, charged by solar power and managed through load management, is already being replicated at other sites such as the Konsumzentrale in Leipzig and the AEG site in Nuremberg.

	Unfortunately, the bidirectional EV charging concept is still in the prototype stage in Germany, and as such, this aspect will not be replicated for the time being.
Realisation horizon for replication	Short term 0-3 years
Business Model Canvas	Complete business model canvas in appendices

Table 16 Intelligent EV charging and storage

6.4.3 Bidirectional charging

Partners involved	CENERO Energy BMW Kostal	CO_2 reduction potential of future replication	medium
Replication potential	Currently not mature enough for replication	Status of replication	-
Use case description	Bidirectional charging allows EVs to draw energy from the grid and return energy to it. This innovative approach hinges on the bidirectional flow of energy, transforming EVs into mobile energy storage units. Charging stations equipped with bidirectional capabilities, when coupled with technically advanced electric cars, enable the electric charging current to flow in two directions. The process involves an exchange of information between the charging station and EV, considering factors such as the battery's charge status, the grid's power requirements, and the scheduled demand for a charged EV. Given that the grid operates with alternating current (AC) while the battery uses direct current (DC), bidirectional charging facilitates the conversion of stored DC energy back into AC electricity for feeding it back into the grid. Throughout the system, sensors and measuring devices are incorporated to support communication protocols. The load management software continuously assesses the grid's status and issues instructions to the vehicle, indicating whether to initiate charging or discharging processes. Additionally, the charging command is influenced by the demand for travel, considering factors such as departure time and distance. If the vehicle is scheduled for a journey in the near future, the system calculates the necessary charging time and incorporates this information into the charging/discharging schedule. This concept has the potential to reduce load peaks, resulting in cost reductions, while also contributing to grid stability and promoting the efficient utilisation of variable renewable energy sources, such as solar power.		
Key results during the project lifecycle	After collaborating with BMW, a system comprising a prototype car and a charging station was developed. The charging station was installed on-site and the power supply tested. The integration of this		

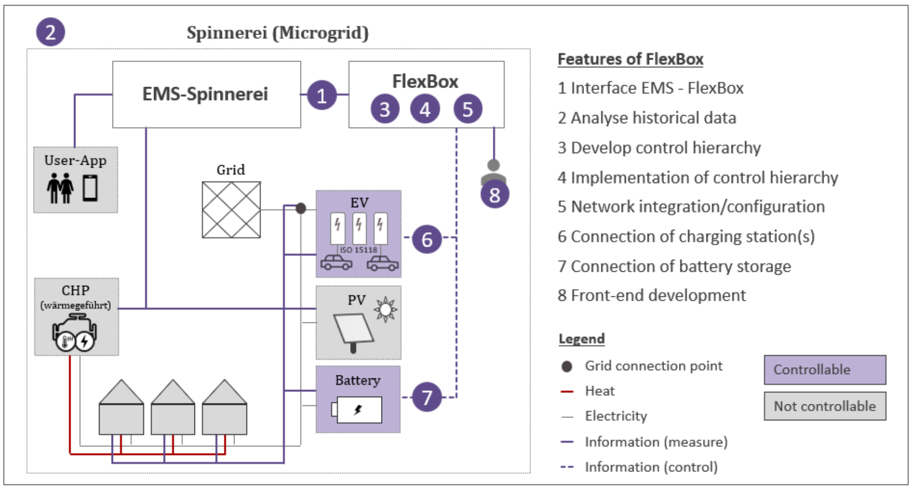
	technology into a digital energy flow management system for the area network, also known as the load management system, was executed. The initial charging column had to be replaced due to technical failures. The second column was installed and tested for unidirectional charging, which proved successful. However, after a brief period, it began displaying charging errors. Subsequently, the second charging column was also replaced. Unfortunately, due to continued technical and communication issues, the bidirectional capabilities of the system could not be tested thus far. Extensive troubleshooting has been conducted across all aspects, including the back-end load management software, the vehicle, the charging column, the power supply, and signal connectivity. Cenero was in regular exchange with Kostal, BMW and the load management programmers. Several potential faults were eliminated, but the issue could not be identified and resolved.
Challenges	Effective communication among all components in the concept is crucial. The novelty and complexity of this intervention present a challenge, especially given the technology's early stage, where potential faults may occur in the hardware or software as it is not yet mature. Identifying these faults can be difficult. Additionally, replacement models are not readily available. It was challenging to obtain a suitable vehicle for this project. The bidirectional-capable vehicle made available to Cenero for the SPARCS project was also part of a research project within BMW. However, the BMW research project reached the end of its lifecycle before that of SPARCS, and therefore BMW had no allocated resources to further actively assist with troubleshooting. To add to the challenge, Cenero was instructed to supply the electricity and monitor the impact of bidirectional charging on the grid via the load management. The vehicle itself, along with its components (i.e., the bidirectional wallbox), were leased by a third party. Consequently, Cenero could not insist on support and could only rely on the good cooperation of BMW, which, in this case, was fortunately provided within the limits of their resources. This legal challenge could serve as a valuable lesson learned from the project, especially when dealing with large cooperation where specific protocols and resource allocations need to be followed. The absence of standards and regulations for such concepts in Germany adds another layer of challenges. Developing a suitable billing structure that considers the battery's depreciation from regular charging and discharging also requires attention. A scheduling system for trips involving bidirectional charging vehicles needs to be developed, and the information must be integrated into the software that sends commands for either charging or discharging. Ensuring sufficient battery capacity for reaching the destination is essential for vehicle users. Developing and integrating a system like this one can be challenging.
Learnings and insights	The knowledge gained from extensive research, exchange, and troubleshooting despite the inability to get the concept running, and test the results, has added great value to Cenero's competencies regarding this new technology. In depth insights gained from experts,

	developers and technicians in an attempt to resolve the problem led to a thorough understanding of the concept and all its technicalities. The project involved a comprehensive exploration of various wallbox interfaces provided by Kostal and Walther-Werke. This examination aimed to understand the specifications, functionalities, and compatibility of these interfaces. Understanding the intricacies of the electrical integration process is essential for the efficient deployment of e-mobility solutions. This was analysed in detail. With the developers, an interface was developed to control and regulate charging stations using the OCPP protocol, both for supplying energy to the grid from the vehicle's discharging, as well as for charging vehicles. This interface is particularly relevant when no Modbus interface is available. Additionally, this OCPP interface can also be used for future projects with (bidirectional) OCPP charging stations. This standard protocol facilitates communication between charging stations and central management systems, contributing to interoperability and efficient data exchange. The project encompassed a thorough market analysis, particularly in the realm of load management with Dibalog. This analysis not only enhanced the understanding of market dynamics but also laid the groundwork for potential collaboration and application of findings. An important outcome was also to establish valuable connections with key stakeholders, such as BMW and Kostal. There is a theoretical understanding of using bidirectional charging for load management, flattening peak loads, and using renewable energy sources more efficiently, as it aligns with connecting a conventional battery. Therefore, the potential results of such a scenario can be derived. The advantage of the bidirectional charging concept lies in the added value of sustainable mobility. However, the disadvantage is that the availability of the battery is inconsistent, and the available battery capacity is relatively small. Bidirectional e-mobility has not reached the required technology readiness level to be applied in a project such as SPARCS. As the goal was to monitor the impact this technology could have in a microgrid environment, the lack of availability of replacement prototype vehicles and wallboxes, along with the inability to identify and successfully resolve the technical issues makes this evident. In summary, the bidirectional charging intervention has provided valuable insights into the technical, operational, and collaborative requirements.
Evaluation of the replication potential	The bidirectional concept is currently still in the prototype stage in Germany and is therefore not mature enough for replication yet. Once this concept is on the market, it holds great potential, especially when upscaled to larger fleets. At this stage, bidirectional charging is better suited for private home use cases as a flexible energy storage. For this purpose, wallboxes are already available. The feed-in to the public grid is still challenging regarding the lack of regulations and billing concepts.
Plans for replication - Outlook	Cenero is in communication with BMW and has expressed interest in participating in future pilot projects concerning bidirectional charging. If this is realised, it would, however, only be realised in two years' time.

Realisation horizon for replication	none
Business Model Canvas	No business canvas

Table 17 Bidirctional charging

6.4.4 Energy and load management

Partners involved	CENERO Energy	CO_2 reduction potential of future replication	high
Replication potential	medium	Status of replication	Replication in progress
Use case description	Energy monitoring entails the continuous collection and analysis of data related to energy consumption and generation. This data is sourced from various devices, including smart meters and sensors. The objective is to gain insights into the patterns of energy usage, enabling informed decision-making and the implementation of energy-saving strategies. By closely examining how, when, and where energy is being utilised, stakeholders can make calculated choices to optimise energy systems and consumption, enhance efficiency, and reduce overall energy costs. The insights gained from energy monitoring empower individuals and organisations to adopt sustainable practices and contribute to a more resource-efficient and environmentally conscious approach to energy management. Energy monitoring also facilitates integrated energy and integrating decentralised generating plants into the local energy grid.  *Figure 8: Scheme of Baumwollspinnerei microgrid enabled by digital Energy and Load Management Setup (source: CEN)* Frequent energy data collection facilitates swift fault detection within the grid or with specific equipment. Understanding the historical patterns of

	energy supply and consumption in a property helps determine parameters for irregularities, enabling the setup of an automated notification system. Granular monitoring has proven valuable for pinpointing the location of faults and energy losses, especially in situations where access to the network is restricted or obstructed. Plausibility checks and threshold monitoring are additional advantages of implementing energy monitoring systems. These features contribute to the overall effectiveness of the monitoring process by ensuring the accuracy and reliability of the data collected. Plausibility checks help verify the coherence and consistency of the data, ensuring that it aligns with expected patterns and values. However, threshold monitoring establishes predefined limits for certain parameters, triggering alerts or actions when these limits are exceeded. This proactive approach allows for timely responses to deviations from normal operating conditions, promoting system efficiency and reliability. Energy monitoring plays a pivotal role in ensuring compliance with regulations and reporting requirements in the energy sector. By systematically collecting and analysing data on energy consumption and generation, organisations can accurately track their adherence to established energy regulations. This proactive approach not only helps in avoiding potential non-compliance issues but also allows for the timely adjustment of operations to meet evolving regulatory standards. Additionally, energy monitoring provides the necessary data for comprehensive and accurate reporting, supporting transparency and accountability. This not only fosters a culture of compliance but also aids in demonstrating a commitment to sustainable and responsible energy practices, contributing to a positive relationship with regulatory bodies and stakeholders. Digital energy monitoring is crucial for improving energy billing and trading processes. By providing real-time granular insights into energy consumption patterns, these systems enable more accurate and transparent billing based on actual usage. Additionally, the data-driven nature of digital energy monitoring enhances precision in forecasting energy demand and supply, facilitating informed decision-making in energy trading. Ultimately, the integration of digital energy monitoring in billing and trading not only ensures fair and precise financial transactions but also contributes to a more agile and responsive energy market. Load management, however, involves the proactive control of electricity consumption within a power grid. This is achieved through the utilisation of the data obtained by extensive energy monitoring and a steering function to direct the flow of electricity. Based on real-time data of the grid situation, the system strategically directs the flow of energy to attain predefined, favourable outcomes. This includes guiding the energy flow from generation facilities or the public grid to specific users or storage locations, adhering to a predefined hierarchy. Load management proves particularly useful when integrating renewable energy sources with electrical storage to maximise the use of decentralised renewable energy directly on-site. The overarching goals of load management encompass flattening peak loads, optimising the utilisation of sustainable energy sources, enhancing grid stability, and reducing costs. Implementing load management practices makes the

	energy infrastructure more resilient, efficient, and capable of supporting a sustainable and well-organised energy distribution system.
Key results during the project lifecycle	At the Baumwollspinnerei, an extensive LoRa network of digital sensors and meters has been installed. The energy management tool cenero.one has been enhanced to incorporate various communication input protocols, increasing compatibility. The continuous refinement and development of cenero.one, guided by experiences and findings at the Baumwollspinnerei, demonstrate a commitment to ongoing improvement. Configurations for easy-to-analyse charts and dashboards have been implemented for the site, with parameters for threshold monitoring and plausibility checks in place. The monitoring enables benchmarking of the various buildings on the site, further aiding in drawing conclusions regarding the energy network and consumption. The collected data is also utilised for accurate billing. An intelligent heat demand control concept was introduced through energy monitoring and management. The digital network and the collected data are employed to incorporate load management on-site. The load management software, developed and installed, analyses the grid and generation plants' status. A hierarchy has been established; when generation capacity exceeds demand, excess energy is directed to electrical storage and EVs or once fully charged, to the public grid. Load management can also up or down regulate the charging of intelligent EVs to align with the grid demand, contributing to peak shaving on the site. These initiatives lay the foundation for increasing the self-consumption share from renewable energy sources on-site, fostering sustainability. Analysing the data helps to design the economic optimum for future generation plants optimally. The interplay between electricity tariffs and generation peaks identified by energy monitoring has given rise to the idea of a new business typology. Consumers can be offered lower prices if they shift consumption to low-peak times. The details of this typology are currently being examined. Overall, these results underscore the transformative impact of energy monitoring and load management in creating a more efficient, sustainable, transparent, and resilient energy infrastructure.
Challenges	A significant obstacle in the implementation of a digital network of energy meters is the shortage of workforce skilled and authorised to install and replace meters. This, together with prolonged delivery times can lead to delays. The replacement of some meters may necessitate a temporary network shutdown, requiring meticulous coordination with property management and tenants. This coordination is crucial to minimise disruptions and ensure the smooth implementation of new monitoring systems. The task becomes further complicated when entering tenanted or obstructed areas to carry out the necessary work, requiring careful planning and communication to address privacy and access concerns. Network plans of old buildings are sometimes outdated or unreliable, which poses another hurdle. Accurate and up-to-date information is

	essential for successful implementation, and discrepancies in historical plans can lead to complications and inefficiencies. Interoperability and the lack standardisation of device communication protocols present a challenge, as diverse technologies and systems need to communicate and relay data for effective energy management. Moreover, regulatory requirements in the energy sector are not always sufficiently defined and often change.
Learnings and insights	Establishing a methodical meter structure in the form of a hierarchical chart within the monitoring tool is crucial. The structure must distinguish between main meters and submeters, and it must be evident which submeters fall under specific main meters. A clear and organised naming system should be established and used consistently for all data points. The naming code should enable the derivation of basic characteristics about the meter or data point, such as the medium it monitors and the building in which it is installed. This structured approach streamlines data management, ensuring efficient tracking of energy consumption and generation across the network. It is important to consider these points from an early stage as renaming each data point could become complicated. Insights and detection of inefficient processes, consumers, or grid components were gained. Identifying and addressing these are critical for optimising energy usage and reducing waste. Profiling the grid has proven instrumental in designing strategies for replication and upscaling efforts. Understanding the interplay of complex consumers and generation plants is crucial for implementing effective load management strategies. As regulatory compliance becomes increasingly stringent, there is a growing need for energy monitoring and management to maintain transparency and facilitate accurate reporting. Grid services as a business typology show potential. Precision profiling of the thermal characteristics of buildings has been another important development derived from monitoring. Analysing how effective temperature is distributed within a building and the buildings ability to retain heat allows us to optimise the heat production accordingly. This information can also assist with reducing heating peaks, buy scheduling heating during low peak times and allowing the building to gradually cool during high peak times. Benchmarking, comparing the performance of various buildings or components, has been a valuable tool for setting performance standards and identifying areas for improvement. Developing a grid structure that allows for future upscaling efforts has been underscored as a critical lesson. This involves anticipating evolving energy needs, technological advancements, and regulatory changes to ensure adaptability and sustainability in the long term. Energy monitoring plays a key role in this.
Evaluation of the replication potential	This use case has a high replication potential. Digitalisation of the energy sector is becoming a requirement and hardware, and software is readily available. Even though the hardware and software are readily available, an overview of the market needs to be established first. As it is a relatively

	new business field, there are countless systems on the market. It is essential to carefully consider what fits the required needs. Load management software will in most cases need to be specifically configured for each individual site as no use case will be exactly identical.
Plans for replication – Outlook	The replication of load management and energy monitoring initiatives is actively underway with several plans in place. Firstly, there is an ongoing expansion of the LoRa network at the Baumwollspinnerei, and the site is expected to be entirely digitalised soon. Moreover, energy monitoring has been successfully implemented on the majority of other Cenero sites, demonstrating scalability and effectiveness. Additionally, cenero.one has been extended to external customers, providing a software as a service. Load management is the next focus, with plans in motion for its implementation at specific sites, namely Auf AEG in Nuremberg and Konsumzentrale in Leipzig. These targeted implementations aim to optimise energy consumption, enhance grid stability, manage e-mobility and contribute to overall efficiency.
Realisation horizon for replication	Short term 0-3 years
Business Model Canvas	Complete business model canvas in appendices

Table 18 Energy and load management

6.4.5 Balancing the microgrid inside the public grid

Partners involved	CENERO Energy Leipziger Stadtwerke	CO_2 reduction potential of future replication	medium
Replication potential	medium	Status of replication	Replication in progress
Use case description	A microgrid is a localised and often independent energy system that can generate, store, and distribute electricity. It operates as a small-scale, self-contained energy network within a larger power grid. Unlike traditional centralised power systems that rely on large power plants and extensive transmission lines, microgrids are designed to function autonomously or in coordination with the public grid. They can include a combination of various energy sources, energy storage systems, and advanced smart grid control technologies to efficiently manage the production and consumption of electricity. The microgrid components at the Baumwollspinnerei include a 70.47 kWp PV plant generating approximately 63,000 kWh annually, a 50 kW/48 kWh lithium-ion battery, CHP units with capacities of 50 kWe/90 kWth and 99 kWe/173 kWth, an e-mobility hub with a bidirectional charging station, and a system of digital meters and sensors for monitoring and directing energy flows. The glue that holds the concept together is the extensive, near to live collection of energy data from the digital network. The load management software uses this data to evaluate the grid status and steer energy accordingly to optimise both the generation and the consumption. These components contribute to several key benefits. Firstly, they enhance grid independence and resilience. The microgrid enables localised power distribution, thereby reducing losses in the energy transmission process. Efficient integration of renewable energy sources and integrated energy is achieved, promoting sustainability. Moreover, the microgrid results in cost savings by flattening consumption peaks, utilising waste energy effectively and reducing losses. Furthermore, a Peer-2-Peer energy trading interface has been established in collaboration with the LSW, offering additional advantages. The interface serves as a data exchange point that is mutually transparent to both parties, facilitating a prosumer approach in energy trading. The microgrid also provides valuable insights into grid support services such as peak shaving, contributing to a more resilient and adaptive energy infrastructure and trading.		
Key results during the project lifecycle	A significant regulatory milestone was achieved through collaboration with the grid operator, leading to the commissioning of the various components. As a result of the SPARCS project, direct contact with the grid operator was established. The project facilitated mediated workshops, extensive exchanges, and collaboration, eventually resulting in a suitable metering concept. The agreed-upon metering concept, established as a pilot project, holds the potential to serve as a foundation for future projects, showcasing the success and viability of the microgrid model.		

	A more detailed description of the process and the results can be found in the report and in Chapter 7.2 Furthermore, the microgrid has witnessed a notable increase in the share of renewable energy sources and decentralised energy production, particularly through the integration of PV systems and CHP units. Sustainable e-mobility availability has been enhanced, and the microgrid, with its load management component, uses intelligent e-mobility for grid stabilisation and peak shaving purposes. The microgrid has demonstrated effectiveness in decreasing overall energy consumption through meticulous energy monitoring and the demand orientated heat control concept. Continuous advancements have been made to the energy monitoring tool, cenero.one, ensuring its development and functionality align with the evolving needs of the microgrid and the evolving energy sector. Additionally, load management software has been implemented and refined, facilitating Integrated Energy to enhance efficiency between various consumers and generating plants within the microgrid. This approach contributes to a reduction in the site's carbon footprint and an increase in its degree of self-sufficiency and efficient use of renewable energy sources. Another notable achievement is the establishment of a Peer-2-Peer trading interface with LSW, fostering a transparent and collaborative approach to energy trading and consumption within the microgrid. Overall, these results highlight the success of the microgrid concept at the Baumwollspinnerei in achieving regulatory, environmental, and operational milestones.
Challenges	The microgrid concept at Baumwollspinnerei has encountered numerous challenges, highlighting its intricate nature. Regulatory hurdles have been a significant obstacle, as existing frameworks are often tailored for conventional centralised power systems and may not effectively address the distinctive characteristics of microgrids. Lack of clarity and the frequent changing of regulations, especially in Germany, where the regulations do not fully address individual metering concepts involving multiple generation plants, have led to varied approaches among grid operators. Establishing standardised processes would streamline commissioning and promote broader adoption of microgrids. Compliance with current subsidy guidelines in Germany, which mandate the precise allocation of the energy fed into the public grid to the generation plant where it was produced, has increased complexity for grid operators, particularly in systems with diverse energy sources and storage. Beyond regulatory hurdles, shortages in workforce capacity for managing the commissioning of the microgrid components has resulted in operational delays. The shortage of skilled workforce corresponds with a national shortage, possibly exacerbated by the energy crisis and the resulting high demand for skilled workers in the energy sector. Furthermore, deploying the microgrid on a historical site has required navigating restrictive monumental protection laws. Challenges in structural building statics, historical networks and the reliance on old, often outdated network plans further complicate the implementation process.

	The increasing complexity of consumers and generating plants within the microgrid intensifies operational intricacies. Integrating bidirectional charging has proven challenging, primarily due to the novel and complex communication protocols required. Collaboration with partners, managing contractual complexities, and developing billing concepts for bidirectional charging have also posed challenges. The bidirectional charging technology is in the prototype stage in Germany, introducing uncertainty that could be addressed by further research in this direction. The lack of interoperability and standardisation of components presents additional challenges. The integration of diverse energy sources, energy storage, and advanced control systems introduces technological complexities unique to each system. Ensuring seamless operation and communication between various components demands sophisticated engineering solutions and skilled personnel.
Learnings and insights	The project increased understanding of the current state of microgrid legislations and regulations in Germany, providing valuable insights into the regulatory landscape and paving the way for informed decision-making in future microgrid endeavours. The complexity of the regulatory aspects of microgrids was highlighted, emphasising the importance of early engagement with the network operator. Additionally, it became apparent that face-to-face meetings and collaborations for conceptualising and agreeing on the metering concept are of great value. Due to the complexity of the topic face-to-face meetings are essential. In-depth energy monitoring emerged as a crucial tool, uncovering the intricacies of the energy system and revealing consumption and generation patterns. The data collected from the digital meters are highly important for the implementation of an effective load management system. Implementing a microgrid at a historic site provided insights into monumental protection laws and how to navigate and adhere to these. It also emphasised the importance of thorough site evaluation during the initial stages of conceptualising, as dealing with historical, outdated, or incomplete network plans could pose challenges. In many cases, access to certain parts of the network may be restricted, either structurally or by tenants. Furthermore, structural strength and the need for refurbishments (within the confines of monumental protection regulations) need to be assessed thoroughly. The project demonstrated the need for flexible solutions that can accommodate the unique characteristics of historic sites. Tenant sensitisation and transparency were addressed through energy monitoring, highlighting the importance of keeping end-users informed about their energy consumption. The project also emphasised the significance of community engagement and garnering support from stakeholders with a vested interest in both the preservation and the development of the site. Exploration into energy services uncovered various potential business model typologies for microgrids, including peak shaving and load management grid services. This insight broadened the perspective on the diverse applications and benefits microgrids can offer in different operational contexts.

Evaluation of the replication potential	Due to the novelty of this concept and the lack of standardised regulations set out by the legislator in Germany, the replication potential is currently considered to be medium. It is expected that the amount of decentralised generation plants will continue to grow at a rapid rate. There is also an increase in tenant electricity models where decentralised electricity generation is used directly on-site. This can already, to some degree, be considered a microgrid. However, it should be emphasised here that the regulatory burden should be simplified in order to incorporate a mix of generating plants and storage and a connection to trade with the upstream public grid.
Plans for replication - Outlook	At Baumwollspinnerei, the introduction of an additional 80 kWp PV system on Hall 17, and a larger 310 kWp PV system on Hall 9 are expected to enhance the renewable generation capacity of the existing microgrid by an additional 352,000 kWh per year. Additionally, the implementation of geothermal heating with seasonal storage is also in the pipeline. The digital LoRa Network is continuously growing, and the site will soon be completely digitalised. The neighbouring project at Saarländerstraße 25 aims to create a sustainable energy ecosystem. This includes a mix of renewable energies, incorporating Integrated Energy principles by integrating PV systems, e-mobility infrastructure, geothermal heating, waste heat utilisation, and seasonal and electrical storage. The emphasis on load management and peak shaving strategies exemplifies a comprehensive approach to grid optimisation and energy consumption efficiency. The inclusion of efficient heating with thermal precision profiling of buildings aligns with the overarching goal of achieving energy-efficient solutions across both sites. Together, these planned developments reflect a strategic and integrated approach to replicating the success of the microgrid concept at Baumwollspinnerei, fostering sustainability and innovation in the broader energy landscape.
Realisation horizon for replication	Medium term 3-5 years
Business Model Canvas	Complete business model canvas in appendices

Table 19 Balancing the microgrid inside the public grid

6.5 Overarching tools and processes

6.5.1 Decision support system for decarbonisation of the district heating system

Partners involved	ULEI LSW	CO_2 reduction potential of future replication	high
Replication potential	high	Status of replication	Replication in planning
Use case description	The city of Leipzig aims to be fully decarbonised by the year 2038. However, the “heating in buildings” sector still makes up a large part of city-wide emissions. Expanding and decarbonising the existing district heating system is a sensible approach to support the decarbonisation efforts of the city of Leipzig. To meet that goal, four generation scenarios are proposed based on different development assumptions. They each focus on different energy carriers. They vary strongly and can be considered extreme scenarios: (1) Natural gas with carbon capture and storage (2) Hydrogen (3) Diversified mix of biomass, waste heat and solar, (4) Electricity The scenarios’ robustness towards commodity prices (natural gas, hydrogen, electricity and biomass) is investigated using a sensitivity analysis. Herein, 30 model versions with varying commodity prices (called sensitivities) are investigated in detail. The energy system model IRPopt was used to optimise the hourly economic dispatch of the heat generation plants of the respective generation scenario. The techno-economic data and the economic dispatch of the generation plants are used to calculate the Levelised Cost of Heating (LCOH) using a MS Excel tool. The results of all scenarios and sensitivities are compared and analysed.		
Key results during the project lifecycle	The district heating demand of the city of Leipzig for the year 2038 was approximated in collaboration with LSW. Thereafter, four distinct generation scenarios (based on different assumptions as previously mentioned) were designed, each able to meet the previously calculated district heating demand. Relevant techno-economic data to be implemented throughout all generation scenarios was gathered with the support of LSW. The designed generation scenarios were then implemented in IRPopt. Furthermore, a calculation tool for the variable cost, annualised investment cost, revenue and the resulting LCOH for all considered generation technologies of each generation scenario was constructed.		

	To evaluate the robustness of the various generation scenarios, a sensitivity analysis of relevant commodity prices was performed. Regular meetings with LSW were established to inquire additional techno-economic parameters and to reflect and discuss results. The resulting LCOH were calculated for all generation scenarios and commodity price sensitivities. The results were evaluated in collaborative meetings with LSW as well as in the form of a peer-reviewed scientific publication. The results (LCOH) can be used to a certain degree as an indication regarding future pricing of the district heating system.
Challenges	The current uncertain geopolitical situation complicates the prognosis of realistic future LCOH connected to the scenarios, as they are based on uncertain assumptions regarding fuel prices. Furthermore, uncertainty and data inaccessibility regarding the considered generation technologies exists (mostly for novel technologies like hydrogen powered CHP-plants, carbon capture plants, etc.). Additionally, there is further uncertainty regarding the development of the regulatory framework over the coming decades, which technologies will be penalised, and which will be subsidised. The calculation of realistic infrastructure expansion cost was out of scope for the LCOH calculation at hand. Therefore, the calculated costs are missing a certain dimension, e.g. the cost of connecting new districts or new generation plants to the system. Ideally, these costs are similar over all generation scenarios, as comparable generation capacities and district heating demand has been connected to the district heating system.
Learnings and insights	A relevant and valid source of techno-economic data is essential when working with any energy system model. The design and consideration of extremely distinct generation scenarios is interesting; however, it only gives a very broad indication of realistic future system cost; the consideration of more realistic scenarios may be a valued addition to the considered cases. The current uncertain geopolitical situation and national framework further complicates the prognosis of realistic future LCOH connected to the scenarios. The critical reflection and – if necessary – adjustment of techno-economic assumptions and commodity price sensitivity analysis are sensible approaches to tackle these problems. In generation scenarios with higher diversification regarding the fuel sources, fluctuations in fuel prices have a less significant effect on the LCOH. Conversely, the focus on singular fuel sources (scenarios with natural gas and hydrogen) has major effects on the LCOH in the event of variation in the respective fuel prices. The integration of CHP plants in the generation scenario and corresponding sale of co-generated electricity at wholesale prices can

	counteract the negative effects of rising electricity prices; this is the case in the scenarios considering natural gas and hydrogen.
Evaluation of the replication potential	The replication potential of this use case is quite good. In section 2.3 the federal regulatory framework for the heat planning process and the German goal of climate-neutrality by 2045 are presented. These goals require solutions like these. Consequently, many engineering companies are starting to offer more detailed support on the heat planning process for the communities that have to go through such a process. The tools and approaches designed by these actors somewhat dampen the potential of the tool developed by ULEI. Beyond the federal policy measures, long-term planning of energy systems has always been very relevant for energy producers or municipal utilities. This tool can support those actors with their energy system planning process while considering and abating the existing uncertainties.
Plans for replication - Outlook	The use case has been published as a conference paper last summer at the European Energy Markets Conference. Therewith, the dissemination of the gained knowledge and understanding into the scientific community has been achieved. It is accessible under the following link. Therewith, the chosen approach has been shared in a detailled and scientific manner. A replication by interested parties should already be possible. Additionally, it is planned to apply the methodology in future projects with the aim of decarbonisation of district heating grids in the new federal political frame of Germany (Gesetz für die Wärmeplanung und zur Dekarbonisierung der Wärmenetze [Act for heat planning and decarbonisation of heating networks]); the chosen methodology was evaluated and will be partially expanded upon in the following project(s). Herein, ULEI hopes to support smaller municipalities in their efforts to decarbonise energy systems in general and district heating systems specifically. Lastly, the gained insights and knowledge will hopefully be integrated into university teaching to a certain degree.
Realisation horizon for replication	Short term 0-3 years
Business Model Canvas	Complete business model canvas in appendices

Table 20 Decision support system for decarbonisation of the district heating system

6.5.2 Integrating climate and energy data into the municipal urban data platform - Energy-Map Leipzig

Partners involved	Several departments in the municipality of Leipzig	CO_2 reduction potential of future replication	high
Replication potential	high	Status of replication	Replication in progress
Use case description	The Energy Map Leipzig is a navigation tool designed for the energy transition, serving as a digital twin of renewable energy potentials and plants. The primary goal of the Energy Map Leipzig is to identify renewable energy potentials and to present the expansion status of renewable energy systems (L19). To achieve this, various data spaces are integrated into a unified dataset, allowing for the visualisation and analysis of information. Moreover, it facilitates data exports for further utilisation. The local data incorporated into the Energy Map Leipzig is sourced from LeipziGIS, while federal data is drawn from the Master Date Register and the Federal Grid Agency, including information from the E-Mobility Register. At state level, the Energy Map Leipzig includes data on geothermal potentials to provide a comprehensive overview of renewable energy resources and their current status.		
Key results during the project lifecycle	In the context of Leipzig's energy landscape, the concept of 'one data space' envisions a unified platform where all stakeholders converge to collectively develop ideas. This singular tool facilitates collaboration among stakeholders, fostering a shared approach to brainstorming and ideation, particularly in the realms of renewable energy expansion and monument protection. A unique aspect involves the joint consideration of renewable energy expansion and monument protection, encouraging stakeholders to synergise efforts and address challenges collaboratively. The integrated approach extends to understanding the effects of integrated energy, ensuring a comprehensive grasp of how different sectors interconnect in the pursuit of sustainable energy solutions. Functioning as a decision tool for renewable energy expansion, this unified platform empowers stakeholders with the data and insights needed to make informed decisions, shaping the future of Leipzig's renewable energy landscape.		
Challenges	The biggest challenge for the Energy Map now is to stabilise and further develop it in the long term. In addition to the working level, the management level must also be convinced to use the Energy Map. In addition, the use and benefits of the Energy Map must be publicised. This is an ongoing process. It has become apparent that not all people in the individual offices are aware of the existence of the Energy Map. Also, not everyone knows how to use a GIS. This means that there is still a major hurdle to utilisation at this point.		
Learnings and insights	The learning from this challenge is that rapid prototyping becomes instrumental in conveying ideas more effectively, allowing offices to comprehend and engage with concepts swiftly. Insights from fast feedback loops have proven invaluable, ensuring a swift development process. The iterative nature of feedback loops accelerates decision-making and implementation, promoting agility in the project. A central theme that emerged is that cooperation is the key to overcoming challenges and fostering a harmonious working environment. The		

	success of the Energy Map Leipzig is deeply rooted in the collaborative efforts of all stakeholders involved. Acknowledging that errors are an inevitable part of the development process, the project has embraced an error culture. Allowing room for mistakes has not only led to valuable learning experiences but has also contributed to the overall resilience and adaptability of the Energy Map Leipzig initiative.
Evaluation of the replication potential	The Energy-Map Leipzig has considerable potential for imitation, as it is a digital tool for administration and citizens that can contribute to a better understanding of the energy transition, support its planning and accelerate its implementation. This is achieved by visualising all information in one tool.
Plans for Replication - Outlook	The plans for replication involve integrating the results of municipal heat planning, recognising the significance of incorporating localised insights into broader energy transition strategies. As part of the replication strategy, an Energy Transition Dashboard is envisioned to provide a comprehensive overview of the ongoing energy transition efforts, offering stakeholders a centralised platform for monitoring and analysis. Another key element in the replication plan is the creation of an E-Charging Pole Dashboard, aiming to streamline information EV charging infrastructure. This dashboard will serve as a tool for managing and expanding e-mobility initiatives. The Energy Map, beyond its technical capabilities, is envisioned to be a powerful communication tool for citizens. The replication plan involves leveraging the map to disseminate information effectively, engaging and informing the public about the city's sustainable energy initiatives. Various funding applications for federal and EU programs have already been submitted to further develop and consolidate the Energy Map.
Realisation horizon for replication	Short term 0-3 years
Business Model Canvas	Complete business model canvas in appendices

Table 21 Integrating climate and energy data into the municipal urban data platform – Energy Map Leipzig

6.6 Further Reports

The work done in WP4 and this project Deliverable D4.7 has linkages to other Deliverables and reports in the WP4 of the project. The most relevant linkages are described in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Further replication potential is presented in the following reports.

Title of the Report	Short description	Link
Investigation into the optimisation of charging processes for LVB e-buses	The study analyses data from August 2021 to July 2022 on 21 electric buses across three routes in Leipzig. It aims to assess load shifting potential by reducing charging power at a final stop. Data includes trip details, distances, and State of Charge percentages. The analysis involves mapping routes, creating distributions, and calculating averages. Results indicate that reducing charging power to 90 % meets energy demands, but at 80 %, energy shortages occur. The study offers insights for optimising electric bus charging strategies.	https://sparcs.info/en/deliverables/d4-05-ev-mobility-integration-and-its-impacts-in-leipzig/
Tenants electricity study: Leipzig Model to integrate PV electricity into the general power supply	The study examines the utilisation of renewable electricity in apartment buildings, particularly focusing on tenant electricity within the housing industry. It begins by outlining Germany's legal framework evolution, defining key terms and stakeholders, and assessing different models. The second part addresses economic factors, project realisation conditions, and identifies implementation challenges. Findings highlight the complexity of legal regulations and technical demands, which diminishes the attractiveness of implementing tenant electricity models in the housing sector.	https://sparcs.info/en/deliverables/ in WP4 – Demonstration Lighthouse City Leipzig
Challenges of the Energy Transition and their Solutions – Field report from SPARCS Leipzig	The SPARCS project in Leipzig involved demonstrating renewable energy systems, including large-scale PV installations in Dunckerviertel and a microgrid at Baumwollspinnerei. Delays connecting these systems to the local grid occurred due to issues with system and grid operators. Workshops involving the LEI, WSL and CENERO with the grid operator facilitated solutions for implementing innovative energy and metering systems. These efforts aim to advance sustainable energy practices and address challenges in renewable energy integration.	

Standard model for climate just district development	Standardised processes for energy-efficient district development are needed to achieve the SECAP objectives (see Chapter 3).The SPARCS task "Standard model for smart and climate-neutral district development" was hence aligned with the municipal climate strategy to support this. As part of this task, templates and visual aids were created to facilitate discussions on promoting socially equitable and energy-efficient district development.	https://sparcs.info/en/deliverables/ in WP4 – Demonstration Lighthouse City Leipzig

Table 22 Overview of further reports

7. CONCLUSIONS

7.1 Summary of achievements

The collaboration within the framework of SPARCS has led to a significant improvement and the establishment of networks between the partners and with the city of Leipzig, in particular the Digital City Unit. The role of the Digital City Unit as a supporter, facilitator, moderator and liaison office was crucial in this process. It was recognised that only joint action can lead to success, as everyone involved has to overcome similar challenges. The exchange of experiences helped to tackle these challenges more effectively.

In Leipzig, a general planning tool for the energy transition was developed, the "Energy Map Leipzig". The results of the project emphasise the importance of joint planning tools for the development and implementation of joint strategies. The requirements in the context of the energy transition and climate change adaptation measures can only be met through a joint approach, which is why a common tool is needed to enable the joint development of solutions. The tool is being continuously developed and serves as a standard tool for future projects and the management of new processes. It is not only used for the current project, but is also applied in other joint projects such as municipal heat planning.

LSW has set up a VPP by purchasing and developing hardware such as L-Boxes and charging points. A digital platform was created that serves as the foundation for various services, and the devices were successfully integrated into the platform's productive mode. The biggest difficulty in SPARCS with regard to the solar thermal system was that the originally planned area turned out to be unsuitable during the course of the project. A new area therefore had to be found. The short-term procurement of a new area also represents a major success for the project. The improved cooperation with the city accelerated the approval process.

WSL utilised PV systems and storage for general electricity for the first time and developed a new business idea. In a tenant electricity study, the WSL found that tenant electricity is not applicable in its current form. This is mainly due to the high complexity of the requirements and the high additional costs for potential operators of the tenant electricity model. This additional effort reduces the financial viability and thus the economic viability. Instead, a new business model was designed and is currently being developed. This is a modified approach to the tenant electricity model, in which the VPP of LSW can be used to give all tenants access to PV electricity, even if it is not possible to install a PV system on their roof.

A major success for Cenero is the development of a measuring point concept for the complex micro-grid of the cotton mill, in which a wide variety of renewable energy systems are controlled together. In the course of the project, it emerged that the current regulatory framework does not yet take these complex and innovative approaches into account, and innovative solutions were developed in a moderated process.

Seecon set up a citizen participation network in a neighbourhood where no citizen participation had previously taken place. The LWB is therefore considering setting up neighbourhood meetings and energy consultation hours at other locations as well. This means that the networks created and the associated services for LWF tenants will continue after SPARCS and may also be offered in other neighbourhoods.Impacts

The intangible results of the SPARCS project are diverse and impressive. Despite the challenges posed by multiple crises, most of the interventions were successfully implemented, which illustrates the high adaptability and cohesion of the partners involved. In addition, new collaborations have emerged that go beyond SPARCS, such as the innovative tenant electricity models. The links between industry and research partners were also strengthened, leading to a fruitful exchange and a deepening of cooperation.

Another important aspect is that the results of SPARCS flow directly into municipal strategies. This can be seen, for example, in Leipzig's recently accepted application to become a Mission City, which was supported by the findings and successes of the project. The holistic view of all components - buildings, facilities, vehicles and people - has contributed to a more effective CO2 reduction. This comprehensive perspective makes it possible to develop more sustainable and efficient solutions.

The project has also expanded the skills of the organisations involved, particularly in the areas of data science and artificial intelligence. These new skills are valuable for the future development and application of smart technologies. The process results of SPARCS can also be transferred to other parts of the city, which underlines the scalability and long-term benefits of the project.

Within the city of Leipzig, SPARCS has promoted cross-silo working processes that combine smart city and climate neutrality measures. These holistic approaches contribute to a more coherent and efficient implementation of sustainable urban development strategies and strengthen cooperation between different city actors.

7.2 Other conclusions and lessons learnt

The experience gained from the SPARCS project has revealed valuable lessons for the companies involved. One general lesson learnt is that it is often regulatory hurdles, rather than the technology itself, that pose the greatest challenge.

In the case of the LSW’s solar thermal plant, it became clear that the early search for and acquisition of land is the top priority. The importance of early joint planning and coordination with all stakeholders, in particular with the city of Leipzig and its relevant specialist departments, was also emphasised to ensure that the project runs smoothly and quickly. For LSW’s VPP, it was emphasised that the creation of an interdisciplinary team is crucial in order to meet the requirements of smart city developments, as different expertise and different perspectives are required.

WSL achieved major savings through its energy management at comparatively low investment costs. It was also realised that tenant electricity models are theoretically possible but difficult to implement in practice. Therefore, a concept for universal PV electricity for the houses was developed to promote social justice in the energy transition and ensure that all households can benefit from PV electricity.

The development of digital tools, such as the "Energy Map", showed that agile product development with short feedback loops is recommended for rapid development. In order to better communicate the added value of a product to all stakeholders, the development of prototypes proved to be very helpful.

Cenero learnt that small human errors can sometimes lead to technical challenges that are often difficult to detect, resulting in delays.Technical challenges are often caused by small errors, which makes troubleshooting more difficult. In addition, Cenero learnt that for large and complex system installations, early face-to-face coordination with the grid operator helps to speed up system commissioning.

The University of Leipzig emphasised that regular reflection on the data basis used is particularly important. With regard to citizen participation, it became clear that local networks and stakeholders should be used to promote citizen participation in order to be able to get in touch with people quickly. It was emphasised that quick results and the implementation of small-scale measures are crucial for people's trust in the participation process. Finally, the creation of explanatory videos proved to be helpful in making complex topics easier to understand.

8. Acronyms and Terms

8.1 List of Abbreviations

AC:	Alternating current
CCU:	Central Control Unit
CMS:	Central Management System
CHP:	Combined heat and power plant
DC:	Direct current
EV:	Electric vehicle
GDR:	German Democratic Republic
ICT:	Information and Communication Technologies
IoT:	Internet of Things
LCOH:	Levelised Cost of Heating
LoRaWAN:	Long Range Wide Area Network
LSW:	Leipziger Stadtwerke
LWB:	Leipziger Wohnungs- und Baugesellschaft GmbH
OCPP:	Open Charge Point Protocol
PV:	Photovoltaic
SECAP:	Energy and Climate Action Programme 2030
VPP:	Virtual Power Plant
WBS:	Wohnungsbauserie
LHC	Lighthouse City

8.2List of partner acronyms used in SPARCS

PARTNERS	
Stadt Leipzig	LEI
Fraunhofer Gesellschaft Zur Forderung der Angewandten Forschung e. V.	FHG
BABLE UG	BABLE
WSL Wohnen & Service Leipzig GmbH	WSL
Leipziger Wohnungs- und Baugesellschaft mbH	LWB
Stadtwerke Leipzig GmbH	LSW
Cenero Energy GmbH	CEN
Seecon Ingenieure GmbH	SEE
University of Leipzig	ULEI
Suite5 Data Intelligence Solutions Limited	SUITE5
Gopa Com	GOPA

9. Appendices

9.1 Business Model Canvas

Project: Energy Management
Partner: WSL

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

Owner of the building
Owner of the heating station
Energy-monitoring / -management software company
Hardware producer / supplier

CITY GOVERNMENT ROLE

can help to rollout by giving a specific financial support for installation and operation
can help by giving an energy consumption limit or energy efficiency limit

ASSET OWNERSHIP

Owner of the building
Owner of the heating station
Owner and operator energy management product

BUSINESS MODEL TYPOLOGY

EPC – energy performance contracting

Service that provides energy saving potential.

FUNDING & FINANCING

focus on “low" installation costs

Financed by own funds and future services

CUSTOMER SEGMENTS

City and the people living and consuming energy in the City
The Leipzig City Council,
Local enterprises / comanies

CUSTOMER

Consumers in the city

BENEFICIARY

Decrease of heating energy in the buildings / city and use reduction of CO_2

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Reducing of heating energy and reducing of CO_2 emission
Reducing fo energy costs
Increase of digitalization of the building
Better and easier performance
Digital integration and data analytics.

Environmental benefits such as carbon footprint reduction and contribution to climate goals.

COST STRUCTURE

installation costs hardware
softwarecost
Personal costs operating

SURPLUS

Decrease of energy consumption, decrease of CO_2 emission
decrease of energy Costs (heating Bill)
increase of digitalization of the building (smart City)

Local workshop with tenants (energy consultation)

REVENUE STREAMS

Optimization of energy consumption – reduction of heating energy, costs and CO_2 emission

Additional services like consultation and analysis

SOCIAL & ENVIRONMENTAL COSTS

Electronic waste and battery waste as sensors are mostly battery powered
Life cycle of equipment.

SOCIAL & ENVIRONMENTAL BENEFITS

Decrease of energy consumption, reducing CO_2, reduce energy costs (heating bill)
digitalization (smart building / city)
Increased awareness of energy use
Empowerment of citizens on energy use.

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
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

Project: PVs Installation
Partner: WSL

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

Owner of the building

energy supplier (“Mieterstrom” supplier)
power grid operator
City Government (sometimes)

CITY GOVERNMENT ROLE

can help to rollout by giving a specific financial support for installation

can help with an energy potential mapping

ASSET OWNERSHIP

Owner of the building - area for PV Installation (rent the roof)
Owner and operator of the PV plant (costs of installation)

energy supplier (Mieterstrom supplier) - manages the sales of the product (electricity) and contracts with the consumers

BUSINESS MODEL TYPOLOGY

Energy selling contracts – different scenarios possible
- 100% grid connecting
- Self consumption
- Energy seling

FUNDING & FINANCING

"focus on ""low"" installation costs--> define the price for the electricity by the PV plant focus on ""feasible projects / objetcs

CUSTOMER SEGMENTS

City and the people living and consuming energy in the City

CUSTOMER

Consumers in the city
Tenants
utilities

BENEFICIARY

Increase of renewable power plants in the city and use of renewable energy and decrease of CO2
Local community, local grid

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Increase renewable energy, decrease electricity bills and increase property value because of the PV Systems, energy independence.
Reduce CO2 emissions.
Building with integrated PV help to a more sustainable energy grid
For local community, the cost savings and decrease the dependence of fossil fuels.
For companies, act responsibly in the face of climate change.

COST STRUCTURE

installation costs of the PV plant--> define the electricity production price €/kWh
Personal costs operating

SURPLUS

installation more PV plants
Increase of renewable energy plants and decrease CO2 emission

Workshop for tenants / consumer

REVENUE STREAMS

"PV plant produces electricity to stable prices - so could have an stabelized effect on the energy prices also could be an attractiv price - defined by the installation costs

Green energy certificats can be also an option

SOCIAL & ENVIRONMENTAL COSTS

Grid costs
Electronic waste and battery waste as sensors are mostly battery powered
Life cycle of equipment.

SOCIAL & ENVIRONMENTAL BENEFITS

Increase (production) renewable electricity in the city + reducing CO2 by installing PV plants (renewable energy in the grid)
green City
Increased awareness of energy use
Empowerment of citizens on energy use

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
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

Project: Solar Thermal Plant
Partner: LSW

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

- City/municipality or community
- operators of district heating grids
- private & municipal housing companies or housing developers
- Local businesses (engineering, construction, hardware supply)
- plant manufacturers
- plant operator (if separate)
- providers of funding & subsidies (local shareholders, investment opportunity)

CITY GOVERNMENT ROLE

Majority shareholder of company operating the business model (LSW). Control in terms of strategic guidelines and supervisory board participation. Also, main approval authority for the project.

ASSET OWNERSHIP

Depending on use case. Owners of a solar thermal plant can be:

- municipal or private energy company
- district heating grid operator
- housing company (municipal or private) or developers in combination with service providers or contractors
- home owners or a community (e.g. via a cooperative)

BUSINESS MODEL TYPOLOGY

- green energy supply contract via district heating grid (local energy company) or the house heating system (e.g. in case of a rooftop plant)
- contracting business models

FUNDING & FINANCING

Depending on use case. Usually, a mix of external and internal capital as well as funding provided by the municipality, state or federal government.

CUSTOMER SEGMENTS

CUSTOMER

Existing heat customers of LSW benefit by receiving green heat. If your renewable energy supply is above a certain level further benefits may be eligible (e.g. less energy-oriented refurbishment).

BENEFICIARY

Beneficiaries are mostly energy providers, Leipzig district heating customers (or local heating grid or housing customers) and the city by reducing the carbon footprint and keeping with transition goals.

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Customer: Supply of renewable heat and reduction of CO2 emissions, assisting with transition goals and increasing energy independence.
Local Government: Reducing energy dependence and advancing energy transition goals.
Local Businesses: Business opportunities include engineering services, construction work, and maintenance.
Climate: Reduction of carbon footprint

COST STRUCTURE

CAPEX: development cost (engineering, approval planning, property acquisition, ...), Infrastructure (e.g. grid construction or extension, electrical & data connection), plant construction (components, building, ...), testing/ technical acceptance
OPEX: power supply (mainly pumps), frost protection & operating resources, area & plant maintenance, grid operation (large district heating grids)

SURPLUS

Revenue will potentially be invested in further integration of energy or housing sectors and respective value added services for customers.

REVENUE STREAMS

1. Energy sales or savings (depending on use case)
2. Reduced fuel cost (fossil fuels) or power cost (heat pumps, Power-to-Heat)

SOCIAL & ENVIRONMENTAL COSTS

1. space requirements (not with rooftop plants)
2. loss of agricultural land (depending on plant concept and land acquisition)
3. manufacturing & construction footprint (incl. materials)

SOCIAL & ENVIRONMENTAL BENEFITS

1. CO2 reduction by providing renewable energy
2. Reduction of fossil fuel share
3. Increased energy independence
4. Large, open-space solar thermal plants can provide habitats for flora & fauna
5. Green heat & district heating offers opportunities for housing which is hard to energy-refurbish (e.g. historic preservation)

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
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

Project: Smart sockets
Partner: LSW

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

1) Customers which use the devices

2) Municipal utilities that are interested in gathering the data about user behavior.

3) Grid operators that aim to increase resilience in distribution grid

4) Research institutions that make use of the harvested data.

5) hardware manufacturers

CITY GOVERNMENT ROLE

Majority shareholder of company operating the business model (LSW). Control in terms of strategic guidelines and supervisory board participation.
- Integration with Smart City Initiatives
- Could support public awareness
- Can establish regulations and standards for the manufacturing and use of smart sockets to ensure they meet safety and interoperability requirements

ASSET OWNERSHIP

IoT devices: Customers

BUSINESS MODEL TYPOLOGY

Energy performance Contracting (EPC), or hardware as a service (HaaS) or IoT-subscriptions.
The smart sockets can either be sold or provided to the customer free of charge when an electricity contract is concluded.
Further services can be offered on top.

FUNDING & FINANCING

Currently the business model is financed based on internal resources and partly from EU resources.
Additional funding from public side may be applicable.

CUSTOMER SEGMENTS

CUSTOMER

Existing electricity customers of LSW benefit by being offered additional services and value with new IoT devices.

BENEFICIARY

Energy providers: in a bigger scale smart sockets can contribute to load management and grid optimization

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Customer: monetary benefits through energy savings, signalling of ecological behaviour by representation of carbon dioxide reduction, additional functionalities e.g. energy management, remote monitoring; Identification of savings potential.
Local Government: Highly reliable data on energy consumption, Identification of savings potential

COST STRUCTURE

IoT device costs (e.g. smart sockets), IT (re-)development costs (apps) and communication costs for addressing new customers

SURPLUS

Revenue will potentially be invested in further development and e-mobility sectors and respective value added services for customers.

REVENUE STREAMS

Potential revenue streams:
- Product sales
- Subscription services
- Data monetization
– customization and upgrades through app
Ecosystem partnerships

SOCIAL & ENVIRONMENTAL COSTS

Social Costs:
- Data Security risks/concerns
- Privacy concerns

Environmental Costs:
- Manufacturing and E-Waste
- Rare materials → Increased use of hardware devices comes along with negative impacts in terms of resource sustainability (mining of lithium for batteries, etc)

SOCIAL & ENVIRONMENTAL BENEFITS

1) **Energy Efficiency:** Carbon dioxide reduction by providing energy flexibility, thus minimizing balancing energy capacities.
2) **Knowledge gain**: by harvesting highly granular data on user consumption and distributed energy resource generation.
3) **Education and Awareness:** Signalling of efficient energy use to peer groups is likely to create awareness and incentivize positive mimetic behaviour.

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
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

Project: ICT Platform
Partner: LSW

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

1) Local businesses to provide energy flexibility.

2) Manufacturers of hardware devices and electric vehicles that are interested in tracking the C02 reduction of their assets.

3) Industrial companies that provide insights in their production processes for resilience analysis in the entire grid.

4) Research institutions that make use of the harvested data.

CITY GOVERNMENT ROLE

Majority shareholder of company operating the business model (LSW). Control in terms of strategic guidelines and supervisory board participation.

ASSET OWNERSHIP

IoT devices: Customers; **Renewable Energy Assets**: Private customers (crowdfunding), LSW, City, private companies; **Electric vehicles**: Private customers or company fleet; **Metering devices**: Metering point operator

BUSINESS MODEL TYPOLOGY

Energy performance Contracting (EPC), crowdfunding

FUNDING & FINANCING

Currently the business model is financed based on internal resources and partly from EU resources. Additional funding from public side may be applicable.

CUSTOMER SEGMENTS

CUSTOMER

Existing electricity and heat customers of LSW benefit by being offered additional services and value with new IoT devices. E-Mobility customers are being offered functions to dynamically manage their EVs.

BENEFICIARY

Beneficiary are mostly Leipzig citizens that benefit from a streamlined energy systems throughout the whole city that allows flexible use of distributed assets and prevents blackouts.

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Customer: Flexible control over all devices, monetary benefits by collecting bonus points, signalling of ecological behaviour by representation of carbon dioxide reduction. Also, options to invest in local renewable energy assets (pv); **Local Government**: Highly reliable data on energy consumption and generation in households and districts; **Local Businesses**: Opportunities for flexible energy trade

COST STRUCTURE

IoT device costs (e.g. smart sockets), IT (re-)development costs (apps), IT integration costs (integrating new assets into virtual power plant), search and communication costs for addressing new customers

SURPLUS

Revenue will potentially be invested in further integration of heat, electricity and e-mobility sectors and respective value added services for customers.

REVENUE STREAMS

1. Bundling of surplus services for customers: e.g. advanced scheduling functionalities for IoT devices; **2.** Issue of tokens representing 2nd hand CO2 reduction to manufacturers of connected devices (electric vehicle, lawn mower); **3.** Provision of flexibility and short term energy trade with local businesses.

SOCIAL & ENVIRONMENTAL COSTS

Increased use of hardware devices comes along with negative impacts in terms of resource sustainability (mining of lithium for batteries, etc)
-- Data Security concerns

SOCIAL & ENVIRONMENTAL BENEFITS

1) Carbon dioxide reduction by providing energy flexibility, thus minimizing balancing energy capacities.
2) Knowledge gain by harvesting highly granular data on user consumption and distributed energy resource generation.
3) Signalling of efficient energy use to peer groups is likely to create awareness and incentivize positive mimetic behaviour.

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
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

Project: Fleet Management
Partner: LSW

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

- **Charging Infrastructure Provider (LSW):** strategic partnerships for infrastructure deployment
- **Fleet Operators**: key customers and partners adopting bidirectional charging
- **Electric vehicle / hardware device manufacturers**: that are interested in tracking the C02 reduction of their assets; collaboration for vehicle compatibility;
- **City government**: regulatory support, infrastructure planning, collaboration
- **Industrial companies** that integrate their own fleet in the program.
- **Research institutions** that make use of the harvested data.

CITY GOVERNMENT ROLE

Majority shareholder of company operating the business model (LSW). Control in terms of strategic guidelines and supervisory board participation.
Possible future role:
- Data sharing and collaboration
- Regulatory support, infrastructure planning
- Grid integration

ASSET OWNERSHIP

Electric vehicles: Private customers or company fleet;
Charging Infrastructure: Municipal electric utility

BUSINESS MODEL TYPOLOGY

Energy performance Contracting (EPC), crowdfunding
As potential product or service innovation which offers intelligent charging solutions for companies or private homes. Or as platform for fleet operators to manage charging solutions for electric mobility fleets.

FUNDING & FINANCING

Currently the business model is financed based on internal resources and partly from EU resources. Additional funding from public side or funding through private investments for infrastructure development may be applicable. Also possible are generating revenue through subscription fees from fleet operators.

CUSTOMER SEGMENTS

CUSTOMER

E-Mobility customers (companies or private households) are being offered functions to dynamically manage their EVs.

BENEFICIARY

- Fleet Operators
- City government
- Charging infrastructure providers
- Citizens

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Customer: Flexible control over the charging process of e-vehicles
Local Government: Highly reliable data on energy consumption from EV-fleet and identification of potential savings.
Cost savings: optimized energy management for potential cost savings.

COST STRUCTURE

- IoT device costs (e.g. charging point)
- IT (re-)development costs (apps)
- Research and development costs
- Potential infrastructure costs related to the deployment and maintenance of charging stations

SURPLUS

Revenue will potentially be invested in further development and e-mobility sectors and respective value added services for customers.

REVENUE STREAMS

- Subscription or licensing fees
- Infrastructure sales
- Grid support services

SOCIAL & ENVIRONMENTAL COSTS

Social Costs:
- Data Security risks/concerns
- Privacy concerns

Environmental Costs:
- Manufacturing and E-Waste
- Rare materials → Increased use of hardware devices comes along with negative impacts in terms of resource sustainability (mining of lithium for batteries, etc)

SOCIAL & ENVIRONMENTAL BENEFITS

- **Reduced Emissions:** Carbon dioxide reduction by providing energy flexibility, thus minimizing balancing energy capacities.
- **Knowledge gain:** by harvesting highly granular data
- **Grid stability:** supporting the stability of the energy grid during peak demand

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Project name: Microgrid inside the public grid
Partner: CENERO

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

Property owners
Grid operators: These entities are responsible for managing and maintaining the larger public grid.
Utility companies: They have a vested interest in grid stability and distributed energy resources.
(Renewable) energy plant owners or operators: Supplying energy sources for the microgrid.
Storage/battery owners or operators
Backend load management and energy management companies
Local municipalities, government regulatory authorities, utility companies: interest in the safety and power security within the microgrid and the adjoining public grid

CITY GOVERNMENT ROLE

Regulatory & Permitting Authority: They can streamline permitting processes.
Zoning and Land-Use Planning: Establish zoning regulations that allow construction of energy infrastructure.
Public-Private Partnerships: Can enter into partnerships with private energy companies to jointly fund, build, and manage microgrids.
City governments can oversee or assist in **Design and Planning, Grid Integration and Management, Energy Policy Development, Energy Efficiency Programs**

ASSET OWNERSHIP

Private Energy Companies: Own physical assets such as generation facilities, energy storage systems, EV charging stations and control infrastructure.
Utility Companies: Own transmission and distribution infrastructure, incl. substations and grid connections that interface with the microgrid.
Landowners
Renewable Energy Developers and Independent Power Producers (IPPs)

BUSINESS MODEL TYPOLOGY

Private Ownership and Operation: For-profit venture, selling energy services to the grid, end-users, or businesses within the microgrid's jurisdiction.
Energy Performance Contracting (EPC): Third-party service providers design, build, & operate. Compensated based on energy savings.
Public Ownership: To enhance grid resilience and provide critical services during outages.
Virtual Power Plant (VPP): Aggregating multiple distributed energy resources, including microgrids, into a VPP to sell energy, capacity, or grid services to utilities or grid operators.

FUNDING & FINANCING

Private Energy Companies
Private Equity
Property Owners
Funding may be supplemented by National, Provincial or Regional Government Funding, European Union (EU) Funding: Utility Investment, Energy Performance Contracts (EPC), Green Bonds and Sustainable Finance, Bank Loans and Project Finance, Renewable Energy Incentives, Energy Efficiency Grants

CUSTOMER SEGMENTS

CUSTOMER

Tenants (end-users): Purchase decentralised renewable electricity from the microgrid
Grid Operators: Purchase surplus electricity from the microgrid
Property owners: Use energy for general running of the property.

BENEFICIARY

Local Residents/End users: Benefits from improved energy reliability, reduced outages, and increased renewable energy ratio at an (often) reduced price.
Businesses and Employers: Local businesses, benefit from stable and sustainable power supply. This is valuable when considering CO2 footprint of the business.
Property owners or Real Estate Investment companies: Increased sustainability ratings increase value and attractivity of property.

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Cost Savings: Microgrids, through energy efficiency and renewable energy integration, lead to reduced energy costs.
Enhanced Energy Reliability: Ensure a stable and uninterrupted power supply. Enhance the capabilities of emergency services during power outages or disasters, which can be assessed by response time and effectiveness.
Environmental Sustainability: The use of renewable energy sources in microgrids decreases carbon emissions leading to improved air quality and ecosystem health.
Economic Growth: Improved energy reliability attracts businesses and investments, leading to job creation, increased local economic activity.

COST STRUCTURE

<u>Capital Expenses:</u>
Infrastructure Development: Initial installation of microgrid infrastructure, such as solar panels, CHPs, energy storage systems, control systems, meters.
Grid Integration, Transmission and Distribution Equipment
Energy Management and Monitoring Systems
Permits and Regulatory Compliance
<u>Operational Expenses:</u>
Maintenance and Repairs, Personnel, Energy Procurement: Expenses related to procuring energy from various sources, including renewable energy suppliers or the central grid. **Monitoring and Control Systems, Insurance & Security**

SURPLUS

Increasing the measures renewable energy ratio in the microgrid: Adding more PV Plants
Further surplus energy can be spent on:
Energy Efficiency: Implement energy-efficient technologies and practices
Energy Access Expansion: Extend microgrid services to neighbouring areas
Supporting Local Businesses: The surplus can be used to provide low-cost energy for local businesses, fostering economic growth and job creation.
Community Development: Part of the surplus can be directed towards refurbishment and enhancing public space to improve the overall quality of life for residents.

REVENUE STREAMS

Energy Sales: Selling energy to tenants and selling surplus energy to the public grid or nearby consumers.
Demand Response Services: Earn payments for adjusting its energy supply based on grid needs during peak demand.
Performance Contracting: Reduce peak demand charges for customers, and customers may pay fees for this service.
Environmental Credits: Trading environmental credits, e.g. carbon credits.
Ancillary Grid Services: Provide services to the public grid, e.g. frequency regulation or voltage support, receiving payments for grid stability contributions.

SOCIAL & ENVIRONMENTAL COSTS

<u>Social Costs:</u>
Job Displacement: In traditional energy sectors.
Privacy Concerns: The collection and use of data may raise concerns about data privacy and security.
Economic Inequalities: Initial implementation costs are high which could leave some residents without access to microgrid opportunities.
Aesthetics: May have an impact on the visual aesthetics of the community.
<u>Environmental Costs:</u>
Energy Consumption and CO2 Emissions: Manufacturing of components, can lead to increased energy consumption and pollution.
Natural Resource Depletion: The extraction and use of materials for microgrid components, especially lithium-ion batteries, can contribute to natural resource depletion.
Electronic Waste, Land Use and Habitat Impact

SOCIAL & ENVIRONMENTAL BENEFITS

<u>Social Benefits:</u>
Job Creation: renewable energy, energy management, technology, and maintenance
Sustainable Practices: Reducing the carbon footprint of the community and promoting environmentally responsible behaviour.
Community Resilience: Ensuring power supply during natural disasters, emergencies, and grid disruptions.
<u>Environmental Benefits:</u>
Increase in Energy Efficiency: Optimise energy use and reduce transmission losses.
Renewable Energy: The integration of renewable energy sources, such as solar panels reduce carbon emissions.
Sustainable Mobility: Support the charging infrastructure for electric vehicles

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Project name: Heat demand control
Partner: CENERO

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

Energy supplier and energy strategists (CENERO Energy)
Network operators
Energy monitoring and management company (Cenero.one)
Hardware producer/supplier (Homeatic suppliers)
Technicians for installation
Investors and Shareholders (European Commission)
Government and Regulatory Authorities
Research institutes and academia
Tenants (Seecon)

CITY GOVERNMENT ROLE

Price structures- Are electricity/gas or heating prices static or dynamic. How far in advance do you know what the price will be (e.g. 24 hours ahead).
Establishing responsibility for expenditure - Can hardware costs be transferred onto tenants or are owners responsible.
Policy development
Monitoring and Compliance laws
Data privacy laws

ASSET OWNERSHIP

Metrology and remote reading equipment - Saas owns equipment and leases it to customer
License/Software can be an intangible asset or an PP & E, depending on the situation
Customer base: owned by the company
Expertise and human resources
Brand ownership
Networks (heating and electrical) - owned by property owner, supplier or municipality

BUSINESS MODEL TYPOLOGY

Saas: Monthly fee for data collection per data point (3€). Initial onboarding fee for integrating the data points into the software, setting up access and creating desired charts/dashboards and automations.
Hardware provider: Sells or leases out the metrology and remote reading equipment.. The below are other options for this use case:
Energy efficiency service provider: as in contracting model below.
*Energy performance Contracting (EPC): An energy service company enters a contract with a building owner or operator to design, implement and finance energy-savings measures in the building. The contract includes a guarantee of energy savings, and the cost of the project is paid for out of the savings achieved over the contract term.
*Outcome-based Contracting: The public entity contracts a private organization to develop a specific outcome in the project and the private organisation takes on the risk and its paid should be based on the level of the achievement of the outcome.

FUNDING & FINANCING

Dependant on project scope, size, and geographical location:
Government Grants and Incentives: Many governments and local authorities offer grants and financial incentives to promote energy efficiency and sustainable heating practices.
Energy Efficiency Loans: Financial institutions and energy companies often provide loans specifically designed for energy efficiency projects. These loans may have lower interest rates or longer repayment terms.
Energy Performance Contracts: Energy performance contracts (EPCs) are agreements between the building owner and an energy service company (ESCO). The ESCO finances, implements, and maintains energy-saving measures, including heat demand control systems, in the building. The cost savings achieved through reduced energy consumption are used to repay the ESCO over a specified period.
Carbon Offsetting and Trading: In some regions, carbon offset programs or carbon trading schemes exist, allowing organizations to invest in projects that reduce greenhouse gas emissions.
Green Bonds and Financing: Green bonds are fixed-income financial instruments specifically dedicated to funding environmentally friendly projects.
Hardware and the installation thereof is relatively affordable.
An energy savings potential of up to 15 % is predicted.
In some cases, hardware costs can be transferred to tenants and added to rent. For instance, in the case of rented meters. (Germany)

CUSTOMER SEGMENTS CUSTOMER BENEFICIARY

Energy Efficiency and increased efficiency of resource use
Comfort and Indoor Environment Quality
Reduced Environmental Impact
Integration with Renewable Energy Sources
Regulatory Compliance and Certifications / Reporting / ESG
Sensibilisation of consumers/creating awareness
Data gathering fur further research and evaluation

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Reducing heating/cooling consumption - therefore lowering utility expenses.
Improve efficiency of energy generating plants, increase self-sufficiency (decentralised energy production)
Increase digitalisation (recognise potentials for coupling heating and cooling needs).
Reduction of CO_2 emissions
Improve thermal comfort of tenants/users

COST STRUCTURE

Equipment costs: Hardware and the installation thereof is relatively affordable.
An energy savings potential of up to 15 % is expected, dependant on several factors for instance previous system and cost structure.
In some cases, hardware costs can be transferred to tenants and added to rent.
For instance, in the case of rented meters. (Germany)
Cloud severs - Entry costs from 45 -950 €
Operational Costs: Office space, salaries, marketing, development, maintenance and support etc.

SURPLUS

Software developments to support innovative energy efficiency projects (Research and Innovation)
Environmental conservation efforts
Encourage customers to use savings to further improve systems

REVENUE STREAMS

Energy savings
Demand Response Programs - incentives for adjusting energy consumption during peak demand periods to alleviate strain on the grid
Equipment sales, rentals and installations
Saas fee
Initial Software set-up/connection fee
Consulting and Engineering Services
Data Analytics and Reporting
Potential for sale of Green Certificates
Potential to recognise waste heat and redirect it where it is needed. Customers could perhaps trade like this in the future.

SOCIAL & ENVIRONMENTAL COSTS

Job reduction in certain fields through digitisation
Stress and discomfort or mistrust among older generations who are not familiar with IT/IoT solutions
Increased demand for energy-intensive servers
Risk of privacy and cyber attacks
Electronic waste and battery waste as sensors are mostly battery powered
Life cycle of equipment. Shorter depending on the aggregation of data collected (due to battery lifespan

SOCIAL & ENVIRONMENTAL BENEFITS

Job creation in different sectors i.e. software development
Energy Efficiency and increased efficiency of resource use
Comfort and Indoor Environment Quality
Reduced Environmental Impact
Integration with Renewable Energy Sources
Regulatory Compliance and Certifications
Sensibilisation of consumers/creating awareness
Data gathering fur further research and evaluation

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas
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Project name: Decarbonisation of District Heating
Partner: ULEI

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

City council members, NGO, District managers, Energy and climate managers.

Open Data / Restricted data can be provided by stakeholders such as energy potential mapping, load profiles etc. Data protection rules must be considered within the project.

CITY GOVERNMENT ROLE

Providing regulatory framework that incentivizes the planning actions at the district level. Role as neutral stakeholder can encourage citizens with communication actions (citizen engagement, acceptance), workshops and stakeholder management (LSW, waste heat supplier).

ASSET OWNERSHIP

IRPopt modeling toolbox:
Leipzig university – process know-how,
Uni data center – hosting,
Software – open source

Data: Utility, Grid operator, City

BUSINESS MODEL TYPOLOGY

Service contract based on project proposal

FUNDING & FINANCING

National funding can boost the business model such as BEW or WPG in Germany for heat transition planning but not a need. Enabler for smaller utilities which could not afford a project otherwise.

CUSTOMER SEGMENTS

Business strategy units in the energy and buildings sector

CUSTOMER

Operators of district heating grids, Municipal utility, Energy service provider, District developers

BENEFICIARY

Tenants, Building owner, city government

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Customer:
decision support material for creating commercial business model and risk management, SDG, company image
Citizens:
improved air quality, decreased CO_2 price
City government:
improved image, possibility of replication to other districts, SDG, reaching of set emission reduction targets
University students:
Knowledge sharing through university

COST STRUCTURE

Personnel costs, Data center fee, Overheads

SURPLUS

As a university will not make profit only cover the cost of the project (see cost structure), there is no room for reinvestment.

There is, however, the possibility to apply for follow-up projects to further generate benefits for the community and citizens

REVENUE STREAMS

Project costs (time and material or fixed price)

SOCIAL & ENVIRONMENTAL COSTS

Carbon footprint of the project phase: Energy consumption, travelling to meetings

SOCIAL & ENVIRONMENTAL BENEFITS

Benefits can be determined after the project when concrete investment decisions are triggered. Such follow-up projects can increase local added-value. Citizenship can benefit from cost-efficient climate protection strategies, knowledge-sharing and rational public debate that leads to an increase in acceptance.

Inspired by MAtchUP Business Model Evaluation Framework, Social Business Model Canvas and MOVE2CCAM Business Model Canvas

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Project: Leipzig Energy Mapping
Partner: Leipzig Municipality

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

Partners:
- Office for Geoinformation and Land Use Planning
- SPARCS-Partners (LSW, WSL, LWB, CEN)
- German Federal Environmental Agency

Key stakeholders:
- Departments of Leipzig:
  - City planning office
  - Sustainable Development and Climate Protection Unit
  - Department of Housing and Urban Renewal
  - Office for Economic Development

CITY GOVERNMENT ROLE

- Stakeholder engagement
- Assure the financing
- Make the contracts
- Monitoring and evaluation planning
- Risk management

ASSET OWNERSHIP

- Municipality:
  - Urban Data Platform of City of Leipzig
  - intellectual property
  - It-licences

BUSINESS MODEL TYPOLOGY

Public owns/operates

FUNDING & FINANCING

Developing-Phase:
- Project SPARCS (EU funding)
- Project CUT (National funding: Federal Ministry of Housing, Urban Development and Construction)

Financing of the operation:
- Municipal

CUSTOMER SEGMENTS (3)

CUSTOMER

None – service is for free

BENEFICIARY

Departments of Leipzig:
- City planning office
- Sustainable Development and Climate Protection Unit
- Department of Housing and Urban Renewal
- Office for Economic Development

Citizens

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

Municipality
- one data space
- all stakeholders look at one tool: Developing ideas together
- think RE expansion and monument protection together
- understanding the effects from sector coupling
- Decision tool RE expansion
- Faster development of strategies, as data and analyses can be created within the administration

Citizens
- Public information and participation in measures to expand renewable energies

COST STRUCTURE

Developing cost >SPARCS, CUT
Financing of the operation > Municipal (staff costs, IT-developing, electricity, moderated process, building a structure > participating all developments and partners

SURPLUS

- Some Energy Map products are open source, allowing other municipalities to use them.
- Illustration of the expansion of renewable energy plants
- Presentation of the monitoring of the expansion of renewable energy plants

REVENUE STREAMS

Economic efficiency in terms of cost savings

SOCIAL & ENVIRONMENTAL COSTS (4)

Regarding Environmental Costs:
- The rising utilization of hardware devices has repercussions on resource sustainability.

Regarding Social Costs:
- Concerns related to data protection.
- Residents perceive ICT and Smart Energy Mapping initiatives as overreaching and exploitative because of mistrust.

SOCIAL & ENVIRONMENTAL BENEFITS (4)

Regarding social benefits:
- Increasing the efficiency and effectiveness of municipal services, boosting the liveability and productivity of the city.
- Strengthened democratic procedures and decision-making.
- Greater control over infrastructure and increased access to localized information for community residents.

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Project name: Continuation of citizen engagement in LWB-Kiosk "Nachbarschaftstreff" (LWB-Community Meeting Point)
Partner: Seecon

SPARCS BUSINESS MODEL CANVAS

PARTNERS + KEY STAKEHOLDERS

- LWB - Leipziger Wohnungs- und. Baugesellschaft mbH
- Seecon
- Municipality of Leipzig
- WSL
- Caritas
- Verbraucherzentrale
- Mosaik

CITY GOVERNMENT ROLE

- Strategic Approach
- Indirect role: for example, by covering ongoing energy and rental costs for tenants leaving in the district with low incomes

ASSET OWNERSHIP

LWB owns and provides for local citizens' engagement the LWB-Kiosk. In recent months, collaboration with the LWB employee responsible for social management, as well as its involvement in neighbourhood events, has exponentially increased.

BUSINESS MODEL TYPOLOGY

Seecon employees have worked within the framework of SPARCS. LWB social management employees provide a social service as part of their duties. The 3 NGOs are funded by local and national projects.
- Development of a citizen engagement model to be utilized from seecon in others similar activities. Funding needed!

FUNDING & FINANCING

Resources needed, for renting the place, marketing activities, specific social management personnel and employees. for purchasing giveaways or organizing specific activities such as film screenings and crafting sessions. However, our product would not operate without funding. LWB financed structure & employees. Seecon utilized SPARCS Budgets for Marketing and similar.

CUSTOMER SEGMENTS

CUSTOMER

So far, any products or services have been sold. maybe it could be possible to introduce and involve local partners who could sell food, drinks or craft products.

BENEFICIARY

The beneficiaries are the local citizen engaged in the activities.
Tenants benefit from a meeting place that offers a variety of activities provided by both LWB social workers and the SPARCS actors.
Input and contributions are also on our Instagram and LinkedIn channels.

VALUE PROPOSITION (CUSTOMER, IMPACT MEASURES & BENEFICIARY)

- The new cooperation between LWB-Kiosk and other NGOs offers a combination of products and services aimed at enhancing community engagement.
- The LWB-Kiosk plays a crucial role in promoting a sense of community and facilitating communication among Dunckerviertel residents.
- For seecon, this collaboration provides an opportunity to develop diverse formats of citizen engagement that can be replicated in the future by similar activities, adding value to their initiatives. Therefore, seecon as multiplicator by other cities if funding is found.

COST STRUCTURE

- Operational expenses: rent utilities, salaries, marketing, professional services

SURPLUS

Regarding the first point, although there may not be direct profits involved, it is possible to structure the offer in a way that allows for payments. For example, organizing a fair where participants can generate income from their stands. In this case, external benefits would be produced.
Moving on to the second point, offering proposals that can save money for citizens is important. For instance, introducing initiatives like tenant electricity (Mieterstrom) or our consultant model, which can provide cost-saving opportunities for residents.

REVENUE STREAMS

- Not determined

SOCIAL & ENVIRONMENTAL COSTS

Any social and environmental costs.
However, there are also potential risks involved, such as the non-acceptance of the proposed offers. There is a possibility of investing money and resources without receiving a positive feedback or the necessary participation. To address this, a contingency plan could include:
- Evaluating the target groups' interest and ensuring the planned activities resonate with them.
- Setting clear, achievable, and relevant KPIs for all stakeholders, including both the investing companies and the participating citizens.

SOCIAL & ENVIRONMENTAL BENEFITS

*Social:, social inclusion, citizen engagement, sustainable practices,
*Environmental: decrease energy consumption, reducing greenhouse gas emissions, decrease in external costs associated with the use of traditional energy sources.
* Attention to the sustainability of the materials used for the different activities and to the processes for management

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