D3.2 Midterm report on the implemented demonstrations of solutions for energy positive blocks in Espoo

27/10/2021

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SPARCS

Dissemination level

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

Deliverable administration

No & name	**D3.2 Midterm report on the implemented demonstrations of solutions for energy positive blocks in Espoo**				
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Description of the related task and the deliverable. Extract from DoA	**T3.1 Local coordination in Espoo (ESP) M1 – 60** This task ensures the achievement of SPARCS objectives and efficient co-operation within the Espoo Lighthouse Demonstration Team, parallel work packages, other stakeholders and supporting partners, and the Sustainable Espoo development programme. The main activities include, among others: keep strict control of the lighthouse implementation process and schedule. This report presents the progress of the Lighthouse City Espoo demonstration actions compared to deliverable D3.1, including possible changes towards reaching Milestone 3.4, due M30.				
Participants	ESP, VTT, KONE, SIE, PIT, CIT, RIL, ADV, BABLE, CIVIESCO				
Comments					

V	Date	Authors	Description
0.1	10/2021	All	working document
0.2	08/2021	All	Finalisation of the content
0.3	6/9/2021	VTT	Ready for internal review
0.4	25/09/2021	WP leader	Deliverable checked by WP leader and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1	27/10/2021	VTT	Coordinator submits the deliverable to the EC

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About SPARCS

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

Partners

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EXECUTIVE SUMMARY

This report updates detailed plans and the progress of all the demonstration actions that SPARCS will realise in the city of Espoo, Finland by the end of second project year. At beginning, an overall summary of the Lighthouse demonstrations in Espoo is presented, and then continue summarising the details in the demonstration areas. The demonstration actions cover broadly various low carbon improvements of urban area development, including buildings, energy systems, transportation, urban planning and citizen involvement.

Espoo city structure has five large district centres, and our demonstration areas focus on two of these centres in Leppävaara and Espoonlahti districts. Sello area at the centre of Leppävaara district is an existing urban area, where demonstration actions focus on improving the existing urban infrastructure, although there are currently massive construction sites improving the public transportation connection. Lippulaiva block at the centre of Espoonlahti district is a new block that is currently under construction, hence, offering us a potential to test and demonstrate energy positive block solutions in new buildings. In addition to more practical demonstrations, we have a 3rd demo site concentrating on urban planning in the Kera area, with the high ambition level for sustainable and smart district development. And finally, SPARCS also studies macro level demonstration actions in the city of Espoo.

This report describes the detailed plans and the summary of the progress at toward the second project year, including planning of the work, targeted outcome, schedule and partners' roles and responsibilities. A detailed Gantt summarises the demonstration phases, aiming towards Milestone 8 - Completion of the demonstration sites, which is due in M30.

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1. INTRODUCTION

1.1 Purpose and target group

This report provides a throughout overview of the Smart city lighthouse demonstration actions realised in the City of Espoo, Finland. SPARCS project has three demonstration sites in Espoo. Sello area as the centre of Leppävaara district offers a fruitful place to test innovative energy positive block solutions incorporated in existing urban environment. Lippulaiva block at the centre of Espoonlahti provides a demonstration site for constructing a new energy positive block. Kera development area focuses on the planning phase, aiming to develop and demonstrate solutions for the planning process of an energy positive block. In addition, SPARCS has various macro level interventions focusing on the broader level aspects.

In the demonstration sites, SPARCS is making interventions related to various aspects of energy positive blocks: buildings, energy, transportation, ICT, people involvement and urban planning. These interventions done in the demo sites are formulated from many detailed level demonstration actions.

A detailed Gantt shows the schedules for the demonstration phase, acting as an efficient tool for following the overall project situation and reflecting the status of each action. The detailed plans of demonstration actions include work plan, targeted outcome, partners' roles and responsibilities. The detailed planning includes preparation for the monitoring phase that will follow the demonstration phase after M36.

The demonstration actions presented in this report follow the task structure of WP3:

- A summary of the Espoo lighthouse actions activities in section 2, following the work done in T3.1 Local coordination in Espoo.
- Energy positive blocks demonstrations (task 3.2) in section 3, including:
    - Lippulaiva site in section 3.2,
    - Leppävaara site in 3.3,
    - Kera urban planning actions in section 3.4, and
    - Macro level energy related action in section 3.5.
- ICT and interoperability demonstrations (task 3.3) in section 4.
- E-mobility integration activities (task 3.4) in section 5.
- The planning of energy positive districts (task 3.5) in Espoo in section 6.
- The community engagement activities (task 3.6) in section 7.
- Air quality (task 3.7) in section 8.
- Smart business models (task 3.8) in section 9.
- Macrolevel interventions for energy positive solutions in section 10.
- Replication and exploitation preparation (task 3.9) are discussed in section 11.

This report is primarily targeted for organisations working in the SPARCS and collaborative Smart City stakeholder groups. It can also provide insights to other lighthouse projects and cities, and stakeholders; as well as for other cities starting to plan similar kind of smart city developments.

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1.2 Contributions of partners

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

Table 1: Contributions of partners

Partner	Contributions
VTT	Editor of the deliverable. Content planning, allocation of writing responsibilities. Section 1, 5.5, 8, 9.3, and 11.
ESP	Lead of sections 2, 3.1, 3.4, 3.5, 4.3, 5.1, 5.4, 6, 7.4, 9.4, and 10.
CIT	Lead of sections 3.2, 5,2,
SIE	Lead of sections 3.3, 4.1, 4.2,
KONE	Lead of sections 4.4, 7.1, 7.2, 7.3, 9.1, 9.2,
PIT	Lead of section 5.3
ADV	Detailed plan of Action E1-6 in section 3.2

1.3 Relations to other activities

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

Table 2. Relation to other activities in the project

Deliverable / Milestone	Contributions
D3.1	This deliverable D3.2 is an updated version of the D3.1, which described the plans for the demonstrations of solutions for energy positive blocks (due in M12).
D3.3	D3.3 will be developed further from D3.2, describing the implemented demonstrations of solutions for energy positive blocks in Espoo (due in M36).
M8	This deliverable supports for completion of the demonstration sites in Espoo by M30.
WP2	KPIs development initiated and supporting the monitoring of the actions. The KPI's have been identified, paving the way for impact assessment in work package 2 and supporting the preparation for the monitoring phase.
WP6	Knowledge change between other SCC1 projects and other networks and cross-horizontal collaboration activities. Contributions to recommendations building in T6.2.
WP7	Links to business models development and exploitation; aiming for wide knowledge exchange.
WP8	Dissemination and communication of activities in Espoo.
WP10	WP10 supports and ensures ethics issues in the practical work in Espoo.

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2. Overview of Lighthouse demonstrations in Espoo

2.1 Introduction to activities in Espoo

Espoo is the second largest city in Finland with some 280 000 residents. The city has had goals in sustainability since 1990's and currently the topic of City strategy 2017-2021 is "The most sustainable city in Europe – now and in the future". One special character of Espoo is its urban structure: instead of one city centre, Espoo has altogether five city centers that are actually like smaller cities in the city, providing all necessary services close to our residents. In this project, we have demonstration areas located in two city centres: Sello demonstration in Leppävaara and Lippulaiva demonstration in Espoonlahti. Both city centres are currently developing rapidly and foreseeing many new residents in the next ten years. Leppävaara is already now the largest city centre and if it was an independent city, it would be 13th – 15th largest city in Finland by population. The smart city lighthouse demonstration and replication sites in Espoo are showed in Figure 1.

Figure 1. A map shoving the SPARCS demonstration and replication locations in Espoo, Finland.

The demo area in Leppävaara is located around the Sello shopping centre and its block, which is a mixed-use space. In addition to the shopping center, there are residential buildings, public services and entertainment. The Sello shopping center opened in 2003 and new energy management solutions by Siemens include demonstrating direct impact on energy efficiency. Solar panels and battery energy storage are well-known solutions, but their optimized integration to the building energy system requires new approaches. Controlling electric loads like lighting, HVAC and elevators support total system balancing and increase the total flexible capacity that can be sold to Fingrid's Frequency Containment Reserves. Electric vehicle and e-Bus charging will also be integrated. District Heating is business-as-usual in Espoo, but demand side management by leveraging the thermal mass of building structures will allow Sello to reduce peak load and produce savings both in energy expenses and CO_2 emissions. Geoenergy potential will be assessed during the up-coming planning

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of a new Sello extension. In Sello, continuous work towards better energy-efficiency has been done for years. Sello has been rewarded with EU energy service award and LEED Platinum level certification for the operating time.

The Lippulaiva shopping center with surrounding residential block buildings is under construction by its owner Citycon, and it will utilize new energy solutions from day one. The shopping center will host the largest geothermal heating and cooling energy plant in Europe for a commercial building, built under Lippulaiva. The regenerative geoenergy system by Adven will cover 100% of the cooling demand and almost the entire heat demand of the shopping center and residential buildings nearby, leaving only a fraction of heat to be sourced from the district heating grid in case of prolonged cold weather. Excess heat recovered from summertime air conditioning and refrigeration systems is injected into the geoenergy field, increasing the capacity and efficiency of the system. This makes the geoenergy system in essence a seasonal thermal energy storage solution. PV panels provide clean on-site renewable electricity and electric battery storage has been decided to be invested. Lippulaiva is an important mobility hub comprising a metro station, bus terminal and facilities for cycling and e-mobility. Citycon is also engaging citizens, and young customers in particular, to participate in the co-creation of the new shopping center. Collaboration with local schools has led to the establishment of Buddy class actions, and students will work directly with Citycon on specific sustainability themes. City of Espoo will concentrate on promoting sustainable lifestyle among its citizens. The shopping centre part of Lippulaiva block is planned to open in March 2022 and the West metro line extension will start operating in 2023.

The Kera area is a deprived industrial area developed in the 1970s and it will now be reallocated for mostly residential use. Existing landowners include the retail group S-Ryhmä, currently one of the largest producers of renewable energy in Finland, and Nokia, with headquarters in immediate vicinity and strong support to the 5G based smart infrastructure development in Kera. SPARCS will develop and pilot new models for co-creation, energy communities and stakeholder engagement to bring residents in the new Kera district to the center of energy ecosystem, maximizing local production and encouraging prosumer models to enhance the utilization of distributed generation.

Solutions will be replicated in other sites around Espoo, particularly in Finnoo district and in collaboration with Smart Otaniemi innovation ecosystem. Demand side management will be rolled out throughout the city building stock, including city's rental housing provider Espoon Asunnot.

2.2 GANTT

A detailed Gantt shows the schedules for the demonstration phase from M1 to M36 in Table 3, providing an efficient tool for all partners in following the overall project situation and reflecting the status of each action. The milestones defined for each action are highlighted in the table, with columns representing the month number (1-60), but for actions with a more continuous nature only the end date has been specified. The Gantt also includes information about the contributing partners of each task. The order of entries follows the structure of this report.

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Table 3: GANTT for Espoo demonstrations

Action	Task & contributing partners
E1-1	NZEB optimization (CIT ADV VTT)
E1-2	PV optimization (CIT VTT)
E1-3	Battery storage (CIT VTT)
E1-4	Surrounding blocks (CIT VTT)
E1-5	Predictability (CIT ADV VTT)
E1-6	Automation (ADV, CIT)
E5-1	Structures store energy(SIE VTT)
E5-2	District Heating integration (SIE)
E5-3	Sello Extension (SIE)
E10-1	3D City Model (ESP VTT)
E10-2	Energy Infrastructure (ESP)
E10-3	Energy System planning (ESP)
E16-1	Heating DSM (ESP VTT)
E6-1	Sello VPP prediction (SIE VTT KONE)
E15-1	Municipal buildings VPP (SIE ESP)
E16-2	Blockchain DSM (ESP VTT SIE)
E17-1	Sello virtual twin (VTT)
E6-2	Smart energy services (SIE ESP)
E12-1	Kera 5G opportunities (ESP)
E12-2	5G as enabler (ESP)
E12-3	Blockchain energy transfer (ESP VTT
E6-3	Smart bldng energy mgnt (KON SIE)
E2-1	EV charge grid integration (CIT VTT)
E2-2	E-bicycle parking (CIT ESP)
E2-3	E-mobility uptake (ESP CIT VTT PIT)
E7-1	Leppävaara E-mobility (PIT VTT ESP)
E7-2	EV Charging (SIE PIT VTT)
E7-3	Commercial charging (PIT VTT)
E8-3	Shopping behavior (SIE)
E13-1	Multi-modal transport (ESP)
E13-2	E-mobility replication (ESP VTT SIE PIT)
E18-1	Optimal EV charging (VTT SIE PIT ESP)
E17-2	CityGML as a tool (ESP VTT)
E20-1	Finnoo Replication (ESP)
E22-1	Co-Creation model (ESP)
E3-2	Change mobility habits (KONE)
E8-2	Encourage e-mobility (KONE)
E11-1	Citizen mobility (KONE)
E19-1	Urban people flow optimisation (KONE)
E3-1	Energy positive behavior (CIT KONE VTT)
E3-3	Co-creation with young people (CIT ESP)
E8-1	Lead user mobility behavior (KONE)
E19-2	Sustainable lifestyle (ESP)
E21-1	Air Quality (VTT HSY)
E4-1	Lead users, business Lippulaiva (KONE)
E9-1	Lead users, business Sello (KONE)
E23-1	Smart Otaniemi (VTT ESP)
E23-2	Smart business
E14-1	Replication and co-creation (ESP)
E22-2	UN Agenda 2030 coordination (ESP VTT)

2.3 Preparing for the monitoring

A plan for the performance monitoring and prospective KPIs has been developed in Work Package 2 for each intervention considering all demonstration actions. As part of the building demonstration actions, the needed data sources and monitoring is being developed simultaneously.

3. Positive energy blocks in Espoo lighthouse demonstrations

3.1 Introduction to task 3.2

The objective of Task 3.2 is to demonstrate solutions for positive energy blocks and Districts. Positive energy districts (PEDs) are expected to generate more energy than they consume annually. In theory this could thus operate in isolation of surrounding

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infrastructure, but this is not necessary nor desirable in practice. The key driver to developing PEDs is to empower local stakeholders, engage citizens and gain public support for the low carbon energy transition. Ideally, PEDs are independent and locally administered, highly energy efficient entities with local renewable energy generation, storage and distribution, and they interact with the wider energy system. This interaction includes energy trade, flexibility services and storage among others.

The Espoo demonstration sites assume a comprehensive approach to energy systems. Electricity, heating, cooling, mobility, fuels, flexibility and storage capacity are controlled by smart solutions that minimise emissions and costs while ensuring reliability and local ownership. Sector coupling yields more degrees of optimisation, but requires comprehensive automation, new business models and transaction platforms such as blockchains.

Two of the demo sites, Sello and Lippulaiva, comprise of a shopping center, residential buildings, libraries, public services, and rail and bus terminals with improved e-mobility, cycling and pedestrian options. Citizens have various roles as customers, passengers, residents, or simply socializing without being confined in any specific category. Kera, which is a new residential district and due to be developed in the next 10-15 years, acts currently as the third demo site focused on city planning. In all sites, promotion of sustainable lifestyles is as important as adopting new technologies.

What differentiates the three demo sites from each other are their different stages of development. The Leppävaara center with the Sello shopping center has been in use for several years. The Lippulaiva shopping center with residential buildings and metro station is under construction and scheduled to be opened in 2022 (the shopping centre). The development of Kera district (replication area) is currently in city planning phase and its entire construction goes beyond the timeframe of the SPARCS project.

3.2 RES integration in Energy Positive Lippulaiva blocks

The Subtask 3.2.1 RES integration in Energy Positive Lippulaiva blocks focuses on the energy systems in the new Lippulaiva shopping center and the surrounding residential building blocks. Leasable gross area of the shopping center alone is 44,000 m^2, with 550 residential apartments and a senior house with approximately 120 apartments. The heated area of Lippulaiva in total is approximately 150 000 m^2. Figure 2 below show an architecture sketch of Lippulaiva shopping center with residential blocks and the main functions of different buildings in Lippulaiva block. The opening of Lippulaiva shopping center is planned to be on March 31st 2022.

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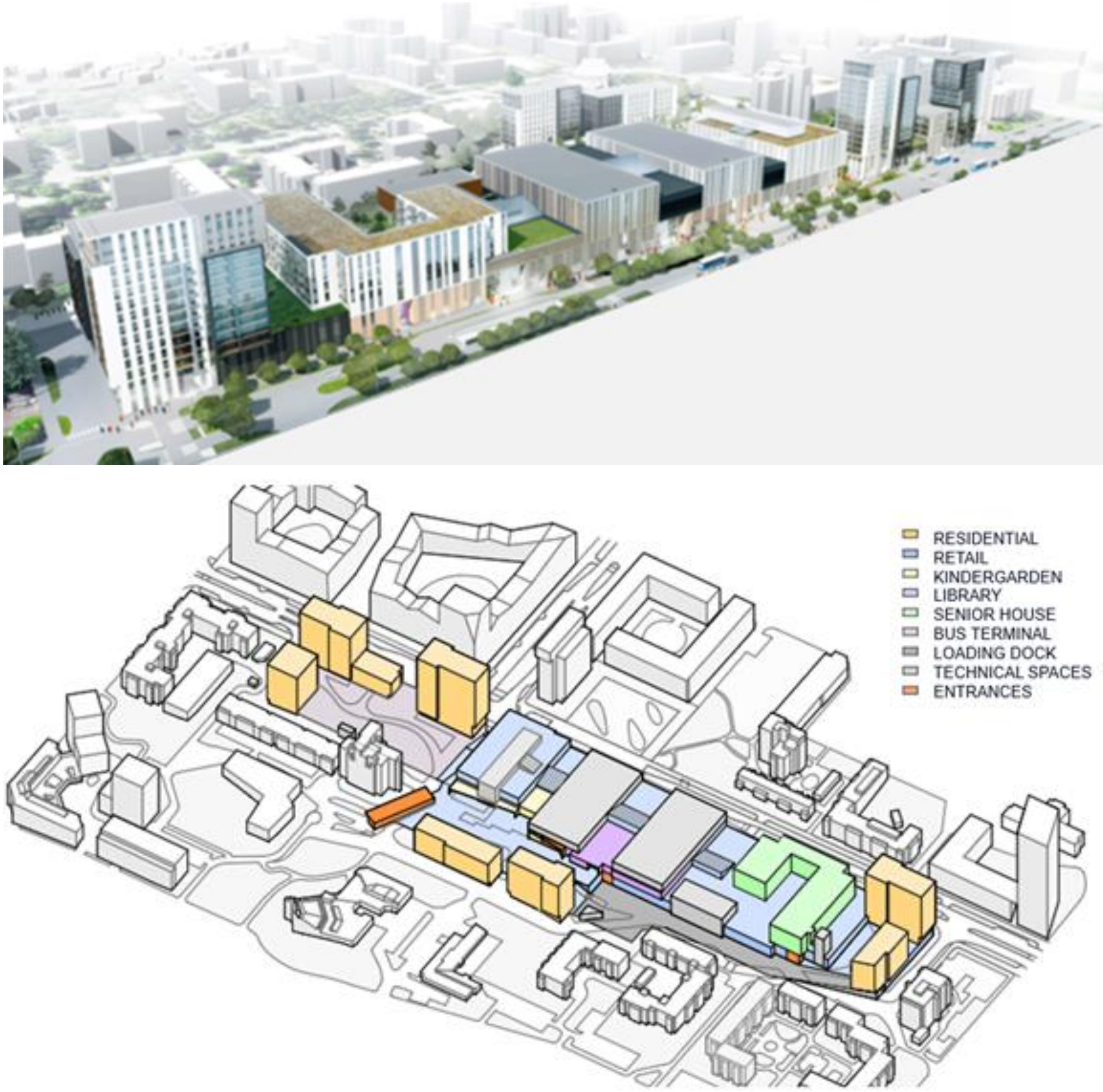

Figure 2. Lippulaiva architecture picture as it will be when ready (above) and the main functions of different buildings in Lippulaiva (figures from Citycon Oyj).

The new Lippulaiva shopping centre together with surrounding buildings creates a district with a multi-mix consumption and the potential to achieve zero-energy level and beyond. Heating and cooling demand of Lippulaiva shopping center as well as residential buildings and senior house is mostly covered with heat pump plant. On-site RES production includes a 4 MW regenerative ground source heat pump plant, approximately 50,000 m of bore holes and a PV system with peak power of approximately 634 kWp. Figure 3 below shows hourly heat consumption profile in one year of Lippulaiva (simulated data) where the orange color represents the share of heat demand provided by heat pump system.

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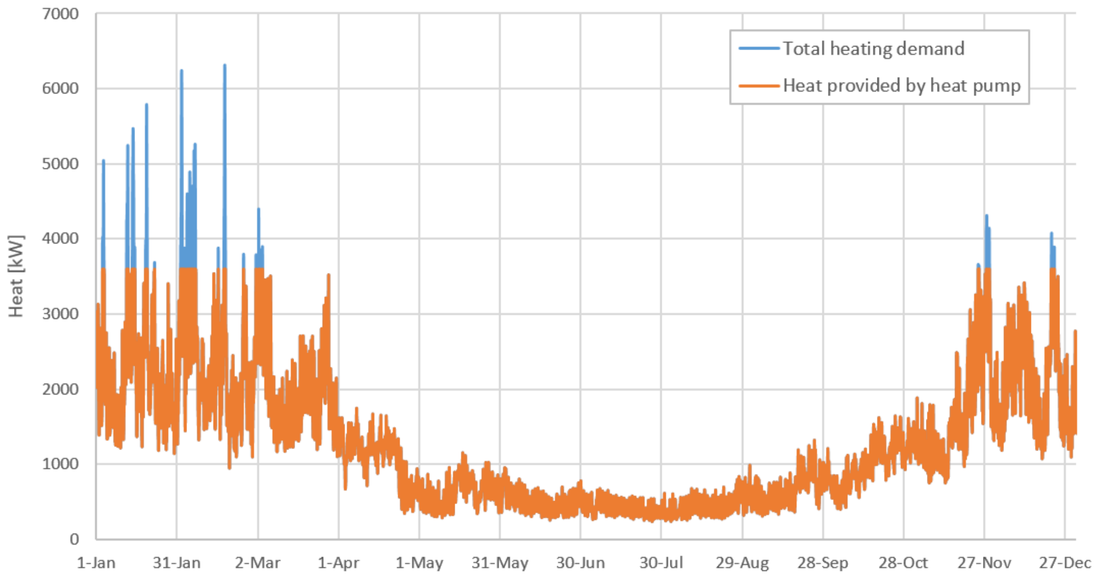

Figure 3. Total heating demand in Lippulaiva and heat provided by heat pump system (simulated data). Smart control strategies will decrease the need for peak heat demand.

SPARCS interventions (E1) for solutions for Positive Energy Blocks in Lippulaiva are presented in the following tables. Actions E1-1 and E1-2 concentrate on on-site energy production. The target is that heating and cooling demand in Lippulaiva shopping center is mainly covered with on-site geothermal heat with heat pump (system by Adven). Beside the heat pump system, Lippulaiva will have district heating connection and electric boiler for back-up heating system and for peak heat demand. The on-site waste heat is utilized when possible. Electricity demand is covered with PV panels (roof) and certified renewable electricity. The capacity of PV panels is assessed in Action E1-2.

The target is that energy consumption and production are smartly controlled. In Action E1-3 the potential to use an electricity battery as an emergency power is assessed. Together with this, the smart control system and participation to Nordpool's reserve markets is assessed. With this type of smart electricity control service, it would be possible to decrease electricity costs with smart control strategies, which follow the electricity market price and thus control the consumption level and utilize the electrical battery. The idea is to follow tomorrow's day-ahead market price for electricity and participate in reserve market with battery storage. Simultaneously, the smart electricity control service would cut peak loads and gain savings in electricity costs.

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Action E1-1	Optimisation of the NZEB energy system with integrated RES and Virtual Power Plant (ADV CHP-bio, electricity contracted via Nord Pool) based on big data and predictive building control strategies. The system uses a regenerative geo-energy field also storing thermal energy to the ground. The source provides enough heating and cooling for the Lippulaiva blocks. Momentary excess can be exchanged with renewable DH network.
Detailed plan	• To determine the energy consumption profiles in Lippulaiva shopping center and residential blocks (simulations) as well as to describe the consumption of heating, cooling and electricity and possible waste heat sources that can be utilized. • To provide the description of the thermal energy system (heating and cooling) including the Virtual Power Plant, on-site heat recovery and control strategies. • To examine the possibilities of heat recovery from metro tunnel.
Targeted outcome	To achieve Lippulaiva as NZEB with integrated RES and purchased certified renewable electricity with utilizing on-site excess heat, smart control strategies and smart thermal energy storage system.
Roles and responsibilities	CITYCON: As owner of Lippulaiva, Citycon acts as Action leader. CIT provides simulated energy consumption data for partners and ensure that Lippulaiva will be as energy efficient as possible. ADVEN: Adven is the energy partner in Lippulaiva providing heating and cooling energy and investing in thermal energy system. Adven provides the thermal energy system description including thermal storage. Description of big data and predictive building control strategies concerning heating and cooling is done together with Citycon. VTT: VTT defines the terminologies and calculates the KPI's defined. VTT provides feasibility studies on heat recovery from metro tunnel and connecting geothermal to local DH network together with CIT.
Schedule	• CIT: provides simulated energy consumption data M6 and consumption description in M12 • ADV: system description and description of control strategies together with Citycon M18 • VTT: feasibility studies on heat recovery from metro tunnel M6 (done)
Deviations from initial plan (in GA)	Electricity demand for Lippulaiva (other than produced with on-site PV panels) is purchased in practice as certified renewable electricity contracted via Nord Pool instead of Virtual Power Plant (CHP-bio).
New deviations into plan (as compared to D3.1)	It was not contractually viable to make the contracts that assure that Lippulaiva uses exactly the green energy produced by Adven's bio-CHP plant. In practise, Adven's bio-CHP plants produce more electricity than Lippulaiva needs, which will be emulated by comparing the generation by Adven and the electricity demand in Lippulaiva.
Progress until M24	Action E1-1 has progressed as planned. • Energy consumption simulations are done in Lippulaiva shopping center as well as residential block and senior house (heating, cooling

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	and electricity). This data has been shared with partners involved in this action. • Adven's energy system (regenerative geoenergy with heat pump system) is built and installed, trial run and heat deliverable has started in early 2021. • Adven has provided system description of geoenergy heat pump system and description of control strategies together with Citycon • Feasibility study on heat recovery from metro tunnel has been done by VTT.

Action E1-2	Final dimensioning of the PV plant (capacity depends on the detailed design of the roof structures, and relations between PV and the green roofs)
Detailed plan	To assess the final dimensioning of the PV plant. The target is to maximize the amount of PV panels in Lippulaiva shopping center and the amount depends on the detailed design of the roof structures.
Targeted outcome	The final dimensioning of the PV plant in the rooftop (size, energy production, effect).
Roles and responsibilities	CIT: Providing input data and dimensioning the PV plant. VTT: Calculating needed KPI's (will be done after M36).
Schedule	CIT: Dimensioning of the PV plant by M12.
Additional info	The architecture of Lippulaiva shopping center has changed since the original SPARCS project plan, affecting changes to the original approximation of PV plant size.
New deviations into plan (as compared to D3.1)	
Progress until M24	Action E1-2 has progressed and the final dimensions of the Lippulaiva PV plant are ready. Calculating KPI's will start in M36.

Action E1-3	Assessing the potential to use a battery energy storage system as emergency power while it provides frequency-controlled reserves and local cost minimization. Control strategies are developed together with business models.
Detailed plan	• To assess the optimal size of battery energy storage • To assess the potential to minimize electricity costs in Lippulaiva by optimizing electricity usage, producing own energy and participating in electricity reserve markets • To assess different control strategies for smart electricity consumption, production and battery usage
Targeted outcome	To assess the potential and describe the benefits of battery energy storage together with smart electricity control strategies and participating in frequency-controlled reserve markets.

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Roles and responsibilities	CIT: To assess the potential to use a battery energy storage system and the suitable control strategies as emergency power to minimize costs. VTT: Description of benefits and possible risks for Citycon if participating in reserve markets. To assess different control strategies for smart electricity consumption, production and battery usage. To support Citycon to assess the potential to use a battery energy storage system as emergency power for cost minimizations.
Schedule	M15: assessments finalised
New deviations into plan (as compared to D3.1)	Battery solution will be implemented in Lippulaiva. Electrical battery will not be used as emergency power but instead it will be used in reserve markets. Battery use as emergency power was assessed but will not be implemented.
Progress until M24	Action E1-3 has progressed as planned. • The optimal size of electric battery storage has been assessed. • The potential to minimize electricity costs in Lippulaiva by optimizing electricity usage, producing own energy and participating in electricity reserve markets as well as different control strategies has been assessed. Citycon has decided to invest to an electric battery which is used in reserve markets.

Action E1-4	**Improving the self-sufficiency of surrounding blocks, emulating the heat export from the ground source heat pump to the surrounding residential building blocks through the local heating network.**
Detailed plan	Action E1-4 is closely related to Action E1-1 and the work is partly overlapping. In this action the plan is: • To determine the energy consumption profiles in residential buildings of Lippulaiva • To determine waste heat possibilities from residential buildings and assess their possibilities for heating • To assess the use of Lippulaiva geothermal heat to residential heat • To examine the possibilities of connecting geothermal to district heating network (operated by Fortum)
Targeted outcome	Delivering Geothermal heat and cooling to residential towers and service home to be built in connection to Lippulaiva shopping centre.
Roles and responsibilities	CIT: Providing input data of energy consumption in Lippulaiva shopping center and surrounding residential blocks. Writing the description of consumption. ADV: Providing system description of thermal energy. VTT: Assisting in action when needed. Calculating needed KPI's. Providing feasibility studies on connecting geothermal to district heating network (operated by Fortum) together with Citycon and Adven.
Schedule	• CIT: Writing the description of consumption M12. • Adven: Writing system description of thermal energy M18. • VTT: Providing feasibility study on connecting geothermal to local district heating network (to Fortum) M18

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New deviations into plan (as compared to D3.1)	
Progress until M24	Action E1-4 is progressing as planned. Simulations of energy consumption in Lippulaiva has been done and description of thermal energy is ready. Study on connecting geothermal to local district heating network is being processed.

Action E1-5	**Proof for the predictability for the energy costs and the profitability of the nZEB solution, paving way for scaling up.**
Detailed plan	• To determine base-case where energy costs are compared to • To calculate the energy costs in Lippulaiva • To calculate the profitability of the nZEB solution in Lippulaiva case Due to timing of Lippulaiva construction (opening in April 2022), the costs are calculated based on simulated consumption figures and the proof for the costs will be calculated in project years 4 and 5 with actual consumption data.
Targeted outcome	Finalized energy costs for Geothermal and PV energy production. Cost comparison to base-scenario.
Roles and responsibilities	CIT: Providing consumption and cost data for base-scenario and Lippulaiva case. Providing data for "base-scenario" for cost comparison. ADV: Providing needed input data VTT: Calculating energy costs of Lippulaiva and needed KPI's
Schedule	• CIT and ADV: Data provided for cost calculations M35 and M59 • VTT: The costs are calculated based on simulated consumption data M36 • VTT: The proof for the costs will be calculated in project years 4 and 5 with actual consumption data M60
Additional info	Due to timing of Lippulaiva construction (opening in April 2022), the costs are calculated based on simulated consumption figures and the proof for the costs will be calculated in project years 4 and 5 with actual consumption data.
New deviations into plan (as compared to D3.1)	
Progress until M24	Action E1-5 will start later after Lippulaiva is ready and actual energy data will start running.

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Action E1-6	Automation steering system development. Development work on optimizing the efficiency of the building automation steering of HVAC systems in connection to geothermal energy production, including system control, air conditioning, demand flexibility and the utilization of weather forecasts. Case Lippulaiva act as pilot.
Detailed plan	Optimising and developing the automation steering system.
Targeted outcome	By connecting building automation to Adven energy production automation we are able to optimize more efficiently energy production and minimize expenses and CO2 emissions.
Roles and responsibilities	ADV: Specifying interface and steering procedure together with building automation service provider CIT: Connecting Adven to Citycon's chosen building automation service provider
Schedule	Ready by M36
New deviations into plan (as compared to D3.1)	
Progress until M24	CIT and ADV are having same service provider for system automation. ADV for energy production and CIT for building technology (HVAC systems). The same service provider enables to connect partly these systems to optimize energy usage and production. First introductory meeting between the parties has been held. Next, more detailed information of the building technology system (HVAC) is needed in order start planning interfaces and steering features. Now waiting more detailed System Architecture of the HVAC system to proceed with the planning.

Actions related to Lippulaiva energy systems have progressed according to the plan. Lippulaiva will utilize onsite energy as much as possible and will be carbon neutral in terms of energy use from the opening day in March 2022.

One of the largest achievements by M24 in Lippulaiva energy system was the trial operation of the geoenergy system supplied by Adven, which began in early 2021 to provide heating to the construction site. The operation of the heating and cooling system, the utilization of waste heat, energy storage and the control strategy are described in more detail in the thermal energy system description. The feasibility study of heat recovery from metro tunnel was made, and the results showed that it is not feasible to utilize heat from metro tunnel.

The final dimensioning of PV-system was also conducted resulting in a slightly smaller PV system than originally planned. The reason for this is the changed architecture of Lippulaiva. In the end, the size of the PV plant for the roofs are 577 kWp. Additional PVs for façade were dimensioned and the peak power for façade PV system is 57 kWp.

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The rest of the electricity demand is covered with certified renewable electricity from the grid (Figure 4).

Figure 4. Lippulaiva will have extensive amount of onsite energy production: Sketch of solar panels in Lippulaiva façade.

Work done in Action E1-3 (Assessing the potential to use a battery energy storage system) resulted a large investment of electricity battery and smart control strategies to Lippulaiva. Citycon will invest in a 1,5 MW / 1,5 MWh electric battery with which Lippulaiva will participate in Fingrid's reserve markets balancing the national grid and gaining extra income. Optimization of energy use is done with smart control strategies. As Lippulaiva's thermal system runs with electricity (heat pumps and electric boiler) and shopping center has different electric consumption, Lippulaiva has a great potential to optimize its energy use. The aim is to connect the electricity system and the heating system so that the control strategies of the systems optimize energy consumption and save the customer energy costs. The principle figure of Lippulaiva energy system is showed in Figure 5.

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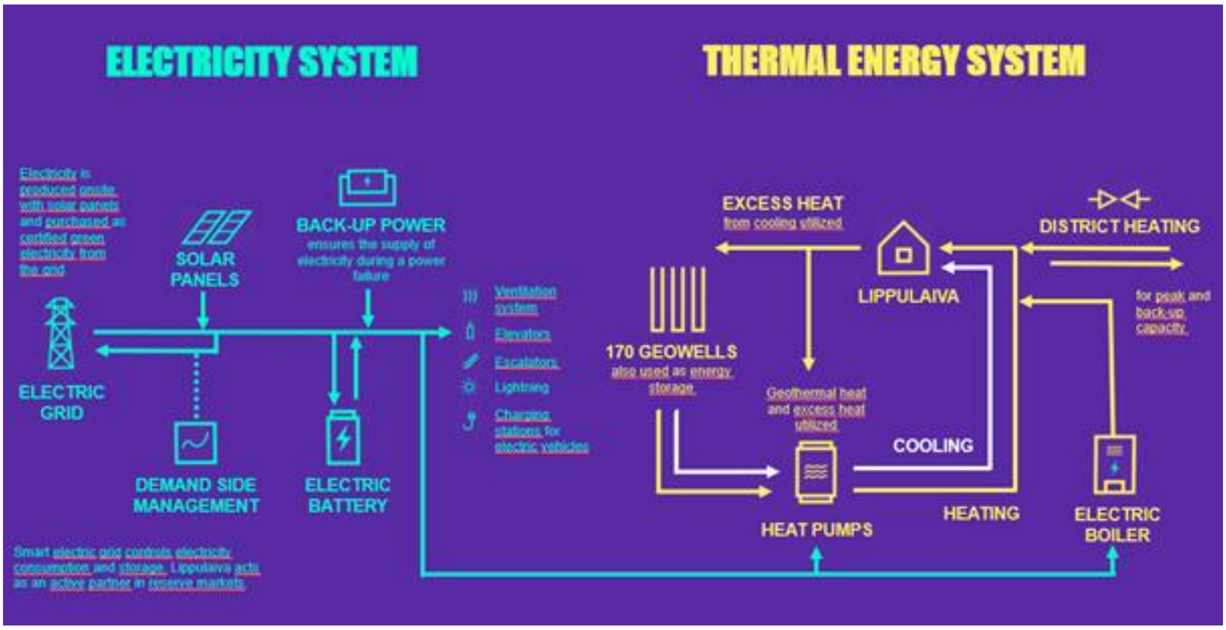

Figure 5. Principle figure of Lippulaiva's energy system and connections of electricity system to thermal system.

3.3 Smart energy solutions for self-sufficiency in the Leppävaara center

Subtask 3.2.2 Smart energy solutions for self-sufficiency in the Leppävaara center focuses on increasing efficiency, flexibility and self-sufficiency through digital tools and through local thermal energy production.

Leppävaara is one of the fastest growing areas in Espoo and Sello Center is the local Energy hub of Leppävaara (Figure 6). Sello multipurpose centre has an area of 102 000 m^2 including shops, a library, concert hall, and movie theatre. Sello center has 2900 parking lots that includes tens of EV charging station. Sello receives 23 million visitors yearly.

Figure 6 PV Panels on Sello Center. (Source: Siemens)

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In Action E5-1 Sello's thermal energy processes are modelled to understand the potential increased energy efficiency, self-sufficiency and thermal flexibility. In Action E5-2 Sello's flexibility potential is realized by providing the thermal flexibility to local district heating company (Fortum). In Action E5-3, increasing the self-sufficiency through deep heat geothermal well is evaluated using the Power System Simulator PSS.

Details of SPARCS interventions E5 Solutions for Positive Energy Blocks in Sello are presented in the following tables.

Action E5-1	**Predictive model for the storing energy to the building structures and battery storage to be created and evaluated.**
Detailed plan	• Define solution architecture • Integrate data flow from Sello BMS to VTT platform • Install thermal submeters for needed granularity • Calculate time constant and create prediction algorithms for storing energy (heat and cool) in Sello based on physical structure (if available), historical and real time energy data: energy, indoor environment, weather and (visitors and people flow, if available). • Integrate the time constant and prediction algorithm to Sello energy management system via APIs • Integrate Sello energy management system through APIs to local DH company for DH demand side management Additional, if resources are available: • Creating a BIM model of Sello block (in IfcSpace format) • Integrate the prediction model to Digital Twin model via APIs
Targeted outcome	Predicts 48hrs ahead Sello's heating and cooling flexibility with high accuracy based on the different heating and cooling strategies. Use the prediction model to provide increased flexibility for DH DSM in E5-2 and demand peak optimization. Continue co-operation beyond SPARCS
Roles and responsibilities	SIE: Define solution architecture, provide data needed and create APIs towards VTT and Fortum, integrate algorithm to BMS control system, acquire BIM model creation VTT: Define solutions architecture, calculate time constant and prediction algorithm, (integration to digital twin, temperature data linked to 3D BIM-model to e.g. visualize temperature, CO_2 and RH, changes during demand response period)
Schedule	Solution architecture defined — M14 - Done Time constant defined — M19 - Done Prediction algorithm — M21 – 1st version online Integrated to Digital Twin — M27
Deviations from initial plan	SIE: installation of sub heat meters to Sello. At the moment, Sello's heat is metered on 2 main meters. In order to have a good enough granularity for the predictive model, new submeters will be installed.
New deviations into plan (as	

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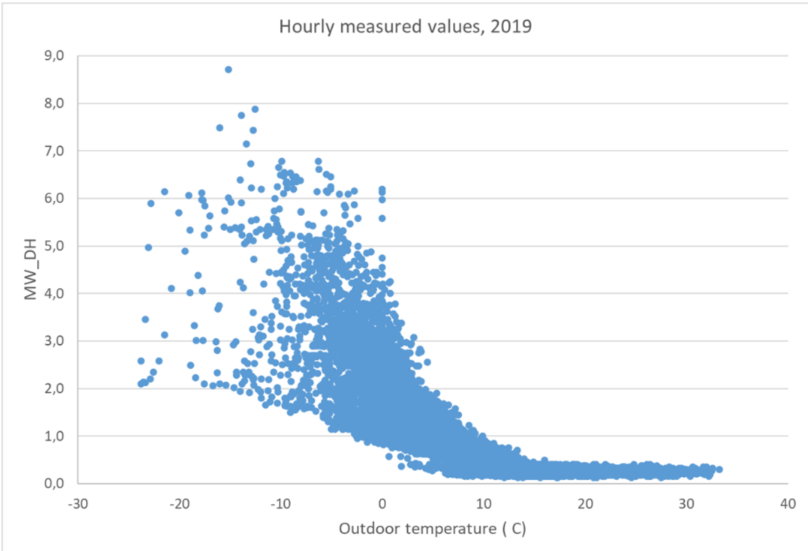
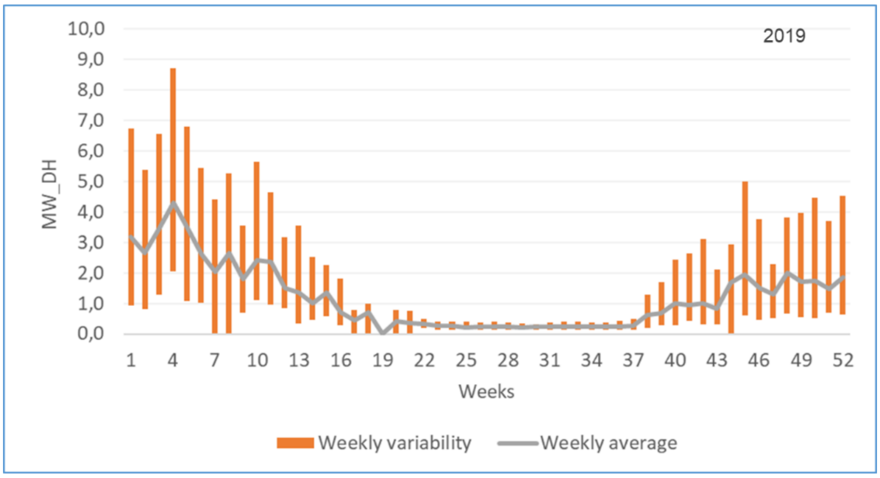
compared to D3.1)	
Progress until M24	Siemens has created a solutions architecture. Siemens has created API from Sello energy system and provided historical data for prediction algorithm. VTT has calculated time constant for Sello. At first, the specific heat loss of Sello's spaces is calculated based on historical energy data (Figure 7). Then, from this, the time constant was calculated (Figure 8). Time constant [h] was calculated by dividing the internal thermal capacity [Wh/K] with the specific heat loss [W/K]. Time constant describes how fast the building starts to cool down, and it is useful when studying the thermal storage capacity of the building, e.g. if the heat demand response is applied in the building. VTT's online prediction model is automatically updated each day via machine learning neural network models online for the next day. Hourly level prediction data includes electricity and heating demand, PV production estimate, EV charging demand, etc. Prediction model uses among others weather data, time and date, and historic energy data measured. An example view of the model is in Figure 9.





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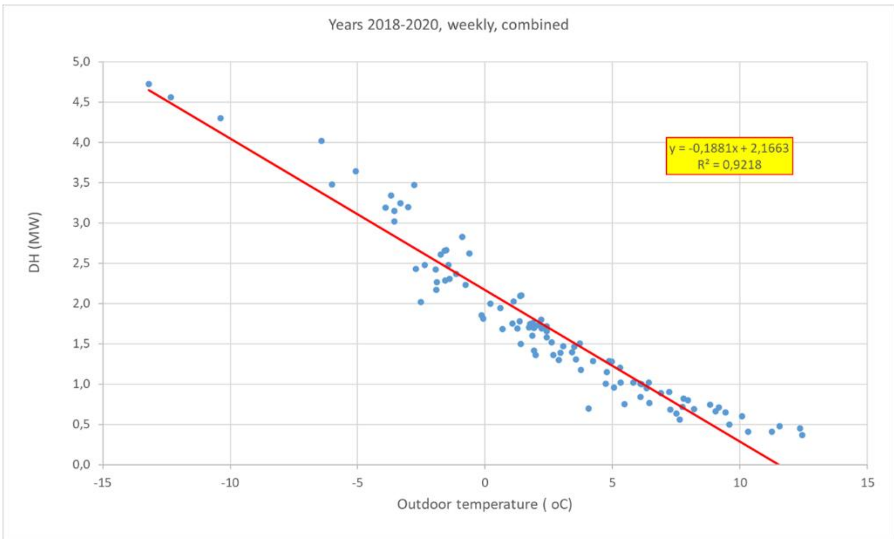

T ulko		T sis = 20	avg
(°C)		conductance	kW/K
	kW	kW/K	128
-25	6 869	153	
-20	5 928	148	
-15	4 988	143	
-10	4 047	135	
-5	3 107	124	
0	2 166	108	
5	1 226	82	
Time constant D5 (2013) (yhtälö 5.15)			
	tau = Rak lämpökapasiteetti * Pintaala / konduktanssi		
	70	(Wh / K) kevyt rakennus	
	110	(Wh / K) keskiraskas rakennus	
	182 403	(m2) Sellon pinta-ala	
	128	(kW / K) mitattu konduktanssi	
	100	(h) time constant light construction	
	157	(h) time constant semi heavy construction	

Figure 7. Analysis of the recorded heating consumption data in Sello for the period 2018-2020 (figure from VTT)

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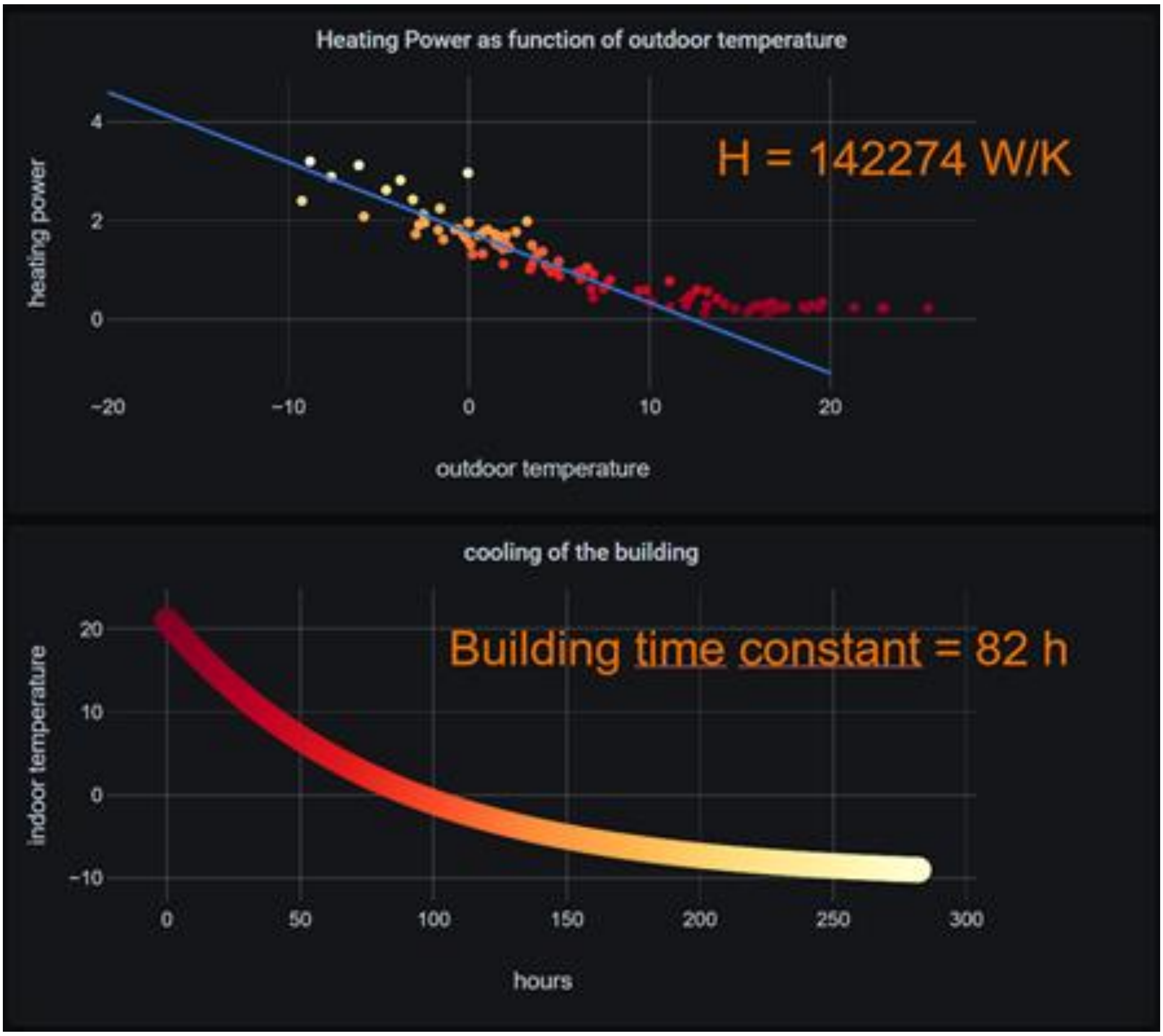

Figure 8. Time constant in Sello. H is the specific heat loss of the building spaces, and the time constant in Sello is 82 h. (figure from VTT)

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Figure 9. Example view of online energy prediction model for Sello in Action E5-1. This is a short term view (2 days prediction for electricity demand for 1 electricity metering point. (figure from VTT)

Action E5-2	**Integration with the local district heating grid operated by Fortum (Bio oil Plant 40 MW) for selling cooling/heat and heat demand side management.**
Detailed plan	• Define system architecture • Provide flexibility data via API to Fortum • Execute flexibility based on Fortum's signal via API
Targeted outcome	To lower CO_2 emissions level of local DH. To enable consumers to become active part of the energy sector by providing flexibility.
Roles and responsibilities	SIE: Define system architecture, coordinate the work with Fortum and Sello, responsible for implementation
Schedule	System Architecture Defined M3-done APIs integrated M5-done Execute Flexibility Requests M9-done Preanalyse results M16-done Final report M25
New deviations into plan (as compared to D3.1)	NA
Progress until M24	Siemens has defined the system architecture, created a integrates flexibility with District Heating and flexibility request test have been carried out. Siemens created solution includes flexibility forecast and the actual demand response request sent by Fortum. The required actions are made by Siemens platform, which adjusts the required flexibility based on the consumption at the time. The messages are used as adjust messages varying between -100…0 %, where -100 % means full response and 0 % means that no action is needed.

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	In Figure 10, is presented data series of local district heating network, how the district heating demand and production vary. Normally the heat production is adjusted based on the consumption (orange line). In other words, the green area would match the orange line. Instead, now part of the consumption is adjusted, so that the production could be steadier at the more optimal, high efficiency level. The solution could also allow avoiding the use of peak heat demand plants, which are typically oil or gas-based plants. In Figure 11 is presented the profile of the shopping centre Sello for the same period. The blue line represents the actual consumption with the demand response and the orange dotted line, what it would have been without the demand response.

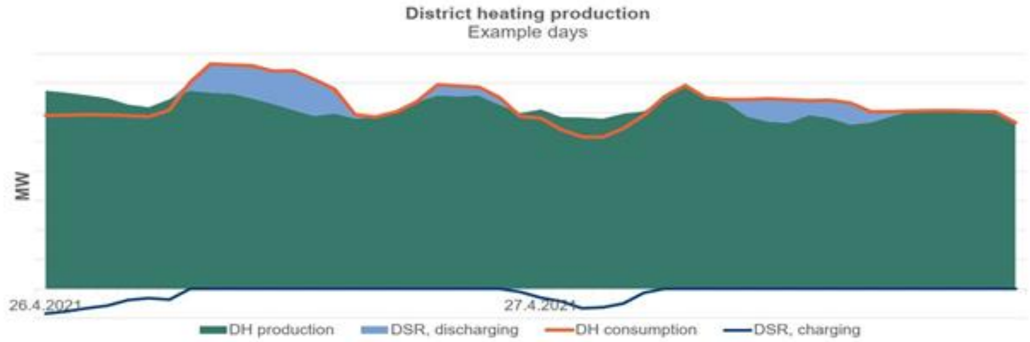

Figure 10. District heating production and consumption 26-27.4.2021 (Figure from Fortum)

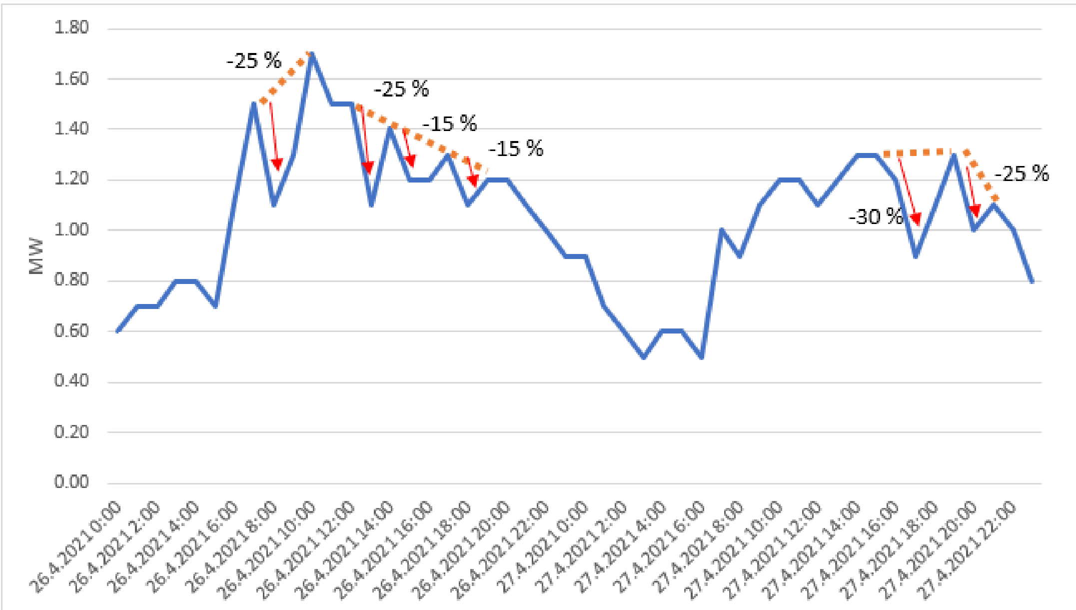

Figure 11. Sello district heating consumption days 26-27.4.21 (Figure from Siemens)

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Action E5-3	Evaluate increase of self-sufficiency through the Sello extension. Evaluate deep heat station in new build.
Detailed plan	• Define scope of the study and limitations. • Gather input data from Sello and solution providers. • Analysis and conclusions.
Targeted outcome	Increase of self-sufficiency of a Sello Block. Understanding technical barriers and commercial potential compared to DH. Understanding technical barriers and commercial potential of P2P heat trade.
Roles and responsibilities	SIE responsible for defining the scope, gathering the input data and analysis.
Schedule	Define Scope of Work M12 (done) Gather input data M22 (started) Analysis and conclusions M26
New deviations into plan (as compared to D3.1)	The calculations and data will be gathered from the existing part of Sello and not the extension (which is at very early planning state). Updated the schedule to match the progress.
Progress until M24	Started to gather input data. License to the simulation tool PSS has been acquired and simulations has been started.

3.4 City planning for Positive Energy blocks

Subtask 3.2.3 City planning for positive energy blocks focuses on tools in the development and planning of new areas, such as the Espoo 3D city model, and new energy infrastructure solutions for positive energy blocks. The aim is not only to develop guidelines for the development process of new areas, such as Kera, but also to identify new potential sites or buildings to harness thermal capacity for demand response.

This intervention makes Kera a testbed for locally adapted PED solutions. In normal circumstances, commercial utilities would invest in traditional infrastructure like 3rd generation one-directional district heating at temperatures up to 120ºC. As waste heat sources are typically available at much lower temperatures, grid feed-in requires expensive heat pumps and makes bi-directionality difficult. A bi-directional low-temperature 4th generation district heating network would operate at temperatures below 70°C, improving overall efficiency, reducing thermal losses and making cheaper pipe materials technically feasible.

In the electric distribution grid, remotely read meters are mandatory but enhanced smart grid solutions require additional functionality for demand side management and prosumer support. Energy communities could be established to collaborate with peers and improve self-consumption. New business models for electricity aggregators facilitate participation in Fingrid's flexibility markets. The SPARCS actions under this intervention demonstrate city planning tools to facilitate an innovative and citizen-centered approach to energy grids.

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The city planning function is a combined effort by different city departments. For key development projects like the Kera site, the city assigns one project manager to coordinate city planning, stakeholder engagement and the various city projects active in the district. There are several projects actively contributing to the development of Kera. Besides SPARCS, participating projects are Clean and Smart Kera, Neutral Host Pilot, Vähähiilinen Liikkuminen (Low-Carbon Transport in Mobility Hubs), Kestävien Kaupunginosien Kumppanuusmalli - 'KIEPPI' (partnership model for sustainable neighborhoods - circular & sharing economy), and Ratkaisupolku Kestävän Kasvun Ekosysteemeihin (pathway to sustainable ecosystems). The LuxTurrim5G project, which was piloting a 5G smart pole concept in Kera, ended in June 2021.

As for now, the Kera area is mainly in industrial use and part of the buildings are empty and no longer in use at all. Industrial and logistic operations are going to move out of the Kera area as a new urban center will be developed. The land use of Karamalmi, Kera station area and Nihtisilta are laid down in the Component Master Plan of Kera. Architectural sketches of the new plans for the Kera area are in Figure 12 and Figure 13.

Figure 12 Architect picture of Kera, Aerial view

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Figure 13 Architecture picture of Kera, Street view

SPARCS interventions E10 - Solutions for Positive Energy Blocks and related demonstration actions are presented in the following tables.

Action E10-1	**City Planning for Positive Energy Blocks. Exploring the possibilities to utilize the continuously updated Espoo 3D City model as a support and tool in the development and planning of the new Kera area.**
Detailed plan	• Communicate with city architects and zoning personnel to understand and document the role of the 3D city model in Kera planning. • Map technical, economic and regulatory barriers in piloting innovative PED solutions. • Identify opportunities offered by energy community legislation and new cost-efficient renewable energy generation and distribution technologies • Assess new business models for generation, aggregation, storage and distribution. • Explore the benefits of using 3D city model in pursuing new opportunities and implementing PED solutions • Draft process to mainstream 3D city model support in PED development in Espoo.
Targeted outcome	Mainstreamed process to routinely integrate PED considerations in the early stages of city planning will reduce costs and improve the effectiveness of energy efficiency and distributed energy generation measures in new area development.
Roles and responsibilities	ESP: Main responsibility

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	VTT: Support in identifying technologies relevant to PED development leveraging experiences from similar Lighthouse projects Siemens, Adven, PlugIt, Kone, stakeholders: Propose private sector solutions and new business models for public private partnerships in PEDs
Schedule	M18: 3D model in city architecture and zoning process documented M21: Barriers, opportunities and business models assessed M28: Assessment of 3D model feasibility in PED implementation finalized
Financial scheme	This action does not require infrastructure investment. The city is actively engaged in projects to support renewable energy, circular economy and low-carbon mobility solutions, with specific budgets allocated to local pilots.
New deviations into plan (as compared to D3.1)	
Progress until M24	The role of 3D city models in the development of PEDs in general was identified and the process of 3D modelling in Kera documented. For that a meeting with the Technical and Environment Services department and architects from the masterplanning department was held. Additionally, technical, economic and regulatory barriers in piloting PED solutions were assessed. The assessment of opportunities by energy communities and business models was finalized. In May 2021 the SPARCS project participated in arranging a webinar focusing on energy communities. The event focused on walking through different practical examples of energy communities, with presentations from several Finnish experts. Insights gained during the webinar are contributing to the assessments under action E10-1.

Generally, the city planning process in Kera is continuously progressing. A proposal of the detailed plan for the area located south of the railway (see Figure 14) has been prepared by the City Planning Board. The approval of the plan by the City Council is expected within autumn 2021. A first plan for the area located on the northern part of the railway is expected to be available for viewing at the beginning of autumn 2021.

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Figure 14: Detailed plan of the southern area of Kera (plan 130140[1], City of Espoo)

Action E10-2	**Energy infrastructure. Planning and on-site follow up of energy infrastructure solutions for positive energy blocks. Solutions enabling energy transfer (consumers as prosumers), including a bi-directional electricity grid and open district-heating network.**
Detailed plan	• Identify emerging and established clean energy solutions relevant to Kera, comprising technology, business models and citizen engagement • Assess technology readiness, cost-efficiency, required stakeholder engagement, policy implications and replicability • Develop prosumer models based on new energy community legislation • Assess financial and climate impact of bidirectional electricity and DH grids • Develop guidelines to enhance the uptake of solutions in collaboration with relevant city departments, communities and technology suppliers, aligning with 3D city model support from E10-1 • Pilot guidelines in development of Kera, Finnoo or other sites • Follow-up on PED infrastructure implementation
Targeted outcome	Adequately planned energy infrastructure improves the availability and feasibility of local energy solutions like waste heat utilisation, peer-to-peer energy markets, aggregation of demand side management and feasibility of distributed energy generation.
Roles and responsibilities	ESP: Main responsibility Stakeholders: Propose additional solutions

[1] City of Espoo, Town board (2021, August 23). Minutes (in Finnish) 23.08.2021/article 276: additional material: Kera, map of a plan https://espoo.oncloudos.com/kokous/2021396-7-69168.PDF pyk

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Schedule	M18. Key solutions identified and documented (ref. M28 of E10-1: 3D city model assessment for PED completed) M36: Guidelines for PED infrastructure development completed M60: Guidelines applied and follow-up in Kera
New deviations into plan (as compared to D3.1)	No deviations
Progress until M24	Key energy solutions relevant to Kera were identified and documented. Different concepts were reviewed and evaluated based on their feasibility in the Kera area.

In order to establish an energy positive ecosystem in Kera, possible energy solutions and models, as well as foundations for an energy positive ecosystem were studied. Solutions that were identified to have most potential to be implemented in the Kera area are presented in the following Table 4.

Table 4. The most potential PED solutions identified for Kera area

Local energy production	Energy distribution & measuring	Energy recovery & storage	Services
Solar electricity	Smart electricity grid	Local electricity storages/batteries	Energy as a service
Ground source heat pumps (300m)		Waste to heat	Involvement in DSM
Water to air heat pumps		Power-to-X solutions	Virtual Power Plants
Hybrid heat pumps			Local energy exchange
Deep wells (2km)			
Geothermal heat (7km)			

A decision about the main concept to cover Kera's heating and cooling needs was reached. A bi-directional low-temperature district heating network will serve as an innovative base for the further development of local energy solutions. A new heat pump station will produce heat not only for the whole Kera district, but also for other districts in Espoo. The heat pump station will also be connected to the bi-directional district heating network. This allows the use of excess heat also outside of the Kera area and peak demands can be covered by the carbon-neutral district heat. The heat pump will use outdoor air as well as waste heat as heat sources. The required electricity will be produced from renewable energy sources. The low-temperature district heating network allows to use waste heat more efficiently, which creates a good base for bi-directional heat trading schemes and new business models. The buildings' own combined heating and cooling heat pumps provide cooling - at the same time the condensation heat can be used as a heat source for the heat pump station (Figure 15).

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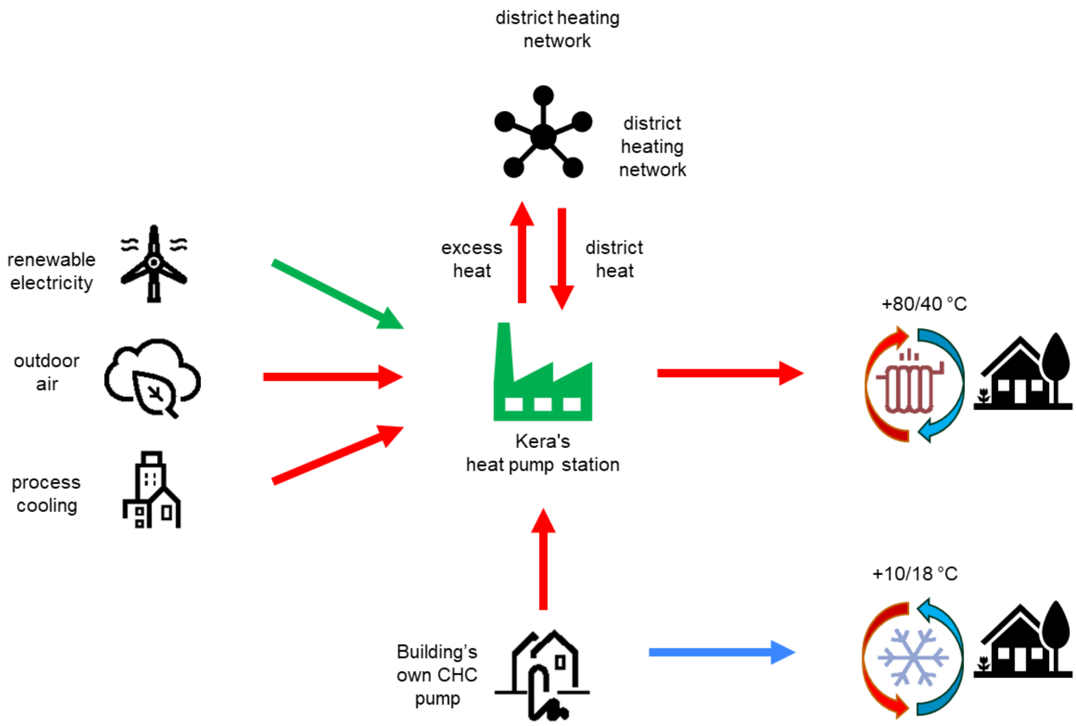

Figure 15: Kera's future district heating/cooling network

Action E10-3	Energy system planning. The energy system planning explores options for energy demand side management of all buildings by using energy demand response and energy efficiency, as well as acting as heat storage, and enabling the use of emission-free eco heating energy products and services, and demand flexibility.
Detailed plan	• Categorisation of public building stock to reveal low hanging fruits like swimming pools and sport facilities with specific heating and cooling requirements. • List most promising sites and assess thermal energy consumption. • Develop solutions to harness thermal capacity for demand response. • Document results and disseminate results. Related Actions: E16-1 on Espoon Asunnot, E15-1 on 1MW power VPP aggregation in Espoo City properties, E6-1 and E6-2 on digital platforms in Leppävaara and Kera
Targeted outcome	Demand side management reduces peak demand for heating and power. As peak generation units are typically most carbon intensive, annual carbon emissions decrease with added demand flexibility. System-level planning supports the integration of RES and development of 100 PEDs in EU.
Roles and responsibilities	ESP: Identify suitable sites Stakeholders: propose solutions for demand response
Schedule	M24: list of most suitable sites for demand response M36: technical solutions for DR assessed and documented
New deviations into plan (as	

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compared to D3.1)	
Progress until M24	After a pilot phase that started in 2019 in 5 schools and day care centers in Espoo, energy demand side management was extended to ~120 city owned buildings. The pilot project confirmed that demand side management is feasible, and no major problems were observed during the piloting phase. At the moment, there are over 500 buildings connected to Espoo's district heating demand side management system. A meeting with the city's premises department was held in order to discuss the current situation and the demand side management potential within the public building stock. Additionally, to categorize the public building stock, energy data of city owned buildings were analyzed.

An assessment of the thermal energy consumption of the public building stock was conducted, using the Granlund Manager software and data from the latest heating report. In total, a dataset including 718 buildings (directly owned by the city of Espoo) was analysed. Buildings of the public building stock can be divided in to 12 building types as shown in the Figure 16 below.

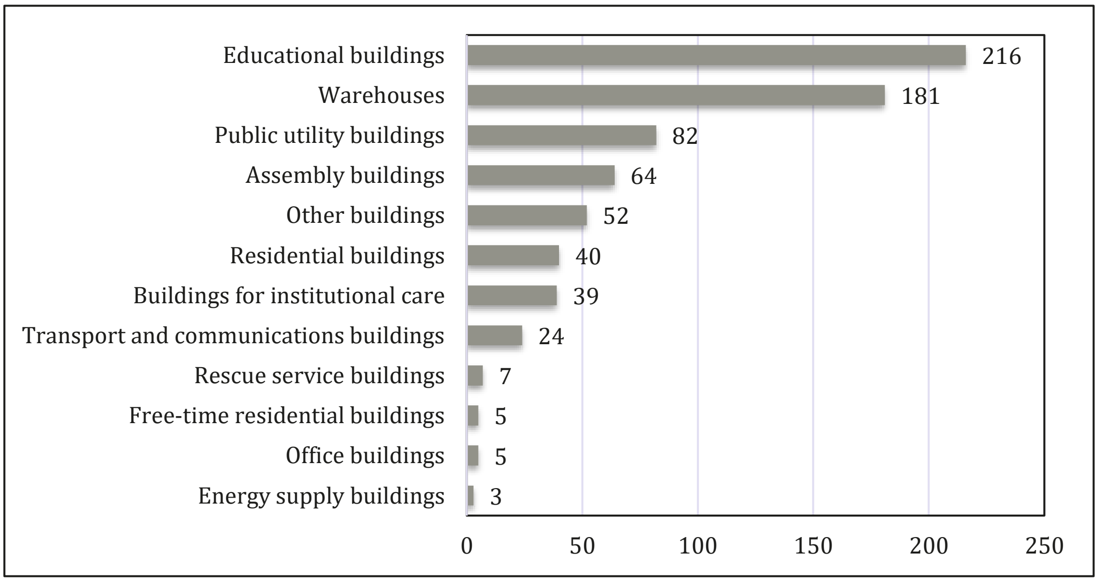

Figure 16:Total amount of buildings by building type (Source: City of Espoo)

In order to compare different buildings and analyse their thermal energy consumption, the building's energy efficiency (kWh/brm^2) was studied. Out of the 718 buildings however, data about the energy efficiency are available for only 216 buildings.

When comparing the average energy efficiency of different building types, warehouses are the least efficient (average efficiency of 414 kWh/brm^2) and educational buildings the most efficient (average efficiency of 211 kWh/brm^2). When looking at the boxplot below (Figure 17), it can be seen that for some building types (such as e.g. office- and transport and communication buildings) the values are highly scattered. This is due to the low number of buildings within each subgroup. When looking at the boxplot below at Figure 17, it can be

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seen that for some building types (such as e.g. office- and transport and communication buildings) the values are highly scattered. This is due to the low number of buildings within each subgroup.

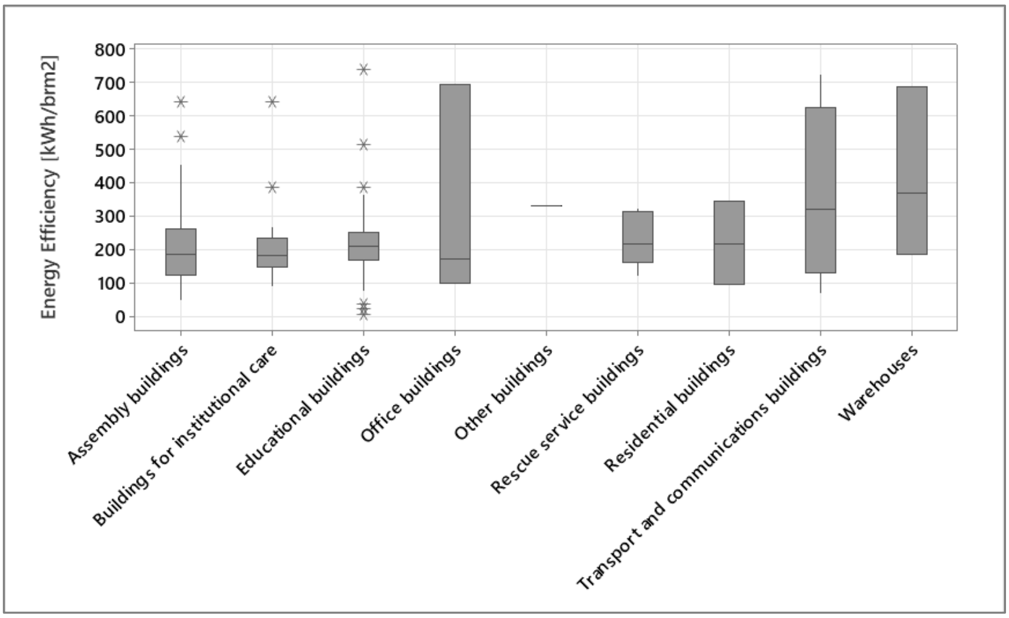

Figure 17: Boxplot of buildings' energy efficiency by building type (Source: City of Espoo)

While the energy efficiency by building type is as poor as 414 kWh/brm² for warehouses, the histogram in Figure 18 shows that there are buildings with an even poorer energy efficiency of over 700 kWh/brm².

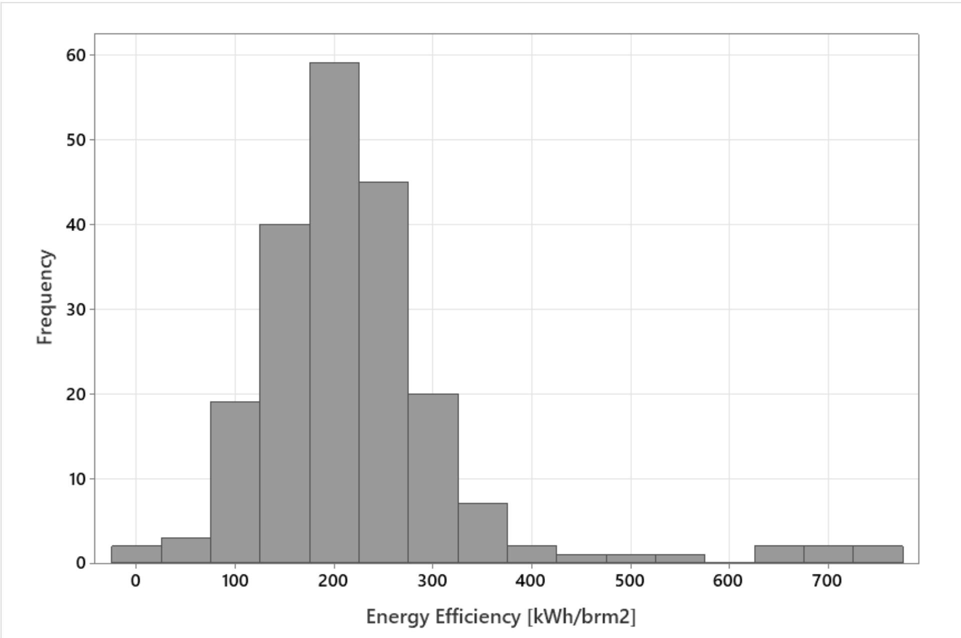

Figure 18: Histogram of buildings' energy efficiency (Source: City of Espoo)

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Additionally, a list of 15 buildings with the poorest energy efficiency was created to examine single buildings in more detail. While the cross area of these 15 buildings varies between 300 m² up to almost 10 000 m², there is no direct correlation between the size of the building and its energy efficiency. From the 15 buildings only two buildings are currently part of Fortum's SmartLiving service, which helps to optimize buildings' energy consumption.

Several recommendations for future research and actions are presented in the report of the assessment about the categorization of the public building stock.

3.5 City scale smart heating and thermal demand response

The city of Espoo has implemented demand side management (DSM) of heating in the social housing company Espoon Asunnot Oy. Leanheat Oy, the service provider of the thermal DMS, reports 10% saving in heat consumption and 24% reduction in peak load. City of Espoo has extended the DSM service to 115 other public buildings, which were found beneficial and technically suitable. For example, buildings close to end of their lifecycle were not considered. DSM will decrease peak heat demand and lead to financial savings and lower CO_2 emissions. This subtask extrapolates existing DSM activities to promising subsets of the city's building stock.

Action E16-1	Buildings demand side management and demand flexibility. The aim is to implement demand side management to achieve demand flexibility on large scale in both public and private buildings. Solutions based on emission free district heating. Espoo Asunnot Oy (Espoo social housing company) has already connected all its 15,000 apartments to demand response and eco heating. During SPARCS, the solution is further developed and replicated. The development of energy efficiency and energy consumption peak loads are monitored to optimize the city level energy system.
Detailed plan	• Assess DSM scheme for Espoo Asunnot in terms of heat demand, peak load and emissions reduction. • Assess additional energy efficiency and distributed energy generation potential. • Investigate potential to replicate around Espoo. • Prepare plan and guideline to replication. This task is closely linked to electricity DSM in Action E15-1.
Targeted outcome	Demand side management reduces peak demand for heating and power, presenting an opportunity to reduce capex for distribution infrastructure. As peak generation units are typically most carbon intensive, annual carbon emissions decrease with added demand flexibility.
Roles and responsibilities	ESP: Document buildings and heat demand under DSM VTT/Fortum: Estimate carbon emission reduction potential Siemens: Propose technical approach to optimise DSM
Schedule	M12: Document extent and benefits of current DSM measures M18: Prepare plan and estimate techno-economic benefits of scale-up M24: Document findings, report and communicate with stakeholders

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New deviations into plan (as compared to D3.1)	Gathering of input data delayed due to a need of approval from facility services for data acquisition. M27: Estimate carbon emission reduction potential M32: Prepare plan and estimate techno-economic benefits of scale-up M36: Document findings, report and communicate with stakeholders
Progress until M24	VTT received data of the carbon emission reduction potential for Espoon Asunnot using heat demand response from year 2018. An additional data request was made by ESP to Espoo Asunnot in order to receive more data about the energy consumption of Espoo Asunnot.

By the end of 2020, Espoo Asunnot owned in total 15 724 apartments, which is 271 more than in 2019. At the same time the energy consumption for heating was 137 525 MWh in 2020. By the end of 2018 Espoo Asunnot connected all its apartments to the Leanheat heating optimizing system. Since then the weather-adjusted heating consumption decreased from 156 698 MWh to 154 011 MWh. With the help of the current DSM measures, Espoo Asunnot is able to cut energy peak loads without affecting the living comfort of its customers. The energy consumption development over the last three years is presented in the following Table 5.

Table 5. Energy consumption in the rental apartments owned by Espoon Asunnot[2]

Heating	**2020**	**2019**	**2018**
Consumption, MWh	137 525	147 631	153 908
Weather-adjusted consumption, MWh	154 011	154 957	156 698
Heating index, kWh/Rm^3	39,8	40,1	40,6
Electricity			
Consumption, MWh	18 040	18 972	19 242
Consumption, kWh/Rm^3	4,7	4,9	5,0

[2] Espoon Asunnot Oy, “Hallituksen toimintakertomus ja tilinpäätös 2020,” 2020. [Online]. Available: https://e.issuu.com/embed.html?d=toimintakertomus_2020&pageLayout=singlePage&u=espoonasunnot. [Accessed 28 June 2021].

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4. ICT AND INTEROPERABILITY IN ESPOO LIGHTHOUSE DEMONSTRATIONS

4.1 Introduction to task 3.3

The trend towards greater digitalization of energy has been enabled by advances in data, analytics and connectivity. Digitalization can greatly increase the lifetime, efficiency and utilization of energy infrastructure and reduce costs. Connectivity helps to couple different energy sectors, so that consumers and producers in any sector can actively participate across energy system operations, which increases the flexibility with which the system can cope with regarding the imbalance of supply and demand, while also reducing the cost of integrating new technologies like distributed generation, energy storages and electric vehicles.

The EU is moving from centralized electricity generation in power plants operated by large utilities towards a mix of decentralized and often renewable energy production in small facilities. This change in energy sector combined with electrification of mobility and heat creates a new challenge to power grids. Virtual Power Plants are a critical element in this transition and are enabled by digitalization.

A Digital Twin allows a connected, digital representation of a building and of ongoing processes in the building. It brings together dynamic and static data from multiple sources in 2D/3D models and enables informed and effective decisions making. It bridges the physical and digital worlds through sensors that collect real-time data within the physical environment. It provides real-time understanding of how a building is performing – enabling immediate adjustment to optimize efficiency and to provide data to improve the design of future buildings. The result is a more cost-effective, straightforward and sustainable smart building.

The energy sector is expected to benefit from blockchain technology. Blockchain enables innovative platforms that help the buyer find all available renewable energy resources and make direct purchases, thus accelerating the transition to low-carbon energy and expanding access to clean energy markets for all. Distributed energy resources will play a valuable role providing grid services, such as helping to balance supply and demand in flexibility market. Blockchain technology can make it easy for distributed energy resources to participate and get compensated for delivered grid services.

Decentralized and complex energy systems require also fast communication with high capacity, bit rate, throughput, latency and energy efficiency and resilience. 5G networks are expected to provide the communication requirements for the new decentralized complex energy systems.

The objective of task 3.3 is to enable sector coupling and increase the interoperability, monitoring and control of various energy systems by ICT between smart buildings, smart grid and district heating and cooling systems, EV charging infrastructure, and the allocation of open data.

Task 3.3 Includes following subtasks:

- T3.3.1 Virtual Power Plant for optimized RES energy use (presented in Section 4.2)
- T3.3.2 Smart energy services (presented in Section 4.3)

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- T3.3.3 Smart Building Energy Management (presented in Section 4.4)

4.2 Virtual Power Plant for optimized RES energy use

A Virtual Power Plant is a pool of several small and medium scale installations, either consuming or producing electricity. When small and medium scale installations are integrated into a Virtual Power Plant, the power and flexibility of the aggregated assets can be traded collectively.

In this subtask, Sello's multipurpose center Virtual Power Plant platform is utilized. Sello is buying power from Nordpool and is locally producing energy with PV (750 kWp). Sello's power system includes microgrid functionality with integrated electrical equipment, mostly HVAC and stationary energy storage (2 MW and 2.1 MWh). Microgrid functionality enables Sello to participate through Vibeco Virtual Power Plant in electricity reserve markets operated by Fingrid. The system is visualised in Figure 19 and Sello's power usage is shown in Figure 20.

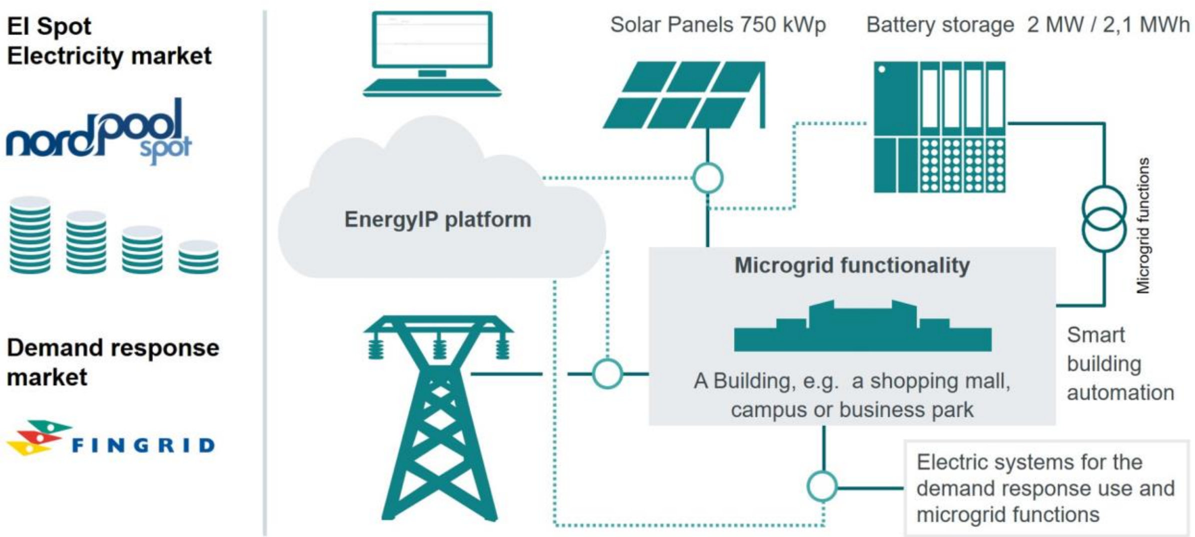

Figure 19. Sello's smart energy system. Source: Siemens

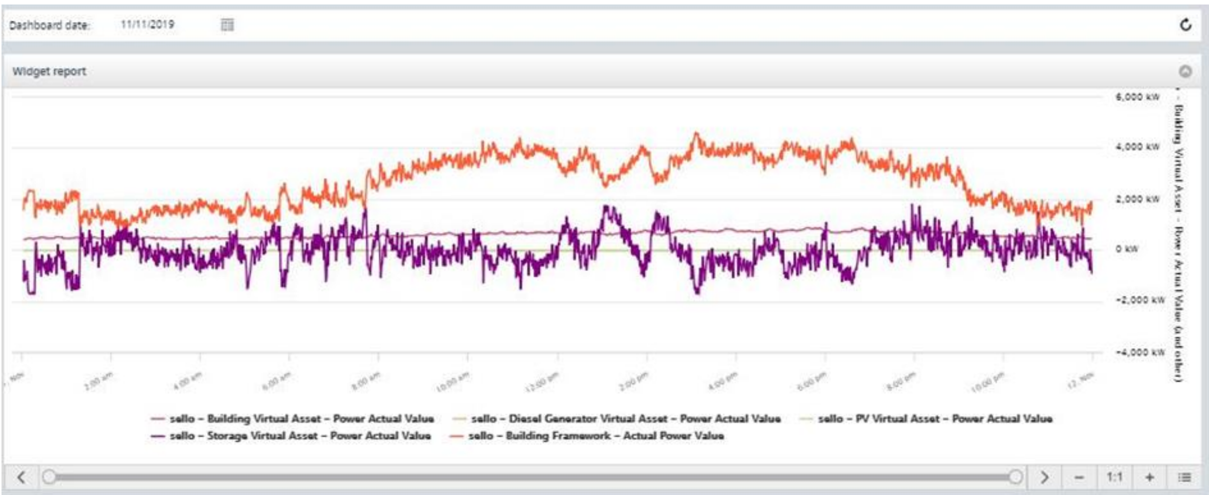

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Figure 20. Sello's power usage during a normal weekday. Source: Siemens

In Action 17-1, Digital twins can be used to replicate the physical and operational characteristics of a power generation plant or other utility asset prior to construction and also to help improve operations and maintenance over the useful life of physical installation.

Some of the key goals of the digital twin are cost savings, increased revenue, reduced outages, improved operations, and managing market dynamics. We now delve into the following specific benefits for the electricity sector.

Virtual Power Plant connected assets are optimised based on a self-learning algorithm to increase the flexibility potential of each asset. One of the major issues of optimising a Virtual Power Plant is the lack of standardized semantic descriptions of the physical, logical and virtual assets. In this subtask a data model is tested on the Sello block. The Action also includes creation of a BIM model of the Sello block that will be used in the creation of a Digital Twin in Action E17-1.

In Action E15-1, public entities are the forerunners in achieving carbon neutrality. Buildings are responsible for 40% of CO_2 emissions in the world. Thus, new solutions for energy-efficient buildings and operating models need to be developed. One of these solutions could be connecting buildings to a Virtual Power Plant that enables them to become an active part of the power system. The flexibility potential of city owned assets is evaluated, and according to this information chosen buildings are connected to a Virtual Power Plant. In addition, the reduction of CO_2 emissions is evaluated. In action E15-2, the use of blockchain technology for supporting Demand Response (DR) and Virtual Power Plant (VPP) solutions is evaluated. Blockchain could be a cost-efficient, secure and reliable way of enabling peer-to-peer transactions between energy prosumers within a more decentralized energy system, and in enabling new demand response solutions. These aspects are investigated in a feasibility study within the action.

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The detailed plans are presented in the following tables.

Action E6-1	Improving the prediction of the energy performance, both heat and electricity, and the predictions for energy market participation for Sello block based on data collected nearly in real time and stored historic data pursuing the Virtual Power Plant (VPP) operations. VPP considers Kone's elevators energy control, optimal use of local PV generation, electricity storage, air conditioning, lighting and emergency power systems. Introducing peak-load management, artificial intelligence technologies.
Detailed plan	• Define solution architecture • Integrate real time data from Sello's elevators and escalators, people flow via APIs to Sello's VPP (Elevator data integration test on-going in E6-3. 14 escalators equipped with VPP-integrated power meters. Need for additional escalator data through APIs to be discussed. People flow analysis and integration to be started.) • Integrate Sello's energy data via API to VTT (DONE) • Create self-learning algorithms of Sello's energy performance (1st version available for heat and electricity, for both consumption and PV production) • Develop the prediction algorithms until prediction and actual are sufficiently close enough (1st version available) • Provide control strategies via prediction algorithm to increase flexibility towards TSO and improve energy performance Additional, if resources are available: • Integrate prediction algorithm (Digital Twin) to Sello energy management system via APIs • Creating a BIM model (ifcSpace) of a Sello block • Integrate the prediction model to Digital Twin model via APIs to visualize the energy performance • Visualization of energy performance
Targeted outcome	Creating a prediction model based on real time data of Sello blocks energy performance to increase the energy performance of a Sello block and flexibility towards the TSO. Create a co-operation model beyond SPARCS.
Roles and responsibilities	SIE: Provide historical and real time data, provide BIM model, supporting in developing self learning algorithm VTT: Develop self learning algorithm, link data to BIM model and develop KPIs KONE: Provide analyzed data of selected elevators and escalators. Install additional meters if needed.
Schedule	Define system architecture M14 Prediction algorithm first iteration completed M25 Integration of prediction algorithm to Digital Twin completed M29
New deviations into plan (as compared to D3.1)	SIE: Develop data model for Sello's Building automation data.

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Progress until M24	VTT: 1st version of self-learning algorithms for energy consumption and the production of PV panels is available online. SIE: Data integrated from Siemens systems to VTT. First version of data model done. KONE: Elevator short-term power demand forecast algorithm developed and tested live with an elevator group. Communication protocol agreed with Siemens (E6-3) See Figure 21

Figure 21: Example view of online energy prediction model for Sello in Action E6-1. This is a short term view (2 days prediction for electricity demand for 1 electricity metering point. Source: VTT

Action E15-1	**Feasibility study paving the background for the Virtual Power Plant formed from the loads of the local buildings to balance RES boosted local power network, identifying new business opportunities for aggregators in order to combine small demand response loads and offering them to reserve market (Fingrid). The target is to find and connect enough flexible loads from a local building stock (swimming pools, ice skating halls, sport halls, and office buildings) for 1 MW demand response, to participate in the electricity reserve markets.**
Detailed plan	• Gather data on all the Espoo city properties • Analyze reserve flexibility potential of different properties • Connect chosen loads and properties to VPP • Aggerate loads and offer them to reserve markets • Analyze results Similar activity on heat DSM in Action E16-1.
Targeted outcome	Enables city's properties to become active in energy sector by providing flexibility to reserve markets, to play a vital role in energy transformation. Understand flexibility potential of different type of properties.
Roles and responsibilities	SIE: Analyze flexibility potential, connect buildings to VPP and trade flexibility in reserve markets.

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	ESP: Provide data on all Espoo city buildings. Enable work in the properties and in the systems required by VPP. VTT: Assess emission savings by VPP solution
Schedule	Input data gathered M12 Analyze carried out M17 First loads traded in reserve markets M24
New deviations into plan (as compared to D3.1)	Analyze carried out M29 First loads traded in reserve markets M36
Progress until M24	VTT collecting data for the assessment of emissions. ESP has met with city premises department and discussed means of analyzing buildings that meet SIE requirements. Site information has been collected from Caruna, and building information including usage data from ESP software. Data has been sent to SIE for analysis.

By M24, input data of feasible Espoo city properties was gathered and sent to Siemens for further analysis within action E15-1. The properties analyzed for this action had to meet a minimum annual electricity consumption of 150 MWh. In total, 98 public properties were identified for further analysis. These properties had a total electricity consumption of 51 000 MWh between 6/2019 – 6/2020, and an average consumption of 516 MWh in the same timeframe.

For action E15-2, a literature review was conducted to assess the pros and cons of blockchain for supporting Demand Response and Virtual Power Plant solutions. In addition, the identification of possible applications for blockchain and an assessment of the legal framework was initiated. To assist with the literature review process, meetings with experts from Siemens, VTT and other organizations relevant to the field were conducted. These meetings are expected to continue as the work on this action goes on.

Action E15-2	**Blockchain technology options for supporting demand response and Virtual Power Plant in positive energy districts. Blockchain enabled business cases and control strategies will be studied, while possible policy and regulation related challenges will be identified.**
Detailed plan	1. Assessment of pros and cons of blockchain solutions. 2. Identification of most promising applications for blockchain. 3. Assessment of legal framework. Ref Action E12-3 Blockchains for Kera energy transactions.
Targeted outcome	Blockchains may prove a cost-efficient and reliable platform for energy prosumer and demand side management transactions
Roles and responsibilities	ESP: Overall coordination VTT: Technical support on blockchain solutions SIE: Commercialized blockchain services
Schedule	M15: Blockchain pros and cons assessed

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	M30: Applications identified and mapped, legal framework assessed
New deviations into plan (as compared to D3.1)	Number of action corrected to E15-2 to be in line with grant agreement.
Progress until M24	ESP: Pros and cons of blockchain solutions have been identified. The mapping of most promising applications for blockchain within VPP and DSM solutions and assessment of legal framework ongoing. Writing of feasibility assessment paper ongoing.

Action E17-1	**Virtual twin of a real demo for a positive energy building block, to build a showcase and support replication. Provides both the visual of the building and the operational behavior (same energy load as in the real buildings and the block) for the building energy system.**
Detailed plan	Building of a virtual twin for Sello. Virtual twin focuses on predicting electricity demand and on-site electricity production from PV. It can also help to run Virtual Power Plant (VPP) in Sello. Optional (if suitable data received from Sello) to include electricity battery, EV charging and participation to the electricity market (FCR-N). Virtual twin visualises also the measurement values and the results in a building model. Virtual twin also will have heat energy included, in connection to action E5-1: heat performance and storing energy to building structures.
Targeted outcome	Virtual twin predicts online the electricity and heating demand, as well as PV production in Sello for the next 24 hours (with as small difference to monitored data as possible). This can be used also for optimisation purposes. The monitored data and results of virtual twin can be visualised in a building model.
Roles and responsibilities	VTT: Virtual twin planning and building. Stakeholders: Giving data (and BIM if available) from Sello.
Schedule	First version of Virtual twin for predicting electricity demand during 2020 (by M15). PV production added in spring 2021 (M20). Visualisation during 2021 (by M27). Final virtual twin ready by M30.
New deviations into plan (as compared to D3.1)	
Progress until M24	*Dynamic virtual twin of Sello: 1st version available. BIM model not yet available.*

4.3 Smart energy services

Modern energy services can be provided more efficiently, flexibly and reliably if they are based on an appropriate ICT platform. 5G technology is an established global standard for mobile connectivity, and it enables the control of a high number of

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appliances. Blockchain and IoT are evolving quickly, presenting new opportunities for optimised energy performance and innovative new business models. The detailed plans are presented in the following tables.

Two actions within this subtask focus on identifying opportunities offered by the Kera local district 5G network piloted within the LuxTurrim5G, Luxturrim5G+ and Neutral Host Pilot projects. The results of these projects were utilized to identify synergies between 5G, smart energy infrastructure and e-mobility. An additional aim was to identify possible service models to be used within Kera or in additional regions where this local 5G network could be expanded to. As both LuxTurrim5G+ and Neutral Host Pilot are expected to end by the end of 2021, the final reports of these projects are expected to be available soon. In addition, opportunities brought to Kera by blockchain technologies were investigated in Action E12-3.

Action E6-2	Developing new potential smart energy services based on the digital platform (open cloud based IoT operating system, MindSphere by SIE) from the energy performance view point in the Leppävaara area by finding new value for residential buildings of being flexible part of the greater energy system, including district heating and cooling usage control based on the grid conditions.
Detailed plan	• Assess feasible scope of buildings in Leppävaara district to be included. • Estimate heat and power demand profiles. • Assess flexibility potential. • Propose actions to exploit DSM measures. • Document and communicate to stakeholders.
Targeted outcome	The Sello center is contributing to distributed energy production and grid balancing using smart DSM solutions. Extending this service to adjacent buildings yield economies of scale and demonstrate scale-up potential
Roles and responsibilities	SIE: Assess the flexibility potential, create a technical solution, assess business model ESP: Engage stakeholders including public buildings and Espoon Asunnot in Leppävaara district
Schedule	M25 Mapping the scope of buildings M29 Technical solution and business model M36 A feasibility study carried out
New deviations into plan (as compared to D3.1)	Evaluating smart energy concepts for residential and office buildings, based on digital platform, district level sustainable energy systems, including EV charging, stationary battery energy storage and VPP.
Progress until M24	Tools to assess the flexibility potential chosen.

Action E12-1	Smart infrastructure 5G. Investigating opportunities offered by the Kera digital platform and local district 5G network for management of the

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	smart power grid, optimization, bi-directional energy flows, energy demand side management and demand flexibility.
Detailed plan	• Investigate and document current 5G projects in Kera and elsewhere. • Conduct literature review on 5G and smart infrastructure • Identify opportunities for synergies in energy efficiency, DSM, prosumer. transactions and innovative business models. • Map and document key stakeholders. • Document findings, report and communicate.
Targeted outcome	Energy performance optimization requires automation and smart solutions to ensure energy savings, cost effectiveness and reliable operation. 5G infrastructure facilitates smart energy.
Roles and responsibilities	ESP: Main responsibility. Stakeholders
Schedule	M15 Current projects documented, and literature review conducted M25 Opportunities identified, stakeholders mapped and documented M30 Findings reported
New deviations into plan (as compared to D3.1)	Due to the lack of energy-focused organizations in current Kera 5G project consortiums, the focus will be on documenting other projects and conducting a literature review to identify opportunities in Kera.
Progress until M24	Current Kera 5G projects investigated. Other EU and Finnish 5G projects investigated. Literature review conducted.

Action E12-2	**5G as service enabler. Developing new service models for autonomous transport and e-mobility linked to the local 5G network, solutions enabling the use of car batteries as energy reserve and the operation of autonomous transport. (ESP, stakeholders)**
Detailed plan	Identify smart infrastructure requirements for autonomous transport and e-mobility. Open discussion with smart city Kera area development, relevant stakeholders and ongoing projects developing autonomous transportation and 5G technologies in Kera (including LuxTurrim5G+ / Neutral Host Pilot -project; Six Cities: Low-carbon transport in mobility hubs -project). Estimate car battery capacity available for energy reserves in different scenarios.
Targeted outcome	Car batteries and smart charging can improve power balance and reduce emissions and costs. 5G technologies can support the use and operation of autonomous transportation and enable e-mobility in local networks.
Roles and responsibilities	ESP: Main responsibility.
Schedule	M3-12 Opening discussion with relevant stakeholders. M12-36 Assessment of car battery solutions. Assessment of local 5G network in the operation of autonomous transportation.

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New deviations into plan (as compared to D3.1)	M3-M24 Opening discussion with relevant stakeholders, as stakeholder engagement has continued with a survey done on M24.
Progress until M24	Current Kera 5G projects investigated. A questionnaire on 5G as a service enabler with stakeholders done on M24.

Action E12-3	**Blockchain technology as enabler. Enabling energy transfer and tracking in bi-directional power grids (electricity and heat) with the use of blockchain technology.**
Detailed plan	Conduct literature study and compile blockchain models globally Create SWOT table for blockchain utilization in Kera Propose blockchain model for electrical and thermal energy transactions and flexibility aggregation in Kera Estimate costs and benefits Investigate legal barriers Ref: Action E16-2 blockchains for city-wide DSM.
Targeted outcome	Cost-efficiency and uptake of distributed power and heat generation is enhanced if prosumer model is streamlined and automatic. Blockchains ensure prosumer model transparency and verification functionality.
Roles and responsibilities	ESP: Overall coordination. VTT and Siemens: technical support. Stakeholders
Schedule	M14 literature and models studied M18 SWOT table prepared M22 Blockchain model proposed M25 Costs, benefits and legal barriers investigated
New deviations into plan (as compared to D3.1)	M23 literature and models studied M24 SWOT table prepared M28 Blockchain model proposed M30 Costs, benefits and legal barriers investigated
Progress until M24	Literature review done within E15-2/E12-3, and study of different use cases within Kera ongoing. SWOT table prepared.

By M24, an assessment of the Espoo city properties within southern Leppävaara was finished, and requested input data was gathered and sent to Siemens for further analysis within action E6-2. This process will continue with the Espoon Asunnot properties in the future.

In action E12-1, the links to smart infrastructure and energy of current projects within Kera were analyzed. As the 5G projects within Kera didn't have a strong link to energy, the analysis was expanded to other relevant projects mostly situated within Finland and the EU. According to the information found from this analysis and a further literature review, the process of finding synergies between 5G and smart energy

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infrastructure has begun on a broad level and within the Kera demo area. In action E12-2, discussions were opened between relevant projects in the Kera area and SPARCS, and a survey on the opportunities of 5G within the mobility sector was developed.

In action E12-3, a literature review done within action E15-2 was heavily connected to this action as well. Thus, a lot of the information found within the E15-2 review was deemed applicable for E12-3. In addition, a SWOT-table for blockchain utilization within Kera was developed.

4.4 Smart Building Energy Management

Subtask 3.3.3 Smart Building Energy Management demonstrates how domain knowledge and real-time monitoring of elevators, escalators and people flow can be employed for smarter decision making and demand response actions by the building energy management system.

Action E6-3	Solutions in Smart Building Energy Management. The activity demonstrates how elevators, escalators, and people flow intelligence solutions, could be utilized in smart building energy management and demand response via interoperability with energy management system through APIs. Aim to reduce peak demand.
Detailed plan	1. Define technical architecture 2. Define algorithm and software specification 3. Validate technical performance in development environment 4. Test data communication performance between building management and KONE devices 5. Use communicated data of KONE devices in smart building energy management system, for example, to momentarily supply more power from an on-site battery bank or reduce consumption of other appliances when an elevator is accelerating in order to limit the power demand peak visible to the electricity grid and verify the desired effect.
Targeted outcome	Enabling solutions for elevators, escalators and people flow intelligence solutions to interlink with building energy management systems to provide additional value to the building owner/operator, especially in the form of power demand forecasting.
Roles and responsibilities	KONE: Algorithm and software development in KONE devices, which allow real-time communication with building energy management systems. Installation/updating of required KONE components in the pilot building(s) SIE: Read the transferred KONE data and showcase its applicability in making smarter decisions for building energy management and demand response (Sello): Potential testbed for implementing the on-site communication system with high-end monitoring and control capabilities on existing Siemens VPP
Schedule	Data transfer test and verification M9 Data transfer test with an actual on-site elevator M21 Peak power reduction test and analysis M26 Reports and further analysis M33

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New deviations into plan (as compared to D3.1)	Schedule of on-site peak demand reduction testing slightly delayed (M21->M26) due to issues related to installation of additional cabling within the pilot building (Sello)
Progress until M24	KONE has developed an algorithm that can forecast the short-term (~30s), high-resolution (1-s) power demand of selected elevators. The algorithm has been implemented as a software running on KONE devices and its functionality has been tested with on-site elevators. The data points and communication protocol between KONE devices and Siemens VPP have been agreed. Necessary equipment for first on-site tests in the pilot building have been installed. See Figure 22.

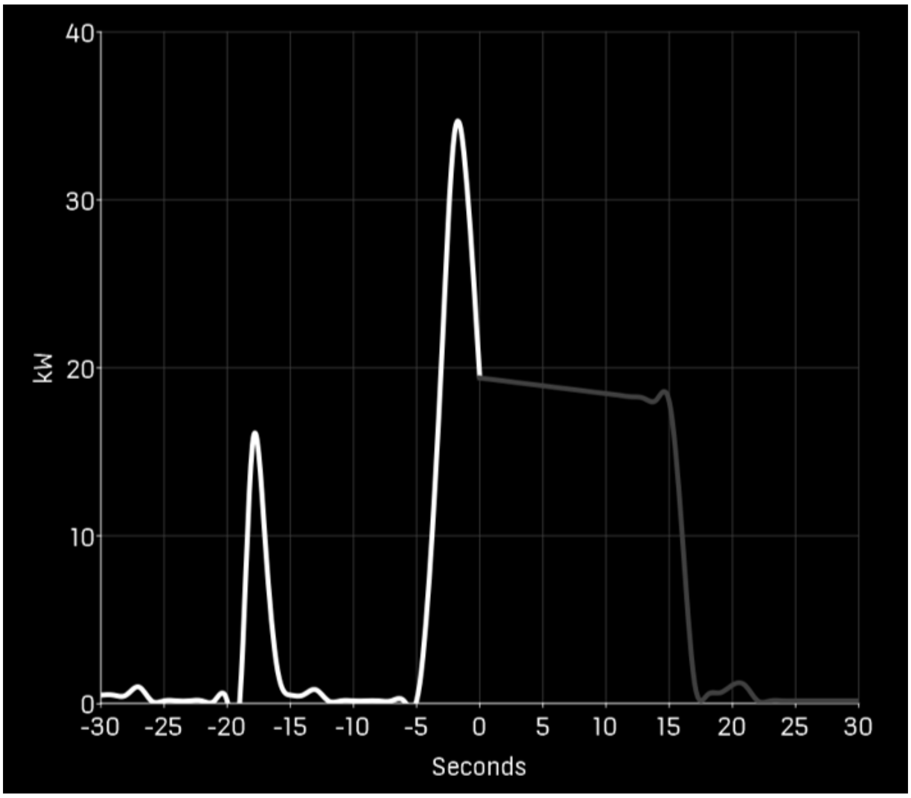

Figure 22. Example of live power demand forecast (0…30 s) of an actual non-regenerative elevator and its historical power demand forecast (-30…0s) (Figure from Kone Oyj)

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5. E-MOBILITY INTEGRATION IN ESPOO LIGHTHOUSE DEMONSTRATIONS

5.1 Introduction to task 3.4

Mobility has a large impact on sustainable urban development from ecological, economic and social perspectives. The objective of task 3.4 is to boost electric mobility (e-mobility) in the Espoo area focusing especially on mobility hubs, EV charging infrastructures and their integration to the smart grid, and mobility and accessibility through sustainable transportation options. Espoo as a city is characterized by multiple smaller urban centres, situated around rail tracks (metro and local commuter train connections; metro opened in 2017, extension to open in 2023; also a light rail system from 2024 onwards), which makes it possible to develop dense and mixed-use urban cores that favour sustainable modes of mobility, including public transportation, walking, bicycling, different shared mobility services and 'last mile' solutions, and e-mobility. In 2019 and 2020, transportation caused around one third of the greenhouse gas emissions in Espoo[3], so mobility plays a key role in the city's carbon neutrality target 2030 and beyond.

5.2 Boosting E-mobility uptake in the Espoonlahti district, Lippulaiva blocks

The task is divided into four subtasks that focus on the development of e-mobility in Espoonlahti district and Lippulaiva blocks (subtask 3.4.1), Leppävaara district and Sello blocks (3.4.2), Kera area (3.4.3), and on the general urban planning requirements level (3.4.4). In the tasks, the requirements, demands, models and possibilities of electric mobility solutions are mapped and assessed, and their prospective applications for replication are examined. The overall aim is to support the formation of multimodal e-mobility hubs in Espoo – that combine public transportation with e-mobility solutions and logistics – and to produce feasible solutions for replication elsewhere.

5.3 Boosting E-mobility uptake in the Espoonlahti district, Lippulaiva blocks

This subtask 3.4.1 concentrates on Boosting E-mobility uptake in the Espoonlahti district, Lippulaiva blocks. E-mobility solutions will be developed in Lippulaiva district (shopping center, residential buildings and senior house) by offering EV parking and charging capacity as well as facilities for e-bicycle. SPARCS Interventions E2 for Boosting E-mobility uptake and related demonstration action plans are presented in the following tables.

Action E2-1	Integrating and grid impact assessment of community and residential EV parking in the Lippulaiva blocks: up to 140 charging units, currently grid access dimensioned for maximum 400 EV.

[3] https://www.hsy.fi/ymparistotieto/avoindata/avoin-data---sivut/paakaupunkiseudun-kasvihuonekaasupaastot/ Accessed 5.8.2021.

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Detailed plan	• Dimensioning and designing EV parking for shopping center customers and residential buildings in Lippulaiva • Designing smart charging infrastructure to EV together with service provider • Assessing possibilities of Vehicle to Grid solutions in Lippulaiva.
Targeted outcome	To have community and residential EV parking in the Lippulaiva blocks and offer EV charging capacity for Espoonlahti area.
Roles and responsibilities	CIT: Dimensioning and designing EV parking with service provider VTT: Estimation of required amount of charging units using ABTM (Activity based transportation model). Literature review on Vehicle to Grid (V2G) solutions and assessing the possibilities of V2G in Lippulaiva, how could V2G support the Positive Energy District idea
Schedule	• Dimensioning and designing EV parking and charging capacity for Lippulaiva, M12. (done) • Estimation required for charging data during mid August 2020; literature review on V2G, M12 (VTT)
Additional information	Citycon will decide the specific amount of EV parking and charging units which can deviate from the original plan since new design and architecture of Lippulaiva.
New deviations into plan (as compared to D3.1)	Citycon invests 70 AC charging stations and 10 DC charging stations to Lippulaiva for customers and residents. Additional charges will be invested when profitable.
Progress until M24	During the first 24 project months, Citycon has dimensioned and designed EV parking for customers and residents of Lippulaiva. V2G literature review pending.

Action E2-2	**Opportunities to support and enable e-bicycling with appropriate parking and charging infrastructure (inverters, parking facilities, size demands, secure charging infrastructure) boosting the E-mobility in the whole Espoonlahti district.**
Detailed plan	• Examine existing city-level plans and local and regional bicycling strategies, and existing shared city bike system in relation to SPARCS goals, and facilitating discussion with different city departments. • Assessing e-bicycling possibilities in Espoo (integration to city transportation system, integration to existing and future mobility hubs). • Assessing the possibility to offer warm storage room for e-bikes. • Organizing a public event in Pikkulaiva for locals where e-bikes and sustainable mobility are presented and promoted, possibility to try e-bikes (connections to Task 3.6), together with local companies and other stakeholders. • Assessing e-charging requirements and facilities.

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Targeted outcome	Support and develop e-bicycling in Espoonlahti and Lippulaiva area, and sketch possibilities for the city in general. E-bicycling can, in specific, answer to the first/last mile challenges related to sustainable mobility.
Roles and responsibilities	CIT: Assessing the possibilities to have appropriate parking and charging infrastructure in Lippulaiva, arrange event in Pikkulaiva for promoting e-bikes. ESP: Assessing e-bicycling development possibilities, including already set local and regional bicycling strategies, existing shared city bike system goals, and targets of the city. Analysis of future possibilities/bottlenecks for wider e-bike utilization.
Schedule	M36: Assessing key concepts and cases on e-bicycling development; learnings and insights. Analyzing possibilities/bottlenecks for wider e-bike utilization in the city through desk study and workshops. (ESP) (Note: The overall timeline of Espoonlahti development and Lippulaiva construction is highly relevant for the scheduling here, as is the Covid-19-virus situation.)
New deviations into plan (as compared to D3.1)	Schedule revised. CIT: Event in Espoonlahti Lippulaiva promoting e-bikes will not be organized. The possibility of smaller campaigns to promote e-bicycling to replace this event is being assessed.
Progress until M24	• ESP: Discussion on e-bicycling development opened with relevant stakeholders (e.g. city departments and units). • ESP: Desk study and workshops (SWOT) on e-bicycling development in progress. • CIT: Plans for appropriate parking for bikes and charging for e-bikes is done and construction phase is starting.

Action E2-3	**Boosting the uptake of e-mobility: Sustainability strategy for how to access Metro and Lippulaiva with other sustainable mobility modes, developing Lippulaiva as hub for shared eVs. Development of commercial electric vehicle charging services. Analysis of energy demand for electric buses, taxis, garbage and delivery trucks and other service vehicles and impact on electric grid. Development of smart charging services.**
Detailed plan	Developing a sustainability strategy with a focus on 'last mile' solutions and e-bicycles, assessing similar strategies globally for Metro (or similar public transportation connection) access. Examining potentials for different electric vehicle type charging services (with relevant stakeholders) and EV sharing (services) - and analysis of the impacts on the grid.
Targeted outcome	Insights on e-mobility hubs on accessibility, shared mobility services, energy demand and impact assessments and integration of smart charging services.
Roles and responsibilities	ESP: Assessing mobility hub accessibility, linking e-mobility concepts with other city and regional plans and frameworks on sustainable mobility; assessing other examples of similar cases in national and international

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	contexts. Facilitating discussions with HSL and HSY and the project partners. Examining possible connections with Task 3.6 on mobility development. CIT: Support other partners in the Action. VTT: Simulation of vehicle fleets and their impact on grid. KONE: Support other work in the Action, especially through Task 3.6 and help in traffic analysis within buildings if needed. SIE: Support action leader in analysis of energy demand for electric utility vehicles. PIT: Support other work in the Action, especially charging.
Schedule	M1-36: Opening and expanding discussion on hub development with relevant stakeholders (incl. HSL, HSY). M36: Identifying and analyzing key aspects of e-mobility hub development; desk study on key concepts and cases; workshops with different stakeholders.
New deviations into plan (as compared to D3.1)	Schedule revised.
Progress until M24	• Discussions opened with relevant stakeholders (incl. HSL, HSY) on hub development. • Desk study and workshops on e-mobility hub development in progress (in connection to E7-1, E13-1; see also sections 5.5 and 7.2.1 on e-mobility hub conceptualization workshop series). • E-hub simulations initiated.

By project month M24, charging capacity for e-cars and e-bikes with proper parking facilities has progressed in Lippulaiva (CIT). The charging capacity of electric cars coming to the Lippulaiva will significantly increase the amount of public charging in Espoonlahti. Today, there is only 5 publicly available AC chargers in Espoonlahti (source: latauskartta.fi). Citycon has decided to invest in 70 AC chargers and 10 DC fast charging spots for customers and residents by the opening of the Lippulaiva. This amount will be increased when necessary. The user-friendliness of the charging has been taken into account when designing the charging stations. For example, the locations of DC chargers are wider than other parking spaces. A charging station will also be brought to the car park dedicated to drivers with physical disabilities.

Designing of parking facilities especially for e-bikes has started. Citycon has decided to dedicate a warm storage room for bike parking with possibility to charge e-bikes and prepare bikes. There will be charging capacity for 5 bikes and the amount will be increased if needed by customers. In general, Lippulaiva will have an extensive amount of bike parking around Lippulaiva block, over 1200 parking places from which part will be covered.

Promoting sustainability in mobility is a high priority and work has started. Workshop of micromobility was held to Lippulaiva buddy class and buddy families of Espoonlahti (Figure 23). A questionnaire for understanding micromobility was developed for Espoonlahti residents and a total of 79 responses were received (see T3.6 for details).

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Due to the current circumstances, smaller events will be organized to replace a previously planned large event.

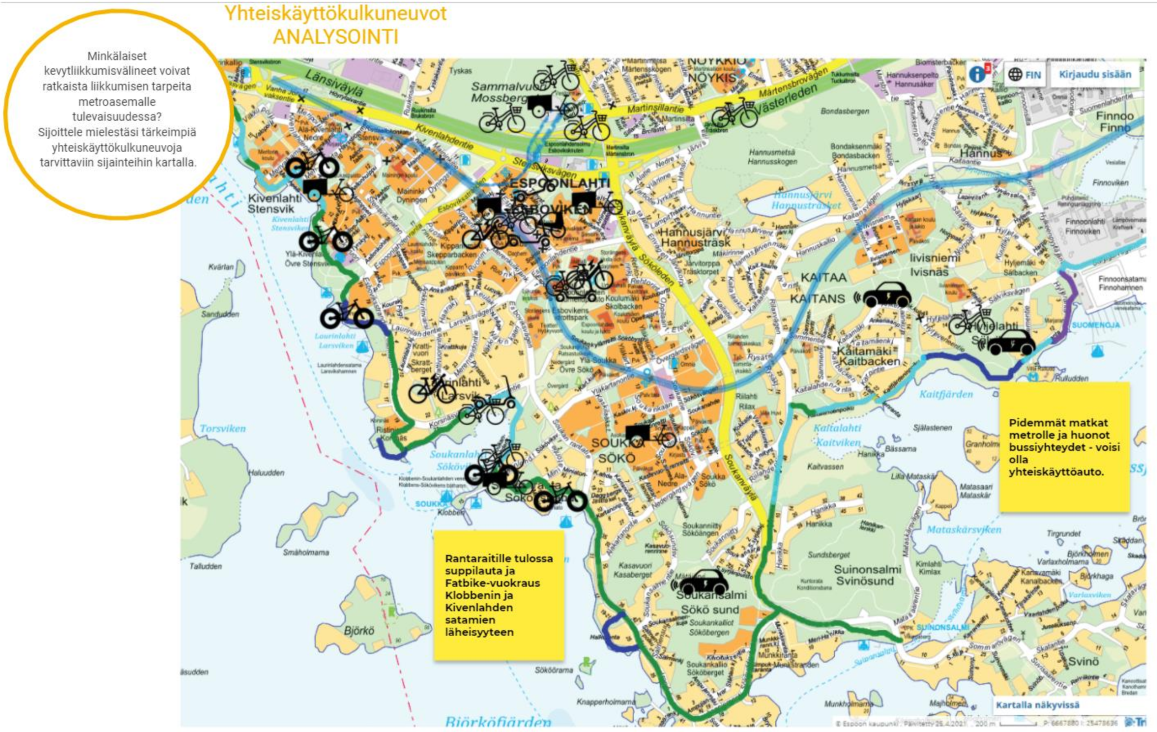

Figure 23. Results of micromobility workshop arranged by KONE and Citycon: Espoonlahti residents' view where shared micromobility vehicles should be placed in Espoonlahti area. (Source: KONE Oyj)

5.4 New E-mobility hub in Leppävaara

This subtask 3.4.2 New E-mobility hub in Leppävaara aims to develop large-scale EV charging systems. The subtask implements a charging system which could be used by multiple EV types in Leppävaara. This E-mobility hub includes Finland's first large-scale public E-bus charging infrastructure. Upcoming EV types such as service vehicles, mobile machinery and electric car sharing are investigated. The subtask analyses different charging strategies and how to optimize large–scale charging systems. Impacts on the grid are also analysed. It investigates commuter parking as a part of the total building power management. The subtask will look into the financing and business models for the charging systems with multiple stakeholders. One aim is also to provide sufficient knowledge for replication and improvement of a similar charging solutions in other nodal points in transit system (such as Espoonlahti and Kera). SPARCS interventions E7 for New E-mobility hub include following demonstration actions.

Action E7-1	Developing Leppävaara EV-mobility hub as a whole. Helsinki Region Transport (HSL) and the City of Espoo have high targets for the

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	electrification of transport. The Sello block and area will be developed into a new E-mobility hub connecting local and long-distance trains, city E-buses, and a new fast E-tramline. First mile/last mile services will be enhanced by including charging services for car sharing. Interoperability of charging infrastructure will be ensured to provide access for other user groups, e.g. electric service vehicles and mobile machinery. The requirements and impacts on the electrical grid will be analysed in collaboration with all relevant stakeholders.
Detailed plan	1. Implementing a bus charging system in Leppävaara. 2. Examine the possibilities to further development of the charging system into EV-mobility hub. Analyze the EV-mobility hub charging for some of the following: passenger cars, taxis, shared cars, service vehicles, mobile machinery and electric bikes. Possible implementations if right partners found. 3. Data gathering from the Leppävaara charging system. 4. Analyzing the requirements and impacts on the electrical grid.
Targeted outcome	Future charging systems must be built as EV-mobility hubs due to rapid growth of electric vehicles. For optimizing the hubs, it is important that as many vehicles as possible are connected to the same charging system. This action aims to improve the future EV-mobility hubs based on the charging system in Leppävaara.
Roles and responsibilities	PIT: Implementing the bus charging system. Gathering data to cloud and analysis. EV mobility hub charging analysis. Possible future implementations. VTT: Analysis of commercial vehicles and their charging needs. Simulation of requirements and impacts on the electrical grid. ESP: Facilitating discussions with relevant stakeholders (HSL and HSY). Connecting the demonstration activities in Leppävaara with the district, city, and region development in a broader sense.
Schedule	M3: Bus charging system. Data gathering from the system starts. M16: Analysis of charging needs of vehicles in EV-mobility hub. M25: EV-mobility hub analysis ready. M28: Simulations of the requirements and impacts on the electrical grid ready. M30: Possible implementation of other chargers into the system. M30: Possible service vehicle testing with charging system.
New deviations into plan (as compared to D3.1)	Schedule revised.
Progress until M24	• Discussions opened with relevant stakeholders (incl. HSL, HSY) on hub development. • Desk study and workshops on e-mobility hub conceptual development (incl. EV sharing utilization) in progress (in connection to E2-3, E13-2; see also sections 5.5 and 7.2.1 on e-mobility hub conceptualization workshop series). • EV-mobility hub charging requirements mapped out and simulations initiated. • Charging system for electric buses implemented

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	• Charging system tested with passenger cars • Tested that the implemented charging system could be expanded to EV-mobility hub for all kind of vehicles.
Action E7-2	**Development of EV charging for customers of the shopping centre and commuter parking as a part of the total building power management and microgrid solutions. Optimisation of EV car charging and power management. Utilisation of activity based models for load prediction and development of energy demand response services (V2G), control strategies based on business models (Park&Charge concept). Dynamic pricing models for electric vehicle charging and price of electricity depending on the flexibility resource the EV can bring. Test would focus also to gain user experience data out of the EV charging usage for the future energy optimization purposes and to connect EV charging stations to VPP. Integrating data and services. 5G is enabling the data transfer.**
Detailed plan	1) Integrate EV charging software system to Sello building automation system to integrate different platforms together in order to perform peak-load management on the whole building level. 2) Extend charging data to partners or to a 3rd party for load prediction and analysis purposes.
Targeted outcome	To enable EVs participation in peak-load management on the whole building level, understand EV load profiles, further research and develop more sophisticated business models for dynamic charging or/and V2G applications.
Roles and responsibilities	SIE: Integrate EV charging for building level peak-load management, extend data for partners and further study dynamic pricing and V2G models. PIT: Providing electric bus charging data for peak load review of the whole Sello area. Support other work. VTT: Estimation of EV peak load and grid impact using combination of VTT simulation methods (VTT Smart eFleet and ABTM)
Schedule	1) Integrate EV and BMS software platforms together at M15 2) Send charging data from summer 2020 period (time-series) to partners at M15 3) Use history data (time-series) to show peak-load management capabilities at M24 4) Draw conclusions at M24
New deviations into plan (as compared to D3.1)	No deviations to plans, time schedule on this action will be postponed by estimate of 6 months on all task due to delays in software developments.
Progress until M24	Integrated EV chargers to whole building level as an one asset, that can be controlled together with rest of building energy assets (HVAC, lightning, etc) to control peak-loads

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Action E7-3	Optimal charging strategies for commercial vehicle fleet. Utilisation of activity-based models for demand response prediction. Plugit Finland will be responsible for developing the services related to electric commercial vehicle charging.
Detailed plan	1) Mapping out relevant stakeholders in simulation area (Leppävaara) 2) Analysing the charging demand of different commercial vehicle fleets 3) Creating charging strategies and activity-based models 4) Simulations and analysis of different scenarios in current situation 5) Simulations and analysis of different scenarios in future
Targeted outcome	Future commercial fleets will be electric, and EV-mobility hub has to provide adequate level of service to all stakeholders. Optimizing the whole system is even more necessary in the future. This action aims to find different suitable charging strategies with simulations based on Leppävaara area. The outcome is reached by simulating different scenarios with multiple stakeholders and analysing the outcome.
Roles and responsibilities	PIT: Analysis of charging needs of a commercial vehicle fleet. Data from Leppävaara charging system. Support VTT creating simulation scenarios and analysing the results. VTT: Building commercial vehicle fleet simulations and analysis of different charging strategies
Schedule	M12: Mapping out relevant stakeholders M20: Charging demands of different vehicle fleets M25: Charging strategies and activity-based models M28: Simulation results, analysis of different charging strategies
New deviations into plan (as compared to D3.1)	Schedule revised
Progress until M24	We have mapped out relevant stakeholders in the simulation model (buses, taxis, logistic trucks, taxis and cars). We have also mapped out demands for different vehicle types and started to build the simulation model.

Action E8-3	Evaluate feasibility for shopping behaviour in the EV charging concept
Detailed plan	Research dynamic pricing models and its suitability for charging operations with literature review and end-consumer questionnaire.
Targeted outcome	To understand how to implement EV charging business models to enable EVs to participate in balance management (e.g. V2G)
Roles and responsibilities	SIE: Execute end-consumer questionnaire. Draw conclusions on how to implement dynamic pricing or V2G business case
Schedule	End consumer questionnaire at M15-M27, conclusions at M29

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New deviations into plan (as compared to D3.1)	The Action schedule is updated due to the pending permission from Sello to carry out questionnaire.
Progress until M24	

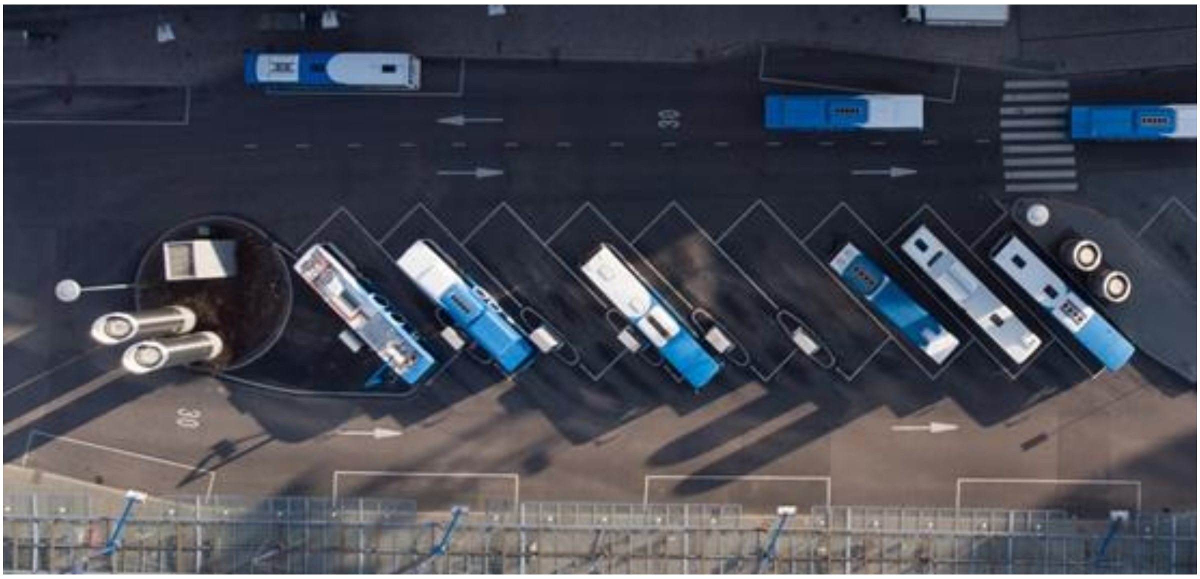

Figure 24. The bus charging system next to Sello shopping centre (Source: Plugit)

By project month M24, EV charging infrastructure implementations in Leppävaara area are ready (Figure 24). The bus charging system is located next to Sello shopping center, where around 20 electric buses use it. The implemented bus charging system consists of 10 GB/T cable charging spots (120kW), 1 cable charging spot (CCS) (120kW) and 5 pantograph charging spots (350kW). The existing bus charging system could be expanded into EV-mobility hub. It has already been tested with passenger cars and could be easily expanded with 10 CCS cable charging spots. Overall power of the system is currently 3 MW and it is expandable to 4 MW. In addition to that, Sello shopping center has 24 AC charging spots (22kW) for customers. The number of AC parking spots in the shopping center is increased if needed in the future (See Figure 25 and Figure 26).

Figure 25: Electric buses in Sello (Source Plugit)

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Figure 26: Bus charging system in Sello (Source Plugit)

The simulation model for Leppävaara area EV-mobility hub is in progress. VTT and PIT have mapped out relevant stakeholders for the simulation and estimated their charging needs. VTT has started to build the simulation model which will be able to simulate current and future scenarios (Figure 27).

Figure 27: Bird's eye view of Sello (Source Plugit)

5.5 E-mobility solutions replication and uptake in Kera

This subtask *3.4.3 E-mobility solutions replication and uptake in Kera* focuses on the development of e-mobility and multi-modal mobility solutions in Kera area. Kera is currently in the first stages of a redevelopment process of being turned during the 2020s and 2030s from a brownfield, logistics and industrial area, into a new vibrant city district. This mixed-use area will comprise housing, workplaces and shared cultural

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and social spaces. From a mobility perspective, the area is already connected by a local commuter train line to the rest of the Espoo city and the overall Helsinki Metropolitan Area – the new local centre of the Kera area will be developed around the train station, providing valuable possibilities for multi-modal transportation solutions, e-mobility, sustainable 'last mile' -strategies and an urban structure emphasising walking and bicycling, with further rail-based solutions planned for the future as well.

The subtask is divided into two actions that aim to support the development and the implementation of multi-modal transport solutions in Kera, and to help replicate the prospective solutions developed in the other actions of the task (mainly Action E7-1 in Leppävaara district) for urban planning process of Kera. This will support the development of sustainable e-mobility solutions in the area that already exist from the planning and design stages onwards. The project's activities in Kera are actively connected with the overall Kera development process as well as multiple other projects and stakeholders involved in the development of this new major city district in Espoo.

Action E13-1	Multi-modal transport solutions with focus on last- mile including charging of the e-fleet. The aim is for an emission-free, clean multi-use area (living, shopping and services) by minimizing the need for private cars.
Detailed plan	Utilisation of insights from the other task actions in Espoonlahti and Leppävaara districts. Assessing replication of the appropriate solutions in an urban planning –context in Kera (urban planning and design phase). Close follow-up and linkages with different Kera development stakeholders and projects (including the City of Espoo's area development leader and urban planning department; HSL and HSY; other projects developing Kera area [Clean and Smart Kera; The Six Cities Strategy: Low-carbon mobility in transportation hubs; The Six Cities Strategy: KIEPPI – Partnership model for sustainable neighbourhoods; LuxTurrim5g/Neutral Host]). Assessing successful multi-modal districts and mobility hubs globally, and the process of implementation through urban planning processes.
Targeted outcome	Supporting the planning and design of Kera area to enable multi-modal transport solutions and last mile -mobility services by making use of the learnings on e-mobility from Leppävaara and Espoonlahti districts. The co-operation with the multiple and diverse Kera area stakeholders is important, and provide a platform for active dialogue. Insights and learnings for future PED areas from mobility perspective are examined in an urban planning and design context.
Roles and responsibilities	ESP: Main responsibility.
Schedule	M19: Identifying key elements of Kera mobility development with stakeholders; multimodal, 'last mile' approach. M36: Insight and learnings analyzed for future Kera development from workshops, discussions with developers, and desk study on e-mobility hub development (see also E2-3, E7-1). (The overall Kera area development timeline and the schedule of the other task actions are highly relevant for the schedule of this action.)

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New deviations into plan (as compared to D3.1)	Schedule updated.
Progress until M24	• Co-organizing mobility-focused working group for Kera multimodal and 'last mile' development. Co-organized with other Sustainable Espoo development projects: *Clean and Smart Kera, SixCities: Low-carbon mobility in transportation hubs,* and *Smart Stations*. (M9-M19.) See more details below. • Discussions opened with relevant stakeholders (incl. HSL, HSY) on hub development. • Desk study and workshops on e-mobility hub development in progress (in connection to E2-3, E7-1; see also sections 5.5 and 7.2.1 on e-mobility hub conceptualization workshop series).

Action E13-2	**Replication of e-mobility solutions. Further development and implementation of Leppävaara e-mobility solutions. (Action E7-1) Charging stations for company-owned electric vehicles.**
Detailed plan	Close follow-up and review of Action E7-1 (developing Leppävaara EV-mobility hub as a whole) results and insights, also other task actions. Assessing appropriate replicated activities for Kera area (urban planning context) in relation to the Kera area plan and development process. Communication with other relevant Kera area stakeholders and projects (see also Action E13-1).
Targeted outcome	Drawing insights from the Leppävaara solutions and assessing the implementation of prospective solutions for mobility hub development in Kera area and for the development and drafting of charging stations in Kera area planning where available.
Roles and responsibilities	ESP: Main responsibility. Gathering an overview on the possibilities for replication in Kera area (urban planning and design process). VTT: Support action leader with expertise on e-mobility solutions and demand estimation SIE: Support action leader with know-how on infrastructure development (microgrids, VPPs, digital energy community platform). Expert role based on Leppävaara e-mobility solutions. Sello charging system maintenance and development. PIT: Support other work. Possibly implementation of the charging system. System planning and development based on Leppävaara charging system.
Schedule	M1-M60: Follow-up and review of the task's Leppävaara and Espoonlahti demo actions and identifying key learnings and prospects for Kera (e.g. through workshops). (ESP) M3-M60: Opening and expanding an active and ongoing dialogue between different Kera area stakeholders on mobility development in the area, including workshops.

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	(The schedule is connected with the timelines of other actions in the task as well as to the overall Kera area development process.)
New deviations into plan (as compared to D3.1)	Schedule updated.
Progress until M24	Regular meetings organized (online) between T3.4 partners and relevant city units and development projects on Kera area since fall 2020; sharing learnings and best practices for future Kera development from the demos. (Also supporting E11-1 in T3.6.) (ESP)

Kera area is developed in close co-operation between the city and different stakeholders, including landowners, companies, organizations, and citizens. In summer 2020, a working group was formed to develop the future visions and goals for transportation and logistics services for Kera area up to 2030 and beyond, and to create a basis for the formation of a (e-)mobility service ecosystem in the area that could foster the development of a local 'last'/'first mile' services (E13-1). The group was led jointly by multiple the City of Espoo's sustainable development projects: *Clean & Smart Kera*, SPARCS, *SixCities: Low-carbon mobility in transportation hubs*, and *Smart Station*, and consisted of city's Kera developers and different companies and organizations (including PIT and HSL). The group held multiple meetings and workshops (during M9-19) in order to develop a mobility vision for Kera 2030. The meetings/workshops addressed the development of a shared vision, bicycling infrastructure, public transportation service timeline, and the evolutionary development process of the already existing Kera station area.

Since fall 2020, City of Espoo has organized regular meetings between Kera developers from the city (including the area manager, urban planners, Clean and Smart Kera development project) and the relevant WP3 SPARCS partners on e-mobility development in the Kera area. The meetings have been used as a platform to provide both up-to-date insight about the Kera area development process for SPARCS partners and to present the results and learnings of the SPARCS demonstrations from the other two Espoo demonstrations areas (Leppävaara and Espoonlahti) for the Kera developers. The learnings and insights of SPARCS project can help to shape the Kera area into a new (smart) urban district by incorporating novel solutions, ideas and approaches already in the urban planning and design phase of the area.

The City of Espoo has also initiated, led, co-planned and co-organized a series of workshops on e-mobility hub concept development since spring 2021. The workshops aim to develop a working concept for e-mobility hubs of the future considering the hub user and mobility service provider perspectives (also E2-3 and E7-1). So far, the workshops have engaged SPARCS partners (M20) and citizens (M21, with 8 citizen participants). Further workshops are planned for Autumn 2021 for additional stakeholders, including service providers. The insights and learnings gained from the workshop series will be used to sketch further guidelines for Kera's (e-)mobility hub development in order to create a new kind of an urban area with a multimodal mobility

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focus, relying on mass transit (already existing commuter train station), walking and bicycling, and shared (e-)mobility services.

5.6 E-mobility urban planning requirements

This subtask 3.4.4 *E-mobility urban planning requirements* aims at the optimal integration of charging for all vehicle types, both privately owned and commercial vehicles. The work is aiming for a holistic view of the city of Espoo with a special emphasis on the demonstration areas, i.e. Leppävaara, Espoonlahti and Kera. In order to carry out the task, VTT will utilize two in-house simulation methods: VTT Smart eFleet and an activity-based transport model (ABTM).

VTT Smart eFleet has been developed for the simulation of commercial vehicle fleets where the routes are predefined. Hence, the simulation model is very well suited for public transport simulation, but also other commercial vehicles, such as delivery trucks and refuse trucks, can be simulated. Based on the given routes and schedules, detailed information on energy consumption and need for charging at different locations is obtained. Various charging management strategies can easily be implemented and tested within the simulation framework.

The ABTM is focused on urban personal mobility and it can be used to simulate the entire transport network of a city or area. The model is based on statistical data on households and mobility patterns, and the model can be used to obtain the traffic flow for the area under study. The model can easily be scaled up to study the impact of new residential areas or modifications in the public transport network. Hence, the ABTM will be used for forecasting the traffic situation and energy demand beyond 2030.

Action E18-1	Optimal integration of EV charging, taking into account all modes and types of electric vehicles, commercial as well as private, in the E-mobility nodes of Leppävaara (Sello block), Espoonlahti (Lippulaiva blocks) and Kera, managing of peak power demand and related effects from the urban planning. Analysis of future demand and development of smart charging strategies for different scenarios. This takes into account predictions of expected numbers of electric vehicles in each use case segment up to 2030 and beyond, the foreseen demand for power and energy and their impact to the grid.
Detailed plan	1) Generating and simulation of fleet scenarios in VTT Smart eFleet 2) Demand generation from co-created visions. Transport and charging network loading from the demand. Resilience testing through variety in inputs.
Targeted outcome	Charging scenarios through ABTM. Recommendations for spatial development.
Roles and responsibilities	VTT: Demand generation, modelling, simulations. SIE: Support action leader on simulation models. PIT: Support/ Advisor ESP: Supporting the development and analysis of future scenarios for the districts, help VTT to gather the required data, especially with Kera area development process.

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Schedule	M1 – M60: The schedule is connected with E7-3 Action and iteratively builds up on the feedback from the project.
New deviations into plan (as compared to D3.1)	
Progress until M24	• Provided data and support for VTT about Kera area for the update of the simulation model. (ESP) • ABTM model has been adjusted for the Kera area.

The ABTM model for the Helsinki capital region has been revised, and the Kera area has been updated according to the construction plans. Assumptions were used to generate the capacity for the Matsim model based on the floor area available to each type of activity (Figure 28).

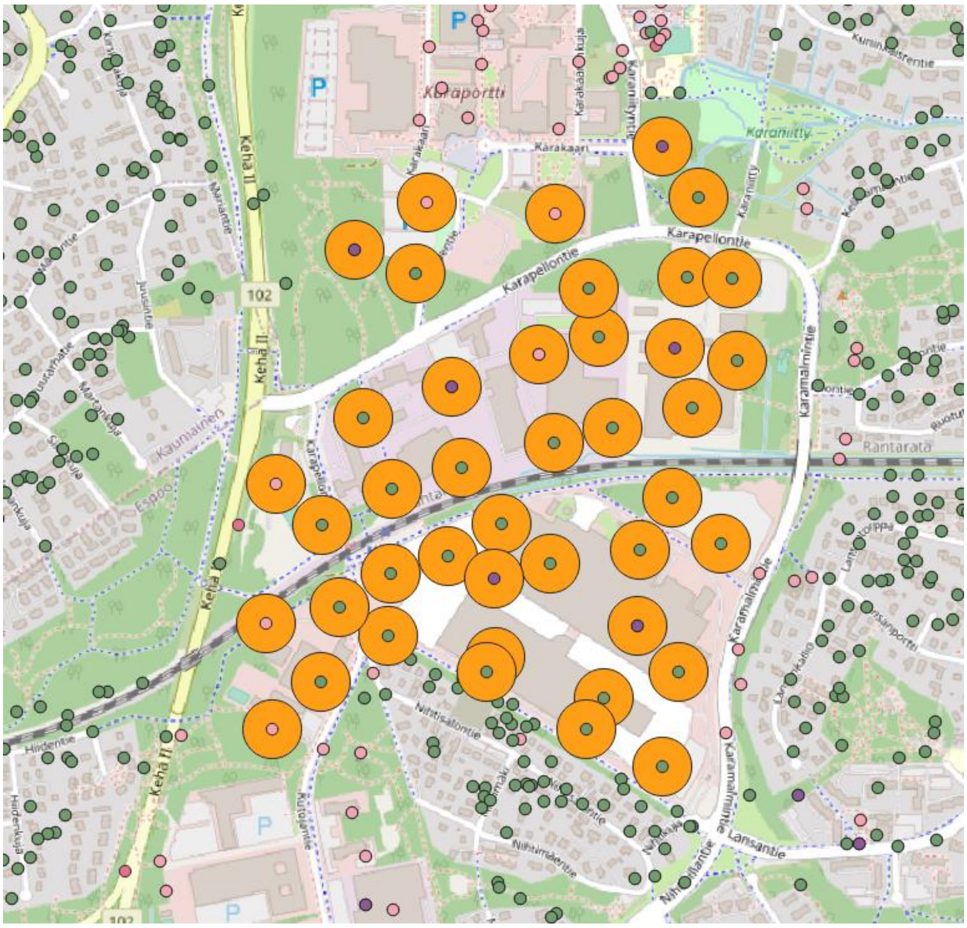

Figure 28: Kera district in the ABTM model. Visualized with QGIS and OSM map tiles. Source: VTT

In Figure 28 the rounded dots represent the newly inserted buildings from Kera area into the model. Capacity has been assumed according to the plans provided by the city of Espoo. Buildings that are expected to be demolished (mostly current industrial part) are removed from the model and agents are unable to use them in their daily routines.

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The dots without the orange round were present in the original model, green represents the residential buildings, pink is for industrial/offices and purple is dedicated for services and shopping areas.

Furthermore, agents were run through a “relocation” script to relocate their activities according to the newly available possibilities. The first mobility simulations were run with satisfying results. Results will be further used to generate duty cycles of the vehicles interacting with Kera and later on charging curves can be obtained from the dataset.

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6. Planning of Positive Energy Districts in Espoo

Energy infrastructure like electricity distribution grids, district heating networks, renewable gases and other fuel provision lays the foundation to modern energy services for households, businesses and industries. In new city development areas, solutions must be designed and infrastructure investments made before residents arrive. This requires careful analysis and accurate estimates on future needs. Heating and cooling needs could also be affected by changing weather patterns. New innovations, ambitious climate actions, shifts in consumer behaviour and changes in economic performance may over time result in situations, where the built infrastructure is not optimal for the needs of residents. Lock-in effects, like dependence on one specific fuel type or heat supplier can be mitigated by favouring flexible infrastructure designs. In a worst-case scenario, expensive energy infrastructure may turn into stranded assets if consumers choose competing technologies.

Data rich 3D city models not only support urban planning in obtaining a greater understanding of given urban opportunities and challenges, but also provide benefits during the planning and implementing process of PED solutions. The 3D city models may be offered on open platforms and formats so stakeholders can easily access and utilise the data. Software developers can develop new online services for local consumers. The data also allows detailed simulation analyses and automatic calculation of solar, wind and geoenergy potential to support the selection and sizing of energy infrastructure. Using a common and regularly updated city model facilitates collaboration of different engineering companies and engagement of stakeholders and citizens in the process.

With regard to PEDs in Espoo, two scientific articles have also been published to address the topic in detail. The first paper *Positioning Positive Energy Districts in European Cities*[4] discusses aspects that should be accounted for when planning and implementing different types of PEDs in different regions throughout the European Union while the second paper *Positive Energy District: A new puzzle piece for cities' energy transformation*[5] talks about positive energy districts being developed across Finland.

Action E17-2	**CityGML as a tool for energy positive block development. Starting 2019, The City of Espoo offers an open, and public, Espoo 3D City model. The model covers all of Espoo and all objects included are described in the CityGML standard, except for bridges and tunnels. The action implements the MODER tool using Apros simulator and City GML integration, for assessing the potential for energy positive blocks in Espoo. The methodology has been developed in the H2020 project MODER, Mobilization of innovative design tools for refurbishing of buildings at district level (Innovation Action, EeB-05-2015).**

[4] Lindholm, Oscar, Hassam u. Rehman, and Francesco Reda. 2021. "Positioning Positive Energy Districts in European Cities" Buildings 11, no. 1: 19. https://doi.org/10.3390/buildings11010019

[5] Hukkalainen, M., Reda, F., & Klobut, K. (2021). Positive Energy District: A new puzzle piece for cities' energy transformation. Rakennustekniikka, 2021(2), 38-43. https://view.creator.taiqa.com/ril/rakennustekniikka-22021?viewer=embed#/page=38

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Detailed plan	This action studies in practice, how CityGML could be integrated in the planning and development of energy positive blocks, local energy production and energy efficiency of buildings. This action includes: • Formulate the selection criteria for choosing a suitable area. The defining factors are e.g. the availability of data and its level of detail. (For the new areas data might be not available.) (ESPOO, VTT) • Identify a suitable mixed-use area, which will act as a reference site with the adequate level of detail in CityGML. Potentially, the district could be Kera or Finnoo. If another site is chosen, opportunities may later be exploited in Kera to support PED development. (ESPOO) • Espoo will provide data related to the identified district in CityGML format. Espoo will check and improve the semantics of the data provided in the CityGML, to include e.g., construction year, building use, heating and cooling type, number of occupants, ventilation heat recovery, etc. In case of seasonal storage - possibly geometric description in CityGML). • Identify a set of technologies to support local PED development, including energy efficiency improvements and distributed energy generation opportunities. The related objectives for the energy solutions will be formulated. (VTT, ESP) • Establish a design scenario portraying positive energy block solutions (VTT, ESP) • Carry out block level 12-month simulation using Apros simulator and City GML integration, using both a cold winter and warm winter scenario. (VTT) • Optional: If seasonal storage is included, estimate time needed for storage patterns to stabilise. (VTT) • Calculate On-site Energy Ratio for all scenarios (VTT) • Optional: assessing CAPEX and OPEX. carbon emissions. • Assess opportunities revealed by the 3D data to fast-track such technologies (ESP) • Visualising the results (VTT, ESP) • Engage with stakeholders to validate processes (ESP) • Document the process described above (ESP, VTT)
Targeted outcome	New development sites differ in geographies, building stock and local energy sources, so there is no one-size-fits-all model for a district energy solution. This work aims to clarify how CityGML could support low carbon urban planning and block/district level energy analysis. This work can also provide a good practical use case for the municipality for collecting and incorporating needed building and energy related semantics into the CityGML. The geographic and building data combined with energy simulation results allows techno-economical assessment of proposed solutions and enables informed decisions based on local specifics.
Roles and responsibilities	ESP: Identify Kera, Finnoo or another suitable district in Espoo, and provide data related to the identified district in CityGML format, check and improve semantics of the data. VTT, ESP: Identify baseline energy solutions and propose new positive energy block solutions. VTT: Carry out required analysis as specified above ESP, VTT: Engage with stakeholders to validate results

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Schedule	M14: Site identified M20 Energy solutions identified M28 Simulation completed M34 Results validated and communicated
Deviations from initial plan	Visualization of the results can look a bit different than shown in DoW, due to recent changes related to the MODER tool.
New deviations into plan (as compared to D3.1)	M25 Energy solutions identified
Progress until M24	ESP: Together with the city's premises department a suitable site was identified and the CityGML data about the site were provided to VTT.

The following criteria were considered when choosing a suitable site:

- site to be of interest for the City of Espoo
- several buildings to be located in the area of interest (more than one building needed for the analysis)
- preferably the site incorporates the use of renewable energy sources (e.g. solar energy)
- data provided in the CityGML to include e.g.
    - construction year
    - building use
    - heating and cooling type
    - number of occupants
    - ventilation heat recovery

Considering the criteria above, the Espoonlahti sports park was selected as suitable site (Figure 29). Within this site 7 buildings with different building types (educational -, assembly -, and rescue service buildings) were selected.

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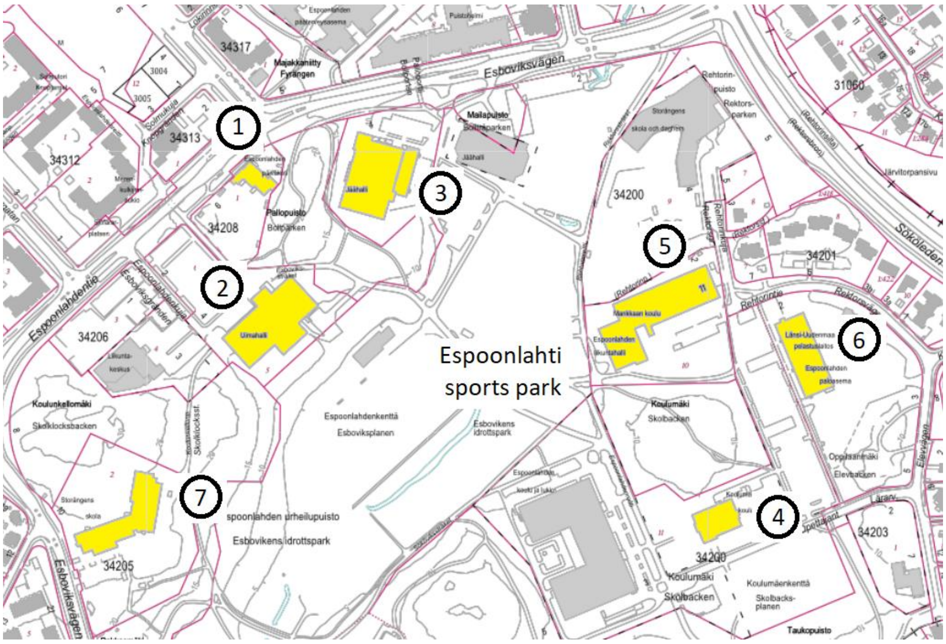

Figure 29: Espoonlahti Sports Park

Figure 30 shows part of the CityGML attribute list for one of the buildings, as well as the presentation of the building in 3D format.

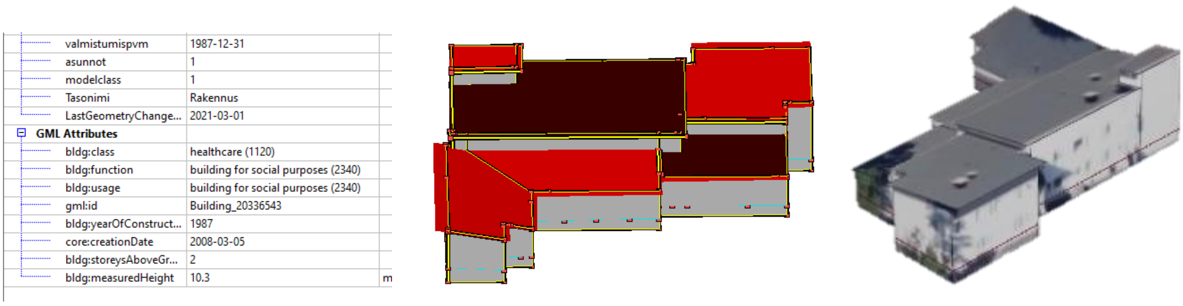

Figure 30: CityGML attribute list and example of a building of the Espoolahti sports park visualized with Trimble Locus based on Espoo's open data. (Source: City of Espoo)

When building new energy-efficient and low-carbon residential districts, highly sustainable development principles must be adopted for planning solutions, energy solutions, as well as material selection. Action E20-1 focuses on requirements and local energy solutions for the Finnoo district.

Action E20-1	**FINNOO REPLICATION. Identifying the requirements for buildings to be integrated in the energy infrastructure; smart building requirements. The smart building and open interface requirements can be put into practice through terms for the plot assignment.**
Detailed plan	Document Finnoo site specification, building stock and terms for developers Assess the proposed local energy solution, prospectively based on semi-deep boreholes and local low-temperature heating network

	Assess requirements for building-level heat exchangers and heat distribution system Assess opportunities for bidirectionality, waste heat and heat storage Assess metering requirements to facilitate smart automation and forecasting Estimate OER, financial and carbon savings Adjust terms for the plot assignment to reflect lessons learnt and enhanced replication
Targeted outcome	The Finnoo district will utilize new local energy solutions. Successful implementation provides excellent basis for replication
Roles and responsibilities	ESP: Main responsibility Stakeholders: Propose new solutions
Schedule	M18: Document Finnoo specification and requirements for energy efficiency M25: Identify and assess further development options M28: Report findings
New deviations into plan (as compared to D3.1)	*No deviations*
Progress until M24	Energy efficiency- as well as sustainability criteria for buildings were defined for developers of the Finnoo district. According to the specifications, the developers must achieve a minimum of certain criteria points in order to fulfill the construction requirements. This requirement will accelerate the energy efficiency and the sustainable development level of the construction process above average.

Action E22-1	Co-creation for smart city development. Co-creation models to support land use planning are developed as a collaboration between industry, SMEs, citizens and other stakeholders to support functional solutions of new development areas regarding e.g. energy, mobility, and service solutions based on digital platforms and fast networks.
Detailed plan	Co-creation model is facilitated by 3rd party subcontracting, which is now under preparation. The model will first be made for Kera and only after that, a more general model for whole city of Espoo.
Targeted outcome	For sustainable smart city development, co-creation model towards actualization as alliance model is needed to support collaboration and best practices.
Roles and responsibilities	ESP: to tender and choose the service provider for creating these models. stakeholders: to participate in the co-creation process
Schedule	M12 Subcontracting documents ready to start the actual subcontracting process. M15 Process finalized, subcontractor chosen M16 Project to create co-creation model starts M24 Model for Kera finalized

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	M30 More general model for City of Espoo finalized M36 Internal work, communication to introduce models to different stakeholders in city organization, as well as outside the city organization.
New deviations into plan (as compared to D3.1)	Schedule revised due to delays in the process. M24 Subcontracting documents ready to start the actual subcontracting process. M26 Process finalized, subcontractor chosen M26-M27 Project to create co-creation model starts M35 Model for Kera finalized M39 More general model for City of Espoo finalized M40-M45 Internal work, communication to introduce models to different stakeholders in city organization, as well as outside the city organization.
Progress until M24	The tendering and procurement process of the co-creation model has been delayed due to covid-19 pandemic and the related effects in the internal processes of the city administration e.g. approval of framework agreement.

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7. Community engagement in Espoo

7.1 Introduction to task 3.6

The objective of task 3.6 is to engage citizens in the energy transition in Espoo, through different channels focusing on different citizen groups. Furthermore, the task aims to ensure a continued sustainable lifestyle, with a special emphasis on urban mobility behaviours and citizens' daily journeys. The task is divided into three subtasks that focus on defining and validating solutions for encouraging people to change their daily mobility habits, co-creating for energy positive behaviour, and supporting a sustainable lifestyle by offering teaching and education.

The task follows a design thinking process, utilizing methods from co-design. It started with expert and lead user interviews for understanding the big picture and trends of current and future (sustainable) urban mobility (in Espoo). Based on the expert and lead user interviews, themes for more detailed research were identified, and these themes will guide the following user studies. The user studies provide an end-user point-of-view and insights into the process of defining solutions for encouraging more sustainable mobility behaviours. Based on the findings from the studies, design sprints are organized. The design sprints will gather all relevant stakeholders (identified through expert interviews and user studies) into the ideation and validation of innovative solutions for future sustainable mobility in Espoo, more precisely Leppävaara and Espoonlahti. In addition to the aforementioned actions, a Buddy class concept idea has been developed, and educational workshops with young people as well as events for locals to present and test sustainable mobility solutions are arranged. By engaging diverse stakeholders into the design thinking process of task 3.6, a bottom-up collaborative approach for creating sustainable change is enabled.

Based on the gathered knowledge as described in the sections below, a scientific article focusing on citizen engagement in Espoo and Leipzig has also been published. The article is titled Citizens and Positive Energy Districts: Are Espoo and Leipzig Ready for PEDs?[6] and has been published as part of the journal *Buildings.* The article assesses the status quo of citizen engagement in Espoo and Leipzig to know if the cities are prepared to develop PEDs together with citizens. The article describes different methods of participation that the cities have been using until now.

7.2 People flow and daily journey

This subtask 3.6.1 People flow and daily journey aims to define and validate solutions for encouraging people to change their daily mobility habits optimizing people flow from an energy and user experience perspective. This is was achieved through lead user studies and mobile probing with citizens of Leppävaara and Espoonlahti. The lead user studies provided understanding of successful solutions to the identified mobility challenges while mobile probing provided understanding of end user needs, challenges, and desires related to smooth and sustainable daily journeys and urban

[6] Fatima, Zarrin, Uta Pollmer, Saga-Sofia Santala, Kaisa Kontu, and Marion Ticklen. 2021. "Citizens and Positive Energy Districts: Are Espoo and Leipzig Ready for PEDs?" *Buildings* 11, no. 3: 102. https://doi.org/10.3390/buildings11030102

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mobility. Also, workshops and testing were conducted with local citizens for defining and validating the most potential sustainable urban mobility solutions for Leppävaara and Espoonlahti. Finally, the solutions will be reflected on in order to form macro level conclusions, and insights will be conveyed to city planning authorities. SPARCS Interventions for Engaging users are presented in the following tables.

In Espoonlahti, the new shopping center with residential buildings and senior house is under construction. During the construction period as well as after opening of the shopping center, citizens have been engaged in multiple ways, such as informing local citizens of the progress of construction, engaging young people in the design processes of the shopping centre and long-term commitment of youngsters with Lippulaiva Buddy class initiative. Users' engagement activities are conducted in close co-operation with SPARCS partners.

Action E3-1	Piloting ways to engage and encourage citizens' energy positive ways of behaviour, developing new energy positive district solutions and improving the awareness of existing ones during the construction time and the daily use of the Lippulaiva services.
Detailed plan	• Developing new energy positive district solutions based on studied lead user innovations focusing on mobility through **design sprints** and **co-creation workshops.** • Piloting ways to engage and encourage citizens' energy positive ways of behaviour through **user involvement in workshops** and by **testing** developed lead user solutions. • Improving the awareness of existing solutions during the construction time and the daily use of the Lippulaiva services **through co-creation workshops, informing letters for neighbours and visualizing solutions with informative way** (for example videos of energy system).
Targeted outcome	Through citizen involvement we aim to engage and encourage citizens' sustainable behaviors.
Roles and responsibilities	CITYCON is responsible for planning and conducting enagement actions in Lippulaiva and Espoonlahti area KONE is responsible for planning and conducting the user research and design sprints/workshops and for testing the developed lead user solutions VTT provides support in developing the user research method for different citizen target groups. ESPOO is supporting citizen engagement pilots and activities on raising awareness of new and existing solutions.
Schedule	Engagement actions are ongoing and will take place during the project months M1-M36, reporting done in project month M36.
New deviations into plan (as compared to D3.1)	The Covid-pandemia has had some impact on the plans, for example face-to-face meetings (e.g. workshops or information events for city dwellers) have been canceled and different ways to involve citizens, e.g. through online tools and platforms have been planned and implemented in its place.
Progress until M24	Piloting ways to engage and encourage citizens' energy positive ways of behaviour has proceeded according to the plans, despite the Covid-related restrictions.

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	• Citycon has conducted Lippulaiva specific actions to promote PED solutions for Espoonlahti citizens:
	  ◦ Buddy class actions planned and started (see more in Action E3-3), continues until M36
	  ◦ Buddy family actions planned and started in 12/2020, continues until M36
	  ◦ Lippulaiva virtual room planned and implemented. It is online virtual room where you can go around and look inside Lippulaiva and read information for example on its sustainability solutions (https://webar.arilyn.com/lippulaiva/), over 3500 viewers from 7 countries with average time to visit 1min 26sec (until 29.6.2021)
	  ◦ Planning phase done for playground area for kids promoting sustainable energy solutions in Lippulaiva
	  ◦ Planning of Lippulaiva energy info-screen for customers has been started 02/2021
	  ◦ Lippulaiva LIVE info-webinar held for Espoonlahti residents where sustainability solutions were promoted (04/2021), the recording of the webinar is online, 1600 viewers (until 28.6.2021)
	  ◦ Multiple news in different medias where Lippulaiva sustainability solutions have been promoted
	• Survey on micro-mobility solutions to Espoonlahti citizens [M19]
	  ◦ KONE and CITYCON conducted an online survey about micro mobility experiences and services in Espoonlahti and Leppävaara.
	• Identifying lead user solutions for micro mobility and shared mobility based on user research, expert interviews and desktop research
	• Design Sprints: Last-mile micro mobility and community vehicles [M19-M20]
	  ◦ Design field trip to Espoonlahti
	  ◦ Qualitative Interviews with 5 Espoonlahti residents on micro mobility
	  ◦ Co-creation workshops with citizens on micro mobility, mobility hub navigation and community vehicle concepts
	• Car sharing study in Espoonlahti (collaboration with Aalto University) [M13-M21]

Action E3-2	**Define and validate solutions for encouraging people to change their daily mobility habits optimizing people flow from energy and user experience perspectives. Developing and validating the chosen lead user innovations in the Espoonlahti district. Encouraging people to use positive district solutions for their daily lives, optimising urban flow from energy and user experience perspectives.**

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Detailed plan	• User research about Espoonlahti citizens' mobility habits, experiences, needs, challenges and desires through **mobile probing** and **workshops with diverse stakeholders** following the citizen engagement principles • **Defining relevant focus area** for interventions based on the user research • **Identifying relevant lead user innovations** for sustainable mobility through **snowballing** etc. • Developing and validating (chosen lead user innovation) solutions for encouraging sustainable mobility behaviors from energy and user experience perspectives with Espoonlahti citizens through **workshops** and **testing** • Encouraging people to use positive district solutions for their daily lives through sharing information of LU innovations through **workshops and arranging events for locals to present sustainable mobility possibilities** (e-bicycles, EV's)
Targeted outcome	In order to define and validate solutions for encouraging more sustainable mobility behaviors, we need to first understand which motives and values drive current behaviors and how this knowledge can be utilized in facilitating a sustainable and citizen-driven change towards more sustainable mobility habits.
Roles and responsibilities	KONE is responsible for planning and conducting the user research and workshops. Citycon is responsible for arranging events for locals where sustainable mobility habits are presented.
Schedule	Mobile probing ready by M15. Lead user research, workshops and local events done by M36. Mobile probing activities were postponed from Spring to Autumn 2020, due to the COVID-19 situation affecting citizens' mobility behaviors. This should not considerably affect other planned activities.
New deviations into plan (as compared to D3.1)	A survey on micro mobility Some of the planned physical events have been postponed or cancelled due to Covid-restrictions. New ways of promoting sustainable mobility habits are being planned, enabling online engagement and participation.
Progress until M24	Conducting user research and workshops have progressed according to plans despite the delays caused by COVID-19 related restriction. COVID-19 has impacted radically citizens' mobility behavior and prevented from organizing face-to-face citizen engagement activities. Most of the user studies, workshops and events have been therefore conducted remotely through online platforms and tools. - 8-week mobile probing study was conducted in the Autumn 2020, engaging 5 residents from Espoonlahti and 5 residents from Leppävaara [M12-M15] - An analysis of the mobile probing study was conducted, which served for definition of thematic focus areas, personas and concept ideation: o 11 initial mobility concepts were developed based on the identified focus areas, reflecting the needs and current pain points of Espoo citizens [M14-M17]

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	○ 8 mobility concept solutions were further developed and clustered under four main themes [M18-M21]: ▪ Micro mobility ▪ Shared mobility ▪ Navigation & hybrid travel chains ▪ Autonomous mobility - Identification of lead user innovations and solutions related to the four main themes based on user interviews, expert interviews, desktop research and benchmarks [M14-M21] - User research, concept development, prototyping and testing in Espoo context in collaboration with Aalto University student teams on micro mobility, shared mobility and autonomous mobility [M14-M24] - Co-creation workshops to develop mobility concepts further and to validate them from user experience perspectives [M15-M23] - Starting collaboration with an external partner to conduct CO_2e footprint calculations to validate the developed mobility concepts from a sustainability perspective [M20-M24]

Action E8-1	**Study lead user citizens' energy positive mobility behaviours, develop new and improve the awareness of existing positive district solutions during the daily use of Sello services. Input for actions in Lippulaiva and Kera. Identifying lead users and studying their behaviour related innovations, which have the most extensive impact on everyday energy consumption. Developing new energy positive district solutions and improving the awareness of existing ones. Input for experimentation and piloting in Leppävaara and Espoonlahti districts.**
Detailed plan	• **Identify lead users** and study their behaviour related innovations, which have the most extensive impact on everyday energy consumption through **interviews,** possibly **planet-centric design canvases** and **the four lenses of innovation.** • Study lead user citizens' energy positive mobility behaviours through the **sustainable mobility innovations** they have developed. • Develop new energy positive district solutions through **co-creation workshops with citizens** / diverse stakeholders. • Improve the awareness of existing positive district solutions during the daily use of Sello services through sharing knowledge of lead user innovations through **workshops.** • **User insight** input for experimentation and piloting in Leppävaara and Espoonlahti districts, and for actions in Lippulaiva and Kera.
Targeted outcome	Through lead user involvement and studying their innovative solutions, we aim to come up with and test innovative sustainable mobility solutions for energy positive districts. Workshops serve as a means to communicate and share knowledge of existing solutions with citizens.
Roles and responsibilities	KONE
Schedule	Studies of sustainable mobility innovations and co-creation workshops are organised by M36. Experimentation and piloting is done during M25-M36.

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New deviations into plan (as compared to D3.1)	Organisation of e-mobility hub workshops in collaboration with T3.4 and T3.8
Progress until M24	• Identifying central eV service providers and studying eV lead users [M19-M21] • Understanding citizens' mobility needs for eVs through e-Mobility Hub co-design workshops in close collaboration with T3.4 and T3.8 [M19-M22] • Co-defining future e-mobility hub concepts in two workshops with SPARCS partners and eV lead users • CO2e footprint calculations to evaluate the developed mobility concepts [M23-M25] • Collaboration started with Sello stakeholders

Action E8-2	**Experiment concepts for encouraging people to use E-mobility solutions for their daily mobility habits optimizing people flow from energy and user experience perspectives. Experimenting lead user innovations in the Leppävaara district. Encouraging people to use existing positive district solutions for their daily lives, optimising urban flow from energy and user experience perspectives.**
Detailed plan	• **Experiment** concepts for encouraging people to use E-mobility solutions for their daily mobility habits optimizing people flow from energy and user experience perspectives. • Experimenting lead user innovations in the Leppävaara district through **testing** • Encouraging people to use existing positive district solutions for their daily lives through sharing information of lead user innovations through **workshops.**
Targeted outcome	Experiments and test help us to understand what works and what does not, and why. This information will help us to develop better solutions for citizens' needs.
Roles and responsibilities	KONE
Schedule	Experimentation is based on mobile probing insights and has started. Experiments and tests will be done, together with workshops, by M36.
New deviations into plan (as compared to D3.1)	E-mobillity Hub development in connection with T3.4 and T3.8 [M18-M24]
Progress until M24	- E-mobility hub development through an online workshop and e-mobility hub design game (SPARCS stakeholders and citizens) - Design field studies with an electric car at Leppävaara/Sello area and Espoonlahti/Lippulaiva area - Carsharing services at Espoonlahti area, collaboration with Aalto University Master thesis worker [M13-M21]

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	- Shared electric vehicles and business model development, collaboration with Aalto University students [M13-M21] - Validating mobility concepts with citizens and designing experiments

Action 11-1	**Citizen mobility. Conveying insights to city planning authorities of citizens' preferable future multimodal mobility habits, schedules and routes to optimize the people flow from energy and user experience perspectives. Utilize input from actions in Leppävaara and Espoonlahti.**
Detailed plan	Citizen's needs and tested solution ideas (best practice insights for enabling more sustainable behaviors) are conveyed to city planning authorities through a **report**, possibly including personas/design drivers /scenarios/storytelling.
Targeted outcome	The aim is to share best practice insights to utilize gained knowledge for Kera development.
Roles and responsibilities	KONE
Schedule	City planning authorities are met in M13 for planning the format of reporting. Reporting is done by M36.
New deviations into plan (as compared to D3.1)	The reporting is done through regular meetings in connection to T3.4 and by sharing results and presentation material on citizen mobility.

Progress until M24	The reporting to Espoo city planning authorities has started and is done through regular meetings with the KERA team and relevant city stakeholders during the project [M13-M36]
	• City of Espoo organizes the meetings in connection to T3.4 and KONE has joined each meeting to discuss and share results
	    • KONE presented expert interview insights on mobility drivers [M13]
	    • KONE presented results from the mobile probing study and shared the initial mobility concept ideas applicable also at KERA area. Followed by Q&A and recommendations for KERA specific citizen engagement and mobility related actions [M18]
	    • Plugit presented e-bus charing and ev-charging solutions which are implemented in Leppävaara, Sello area [M19]
	    • Espoo presented the upcoming e-mobility hub workshops, which can be also applied at KERA area [M23]
	Presentation materials are shared with the KERA team to report the results in visual and sharable form

Action E19-1	**Define and validate solutions for optimizing urban people flow from energy and user experience perspectives. Identifying the benefits and the added value for citizen and other stakeholders in different district lifecycle phases.**

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Detailed plan	• Identifying the benefits and the added value of developed solutions for citizens and other stakeholders in different district lifecycle phases through **design sprints.** • **Reflecting** on the solutions developed and tested/validated in actions E3-1, E3-2, E8-1, E8-2 and forming macro level **conclusions** of the most potential solutions (balancing and energy positivity aspects) and their possible risks.
Targeted outcome	We aim to provide ideas of most potential solutions (that have a balance between the user experience and energy positivity aspect, cf. four lenses of innovation) for macro level development, to enable replication/scaling and further development and testing of the developed solutions.
Roles and responsibilities	KONE
Schedule	Design Sprints are planned in collaboration with stakeholders in M10-15. First Design Sprints are conducted in M15-17. All Design Sprints are conducted by M36.
New deviations into plan (as compared to D3.1)	Design sprints were planned in M15-M21, and conducted together with different stakeholders related to different themes.

Progress until M24	• Micro mobility design sprint was conducted in the spring 2021, including a survey, a field visit, qualitative interviews and a workshop with Espoonlahti residents to identify existing micro mobility needs and solutions, and to develop new solutions. As part of the design sprints, existing micro mobility solution providers were also mapped out and benchmarked.
	• Design Sprints: Last-mile micro mobility, mobility hub navigation and community vehicles [M19-M20]
	  ○ Design field trip with an eV
	  ○ Qualitative Interviews with 5 Espoonlahti residents on micro mobility
	  ○ Co-creation workshops with citizens on micro mobility, mobility hub navigation and community vehicle concepts to pilot ways for citizen engagement and encouragement of energy positive behavior and to validate solutions
	• Master thesis project with Aalto University on design sprints for designing mobility behavioral change to boost the use of bicycles [M17-M24]

7.2.1 Work done with regard to citizen engagement, user studies, concept development and workshops

a) Piloting ways for citizen engagement and user studies

In the Espoonlahti area, citizen engagement actions have progressed as planned. Sustainable solutions in Lippulaiva have been promoted for citizens in a variety of ways, such as disseminating news through different medias (local, national and

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industry media). Citycon also hosted a large online event called Lippulaiva Live in 15. April 2021 that attracted 1600 viewers[7]. The event discussed current issues related to construction and the relevant sustainable solutions for Lippulaiva neighbours and residents. In another online event hosted by Citycon to showcase a virtual Lippulaiva[8], 3500 viewers participated in the virtual room (Figure 31).

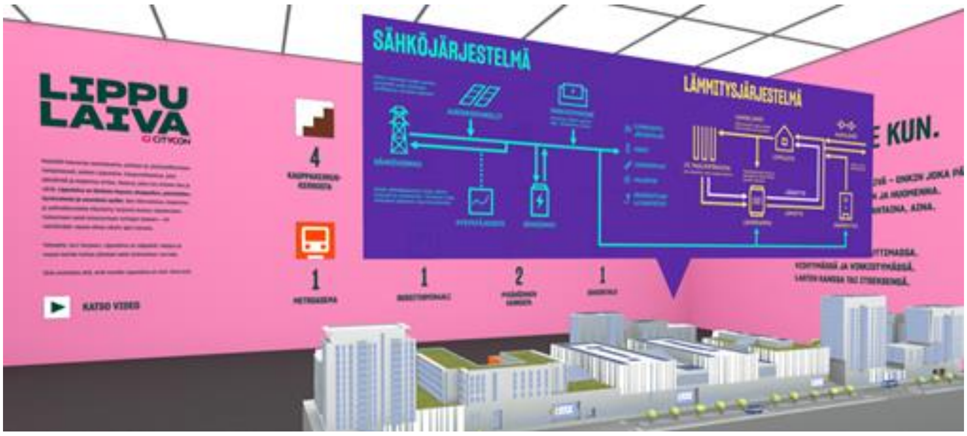

Figure 31: Lippulaiva virtual room promoting sustainable solutions in Lippulaiva

A large user study was conducted in Autumn 2020 by utilizing a self-documentation method called mobile probing. For eight weeks, ten citizens of Espoo with diverse manners of living documented their everyday habits and mobility through WhatsApp. The citizens were interviewed before and after the documentation period and they also attended a final workshop where different mobility solutions were ideated. Through qualitative research methods, KONE has gained a wide understanding of motivations and drivers of citizens' needs, challenges, and behaviors.

Based on the mobile probing study results, four different persona types were defined: 1) the electric traveler, 2) the conscious traveler, 3) the private driver and 4) the temporal driver which reflect upon the key sustainable mobility behavioral characteristics of Espoo citizens sustainable mobility behavior characteristics. A thematic analysis for the mobile probing data revealed several themes related to multimodal and hybrid mobility modes, sustainable mobility, behavior change and material logistics. The themes served as a starting point for defining design criteria and user experience goals for concept design.

b) An online user survey on micro mobility

To engage a wider public and to gain understanding of the current state of micro mobility solutions at Espoonlahti, KONE and Citycon organized an online survey to collect first-hand experiences from the residents. In total, 79 residents from Espoonlahti responded the survey. Through the survey, it was found that the current infrastructure for bicycling and walking in Espoolahti is excellent and that relatively many citizens already have an experience in electric bikes or smaller electric vehicles. The local improvement suggestions are related to the limited availability of shared city

[7] https://citycon.videosync.fi/lippulaivalive

[8] https://webar.arilyn.com/lippulaiva/

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bicycles and safer locking and parking solutions in public transport connection points, such as Lippulaiva area. Due to the rich nature and extensive seaside micro mobility routes, Espoonlahti provides urban city dwellers a place to enjoy recreational activities and nature resorts. There is a high interest to try out electric vehicles (cars, bikes, e-scooters), but lack of trust in shared mobility and a need for effortless registration and payment systems for multiple mobility modes and services. The survey was replicated in Leppävaara area with 41 respondents. In the Leppävaara area, the ongoing construction sites were impacting the use of micro mobility vehicles and compromising the routes. The survey respondents in Leppävaara were living in smaller households and were owning fewer cars compared to Espoonlahti respondents. Short distances in Leppävaara and easiness to use micro mobility devices were also increasing the use of bicycles and walking.

c) Concept development

To address the identified mobility themes, KONE co-developed 11 initial mobility design concepts based on citizens' needs and challenges in Espoo. The concepts were validated and further developed iteratively in co-creation workshops with citizens and SPARCS stakeholders. As a result, 8 concepts were developed reflecting user needs and wider mobility trends (Figure 32). The concepts are clustered under four major themes: micro mobility, shared mobility, navigation & travel chains', and autonomous mobility. Each concept contains a description of the solution, a problem statement, user value, two use cases and three benchmarks of existing solutions. More results from the concept development are described in T3.8 Smart Business Models.

Figure 32: KONE has designed 8 mobility concepts to meet the needs from Espoo citizens based on end-user studies and lead user innovations. The concepts have been further evaluated and prioritized in co-creation workshops, described in T3.8 Business model co-creation. (Source: KONE Oyj)

d) Design sprints and co-creation workshops

A co-creation workshop with mobile probe user study participants was held in December 2020 in which the participants evaluated and ideated on the 11 initial mobility concepts. During 2021, a series of co-creation workshops have been conducted to validate and develop mobility concepts with citizens through an iterative design process. In the workshops, citizens from SPARCS demonstrations areas, Espoonlahti and Leppävaara suburbs, have ideated and validated new mobility concepts. Due to COVID-restrictions, all citizen engagement workshops were organized online and utilized different engagement methods and interactive online tools for co-creation. In the project, KONE has also collaborated with Aalto university. Two student teams and two thesis workers have done user research and conducted workshops with citizens to ideate and evaluate new mobility concepts.

e) Micro mobility

KONE and Citycon organized a co-creation workshop on micro mobility with 7 Espoonlahti residents in April 2021. The participants co-created new ways to park and lock different micro mobility vehicles and solutions for moving goods in the Espoonlahti area. The results indicate improvements in shared micro mobility services: better coverage for city bike services, e-scooters and special bikes, e.g. cargo bikes, 2 and 4-wheelers and fat bikes; safer public parking places for micro mobility vehicles; service and charging stations for (e-)bikes and better infrastructure for micro mobility users. The workshop results were directly utilized in developing the Micro mobility parking and Shared cargo vehicle concepts.

A thesis project was conducted on this topic together with Aalto University to study how designing mobility behavioral change could boost sustainable mobility behavior in Espoo, especially to increase bicycling. The funding was covered with a separate KONE stipendium. The work done provides valuable knowledge to SPARCS. It included desktop research on behavioral change, development of Behavior Change Design Sprint method, co-creation workshops with citizens of Espoo, a design intervention and user tests with four citizens. The design concept developed for user testing in Espoo was 'Bicycle Bonus' to encourage citizens to bicycle to the grocery store by offering a bonus. The results show that a bonus was perceived as motivating factors to increase biking, however only half of the participants changed their behavior during the 2-4 week test period. Creating a long-term change thus requires a longer test period and various different motivational mechanisms to maintain the interest and help in establishing new behavioral patterns. These insights help to develop the design sprint methods utilized in SPARCS and to design user testing and solution monitoring at the later stages of the SPARCS project.

f) Shared mobility

A six-month project on shared electric vehicles and business model development was done in SPARCS in collaboration with Aalto University students. The project included field research at Leppävaara and around Sello and user interviews on shared mobility and private motoring. Two co-creation sessions were organised to ideate and evaluate eV shared mobility concepts and business model with Espoo citizens. The results are described in more detail in T3.8 Smart Business Models Action E9-1.

Similarly, a qualitative interview study on carsharing services was conducted at Espoonlahti area in collaboration with Aalto University Master thesis worker. However, this thesis work was covered by a separate KONE stipendium. The study was done to understand how carsharing services could succeed, how potential users' mobility habits affect service adoption and how carsharing is perceived in Espoo. Seven residents of the greater Espoonlahti area were interviewed and 5 opinion pieces from a local newspaper analyzed. A neighborhood residential shared mobility model was found to answer best to the residents' needs and the most common concerns at Espoonlahti. The results support mobility knowledge for SPARCS.

g) Autonomous mobility

KONE collaborated with a Aalto University to study last mile delivery services. This student group belonged to a product development course. The study lasted six months and focused on developing drone-based Drop Shop last mile deliversy services. During the project, an international user survey was conducted to obtain quantitative understanding of the practice, experience, attitudes and expectations of lead users on delivery services and related service providers. The respondents highlighted low pricing in delivery services, short delivery time and convenient pick-up points with an easy access. The research continued with development of a high-fidelity prototype and a user scenario. The solution is a last-mile delivery concept that includes drones and an automated pick-up container with a sorting robot for ultraquick last-mile deliveries in urban areas. Two co-creation workshops were conducted to evaluate the feasibility of the prototype and to collect feedback in Espoo. As Aalto University is a collaboration partner of South Korea, the second co-creation workshop was conducted online with South Korean students (10 students altogether). The workshop helped to gain an international perspective for SPARCS. Use of drones and robot technologies were found as positive due to fast delivery times and possibility for more convenient 24/7 pick-up points. From an end-user point of view, the reliability of drone technologies and higher costs remain as a challenge. Where the autonomous mobility services are perceived as highly interesting yet futuristic solutions, the micro mobility and community vehicles were seen as solutions to meet the current mobility needs. These insights helped to validate the mobility concepts developed in SPARCS and narrow down the focus for the piloting phase.

h) Navigation & travel chains

Together with the Espoo partners, a study of electrification of vehicles and its implications to citizens in larger mobility hubs and dense urban environments, this connects directly to T3.4, T3.6 and T3.8. In May 2021, KONE co-developed an online e-mobility hub design board and co-organized two workshops together with the City of Espoo, Citycon, Plugit and VTT on e-mobility hubs.

The eHub workshop contained an online co-design board with diverse citizen profiles and visual templates to map out and diverse stakeholders' travel chains and to identify needs for future electric mobility hubs.

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In the first workshop with SPARCS partner organizations, the participants created travel chains for diverse end-user profiles reflecting different characteristics of citizens in Espoo. User profiles were created for various kind of end-users: passengers, commuters, professional drivers, service technicians etc. The second workshop was targeted to the end-users of electric vehicles in large mobility hubs, such as Sello and Lippulaiva. Eight participants were recruited, which all had first-hand experience of owning or driving eVs: e-cars, e-taxi, e-bicycles, e-cargo bike and public transport.

Through the workshops, diverse travel chains have been visualized from an end-user perspective to meet the needs of different eV users and the future needs of e-mobility hubs. As a result, the most important factors of future e-mobility hubs have been identified and prioritized in a bull eye activity based on mobility modes, ecosystem services, infrastructure and other needs. The eV end-user needs and insights have been utilized in mobility concept development and are used as a further development of e-mobility hubs in Espoonlahti, Leppävaara and KERA. The results from the workshops were also utilized in two concepts: door-to-door travel chains and smooth mobility hub navigation. The concepts aim to provide a smooth travel journey for diverse users of multimodal mobility modes throughout their travel chains. The e-mobility hub results are presented also in T3.4 and T3.8.

i) A field trip with eV

As part of studying lead user innovations and electric vehicles, KONE conducted a design field trip to acquire first-hand knowledge on the use of electric vehicles, eV charging and peer-to-peer vehicles in Espoo (Figure 33). A test drive day with a peer-to-peer shared electric car was arranged to visit Sello at Leppävaara and Pikkulaiva/Lippulaiva at Espoonlahti. Currently, using a peer-to-peer car sharing service provides an access to a small pool of electric cars in Espoo and requires registration and verification by the service provider. Because of the small number of eVs, the pick-up and return of the vehicle causes extra kilometers as well as takes time. The key insights from the test day were that the user experience of driving an electric car is smooth, quiet, and comfortable compared to a gasoline car, nevertheless the charging infrastructure at Espoo is fragmented and used in an inefficient way. Despite the charging stations are usually located in central locations, e.g. in front of a grocery store or in a parking hall (e.g. Sello), regular sized parking spaces and busy traffic is not optimal for the charging. Using different type of chargers also require registration to specific services and the use of different payment methods (an app, a chip, a credit card), which requires digital and technical skills from the end-user. These insights were further utilized in designing e-mobility hub workshops and recruitment of participants.

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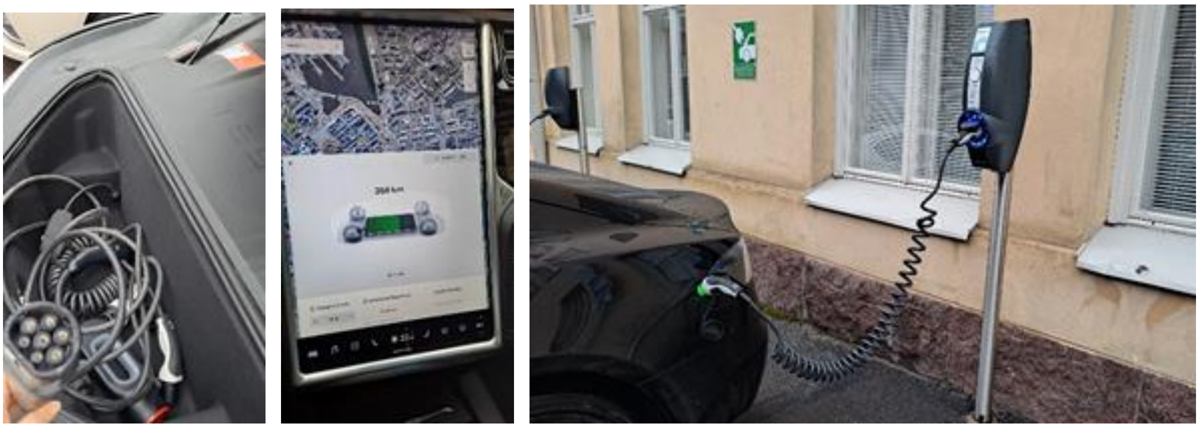

Figure 33: Charging cables and the control panel, while charging an eV at a public charging station during the eV field trip (Source: KONE Oyj).

j) KERA development

Knowledge sharing with KERA team on citizen engagement and mobility insights has progressed through mutual meetings. KONE has presented results from expert interviews summarizing the current mobility drivers, the mobile probing study and the initial mobility concept ideas applicable also at KERA area. The discussions and recommendations for KERA specific citizen engagement and mobility related actions have provided bidirectional insights serving the development of KERA and sharing the best practices from Espoonlahti and Leppävaara. It has emphasized the importance of citizen engagement and introduction of diverse mobility solutions in an early-stage development of a new residential area and throughout the district life cycle.

k) Impact assessment

KONE has started a collaboration with D-mat oy during the Spring 2021 to conduct CO_2e footprint calculations and evaluate the developed mobility concepts from energy and sustainability perspectives. The company was chosen based on the value and quality of the proposal, their expertise in CO_2 footprint calculations and citizen lifestyle studies, as well as their offering of a collaborative 1.5-degree lifestyle workshop targeted for citizens. The CO_2 impact assessment is reported in the autumn 2021 and will be used as an input for two 1.5 degree workshops with Espoo citizens and for mobility concept validation. The footprint calculation data will help to prioritize the mobility concepts, estimate their sustainability impact in Espoo and, through the 1.5-degree workshop, to validate the attractiveness of new mobility solutions among citizens.

7.3 Co-creation for energy positive behaviour

This subtask 3.6.2 Co-creation for energy positive behaviour aims to engage local citizens of Espoo into co-creation for energy positive behaviour. As part of the subtask, user interviews have been conducted to identify solutions for engaging and encouraging energy positive behaviours, design sprints and co-creation workshops have been arranged with diverse user groups and stakeholders, and the local communities have been engaged into planning and building a future energy positive community through a Buddy class initiative. These actions take place in Espoonlahti, Lippulaiva and Leppävaara, Sello, providing user insight input for experimentation and

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piloting in Leppävaara andEspoonlahti districts, and for actions in Lippulaiva and Kera. Most of the user engagement activities are reported under subtask T3.6.1 People flow and daily journey and actions E4-1 and E9-1 are reported under T3.8 Smart Business Models.

Action E3-3	**Co-creation of shopping centre in collaboration with young consumers. Co-creation of the design of Lippulaiva with the aim to improve convenience and usability for young people. Focus on catering to the needs of young people for customer experience and their needs to enable and improve their use of environmentally friendly modes of transportation.**
Detailed plan	• Arranging Lippulaiva Buddy Class action where a school class is engaged to Lippulaiva project. One 7th grade class (starting in Aug 2020) is choosed as a Buddy class and co-operation will continue until they are 9th graders. • Buddy class action includes meetings with students with informative lessons supporting curriculum. Topics include: planning shopping center together with youngsters, physics with sustainable energy solution, sustainable mobility, social studies with making arrangement rules for shopping center, study guidance with topic of "working in shopping center".
Targeted outcome	To engage youngsters in development of their own neighborhood with long-term time-scale. Simultaneously educate youngsters in sustainability especially in energy systems and mobility.
Roles and responsibilities	CITYCON is responsible with arranging Lippulaiva Buddy Class action and gets help from other partners in SPARCs (ESP, KONE, VTT) ESPOO supports connections between young citizens (local schools) and the project. VTT provides support in developing a youth engagement research plan in Lippulaiva, implementing the plan and analyzing the feedback collected
Schedule	Lippulaiva Buddy Class action planning started in 03/2020 (M6), choosing Buddy class 08/2020 (M11), meetings with Buddy Class 09/2020-09/2022 (M12-M36), reporting in project month M36.
New deviations into plan (as compared to D3.1)	• Beside Lippulaiva buddy class hosted by Citycon, Espoo city is hosting another Buddy class from Maininki school, Espoonlahti area. • Co-creation workshops with youngsters in Espoonlahti area: workshops have delayed due to corona-situation and will be starting in autumn 2021 if possible. Instead of postponed workshops, youngsters have been involved with dedicated Instagram account and a questionary as well as participating in Discovering youth work.
Progress until M24	Action E3-3 has progressed as planned. • Planning of Lippulaiva Buddy class action started in 04/2020, the meetings with Lippulaiva Buddy class were held in 09/2020, 12/2020, 04/2021 and 05/2021. • Buddy class meetings with Maininki school started in 08/2020 and continued in 05/2021,

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	• Co-creation of Lippulaiva together with youngsters have started with planning different actions. Due to the covid-pandemia, face to face workshops must have been postponed and they are planned to be held in autumn 2021. Instead of face to face workshops, youngsters have been activated troughs social media (Instagram-account established), questionary and as participating in Discovering youth work with Espoo city youth workers. See Figure 34 and Figure 35

a) Buddy class activities

Buddy class activities have been conducted according to the plans and involve two different school classes in Espoo. Buddy class meetings include different kinds of activities (Figure 34 and Figure 35).

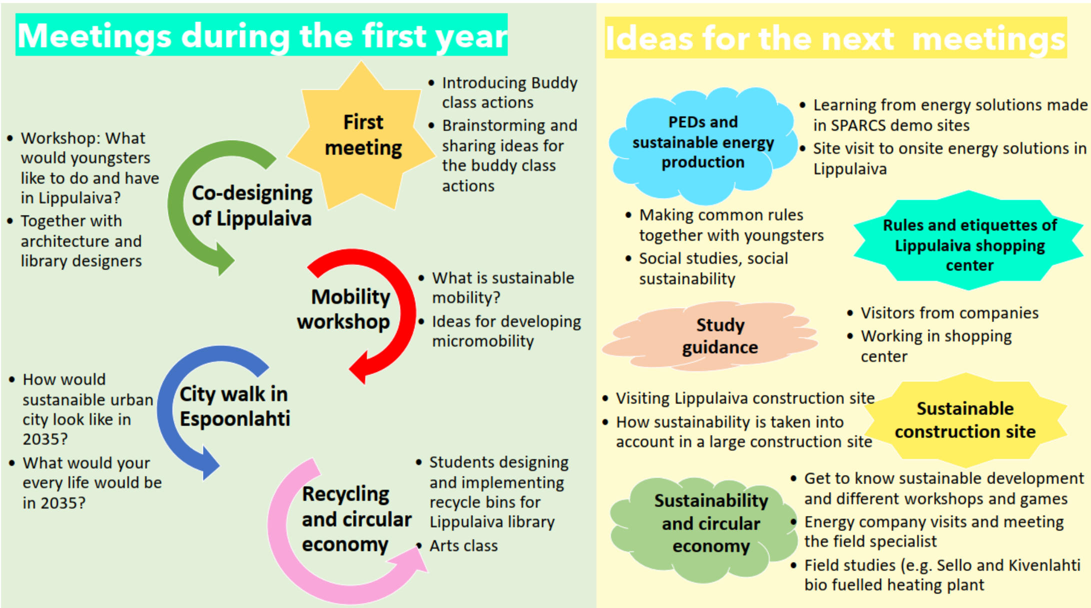

Figure 34: Buddy class plans (Source: Citycon)

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Figure 35: Planning of Buddyclass actions and pictures of meetings with Lippulaiva buddy class in 2020 – 2021 (Source: Citycon)

b) Co-creation activities

See previous subtask 3.6.1. for more detailed results.

7.4 Sustainable lifestyle

While positive energy infrastructure and modern technology can contribute significantly to the overall sustainability of urban districts, citizens need to be informed about the impact of their choices as consumers. Sustainability may be included in curricula of schools and kindergartens, as children are more susceptible and can also educate their parents. The enhanced technical options for measurement, monitoring and analysis in SPARCS demo sites provides valuable data that can be utilised in communicating the benefits of sustainable lifestyles. This subtask 3.6.3 is an ongoing activity with continuous interaction with more implementation-oriented actions. It includes close collaboration with a local school and introduction of a buddy class. Here, all three pillars of sustainable development (ecological, economic, social) are taken into account.

Action E19-2	**Sustainable lifestyle. Espoo wants to be a responsible pioneer. The city is building a sustainable future through mobility, construction and energy solutions, by offering teaching and education supporting a sustainable lifestyle, by providing culture, sports and social and health care services enhancing wellbeing and by maintaining comfortable nature and green areas nearby. SPARCS actors integrate this support in their daily work including support for low-emission solutions, guidance and energy advisor services.**

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Detailed plan	• Sustainable lifestyle options are communicated through-out the project, in conjunction with the city's Sustainable Espoo programme and other projects. The city communicates the various possibilities for sustainable lifestyles that the activities in the project develop and improve on different facets of life, through its both internal and external communication channels and platforms. • Buddy class concept introduced to introduce and develop sustainable lifestyle in city of Espoo.
Targeted outcome	To make Espoo citizens more aware of their potential towards more sustainable lifestyle. Engage citizens into active dialogue on sustainable lifestyles.
Roles and responsibilities	ESP: Main responsibility. Engaging different stakeholders into the process.
Schedule	M12: plan for action finalized, buddy class activities begin M27: communications campaign towards selected target groups to build awareness of sustainable lifestyle M36: reporting of the activities in buddy class concept, cross-pollinating of two buddy classes (see Action E 3-3)
New deviations into plan (as compared to D3.1)	Schedule slightly updated.
Progress until M24	- First kick-off with the Buddy class in autumn 2020 - Clearing the plans towards long-term activities with the Buddy class - First semester in the spring 2021 included two action points (meetings face-to-face) with the Buddy class - Activities continue in the autumn 2021 and will go on until the end of the junior high school - The plans to build the awareness of sustainable lifestyle in different target groups (citizen segments) have been made clearer and the preparations to take the ideas in to practice have began - Espoo Day event in 2020: Facebook-live broadcast from Kera area, presentation of SPARCS and other running sustainable development projects of ESP. - Espoo Day event in August 2021 (cancelled due the Covid-19 situation) - Webinar series on sustainable lifestyles in the making and a survey for citizens about which themes are best for the webinar topics.

The Buddy Class activities have begun nicely and according to plan. It is fruitful to see that the topics of sustainability are taken seriously by the youngsters. First kick-off with the buddy class was in fall 2020 to meet the students for the first time and then start more detailed planning. The City of Espoo together with Citycon was leading the effort to gain permission from the city authorities to work with the youngsters in a research setting. The ethical issues of the Buddy Class activities, together with GDPR related

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issues about the registries and data produced during the activities were carefully examined during the permission application process in collaboration with WP10.

In spring 2021 the buddy class activities have begun with two action points. City of Espoo has had two meetings with their Buddy class in June 2021. The first activity consisted of an urban orientation walk (designed together with CIT) where the students reflected the current urban environment with their desires for more sustainable and livable environments in the future. The second Buddy Class activity was about sustainable mobility: a workshop (designed together with CIT and KONE) was held (face-to-face) for the students, in which they reflected different mobility modes from their own experience, including mobility hubs and their visions about future mobility in 2050.

Buddy Class activities will continue in fall 2021. The plan is to meet the buddy class students two times per semester, which will be four times in the entire academic year (Figure 36).

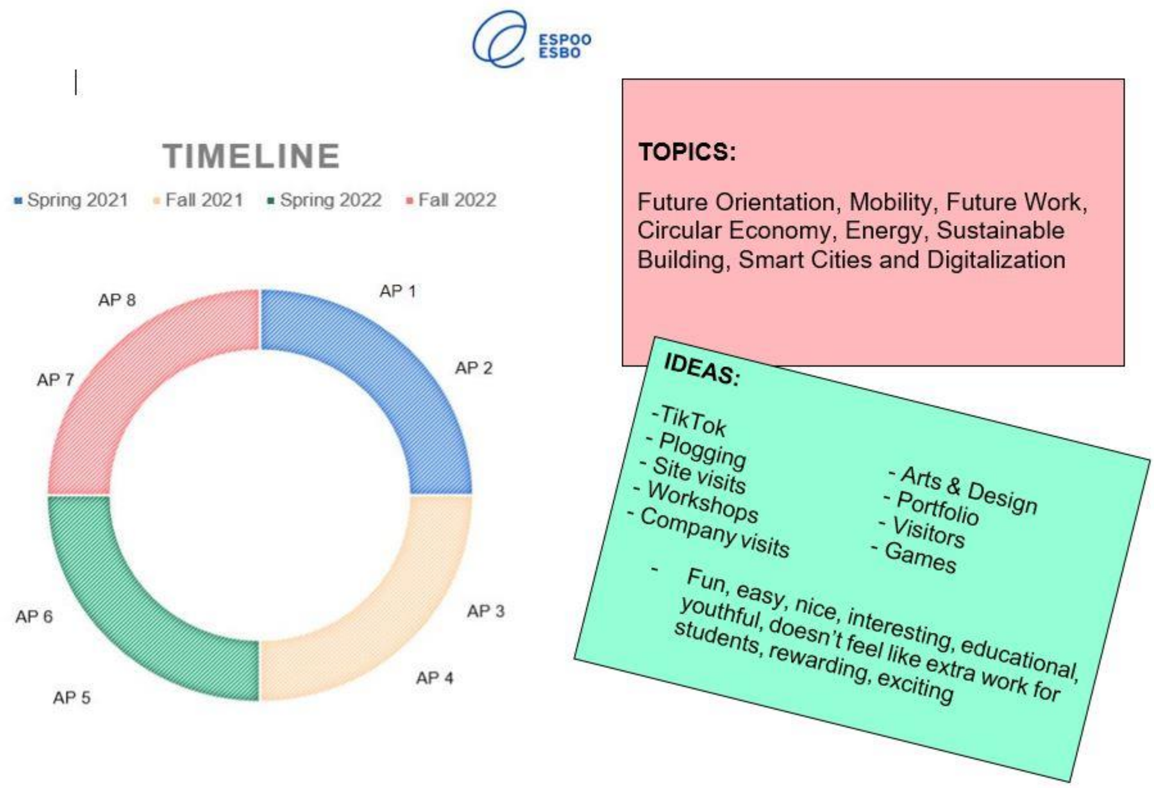

Figure 36: Planning Buddy class activities. Some of the ideas are collected from the students in the first meetings (Source: Citycon).

A small-scale e-bicycling/micromobility event was expected to be organized in the Kera area as part of Espoo Day 2021 in August (M23). The idea of the event was to provide possibilities for users to test different e-bikes and e-scooters, to provide information and get familiar with solar panels and energy communities – and to promote SPARCS themes in general. Four local e-bicycle/micromobility companies were signed on to co-operate with in the event. However, the Covid-19 situation that worsened in Finland during the summer 2021 did not allow the organization of public events in the end and the event was cancelled in mid-August.

As an alternative solution, it was decided that a light survey will be done to know interesting webinar topics for citizens. The Espoo day survey will be carried out as a wide campaign by City of Espoo in their social media channels and website. Different social media channels provide us to reach bigger crowd and hopefully collect more answers. The aim is to collect as much answers as possible to understand the most popular topics of the sustainable lifestyle and provide high quality webinar series during spring 2022. The planning of the webinar series begins in the fall of 2021 in the SPARCS team.

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8. Air Quality in Espoo

The objective of task 3.7 is to ensure the availability of clean air.

Action E21-1	**Effects on air quality. Follow up of air quality development in the Espoo Lighthouse demonstration districts during the project duration.**
Detailed plan	Obtaining the data for air quality from available public resources such as HSY. Comparing air quality throughout the project. Highlighting possible impacts related to SPARCS development.
Targeted outcome	Overview report of the development of local air quality (demonstration areas)
Roles and responsibilities	VTT - air quality data tracking and possible interpretation related to Sparcs HSY - air quality data provision
Schedule	M1-M60 Continuous measurements throughout the project M 6 Baseline data from year 2019 received from HSY M 23 The optimal measuring equipment chosen M 29 Starting the measurements at Lippulaiva site M 60 Reporting of the air quality in Espoo
New deviations into plan (as compared to D3.1)	HSY has constant measuring of air quality in Leppävaara and in Matinkylä. The measurements closer to Lippulaiva are prepared and planned to start in the beginning of 2022. Until that the air quality data is gathered from the measuring point in Matinkylä, about 7km from Lippulaiva, but very similarly placed in relation to the big highway passing both shopping centers and hence giving fairly good idea of the air quality also around Lippulaiva.
Progress until M24	The baseline for air quality in Leppävaara has been received from HSY and the planning of the measuring equipment to be placed in Lippulaiva area has been started.

The air quality data from HSY gives data for each hour. In Figure 37 measurement data is shown for one week in August. This data can be used for comparison of the data received through the SPARCS project.

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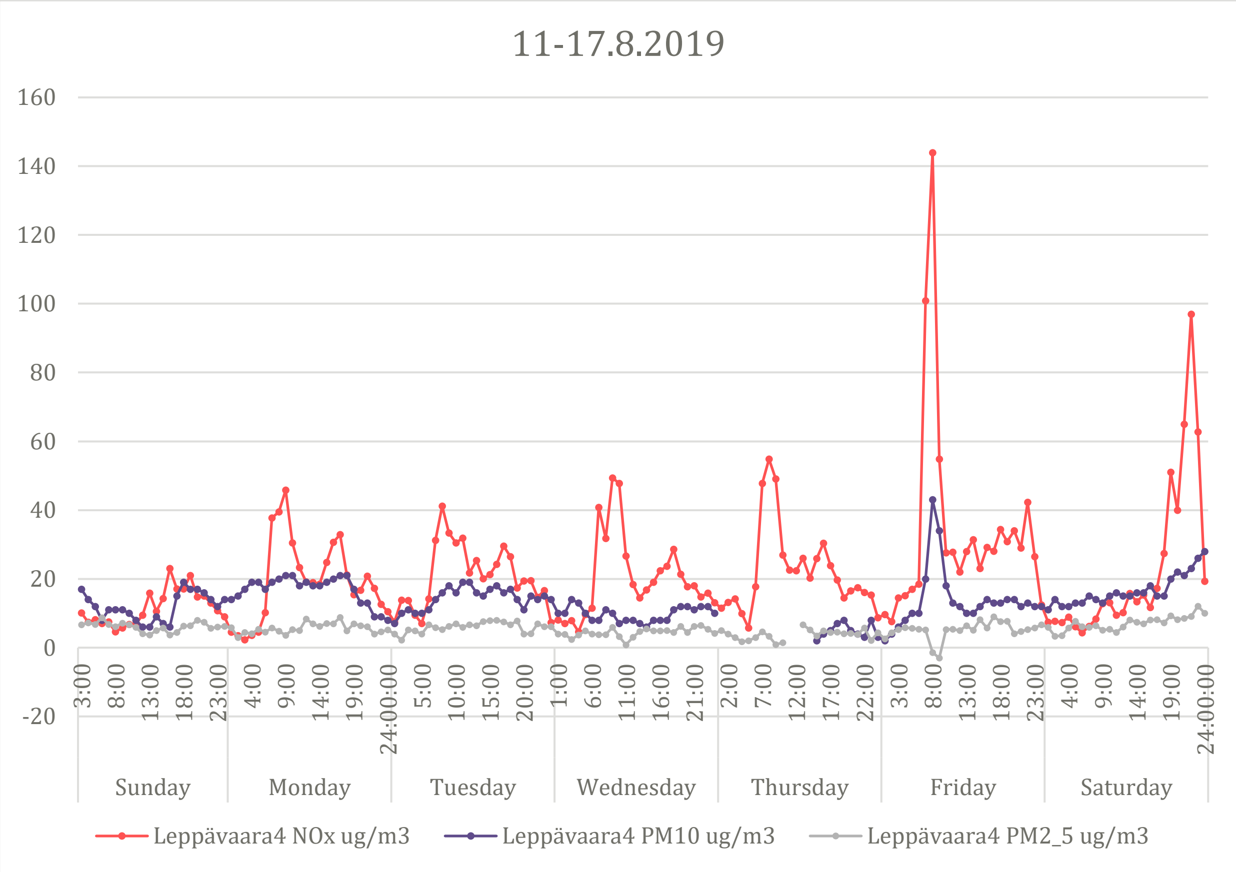

Figure 37 Sample of the baseline data for Sello gathered from Leppävaara by HSY. Data for one week in August 2019, including NO_x, PM10 and PM2,5

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9. SMART BUSINESS MODELS IN ESPOO

9.1 Introduction to task 3.8

The objective of task 3.8 is to identify the city's and other stakeholders' business model concepts supporting the energy transition in cities toward carbon neutral energy supply with the optimal and most cost-efficient ways for arranging the collaboration. The task includes three subtasks connected to five different actions where the objective is to approach smart business models from several perspectives and different scales. In the context of smart cities and energy positive districts, business models are multi layered concepts where various stakeholders are connected forming a larger ecosystem. Through different methods, such as design thinking and business model innovation, the task covers actions where the aim is to recognize and identify the elements of business models that provide new ways of creating value, both economic and social, for Espoo and other stakeholders, including citizens.

In addition, this task focuses heavily on identifying relevant collaboration partners in the possible ecosystem and supports dissemination of SPARCs aiming to generate and foster new future businesses and business models. The task is thematically closely connected to the Work Package 7 (Exploitation and Business Ecosystems) and hence, partners involved are collaborating and aiming to wide knowledge exchange for example by contributing to the project deliverables.

9.2 Engaging (lead) users and co-creating (energy positive) business models

This subtask 3.8.1 Engaging (lead) users and co-creating (energy positive) business models aims to pilot ways to co-create business models together with different stakeholders. (Lead) users involved in the co-creation are both experts and company or organisation representatives as well citizens. In this subtask, KONE focuses especially on mobility, including both people and material mobility. Design thinking and different co-creation methods are utilized to create a dialogue between several stakeholders. The subtask is strongly connected to KONE's actions in T3.6 Community Engagement and it is built on top of findings gained from the engagement activities with citizens. Due to the Covid-19 pandemic, all activities have been arranged remotely. The subtask consists of two actions that are similar but targeted for two different demonstration sites, Lippulaiva and Sello. At this point, most of the activities and co-creation of business models have been combined into common activities, covering both demonstration areas. SPARCS Interventions E4: Smart Business models include actions as follows.

Actions E4-1 and E9-1 have progressed according to the plan and co-creation activities have examined business models from different perspectives while simultaneously engaged several different actors.

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Action E4-1	Engaging (lead) users and co-creating (energy positive) business models in Lippulaiva.
Detailed plan	• Researching and piloting ways to engage users (citizens and companies / other organisations) in business model co-creation • Organising co-creation workshops (e.g. Design sprints) around relevant topics found from user research • Expert interviews to support ecosystem mapping and business model co-creation
Targeted outcome	By engaging users (both citizens and company / other organisation representatives) in co-creation of business models in an early phase, we aim to research and develop business models that create real value for all stakeholders and to pilot ways to co-create business models
Roles and responsibilities	KONE is responsible for planning the methods how to engage users and organising the co-creation sessions and conducting expert interviews.
Schedule	Expert interviews conducted 3-6/2020 (M6-M8), interview analysing 6-9/2020 (M9-M12), co-creation planning and workshops 8-12/2020 (M11-M15) and 2021 (before M27). Co-innovation process to engage diverse stakeholders in co-creation of business models (M21-M27). Developing and piloting new solutions and business models (M25-M40). Iteration of the developed solutions (M30-M40). Engaging stakeholders to evaluate the developed business models (M20-M36).
New deviations into plan (as compared to D3.1)	
Progress until M24	To support the piloting of new energy positive solutions in mobility, KONE has started a co-innovation process to identify and pilot new innovations to meet the citizen needs found from the user research. In the process, KONE launched an open challenge in M24 for other companies to apply and co-create solutions further. Co-innovation process is conducted in collaboration with an external partner, Gaia Consulting Oy, that has been selected based on the different criteria, e.g. previous experiences and expertise related to sustainability and mobility. • Business model co-creation workshops about mobility concepts • Planning of co-creation activities and identifying the target groups • SPARCS Espoo lighthouse consortium workshop • Business design criteria workshop • A series of three workshops (target groups in the workshops: 1) KONE's cross disciplinary teams, 2) leading mobility companies and other external stakeholders, 3) citizens of Espoo) on business models by utilizing business design methods (collaboration with an external subcontractor). Research and concept of electric shared mobility and business models (collaboration with Aalto University master programme of International Design Business Management) Initiating a co-innovation process to co-create and pilot mobility solutions

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	• Planning the co-innovation process and tendering of a partner to support facilitation of the process • Identifying the themes for the challenge • Initiating collaboration with WP7 to align the co-innovation process with the T7.4. start up competition Qualitative expert interviews about the future of energy market • Identifying the relevant interviewees and creating the interview structure • Conducting 7 expert interviews • Analysing and summarizing the interview data Engaging feedback session on developed co-creation tool in SPARCS Business models and Financing Mechanisms webinar

Action E9-1	**Engaging lead users and co-creating energy positive business models in Sello**
Detailed plan	• Researching and piloting ways to engage users (citizens and companies / other organisations) in business model co-creation • Organising co-creation workshops (eg. Design sprints) around relevant topics found from user research realized in task 3.6. • Expert interviews to support ecosystem mapping and business model co-creation
Targeted outcome	By engaging users (both citizens and company / other organisation representatives) in co-creation of business models in an early phase, we aim to research and develop business models that create real value for all stakeholders and to pilot ways to co-create business models
Roles and responsibilities	KONE is responsible for planning the methods how to engage users and organising the co-creation sessions and conducting expert interviews.
Schedule	Expert interviews conducted 3-6/2020, interview analysing 6-9/2020, co-creation planning and workshops 8-12/2020 and 2021. Co-innovation process to engage diverse stakeholders in co-creation of business models (M21-M27). Developing and piloting new solutions and business models (M25-M36). Iteration of the developed solutions (M36-M40). Engaging stakeholders to evaluate the developed business models (M20-M60).
New deviations into plan (as compared to D3.1)	
Progress until M24	To support the piloting of new energy positive solutions in mobility, KONE will conduct a co-innovation process to identify and pilot new innovations to meet the citizen needs found from the user research. In the process, KONE will launch an open challenge for other companies to apply and co-create solutions further. Co-innovation process will be conducted in collaboration with an external partner that has been selected based on the different

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	criteria, e.g. previous experiences and expertise related to sustainability and mobility. Business model co-creation workshops about mobility concepts • Planning of co-creation activities and identifying the target groups • SPARCS Espoo lighthouse consortium workshop • Business design criteria workshop • A series of three workshops (target groups in the workshops: KONE's cross disciplinary teams, leading mobility companies and other external stakeholders, citizens of Espoo) on business models by utilizing business design methods (collaboration with an external subcontractor) Research and concept of electric shared mobility and business models (collaboration with Aalto University master programme of International Design Business Management) Initiating a co-innovation process to co-create and pilot mobility solutions • Planning the co-innovation process and tendering of a partner to support facilitation of the process • Initiating collaboration with WP7 to align the co-innovation process with the T7.4. start up competition Qualitative expert interviews about the future of energy market • Identifying the relevant interviewees and creating the interview structure • Conducting 7 expert interviews • Analysing and summarizing the interview data Engaging feedback session on developed co-creation tool in SPARCS Business models and Financing Mechanisms webinar

9.2.1 Business model co-creation workshops about mobility concepts

KONE has hosted a series of workshops with different target groups for co-creation of business models around the mobility concepts created based on the user study insights. The concept development work is reported as part of the T3.6. The aim of the business model workshops has been to identify relevant stakeholders and ecosystems as well as the value of the concepts for different actors involved. All activities were organized as online workshops and utilized different engagement methods and interactive online tools for co-creation. After planning the activities, a consortium workshop (M16) with Espoo Lighthouse partners was organized for addressing the initial co-designed mobility concepts from a service provider perspective. During the workshop, the participants were asked to provide their thoughts and ideas to the mobility concepts by focusing on four questions:

1. What kind of knowhow and actors are needed and what could be their role and the business models?
2. What kind of risks and worries there are?

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3. How social and ecological sustainability should be taken into account?
4. What kind of role your organisation could have in an ecosystem around in this solution? What kind of touch points there are to your current (or future) business?

The workshop had two objectives. Firstly, the aim was to present the results from the mobile probing user study and the identified challenges and opportunities as well as ideated initial mobility concepts. In addition, the workshop aimed to open up the discussion with the consortium partners about what kind of an ecosystem and knowhow would be needed in order produce the solutions (in Espoo) and what kind of roles and actors are needed for sustainable future mobility (Figure 38).

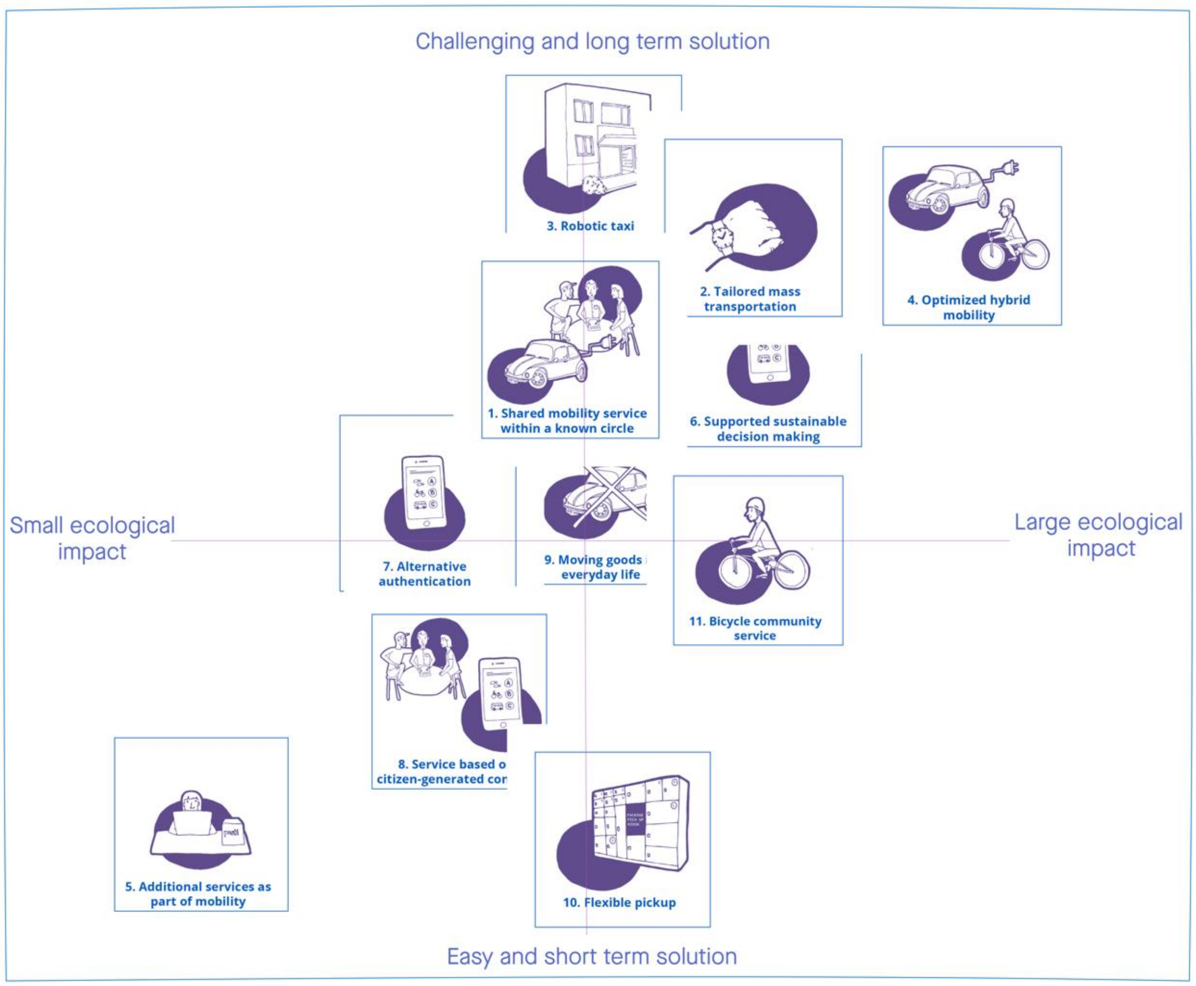

Figure 38: Exercise result about the co-ideated mobility concepts placed in the matrix highlighting the timeframe of the solution and the ecological impact. (Source: KONE Oyj)

In the second workshop (M17), business design criteria were defined to guide the decision-making and evaluation of the mobility concepts from the business perspective. As a result, five criteria were defined: 1) Sustainability, 2) Scalability, 3) Customer value, 4) Differentiation, and 5) Inclusiveness.

In collaboration with a business design agency Embassy of Design, three co-creation workshops (M19-M21) were organized for different target groups. Embassy of Design was chosen as a partner based on business design expertise and previous references

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within the field of mobility. The aim of the workshops was to create a process where eight mobility concepts were evaluated and developed further by ending up with 2-3 more detailed and concrete concepts with business model suggestions. In the first workshop, participants were KONE's representatives from the fields of business and design. The second workshop gathered 15 experts together. The participants represented central mobility players, including companies that operate on shared mobility, micro mobility, sustainability, real-estate, navigation and more as well as public actors. In the workshop, the participants identified success factors and obstacles for mobility concepts through interactive exercises and discussion. To complement the service providers' viewpoint, the third workshop was organized with Espoo citizens. As a result from all of the workshops, the following concepts were developed further.

a) Community vehicles

The shared community vehicles is a service platform that allows a community of people living or working in the same building to access and use a mixed fleet of vehicles for different types of mobility needs. The community vehicles mobility concept answers to the existing and recognized mobility opportunities and needs. Once a community vehicles concept is deeply-integrated within a building, all parking, charging and seamless mobility related issues can be tackled.

Based on the user studies, trustworthiness in shared mobility services is one of the main issues to be tackled. In the concept targeted for communities, the reliability for safety and convenience can be guaranteed partially with a closed circle of users. Other strengths of the concept include access to mixed fleet of mobility solutions for various mobility needs and safety, security and convenience for the user. The solution for the community vehicles mobility concept should take into account both the building centric, "private sharing", and the free-floating "public sharing" in order to become economically viable.

As part of the concept development, a group of Aalto University students took part in the project through a six months' course project. The project was part of Aalto University's IDBM Industry Project, where the client, KONE, set a task for three Aalto University master's students to research and design for more sustainable shared electric transportation solutions. The brief for the project was to design and understand: *What could be all the shared electric mobility solutions that support citizens' sustainable behavior?* The research question was explored through secondary (literature review) and primary (field trip, expert interviews, survey) research, as well as user research and co-design activities. To be able to design the final concept and understand the problem, the team conducted secondary research in the form of literature review regarding sustainability in mobility, electric vehicles, and the sharing economy and shared vehicles. Also, the team conducted primary research in the form of a field trip and multiple expert interviews with experts from both academia and different industries.

b) Mobility Hub Navigation

The mobility hub navigation concept is targeted to solve end-user navigation challenges in existing navigation solutions. The concept includes several different user interfaces and methods to guide people and vehicle flows in smooth ways. It combines

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an application suggesting optimized routes and a ticketing system based on the user needs and preferences. The solution combines seamlessly both indoor and outdoor navigation, including factors such as weather and CO2e emissions. The service platform supports the user to make sustainable decisions. During the mobility workshops, the need for the mobility hub navigation concept was clearly validated. During the citizen workshop, the participants clearly validated the challenges in the existing navigation landscape, found the benefits of the proposed solution, and indicated the willingness to pay for such a solution. The mobility hub navigation concept has a strong UX case, but to be realized, the concept needs various ecosystem partners, including e.g. public transportation operators, building owners, developers, operators. The partner co-operation side was flagged as a bottleneck in the mobility expert workshop.

9.2.2 Four lenses of innovation as a guiding co-creation tool – results from an engaging feedback session in SPARCS Business models and Financing Mechanisms webinar

As part of the SPARCS webinar held on April 22nd 2021, Business models and Financing Mechanisms, KONE held an interactive session about initial co-creation tool setting guiding questions for development of new services and business models. In addition, the session presented KONE’s holistic approach for business modeling through design thinking and co-creation methods. Guiding question for the session was “How can we design business models that are desirable, viable, feasible and sustainable for people, planet and businesses?” Methodological framework initially named as “Four lenses of innovation” stems from design thinking and IDEO’s framework for human-centered design suggesting that innovations can be born if user needs (desirability), business (viability), and technology (feasibility) are combined. To complement the framework, sustainability is suggested to be added as an overarching theme as it also includes different dimensions that cover ecological, social and economic sustainability. In the interactive session of the webinar, 10 participants around Europe, were engaged through Mentimeter online tool to give feedback about the framework and pose questions about what would the most important questions to ask and criteria to achieve under the four lenses of innovation (sustainability, desirability, feasibility, viability). See Figure 39 and Figure 40.

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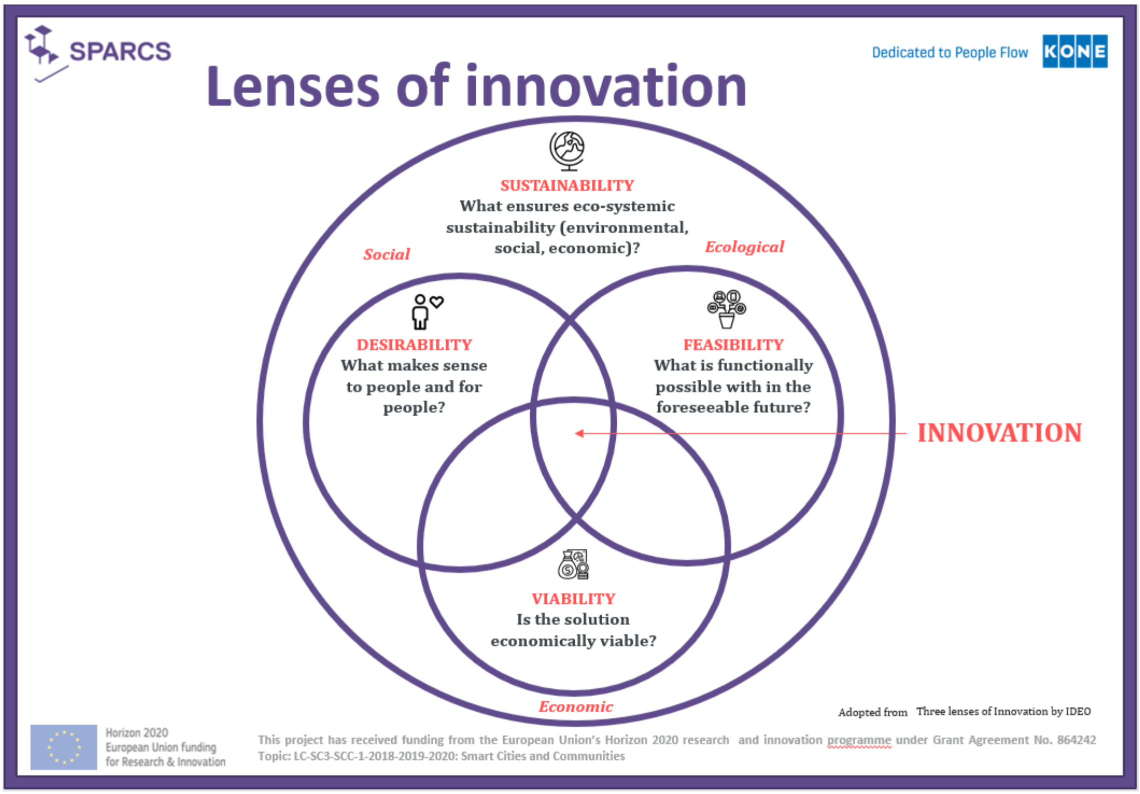

Figure 39: A framework of lenses of innovation combing both desirability, viability, feasibility and sustainability. (Source: KONE Oyj, adopted from Three lenses of Innovation by IDEO)

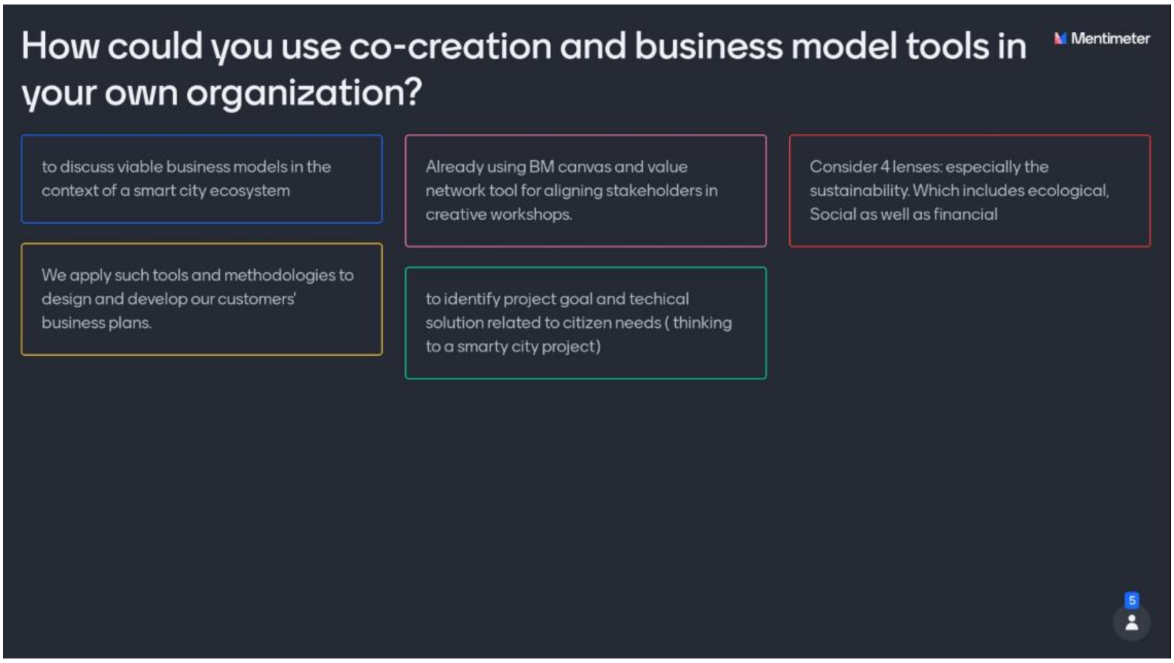

Figure 40: Webinar participants answers about the utilization of business model co-creation tools in their own organization. (Source: KONE Oyj, Mentimeter)

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9.2.3 Co-innovation process to co-create and pilot mobility solutions

KONE has initiated a co-innovation process to support piloting of mobility solutions. In the co-innovation process, KONE together with its partner, will launch an open challenge for other companies inviting them to suggest their solution ideas and co-create them further in the process. KONE has chosen Gaia Consulting Oy as a partner to support the facilitation of the process. The company was chosen from two candidates based on the value and quality of the proposal, expertise in sustainability and mobility as well as previous references from similar challenge processes. By M24 themes for the challenge have been identified as followed: shared mobility, micro mobility, and multimodal navigation. In addition, KONE has started tighter collaboration with lighthouse city Leipzig and WP7 partners, Fraunhofer, Gopa Com and Civiesco, to align the process with T7.4. start-up competition. Partners have agreed to share learnings and knowledge about the processes and KONE will contribute to project deliverables.

9.2.4 Qualitative expert interviews about the future of energy sector

KONE conducted a short study about the future of energy field by interviewing seven experts representing both business and research. The aim of the study was to gain an understanding of the development and the future of energy sector from the experts' perspective and identify challenges and opportunities of global energy transition and new emerging services and business models. All seven interviewees represented Finnish companies (e.g. energy company / producer, electricity distributor) or research institutions and one-hour interviews were conducted online.

Due to rapid increase of electricity demands and regulations for cleaner energy, all operators in the energy sector are phasing new challenges but the ongoing energy transition sets also possibilities for new services and business models. According to the interviewees, the market for news solutions is still immature as each actor is trying to find their own position in the value chain and ecosystems. In the future, renewable energy sources will make energy supply more unpredictable most likely leading to stronger price fluctuation. From a consumer's point of view, the amount of energy may not be the challenge but rather the timing when it is used. One of the major challenges is energy storing. Smart solutions, ICT and data together with business models enable the efficient utilization and balance the flexibility between supply and demand.

9.3 Smart Otaniemi

Smart Otaniemi connects experts, organisations, technologies and pilot projects. It brings the building blocks of a smart future together and works on world changing ideas for smart city solutions that are both sustainable and commercially successful[9].

This subtask 3.8.2 Smart Otaniemi focuses on collaboration between SPARCS and Smart Otaniemi innovation ecosystem. Networking activities aim for knowledge exchange and leveraging further testing of innovative smart city solutions beyond SPARCS activities. As an example, Smart Otaniemi ecosystem has arranged several

[9] https://smartotaniemi.fi/

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events: open clinic, virtual event, workshops and seminars. Smart Otaniemi showroom presents showcases for both international and national visitors (currently showroom is replaced by virtual events due to COVID19).

Action E23-1	Smart Otaniemi pilot platform. Smart Otaniemi innovation ecosystem as facilitator of developing bankable smart city solutions for worldwide replication. Focus areas: efficient use of energy, intelligent use of data, and creating solutions for real customers. https://smartotaniemi.fi/
Detailed plan	SPARCS will collaborate with the Smart Otaniemi network and co-organises common dissemination activities and events locally. SPARCS activities will be presented in Smart Otaniemi events, such as in Otaniemi open doors (seminars or webinars). This action will support leveraging funding for smart city developments beyond SPARCS demonstrations. As an example, this collaboration aims to bring together groups of organisations, which can apply additional funding for collaborative development and demonstration, such as collaborative development of carbon free shopping malls from Business Finland.
Targeted outcome	Increasing the collaboration and knowledge sharing among SPARCS partners and Smart Otaniemi network, to connect SPARCS with other actors in Finland. Increased capabilities of SPARCS partners and stakeholders by increasing their awareness of trending technologies and supporting partners to test more innovations beyond SPARCS demonstrations.
Roles and responsibilities	VTT leading the networking, in collaboration with the City of Espoo and other stakeholders.
Schedule	Continuous collaboration and seeking to identify new opportunities.
New deviations into plan (as compared to D3.1)	
Progress until M24	Broad discussions (led by VTT) on the topic of continuing developing carbon free shopping centres, which led to submitting collaborative proposal for national funding organisation. Smart Otaniemi presented for SPARCS partners in the SPARCS City Forum (topic: services for business) on 1st of July 2021. Examples of local collaborations between city, research and technology providers: - A new project called KETO together with City of Espoo and VTT, funded with regional funding (ERDF), about energy communities. - Open door event: Smart Urban Energy – Discover Otaniemi! 10.6.2021 organized by Urban Mill, with SPARCS presented. (https://urbanmill.org/ and video from the event: https://youtu.be/v7DyB4rS2oA) - Energy community workshops organised by Espoo, VTT and CGI, envisioning the future of energy communities (18.2.2021, 11.3.2021) - Smart Otaniemi project presented for the ETIP SNET Regional Workshop 21.4.2021, Session: Electromobility integration in the energy systems. Presentation about smart EV charging in Otaniemi, Espoo.

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	- SPARCS presented in the Future of built environment, smart energy systems in October 2020.

9.4 Smart business

Positive energy districts require new kinds of technical solutions and business models. Local ownership is enhanced by the emergence of livelihoods and promising export opportunities. The introduction of energy communities will benefit small and medium size businesses, as large corporations are excluded from decision-making positions. Smart and citizen-based business solutions can leverage local opportunities, such as sector coupling of power, heat and mobility, and employ cutting edge ICT services provided by the 5G infrastructure, 3D city models and blockchain platforms.

This subtask 3.8.3 will assess the opportunities for smart business, investigate new companies with relevant products and coordinate with stakeholders to create an enabling environment for private sector participation.

Action E23-2	Smart business. The development of new business out of Espoo Lighthouse actions is supported by connecting and linking to local (e.g.YritysEspoo) and national actors.
Detailed plan	Enabling connections and discussions between SPARCS partners and local and national actors in relation to the actions taken in the project. Promoting SPARCS activities as part of the Sustainable Espoo programme. Assessing the city's role in supporting smart business, describing services for supporting new companies, collaboration or research initiatives, and city as a platform approach.
Targeted outcome	Provide possibilities and support for new smart businesses to emerge from the Lighthouse activities.
Roles and responsibilities	ESP is in charge of the Action. Practical outcomes are done in co-operation with the other relevant SPARCS partners.
Schedule	Ongoing (M1-M60) M23: A report of City of Espoo's current aims for supporting businesses and listing the different channels through which the development of new (smart) business in the city is supported (e.g. city as a platform approach) finished.
New deviations into plan (as compared to D3.1)	Schedule updated.
Progress until M24	• Finished a report summarizing City of Espoo's different aims for supporting businesses and listing the different channels through which the development of new (smart) business in the city is currently supported (e.g. city as a platform approach) (M23).

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The City of Espoo has examined the city's current processes and tools of supporting and attracting new business development in the city in a brief internal report (M23, available in VTT Teams). The paper presents the general purposes of business development support from the city's strategy 2017-2021 (the 'Espoo Story') and the 'city as a platform' approach utilized in the city's service design and development. Additionally, the results from annual surveys about Espoo as an operational environment for businesses from the enterprises' viewpoints, and the Business Espoo service network for companies and entrepreneurs in Espoo are also briefly examined, together with the cooperation through externally funded sustainable development projects that aim to tackle the local carbon neutrality targets and other facets of sustainable development. The report also includes the business development process that takes place through the city's strategic cooperation with different organizations.

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10. Replication and exploitation preparation in Espoo

Espoo is committed to achieving the UN's sustainable development goals (SDGs) by 2025. The voluntary local review (VLR) of Espoo published in May 2020 outlines the statues of each SDG and joint efforts for accelerated action. SPARCS is featured in the report as a key instrument in driving SDGs 7,8,9,11 and many others.

The objective of task 3.9 is to develop and disseminate smart city solutions for reaching the global Sustainable Development Goals (SDGs) of Agenda 2030. It also provides a model for replication throughout other positive energy districts around Europe and, more importantly, a unique case study for global urban development.

Action E14-1	Co-creation for sustainable city development. Coordinated and collaborative and replication of SPARCS Espoo Lighthouse actions in Kera area solutions for smart and energy efficient future living are co-developed as co-creation between the City of Espoo and the local consortia of stakeholders, including close collaboration with e.g. energy utility companies Fortum and Caruna.
Detailed plan	Coordination with other ongoing sustainability projects in Kera. Participation in stakeholder group to outline an energy positive ecosystem and mobility ecosystem. Close co-operation with Smart and Clean Kera –project. Communication with utilities to understand requirements and opportunities of local energy solutions.
Targeted outcome	The development of the Kera are provides a valuable opportunity to test and implement energy and mobility solutions tailor-made for local needs, including the building phase of the area. Involving a wide range of stakeholders, including incumbent utilities improve the outlook of system optimization, reliability and replicability, as well as sustainable urban mobility.
Roles and responsibilities	ESP, stakeholders
Schedule	Coordination is ongoing M8 Positive energy ecosystem study completed M10 Sustainable mobility ecosystem –work started in co-operation with Smart and Clean Kera and Six Cities: Low-carbon transport in mobility hubs -projects. M36 Opportunities for replication and exploitation identified
New deviations into plan (as compared to D3.1)	
Progress until M24	M23 Kera sustainability and climate roadmap workshop by city of Espoo (Clean and smart Kera project)

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Action E22-2	**Ensure global impact of SPARCS actions through the UN SDG 2030 network. UN SDG 2030. The Lighthouse City of Espoo strategy aims at creating an inclusive, safe, resilient and sustainable community, as per the UN Sustainable Development Goal 11. The City of Espoo is also committed, as a selected pioneering city, to begin the work as SDG City with Sustainable Development Goals 4 (Quality Education) and 9 (Industry, Innovation and Infrastructure), and to reach all 17 goals by 2025. The Espoo Lighthouse consortia and actions form an integral part of the roadmap towards reaching these targets, especially goal 7 Affordable and clean energy, 11 Sustainable Cities and Communities, 13 Climate action and 17 Partnerships for the goals. This action coordinates, assembles and channels SPARCS work towards replication and dissemination on European level, towards the European Smart City community, and towards the global international UN community.**
Detailed plan	Leverage the UN Agenda 2030 forerunner city role in communication Engage with UN system and assess the role of Espoo in a global UN context. Participate in other networks, including IEA-EBC Annex 83, the PED City Panel of SET-Plan Action 3.2, Eurocities network and several national initiatives.
Targeted outcome	The effectiveness of innovative concepts is enhanced by active communication and participation in global networks, as good practices can be analysed, refined and replicated
Roles and responsibilities	ESP, VTT, Stakeholders
Schedule	Continuous implementation. M5 Engagement with UNTIL unit in Otaniemi, Espoo to present SPARCS and explore opportunities for collaboration M9 Voluntary Local Review published and Espoo featured at UN High Level Political Forum M20 Espoo city internal SDG sensemaking workshop for SPARCS project group M30-33 SDG workshop for WP3 partner organisations M36 Evaluation report on SDG progress and potential in Espoo by SPARCS demos.
New deviations into plan (as compared to D3.1)	
Progress until M24	Espoo city internal SDG sensemaking workshop with SPARCS Espoo project group to recognize project group's work towards reaching SDGs.

10.1 Post-SCC1 Monitoring strategy

Espoo will continue work on UN SDG achievement and forerunner reporting until 2025 and pursue to maintain the title of most sustainable city in Europe. In alignment with the Espoo Story, activities towards sustainability will be monitored and communicated

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on both local and international level. The Post SCC1 Monitoring strategy will be developed mainly on third year of the project, while replication and exploitation preparation and collaboration with the other Lighthouse project cities in Finland and Agenda 2030 framework will remain at the center of SPARCS implementation throughout the project.

In Espoo, replication will be supported among others through evaluating and packaging guidelines for city planning with the emphasis on energy and mobility, as well as through suggesting concrete action points for enhancing governance model for future replication. Local smart city business models and best practices sharing supports further upscaling.

In Espoo we find great potential in long term development of city internal collaboration culture, more ambitious and defined goals in sustainability and PED themes included in city strategy, which is rewritten every four years. Replication potential is found significant opportunities in renewing collaboration, city planning tools and processes and citizen engagement processes.

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11. CONCLUSIONS

The objective of this report was to present a detailed plan of the smart city lighthouse demonstration activities in Espoo, as well as to document the implemented demonstrations of solutions for energy positive blocks. The previous deliverable D3.1 served as the starting point for this report (deliverable D3.2).

Demonstration activities embark a range of solutions supporting transition towards low carbon areas and testing of possibilities for positive energy blocks in Espoo. 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. Sites for the demonstration activities are the Sello shopping centre and surrounding buildings at the centre of the Leppävaara district and the Lippulaiva block in the Espoonlahti district. The Kera district provides an additional demonstration site, focusing on low carbon urban planning and developing processes, and approaches for positive energy blocks.

Achieved outcomes and to date implemented solutions were documented in this report. Furthermore, deviations to the original activity plans and schedules were added. Even though the current and still ongoing COVID pandemic situation has had an influence on Espoo's demonstration activities and their schedule to some extent, the progress of all demonstration activities has been good.

Collaboration with other work packages in SPARCS was further developed and strengthened.

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12. Acronyms and Terms

AMR	annual mismatch ratio
ABTM	activity-based transport model
API	application programming interface
BIM	building information model
CAPEX	Capital expense
CHP-bio	combined heat and power production using bio fuels
CityGML	City Geography Markup Language
CCS	Cable charging spot
DH	district heating
DSM	demand side management
EV	electrical vehicle
HVAC	heating, ventilation and air conditioning
IoT	Internet of Things
KPI	key performance indicator
NZEB	nearly zero energy building
OER	on-site energy ratio
OPEX	operating expense
PED	positive energy district
PV	photovoltaic
P2P	peer-to-peer
RES	renewable energy source
RH	relative humidity
RMSE	The root-mean-square deviation
TSO	transmission system operator
VPP	Virtual Power Plant
V2G	vehicle to grid

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