D4.3 Implemented demonstrations of solutions for energy positive blocks in Leipzig

5/10/2022

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Deliverable administration

No & name	**D4.3 Implemented Demonstrations of Solutions for Energy Positive Blocks in Leipzig**				
Status	Released	**Due**	M36	**Date**	2022-10-05
Author(s)	See cover page				
Description of the related task and the deliverable. Extract from DoA	Lighthouse City of Leipzig complete demonstrations presenting the overall solutions for energy positive blocks as implemented. The deliverable is the final report of task T4.2, generated in collaboration with tasks T4.3-T4.7. (DEM/PU, M36) This report shows the achievement of the SPARCS objectives and efficient co-operation within the Leipzig Lighthouse Team, parallel work packages, other stakeholders and supporting partners.				
Participants	LEI, LSW, CEN, SEE, ULEI, WSL, FHG IMW, SUITE5, FHG IAO				
Comments					

V	Date	Authors	Description
0.1	29/08/2022	ALL	1st draft Leipzig partners
0.2	01/09/2022	LSW	Control by translation agency
0.3	02/09/2022	LEI, LSW	Deliverable checked by WP leader and released to reviewer (ESP, ULEI)
0.4	09/09/2022	ESP, ULEI	Feedback from reviewers (ESP, ULEI)
0.5	30/09/2022	LSW	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1	05/10/2022	VTT	Coordinator submits the deliverable to the EC

Dissemination level

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

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About SPARCS

Sustainable energy Positive & zero cARbon CommunitieS demonstrates and validates technically and socioeconomically viable and replicable, innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen-centred zero-carbon & resource-efficient economy. SPARCS facilitates the participation of buildings to the energy market enabling new services and a virtual power plant concept, creating VirtualPositiveEnergy communities as an 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 organisations, 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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LIST OF ABBREVIATIONS

API: Application programming interface

AMR: Annual Mismatch Ration

CDR: Community Demand Response

CEN: Cenero Energy GmbH

CES: Community Energy Storage

CHP: Combined Heat power

DPCA: Dual Participation and Collaboration Approach

EEG: Erneuerbare Energien Gesetz (engl. Renewable energy law)

EPB: energy positive blocks

ENWG: Energiewirtschaftsgesetz

EPN: energy positive neighbourhoods

EV: electric vehicle

FHG: Fraunhofer IMW, Fraunhofer IAO

GHG: Greenhous Gases

GmbH: Gesellschaft mit beschränkter Haftung (German for Ltd. Company)

HTTPS: Hyper Text Transfer Protocol

ICT: Information and Communication Technologies

ID: identification

IEQ: indoor environment quality

IoT: Internet of Things

IT: Information Technologies

IRPopt: Integrated Resource Planning and Optimisation (ULEI)

KPI: Key Performance Indicator

LEI: City of Leipzig, Digital City Unit

LCOES: levelised cost of energy storage

LED: light-emitting diode

LoRaWAN: Long Range Wide Area Network

LSW: Leipziger Stadtwerke

MQTT: Message Queuing Telemetry Transport

No: Number

PECM: positive energy community management

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PED: positive energy district

PV: photovoltaic panels

RES: renewable energy system

SC: self-consumption

SCC1: Smart Cities and Communities

SEE: Seecon Ingenieure GmbH

SMA: system measurement and plant engineering

SME: System Management Entity

STP: Spanning Tree Protocol

StromStG: Stromsteuergesetz

UDP: Urban Data Platform

VPP: Virtual Power Plant

WAN: Wide Area Networks

WP: work package

WSL: WSL Wohnen & Service Leipzig GmbH

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EXECUTIVE SUMMARY

This report explains all demonstration activities conducted in Leipzig, Germany, as part of the SPARCS project. An overall summary of the Lighthouse demonstrations in Leipzig will be presented at the outset, followed by a summary of the details in the demonstration areas. The demonstration activities cover various low-carbon improvements in urban development, including buildings, energy systems and the use of e-mobility measures and citizen engagement initiatives.

The Lighthouse City Leipzig focuses on two physical districts ("Leipzig West") and one virtual district. The virtual district consists of the virtual power plant, where a wide variety of assets are connected to create an optimised energy management system with real-time data. The platform (digital ecosystem) creates added value for Leipzig's energy system. The exchange of energy data with the various partners forms the basis for the development of the Virtual Energy Community.
In addition, various use cases were tested, such as the implementation of blockchain technologies, e-mobility concepts and a district heating study, etc. The solar thermal plant will be built in the Leipzig West district, which is part of the project. Finally, SPARCS also studies macro level demonstration actions in the city of Leipzig, for transforming the positive energy community. This step will focus mainly on the replication phase.

This report describes the implementation, the targeted outcome, schedule and partners' roles and responsibilities in the third year of the project.

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1 INTRODUCTION

Purpose and target group

This report shows detailed plans for the introduced actions and their sub-actions. The report is primarily aimed at organisations working in the SPARCS and collaborative Smart City stakeholder groups. It can also be of interest for other lighthouse projects and cities, and stakeholder partners as well as cities starting to plan similar types of smart city development.

Contributions of partners

Table 1 below depicts the main contributions from partners working on this deliverable.

Table 1: Contributions of partners

Partner	Contributions
LEI	Editor of the deliverable, responsible for content planning and allocation of writing responsibilities. Chapters 5.1 + 6
LSW	Chapter 1 “Introduction”, Chapter 2.1 “Introduction of task 4.2”, including the description of the actions and coordination with the partners / Chapter 3.1 “Introduction of the task 4.3” / Chapter 3.2 “Virtual Power Plant and Storage Solution”, including the description of the actions and coordination with the partners / Chapter 3.3 “Blockchain supported energy services”, including the description of the actions / Chapter 4 Introduction “E-Mobility Integration in Leipzig Lighthouse Demonstration” / Chapter 4.2. Description of the actions together with FGH / Chapter 4.3 Description of the action L16-1
CEN	Chapter 2.3 “Optimal energy distribution in industrial Spinnerei Block” Chapter 4.4 “Bi-directional charging for microgrid stabilisation”
SEE	Chapter 5.2 “Community support for energy transformation in the district”, incl. 5.2.1 “Action for community support for energy transformation in the district” and 5.2.2 “Desk support for interested citizens with information regarding cost-efficient installation of renewable energy sources such as PV and participation in the Positive Energy Community and for local businesses and private persons interested in rolling out project solutions”.
WSL	Chapter 2.4 “Efficient and human-centric social housing blocks”
ULEI	Chapter 2.2 Carbon-free district heating in “Leipzig West”, 3.2 Virtual Power Plant and Storage Solution, 3.4 Integration of Community Energy Storage (CES) and Community Demand Response and 5.2.3 Empirical research
FHG IMW + IAO	Chapter 5.2.2 Actions for community support for energy transformation in the district

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	Chapter 4.1 “Introduction to task 4.4” with the partners / Chapter 4.2 “E-Bus charging integration” with the partners / Chapter 4.3 “Load-balanced fleet management” with the partners / Chapter 4.4 “Bi-directional charging for microgrid stabilisation” - Action L1-4 with the partners
SUITE5	Contribution to Chapter 2.4 “Efficient and human-centric social housing blocks with application specific information” Chapter 3.5 “Ambient ICT Applications and User Interfaces for Electricity Consumption Transformation and Improvement”

Relationship to other activities

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

Table 2: Relationship to other activities in the project

Deliverables / Milestone	Contributions
D4.1	D4.1 (due in M12) reported detailed plan of demonstrated actions and sub-actions in Lighthouse City Leipzig.
D4.2	D4.2 (due in M24) is the continuation of deliverable D4.1 (due in M12), which reported the detailed plan of demonstrated actions and sub-actions in Lighthouse City Leipzig.

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2 ENERGY POSITIVE BLOCKS IN LEIPZIG LIGHTHOUSE DEMONSTRATIONS

Introduction to task 4.2

The objective of T4.2 is to demonstrate solutions for Energy Positive Blocks in Leipzig. The Lighthouse City of Leipzig is concentrating on two physical districts and one virtual district.

Leipzig focuses on different energy-related topics and would like to examine and review a wide spectrum of different topics.

The following section provides a description of tasks to make the central district heating system more efficient and, thus, lower in CO_2 emissions while, at the same time, increasing the share of renewable energies:

- Construction and integration of a solar thermal plant in the central district heating system
- Research to increase the share of renewable energies in the district heating network
- Assessing waste heat potential
- Integration of storage solutions

Different tasks to optimise the energy flow in a local micro network and tasks to improve the options for residents to control their thermal energy consumptions are implemented.

The goal of the Leipzig actions is to demonstrate how many small actions can be used to optimise the flow of energy in a district. In future, this should save energy, reduce CO_2 emissions, and increase the share of RES. The Lighthouse City Leipzig will show a concept, which could be used as a master for other districts in the city.

This task includes all demonstrated solutions for energy positive blocks in Leipzig, broken down into the following subtasks:

Subtask 4.2.1 Carbon-free district heating in “Leipzig West”
Subtask 4.2.2 Optimal energy distribution in industrial Spinnerei Block
Subtask 4.2.3 Efficient and human-centric social housing blocks

Carbon-free district heating in “Leipzig West”

The Subtask 4.2.1 “Carbon-free district heating in “Leipzig West” is designed to increase the share of RES in the central district heating system. The RES integration focuses on the planning, construction, and integration in the central district heating system of a solar thermal plant, which should supply the residents in the district with low CO_2 heating.

The next step leading to CO_2 neutrality is to research what this post-fossil future would look like.

The area “Leipzig West” will be used to create a blueprint for other districts depending on the specifics of each district (e.g., technologies).

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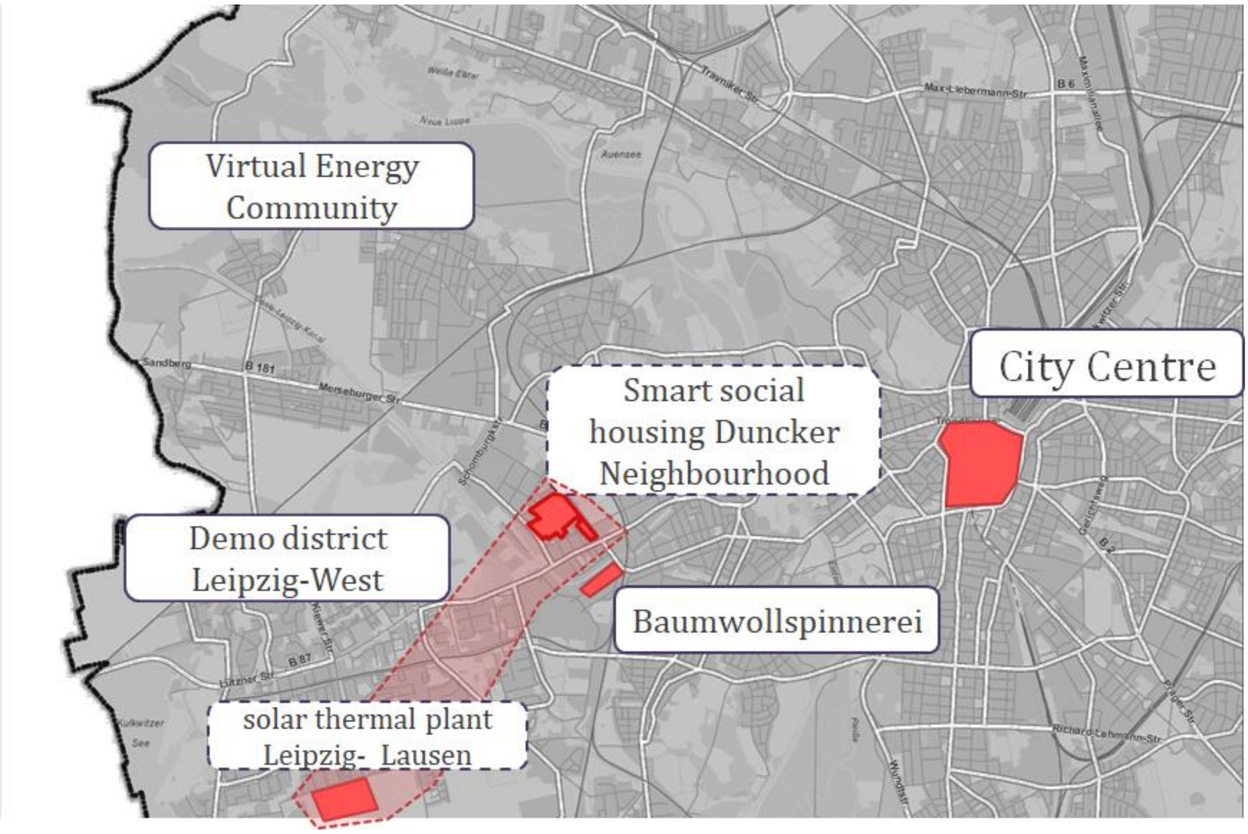

Figure 1: Location of demo district (Source: LEI)

SPARCS interventions for 2.2 Carbon-free district heating in Leipzig West are:

L6-1 The integration of a Solar Thermal Plant to District Heating – specifically in the area of Lausen (part of Leipzig West) with the potential of using approximately 65,000 m2 of collector area in total. At the first stage of expansion, a part of the area will be used to generate approximately 13 GWh/a of solar heat. The total space available makes an extention to 26 GWh/a possible.

L6-2 Estimating the potential of the district heating solution in the extended district of the Duncker neighbourhood for replication in other urban quarters.

L7-1 Integration of a heat storage in the existing district heating network to increase the solar coverage rate and equalise the solar heat output integrated into the heating network.

L8-1 Linking of the existing and newly constructed heat storage solutions with the demand side and allowing for more efficient controlling of the district heating network.

L6-3 Research to increase the share of renewable energies in the district heating network for a post-fossil future.

L6-4 Assessing waste heat potential within the city boundaries for integration in the central district heating system.

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Action L6-1	The integration of a Solar Thermal Plant into District Heating – specifically in the area of Lausen (part of Leipzig West) with the potential of using approximately 65,000 m^2 of collector area in total. At the first stage of expansion, part of the area will be used to generate approximately 13 GWh/a of solar heat. The total space available makes an extension to 26 GWh/a possible.
Demonstration plan	As part of the district heating transformation plan, LSW is committed to increasing the share of renewable heat in its heat generation portfolio. In 2019 a dedicated project team was appointed at LSW and tasked with the planning, building, and commissioning of solar thermal plants in the city of Leipzig to supply renewable heat to the district heating grid. The first steps of the team and its external partners were to create a feasibility study, find suitable locations and conclude the conceptual design phase.The new target date has been set for summer 2024. The following key steps have been taken: • Finalisation of conceptual design phase • Awarding of national funding for the project (innovative renewable CHP plants) • Securing of property (contractual) • Completing the first stage of the approval process (development plan) • Ongoing detailed design • EU tendering of major components has been started The next steps in the project will involve contract awarding (end of the tendering process) for the main components, completion of the detailed engineering phase, construction start of the heat transmission and operation station ("pump house") as well as the solar thermal plant. It is planned to supply approx. 13 GWh/a of heat with a targeted operations start in summer 2024. ULEI has applied a techno-economic model for the demonstration district. Customer groups were clustered according to the demonstration prototype district borders. Thereafter, data regarding the energy balance had been collected for the demand side. Current heat supply technologies determined the status quo scenario. For the green scenario, different amounts of solar heat were added to the system. In parallel, ULEI has supported the planning process of LSW by applying techno-economic modelling of the solar thermal plant that must be integrated in the demonstration district. The details of the modelling

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	approach and the results of this case study have been published in a scientific journal. [1] For this case study, some key performance indicators (KPI) that have been developed for the operationalisation of energy positive neighbourhoods (EPN) are applied. This includes KPIs for the so-called Onsite Energy Ratio (OER), Annual Mismatch Ratio (AMR), Maximum Hourly Surplus (MHS), Maximum Hourly Deficit (MHD), and Monthly Ratio of Peak hourly demand to Lowest hourly demand (RPL). Given the reference case, the AMR is calculated at 0.28. In Figure 3 the impact of the sensitivity analysis on the AMR is visualised depending on thermal storage size (from left to right: 10–100 MWh) and the model foresight (top-down: 48 h - 8760 h). It shows that lower levels of AMR are achieved with larger storage capacity in combination with enhanced forecast accuracy. However, enlarging the storage capacity alone does not necessarily reduce the AMR since a shorter forecast accuracy impedes the potential for utilising the storage. For example, a storage capacity larger than 20 MWh or 30MW will not yield a further decline of the AMR after limiting the optimisation horizon to 48 h or 336 h.  Figure 2: Visualisation of the solar thermal plant in Leipzig West as shown in the public participation of the approval process. (Source: LSW)

[1] Uspenskaia D, Specht K, Kondziella H, Bruckner T. Challenges and Barriers for Net-Zero/Positive Energy Buildings and Districts—Empirical Evidence from the Smart City Project SPARCS. Buildings. 2021; 11(2):78. https://doi.org/10.3390/buildings11020078

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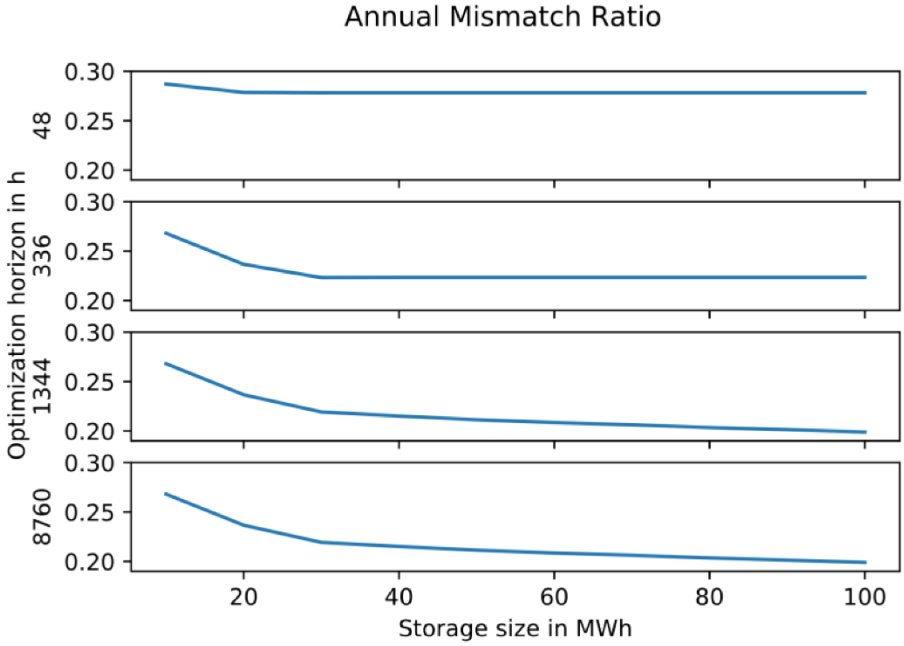
<tr><td></td><td colspan="2">

Figure 3: Annual Mismatch Ratio (AMR) for the demo prototype district depending on the thermal storage capacity and the model foresight (Souce: ULEI).</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>LSW: task leader, coordinator, owner of the generation plant</u>
LPZ: approval process (permit) and support during the search for a location
ULEI: Scientific supervisor</td></tr>
<tr><td rowspan="3">Milestones/ Tangible outcome</td><td>M15</td><td>Model results and evaluation (report, contribution to D4.2)</td></tr>
<tr><td>M56</td><td>Commissioning of the solar thermal plant and integration in the central district heating system</td></tr>
<tr><td>M56-60</td><td>First data received from asset</td></tr>
<tr><td>Outlook until M60</td><td colspan="2">The approval process is progressing according to the updated plan and we expect final approval by the end of 2022 (so, theoretically, start of construction could take place in Q1 next year).
There are several subsidy schemes available for solar plants and we will be handing in the first application. The notification of approval for the subsidy is a prerequisite for the official order to the plant manufacturer. The re-evaluation of the project will be done by mid-November 2022.</td></tr>
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Action L6-2	Estimating potential of the district heating solution in the extended district of Duncker Neighborhood for replication in other urban districts

Demonstration plan	LSW: Development of an expansion concept for district heating to increase energy efficiency in “Leipzig West”, taking into account the ecological aspect in terms of reduced CO_2 emissions by replacing fossil heat generators. The integration of alternative heating solutions in the district heating system will be examined and evaluated.
	
	This also helps to gain important knowledge regarding to the applicability of further district developments.
	
	The aim is to increase the district heating supply in “Leipzig West” and the share of renewable energies in the Leipzig district heating system in the future.
	
	ULEI: ULEI has provided a model-based analysis of alternative district heating solutions. Among others, technology options and potential sites for solar thermal plants are evaluated regarding their technical and economic potential for integration in the district heating network.
	
	In order to carry out the model-based analysis of alternative district heating solutions, ULEI has further developed and subsequently applied the techno-economic modelling framework IRPopt.
	
	Modelling has started with the collection of parameters and boundary conditions assuming the pre-war situation, e.g.:
	
	Wholesale market prices for electricity for the year 2030,
	Commodity prices, e.g., for natural gas, biomass and waste,
	Heat demand profiles and customer types,
	Generation technology costs,
	Decentralised generation technology potential such as solar and waste heat.
	
	The data for the business scenarios were collected and prepared in structured workshops with business units of LSW. Based on the data collection, we implemented the expected state of the generation portfolio for the central district heating system of the year 2030, that consists of the following thermal capacities
	
	• Waste-to-energy plant (CHP waste: 25 MW_{th})
	• Biomass CHP (CHP Bio: 25 MW_{th})
	• Solar thermal plant (Solar: 35 MWth)
	• Gas CHP
	    • Open cycle gas turbine (CHP Süd: 150 MW_{th})
	    • Combined cycle gas turbine (CHP Nord: 200 MW_{th})
	• Gas-fuelled combustion engines (Block units, iBHKW: 27MW_{th})
	• Thermal storage capacities (Tstore: 175 MW_{th})
	• Power-to-heat (iP2H: 3 MW_{th})
	• Gas-fuelled heat plant (Kulkwitz: 150 MW_{th})

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The each unit's expected dispatch for the year 2030 is represented in the following figure. Moreover, we have analysed the impact of increasing CO_2 prices.

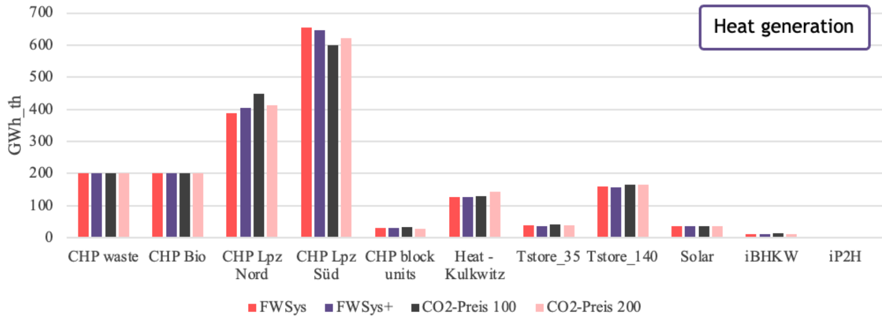

Figure 4: Reference scenario for Leipzig's district heating system (DH) in 2030 (scenario FWsys). Scenario FWsys+ assumes the integration of the Duncker neighbourhood in the DH. The results are compared for increasing CO2 prices of 100 and 200 €/t. (Source: ULEI, own calculation)

The results show that the majority of the annual heat demand will be provided by the large-scale gas CHP plants (ca. 1000 GWh). Nonetheless, part of the thermal base load is generated with waste and biomass CHP units independently of scenario assumptions (200 GWh each). The solar thermal plant contributes 37 GWh p.a. The additional heat demand of the Duncker neighbourhood is mainly provided by CHP Nord (Scenario FWsys+). Moreover, the CO_2 price increase also primarily influences the large-scale CHP units since additional profits can be generated from the electricity market.

In Fig. 5, we demonstrate the economic and environmental benefits of different heat supply options such as district heating, onsite gas boiler, and onsite heat pumps. Based on the levelised cost of heat supply (LCOH, x-axis), district heating has to be preferred, followed by the gas boiler and the heat pump. With respect to the emission factors, which are calculated using the Carnot method (y-axis), DH is advantageous as against heat pumps - and both are far better than the gas boiler option. Introducing a CO2 tax of 200€/t in parallel to the EU ETS has a clear impact on the LCOH of the gas boiler, doubling the initial value by more than 100%. For heat pumps, the grid electricity cost increases, while the emission factor is reduced in return. In contrast, the CHP units of the DH system can yield higher profits from the electricity markets, reducing the LCOH. The analysis shows that the implementation of DH in the demonstration district can reduce CO2 emissions and stabilise the cost of heat provision in the context of rising CO2 prices.

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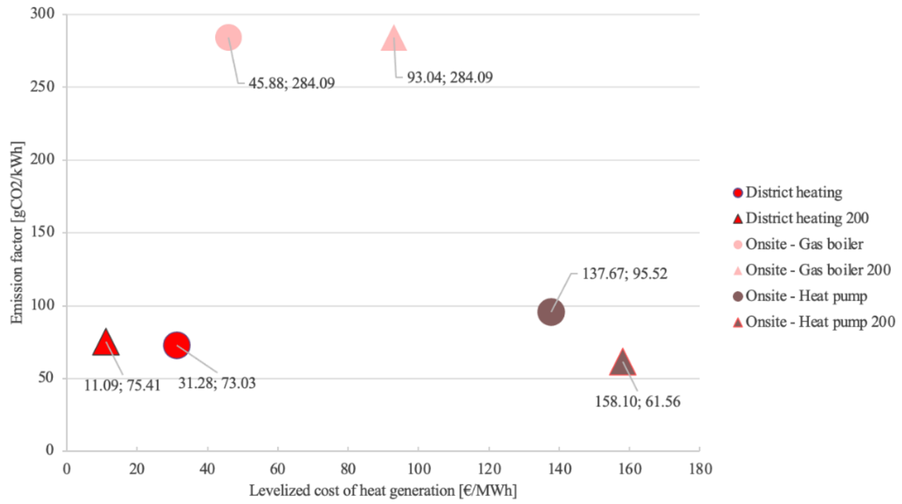

Figure 5: Comparison of thermal supply options for the Duncker neighbourhood in terms of the levelised cost of heat supply and CO2 emissions (w/o cost components for the heating grid). To show the sensitivity we compare the status quo with a CO2 price of 200 €/t. (Source: ULEI, own calculation)

For the analysis of the replication potential we have extended the model as follows:

Extension of the DH to more than one district leading to additional heat demand (Scenario x5, x20),

Extension of the solar thermal capacity, incl. heat storage by a factor of 3 and 10,

Combining the extension path with higher CO_2 prices of 100 and 200 €/t.

Starting with the reference case, an extension of the DH grid by the factor of 20 times the Duncker neighbourhood slightly increases the the emission factor at roughly the same costs (grey data points). Increasing the solar thermal capacity reduces the emission factor at first, increasing CO2 prices reduces the LCOH of the entire system, as shown above. Further upscaling leads to additional emission reductions, but at higher costs now.

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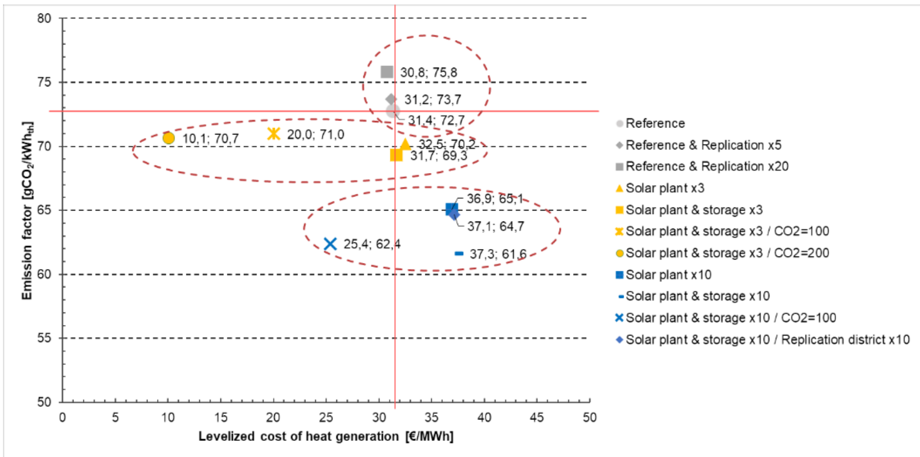

Figure 6: Analysis of the replication potential of an extension of the district heating system, based on the mid-term strategy. (Source: ULEI, own calculatiuon)

Roles and responsibilities	**<u>LSW: Task leader, coordinator</u>** LPZ: Urban Planning Office, strategic planning of STP in urban development ULEI: Potential analysis and review of technical and economic feasibility; scientific supervisor	
Milestone/ Tangible outcome	M36	Report / concept including the following points: Recording the current status Comparison of the supply options Estimating CO_2 reduction potential
Outlook until M60	Parameter update Scientific publishing	

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Action L7-1	Integration of a heat storage in the district heating network to increase the solar coverage rate and equalize the solar heat output integrated into the heating network.
Demonstration plan	LSW build a heat storage system in parallel with the planning and construction activities of the solar thermal plant. Storage parameters: 2-zone hot water storage tank, approx. 1.8 GWh heat capacity, 60m height, max. 120°C storage temperature, 43,000 m^3 stored water volume To facilitate elevated water temperatures and prevent boiling, an insulated layer (metal membrane) divides the tank in two zones. The cooler upper zone increases the pressure in the lower zone, enabling temperatures above boiling point. The heat storage system is part of the new cogeneration plant project, planned in the south of the city. The system will be integrated into the district heating system and can, therefore, be used by all heat generation plants of LSW. The overall plan of LSW is to start storage system operations in 2022.  Figure 7: Completed heat storage (Source: LSW) In M31 the superstructure of the heat storage was completed, including all auxilliary components (except the facade). In M32 the filling with district heating water commenced and takes approx. 3 months. Therefore, commissioning and testing starts in M35-36. ULEI expansion of the scope of L6-2. ULEI integrates the above-mentioned technologies into the model and evaluates the effect on cost and emissions (see section above).

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	 Figure 8: Completed heat storage and power plant buildings. (Source: LSW) The thermal storage is an element of the reference generation portfolio. (See progress L6-2).	
Roles and responsibilities	**<u>LSW: Task leader, coordinator, owner, and operator of the plants</u>** ULEI: Scientific supervisor	
Milestone/ Tangible outcome	M24	Model results and evaluation (report, contribution to D4.2)
	M36	Commissioning start of the heat storage system in combination with the district heating grid

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Action L8-1	Linking of the existing and newly constructed heat storage solutions with the demand side and allowing for more efficient controlling of the district heating network.	
Demonstration plan	Depending on the season, LSW operates the district heating grid at elevated temperatures which exceed the boiling point of water. Therefore, a pressurised hot water storage system was constructed in 2016 to increase the degree of utilisation and efficiency of the CHP Combined Heat & Power plants in the grid. In order to increase the heat storage capacity, a new 2-zone, hot water storage tank is constructed together with a new CHP plant (see L7-1). To facilitate elevated water temperatures and prevent boiling, an insulated layer divides the tank in two zones. The cooler upper zone increases the pressure in the lower zone, enabling temperatures above boiling point. The heat storage system is located to the south of the city, at a different location than the existing heat storage plant. The system will be integrated in the district heating grid and can, therefore, be used by all heat generation plants of LSW. The overall plan of LSW is to start storage system operations by 2022. The thermal storage is an element of the reference generation portfolio. (See progress L6-2).	
Roles and responsibilities	**<u>LSW: Task leader, coordinator, owner, and operator of the plants</u>** ULEI: Scientific supervisor	
Milestone/ Tangible outcome	M22	Start of construction works
	M35-60	Commissioning of the plant and regular operation

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SPARCS

Action L6-3	Research to increase the share of renewable energies in the district heating network for a post-fossil future.

Demonstration plan

Extending the temporal focus of L6-2, we have implemented a potential analysis and evaluation of integral regenerative heat sources in the district heating network for the development of a climate-neutral heat supply system.

Based on the mid-term strategy of LSW, ULEI has modeled and evaluated scenarios of the district heating system for the year 2045. The focus is on the development of the supply side technologies. The impact on CO_2 emissions and costs are evaluated. As a prerequisite for modelling, hydrogen-based conversion technologies were integrated into IRPopt (link to L18-1).

Based on workshops and discussions with LSW, we have developed a vision for the long-term transition of the district heating system. Regarding the technology portfolio, we project four basic scenarios that represent the core and primary energy sources of the heat supply:

Portfolio 1: (Synthetic) Natural gas incl. CCS,
Portfolio 2: Green hydrogen,
Portfolio 3: Diversified mix of carbon-neutral sources, and
Portfolio 4: Electricity.

An overview on the composition of the heat generation capacities for the portfolios is given by the following figures:

Portfolio	1		
Name	*Gas + CCS*		
Assumptions	Natural gas supply at low cost CCS infrastructure available		
	Primary energy	Conversion type	Capacity (MW_th)
Base and intermediate load	Natural gas	Gas OCGT	150
		Gas CCGT	200
		Block engine	35
Peak load and security margin	Natural gas	Heat plant	130
		Heat storage	135
Intermittent			
Total			***650***

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Portfolio	2		
Name	***Hydrogen***		
Assumptions	Hydrogen imports for district heating		
	Primary energy	Conversion type	Capacity (MW_th)
Base and intermediate load	Hydrogen	Gas OCGT	300
		Block engine	15
	Electr/Waste heat (medium)	Heat pump	100
Peak load and security margin	Hydrogen	Heat plant	100
		Heat storage	135
Intermittent			
Total			***650***

Portfolio	3		
Name	***RES mix***		
Assumptions	Diversified use of biomass, waste heat, and solar		
	Primary energy	Conversion type	Capacity (MW_th)
Base and intermediate load	Bio gas	Gas OCGT	150
	Bio mass	Steam turbine	25
	Waste	Steam turbine	25
	Industrial waste heat	Heat exchanger	100
	Electricity/Waste heat (medium)	Heat pump	50
Peak load and security margin	Bio mass	Heat plant	45
		Heat storage	135
Intermittent	Solar	Thermal plant	120
Total			***650***

Portfolio	4		
Name	***Power-to-heat***		
Assumptions	Focus on electrification of heat supply		
	Primary energy	Conversion type	Capacity (MW_th)
Base and intermediate load	Bio gas	Block engine	15
	Industrial waste heat	Heat exchanger	100
	Electr/Waste heat (medium)	Heat pump	50
	Electr/Waste heat (low)	Heat pump	50
Peak load and security margin	Electricity	Power-to-heat	200
		Heat storage	235
Intermittent			
Total			***650***

Figure 9: Composition of heat generation portfolios for the long-term transition of the district heating system in Leipzig (Source ULEI).

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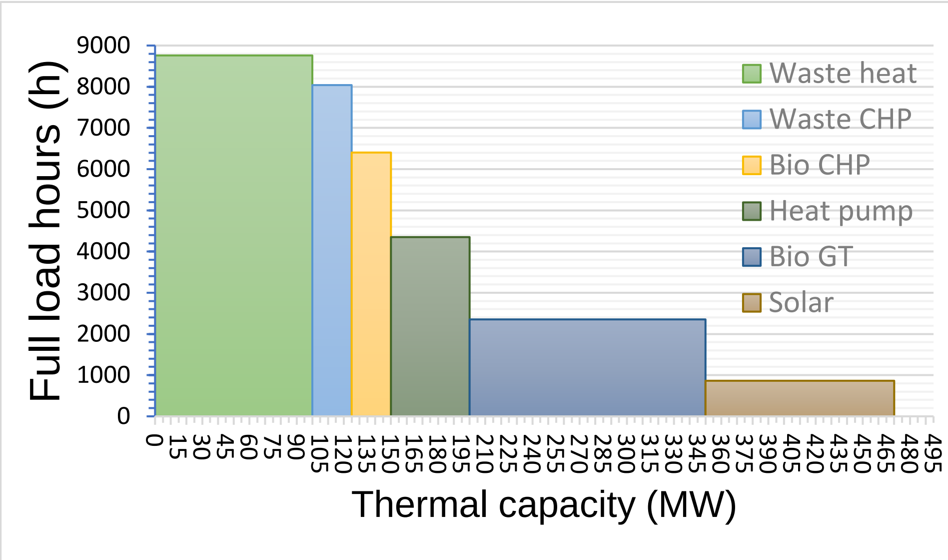
<table>
<tr><td></td><td colspan="2">

Figure 10: Exemplary results of the economic dispatch of portfolio 3 in terms of full load hours (Source: ULEI).</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>LSW: Task leader, coordinator</u>
LPZ: Feedback from municipal strategies
ULEI: Potential analysis and review of technical and economic feasibility</td></tr>
<tr><td rowspan="2">Milestone/ Tangible outcome</td><td>M24</td><td>Intermediate model result and evaluation (report, contribution to D4.2)</td></tr>
<tr><td>M36</td><td>Report which includes the following points:
• Status analysis
• Description of technologies / possible technologies
• Check compatibility with district heating requirements
• Evaluate the impact on CO_2-emissions and costs
• Model results and evaluation with data update (report, contribution to D4.2)</td></tr>
</table>

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Action L6-4	Assessing waste heat potential within the city boundaries for integration in the central district heating system.
Demonstration plan	One objective of our future energy solutions is to couple sectors so that waste heat from industry and commerce can be used for heating applications. Potential waste heat sources in urban areas are to be localised, analysed and their suitability for heat use assessed. Examination of possible waste heat sources suitable for the integration of district heating. An estimate of the waste heat potential in Leipzig, an extensive investigation as well as research are necessary in order to carry out a valid evaluation of usability. The collection of various waste heat potentials represents a particular challenge here. The difficulty so far has been filtering of relevant companies or potential waste heat sites. In order to determine waste heat sources from flue gases, contact was made, and data was exchanged with the regional immission control authority regarding systems subject to approval in accordance with the Federal Immission Control Act. Unfortunately, the desired level of data was not obtained. The further inquiry via the municipal office for the environment unfortunately also had poor results. The route via the Office for Economic Development and the Chamber of Industry and Commerce, therefore, offered a larger database of listed companies in Leipzig and the surrounding area. Filtering according to company size and industries relevant to waste heat (especially telecommunications / data centres and manufacturing) revealed a large number of possible companies with waste heat (approx. 90). Figure 11 shows the district heating supply area (red marker) in Leipzig. With regard to the requirement to integrate waste heat into the district heating network, half of the potential (blue marker) to be tested is located in the district heating supply area.

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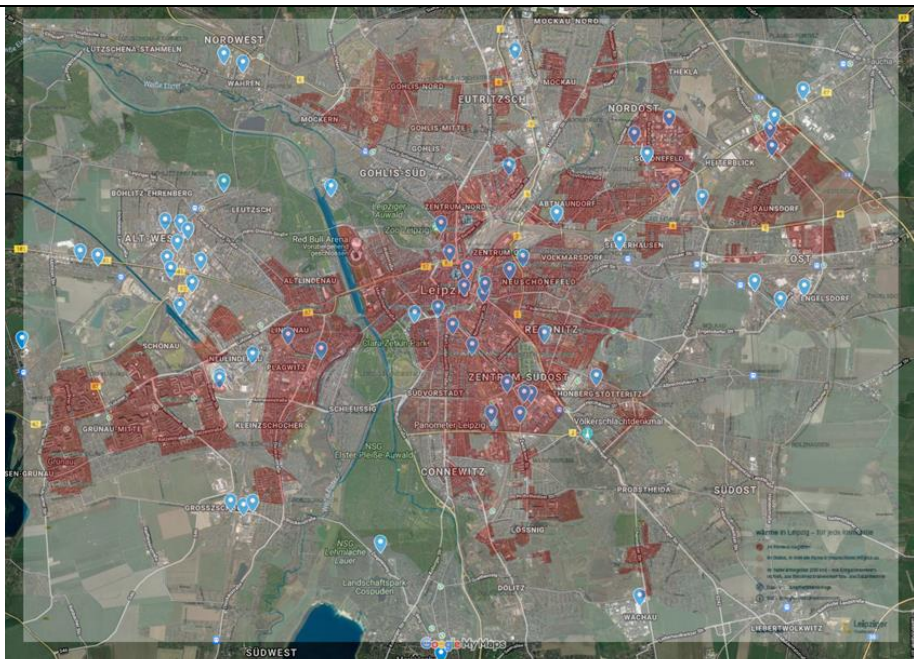

Figure 11: District heating supply area (Source: LSW)

With the current development of a guideline for the use of waste heat for companies and the creation of the catalogue of requirements for the suitability of reusing waste heat, the company audit according to a prioritised procedure begins.

Unfortunately, only few responses to the enquiries regarding a potential query have been received.

With expert support and further focusing on the 20 prioritised companies, we started to approach them again. Through direct contact with the technical managers of the companies, the level of interest increased and is still increasing. After these initial technical discussions, the following general interim balance (minus the sewage treatment plant project) can be drawn:

- Total waste heat output = 5 MW

- Total waste heat quantities = 27.9 GWh

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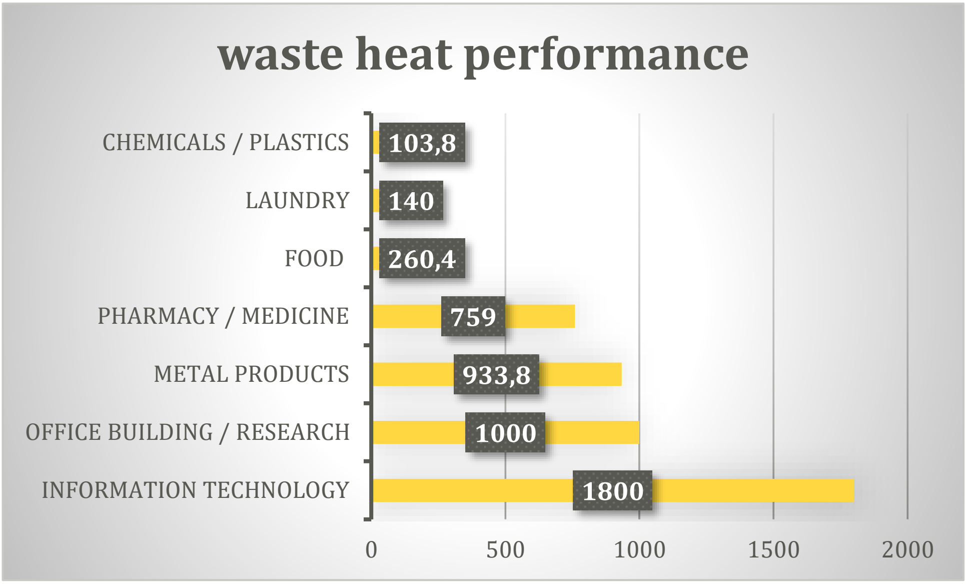

Figure 12: Industries with waste heat performance (Source: LSW)

The company enquiries will be continued.

The following waste heat potentials are currently being planned for implementation:

An existing neighbourhood with around 800 flats is to be supplied with unavoidable waste heat from the oil recoolers of the Leipzig South CHP plant. In order to be able to use the waste heat of up to 50°C, a heat pump will be installed in the oil cooling system. An additional heat storage tank (<10 MWh) will compensate for time shifts between demand and waste heat supply. Thus, between 3500 - 5000 MWh of waste heat can be reused per year.

Furthermore, a 20-km-long district heating transport pipeline is being planned in order to be able to use industrial waste heat from the Leuna chemical site. This can supply up to 84 MW and, as a future base load generator, up to 620 GWh.

</td>
</tr>
<tr>
<td>Roles and responsibilities</td>
<td><u>LSW: Task leader</u></td>
<td>Report including the following points:
Localisation concept
Potential waste heat quantified
Verification of compatibility with district heating requirements</td>
</tr>
</table>

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Optimal energy distribution in the Industrial Spinnerei block

The buildings and premises of the Spinnerei block (former cotton mill) were originally constructed in 1884 and are protected under the Monument Protection Act. The buildings are mainly built of brick and partially renovated. The buildings prototype area is approximately 17,000m^2. Buildings 18 and 14 are the two biggest buildings on site and, in terms of use and substance, they are representative of the other buildings. The area is a best practice example for the revitalisation of a former industrial site used for cultural activities and includes a StartUpLab (‘from cotton to culture’). StartUps have been based here ever since the Spinnerei block was reopened in its current form. The next step is to develop a smart positive energy district with flexible and intelligent heat and electricity management. Future plans include a new and zero-energy Smart Infrastructure Hub and refurbishment strategy derived from buildings no. 14 and 18.

The start-up Accelerator SpinLab, which is based at the Spinnerei block along with the business school HHL, will play an active part in developing new business models along the way. Both the SpinLab and the HHL Business School are central stakeholders and involved in SPARCS already. The measures at the Spinnerei block premises include intelligent heating demand control, utilising the old walls of the buildings which function as a heat storage buffer, integration of RES in the local micro electricity grid and bidirectional charging for electrical vehicles, using their storage capacity as a buffer.

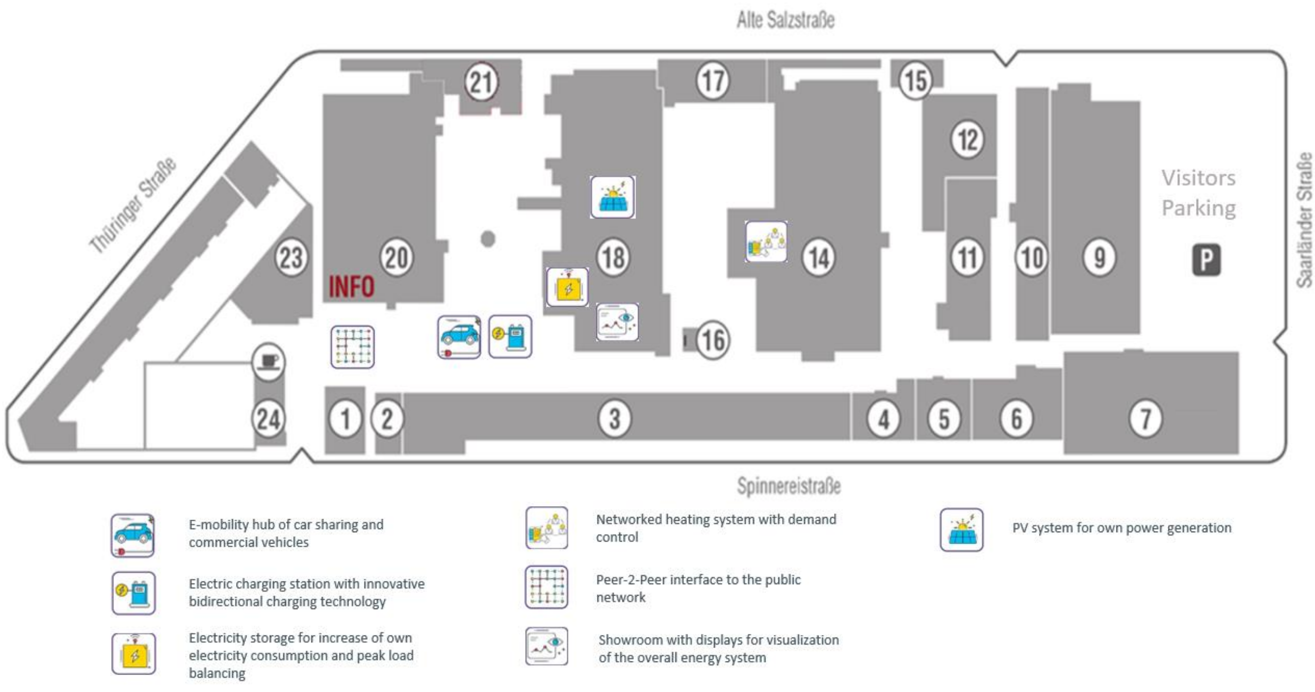

Figure 13: Map of Spinnerei block* (Source: CEN)

* The numbers in Figure 13 refer to the labelling of the different buildings.

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Figure 14: Entrance area of Spinnerei block (Source: CEN)

Figure 15: View of the Spinnerei block (Source: CEN)

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SPARCS measures for optimal energy distribution at the industrial Spinnerei block are:

Action L2-1 Installation of equipment to allow for intelligent balancing of PV, CHP, and user demand control

Action L2-2 Balancing the microgrid against the city-wide virtual power plant selling energy when demand is exceeded in the microgrid and vice-versa. This action will be closely linked to the business models based on blockchain technology.

Action L2-3 Analysing and integrating energy storage solution with bulk batteries to balance production and consumption within the microgrid.

Action L3-1 Coupling the heating needs with the load profile of the microgrid and taking into account the specifics of the historic building which function as a heat buffer.

Action L3-2 Provide user interface with air quality info and implicit demand control: demand is expected to be lowered through direct feedback and consumption overview as well as recommendations for the tenants behaviour.

Action L2-1	Installation of equipment to allow for intelligent balancing of PV, CHP, and user demand control.
Demonstration plan	The Objective of L2-1 is to provide solutions for energy positive blocks and districts that operate as an active part of the city's whole energy system, including solutions for integration of RES (for example solar photovoltaic (PV) panels) in an existing district heating network and in a virtual power plant. An array of solar PV panels is used in combination with an electrical battery to increase the percentage of renewable energy in the network. Sensors and monitoring equipment are installed to ensure the user demand-oriented control of energy flows. As part of this equipment, remotely readable smart meters are pictured in Figure 14 compared to an old meter. A combined heat and power (CHP) unit in the network is also integrated to the intelligent balancing of the energy network.

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Figure 16: Old electricity meter and new remotely readable meter (Source: CEN)

- Smart meters are installed, and connected to theEnergy Management-Software
- Technical components such as the PV plant and the bulk battery are installed, in operation and interconnected through the digital Load and Energy Management

Roles and responsibilities	**CEN: Task leader**	
Milestones/ Tangible outcome	M12	Concept confirmed and aligned with partners
	M30	Installation of the solar PV panels
	M30	Installation of the technical components
	M30	Documentation of fixed parameters for the equipment
	M36	A working database is developed and operational

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SPARCS

<table>
<tr><th>Action
L2-2</th><th colspan="2">Balancing the microgrid against the citywide virtual power plant selling energy when demand is exceeded in the micro grid and vice-versa. This action will be closely linked to the business models based on blockchain technology.</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">Within the SPARCS project, LSW is going to develop a citywide virtual power plant. A Virtual Power Plant consists of a group or network of decentralised energy generation technologies, such as solar PV panels connected to flexible power consumers and energy storage capacity. One part of this system is an interconnection to the energy microgrid at the Spinnerei block to buy and sell energy.
• CEN instals energy monitoring equipment at the transformation station near the Spinnerei block to measure the energy flow between it and the Leipzig citywide energy grid.
• LSW establishes a continuous exchange of information regarding the extra energy supply or demand and prices for this energy and will process and bill these transactions.
• The central Letter of Intent (LoI) between LSW and CEN to realise peer-to-peer trading has been signed and provides the basis for all further action-related tasks.
• Energy monitoring of the transformation station is installed.</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>CEN: Task leader</u>
LSW: Responsible for delivering an interface for peer-to-peer energy trading</td></tr>
<tr><td rowspan="3">Milestones/ Tangible outcome</td><td>M18-M24</td><td>Letter of Intent to confirm which part of the energy network is included in balancing of the microgrid and the virtual power plant.</td></tr>
<tr><td>M32</td><td>Successful installation, qualification, and maintenance plan established for the equipment.</td></tr>
<tr><td>M38</td><td>Present a working diagram of the entire energy system for interested affiliated city consortiums. To include the solar PV panels and an explanation of the sensors and equipment used to monitor the energy system's combined heat and power station and of the electrical and heat grid stabilisation. Due to supply bottlenecks at the component level, commissioning of the PV system is postponed to M38.</td></tr>
</table>

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Action L2-3	Analysing and integrating the energy storage solution with bulk batteries to balance production and consumption within the microgrid.	
Demonstration plan	The bulk battery acts as a central interconnector of temporally fluctuating energy flows between the generators (PV, CHP, electrical feed-in by bidirectional charging) and consumers (daily demand, E-mobility). As storage, it buffers electrical energy when it is not needed and makes it accesible whenever there is a demand. This is an important factor for stabilising the energy microgrid at Baumwollspinnerei. This is further optimised by integrating the battery (together with the other energy-grid components) into load management. The specifically designed control order steers the energy accordingly between consumers, generators and the storage which ensures a higher net stabilisation. Storage is in place, connected and integrated into load management. The interface for digital battery monitoring has been designed and is in operation.	
Roles and responsibilities	**CEN: Task leader**	
Milestones/	M24	Concept confirmed and aligned with partners
	M30	Installation of the battery
	M30	Installation of the technical components for the monitoring system
	M36	Documentation of fixed parameters for the equipment
	M36	The working database is developed and operational

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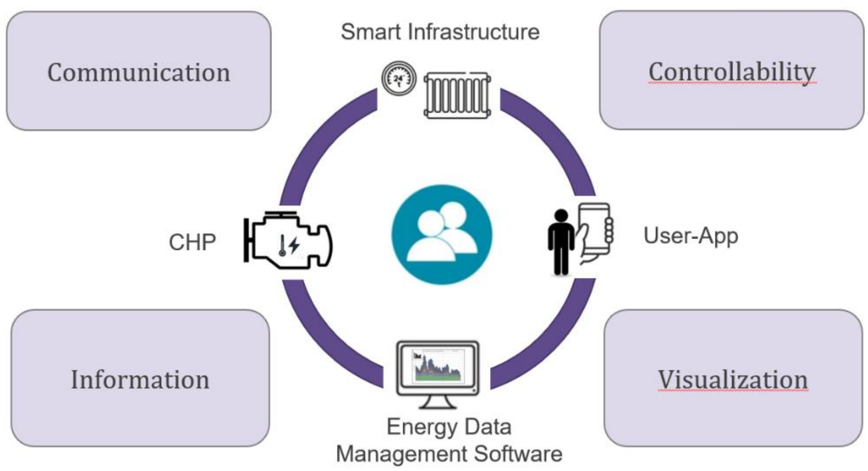
Action L3-1	Coupling the heating needs with the load profile of the microgrid and taking into account the specifics of the historic building which functions as a heat buffer.
Demonstration plan	The aim of this task is to significantly improve the overall energy performance and energy efficiency of building no.14, as well as to optimise energy consumption by installing new technologies in energy management, storage solutions and RES integration. Therefore, smart energy equipment is installed which communicates information about the heating demand of selected rental areas. The intelligent thermostats are also able to learn about their surrounding conditions and to integrate these into the heating process. As a result, the heat-buffering potential of the historical walls of building no. 14 is included in the heating process. If no heat is needed, the components in the rental area communicate this to the corresponding steering valve and pump system which distributes the heat to the different building segments. The resulting heat demand is regularly reported to the tenants by a web tool. Fig.17 shows a scheme of the user-oriented heating concept. Components in the tenant area and the heat distribution are installed and in operation. Thermostats and associated system components are installed. Information tool is set up.  Figure 17: Scheme of the planned heating system (Source: CEN)

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	 Figure 18: Building no. 14 from the outside (Source: CEN)	
Roles and responsibilities	**<u>CEN: Task leader</u>**	
Milestones/ Tangible outcome	M30	Installation, qualification of the sensors
	M36	Database qualification completed

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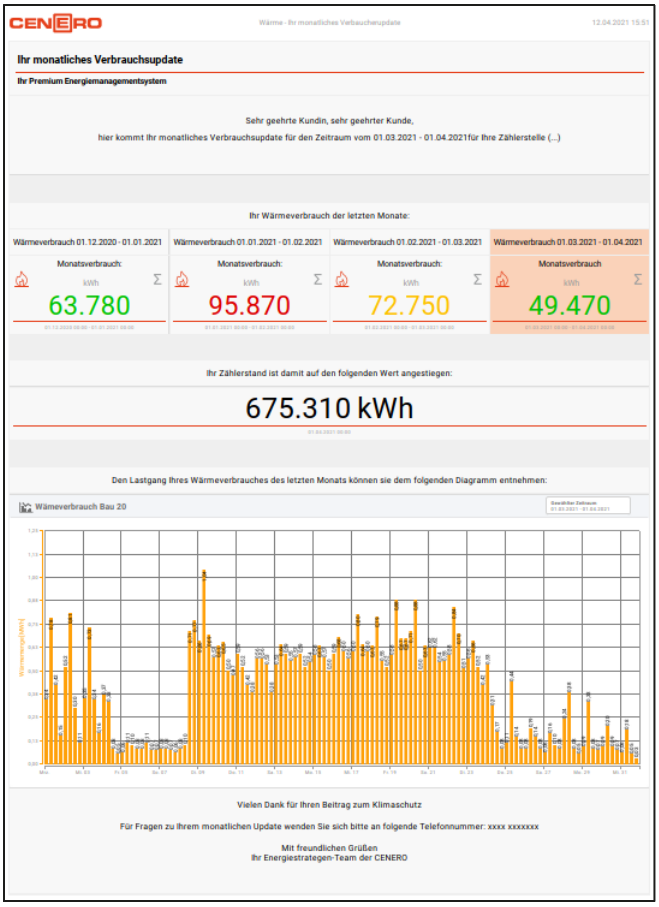
Action L3-2	Provide user interface with air quality info and implicit demand control: Demand is expected to be lowered through direct feedback and consumption overview as well as recommendations for the tenants' behaviour.
Demonstration plan	In the prototype building 18, there are monitors and applications installed to allow the tenants access to the information received by the integrated sensors (Action L3-1). The information includes the current temperature of the building, the amount of energy consumed over various timescales, total share of renewable energy used and air quality. The application is used for the tenants to respond to the information by providing feedback through the application. A picture of the applications concept is listed below in Fig. 16. The displayed interface is based on the usage of smart meters largely installed on-site which transmit information digitally to the energy management system.  Figure 19: Mock-up of the tenants' consumption information interface (Source: CEN) A version of an old meter in the form of an impeller counter is shown in Fig. 20 in contrast to a new smart meter which supports the required

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<table>
<tr><td></td><td colspan="2">remote readability.


Figure 20: Old impeller meter (left) and new smart meter (right) for heat consumption measurement (Source: CEN)
• The information concept is in place.
• Air quality monitoring is in operation.</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>CEN: Task leader</u></td></tr>
<tr><td rowspan="3">Milestones/ Tangible outcome</td><td>M18-23</td><td>Tenant Information Events</td></tr>
<tr><td>M30</td><td>Installation of screen and monitoring application in building no. 18</td></tr>
<tr><td>M33</td><td>Tenant Feedback Event</td></tr>
</table>

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Efficient and human-centric social housing blocks

The Duncker district is located in Leipzig West, near the Spinnerei block. Right next to Lindenauer Hafen, which is an outstanding urban renewal program that brings new life to a vestige port in Leipzig West. It is a melting-pot district with a stock of historic buildings. The district encompasses 31 buildings with a living space of 65,000 m^2 and includes multiple units which are priced for social housing needs. With its active and involved tenants, the district is the ideal testing ground for the proposed user-centric control, via a dedicated platform that promotes active involvement of citizens, to optimise the flow of energy.

Within the district, there are seven buildings with 300 apartments owned by LWB and supplied by district heating. These buildings will be our prototype area. All apartments will be equipped with net (smart) metering technology for thermal energy. Within the district, a novel solution for optimising thermal energy consumption through the implementation of human-centric thermal demand response programs (implicit demand response) operated by WSL will be demonstrated. The optimisation of utilities is important for social housing. For this reason, WSL will implement a dynamic thermal heating controller which optimises heat production based on information regarding the building's real thermal need (demand-centric).

Figure 21: Duncker district, picture 1 (Source: WSL)

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Figure 22: Duncker district, picture 2 (Source: WSL)

Figure 23: Duncker district, picture 3 (Source: WSL)

In addition, the heat generation of the solar plant will be examined and compared (LSW) to the heat consumption of the prototype buildings in a sequential manner relative to the potential for different tariffs from a district heating supplier.

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The aim of this task is to properly configure and deploy an innovative solution for optimising thermal energy consumption through the implementation of innovative human-centric thermal demand response programmes (implicit demand response) in selected residential building blocks operated by WSL. These housing blocks include social housing flats which are available to low- or no-income tenants. The optimisation of dynamic consumption as a cost-saving measure is of particular interest in social housing blocks.

The long-term goal is to configure and deploy an innovative solution for optimising thermal energy consumption through innovative human-centric thermal demand response programs.

L4-1: Personalised informative billing based on real-time energy prices for engaging users in energy saving actions.

L4-2: Demonstration of alternative thermal energy tariff schemes which will be made available to consumers and will allow for understanding their willingness to alter their consumption behaviour under hypothetical scenarios of being exposed to altered tariffs at specific time periods. Exposure of consumers in potential energy prices through the app will be performed in the form of targeted triggers/ surveys and will stand as the first action of engagement in future scenarios for the deployment of dynamic tariffs for energy savings. Alternative tariffs will be created from heating producers, by analysing (offline) demand forecast data, together with production costs.

L4-3: Appropriate normative comparison mechanisms will be applied to help consumers position themselves against best-performing peers and, thus, better quantify their energy bill savings potential, by using their energy consumption flexibility.

L5-1: Defining the detailed and accurate comfort profiles for identifying context-aware thermal demand flexibility profiles, considering energy behaviour patterns, comfort preferences, indoor quality constraints**.**

L5-2: based on action L13-1, targeted guidance on control actions (will be performed manually) for shedding or shifting the operation of thermal loads within buildings and air quality info through user-interface will be provided.

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SPARCS measures for efficient and human-centric social housing blocks are:

Action L4-1	Personalised informative billing based on real-time energy prices for engaging users in energy saving measures.
Demonstration plan	• L4-4 requirement • L4-3 included in both applications • ULEI is conducting a consumer survey (L21-4) • 1st application is the LWB app “Mein LWB” – existing application of the property owner LWB • Development based on the standard equipment used in almost all of the appartments (supply contract with manufacturer) • NEW functions of the application: • Visualisation of monthly consumption (thermal + hot and cold water) and the annual bills • comparison of the consumption with the average consumption of the building according to the size of the appartment (kWh / m²) and give the percentage deviation (L4-3) • comparison with the consumption of the last month and with the consumption of the current month last year (L4-3) • 2nd application is the SPARCs app - generates frequent detailed information of thermal demand in apartments to create real-time dynamic system and planning and to instal new heat cost allocators (sensors) in prototype building which allow the transmission of more frequent data (every 15 min.) and information about temperature in the apartments (every 15 min.). (According to L4-2 and L5-1, L5-2) Application developed by Suite5 will include: • Provision of an overview of thermal consumption, annual billing information, and environmental impact per apartment • Visualisation of historical energy consumption data, billing and environmental impact based on metering equipment to be made available, display of a distribution of thermal consumption between rooms based on the sensors to be made available, apartment and room specific information, such as temperature, etc. For both applications: • New smart heat cost allocators are installed in apartments (L4-4). • New gateways and data transfer systems and internet access points are installed in every building (L4-4).

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- Process of monthly evaluation of the incoming data was developed and the process for transfering the data into the application
- Data protection process was created.
- Information events are done with the tenats (users).

Figure 24: Layout of the “Meine LWB” app, picture 1 (Source: WSL)

Figure 25: Layout of the “Meine LWB” app. picture 2 (Source: WSL)

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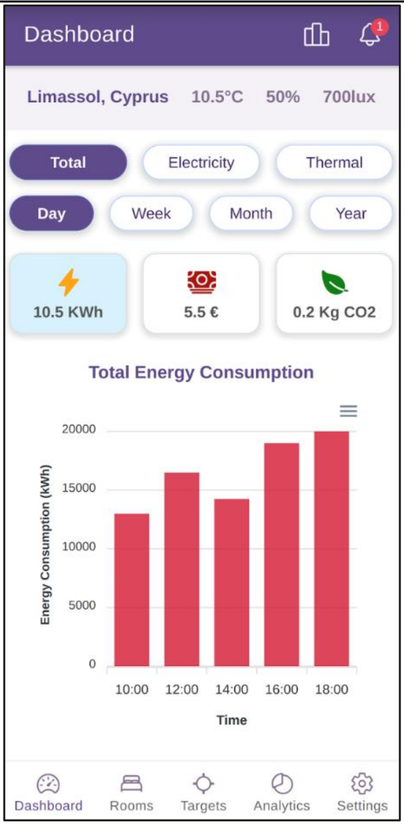

Figure 26: Layout of the “S5” app (Source: Suite5)

Roles and responsibilities	<u>**WSL, SUITE5**</u>	
Milestones/ Tangible outcome	M30	Tested prototype - application and interface for visualisation of thermal energy and cold/hot water consumption – ready for field testing and roll-out Communication with tenants (depending on Covid19).
	M36	Start of roll-out in demonstration area
Outlook until M60	Based on the availability of the actual data from the apartments, and the feedback collected from the application users, fine tuning of the functionalities is offered to better align with the needs.	

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Action L4-2	**Demonstration of alternative thermal energy tariff schemes which will be made available to consumers and facilitate an understanding of their willingness to alter their consumption behaviour under hypothetical scenarios of being exposed to altered tariffs at specific time periods. Exposure of consumers in potential energy prices through the app will be performed in the form of targeted triggers/ surveys and will stand as the first action of engagement in future scenarios for the deployment of dynamic tariffs for energy savings. Alternative tariffs will be created from heating producers, by analysing (offline) demand forecast data, together with production costs.**
Demonstration plan	• Connect to production information (heating system) to generate a forecast as an initial step and to monitor the system in real time as a second step. • Establish building connectivity for collecting the meter data and the heating system data and to bring them together on one platform (raw data) incl. interfaces to transfer data. • Automatic optimisation of central thermal energy production in the basement • Connecting the time resolved consumption data of the building / apartments to the time resolved production data of the solar thermal system Application developed by Suite5 (SPARCs App) will also include power user for the heating station operator: • Forecasting mechanism for the operator/producer of thermal energy in connection with the thermal energy production of the solar thermal system • Pushing of personalised notifications to local consumers to modify their consumption according to the adapted production plan, facilitating energy cost reduction for both sides involved and minimisation of CO_2 emissions due to the shift of consumption to periods of high CO_2-friendly production. Based on the analysis, the producer will build alternative dynamic tariff schemes that could potentially be applied to their customers. Through the application, consumers will be surveyed (at specific time periods) with regard to their willingness to modify their consumption to indirectly test and validate the applicability and acceptance of such alternative dynamic tariff schemes.

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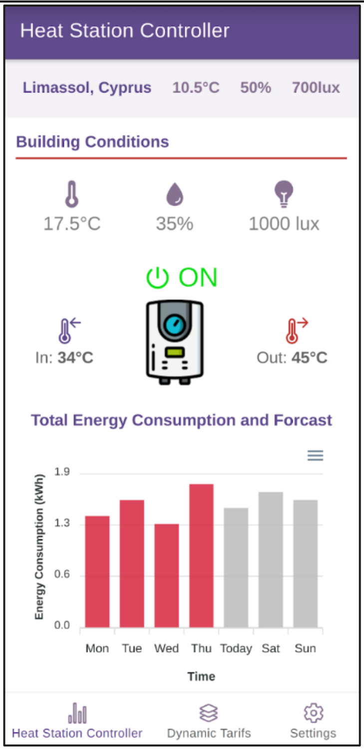
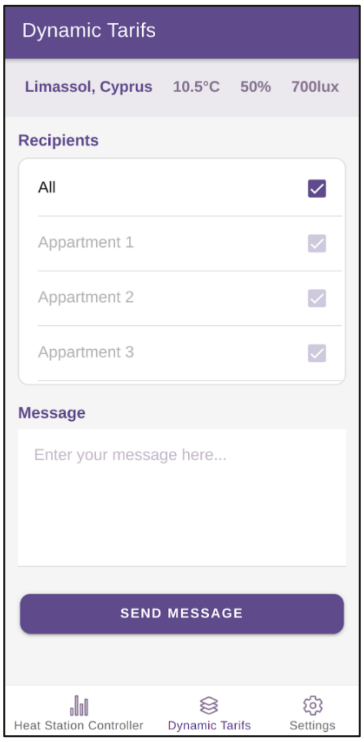
	 Figure 27: Layout of the “S5” app, picture 1 (Source: Suite5)  Figure 28: Layout of the “S5” app, picture 2 (Source: Suite5) • Building selected – Beckerstr. 52-56 (27 apartments) • Special smart heat cost allocators/sensors are installed in

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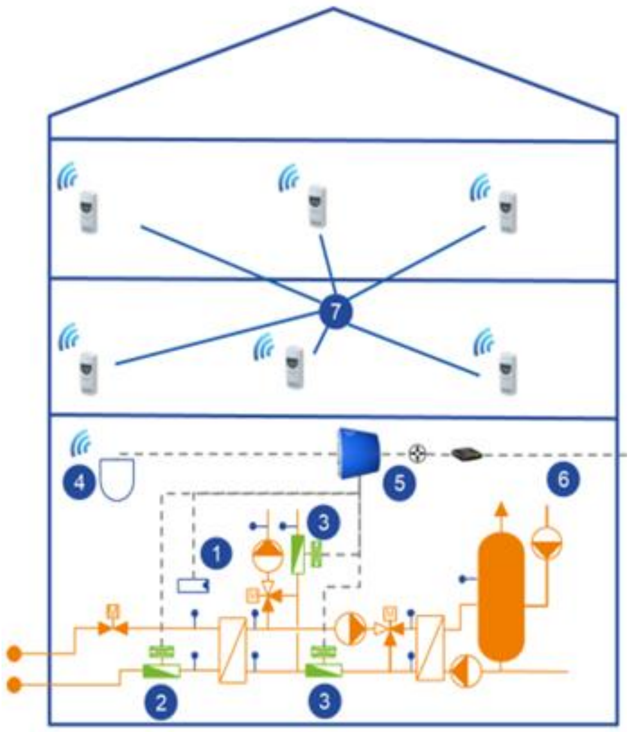
	apartments and the building; these provide aditional information for the thermal need by sending room and surface temperature values every 120 sec. • Building connectivity and data platform to collect data in real time is installed. • New smart heating controller is installed at the heating station in the basement to allow virtual access for automatic optimisation • Linking device for automatic control according to the real-time data and the thermal need of the building is installed • The algorithm process of data evaluation and implementation is done.  Figure 29: Scheme for the connectivity of data transfer from heat cost allocators to the heat controller (Source: Suite5)

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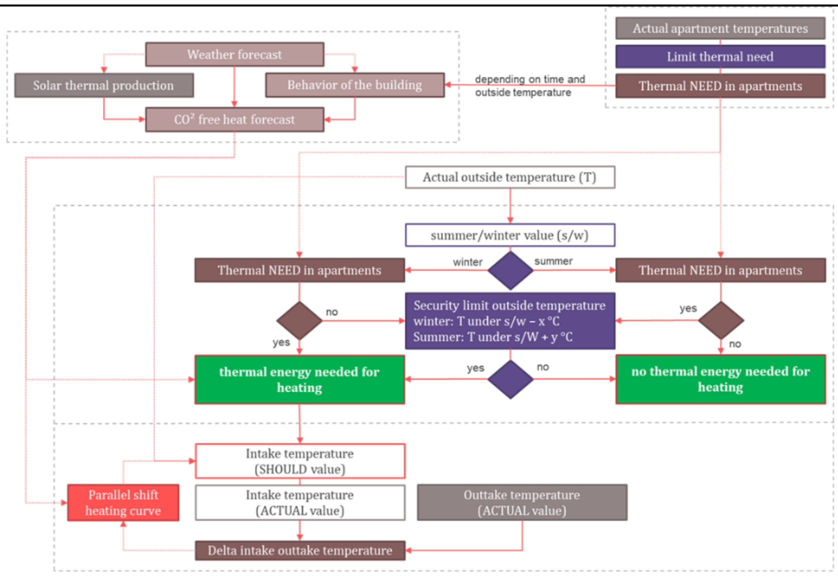
<table>
<tr><td></td><td colspan="2">


Figure 30: Overview of the process flowchart and decision-making matrix for the automatic optimisation of the dynamic heat station controller by using thermal information from the appartments in real time (Source: Suite5)
</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>WSL, SUITE5</u></td></tr>
<tr><td rowspan="3"></td><td>M18</td><td>First full collection of data based on heating period</td></tr>
<tr><td>M36</td><td>Start of roll-out in demonstration area in prototype buildings and automated optimisation with dynamic information of thermal need in the apartments/building</td></tr>
<tr><td>M60</td><td>Complete data analyses regarding energy savings</td></tr>
<tr><td>Outlook until M60</td><td colspan="2">Based on the availability of the actual data from the apartments and the feedback to be collected from the application users, fine tuning of the functionalities will be offered to better align with the needs.</td></tr>
</table>

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Action L5-1 & L5-2	Action L5-1: Defining the detailed and accurate comfort profiles for identifying context-aware thermal demand flexibility profiles, considering energy behaviour patterns, comfort preferences, indoor quality constraints. Action L5-2: based on action L13-1, targeted guidance on control actions (will be performed manually) for shedding or shifting the operation of thermal loads within buildings and air quality info through user interface will be provided
Demonstration plan	Based on more frequent information from the apartments, the application (developed by Suite5) returns information to the consumers. Application developed by Suite5 will include: • Creation of accurate comfort profiles • Creation of targeted recommendations and guidance on control • actions • Based on the equipment available, provision of personalised • information • Verification and adaptation of comfort profiles and preferences • Building selected – Beckerstr. 52-56, 27 apartments • Special smart heat cost allocators/sensors are installed in the • apartments • Building connectivity and data platform are installed.  Figure 31: Special smart heat cost sensors (Source: WSL) S5 Application design finished and ready for roll-out in the demonstration area

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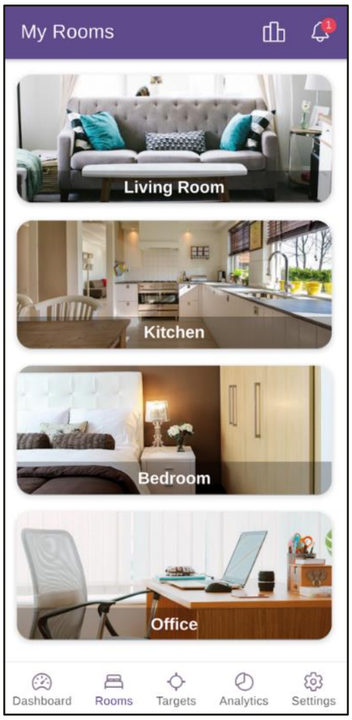

Figure 32: S5 application layout, picture 1 (Source: Suite5)

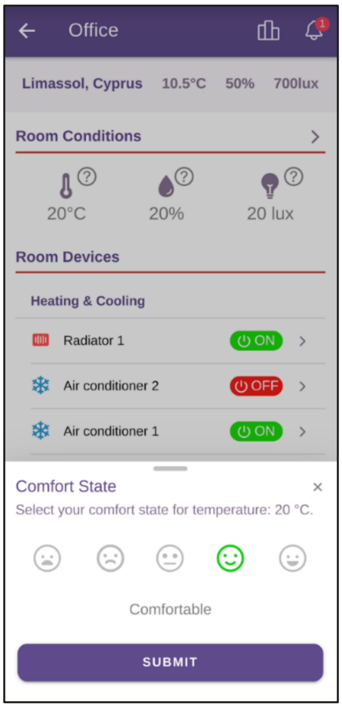

Figure 33: S5 application layout, picture 2 (Source: Suite5)

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	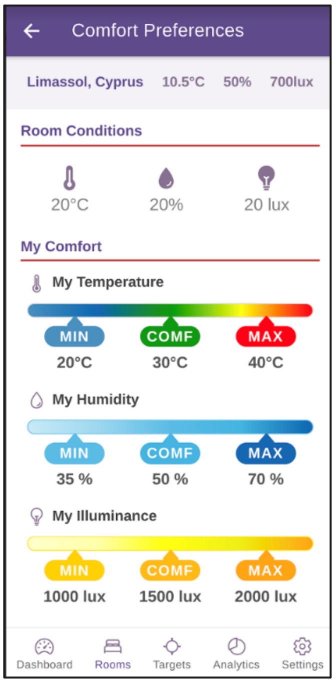 Figure 34: S5 application layout, picture 3 (Source: Suite5)	
Roles and responsibilities	**<u>SUITE5, WSL</u>**	
Milestones/ Tangible outcome	M18	First full collection of data from the heating period
	M36	Start of roll-out in the demonstration area
	M60	Complete analysis of comfort profiles and recommendation schemes
Outlook until M60	Based on the availability of the actual data from the apartments and the feedback to be collected from the application users, fine tuning of the functionalities will be offered to better align with the needs.	

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<table>
<tr><th>Action

L4-3</th><th colspan="2">Appropriate normative comparison mechanisms will be applied so as to help consumers position themselves against best performing peers and, thus, better quantify their energy bill savings potential, through the use of their energy consumption flexibility.</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">
Comparison mechanism in the application “Mein LWB” (L4-1)
Comparison will be between consumption of building energy index (kWh/m^2) □ high or low consumer and historical data
application developed by Suite5 will allow:
Comparison of consumption with peers (neighbours, best/average/worst consumers, etc.) to motivate a change toward lower consumption.
Visualisation of the current performance vs peers via a ranking.
Check of historical performance and rankings achieved
“Meine LWB App” is ready
S5 Application design completed and ready for roll-out in the prototype area

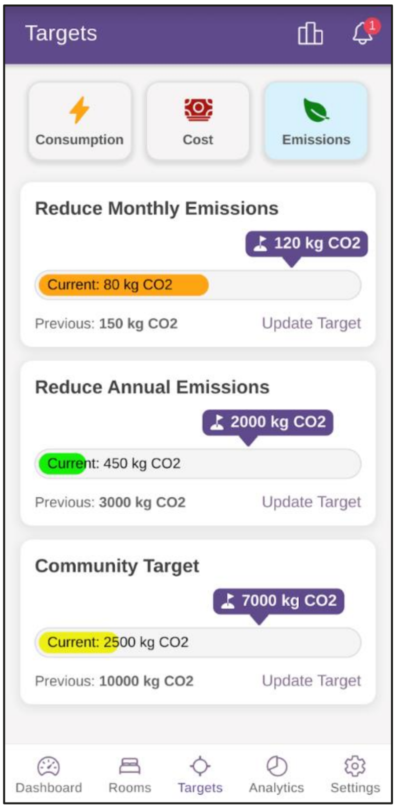

Figure 35: S5 application layout (Source: Suite5)</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>WSL, SUITE5</u></td></tr>
<tr><td>Milestones/ Tangible outcome</td><td>M20</td><td>Tested prototype - application and interface for visualisation of thermal energy and cold/hot water</td></tr>
</table>

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		consumption + comparison mechanism – ready for field testing and roll-out Communication with tenants (depending on Covid19)
	M36	Roll-out start in the demonstration area
	M60	Complete analysis of target setting and comparison mechanisms
Outlook until M60	Based on the availability of the actual data from the apartments and the feedback that will be collected from the application users, fine tuning of the functionalities will be offered to better align with the needs.	

Action **L4-4**	**Improving the connectivity of buildings to allow for integration in the positive Energy Community and the thermal demand response programmes by means of advanced smart meters**
Demonstration plan	• Installing internet spots in basement (WSL “Telemetry”) to connect energy consumption meter (thermal) (L19-1 – integrate energy and building data in urban data platform of the city) (L9-1 – integration of RES (renewable-energy-systems) in active management or/and the energy producer (heating systems). Install gateway to collect metering data (heating bill) from the apartments to obtain data for consumption visualisation (L4-1). • Contact Vodafone to establish building connectivity for collecting and merging meter data on one platform (raw data), incl. transfer system • All buildings (290 apartments) are ready: Beckerstr. 2-24 Beckerstr. 26-34 Beckerstr. 36-42 Beckerstr. 44-50 Beckerstr. 52-56 Leidholdstr. 19-25 Morgensternstr. 18-24 • Internet access points are installed in the basement • New submetering and sensors are installed in apartments • New wireless data infrastructure and gateways for LoraWan are installed for demonstration district is assessed together with Stadtwerke Leipzig (L10-1) • Preliminary action for L4-1 – L4-3 & L5-1 / L5-2
Roles and responsibilities	**WSL, SUITE5**

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Milestones/ Tangible outcome	M30	Complete roll-out in the demonstration area (for actions L4-1 – L4-3 and L5-1 / L5-2)

Action **L4-5**	**Assessment of different tariff schemes, including peer-to-peer tariffs in a collective self-consumption scheme (Mieterstrom model).**	
Demonstration plan	• Assessment of various scenarios/tariff for "Mieterstrom" (PV) from the screen of a housing company (renewable energy) • Economic and feasibility assessment - result used as the basis for L4-6 • Impact on CO2 reduction • Different models and feasibility options examined • New legal framework (EEG 21 and EEG 23) checked • Economic calculation tools established • Risk analyses and recommendation for different models completed • Expert interviews completed • Preliminary action for L4-6	
Roles and responsibilities	**WSL**	
Milestones/ Tangible outcome	M36	Draft study/assessment with recommendation for property owner.

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Action L4-6	Feasibility study for replication of "Mieterstrom" model and informative billing in all buildings operated by WSL.	
Demonstration plan	• Replication "Mieterstrom" on the roofs of buildings in LWB and replication of informative billing • Mieterstrom (L4-5): roofs – how much power can be installed – how much CO_2 reduction can be achieved • Informative billing (L4-1): how many apartments – how many gateways are needed = gateway strategy and what is needed for rollout • Summary regarding potential of housing stock of LWB completed • Part I = PV potential/rollout PV ("Mieterstrom") (L4-5) • Detailed analyses of roofs/houses for PV completed • Tool to calculate the potential, power output and CO2 reduction completed • Calculation for rollout "Mieterstrom" (L4-5) completed • Expert interviews completed • Will be a part of study with L4-5 • Part II = App (L4-1) rollout • Detailed analyses of buildings / data infrastructure for submetering (heat cost billing) for rollout app is completed	
Roles and responsibilities	**WSL**	
Milestones/ Tangible outcome	M36	Draft study with recommendation for property owner.

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<table>
<tr><th>Action
L4-7</th><th colspan="2">Demonstration of decentralised energy storage within building blocks for optimised self-consumption of locally produced energy (PV)</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">Install decentralised energy storage at PV system with self-consumption (electricity for heating station).

• Different types of storage capacities and integration models are examined
• Different feasibility options for storage capacity within a PV plant examined
• Combination with “Mieterstrom” examined and effect of storage capacity calculated
• Roofs in demonstration district checked for compatibility to install PV plant
• PV plant and storage installed

Details PV System:
Power: 29 kWp
Production: 26,363 kWh / a

Storage:
4.6 kW; 12 kWh capacity</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>WSL</u></td></tr>
<tr><td rowspan="3">Milestones/ Tangible outcome</td><td>M10</td><td>Calculation of system / storage</td></tr>
<tr><td>M36</td><td>Installation of storage</td></tr>
<tr><td>M60</td><td>Report about storage and self-consumption (incl. economic report)</td></tr>
</table>

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ICT AND INTEROPERABILITY IN LEIPZIG LIGHTHOUSE DEMONSTRATIONS

Introduction to task 4.3

The main goal of T4.3. is to upgrade the interaction between energy production, storage capacity and the consuming entities from the current level based on the energy network status (district heating and city medium/voltage electrical grid), to a virtually connected community where these entities can exchange energy, based on advanced control functionalities and dedicated communication channels (ICT model, blockchain infrastructure and prediction of demand).

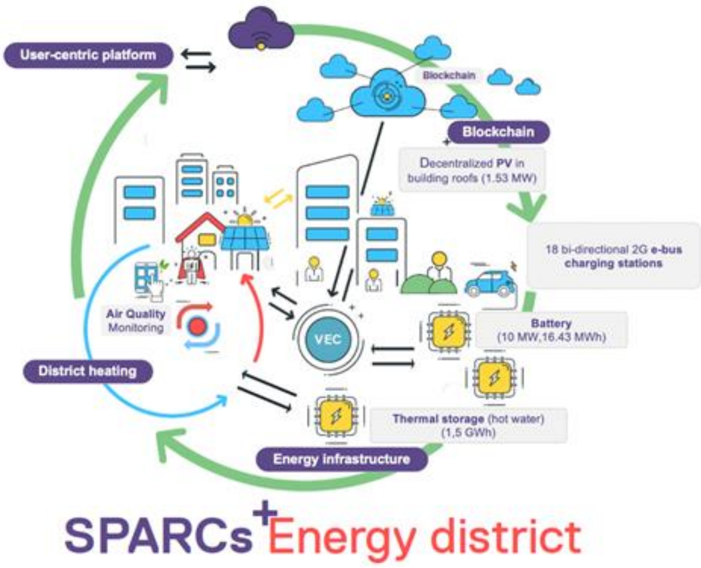

Figure 36: SPARCs Energy district (Source: VTT)

It is important to note here that "Virtual Positive Energy Community'' does not refer to the classic understanding of a physical block of densely located building groups in a suburban area but rather to the variety of energy-related measures virtually connecting the multiple buildings at various locations across the district. The implemented solutions bundle a multitude of actions that will partly be integrated and implemented in "Leipzig West" as well as among other buildings within and across the city.[2] The annual heat production of the solar thermal plant is approx. 13 GWh/a. The Integration of a solar thermal plant into the district heating system can demonstrate how two former industrial areas (Spinnerei block premises and "Leipzig West")[3] can benefit from environmentally friendly solar thermal heat produced within the city-built environment. Besides supplying heat to these two districts,

[2] Notification of PO on necessary change

[3] Notification of PO on necessary change

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the solar thermal plant will also supply heat to the buildings that join the virtually positive energy community and to the city district heating system. Actually, solar thermal plant integration is intrinsically related to virtual positive energy community measures as the way to optimising control of the various energy systems, which is part of the larger scale vision of the city connecting with consumer energy consumption behaviour.

This task includes the introduction of all solutions for a virtual positive energy community in Leipzig broken down according to the following subtasks:

- Subtask 4.3.2 Virtual power plant and storage capacity solution
- Subtask 4.3.2 Blockchain supported energy services
- Subtask 4.3.3 Integration of Community Energy Storage (CES) and Community Demand Response (CDR)
- Subtask 4.3.4 Ambient ICT Applications and user interfaces for electricity consumption, transformation, and improvement

Virtual Power Plant and Storage Solution

One of the major parts of subtask 4.3.2 Virtual Power Plant and Storage Solution comprises the following: The creation of the future regenerative energy system from today's point of view will be the orchestration of consumers, producers, prosumers and energy storage capabilities in locally connected, monitored and (self-)steered environments and systems. In addition to physical energy- related components for generation, distribution and household supply, storage capabilities, such as locally installed storage solutions and mobile storage solutions for temporary capacity extensions, are necessary components to enhance the district ability of autonomous energy management. To achieve this level of integration and control, an open standard-based ICT platform is developed and implemented.

SPARCS measures for solutions for this subtask are:

L9-1 The integration of RES (1,53 MW PV) with flexible consumers (L11-1) interested in active management of their devices from the outside depending on environmental or economical determinants, flexible prosumers interested in an active interaction with the CHP, geo thermal, Leipzig Lausen solar plant, their HVAC and grid participants with controllable and actively manageable energy storage.

L9-2 A study of the replication potential of the positive energy community in the replication district "Stadtraum Bayerischer Bahnhof"

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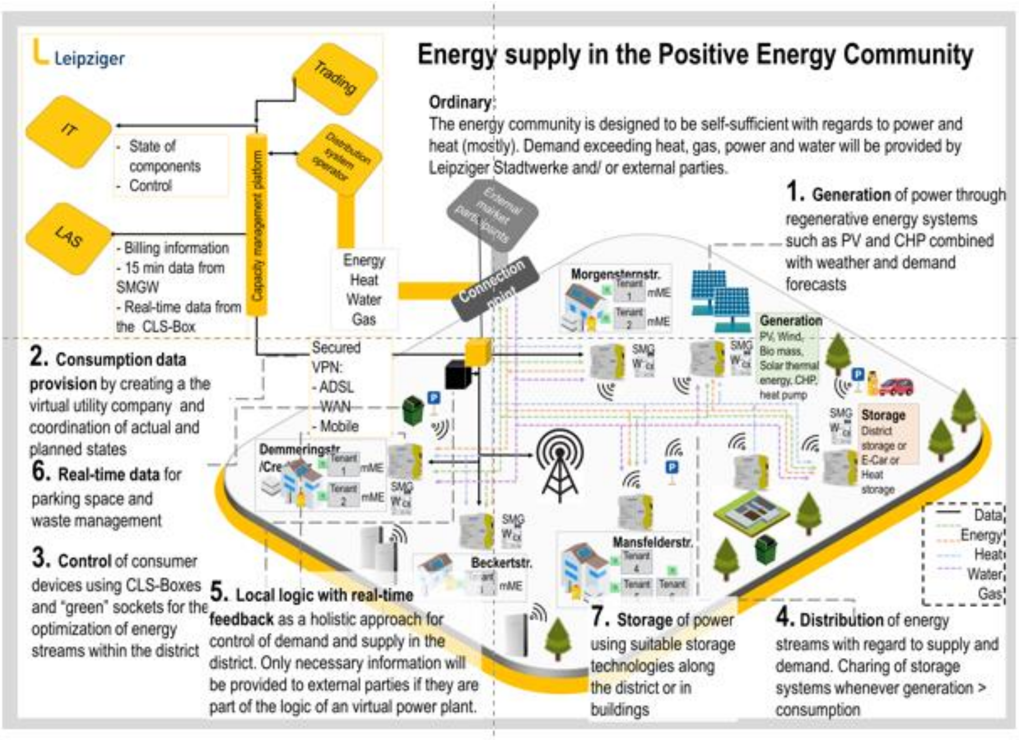

Figure 37: Energy supply in the Positive Energy Community (Source: LSW)

L10-1 Different kinds of technologies will be leveraged to establish Wide Area networks (WAN), such as DSL, LTE, Radio, and LoRaWAN.
Especially, the demonstration and use of the LoRaWAN Network for connecting sensors and devices through a low energy, low frequency bandwidth with a minimum of antennas across district. This will provide the opportunity to integrate a wide range of additional use cases (car parking spot sensors, intelligent waste disposal) throughout the whole district.

L11-1 Establishment of a distributed cloud-centric ICT System which enables an intelligent energy management system. In collaboration with WSL, monitored and externally controlled power outlets will be installed in various living units across multiple buildings to prove economies of scale for larger installations on a citywide level. This demonstrates efficient demand side management by monitoring and controlling energy consuming devices.

L11-2 Real-time simulation of the integration of an existing 10 MW battery storage

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Action L9-1	**The integration of RES (1,53 MV PV) with flexible consumers (L11-1) interested in active management of their devices from the outside depending on environmental or economical determinants, flexible prosumers interested in active interaction with a geothermal system, the Leipzig Lausen solar plant, their HVAC and grid participants with controllable and actively manageable energy storage systems.**
Demonstration plan	This measure comprises the digital foundation of Leipzig's part of the SPARCS project. Here, LSW delivers all prerequisites for peer-to-peer energy trading, energy communities, a citywide decentralised virtual power plant and linking of the heat and power sector. In L9-1 LSW covers all three demo districts. LSW sets up a link to a microgrid at Spinnerei block (realised by CEN). LSW interacts with the solar thermal power plant for the heat demand and the district in "Leipzig West" and LSW integrates solar power from WSL to the citywide virtual power plant. It shows the need to integrate alternative power generation (like solar energy, CHPs, etc.) in the virtual power plant of LSW. Together with consumption data, LSW can then balance energy consumption and generation with respect to ecological and economical restrictions and goals. LSW will work on the basis of near real-time data and continuously. Therefore, LSW has to implement some real-time forecasting and optimisation methods. The integration of an energy storage in this local energy structure will be simulated and LSW aims to demonstrate that the ecological and economic efficiency of the energy supply can be further increased. The citywide virtual power plant forms an important part of Stadtwerke Leipzig's Digital Platform ("Digital Platform"). Here, LSW stores all data related to asset telemetry and offers micro services for ETL as well as performs analyses of jobs running (and numerous other things). To give a deeper insight into the work, LSW wants to give a short description. For each asset type, LSW needs to realise a prototype to prove its availability to connect with Digital Platform. LSW uses its own hardware, called L.Box, for data sourcing and, thus, has to find a way to connect the L.Box to this controller of the asset or the meter etc. When this is completed, LSW can rollout the solution to connect all assets of the same kind. The data transmission is standardised; LSW uses MQTT and HTTPS and stores the telemetry data in a time series database. Once LSW has the data, LSW has to clean it up, i.e. fill out gaps, cut spikes, and calculate mean values, to establish a sound basis for data analysis. On this basis alone, LSW can forecast and optimise the system. LSW assumes that it must find a new method of pre-processing for each kind of data (values in watt behave differently

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	to those in hertz). The share of renewables at M24 is 85%. The link between the SMA-PV plants and the LSW data centre has been established. Non-SMA-PV plants are being integrated with trough local controllers. Data aggregation and optimisation are performed based on heating data.	
Roles and responsibilities	**LSW: Task leader, coordinator** WSL: Partner for the provision of housing units and cooperation	
Milestone/ Tangible outcome	M15	(all) LWB/WSL PV plants are integrated
	M18	Heat supply data from "Leipzig West" available Frontend/Website for plant monitoring Report for KPIs
Deviations	Developer resource repriorisation due to legal requirements in the implementation of Redispatch 2.0 for the protection of critical infrastructure (§§ 13, 13a, 14 EnWG). Therefore, VPP will be fully operable at M39.	
Outlook until M60	Ongoing operation of VPP with optimisation and foreasting of decentralised assets during the monitoring phase.	

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Action L10-1	Different kind of technologies will be leveraged to establish Wide Area networks (WAN), such as DSL, LTE, Radio, and LoRaWAN, and ,in particular, tThe demonstration and use of the LoRaWAN Network for connecting sensors and devices through a low-energy, low-frequency bandwidth with a minimum of antennas across the district. This will provide the opportunity to integrate a wide range of additional use cases (car parking spot sensors, intelligent waste disposal) throughout the whole district.	
Demonstration plan	In Leipzig West, the project partners plan to realise a smart district. That means collecting data, using the IoT device of Leipziger Stadtwerke (L.Box) for energy consumption and generation assets. For some other kind of data, this hardware is not useful (e.g., waste disposal, car parking spot sensors, weather data). LoRaWAN net has been built in the district of Leipzig West and collects data which is needed for some municipal use cases (waste disposal, public parking spots or air quality) and energy related use cases (measure weather data, such as air humidity, radiation). On the basis of this data, it is possible to design models for forecasting air quality and energy usage or generation or set up other smart services, for example parking spot management for third parties. The LoRaWAN Gateway was tested successfully. The gateway was installed in the Dunker district. Connectivity to all seven meters is ensured. Currently, the permanent installation is being prepared.	
Roles and responsibilities	**LSW: Task leader**, responsible for data sourcing hardware, provides a LoRaWAN net in the area of Leipzig West, provides relevant data to third parties (e.g., city of Leipzig, LWB)	
Milestone/ Tangible outcome	M24	LoRaWAN net has been established and first sensors are working
	M27	Use data from LoRaWAN sensor for services and other purposes

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Action L11-1	Establishment of a distributed cloud-centric ICT System which enables an intelligent energy management system. In collaboration with WSL, monitored and externally controlled power outlets will be installed in various living units across multiple buildings to prove economies of scale for larger installations on a citywide level and thereby to demonstrate efficient demand side management by monitoring and controlling energy consuming devices.
Demonstration plan	LSW intends to develop an innovative solution “zero carbon community” (externally controlled power outlet) that enables customers to actively participate in the energy market. It would be necessary to install the solution in the housing units. One goal of the solution is that the user can increase the share of RES for their energy consumption. During the project time, LSW plans to test and modify the solution according to customer’s needs. WSL/LWB supports LSW in the selection of possible customers in their housing units. • Development & implementation of the detailed concept & user story • Development of the demand response software • Front-end development of the LeipzigZERO app for the “Smart Plugs” • Implementation of a digital ecosystem for the • integration and mapping of the "Smart Plugs” • Preparation / design of the use cases of the "Smart Plugs” • Preparation of communication materials (flyers, cover letters) & Packaging of the “Smart Plugs” • Development of the landing page, including the FAQ • Realisation of an explanatory film on the use of the “Smart Plugs”

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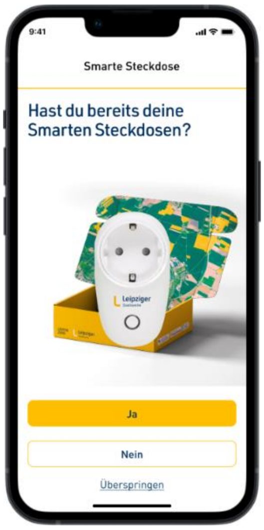

Figure 38: Setting up the smart socket (Source: LSW)

Figure 39: Allocation of individual consumers (Source: LSW)

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<table>
<tr><td></td><td colspan="2">

Figure 40: Consumption overview (Source: LSW)</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>LSW: Task leader</u>
WSL: Partner for the provision of housing units and cooperation</td></tr>
<tr><td rowspan="2">Milestone/ Tangible outcome</td><td>M18</td><td>Conception</td></tr>
<tr><td>M36</td><td>Beginning of rollout</td></tr>
<tr><td>Outlook until M60</td><td colspan="2">After the roll out of the smart plugs, the following aspects should be monitored:
• Acceptance of the smart plugs by the customer (KPI: Rollout of the entire 3,000 smart sockets)
• Change in usage behavior
• Active usage time
• Adoption of gamification as an incentive system for use
Customer feedback via focus group survey by Leipzig University</td></tr>
</table>

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Action L11-2	Real-time simulation of the integration of an existing 10 MW battery storage	
Demonstration plan	Renewable energy systems mostly comprise a highly volatile energy generation. Wind and solar energy are not always available and LSW has to find solutions to fill these energy supply gaps. Big electrical storages seem to be an answer, but it is not totally clear, how to integrate them in an energy system. LSW will investigate in this action to find out whether it is possible and useful to integrate a battery storage in the citywide virtual power plant by simulating the overall behavior.	
Roles and responsibilities	**LSW: Task leader** BMW: Associated partner, has to deliver relevant information about batteries	
Milestone/ Tangible outcome	M39	Additional software component in citywide virtual power plant integrated in the real-time stream (could be used for theoretical optimisations or simulations of the energy system) Reporting advantages and disadvantages of using this battery
Outlook until M60	Use of the simulated battery storage for scenario analyses in the VPP.	

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Action L9-2	Study the replication potential of the Positive Energy Community in the replication district "Stadtraum Bayerischer Bahnhof"	
Demonstration plan	Study the replication potential of the Positive Energy Community in the replication district "Bayerischer Bahnhof". Action is linked to L19-2, identify requirements how buildings can be integrated into the positive energy community (LEI, LSW, WSL) and T4.7: Replication and exploitation preparation	
Roles and responsibilities	**LSW: Task leader** LPZ: Link to L19-2 and T4.7 Replication and Exploitation preparation	
Milestone/ Tangible outcome	M36	Study of the replication potential of SPARCS use cases to replication district "Stadtraum Bayrischer Bahnhof"
Outlook until M60	The approach and the results of this study will contribute to the overall replication concepts to be elaborated within T4.7.	

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Blockchain-supported energy services

It will be demonstrated how blockchain technology helps to tackle the core challenge when it comes to energy distribution: the integration of millions of small-scale distributed energy resources in an energy system that is currently not designed for a large amount of individual market participants. Therefore, the demonstration activity will focus on the conceptualisation and application of a public blockchain for transactions between energy consumers, producers, service providers and grid system operators in a microgrid. The task includes:

<table>
<tr><th>Action L17-1</th><th colspan="2">Feasibility study on the coordinating role of blockchain in local market dynamics between generating plants and consumers and methods on how meter point operation and meter data management might be performed more efficiently and cost-effectively via blockchain.</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">Carrying out a feasibility study on this specific topic.
• basic theoretical research on blockchain, including working principle and classifications
• analysis of network architecture
• discovery of use cases of the blockchain technology for the energy industry
• analysis of use cases for SPARCS
Feasibility study is finished.</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>LSW: Task leader</u></td></tr>
<tr><td>Milestone/ Tangible outcome</td><td>M25</td><td>Feasibility study– based on the following points:
• Feasibility study on the coordinating role of the blockchain in the energy sector
• Based on existing scientific articles, adaptability to the project is to be investigated</td></tr>
</table>

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SPARCS

Action L17-2	Developing new potential blockchain-based solutions to enable prosumers to sell their surplus electricity on a Peer-to-Peer marketplace to prosumers.	
Demonstration plan	Depending on the results of the study from L17-1, LSW would like to test blockchain-based solutions to enable prosumers to sell their surplus electricity on a Peer-to-Peer marketplace. Economic evaluation of potential business models for a blockchain solution will be finished Preparing the practical implementation Implementation follows in Action L17-3.	
Roles and responsibilities	**LSW: Task leader**	
Milestone/ Tangible outcome	M31	Creation of a theoretical concept of a blockchain which could be applied on the real market.

Action L17-3	Demonstration of the integration and interactions of IoT devices, e. g., distributed power production and storage backed by the blockchain.
Demonstration plan	One of the main goals of SPARCS project is to realise a renewable, zero-carbon energy community. That includes decentralised energy suppliers (such as local solar power plants) and a system for a continuous balancing of energy supply and demand. Stadtwerke Leipzig decided to build up a digital platform (see Action L9-1) based on decentralised IoT devices. These devices provide the LSW with the capability to make any existing asset "smart" - that means being able to communicate with the community and know their state at any time. In smart cities, many smart assets in the energy grid have to be optimally balanced. It means dealing with a very big amount of information from all devices simultaneously and finding a way to balance the grid. Blockchain technology can help to do that because it gives one the opportunity to securely share and store information with all partners or, in this case, assets. Stadtwerke Leipzig has a fully functional prototype for this. Scalable prototype with functional Ethereum network connectivity is operational. Transactions have been simulated successfully during pilot phase.
Roles and	**LSW: Task leader**

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responsibilities		
Milestone/ Tangible outcome	M36	Task is completed due to the result.
Deviations	Prototype has been tested successfully. Business case extension not viable due to regulatory barriers (The obstacles of the regulations concerning concern the German market here.): § 5 EnWG: Registration expenditure as an energy provider. Small prosumers have to fulfill the same legal duties as big utilities § 80 EEG: Barriers of small DER to participate in local markets (prohibition of double selling) § 9 StromStG: Taxation of local P2P trade reduces incentives § 26 StromNZV: P2P trade over platform in different balancing group unclear § 20 GDPR: Immutability provides no user data portability	

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Integration of Community Energy Storage (CES) and Community Demand Response (CDR)

This subtask takes on the task of understanding and predicting the behaviour of energy system participants. The reliable integration of the planned “community energy storage” (CES) and “community demand response” (CDR) represent possible business cases for a successful system transformation at the municipal level. The mathematical optimisation model, as a mixed-integer linear programming, will allow a policy-oriented, technology-based, and actor-related assessment of varying energy system conditions in general, and innovative business models in particular. The integrated multi-modal approach is based on a novel six layer modelling framework, which builds on existing high-resolution modelling building blocks.

This subtask includes:

L18-1: Further developing and refining the resource planning and optimisation (IRPopt) modelling approach and of the web-based software environment to allow long-term and short-term scenario calculations. This includes the integration of cascading time slices, policy goals such as renewable energy quota or CO_2 emissions and standard reporting tools.
L18-2: Defining and developing the data acquisition and exchange based on the “Green sockets”. (ULEI, LSW).
L18-3: Demonstrating the optimal prediction of user behavior for the virtual energy community and integrating the data model in the energy platform of the municipal utility. Derivation of implications regarding the formulated policy goals
L18-4: Extending the virtual community to Leipzig. Exploration of development paths with respect to varying scenario assumptions.

Action L18-1	Further developing and refining the resource planning and optimisation (IRPopt) modelling approach and of the web-based software environment to allow long-term and short-term scenario calculations. This includes the integration of cascading time slices, policy goals, such as renewable energy quota or CO2-emissions and standard reporting tools.
Demonstration plan	While the basic modelling framework of IRPopt is already in a mature state, the focus of the research in SPARCS requires the ongoing development. This task serves as a pre-requisite for actions L6-1, L6-2, L6-3 and L18-3, L18-4. Model extensions developed: Supply-side assets: • Operational P-Q-diagram of Leipzig’s CCGT – CHP power plant • Electrolysis facility • Hydrogen storage • Fuel cell • Seasonal heat storage

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<table>
<tr><td></td><td colspan="2">Flexible extension of the optimisation period

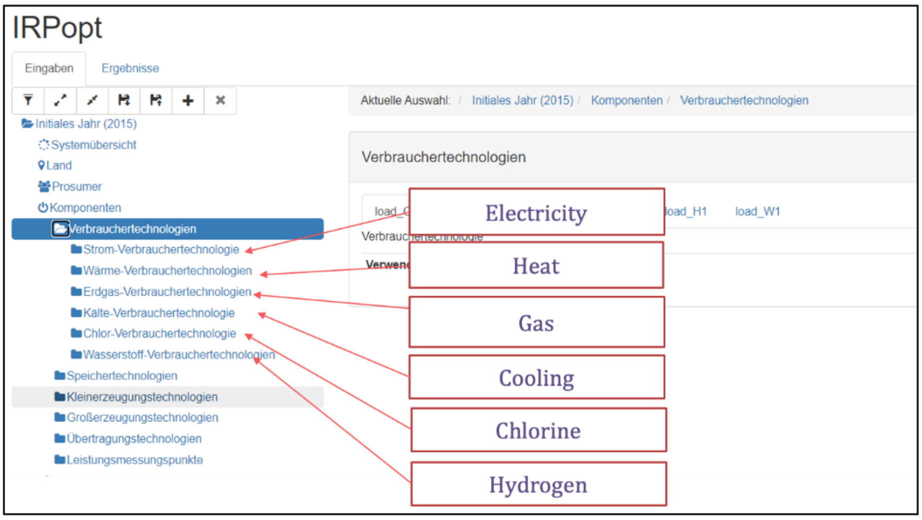

Figure 41: User interface IRPopt (Exemplary visualisation of the supply-side assets) (Source: ULEI)</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>ULEI: Task leader</u></td></tr>
<tr><td rowspan="2">Milestone/ Tangible outcome</td><td>M24</td><td>Documentation of the model status and as part of the detailed description of model application in actions L6-1,2,3 and L18-3 (Intermediary report)</td></tr>
<tr><td>M36</td><td>Extension of the documentation as part of the detailed reporting of the actions</td></tr>
</table>

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Action L18-2	Defining and developing the data acquisition and exchange based on the distributed "Smart plugs". (ULEI, LSW).
Demonstration plan	This task depends on the rollout of sufficient amounts of metering equipment (e.g., L-box) by LSW. LSW provides access to the data (electricity consumption, district heat demand). The demand-side data will be integrated in our model. This task is linked to L9-1 and 11-1. The data exchange is briefly described as follows. The assets are maintained through InfluxDB. After entering into the assets database, one can use SQL-like query commands to explore the data. Generally, the data is stored as points in influxDB. In the assets database, different measurements like Temperature, Active power, etc. are stored with tagset and fieldset. One can select all fields and tags from any measurement. The last step is to export the accessed data into a CSV file into the local system for storage and easy access of the required data.

```
> SELECT * FROM "ReturnTemperature" WHERE "amdID"=[redacted]' LIMIT 10
name: ReturnTemperature
time                 amdID insertion_timestamp value
[redacted] -- -----
[redacted] 33.7
[redacted] 46.8
[redacted] 46.6
[redacted] 46.7
[redacted] 46.7
[redacted] 46.7
[redacted] 46.8
[redacted] 46.6
[redacted] 46.7
[redacted] 46.8
```

Figure 42: Exemplary selection of data fields in the influxDB, e.g., return temperatures of the district heating grid. (Source: LSW)

Roles and responsibilities	**ULEI: Task leader** LSW: Data provision

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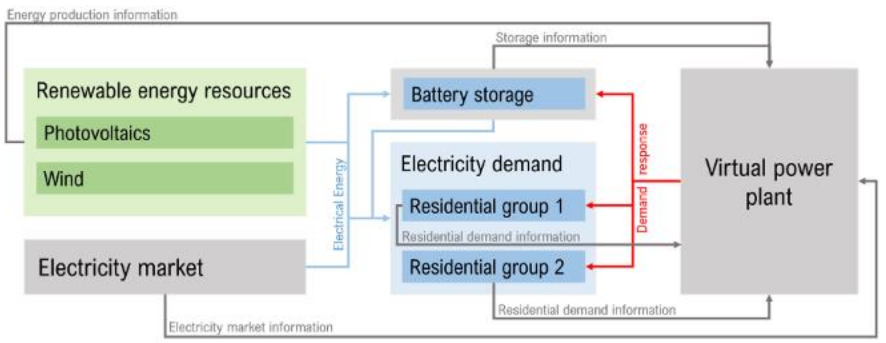
Action L18-3	Demonstrating the optimal prediction of user behaviour for the virtual energy community and integrating the data model into the energy platform of the municipal utility. Derivation of implications regarding the formulated policy goals.
Demonstration plan	The virtual energy community was modeled by ULEI to estimate the potential of residential demand response (RDR) in combination with a virtual power plant (VPP). In particular, the technical, as well as the economic, and ecological potentials are investigated. Consequently, a specific section of a municipal energy system for the hypothetical years 2025 and 2045 was modelled, focusing on electricity. This includes electrical energy generation, storage, demand, and interconnection to the electricity market. The electrical energy originates mainly from rooftop solar power (referring to the WSL facilities). For the projection of the year 2045, it is assumed that the VPP and RDR are widely implemented in the municipal energy system. Thus, the generation of electrical energy is likely to be diversified and therefore some wind power plant capacity is included. Furthermore, the system contains a cumulative energy storage in the form of a battery energy storage system, similar to the BMW facility (see L11-2). Moreover, the final energy demand for electricity is split into two different groups of residential demand types. For the model-based analysis four different electricity tariffs were developed, ranging from very static to highly dynamic. These tariffs all consist of a fixed utility margin and a fluctuating price component.  Figure 43: Structure of the energy system model to evaluate the benefits for the virtual energy community. (Source: ULEI) The need for electricity imports from the spot market has impacts on the degree of self-sufficiency of the local energy system. The optimization results show that the annual mismatch ratio (AMR), representing the grade of autarcy, decreases when the local generations, measured as onsite-energy-ratio (OER) is increasing. Hence, scaling up the generation to gain OER values over 1 does not automatically mean a reduction of the AMR value. Here, the load profiles of the generation units limit the further improvement of the

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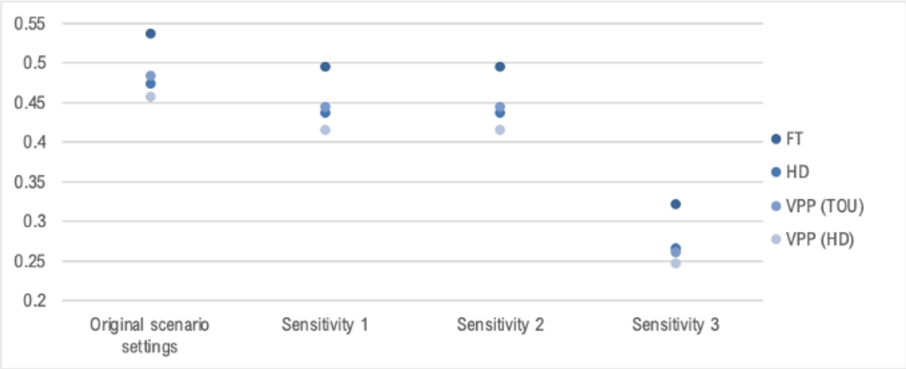
	AMR. This was observed in the year 2025. While the increase of generation capacity along the different sensitivities reduced the AMR in general, the load shifting potential of the scenario combinations had minor effects on the AMR in comparison to the Reference scenario. This can be attributed to the specific generation profile of PV, limited to daytime and the non-shiftable demand at evening and night-time (household appliances with non-shiftable load).  Figure 44: Comparison of the annual mismatch ratio (AMR) in 2045 for different scenario assumptions and electricity tariffs (FT=fixed tariff, HD=high dynamic, VPP(TOU)=time-of-use, VPP(HD)=high dynamic with local components). (Source: ULEI) Sensitivity 1: No curtailment of local RES in case of negative spot prices. Sensitivity 2: Increased battery capacity. Sensitivity 3: Increases RES capacity (OER=1) and battery storage. The residential customer groups recorded costs savings over all scenario combinations in comparison to the fixed tariff in the Reference scenario. The amount of avoided costs differs significantly between the various tariffs. The economic results show that the potential cost savings of residential group 1 (only electricity appliances) are noticeably smaller than the potential cost savings of residential group 2, which is equipped with heat pumps. The smaller monetary outcome can be attributed to the substantially lower amount of shifted load of households of group 1.
Roles and responsibilities	**<u>ULEI: Task leader</u>** LSW: Provision of data, e.g., electricity demand and seizing of controllable assets

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Milestone/ Tangible outcome	M33	Stadtwerke Leipzig and ULEI established an ongoing data exchange to have a common basis for the prediction model of ULEI
	M36	Report (Scope, research question, data, modelling results, conclusion)

Action L18-4	**Extending the virtual community to Leipzig. Exploration of development paths with respect to varying scenario assumptions.**	
Demonstration plan	Based on the results of 18-3, ULEI explores development paths for the energy community up to the year 2050. The question of whether the energy community represents a necessary condition for reaching the development goals of the city vision will be evaluated. This task also gives input for T4.7 Replication and exploitation preparation. The results of task L18-3 and the outcome of the city vision workshop are pre-requisites for this task.	
Roles and responsibilities	**ULEI: Task leader** LPZ: Link to T4.7 LSW: Data provider, supervision of scenario assumptions / provide relevant data and give advices to extend the virtual community	
Milestone/ Tangible outcome	M50	Report on the economic and environmental impact of an extended virtual community for reaching the goals of the city vision 2050

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Ambient ICT Applications and User Interfaces for Electricity Consumption Transformation and Improvement

The aim of this task is to develop and deploy a universal behavioural change framework focusing on the discovery, quantification and revelation of energy-hungry behaviours of residential electricity consumers, aiming to convey meaningful energy-use feedback to occupants and engage them into a continuous process of learning and improvement. It will follow a stepped approach to reveal energy patterns and reshape sustainable energy-efficient behaviours by utilising extrinsic and intrinsic motivation means. Energy will be conserved through the progressive improvement of user behaviours.

This subtask includes:

L12-1: Demonstrating an application which allows for monitoring, controlling and providing normative feedback about the individual energy consumption. Through the application building occupants will be able to trace the impact of their everyday activities and behaviour on the building's energy performance.

L13-1: Demonstration of energy behavioural profiles, revealing the energy-related aspects of behavioural profiles and allowing for self-evaluation and normative comparisons of energy behavioral patterns. Energy saving based on the footprint analysis will be achieved by accurate benchmarking and comparison of normalised energy performance information against peer top-performing consumers with similar characteristics.

L14-1: For maximising of energy savings at the community level, individual consumers will be able to pledge to achieve specific energy savings over specific timeframes. This will cause the social engagement loop to engage and sustain the involvement of consumers in energy saving actions

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This subtask includes:

<table>
<tr><th>Action L12-1</th><th>Demonstrating an application which allows for monitoring, controlling and providing normative feedback about the individual energy consumption. Through the application building occupants will be able to trace the impact of their everyday activities and behaviour on the building's energy performance.</th></tr>
<tr><td>Demonstration plan</td><td>

Describe the realisation plan

Application developed by Suite5 will enable the following:

- Providing an overview of consumption, billing, and environmental impact per apartment.
- Visualisation of historical energy consumption data, billing and environmental impact.
- Based on metering equipment to be made available, displaying a distribution of consumption between appliances.
- Based on the sensors to be made available, apartment and room-specific information, such as temperature, etc.
- Stadtwerke Leipzig can offer energy production and consumption data and provide analytical insights into the building's energy usage (see L9-1).
- S5 Application design finished and ready for rollout in the demonstration area

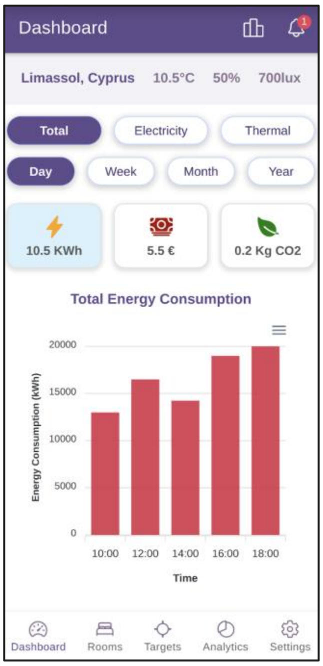

Figure 45: Screenshot SPARCS app, picture 1(Source: Suite5)

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

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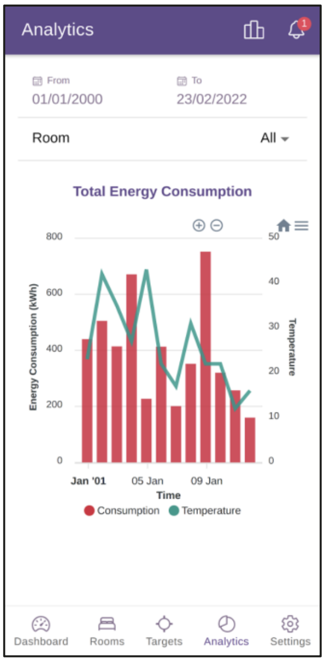
<table>
<tr><td></td><td colspan="2">

Figure 46: Screenshot SPARCS app, picture 2 (Source: Suite5)</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>Suite5: Task leader</u>
WSL, LSW: Supporting role. Building management, occupant’s interface, equipment and data responsibility.

LSW: can provide data, logic, analytics, ideas to Suite5 and WSL, can help with implementation of features.</td></tr>
<tr><td rowspan="3">Milestone/ Tangible outcome</td><td>M12</td><td>Concrete application, specifications and mockups</td></tr>
<tr><td>M24</td><td>Tested and ready to be deployed application</td></tr>
<tr><td>M36</td><td>Start of rollout in the demonstration area</td></tr>
<tr><td>Outlook until M60</td><td colspan="2">Based on the availability of the actual data from the apartments, and the feedback to be collected from the application’s users, fine tuning of the functionalities offered to better align with the needs.</td></tr>
</table>

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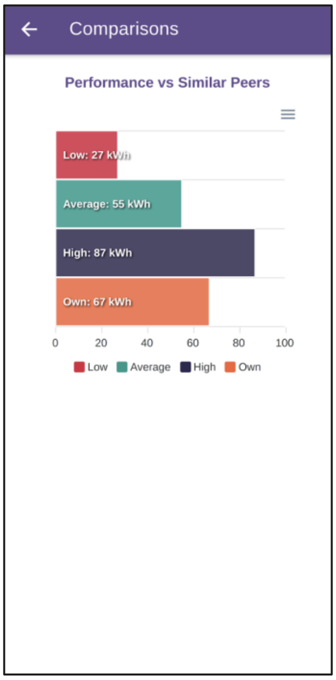
Action L13-1	Demonstration of Energy Behavioural Profiles, revealing the energy related aspects of behavioural profiles and allowing for self-evaluation and normative comparisons of energy behavioural patterns. Energy saving based on the footprint analysis will be achieved by accurate benchmarking and comparison of normalized energy performance information against peer top-performing consumers with similar characteristics.(SUITE5, LSW)
Demonstration plan	Application developed by Suite5 will enable the following: • Comparison of consumption with similar peers (neighbors, best/average/worst consumers, etc.) to motivate a change towards lower consumption. • Visualization of the current performance vs. similar peers via a ranking. • Definition in the app of characteristics, such as number of occupants and age groups, to allow the accurate grouping and comparison of similar peers  Figure 47 : Screenshot SPARCS app, picture 3 (Source: Suite5)

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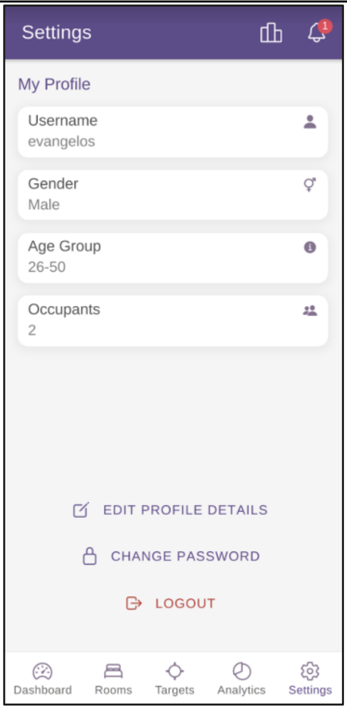
<table>
<tr><td></td><td colspan="2">

Figure 48: Screenshot SPARCS app, picture 4 (Source: Suite5)</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>Suite5: Task leader</u>
LSW: Supporting role. Building management, occupant’s interface, equipment and data responsibility.

LSW: can provide data, logic, analytics, ideas to Suite5 and WSL, can help with implementation of features.</td></tr>
<tr><td rowspan="3">Milestone/ Tangible outcome</td><td>M12</td><td>Concrete application, specifications and mockups</td></tr>
<tr><td>M24</td><td>Tested and ready to be deployed application</td></tr>
<tr><td>M36</td><td>Start of rollout in the demonstration area</td></tr>
<tr><td>Outlook until M60</td><td colspan="2">Based on the availability of the actual data from the apartments, and the feedback to be collected from the application’s users, fine tuning of the functionalities offered to better align with the needs.</td></tr>
</table>

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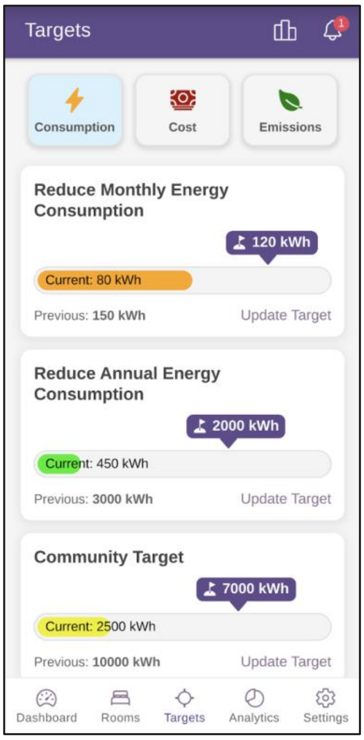
Action L14-1	Action L14-1: For maximising of energy savings at the community level, individual consumers will be able to pledge to achieve specific energy savings over specific timeframes. This will cause the Social Engagement Loop to engage and sustain the involvement of consumers in energy saving actions
Demonstration plan	Application developed by Suite5 will enable the following: Setting common community targets and verification of achievements, offering visual representation of energy consumption, related costs and emissions targets set Visualization of the current performance vs. targets set and achievements. Editing the targets set and setting updated values based on the community and users preferences.  Figure 49: Screenshot SPARCS app, picture 5 (Source: Suite5)

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	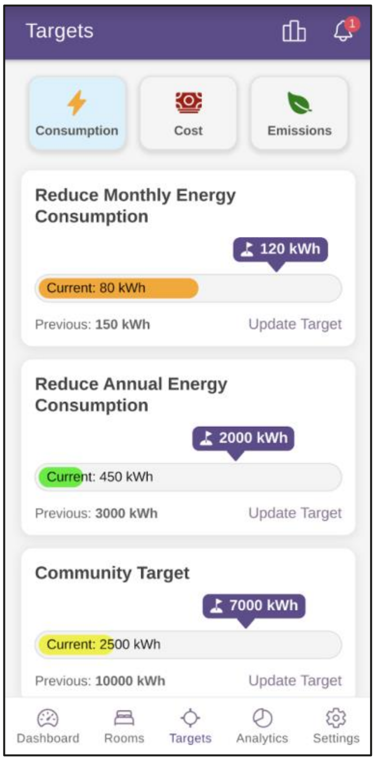 Figure 50: Screenshot SPARCS app, picture 6 (Source: Suite5)	
Milestone/ Tangible outcome	M12	Concrete application, specifications and mockups
	M24	Tested and ready to be deployed application
	M36	Start of rollout in the demonstration area
Outlook until M60	Based on the availability of the actual data from the apartments, and the feedback to be collected from the application's users, fine tuning of the functionalities offered to better align with the needs.	

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Introduction to task 4.4

The aim of WP 4.4 is to analyse electric mobility in Leipzig and integrate e-mobility into the explorations. Electric vehicles and electric buses offer the opportunity for high flexibility, and intelligent charge control and charge management relieve the power grids.

Charging stations for passenger cars were one part of the research. Through the integration of a fleet management system and a charging station management system, mobility needs can be met, and cars can be charged intelligently. Bidirectional charging offers an additional possibility for intelligent charging in the context of SPARCS and is also considered.

E-Bus charging integration

Leipziger Verkehrsbetriebe (LVB) GmbH is responsible for public transport in the city of Leipzig. LVB is owner and operator of the network for busses and trams.

During the last few years, the company participated in different research projects regarding electric mobility. The experience gained forms the basis for the implementation of three E-bus lines until 2022. The plan is to transform the bus lines 89/74/76 and 60 from diesel-fuelled buses to e-buses. Altogether, the company will have 21 e-buses.

Every e-bus line either has already received or will receive an e-charging station (quick charging station) at the final stop. Furthermore, LVB will modernise the central bus garage at the location “Lindenauer Bushof”, also located in Leipzig West. The site will receive a central charging system with about 10 charging points. The goal is to charge the e-buses during the night. This is one activity for a more climate friendly public transport.

As the charging process during the operation of the lines (e.g. at the station Connewitzer Kreuz) often occurs during peak consumption time slots, it creates challenges for the distribution grid's congestion management. However, the nightly charging processes at the central home station take place at times when the consumption pattern exhibits fewer variances. Accordingly, a load shifting away from charging during operation in favour of home station charging ease grid operation and, thus, the overall integration of renewable energy assets (that are difficult to forecast and plan) into the virtual power plant. Therefore, the bus charging data were integrated into the digital platform, and analysed to estimate the optimum state of charge and power reduction for the charging process of line 89. These empirical results then were used to define a new charging schedule with optimised targeted loads.

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The task described includes the following actions:

Action L15-1: Integrating the electric bus charging stations into the positive energy community (LSW, FHG)

Action L15-2: Reducing grid congestion and peak loads in the virtual energy community (LSW, FHG)

Action L15-3: Implementing optimised charging cycles for e-bus line 89 (LSW, FHG)

Action L15-1	**Integrating the electric bus charging stations into the positive energy community**	
Demonstration plan	The bus charging time series of the Connewitzer Kreuz station, as well as the SOC changes during bus operation were integrated into the virtual energy community via the digital platform by LVB and LSW. This data is provided to Fraunhofer for an analysis of balancing potential and emission advantage. The analysis indicates the scope of the optimisation potential. Data from the charging stations is extracted. The regular data transfer to FHG works successfully.	
Roles and responsibilities	**<u>LSW and LVB: Task leader</u>** - Allocate, integrate and provide data regularly - Streamline data integration through automatisation FHG: - Receive data for further analysis	
Schedule	M18 - 24	Conceptualisation
	M25 - M36	Allocate and transfer the bus and station data
Milestones/ Tangible outcome	M25	Regular data integration into digital platform and transfer to FHG

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Action L15-2	Reducing grid congestion and peak loads in the virtual energy community	
Demonstration plan	Considering technical limitations (eg. battery needs), bus schedules (demand & flexibility) and RES in the virtual energy community (supply), the charging data time series will is used to estimate the optimum state of charge (SOC) and possible power output reduction at different charging points of line 89; especially considering flexibility options at intermediary charging stations and during depot charging, to balance loads. Grid congestion and peak loads in the virtual energy community will be reduced by optimising charging of e-buses, using day and night charging flexibilities, according to supply and demand, considering different scenarios. These empirical results will then be used to define a new charging schedule with optimised charging – considering regulated, deferred, or interrupted charging. Task description updated Data transfer has been initiated.	
Roles and responsibilities	**LSW: Task leader** **FHG:** - Analysis of charging processes and optimisation of target loads LVB: - Quantitative support (e.g., pre-processing of the data)	
Schedule	M18 - M24	Conceptualisation
	M25 - M36	Estimation of target loads
Milestones/ Tangible outcome	M36	Estimation completed, guidelines provided to LVB

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Action L15-3	Implementing the optimised charging cycles for e-bus line 89	
Demonstration plan	Based on the estimated optimum state of charge (SOC) and power reduction (L15-2), the charging processes of line 89 will be adjusted with the optimised target loads. This charging process supports the operation of the virtual power plant by increasing the share of easily predictable loads and minimising the need for congestion management in distribution grids along the bus line. Conditions for future flexible management (such as wheather-optimised flexible charging) will be checked. Based on the results of the analyses, suggestions for how to roll out further e-bus lines will be deduced.	
Roles and responsibilities	**<u>LSW and LVB: Task leader</u>** Implement the optimised charging process provided by Fraunhofer in the daily operation of line 89. FHG: Scientific supervision of the implementation.	
Schedule	M18-M36	Preparation of charging process adjustments
	M36-M39	Implementation of the target loads
Milestones/ Tangible outcome	M39 M40	Optimised charging process successfully implemented in daily operation. Reporting and critical reflection of the load reduction in real-world operation
Outlook until M60	Technical feasibility of charging process adjustment has been assessed.	

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Load-balanced fleet management

This subtask will demonstrate load-balanced fleet management and charging based upon user specific inputs to the platform defining their flexibility. The system should provide the opportunity to reserve specific charge points in advance based upon suitable predefined and dynamic charging tariffs. This includes:

Action L16-1: Upgrade existing charging stations to allow for intelligent charging, including bi-directional charging, instal additional charging stations across the district according to needs (LSW)

Action L16-2: Explore business models and services tailored for residents; allow for reservation of charging spaces, allow for selection of charging tariffs and priority setting (FHG, LSW, WSL)

Action L16-3: Implement and test a mobile user application for reservation and configuration of charging/mobility needs of his privately owned or currently used (shared company fleet) vehicle, integrate the necessary interfaces of participants (LSW, FHG, WSL, LPZ)

Action L16-4: Demonstrate load balancing with an electric vehicle fleet in accordance with local grid needs (LSW, FHG, WSL, LPZ)

Action L16-1	**Upgrade existing charging stations to allow for intelligent charging, including demand response, installing add additional 2G charging stations across the city according to needs.**
Demonstration plan	In order to achieve the project objectives, either existing charging stations need be upgraded, or new charging infrastructure need to be procured. Description of the realisation plan: The aim is to upgrade the existing network of public charging infrastructure of the LSW with the intelligent charging. The LSW currently operates a network of approx. 250 public charging points at more than 80 locations. For the function of intelligent loading, possible use cases are first developed in coordination with the IT department and the information available from the charging infrastructure will be analysed. Possible use cases are grid-resilient charging in conjunction with new business models for electric mobility. The software for smart charging has been updated. The use of charging stations that can charge intelligently is being examined.

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	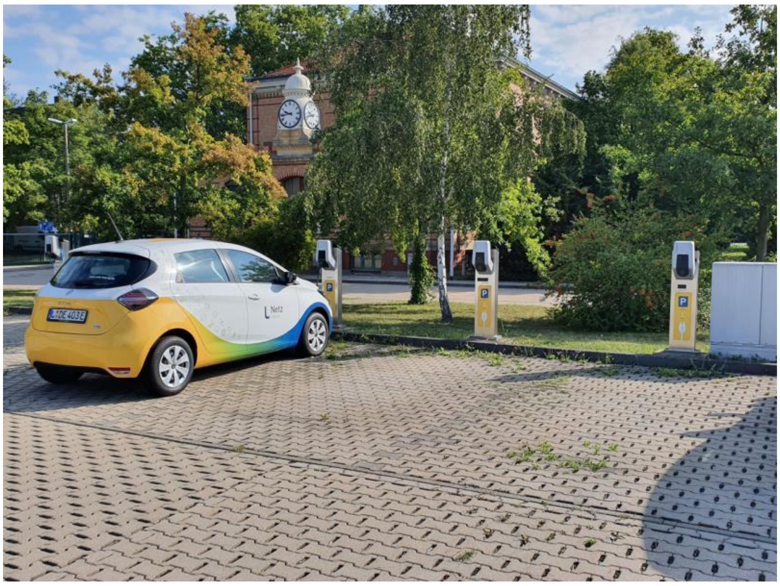 Figure 51: Charging points in Arno-Nitzsche-Straße (Source: LSW)	
Roles and responsibilities	**<u>LSW: Task leader</u>** Charging stations need to be defined Charging stations need to be upgraded Charging stations need to be connected to a charging station backend system that provides the relevant protocols	
Milestones/ Tangible outcome	M25 M36	250 charging points have been upgraded for intelligent charging. The charging stations can be controlled by a charging station backend system.
Outlook until M60		Ongoing operation with the new back-end

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Action L16-2	Explore business models and services tailored for residents; allow for reservation of charging spaces, allow for selection of charging tariffs and priority setting (FHG, LSW, WSL).	
Demonstration plan	Different tariff and business models for the reservation of charging stations and charging electric vehicles are conceivable. For example, time-based, energy quantity-based or load-based tariffs could be implemented. The combination of the corresponding price components are conceivable. Within the SPARCs project, various business and tariff models will be presented and the corresponding protocols and standards will be taken into account. The report is available. It first describes the roles and actors in the context of e-mobility. Based on this, challenges in the implementation of variable customer tariffs are presented. The separation of the roles of *charging station operator* and *e-mobility provider* makes it difficult to pass on variable prices to the customer. Nevertheless, a target to realise the corresponding prices is shown. Finally, different pricing models and their advantages and disadvantages are presented.	
Roles and responsibilities	**FHG: Task leader** Define framework conditions and roles Identify relevant standards and protocols Describe business models and selection of charging tariffs based on the standards and protocols LSW: Define framework conditions WSL: Define framework conditions	
Milestones/ Tangible outcome	M8	Relevant standards, protocols and existing services are identified
	M25	Business models and services are described
	M36	Report completed

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<table>
<tr><th>Action
L16-3</th><th colspan="2">Implement and test a mobile user app for reservation and configuration of charging/mobility needs of his privately owned or currently used (shared company fleet) vehicle, integrate the necessary interfaces of participants.</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">An app for defining mobility needs is to be implemented. First views for a user interface were already set up. These include, for example, the functionality of asking the current and desired state of charge. The views and the app will be finalised after the charging infrastructure and user group are defined.

Figure 52: App view according to current status (Source: LSW)

The e-mobility app is in use for customers. With the L.Drive app, customers can flexibly use innovative charging systems as well as charging solutions. With the matching charging tariff L-Strom.drive, users can "fill up" with electricity for their e-car.

Potential developer resource repriorisation due to legal requirements in the implementation of Redispatch 2.0 for the protection of critical infrastructure (§§ 13, 13a, 14 EnWG) may cause delay until M39. Go live of reservation function is scheduled for 09/22, not certain however.</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2">LSW, WSL, LPZ:

Define framework conditions
Define and provide a fleet</td></tr>
<tr><td rowspan="3">Milestones/ Tangible outcome</td><td>M14</td><td>Views are developed</td></tr>
<tr><td>M25</td><td>App is rolled out and used by the public</td></tr>
<tr><td>M39</td><td>Reservation function is added to app</td></tr>
<tr><td>Outlook until M60</td><td colspan="2">Users are able to reserve stations in real world business case settings.</td></tr>
</table>

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<table>
<tr><th>Action
L16-4</th><th colspan="2">Demonstrate load-balancing with an electric vehicle fleet in accordance with local grid needs.</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">The bookings of a fleet management system serve as input for the optimisation determining charging schedules. In addition, grid constraints will be taken into account. A fleet and charging stations will be defined to demonstrate the algorithms.
Based on OCCP functionalities demand response is operational with LSW fleet.


Figure 53: LSW fleet (Source: LSW)</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2">LSW, WSL, LPZ:
Define framework conditions
Define and provide a fleet support
Define and provide charging stations support
Provide communication between optimisation system and charging stations</td></tr>
<tr><td rowspan="3">Milestones/ Tangible outcome</td><td>M17</td><td>Framework conditions are defined</td></tr>
<tr><td>M36</td><td>Back-end system for intelligent charging implemented</td></tr>
<tr><td>M39</td><td>Load balancing with LSW electric vehicle fleet in accordance with local grid needs can be shown</td></tr>
<tr><td>Deviations</td><td colspan="2">Potential developer resource repriorisation due to legal requirements in the implementation of Redispatch 2.0 for the protection of critical infrastructure (§§ 13, 13a, 14 EnWG) may cause delay until M39. Go-live</td></tr>
</table>

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	of showcase is scheduled for 09/22, not certain however.
Outlook until M60	Continous demonstration of showcase in live settings.

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Bi-directional charging for microgrid

This subtask will demonstrate bi-directional charging for microgrid stabilisation by integration of the e-mobility platform and its integrated charging optimisation. To facilitate the subtask, the charging optimisation algorithms – based on a mixed integer linear program (MILP) – must be extended and evaluated to enable bi-directional charging of electric vehicle fleets. The objective for this subtask is to show bi-directional charging to stabilise a microgrid, based on load and supply forecasts.

This includes:

Action L1-1: Development of bi-directional e-charging system allowing for allowing vehicles to be used as additional storage capacity in the grid. (CEN, LSW).

Action L1-2: Eco-friendly and CO_2-reducing corporate e-car sharing in combination with load-oriented fleet management solution. Analysis of the effects of integration in the micro grid (CEN).

Action L1-3: Demonstrate bi-directional charging for microgrid stabilisation (CEN, FHG).

Action L1-4: Extend the charging optimisation algorithms for EV's bidirectional charging (FHG, CEN).

Action L1-1	Development of bi-directional e-charging system allowing for allowing vehicles to be used as additional storage capacity in the grid.
Demonstration plan	The aim is to test and demonstrate the bi-directional charging system as a pilot project. The central component of the project is a car (BMWi3) which is leased from BMW by SPARCS partner Seecon located in Hall 14 of Baumwollspinnerei. Due to the novelty of the technology, there are only very few providers, which is why a coordinated system concept from BMW and the wallbox manufacturer KOSTAL is used. Two further charging columns from the manufacturer Walther Werke are also part of the E-Mobilty Hub but can only be converted to bi-directional charging in the future. All three charging columns are installed on site and are connected to the electrical infrastructure. The bi-directional BMWi3 is also in place. Furthermore, the work on the connection to the energy and load management system is completed, so that charging processes can be remotely measured and mapped.

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Figure 54: Charging station and charging a car (Source: CEN)

Figure 55: Charging station and BMWi3 (Source: CEN)

Roles and responsibilities	**<u>CEN: Task leader</u>** LSW: Responsible for the construction and operation of the new constructed charging station	
Milestones/ Tangible outcome	M18	Letter of Intent between Seecon and CENERO.
	M21-30	The purchase and integration of an electrical vehicle with bi-directional charging capability.
	M30-36	Bi-directional hardware is installed on site. Integration into exisiting infrastructure completed. The connection to the energy management software is implemented and the first charging processes have been tracked.

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Action L1-2	Eco-friendly and CO_2-reducing corporate e-car sharing in combination with a load-oriented fleet management solution. Analysis of the effects of integration into the microgrid.	
Demonstration plan	In collaboration with the Frauenhofer IAO, CEN will be developing a rudimentary pilot system for eco-friendly and CO_2 reducing corporate car sharing. The solution will be tested in the Spinnerei block as a development opportunity for both the Fraunhofer IAO and CEN to analyse the options and solutions for a fleet management solution. The car provided by Seecon for the bi-directional charging station is included as part of the fleet. Bi-directional vehicle and wallbox in place Conceptual coordination Seecon & FHG for the implementation of fleet management finalised Interface to load management for analysing effects on microgrid in place.	
Roles and responsibilities	**CEN: Task leader**	
Milestones/ Tangible outcome	M18	Letter of Intent with Seecon
	M18	Letter of Intent with LSW
	M21-M30	Installation and qualification of the bi-directional charging station.
	M36	An e-mobility hub consisting of a local electrified car sharing concept and commercial vehicles in close proximity to building 18. In addition, the car will have a parking space there for bi-directional charging and will be marked with the logos of the SPARCS project and the respective cooperation partners.

Action L1-3	Demonstrate bi-directional charging for microgrid stabilisation.
Demonstration plan	The first bi-directional charging stations at the Baumwollspinnerei demonstrates bi-directional charging of electrical cars. The discharging of electric vehicles can feed electricity into the grid. In this way, parked vehicles can help to stabilise the microgrid. In this way, the electric car is used as a battery during times of excess electricity production as it will be fully charged and, during times of low production, the energy can then be fed back into the electricity grid to aid in peak shaving and load management.

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	• Bi-directional vehicle and wallbox in place • Concept for the presentation of the Mobility Hub	
Roles and responsibilities	**<u>CEN: Task leaders</u>**, technical support, define the microgrid and provide relevant information FHG: Extend and adjust constraints regarding bi-directional charging	
Milestones/ Tangible outcome	M36	An E-Mobility Hub consisting of a local electrified car sharing concept and commercial vehicles in close proximity to building 18. In addition, the car has a parking space there for bi-directional charging and is marked with the logos of the SPARCS project and the respective cooperation partners.

Action **L1-4**	**Extend the charging optimisation algorithms for EVs bi-directional charging.**	
Demonstration plan	Version 1 of the charging station optimisation algorithm only provides unidirectional charging. Version 2 provides bi-directional charging. The constraints are adapted in such a way that discharging electric vehicles and feeding electricity into the grid is possible. In this way, parked vehicles can provide energy for the energy community.	
Roles and responsibilities	**<u>FHG: Task leader</u>,** Extend and adjust constraints regarding bi-directional charging CEN: Technical support	
Milestones/ Tangible outcome	M24	Necessary installation is finished, and target is defined
	M32	Extended algorithm exists

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Planning of Energy Positive Communities in Leipzig

The planning of energy positive communities builds upon the learnings from implemented actions. It is set to integrate planning tools of the City of Leipzig (Urban Data Platform) with data and knowledge gathered during the implementation of the positive energy community (L19-1). Furthermore, it determines the requirements to expand and integrate more buildings and stakeholders into the positive energy community (L19-2). The City of Leipzig (LEI) is currently developing an operational concept for the implementation of the urban data platform of the city which is based on the existing geospatial data infrastructure. Based on this infrastructure a use-case "energetic district concepts" will focus on the integration of energy and heating data on building and district level. The goal is to development a planning and monitoring tool as a simplification and acceleration of the investigation procedures for the estimation of the potential of energetic development of existing neighbourhoods in Leipzig as well as developing a monitoring facility for implemented actions. Coming from the demand to transform especially existing building stock to become carbon neutral and (as a second step) to become an energy positive district the City of Leipzig is furthermore developing so called “energetic refurbishment concepts” for three neighbourhoods within Leipzig. These include a baseline assessment of the energy performance of the districts as well as defining measures regarding climate neutral districts. SPARCS demo district Duncker Neighbourhood is part of one of those districts. SPARCS partners LEI, LSW, WSL and SEE are part of the elaboration of the energetic refurbishment concept and evaluating the replication potential of SPARCS measures to the three districts. Additionally, the data needed for the baselining of districts will be integrated into the city’s UDP and results will be used to define requirements for L19-1 and L19-2. The integration of energy and building data from the Duncker Neighbourhood contribute to the overall goal of creating a profound information and knowledge base for urban development and planning decisions within the city.The Digital Twin "Energetic refurbishment Concepts" supports users in different implementation phases. Starting with support for the selection of suitable neighbourhoods, through the transparent presentation of data for inventory and potential analysis, to the development of concepts. It simplifies the formulation of goals and the planning of measures. During the implementation of the measures, the digital twin helps with its planning and monitoring functions. The twin ensures transparency in the individual neighbourhoods as well as in the overview of the entire city.

Action 19-1 will be an excellent use case for the urban data platform to explore the added value of urban data for a municipality and other stakeholders.

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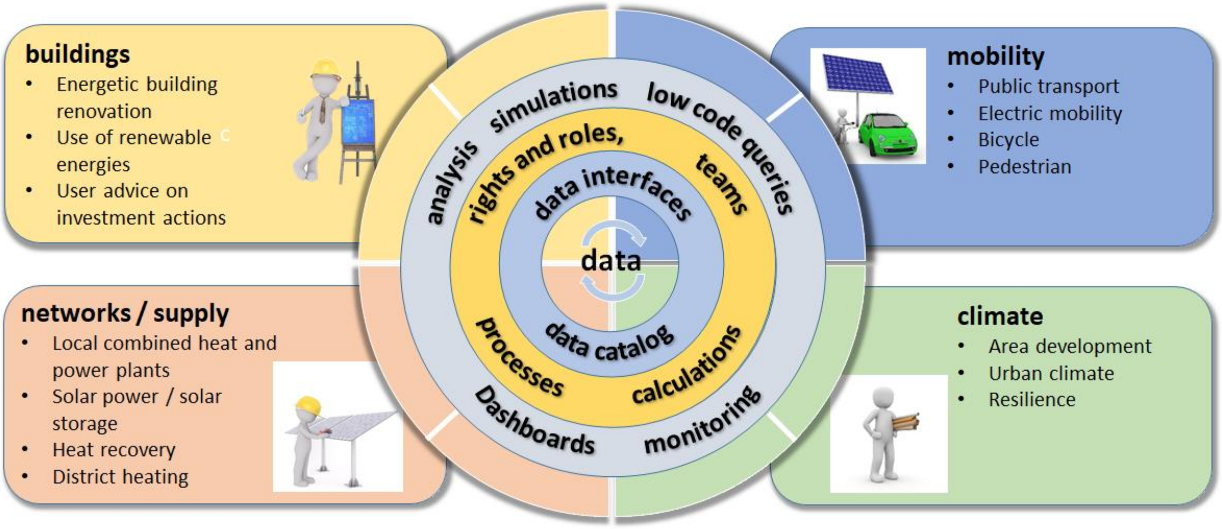

Figure 56: Vision for a digital twin on energetic district development (Source: LEI)

Energy Positive District Planning

Action L19-1	Integrating energy and building data into the Urban Data Platform of the City of Leipzig for advanced and integrated district and building planning.
Demonstration plan	Monitoring and collection of energy and building data during the implementation phase of the energy positive community. Determine requirements for the integration of data into the urban data platform (data formats, APIs, etc.). Determine possible use cases and integrate data into the urban data platform. Workshops were conducted on requirements for climate and building data for municipal planning processes as well as direct contact established towards responsible units within the city administration, namely the Office for Housing Subsidies and Urban Renewal and the Office for Geoinformation. A first set of data necessary for baselining the current status of districts regarding the existing building stock and its energy consumption as well as traffic loads, etc. was defined. It became clear that the data collection and storage is carried out by various stakeholders and often not accessible for other stakeholders. There is a clear need to combine data within one urban data platform.

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Table 3: Examples for data necessary for district baselining

Dataset	Source
Road traffic data	Office for Geoinformation and Land Planning
Digital 3D city model of Leipzig	Office for Geoinformation and Land Planning
Aerial photographs	Office for Geoinformation and Land Planning
Official addresses City of Leipzig	Office for Statistics and Elections
100 x 100 m raster BKG section Leipzig	Federal Agency for Cartography and Geodesy
Population data on 100 x 100 m raster BKG	Office for Statistics and Elections
Traffic count data	Office of Transportation and Public Works
Green volume	Office of Environmental Protection
Trees	Office of Green Space and Waters
Green roof cadastre	Office of Environmental Protection
Solar roof cadastre	Office of Environmental Protection
City lighting systems	Office of Transportation and Public Works
Main network wheel	Office of Transportation and Public Works
Energy data	Energy provider/ net operator

One of the greatest challenges is to retrieve energy and heating consumption data at the block and building level. In some cases, cooperation with energy market stakeholders can help to obtain the necessary data. Fig. 56 gives an examples how heating demands on building level can be visualized (categories: hight/medium/low).

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	 Figure 57: Example Visualisation of heating demand at building level (Source: LEI)	
Roles and responsibilities	**<u>LPZ: Task leader</u>**, coordination	
Milestone/ Tangible outcome	M36	RoadMap for implementing data into an urban data platform Leipzig
	M48	1st integration of energy and building data into an urban data platform Leipzig
Outlook until M60	Futher work will focus on data availability and needs that derive from the standard model for climate-neutral districts (see L20-1) on one side. This will require intensive discussion with the different stakeholders, esp. city departments which are involved in district development and data managers. On the other hand, discussions with various stakeholders will focus on the possibilities of using digital twins for district planing processes as well as monitoring and evaluating the effectiveness of implemented solutions in different districts.	

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Action L19-2	Identify the requirements how buildings can be integrated into the Positive Energy Community; determine the smart building requirements to support the creation of holistic system intelligence.	
Demonstration plan	Identification and description of requirements for buildings and stakeholders to be integrated into the Urban Data Platform (UDP) and Digital Twin of the City of Leipzig. Actions carried out under T4.2, T4.3 and T4.4 as well as findings and recommendations derived from their implementation will be carefully reviewed to determine technical requirements for the further integration of relevant energy-related building data.	
Roles and responsibilities	**LPZ: Task leader**	
Milestone/ Tangible outcome	M42	First interim results can be integrated into D4.4 Interoperability of holistic energy systems in Leipzig (interim report)
	M60	Integration of results in D4.7 on the integration of energy-related building and district data into the UDP
Outlook until M60	Based on the experience gathered in the implementation of L19-1 on the integration of building and district data from the Duncker-Viertel demo district into the urban data platform and engagement with various stakeholders, a checklist/ guideline will be elaborated until M60.	

Standard model for smart cities

In L20-1, a standard approach for Leipzig for developing existing districts into climate-just districts is elaborated. In close collaboration with other city departments, the current approach of a parallel process for three energetic district concepts is being reassessed and refined; action fields are identified; the limits within the current funding approach discovered, data needs clarified and data sharing tackled. Existing approaches are taken into account.

The task concentrates on the existing districts, as opposed to newly constructed districts, as both demo districts and one replication district are existing districts. The aim is to elaborate one standard approach which can easily be modified for different district typologies within Leipzig.

Within this process, necessary fields of action for PEDs are clarified and links will also estasblished made to tasks L19-1 and L19-2 in order to access the role and possibility that the use of urban data platforms and digital twins can play within district development.

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The assessment of the standard model in L20-1 as well as actions L19-1 and L19-2 require a working process across different city departments (e.g., traffic, green and blue infrastructure, urban development, climate protection, environmental protection), with external stakeholders (such as SPARCS partners, e.g., LSW, WSL and CEN) as well as citizens. In a first phase, the working process focusses on bringing together different city departments that play a role in the development of climate-just districts and are already involved in other climate measures throughout the city.

Action L20-1	Assessment of a standard model for the Leipzig replication districts in close collaboration with partners, stakeholders and the responsible city departments and the synchronisation with similar aspirations in Espoo; this includes a survey of resulting benefits for citizens, the city and the possibilities to effect the creation of new smart and clean city solutions.	
Demonstration plan	Discussion will start after M36 in connection with results of WP1, WP3 (Task E22-1), T4.6, T4.7, WP5 (incl. road map for development of standard model, municipal working group, workshop with property developers etc.)	
Roles and responsibilities	**LPZ: Task leader**, FHG IAO	
Milestone/ Tangible outcome	M54	Internal working group established, local workshops and exchange with Espoo carried out
	M60	Definition of standard model, integration of results in D4.7
Completed action	A meeting with Espoo has been carried out in M28, understanding the differences and commonalities in designing a process for a standard model and connections to action E22-1. This was followed by an extensive phase of understanding the needs and constraints of the different Leipzig city departments, and other projects in regard to climate-neutral district development were carried out by interviews to build trust and willingness for cooperation. To arrive at a common understanding, find ways to deal with the conflicts of interest of different city units, and to reach a unified approach, workshops with several city units, which form the working group, are conducted. This group discusses at which point in time the action fields that the city units represent have to be taken into account in a process to climate neutral districts. The first workshop, held on July 13th, 2022, with 15 participants from 8 different city units aimed at building a common information basis	

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<table>
<tr><td></td><td>regarding the current process, improvement needs, understandings of climate-just districts, and a first process draft.

Figure 58: Opening of the first workshop on standard model for climate juste district development. (Source: LEI)

Figure 59: One group working on a draft of an ideal process. (Source: LEI)

Figure 60: Small group discussions during the first workshop. (Source: LEI)</td></tr>
<tr><td>Outlook until M60</td><td>The results of the first workshop will be visualised and organised as a work basis for the next workshops; and first opinions on a potential process model will be obtained.</td></tr>
</table>

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	In M38, a co-creative workshop will be held to elaborate on action fields, improvement needs with the current process, a work further modelised process and on defining data needed and making them available. Further workshops are envisioned on aligning the needs of conservation of national heritage and the needs of renewable energies within district GHG neutrality. Further working steps, such as checks with partners & stakeholders, the reflection with the Espoo model and/or a potential survey on benefits, will be defined with respect to needs later in the process.

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Community support for energy transformation in the district

Introduction to task 4.6

The objective of task 4.6 is to engage and support the citizens in the energy transition through inclusive and participation-oriented measures like well-established energy revitalisation management. The main implementation premises focus on introducing and involving the local communities in activities promoting sustainable energy sources, developing the energy saving habits and raising awareness on the critical yet simple climate change prevention measures that can be done on an individual level through non-invasive adjustment in the current lifestyle.

The SPARCS positive energy community management (PECM) includes two main tasks:

L21-1, strategic, processual, and participative tasks:

- Identification and activation of key participation groups (tenants, local companies based in the examined areas, - in the longterm also including the Leipzig citizens in general).
- Planning and partially organising (or advising) the participation, communication, and information delivery formats.
- Resource-and activity-oriented involvement of technical and strategic SPARCS-partners.
- Involvement of the key strategic partners outside of the SPARCS Leipzig consortium.
- Monitoring and evaluation.
- Quality management of SPARCS products through the interaction with the local communities.
- General coordination and on-schedule control (reference: participation concept).

L21-2, new approach to on-site energy advisory (desk support):

- Information and advice on the cost-efficient use of renewable energies.
- Energy advisory for local communities and companies on the implementation of projects (also outside of SPARCS) that effectively contribute to reinforcing and further developing energy positive communities.
- Constant improvements and expansion of participation options for diverse milieus in the activities related to energy transition and climate change prevention.

The initial premise of L21-2 was to support the tenants from the demo district Duncker neighbourhood and other interested parties with an on-site energy advisory. Due to COVID-19, such activity was no longer possible and, therefore, the whole idea of desk support needed to be redesigned.

Actions for community support for energy transformation in the district

Action L21-1 concentrates on activities realised within the work spectrum of PECM. The purpose of its main elements (foremost participation, communication, and information delivery formats as well as monitoring, evaluation and quality management) enables the

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active involvement of the local communities in the energy transformation process. It also aims to raise awareness of the individual's impact on climate change prevention efforts and to encourage the usually neglected social and cultural groups to take part in the inclusive participation practices.

Action L21-1	Establishing an Energy Advisor action for supporting the residents with the energy transformation towards the newly established Virtual Power Plant.
Demonstration plan	Due to the pandemic situation, the past project period (2020/2021) has been the most challenging for any kind of classic participation approach, which is laid out in more detail under deviations and problems. Only a few technical products are ready for demonstration and evaluation at this point; therefore, most participation actions concentrate on information, raising awareness and activation of the citizens as well as workshops that are not related to the products. In June 2021 (M20), Seecon, Fraunhofer Institute and the City of Leipzig organised the conception, the infrastructure setup, the invitation management, as well as the moderation of the city-wide online workshop: "*Energy positive communities: What are they exactly and how should they look*?". This event took place during the Sustainability Days Festival (German: Umwelttage) in Leipzig. The collaboration with WSL was implemented during this time and the first participation event in the Duncker Quarter were announced. This included analogue activities and activities ibn line with COVID-19 provisions. The so-called "**contact-free**" participation activities consisted of posters pinned up in the stairwells of the residential buildings of LWB in the Duncker Quarter. Besides that, postcards on the topic of "climate protection activities" were sent to Duncker-Quarter households, inviting participants to colour the boxes on the postcard that applied to them.

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	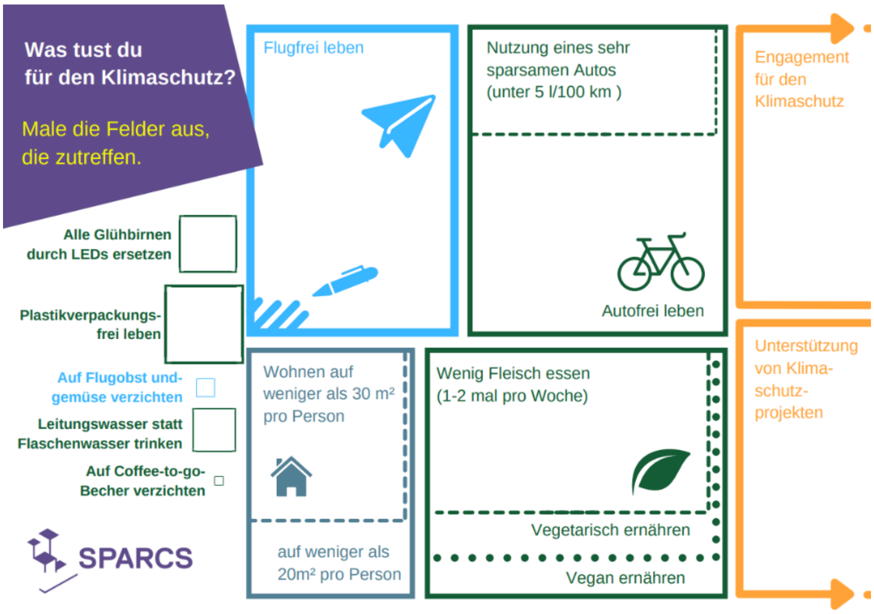 Figure 61: Invitation postcards (Source: SEE) In the autumn of 2021 a booth was set up in the Dunker-Quarter for the first time. This *Coffee & Cake* campaign enabled, Seecon's employees to officially introduced the project on-site. Through direct contact, with the help ofwarm beverages and a cake, the members of Leipzig consortium could get in touch with the local community and talk about the target of the project and the reduction of the energy consumption in urban environments, sustainability, energy transition and climate change. As a result, the residents had the possibility to express their wishes and visions regarding local sustainable development in the neighbourhood: i.e., waste management, green roofs, solar power potential of the apartment blocks.

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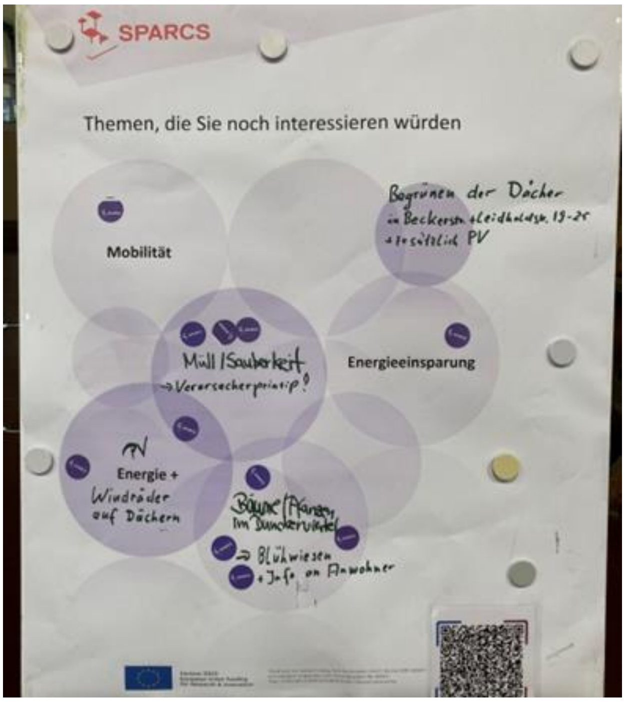

Figure 62: Workshop results on a movable table (Source: SEE)

Figure 63: During the Coffee & Cake campaign in the quarter, children had the possibility to print and do crafts together with the local association, KAOS Cultural Club. (Source: SEE)

These meetings were very important to introduce and involve the local communities in activities promoting sustainable energy sources, developing energy saving habits and raising awareness of climate change.

These events were preceded by several participation and communication activities: i.e., information flyer, article in the local newspaper as well as numerous social media feeds.

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The habitants were also asked to give their anonymous opinion on how much they know about their energy consumption and how they can reduce it and if they are interested in broadening their knowledge of this topic.

On June 16th, 2022, the members of Leipzig consortium met the residents of the Duncker Quarter at the "**Market of Possibilities**", an event conducted in collaboration with a city project to develop an energetic district concept. The location of this district concept includes the SPARCS demo-district and thematically overlaps with the SPARCS project as well as it plans a climate-friendly local development.

The warm and friendly atmosphere of the day was a great opportunity to celebrate the award ceremony of the **Drawing Competition** "*What does your home look like in a future in which polar bears and bees also have a place in the world?",* organised and promoted by Seecon in the previous weeks. The goal of the drawing contest was to raise awareness of the importance of living in a sustainable world in children (3 - 10 years old) and their families.

Figure 64: Drawing competition (Source: SEE)

Through the engagement of a younger generation, we have tried to raise awareness of SPARCS topics among families. Every child had the chance to win a prize based on their age group. All awards (books, child-friendly greenhouses, card games, coloured pencils, bird houses) were made from recycled materials and related to ecological and environmental topics.

In the meantime, adult tenants had access to **advisory services** from local external parties regarding energy-saving topics, neighbourhood projects and design possibilities for a liveable and environmentally

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friendly neighbourhood.

Figure 65: Local participants offering free advisory services (Source: SEE)

Interested citizens could contribute their own ideas and suggestions for an environmentally and climate-friendly design of the Duncker Quarter at a digital participation table (**DIPAS**). In this context, actors of the SPARCS consortium exchanged ideas about sustainable energy supply solutions and mobility alternatives with visitors. The DIPAS table was provided by the city of Leipzig and proved to be an excellent digital system for local citizen participation. DIPAS is a geospatial-augmented reality table that visualises SPARCS products and lets citizens understand their impact through an active, real-time interaction.

Figure 66: DIPAS table in the Quarter (Source: SEE)

The event had been preceded by several **communication activities**: i.e., information flyers distributed to about 3,000 households, contacts with teachers and educators of the local primary and nursery schools, posters in the neighbourhood, an article in the local newspaper as well as numerous social media feeds from different

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	cooperation partners. In June 2022, the Leipzig Ökofete took place. Under the motto *Interesting facts about the environment, sustainability, and nature conservation*, it constituted the largest environmental fair in Central Germany and provided fun, entertainment, as well as a variety of offers for families and citizens. On that day, more than 100 exhibitors presented ideas and suggestions and offered sustainable products. Seecon's employees and the partners of the SPARCS consortium were available to answer visitors' questions about the SPARCS topics. **Lessons learned:** The district tenants are mostly senior citizens and families with children – and often have a migration background. Therefore, analogue participation formats are much more effective than the digital ones, especially, in the summer. We have succeeded in making the project better known. Families with children walked by. Interested citizens have given input and asked questions at DIPAS-Tisch or at the Ökofete booth. We have, however, noticed that citizen involvement requires to tangible offers and activities as well as eyecatchers (Drawing Competition, Coffee&Cakes, DIPAS-Tisch, i.e.). Therefore, good, and timely communication with local schools and after-school as well as day-care centres are very effective in attracting citizens and families. Networking, public relations, articles in the local newspaper as well as numerous social media feeds are also very important to promote local events. At the next workshop, all channels should be intensively used again. Without the COVID-19 situation, these events should have been organised before the development and presentation of the forecast technical products and details to be on schedule also in case of a potential production delay.	
Roles and responsibilities	<u>**SEE**</u>: <u>**Task leader,**</u> management, and control of the action LPZ: Partner; mediator/networker; supervisor and strategic mentoring regarding integrated and inclusive urban development FHG: Partner, innovator, mediator/ networker	
	M20	Workshop: "Energy positive communities: What exactly are they and how should they look?"
Milestones/ Tangible outcome	M23-M24	"Contact-free" participation activities: Postcards und posters
	M24	Two Energy Positive "coffee and cake" events in the

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		district
	M33	- Market of Possibilities - Drawing competition - Leipzig Ökofete 2022
	M34	Internal Replication Workshop 7/07/2022
	M35	Climate Shop Window
	M36	Workshop: Saving energy in times of skyrocketing prices. How to keep your costs under control. - Presentation "My LWB-APP: What does my energy consumption really mean?" - Presentation "SPARCS-APP and dynamic heating control" - In collaboration with: o Caritas o Mosaik e.V.
Outlook until M60	M48. Report on PECM (Deliverable D4.6). Update of the PECM based on feedback and experience collected through the monitoring and evaluation phase.	
	M60. Final report including best practice replication strategies. Involving local high schools in SPARCS activities Climate Shop Window (Klimaschaufenster) Information workshop: Saving energy in times of skyrocketing prices: How to keep your costs under control. Workshop on citizen commitment/energy positive districts APPS User workshop: This user workshop aims to discus the most important aspects of energy consumption reduction though a web and analogue tool that is designed to provide wholesome information on the energy costs monthly.	

The action L21-2 is an inseparable part of PECM coordination. The participation-driven energy management efforts are strengthened by the local desk support and consultancy for every party (either private or commercial) interested in active contribution of co-creating a positive energy living space. The on-site work is also targeted to those that need even basic information of the energy transition and climate change prevention measures. It needs to maintain an inclusive, neutral character.

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<table>
<tr><th>Action
L21-2</th><th colspan="2">Desk support for interested citizens with information regarding the cost-efficient installation of renewable energy sources such as PV and participation in the Positive Energy Community, for local businesses and private persons interested in rolling out project solutions</th></tr>
<tr><td>Demonstration plan</td><td colspan="2">The first activities related to desk support (apart from implementation premises included in the participation concept) will be pursued no earlier than in M24, after the evaluation of the first implementation phase. Between M24 and M30, a decision on the form and location of the desk support that would align with the DPCA will be made. After completing the conception phase of the desk support that included the participation formats, the work on active cooperation with the local community will start. As in the case of the participation concept at the end of each cycle, the efforts will be evaluated and the adjustments for further development set for implementation.</td></tr>
<tr><td>Roles and responsibilities</td><td colspan="2"><u>SEE: Task leader,</u> management and control of the action
LPZ: Partner; mediator / networker; supervisor and strategic mentoring regarding integrated and inclusive urban development
FHG: Partner; innovator; mediator / networker</td></tr>
<tr><td rowspan="4">Milestones/ Tangible outcome</td><td>M12</td><td>Allocation of implementation premises for desk support in the participation concept.</td></tr>
<tr><td>M24, M36</td><td>Work review with Leipzig Consortium.
Our contact details are available at every workshop to offer the possibility of having a constant and transparent Service Desk. Citizens can contact us at: sparcs@seecon.de.
To be able to offer an active desk support, we have maintained cooperation and contacts with external established players like Caritas, German Consumer Organisations, Mosaik in the past months. We have involved these actors through various activities to offer tenants free, provider-independent, and professional advice</td></tr>
<tr><td>M33</td><td>Market of Possibilities: Tenants had the possibility to get free advisories from energy consultants, e.g., from the German Consumer Protection Organisations (Verbraucherzentrale Sachsen VZS).</td></tr>
<tr><td>M36</td><td>Information workshop: “Saving energy in times of skyrocketing prices: How to keep your costs under</td></tr>
</table>

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		control. Workshop on citizen engagement/energy positive districts”. Cooperation with Caritas and Mosaik e.V. on energy saving topics.
		Climate Shop Window: Cooperation with local actors for posting information about energy-saving measures.
	M48	Report on desk support.
Outlook until M60	Consolidate advisory services in the Duncker district in cooperation with local actors.	

The aim of Action L21-3 is to involve all relevant stakeholders in the project activities, to increase their awareness for energy efficiency in general as well as their acceptance for the implementation of the specific SPARCS actions. Participation is an important prerequisite for the successful implementation of energy system transformation and can only succeed with the broad support of the citizens. This support can be gained at various levels, from information and transparency to consultation, co-determination or even decision-making by the citizens. Concerning the SPARCS activities, concentrating mainly on the first two levels, as the measures have already been defined, but there is still room for creativity.

The exchange between Lighthouse and Fellow Cities concerning citizen engagement was continued on 30 September 2021 with a follow-up online workshop on the Adaptation of Citizen Engagement to the "New Normal" (Covid restrictions).

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Action L21-3	Creating a methodological approach for developing positive energy building blocks user-centric solutions in the urban context and facilitating dialogues and discussion with citizens in the format of regularly scheduled workshops (4 per year), building upon Leipzig's long tradition of citizen engagement	
Demonstration plan	Step 1: Stakeholder analysis Step 2: Collection of relevant participation formats (desktop research) Step 3: Evaluation of the experiences of other SCC1 projects regarding their relevance for Leipzig (Task 1.6 questionnaire) Step 4: Collection of participation experiences in Leipzig (interviews) Step 5: Compilation of relevant participation formats for Leipzig Step 6: Development of guidelines for participation in Leipzig Step 7: Implementation, evaluation and adaptation of participation formats	
Roles and responsibilities	**FHG: Task leader**; management and control of the action SEE: Partner; innovator; mediator / networker LPZ: Partner; mediator / networker	
Milestones/ Tangible outcome	M12	Methodological basis for the participation concept (toolbox prepared in Task 1.6)
	M48	Input for the D4.6 Report on Citizens and stakeholders in Leipzig's energy transition
Outlook until M60	Implementation of workshops, continuous evaluation of implemented formats and adaptation of the participation concept based on lessons learned	

Empirical research

ULEI will investigate the socio-psychological factors driving citizens to become, and stay, involved in district-based smart and ecologically sustainable energy management. This enables both improving monitoring and steering of specific community actions (district-based positive energy communities) as well as to derive transferrable knowledge about the "human factor" in implementing pro-ecological community innovations. Specifically, on the one hand, ULEI plans to measure person-level factors, such as personal attitudes or perceived personal competences. In addition, ULEI will capture collective-level factors, such as identification with the community, perceived energy-related and project-related community norms, and perceived collective efficacy to improve sustainable energy use as a community. Individual and collective-level factors will be measured at three time points (longitudinal evaluation study design) during the SPARCS interventions to assess behavioural changes and the effectiveness of interventions.

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ULEI will also make use of an experimental design by implementing control groups with no SPARC measures to ensure that intrapersonal behavioural change and effects of SPARCS measures are not due to "learning effects" by filling out the survey questionnaire repeatedly. This research program will enable ULEI to investigate causality, from which communication strategies can be derived and communicated to project partners.

Action **L21-4**	**Conducting a comprehensive empirical research program on how personal-level (e.g. personal attitudes) and collective level variables (social identity variables) provide pathways to positive energy districts and communities, identifying the ingredients of successfully communicating collective sustainability transitions that in fact change people's course of action.**
Demonstration plan	In close collaboration with WSL, ULEI will gather data at different time points in the implementation phase of subtask T4.2.3 Efficient and human-centric social housing blocks. ULEI aims to distribute household questionnaires at three points of measurement (pre-, post-test, follow-up). The first survey wave consists of three phases: (1) distribution of announcement flyers, (2) distribution of survey questionnaires, (3) collection of survey questionnaires. A week before data collection starts, each household in the sampling area will be informed via flyers about the day and time frame ULEI employees will personally distribute survey questionnaires to households. Surveys will be accessible in a paper-pencil format only, for which participants will have one week to fill out. One week after the distribution of the survey questionnaires, ULEI employees will personally collect filled-inquestionnaires. In case (potential) participants are not at home at phase 2 and/or 3, survey questionnaires or stamped envelopes will be placed in the mailbox. These data collection phases will be repeated at later measurement points (depending on the implementation of SPARCS interventions in the Duncker neighbourhood) to assess the effects of SPARCS-measures. In addition to the survey in the Duncker neighbourhood, where SPARCS-measures are being implemented, the survey will also be conducted in two areas in Leipzig where no measures are taking place. These act as necessary control groups in order to be able to make more robust statements about the effectiveness of SPARCS measures. The data will be analysed, and the results will be presented to both WSL and the Leipzig project consortium, discussing interpretation and implications for improving the implementation process in the Duncker neighbourhood and other places (e.g., with regard to proper communication sustainability transformation). Results of the 1st survey will also be included in D4.6 Citizens and stakeholders in Leipzig's energy transition (report).

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	Data collection of 1st survey was completed by the end of M25. Data collection of 2nd survey was completed by the end of M33.	
Roles and responsibilities	**ULEI task leader:** Conducting empirical survey and experimental research	
Milestones/ Tangible outcome	M28/29	Presentation of results of the Duncker neighbourhood study (1st survey)
	M33	Data collection of 2nd survey completed.
Outlook until M60	Data collection of 3rd survey is planned for March/April 2023 (M42/43). Presentation of the further analyses and findings on effectiveness of SPARCS-measures (M46/47).	

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REPLICATION AND EXPLOITATION PREPARATION

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, e.g., dwellings owned by the municipal housing association spread out across the city and Stadtraum Bayerischer Bahnhof,
- 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.

Results of the task will be included in D4.7 Replicating the smart city lighthouse learnings in Leipzig (report).

The task needs to take into account new and updated municipal strategies and programs at a local level. They include the CO2 immediate action programm, the new SECAP 2030 (city council decision expected for 09/2022) and the participation of Leipzig in the EU Mission on 100 Climate Neutral and Smart Cities until 2030. All those different iniatives and strategies include measures on district level regarding energy efficiency and consumption as well as the decarbonisation of the city's energy and heating system. Therefore, effort is taken to include already existing results and findings of the SPARCS project within those strategies to secure replication beyond the duration of the SPARCS project.

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T4.7	Replication and exploitation preparation
Demonstration plan	Preparing for replication is one major aspect of SPARCS. Based on the development plans of the district roadmaps for replication will be drafted. Furthermore, the results and findings of D4.3, D4.4, D4.5 and D4.6 will be evaluated and recommendations and guidelines for the further developments of PEDs will be drafted. Actual and future strategic documents of the City of Leipzig regarding climate protection and energy transition will be monitored and the possible contribution of the SPARCS actions toward the achievement of the set goals will be illustrated. The replication preparation will consist of several workshops with relevant stakeholders from city administration, SPARCS implementation partners, property developers and civil society. Current strategies and projects within Leipzig focus on the energetic refurbishment of existing city districts. In 2022, so-called “Energetic refurbishment concepts” for three Leipzig neighbourhoods are conducted. In a workshop with the local SPARCS partners in M34, a first evaluation was carried out how the Leipzig SPARCS use cases/ actions (definded under WP1) could be transfered to those districts and what are the regulatory, technical and spatial requirements to do so. The findings of this workshop will be reconsidered when elaborating further replication concepts.  Figure 67: 1st replication workhop with local SPARCS partners (Source: LEI) The set-up of the Post-SCC01 Monitoring Strategy will be closely

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	linked to action 19-1 on integrating building and energy data on the cities' urban data platform.	
Roles and responsibilities	**LPZ: Task leader** WSL, LSW, CEN, SEE, ULEI, SUITE5 – input from local demonstrations (T4.2, T4.3, T4.4, T4.6) BABLE – Input from WP 1 CiviESCo – Input from WP 7	
Milestones/ Tangible outcome	M48	Post SCC01 Monitoring Strategy
	M60	Report on Replication (D4.7 Replicating the smart city lighthouse learnings in Leipzig: technical, social and economic solutions with validated business plans)
Outlook until M60	Following the findings of L20-1 on a standard model for climate neutral district development replication concepts for the chosen districts/building stock will be elaborated in a co-design process between the different stakeholders. Updated and new citywide and district related strategies and projects on climate protection and district development will also be reflected in the replication concepts. For a further distribution of the SPARCS findings and solutions, the cooperation with local and regional stakeholders will be intensified.	

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CONCLUSION

The objective of this report was to give an overview of the smart city lighthouse demonstration activities in Leipzig. The previous project Deliverables D4.1 and D4.2 served as the starting point for this report. The in-depth descriptions of the activities and the implementation processes, together with the gained learnings and insights from these activities, are documented in the thematic Deliverables D4.4 (Interoperability of holistic energy systems in Leipzig), D4.5 (EV mobility integration
and its impacts in Leipzig), and D4.6 (Citizens and stakeholder engagement in Leipzig's energy transition).

The demonstration activities overall embark a range of solutions supporting transition towards low carbon areas and testing of possibilities for positive energy blocks in Leipzig. The activities include energy efficiency improvements, smart energy management, e-mobility, ICT, utilizing local RES production, citizen involvement and urban planning. Many of the activities challenge the old ways of working, enhancing the collaboration at the municipality, companies, citizens, research, and collaboration networks. Monitoring and follow-up of the demonstrations is thus crucial for developing solutions that are also replicable elsewhere.

The Leipzig demonstrations have been completed in September 2022, with some minor delays, and the monitoring phase and production of data will commence thereafter. Especially the two physical demo districts Baumwollspinnerei and Duncker Neighbourhood represent very heterogenous yet very common city districts and their challenges for the development of positive energy districts, e.g. monument protection, social housing structures and existing buidling stock.

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