D3.3 Implemented demonstrations of solutions for energy positive blocks in Espoo

29/09/2022

Elina Wanne, Jani Tartia, Angela Juslin, Joni Mäkinen, Mia Kaurila ESP[1], Mari Hukkalainen, Zarrin Fatima, Krzysztof Klobut, Kalevi Piira, Mikaela Ranta, Petr Hajduk, Tiina Vainio-Kaila, Eveliina Grönroos VTT[2], Elina Ekelund CIT[3], Jaano Juhmen SIE[4], Merja Ryöppy, Saga-Sofia Santala, Toni Tukia KONE[5], Joona Töyräs PIT[6], Timo Koljonen ADV[7]

[1] *City of Espoo, Mayor's Office, Centre of Excellence for Sustainable Development*
[2] *VTT Technical Research Centre of Finland Ltd.*
[3] *Citycon Oyj*
[4] *Siemens Oy*
[5] *KONE Oyj*
[6] *PlugIT Finland Oy*
[7] *Adven Oy*

Disclaimer

The information in this document is provided as is and no guarantee or warranty is given that the information is fit for any particular purpose.

The user thereof uses the information as its sole risk and liability.

The document reflects only the author's views and the Community is not liable for any use that may be made of the information contained therein.

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

Deliverable administration

No & name	**D3.3 Implemented demonstrations of solutions for energy positive blocks in Espoo**				
Status	Submitted	**Due**	M36	**Date**	2022-September-30
Author(s)	Elina Wanne, Jani Tartia, Angela Juslin, Joni Mäkinen, Mia Kaurila, City of Espoo Mari Hukkalainen, Zarrin Fatima, Krzysztof Klobut, Kalevi Piira, Mikaela Ranta, Petr Hajduk, Tiina Vainio-Kaila, Eveliina Grönroos VTT Elina Ekelund, Citycon Oyj Jaano Juhmen, Siemens Oyj Saga-Sofia Santala, Merja Ryöppy, Toni Tukia, KONE Oyj Joona Töyräs, PlugIt Finland Oy Timo Koljonen, Adven Oy				
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. This report, due M36, presents an overview of the finalized Lighthouse City Espoo demonstration actions in Work Package 3. The report is part of the Milestone 8 "Espoo- Completion of the demonstration sites" (M30). The report is based on the earlier Deliverables D3.1 and D3.2 that have presented the detailed plans and work progress on each Action. The detailed descriptions of the Actions, the actual working process, and the gained insights and lessons learned so far can be found in the Deliverables D3.4, D3.5 and D3.6 also due M36.				
Participants	ESP, VTT, KONE, SIE, PIT, CIT, RIL, ADV, BABLE, CIVIESCO				
Comments					

V	Date	Authors	Description
0.1	04/2022	All	Working document.
0.2	06/2022	All	Finalization of the content, 1st version
0.3	08/2022	All	Finalization of the content, final version
0.4	08/2022	ESP	Ready for internal review.
0.5	09/2022	ESP	Deliverable checked and released to the Coordinator and the Quality Manager for quality check and subsequent submission to the EC.
1	29.9.2022	VTT	Coordinator submits the deliverable to the EC.

Dissemination level

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

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

About SPARCS

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

Partners

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

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

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

EXECUTIVE SUMMARY

This report presents the demonstration actions that have been carried out in the SPARCS project in Espoo, Finland by the end of third project year. First, the report presents an overall summary of the Lighthouse demonstrations in Espoo and the demonstration areas, and then summarises the details of each Action in the demonstration areas Task-by-Task (from Task 3.1 to 3.9). The demonstration actions broadly cover various low carbon improvements of urban area development, including buildings, energy systems, transportation, urban planning and citizen engagement.

Espoo city structure is comprised of five large district centres, and our demonstration areas focus on two of these centres: Leppävaara and Espoonlahti. The Sello area, at the centre of the Leppävaara district, is an already existing urban area, where demonstration actions focus on improving the existing urban infrastructure. The Lippulaiva block, at the centre of the Espoonlahti district, is a fully redeveloped urban 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, a third demo site concentrates on urban planning in the future Kera area, with the high ambition level for sustainable and smart district development. And finally, SPARCS also studies macro level demonstration actions in the Espoo city on a general level.

This report describes the work carried out and the summary of the Espoo demonstrations at the end of the third project year, including the outcomes, schedules and partners' roles and responsibilities in each Action. The deliverable is connected to the project's *Milestone 8 Espoo - Completion of the demonstration sites* (due project month M30). This Deliverable provides an overview to all the project Espoo demonstrations, covering the basic elements of each Action. The more in depth results, insights and learnings from these demonstration activities so far are covered in the thematic Deliverables D3.4 (*Interoperability of holistic energy systems in Espoo*), D3.5 (*EV mobility integration and its impacts in Espoo*) and D3.6 (*Optimizing people flow and user experience for energy positive districts)* that focus on the Tasks and Actions on energy, mobility and citizen engagement (respectively), also due M36. The final report of the Work Package 3 is Deliverable 3.7 (*Replicating the smart city lighthouse learnings in Espoo: technical, social and economic solutions with validated business plans*) due M60 in the end of the project.

1. Introduction

1.1 Purpose and target group

This report provides a summary of the implemented smart city lighthouse demonstration actions realised in Espoo, Finland as part of Work Package 3 (WP3) activities.

Interventions related to various aspects of positive energy blocks have been carried out in three demonstration sites in Espoo and on the city-wide level. The interventions are related to topics such as energy, transportation, ICT, citizen engagement, and urban planning and are composed of many demonstration actions. Each demonstration action has a detailed work plan, targeted outcome, and defined roles and responsibilities. Besides detailed implementation plans, the project also includes preparation plans for the monitoring phase, which is following the demonstration phase.

The demonstration actions presented in this report follow the task structure (Tasks 3.1-3.9) 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.

This Deliverable is an updated document of the Deliverables D3.1 (*Detailed plan of the Espoo smart city lighthouse demonstrations*, submitted in M12) and D3.2 (*Midterm report on the implemented demonstrations of solutions for energy positive blocks in Espoo*, submitted in M24) that have presented the detailed plans and work progress on the demonstrations. This document presents the finalized demonstration work by M30 and M36 that is based on the plan and progress descriptions provided in these earlier Deliverables.

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

SPARCS

1.2 Contributions of partners

The table below depicts the main contributions from partners in this deliverable. The deliverable is a joint effort by all the partners contributing to the Work Package 3.

Table 1. Contributions of partners

Partner	Contributions
ESP	Editor of the deliverable. Content planning, allocation of writing responsibilities. Lead of sections 1, 2, 3.1, 3.4, 3.5, 4.3, 5.1, 5.4, 6, 7.4, 9.4, 10, 11
VTT	Sections 5.5, 8, 9.3
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	Action E1-1, E1-4, E1-5, and E1-6 in section 3.2

1.3 Relations to other activities

The table below depicts the main relationships of this deliverable to other activities, milestones or deliverables within the SPARCS project.

Table 2. Relation to other activities in the project

Deliverable / Milestone	Contributions
D3.1	This deliverable D3.3 is a second updated version of the D3.1, which described the plans for the demonstrations of solutions for energy positive blocks in the end of the first project year (submitted in M12).
D3.2	This deliverable D3.3 is an updated version of the D3.2, which described the updated plan and progress up until the second project year for the demonstrations of solutions for energy positive blocks (submitted in M24).
D3.4	The deliverable D3.4 presents the work done and lessons learned in regard to the demonstration activities presented here in more detail. The deliverable focuses on work done in Tasks 3.2, 3.3 and 3.5.
D3.5	The deliverable D3.5 presents the work done and lessons learned in regard to the demonstration activities presented here in more detail. The deliverable focuses on work done in Task 3.4.
D3.6	The deliverable D3.6 presents the work done and lessons learned in regard to the demonstration activities presented here in more detail. The deliverable focuses on work done in Tasks 3.6, 3.8 and 3.5.
M8	This deliverable presents the work on the demonstration sites in Espoo, completed by M30.

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

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.
WP5	Project upscaling and replication in Lighthouse Cities. Replication preparation and planning activities (T3.9) are strongly supported by WP5.
WP6	Knowledge exchange between other SCC1 projects and other networks and cross-horizontal collaboration activities. Contributions to recommendations building in T6.2 of WP6.
WP7	Links to business models development and exploitation; aiming for wide knowledge exchange.
WP8	Dissemination and communication of activities in Espoo on the project level.
WP10	WP10 supports and ensures ethics issues in the practical work in Espoo.

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

2. Overview of Lighthouse demonstrations in Espoo

2.1 Introduction to activities in Espoo

Espoo is the second largest city in Finland with some 300.000 residents. The city has had goals related to sustainability since the 1990's and the main goals of the current City strategy 2021-2025 are to combat climate change, strengthen biodiversity and achieve carbon neutrality by 2030. One special character of Espoo is its urban structure: instead of one city centre, Espoo has consistently developed itself as a network city with five urban centres that are like smaller cities within the city. Two of the three SPARCS demonstration areas in Espoo are located in these city centres: the Sello blocks in Leppävaara area, and the Lippulaiva blocks in Espoonlahti area. Both city centres are currently developing rapidly, as are new smaller districts in between, such as Kera area, the third Espoo demonstration area of the project. The Smart City Lighthouse demonstration sites in Espoo are shown in the Figure 1.

Figure 1. Map showing Espoo's five city centres and SPARCS' demonstration locations in Espoo. Source: City of Espoo

Leppävaara is the largest and busiest of Espoo's urban centres and also the third-largest traffic hub in the capital region. 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 centre, there are residential buildings, public services, and entertainment venues. The Sello shopping centre opened in 2003 and since then it has received several LEED certifications (platinum in 2020 and 2015, and gold in 2011) for its operations. The shopping centre has been the first significant property complex in Finland to be part of the electricity reserve market.

Sello's automation system is provided by Siemens. Since the beginning, their aim has been to build a more self-sufficient energy unit in the shopping centre, which goes beyond the integration of well-known energy solutions such as solar panels and battery energy storage. In Sello controlling electric loads like lighting, HVAC and elevators support total system balancing and increases the total flexible capacity that are sold to electricity reserve markets every day. District Heating DR was implemented in Sello, and the solution has allowed Sello to reduce peak load and produce savings both in energy expenses and CO_2 emissions.

Geoenergy potential of Sello is assessed, to increase Sello's energy self-sufficiency, by carrying out a Feasibility Study on deep geothermal well solutions.

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

The new Lippulaiva shopping centre, which opened in March 2022, with surrounding residential block buildings are constructed during and after SPARCS by Citycon. The Lippulaiva blocks have been utilizing new energy solutions from day one. The shopping centre hosts the largest geothermal heating and cooling plant in Europe for a commercial building, built under the Lippulaiva premises. The regenerative geoenergy system by Adven covers 100% of the cooling demand and almost the entire heating demand of the shopping centre and the 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 grocery stores 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 there is an electric battery storage has been decided to be invested. Lippulaiva is an important mobility hub comprising a metro station (opening in 2023), bus terminal and facilities for cycling and e-mobility. The project partners have engaged citizens, and young customers in particular, to participate in the co-creation of the new shopping centre. Collaboration with local schools has led to the establishment of Buddy Class actions, and students have been working directly with the project partners on specific sustainability themes promoting sustainable lifestyles.

The Kera area is mostly an old industrial brownfield area developed in the 1970s and it will now be reallocated for residential and workplace 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. Some of the properties have been in temporary use for local actors, creating a unique local feel for the area. Actors such as breweries, billiard halls, gyms, tennis halls, and small-scale firms focusing on circular solutions have situated themselves within the old logistics hall, decorated by murals commissioned by the Kera collective. Plans on keeping the local feel as a part of the design and work process of the area are ongoing, even as the demolition of the logistics halls has begun. The site will undergo a city planning process, new zoning, purchase by real estate developers and will subsequently emerge as a modern and vibrant district with train connections. The development of the Kera district is following the existing component master plan for Kera and Kera's district plan. Architectural sketches of the new plans for the Kera area are shown in the Figure 2 below.

Figure 2. Sketches of the planned Kera area. Source: City of Espoo

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

In order to turn Kera into a new urban local centre, with blocks of flats and schools located on either side of the Kera railway station, new detailed land use plans are being prepared. The main local detail plans are the Centre of Kera local detail plan, the Karapelto local detail plan, and the Karamalminrinne local detail plan. On 13.09.2021 the City Council approved the land use plan for the Centre of Kera (located south of the railway). With the new plan, that became effective on 24.11.2021, demolition works of the first buildings were started in the beginning of the year 2022 (Figure 3). First new building projects in the area are expected to begin in autumn 2023.

Figure 3. Demolition works in Kera started in the beginning of 2022. Source: City of Espoo

In SPARCS a new co-creation model is being developed (2021-2022), which will support forming sustainable and smart urban areas in Espoo, such as Kera. Citizen engagement activities bring future residents of the Kera district to the centre of the energy ecosystem, maximizing local production and encouraging prosumer models to enhance the utilization of distributed energy generation. E-mobility solutions from SPARCS also support the development of local sustainable urban mobility solutions as the area is set to emphasize walking, bicycling and public transportation use by making use of the already existing commuter train stop in the area.

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 Preparing for the monitoring

A plan for the performance monitoring of the project and its prospective KPIs has been developed in Work Package 2 for each intervention considering all demonstration actions. To commence the monitoring phase of the demonstration actions as planned, the needed data sources and method of information sharing between relevant partners is being developed simultaneously. To provide a good foundation for the monitoring phase, an analysis of the baseline situation in Espoo was provided in Deliverable 2.3, with information of Espoo, the SPARCS demonstration areas, and the interventions with baseline values for each KPI provided if applicable.

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

3. Positive energy blocks in Espoo lighthouse demonstrations

3.1 Introduction to task 3.2

Task T3.2 is divided into four subtasks and the overall objective is to demonstrate solutions for positive energy blocks and districts. In all three demonstration areas in Espoo (Lippulaiva blocks, Leppävaara center and Kera) the energy system is being developed through a holistic approach, considering smart solutions for electricity, heating, cooling, and mobility.

What differentiates the three demo sites from each other are their different stages of development. The Leppävaara centre with the Sello shopping centre has been in use for several years. The newly built Lippulaiva shopping centre opened in March 2022 and some of its residential buildings are still under construction. City plans for parts of the Kera district (southern part of the railway) have recently been approved and the demolition of some of the industrial buildings has been started at the beginning of this year. Other parts of the Kera district are still in city planning phase and the entire construction of the Kera district goes beyond the timeframe of the SPARCS project.

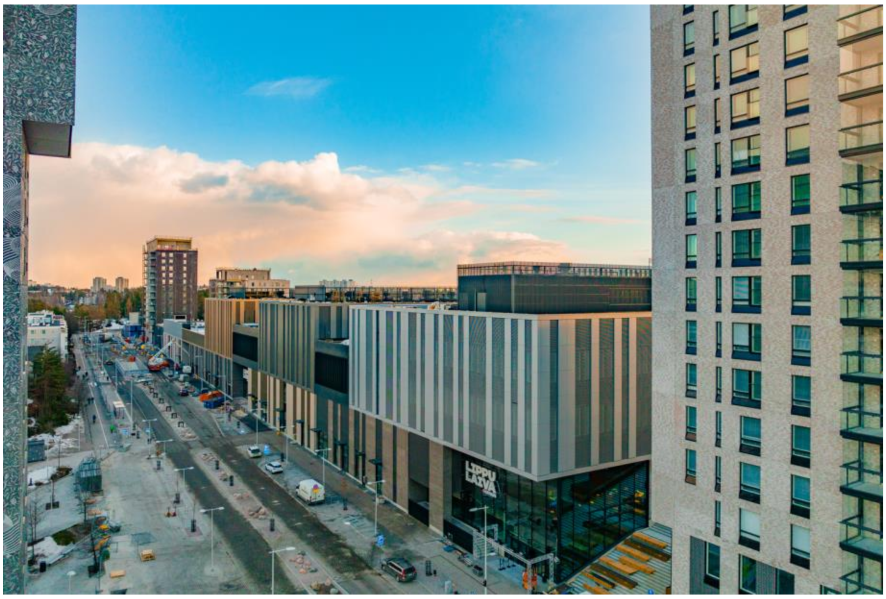
The task's main objectives and concrete steps for the work plan were mapped and laid out as part of Deliverable D3.1. An update about the progress compared to Deliverable D3.1 was given in Deliverable D3.2.

Despite the ongoing global Covid-19 pandemic situation, actions within task T3.2 were progressing well, and no major delays were faced. The four subtasks and their actions are described in more detail in the following chapters.

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 centre and the surrounding residential building blocks. Leasable gross area of the shopping centre 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. The figure below (Figure 4) shows an architecture sketch of Lippulaiva shopping centre with residential blocks and the main functions of different buildings in Lippulaiva block. The Lippulaiva shopping centre was officially opened on the 31st of March 2022.

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



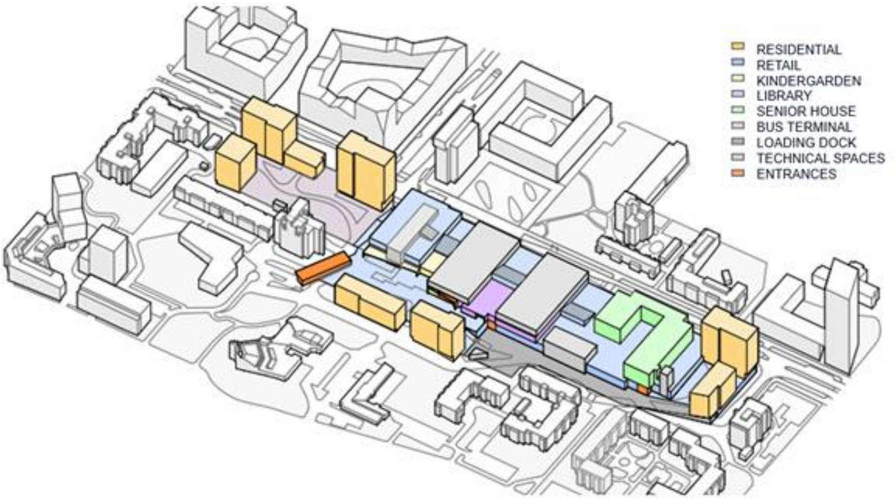


Figure 4. Lippulaiva in March 2022 (above) and the main functions of different buildings in Lippulaiva (below). Source: Citycon

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 centre as well as residential buildings is mostly covered with heat pump plant. On-site RES production includes a 4,4 MW regenerative ground source heat pump plant, approximately 50,000 metres of bore holes and a PV system with peak power of approximately 634 kWp.

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 centre is mainly covered with on-site geothermal heat with heat pump (system by Adven). Beside the heat pump system, Lippulaiva has district heating connection and electric boiler for back-up heating system and for peak heat demand. The on-site

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

excess heat is utilized. Electricity demand is covered with PV panels (roof) and certified renewable electricity. The capacity of PV panels was 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.

The following tables include a short description of the outcomes achieved related to the SPARCS intervention *E1 - RES integration in Energy Positive Lippulaiva blocks.* A more detailed description of each action and its outcomes can be found from Deliverable D3.4.

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 centre 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.
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. • 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. • Adven's energy system (regenerative ground source heat pump system GSHP) is built and installed. Heat deliverable has started in early 2021. • Lippulaiva shopping centre has been completed and opened for commercial operation on 31st March 2022.
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 steers and operates energy flows in Lippulaiva block. Adven provides the thermal energy

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

SPARCS

	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.
Outlook (post M36)	Energy monitoring and KPI calculation will be carried out in connection with WP2. Energy flow optimization will be constantly developed and improved as more energy data about user profiles are collected.

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 centre and the amount depends on the detailed design of the roof structures.
Outcome	The final dimensioning of the PV plant in the rooftop (size, energy production, effect). • PV panels are installed on the roof and embedded into the façade. PV panels have produced energy from the beginning of July 2022.
Roles and responsibilities	CIT: Providing input data and dimensioning the PV plant. VTT: Calculating needed KPI's (will be done after M36).
Outlook (post M36)	Energy monitoring and KPI calculation will be carried out in connection with WP2.

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.
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. • Citycon has decided to invest to an electric battery which is used in reserve markets. The battery was purchased and installed. Citycon has been participating in Nordpool's reserve market since July 2022.

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

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.
Outlook (post M36)	No further activities are planned for this Action.

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).
Outcome	Delivering Geothermal heat and cooling to residential buildings and service home to be built in connection to Lippulaiva shopping centre. • Feasibility study was conducted regarding possibilities of connecting GSHP with district heating system to realize 2-way energy transfer. • GSHP was installed and taken into operation. It primarily provides all energy (heating and cooling) for the shopping centre. • GSHP also provides energy for the surrounding residential blocks (8 buildings that will be completed since 2022). Residential buildings utilize energy from GSHP during construction phase.
Roles and responsibilities	CIT: Providing input data of energy consumption in Lippulaiva shopping centre 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.
Outlook (post M36)	All residential buildings in the block will be connected into Adven geothermal network.

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

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.
Outcome	Finalized energy costs for Geothermal and PV energy production. Cost comparison to base-scenario. • Cost analysis can be made after actual energy data is collected, starting from April 2022. The proof for the costs will be calculated in project years 4 and 5 with actual consumption data M60.
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.
Outlook (post M36)	Cost analysis in project years 4 and 5.

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.
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. • 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. • Efficiency potential has been identified especially in the area of the indoor ventilation steering (HVAC).
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.

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

Outlook (post M36)	Efficiency potential will be further analyzed as we are now getting more reliable data as shopping centre has been opened and energy deliveries has been starting. Shopping centre HVAC interfaces and steering features design will be adjusted to capture energy savings.

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 centre focused 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 the Sello Centre is the local Energy hub of Leppävaara (Figure 5). The Sello multipurpose centre has an area of 102 000 m^2 including shops, a library, concert hall, and movie theatre. Sello centre has 2900 parking lots that includes tens of EV charging stations. Sello receives 23 million visitors yearly.

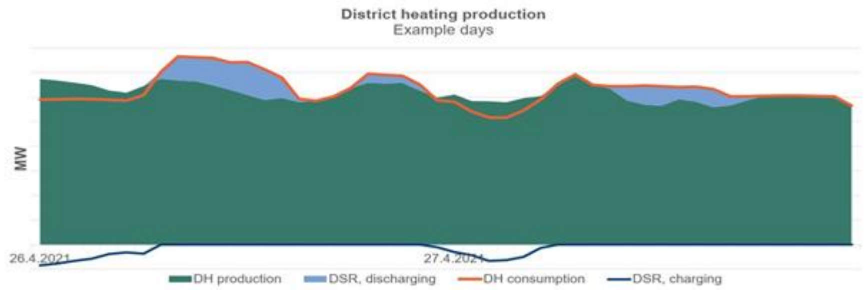
In Action E5-1, Sello's thermal energy processes were modelled to understand the potential increased energy efficiency, self-sufficiency and thermal flexibility. In Action E5-2 Sello's flexibility potential was realized by providing the thermal flexibility to local district heating company (Fortum).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

Figure 5. PV Panels on Sello Centre. Source: Siemens

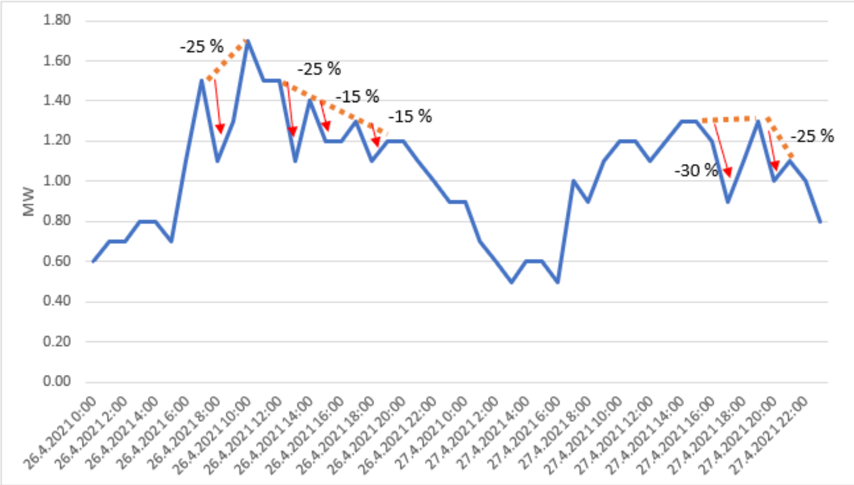
This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

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.
Outcome	SIE: Installation of sub heat meters to Sello was carried out to increase the granularity of thermal metering that was done previously only with 2-heat meters. Rest API was made available for VTT to integrate Sello real time energy data to prediction model and historical data was provided. VTT has calculated time constant for Sello. 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.
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).
Outlook (post M36)	Monitoring will continue in WP2.

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

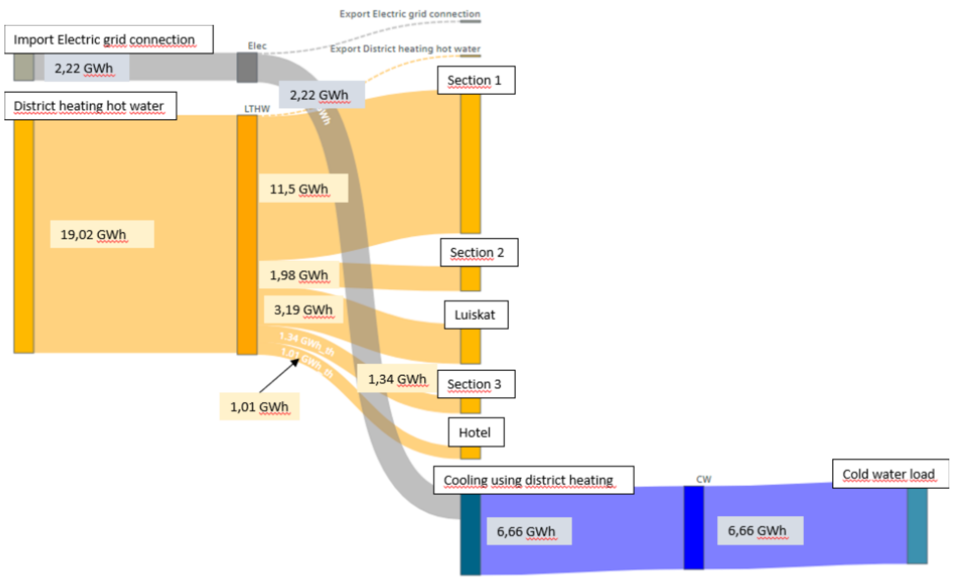
Action E5-2	**Integration with the local district heating grid operated by Fortum (Bio oil Plant 40 MW) for selling cooling/heat and heat demand side management.**
Detailed plan	• Define system architecture. • Provide flexibility data via API to Fortum. • Execute flexibility based on Fortum's signal via API.
Outcome	To lower CO_2 emissions level of local DH. To enable consumers to become active part of the energy sector by providing flexibility. Siemens has defined the system architecture, integrated solutions with local District Heating Company and demonstrated that flexibility request test have been carried out. The required actions to carry out the District Heating flexibility demand 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. In figure below (Figure 6), 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.  *Figure 6. District heating production and consumption 26-27.4.2021. Source: Fortum* In figure below (Figure 7) 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.

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

	 *Figure 7. Sello district heating consumption days 26-27.4.21. Source: Siemens*
Roles and responsibilities	SIE: Define system architecture, coordinate the work with Fortum and Sello, responsible for implementation.
Outlook (post M36)	

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.
Outcome	Increase of self-sufficiency of a Sello Block. Understanding technical barriers and commercial potential compared to DH by carrying out a Feasibility Study. **Some observations from the feasibility study regarding Action 5-3.** As an example of the potential of the deep coaxial borehole heat exchanger is that a single 800 m borehole could provide more heat than 6 conventional 300 m U-pipes. **Simulation introduction:** In Figure 8 below Sello's 2021 heat and cooling demand is visualized in Sankey diagram.

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

	 *Figure 8. Sankey diagram showing Sello's energy demand per area. Source: Siemens* According to simulation results, the total cost of ownership in 20 years of a deep heat system, is 20% less than the Reference Case.
Roles and responsibilities	SIE was responsible for defining the scope, gathering the input data, installing and commissioning the analysis.
Outlook (post M36)	Analysis of increase in self-sufficiency and iteration of the simulations.

3.4 City planning for Positive Energy blocks

The subtask 3.2.3 *City planning for positive energy blocks* focuses on the development and the planning of positive energy blocks. The aim is not only to explore the possibilities to utilize tools (such as the Espoo's 3D city model) in the development and the planning of new areas, but also to find energy infrastructure solutions and develop guidelines that enhance the uptake of such solutions. While the actions E10-1 and E10-2 mainly focus on the Kera area, action E10-3 is about energy system planning in Espoo generally - focusing on exploring new options for demand side management.

Kera has been identified as a testbed for locally adapted PED solutions, offering the unique opportunity for designing the future positive energy district from scratch. 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 centre will be developed. The development of the Kera district is concentrated in three areas: Centre of Kera, Karapelto, and Karamalminrinne. On 13.09.2021 the City Council approved the land use plan for the Centre of Kera (located south of the railway) and on 24.11.2021 the plan has become effective. The land use plan for Karapelto, which is the area located north of the railway,

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

is still pending (in acceptance phase). The City Planning Commission has approved the Karapelto draft plan for consideration by the City Council earlier on 24.5.2022. The land use plan for Karamalminrinne, which is located between Karapellontie and Karakaari, is still in the proposal phase. The plans for each area are shown in the figures below (Figures 9-11).


Figure 9. Left: Detailed plan of the Centre of Kera. Right: Sketch of the planned Centre of Kera area. Source: City of Espoo

City planning takes on an important role in supporting the future functionalities of the energy system and creating more sustainable and positive energy districts requires perhaps new approaches to planning. City strategies can support and guide city's operations towards exploring and finding new ways of city planning. Espoo's strategy, the Espoo Story, directs all of the city's operations toward common goals. The Espoo Story states that during planning and construction, the city will highlight the principles of sustainable development and pay attention to the life-cycle emissions of buildings. Furthermore, the Espoo Story states that municipal regulations related to zoning and construction will be reduced without compromising the regulatory quality. At the same time clearer operational objectives will be set for districts and regions in Espoo.


Figure 10. Left: Aerial view of the Karapelto area. Source: City of Espoo. Right: Architect picture of Karapelto. Source: Tietoa Finland

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

Figure 11. Left: Aerial view of the Karamalminrinne area from 2017. Source: City of Espoo. Right: Architect picture of Karamalminrinne. Source: Arkkitehtitoimisto B&M Oy

In Espoo, 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.

During the last couple of years, several development projects have contributed to the development of Kera:

- *6Aika: Vähähiilinen Liikkuminen liikennehubeissa* (SixCities; Low-Carbon Transport in Mobility Hubs) (2019–2022)
- *Clean and Smart Kera* (2019-2021)
- *LuxTurrim5G* (2019-2021)
- *Neutral Host Pilot* (2019-2021)
- *6Aika: Kestävien Kaupunginosien Kumppanuusmalli - 'KIEPPI'* (SixCities: Partnership Model for Sustainable Neighborhoods - Circular & Sharing Economy) (2019–2021)

Besides SPARCS also the *Clean - Collaborative Kera*, the *Ratkaisupolku Kestävän Kasvun Ekosysteemeihin (Pathway to Sustainable Ecosystems)*, and the *Kestävän kasvun kehitysympäristöjen toteutuspolku (Implementation Pathway for Environments that Accelerate Sustainable Growth)* projects are actively contributing to the development of the Kera area.

The following tables include a short description of the outcomes achieved related to the SPARCS intervention *E10 - Solutions for Positive Energy Blocks.* A more detailed description of each action and its outcomes can be found from Deliverable D3.4.

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

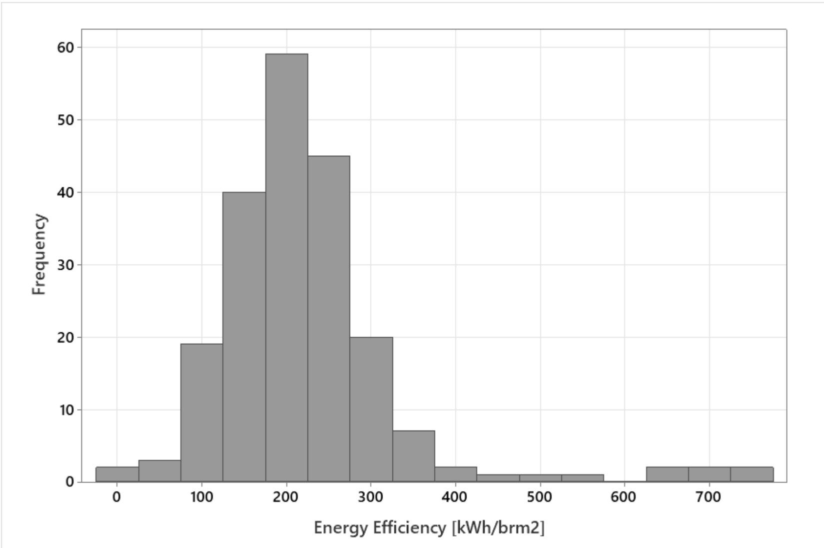
SPARCS

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.
Outcome	A 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. As a result of action E10-1, the role of 3D city models in the development of PEDs in general was identified and the process of 3D modelling in Kera documented. 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. Infrastructure investments were not required by this action. A more detailed description of the results of action E10-1 is given in Deliverable D3.4.
Roles and responsibilities	ESP: Main responsibility. 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.
Outlook (post M36)	After M36, action E10-1 will be monitored (as part of WP2 activities).

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

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.
Outcome	An 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. 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. A bi-directional low-temperature district heating network, managed by the local energy company Fortum, will serve as an innovative base for the further development of local energy solutions. Guidelines to enhance the uptake of energy infrastructure solutions for positive energy blocks were developed, including a workshop with Kera's stakeholders and developers as well as different city department representatives. A more detailed description of the results of action E10-2 is given in Deliverable D3.4.
Roles and responsibilities	ESP: Main responsibility. Stakeholders: Propose additional solutions.
Outlook (post M36)	M60: Guidelines for PED infrastructure development applied and follow-up in Kera.

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

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.
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. After a pilot phase that started in 2019 in five 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. Currently, there are over 500 buildings connected to Espoo's district heating demand side management system. To categorize the public building stock, an assessment of the thermal energy consumption of city owned buildings was conducted, using the Granlund Manager software and data from recent heating reports. Not only energy efficiency values of the buildings, but also energy consumption values have been analysed. The results were documented and presented to the city's premises department.  *Figure 12. Histogram of buildings' energy efficiency. Source: City of Espoo* A more detailed description of the results of action E10-3 is given in Deliverable D3.4.

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

Roles and responsibilities	ESP: Identify suitable sites. Stakeholders: propose solutions for demand response.
Outlook (post M36)	Further dissemination of results within the City of Espoo.

3.5 City scale smart heating and thermal demand response

The social housing company Espoon Asunnot together with the energy company Fortum have started the piloting of Demand Side Response (DSR) already in 2015. By establishing a two-way data connectivity to the buildings connected to the district heating network, Fortum is able to steer the heat demand in the buildings in a flexible way. The building level optimization system controls the heating volume of the connected buildings by optimizing the energy usage in entire building. The integration of the connected buildings into system level optimization offers even more flexibility to the whole district heating network. With DSR, Fortum is able to reduce peaks in heat consumption, since all the buildings are not heated in maximum volume at the same time. When the consumption peaks are lowered, there is no need to use peak load production units which reduces the amount of fossil fuels in heat production and therefore emissions. The service provider of the DSR (Leanheat Oy) reports 10% savings in heat consumption and 24% reduction in peak load. Nowadays, almost the entire real estate of Espoo Asunnot is connected to the Leanheat heating optimizing system.

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.
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. By the end of 2021, Espoo Asunnot owned in total 15 879 apartments, which is 155 more than in 2020. The normalized energy consumption for heating was 159

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

	713 MWh in 2021, which means an increase of heating consumption by 2% compared to the year 2020. At the same time, heating has been more efficient compared to the previous year. The energy consumption development over the last three years is presented in the following Table 3.

Table 3: Energy consumption in the rental apartments of Espoon Asunnot. Source: Espoon Asunnot[1]

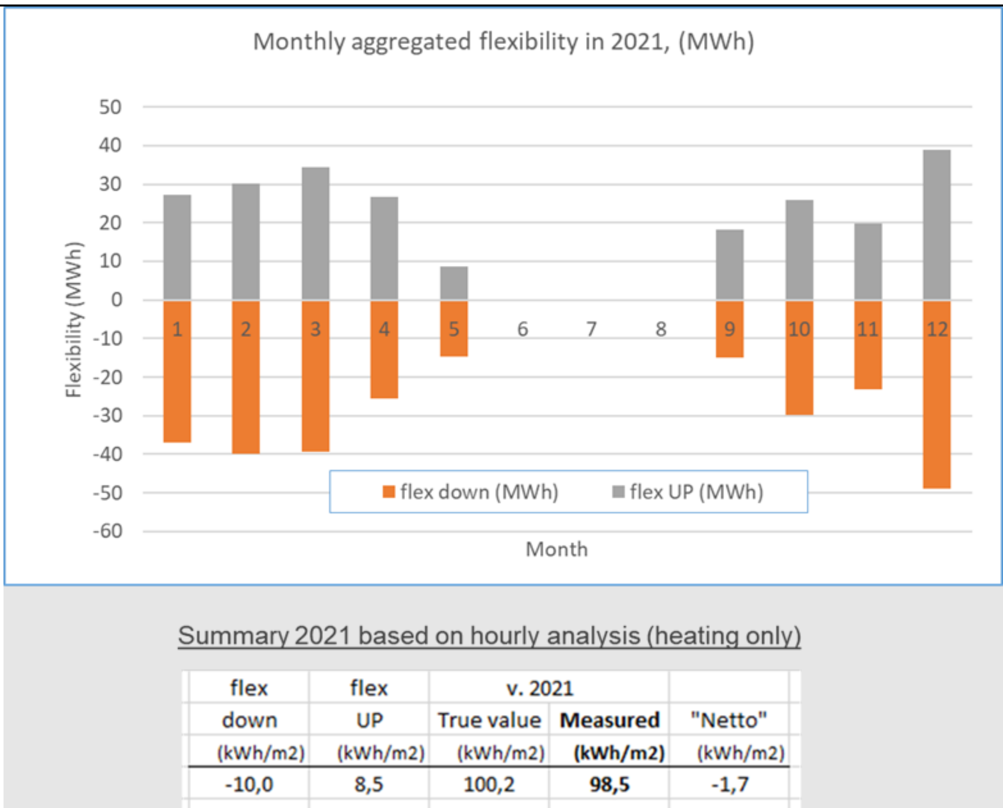
Heating	**2021**	**2020**	**2019**
Consumption, MWh	158 991	136 971	147 631
Weather-adjusted consumption, MWh	159 713	156 992	154 957
Heating index, kWh/Rm³	40,6	41,0	40,1
Electricity			
Consumption, MWh	18 769	18 040	18 972
Consumption, kWh/Rm³	4,7	4,7	4,9

In order to assess the emission reduction potential of the DSM scheme the past energy consumption of the Espoon Asunnot building stock has been statistically analysed. A detailed energy and DSM flexibility analysis was performed for 8 selected buildings. Analysis was based on recorded hourly values for the years 2019-2021. Aggregated flexibility values displayed by months are presented in figure below (Figure 13). The analysis has shown that using monthly values of emission factors (obtained from the energy provider), emissions avoided in 2021 due to DSM flexibility in the analysed group of 8 buildings was 4470 kg CO_2.

A more detailed description of the analysis and the results of action E16-1 is given in Deliverable D3.4.

[1] Espoon Asunnot Oy, " Hallituksen toimintakertomus ja tilinpäätös 2021", 2021. [Online]. Available: https://www.espoonasunnot.fi/sites/default/files/2022-08/Espoon%20Asunnot_hallituksen%20toimintakertomus_ja_tilinpaatos_2021.pdf. [Accessed 02.08.2022]

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



flex down (kWh/m2)	flex UP (kWh/m2)	v. 2021 True value (kWh/m2)	**Measured (kWh/m2)**	"Netto" (kWh/m2)
-10,0	8,5	100,2	**98,5**	-1,7

Figure 13. Aggregated flexibilities in investigated 8 buildings in 2021. Source: VTT

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.
Outlook (post M36)	The energy consumption of the selected buildings will be further monitored and followed up on.

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

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 the energy sector combined with the electrification of the mobility and heat sectors 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 also require 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.

In the task 3.3 actions were carried out to demonstrate 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.

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

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)
- 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 centre Virtual Power Plant platform is utilized. Sello is buying CO2 free electricity from Nordpool and is locally producing energy with PV (750 kWp). Sello's power system includes microgrid functionality with integrated electrical equipment, HVAC, elevators, EV-chargers and stationary energy storage (2 MW and 2.1 MWh) (Figures 14-15). Microgrid functionality enables Sello to participate through Virtual Power Plant in electricity reserve markets operated by Fingrid.

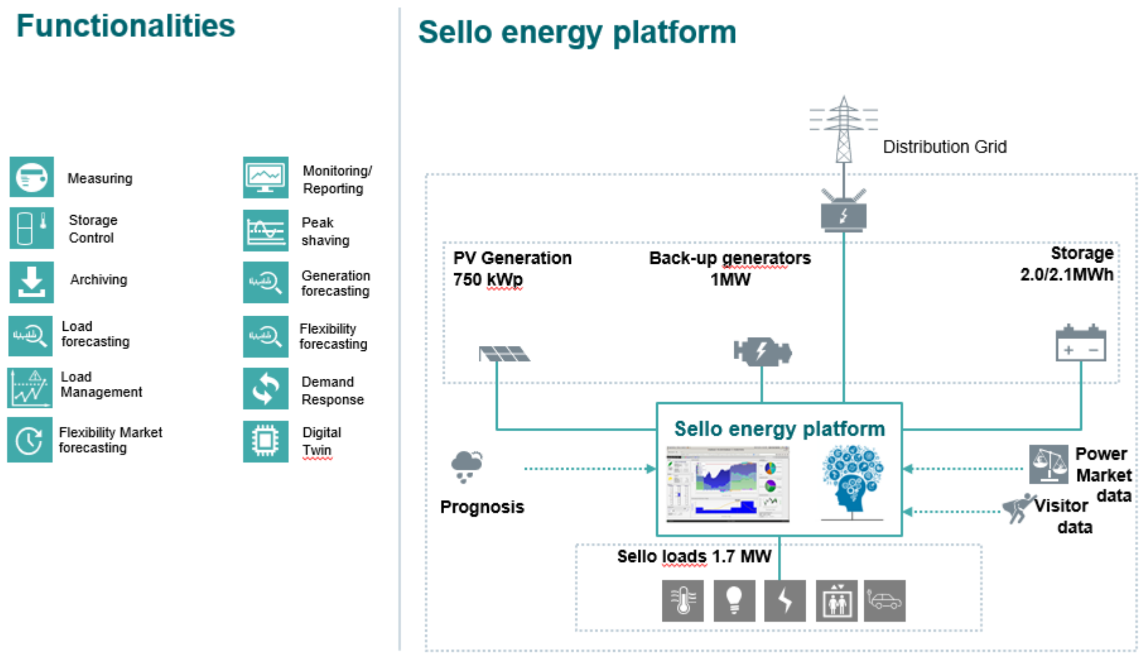


Figure 14. Sello's smart energy system. Source: Siemens

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

Figure 15. Sello's electricity consumption in MWh from 4.7.2021 to 10.7.2021. 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 included 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 is connecting buildings to a Virtual Power Plant that enables them to become an active part of the power system. During this action, the flexibility potential of city owned assets was evaluated, and according to this information chosen buildings were assessed based on their Virtual Power Plant connectivity during site visits and off-site analysis. An ice-hall was chosen as a pilot site to connect existing assets in the ice-hall, in addition install and connecting EV chargers to virtual power plant. In action E15-2, the use of blockchain technology for supporting Demand Response (DR) and Virtual Power Plant (VPP) solutions was 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 were investigated in a feasibility study within the action. More information on this feasibility study can be found in deliverable D3.4.

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

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 selected Sello elevators, escalators and moving walks with the Siemens platform. • Integrate Sello's energy data via API to VTT. • 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.
Outcome	• Creating a prediction model based on different data source of Sello blocks energy performance, energy markets to increase the energy performance of a Sello block and flexibility towards the TSO. • Create a data model, which would allow creating more intelligent, scalable, and interoperable programs that would not need manual mapping of data between systems. • Building Information Modelling (BIM) is an important aspect of efficient energy and facility management in buildings, and its growth in popularity is ever increasing. The purpose of this actions was to explore the creation process of BIM models, and their utilization potential in building automation. • Elevator data integration with to Siemens system implemented in action E6-3. Additionally, 13 escalators equipped with Sello BMS–connected power meters.

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

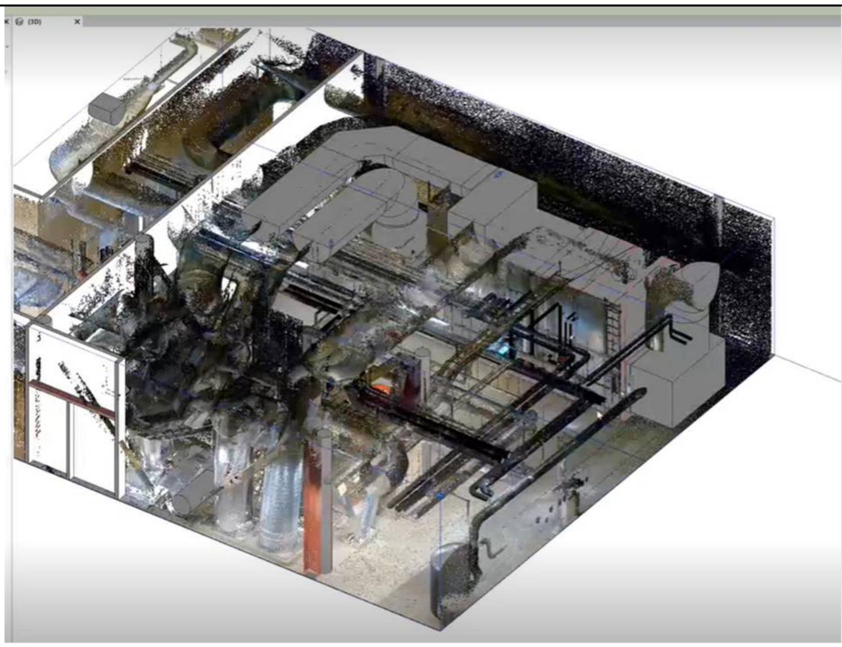


Figure 16. Sello BIM Models and point cloud scan together. Source: Siemens

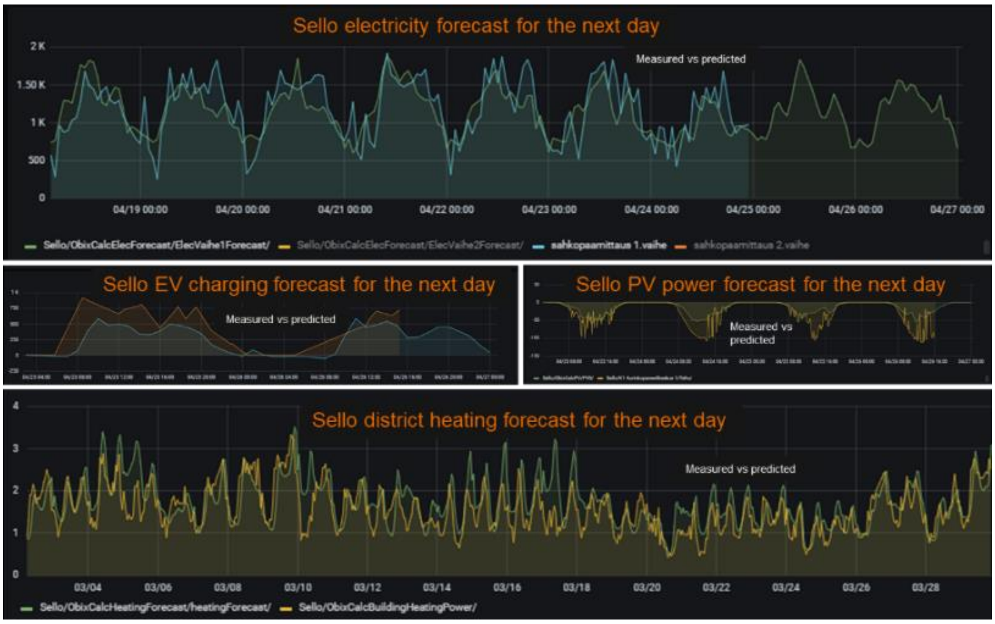
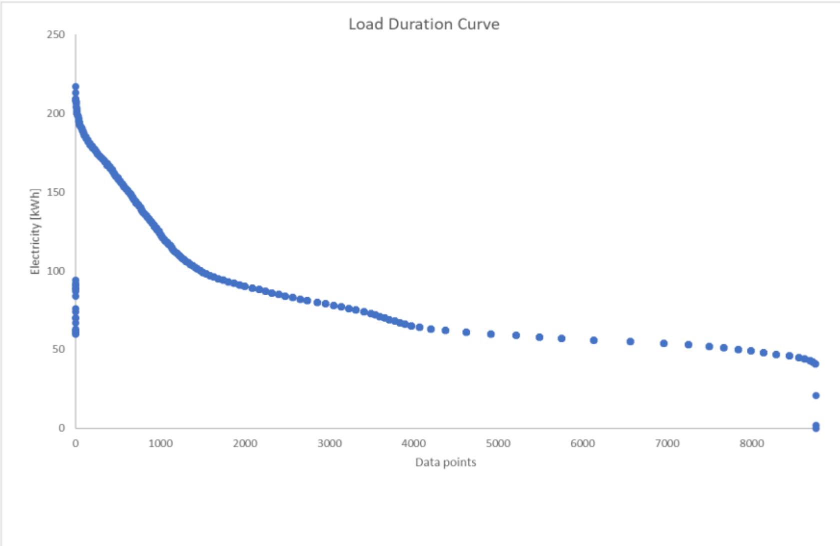


Figure 17. Example view of online energy prediction model for Sello in Action E6-1. This is a short term view (next prediction for electricity power demand, district heating power, PV power generation and EV charging power). Source: VTT

Roles and responsibilities	SIE: Provide historical and real time data, provide BIM model, create self-learning algorithm for flexibility and power markets. Point cloud model of part of Sello with BIM model of automation and HVAC. VTT: Develop self-learning algorithm, link data to BIM model and develop KPIs. KONE: Provide refined data of selected elevators, escalators and moving walks.
Outlook (post M36)	SIE: Iterations of Sello Asset Flexibility / Market prediction model. Monitoring of the outcomes in WP2.

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

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	• Data on all the Espoo city properties gathered. • Assess flexibility potential of different most potential sites. • Site visit. • Chose pilot site. • Aggerate loads of pilot site and demonstrate control of asset flexibility. • Analyse results. Similar activity on heat DSM in Action E16-1.
Outcome	The flexibility potential of different types of public buildings, such as swimming halls, schools and ice hockey halls, was analyzed for further understanding of VPP solutions within the public sector. 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. From these buildings, 13 buildings were chosen for further analysis and site visits. These included 10 schools, 1 swimming hall, 1 ice hall and 1 shelter facility. All sites were visited and flexibility potential estimated based on energy consumption, load duration curve, assets type and characteristics.  *Figure 18.Example of Load Duration Curve Kaitaa school close to Espoonlahti demonstration area. Source: Siemens.* An ice-hall, Ilmatar Areena, was chosen as a pilot project. The objective of the actions was to demonstrate a concept for Espoo city, on integration of loads into peak power limitation in order to allow installation of electric vehicle (EV) charging units without a possible electricity grid connection upgrade. Aim was

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

	also to demonstrate integration of EV loads and manage electrical loads of an ice hall for purposes of peak shaving and frequency reserve markets.  *Figure 19. Pilot project included 8x22AC chargers and 1x160kW DC charger. Source: Siemens.*
Roles and responsibilities	SIE: Analyze flexibility potential, connect pilot building and its loads, install EV chargers. 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.
Outlook (post M36)	The operation of the implemented pilot is assessed and replication opportunities within other public buildings are identified.

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. The architecture of blockchain solutions was identified. 2. Pros and cons of blockchain solutions were assessed. 3. The most promising opportunities and applications for blockchain were identified, together with their connection to the city strategy. 4. The role of the City of Espoo in possible blockchain applications or pilots was identified. 5. The legal framework around blockchain was assessed. 6. Findings were documented, and a roadmap for the future was devised. Ref Action E12-3 Blockchains for Kera energy transactions.
Outcome	According to the completed feasibility study, blockchain can be a beneficial solution for the energy sector, as long as the chosen use cases are targeted with the benefits of the solution in mind. The most beneficial solutions are focused on situations where differing parties need to act together on a trusted basis without a central authority. An example of this is a P2P transaction platform for prosumers. However, blockchain still has many technical, regulatory and knowledge-based constraints that need to be solved before full scalability is

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

	achieved. In the end, it was proven that blockchains may prove a cost-efficient and reliable platform for energy prosumer and demand side management transactions, if the constraints identified in the documentation are tackled, and the use case is carefully defined to meet the benefits of the solution.
Roles and responsibilities	ESP: Overall coordination. VTT: Technical support on blockchain solutions. SIE: Commercialized blockchain services.
Outlook (post M36)	Opportunities on implementing the identified pilots during future activities will be constantly monitored, and results are reviewed and discussed according to the devised roadmap.

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 visualized 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.
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 visualization purposes. The monitored data and results of virtual twin can be visualized in a building model.
Roles and responsibilities	VTT: Virtual twin planning and building. Stakeholders: Giving data (and BIM if available) from Sello.
Outlook (post M36)	

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

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 appliances. Blockchain and IoT are evolving quickly, presenting new opportunities for optimised energy performance and innovative new business models.

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. To expand the horizon of the feasibility study, other projects within Finland and the EU were analysed as well, while the synergies were expanded from the local small cell 5G infrastructure implemented in Kera to 5G in general. An additional aim was to identify possible service models to be used within Kera or in additional city regions where 5G could be exploited. In addition, opportunities brought to Kera by blockchain technologies were investigated in Action E12-3.

Action E6-2	Feasibility study on a smart energy services for residential and office buildings, based on digital platform, including EV charging, centralized battery energy storage and VPP. Evaluation of Electric Peak load management for residential and office buildings including EV charging stations
Detailed plan	• Feasible scope of buildings in Leppävaara district to be included has been analyzed. • Assess flexibility potential via together with EV chargers, stationary battery and on-site PV production. • Propose actions to exploit DSM measures. • Document and communicate to stakeholders.
Outcome	The City of Espoo assessed the possible Espoo city and Espoon Asunnot OY -owned properties to include in the future Siemens simulation activities. In the end, a list of the properties situated within the Leppävaara district, near Sello, was procured to Siemens together with relevant input data. The input data included information about energy consumption, grid connection and the amount of parking spaces. The PSS based simulation mimics the operation of proposed system for the chosen residential buildings, EV-chargers, stationary batter and on-site production thus providing evidence for stakeholders for decision-making by being able to test different scenarios or process changes. Table below presents the results of the simulation including total cost and payback time for Espoon Asunnot only upgrading the grid for two different EV chargers configurations, as well as for the configuration including PVs and a 200 kW battery. The configurations include either 18 or 49 charging points (CP).

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

Table 4. Results from configurations with and without PV and ESS

	CP = 18		CP = 49	
	w/o PV+ESS	w PV+ESS	w/o PV+ESS	w PV+ESS
Total cost[EUR] [1]	1 810 092	1 478 638	4 048 513	3 653 608
Payback time[y]	-	9.2	-	8.3

Roles and responsibilities	SIE: Carry out feasibility study. ESP: Engage stakeholders including public buildings and Espoon Asunnot in Leppävaara district.
Outlook (post M36)	The results of the simulation activities are assessed and replication opportunities are identified.

Action E12-1	**Smart infrastructure 5G. Investigating opportunities offered by the Kera digital platform and local district 5G network for management of the smart power grid, optimization, bi-directional energy flows, energy demand side management and demand flexibility.**
Detailed plan	• Current 5G projects in Kera and elsewhere have been investigated and documented. • Literature review on 5G and smart infrastructure conducted. • Opportunities for synergies in energy efficiency, DSM, prosumer transactions and innovative business models identified. • Key stakeholders mapped and documented. • Findings documented, reported and communicated.
Outcome	Enhanced smart infrastructure, such as smarter energy grids, require enhanced use of data and new smart solutions to ensure reliable operation. This requires new solutions for communication within the energy sector, of which 5G is one opportunity. 5G can enhance the grid in the themes of grid control and data collection. This includes use cases in enhanced grid protection, distribution automation and the control and forecasting of renewable production. The opportunities that 5G provides for drone services can also aid in grid inspection and maintenance. The main question that remains is if enhanced mobile communications are a requirement for fairly static infrastructure. Still, 5G has clear benefits when the amount of smart devices that provide data to utilities, service providers, and consumers increases substantially, and opportunities in network slicing provide dedicated channels for integral safety operations via the Ultra Reliable Low Latency Communications (URLLC) slice. The full opportunities of 5G within the energy sector are still to be seen.
Roles and responsibilities	ESP: Main responsibility. Stakeholders.
Outlook (post M36)	The development of smart solutions within the energy infrastructure, together with new developments in the utilization of 5G within these solutions, will be constantly monitored and the literature review will be updated if needed.

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

SPARCS

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	Smart infrastructure requirements for autonomous transport and e-mobility identified. Discussions had 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). A survey to relevant stakeholders conducted. The role of 5G in V2G solutions investigated, and available car battery capacity for energy reserves estimated.
Outcome	The development of autonomous mobility will require enhanced communications solutions from intra-vehicle sensing systems all the way to long-range communication between the vehicles and everything around them, known as Vehicle-to-Everything (V2X). 5G is an enable to this long-range communication section of autonomous transport development. For the foreseeable future, autonomous vehicles will need an opportunity for human control in unexpected situations. Without new communication solutions, this human control needs to be provided on-site. Another opportunity that 5G provides is network slicing, where a dedicated slice of the 5G network is provided for V2X communications to ensure the reliable exchange of operation-integral data. As with the energy sector, 5G provides the most benefits as a critical mass of autonomous vehicles is reached and the rate of data collection and exchange has increased rapidly. Still, the development of new products and infrastructure within the telecommunications and automotive sectors is a long process, and thus stakeholders in both fields have already begun working on the needed enhancements. So far, the amount of research on the opportunities of 5G within Vehicle-to-Grid (V2G) solutions has been low. However, some research has still been made within this field. A massive increase in the number of smart chargers and other required smart devices as the implementation of EV's increases is expected. 5G can enhance the communication between this massive amount of devices. As eV fleets scale up, 5G can ensure reliable communication between the charging infrastructure and the mobile fleets. Still, current state-of-the-art research mostly centralizes on communication within the charging station, and does not consider communication needs for mobile EV's. This research often focuses vehicle-to-infrastructure communication (V2I) and autonomous vehicles (AV's), which do not consider grid connection as extensively as other issues, such as safety. Within 5G, network slicing can be used to provide reliable communication solutions to the charging infrastructure as the amount of chargers increases. In addition to network slicing, the added possibilities of edge computing as a 5G service can provide the processing power needed nearby the eV users. Edge computing is proposed as an interesting innovation for EV's due to the high mobility of the vehicles themselves, in addition to the EV-situated computing power needed to make decisions on charging and discharging based on user preferences and grid condition. These decisions also need to be made in real-time due to the nature of electricity trade, thus

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

	providing a need to construct a communication network that minimizes delay in V2G communication. From the analyzed research, an intent to overlook V2G when piloting 5G solutions for mobility can be seen, as V2X and autonomous mobility are much more viable options for research in the sphere of 5G and mobility. However, the role of 5G within the enhancement of V2G communications can be substantial as the amount of EV's in circulation increases. Still, the full role of 5G is only seen as the implementation of the V2G services continues.
Roles and responsibilities	ESP: Main responsibility.
Outlook (post M36)	The development of autonomous mobility and Vehicle-to-Grid solutions, together with new developments in the utilization of 5G within these services, will be constantly monitored and the literature review will be updated if needed.

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	A literature study was conducted and blockchain model architecture was compiled and explained. A SWOT table for blockchain utilization in Kera was completed. Blockchain solutions for electrical and thermal energy transactions and flexibility aggregation in Kera were analyzed. Costs and benefits were identified. Legal barriers were investigated. Ref: Action E15-2 blockchains for city-wide DSM.
Outcome	According to the completed feasibility study, blockchain can be a beneficial solution for the energy sector, as long as the chosen use cases are targeted with the benefits of the solution in mind. The most beneficial solutions are focused on situations where differing parties need to act together on a trusted basis without a central authority. An example of this is a P2P transaction platform for prosumers. However, blockchain still has many technical, regulatory and knowledge-based constraints that need to be solved before full scalability is achieved. In the end, it was clear that the increased cost-efficiency and uptake of distributed power and heat generation will depend on the enhancement of blockchain as a solution, as the technology still has some issues with scalability. The identified pros and cons prove that blockchains can ensure prosumer model transparency and verification functionality. However, the transparency of blockchain can sometimes be interfering with Finnish regulation.
Roles and responsibilities	ESP: Overall coordination. VTT and Siemens: technical support. Stakeholders.
Outlook (post M36)	Opportunities on implementing the identified pilots during future activities will be constantly monitored, and results are reviewed and discussed according to the devised roadmap. The landscape around the blockchain

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

	technology will be monitored and the literature review will be updated if needed.

4.4 Smart Building Energy Management

Subtask 3.3.3 about Smart Building Energy Management demonstrates how domain knowledge and real-time monitoring of elevators, escalators and people flow enables the creation of novel data sources to be employed in modern Smart Building Energy Management systems.

The aim of this task was on technological enablers and collaborative development activities to achieve low-latency and robust methods of data integration. As a result, the created solutions can also be seen to reduce the need for additional physical meters and other costly sensors, while providing additional value from the existing equipment.

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 to 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.
Outcome	The scope of the action was on technical demonstration. Main outcome of the work is a live setup running in Sello, where the power forecast of an elevator group is used to control the power demand of a selected controllable device (air-handling unit) or system via the Siemens platform in order to limit the total peak power. Second outcome of the action is a power demand–based people counting solution for escalators and moving walks, which reduces the need for additional people counting sensors and potentially, in the long term, improves the decision making of the aforementioned self-learning algorithm of the VPP. Both solutions are discussed in more detail in deliverable D3.4.
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): Testbed for implementing the on-site communication system with high-end monitoring and control capabilities on existing Siemens platform.
Outlook (post M36)	Monitoring the performance of the solutions in Sello will be part of WP2. Analyzing the business potential of the solutions continues within SPARCS.

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

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, or ‘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. The task also aims to look into the future and examine how the urban mobility systems are changing as the service-based mobility behaviour and electrification of all vehicle types are progressing rapidly globally.

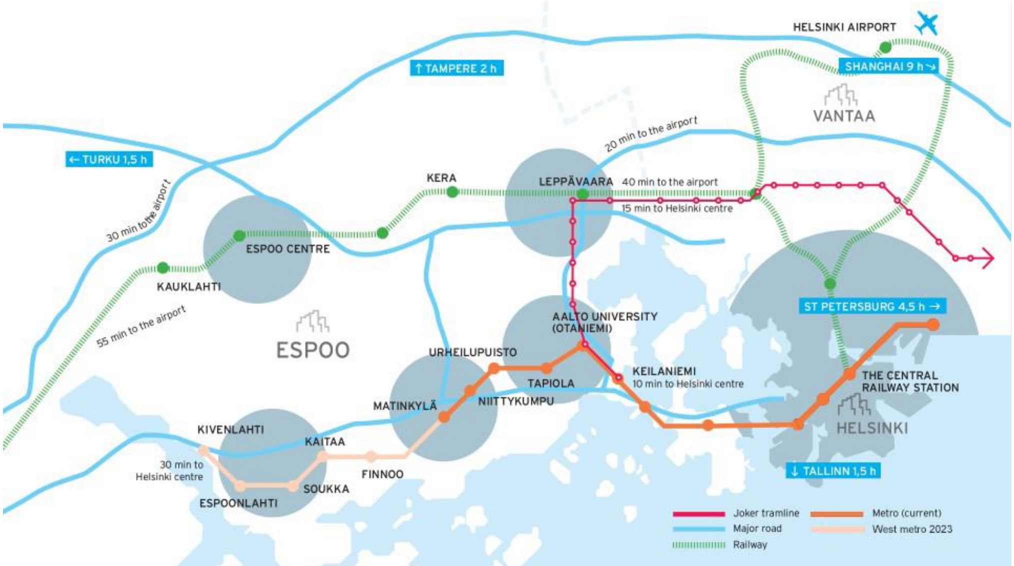


Figure 20. The five urban centers of Espoo: Espoo Centre, Leppävaara, Tapiola, Matinkylä and Espoonlahti (in clock-wise order). The existing rail-based connections between the centers (and the neighboring Helsinki, Vantaa and Kauniainen cities in the capital Helsinki Metropolitan Region) will be complimented by the West Metro extension in 2023 and the 'Joker' fast-tram line in 2024. Source: City of Espoo

Espoo city is characterized by five urban centres that are actively developed as service, workplace and residential nodal areas (Figure 20). Four of the five centres are already connected by rail to the other centres and the region, and by 2023 all centres are expected to have rail-based public transportation, providing the basis for sustainable travel behaviour. A train connection links Espoo centre, Kera and Leppävaara - which of the two latter are location of the SPARCS demonstration area Sello blocks and Kera area - and a relatively new metro line, opened in in 2017, connects Tapiola, and Matinkylä centres. An extension of the metro line under construction will connect Matinkylä to Espoonlahti - the location of SPARCS demonstration area Lippulaiva blocks - in 2023, and a fast tram line will further connect Leppävaara and Tapiola centres. This network of rail-connections, i.e. fast and reliable public transportation, makes it possible to develop dense and mixed-use urban cores that favour sustainable

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

modes of mobility: public transportation, walking, bicycling, different shared (e-)mobility services as 'last mile' solutions, and e-mobility in general. The redeveloped smaller Kera area - a SPARCS demonstration area - represents this sustainable mobility planning idea as it is planned to be walking, bicycling and public transportation focused area from the start.

In 2021, transportation caused around one third of the greenhouse gas emissions in Espoo[2], which means that mobility plays a key role in the city's carbon neutrality target 2030 and beyond. The Covid-19 pandemic has an effect on the emissions, causing a temporary drop as people moved less in the early stages of the pandemic, but these numbers are again on the rise. However, public transportation still struggles to achieve the same user level as before the pandemic.[3] The role of transport in the city's overall emissions is expected to increase in the near future as steps in the heating energy sector have been taken to decrease the emission in major leaps, for example, as the use of coal in heat production in Espoo is planned to end in 2025. In the mobility sector, similar major singular actions are more difficult to achieve due to the scattered sources of energy consumption (as individual vehicles) rather than singular larger systems. Influencing mobility behaviour - active mobility modes, shared mobility services and public transportation, and electricity as a powertrain - and creating environments and urban structures that support this behaviour are thus essential.

The Task 3.4 on *E-mobility integration* 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 scenarios, and the future potential of electric mobility solutions are mapped and assessed, and their prospective applications for replication are examined. The overall aim of the task and its Actions 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.

In addition to the direct Action related activities, the Task 3.4 has also co-organized meetings with Leipzig and Fellow Cities on e-mobility development, as well as collaborated with other Finnish Lighthouse cities on mobility themes, mobility hub development in specific.

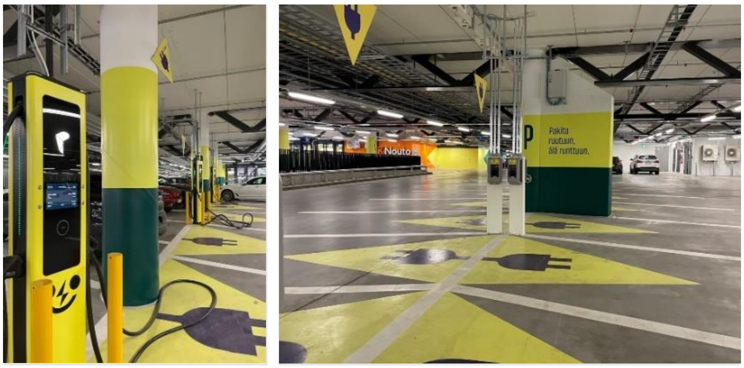
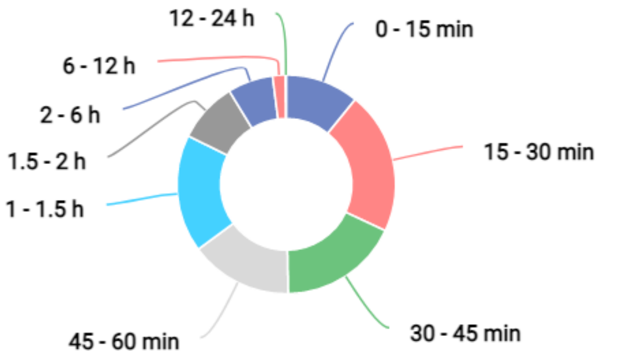
5.2 Boosting E-mobility uptake in the Espoonlahti district, Lippulaiva blocks

This subtask 3.4.1 concentrates on Boosting E-mobility uptake in the Espoonlahti district, Lippulaiva blocks. E-mobility solutions have been developed in Lippulaiva district (shopping centre, residential buildings and senior house) in Espoonlahti area by offering EV parking and charging capacity as well as facilities for e-bicycles. An overview of the Espoonlahti area and Lippulaiva blocks from sustainable mobility perspective have also been drawn and possibilities for further (shared) e-mobility uptake have been examined.

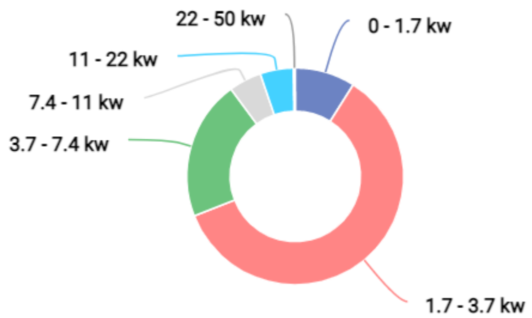
[2] https://www.hsy.fi/ymparistotieto/avoindata/avoin-data---sivut/paakaupunkiseudun-kasvihuonekaasupaastot/

[3] https://www.hsl.fi/hsl/tutkimukset/koronakyselyt

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

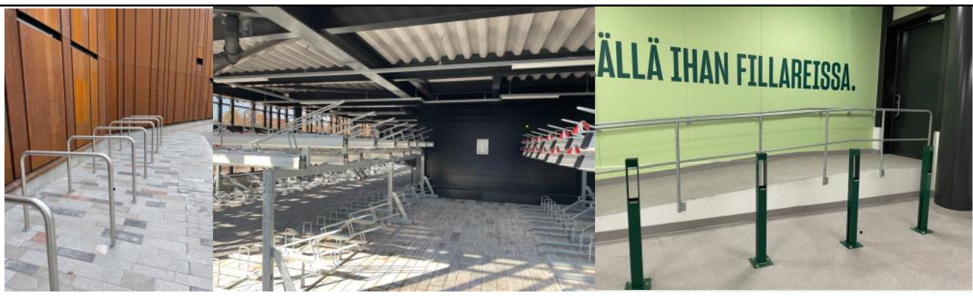
Action E2-1	Integrating and grid impact assessment of community and residential EV parking in the Lippulaiva blocks: up to 140 charging units, currently grid access dimensioned for maximum 400 EV.
Detailed plan	• Dimensioning and designing EV parking for shopping center customers and residential buildings in Lippulaiva. • Designing smart charging infrastructure to EV together with service provider. • Assessing possibilities of Vehicle to Grid solutions in Lippulaiva.
Outcome	To have community and residential EV parking in the Lippulaiva blocks and offer EV charging capacity for Espoonlahti area. 124 charging stations and 10 DC charging stations are installed in Lippulaiva. Charging stations have been available to customer since the opening of Lippulaiva (31st of March 2022). The first residential buildings will be completed in autumn 2022 and after that the residents will also be able to utilize charging stations. There is also a technical reservation for expanding EV charging system.  *Figure 21. EV charging stations in Lippulaiva. Source: Citycon* 

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

	 *Figure 22. EV charging statistics (Transactions by duration and Transactions by average power) from Lippulaiva. Source: PlugitCloud* V2G literature review has been carried out in a separate document. A summary is provided in D3.5.
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.
Outlook (post M36)	Citycon monitors the use of EV charging points and the usage profile through the PlugitCloud portal. Based on that data, Citycon will also assess whether it is necessary to expand the EV charging system.

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. • Assess e-bicycling possibilities in Espoo (integration to city transportation system, integration to existing and future mobility hubs). • Assess the possibility to offer warm storage room for e-bikes. • Assess e-charging requirements and facilities. • Organize a public event in Pikkulaiva for locals where e-bikes and sustainable mobility are presented and promoted, possibility to try e-bikes (in connection to Task 3.6), together with local companies and other stakeholders.
Outcome	Support and develop e-bicycling in Espoonlahti and Lippulaiva area as a 'first/last mile' sustainable urban mobility solution. The new Lippulaiva shopping centre (Lippulaiva blocks) provides parking facilities for 1.383 bicycles (1.363 outdoors, 20 indoors; 533 are under cover). Charging cabinets for e-bicycle batteries provide charging possibilities and safe storage for 10 batteries. Due to challenges of global supply chains, the charging cabinets are not yet in place in Lippulaiva.

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

	 *Figure 23. Parking facilities in Lippulaiva. Source: Citycon* The e-mobility test event (and once already cancelled due to Covid-19 situation in August 2021) for citizens at Lippulaiva premises in August 2022 aimed to bring e-mobility vehicles closer to people and provide first-hand experiences for those who have not yet tried light electric vehicles for themselves. The event was conducted in connection with T3.6 citizen engagement activities (see D3.6 for more details). The current development of e-bicycling in Espoo and beyond have been examined in a separate (internal) report *Electric bicycling and urban mobility in Espoo and beyond* (2022) available in the project resource bank. The report provides background, context and theoretical and case example approaches that can utilized in e-bicycling development. The main elements of the report are presented in D3.5. ESP has organized two (2) SWOT (strengths, weaknesses, opportunities, threats) workshops to examine the potentials and barriers of e-bicycling development in Espoo, and their linkages with the city's *Program for advancing bicycling* 2013-2024, and beyond with 1) SPARCS partners and 2) Espoo's city departments in 2021. The results of the workshops are presented in D3.5.
Roles and responsibilities	CIT: Assess the possibilities to have appropriate parking and charging infrastructure in Lippulaiva, arrange event in Pikkulaiva for promoting e-bikes. ESP: Assess 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.
Outlook (post M36)	No further activities are planned for this Action.

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

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	Develop a sustainability strategy with a focus on 'last mile' solutions and e-bicycles, assessing similar strategies globally for Metro (or similar rapid 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.
Outcome	Insights on Espoonlahti district and Lippulaiva hub development on accessibility, shared mobility services, energy demand and impact assessments and integration of smart charging services have been compiled into a separate (internal) report *Sustainable urban mobility in Espoonlahti : A strategic approach for boosting sustainable mobility in the area* (2022) available in the project resource bank. An internal SPARCS workshops was held to analyze local accessibility with different mobility modes, and to gain insights on the barriers and drivers related to shared mobility services and their uptake in the area. The energy demand and impact assessment of smart charging services was compiled based on the learnings from Leppävaara and Sello demonstration. The insights were gathered into the report. The main elements of the report are presented in D3.5.
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 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. PlT: Support other work in the Action, especially charging.
Outlook (post M36)	The Action is scheduled to continue up to M60. The planned opening of the Espoo metro extension - including the Espoonlahti station at Lippulaiva premises - in 2023 will have a strong impact on the mobility behavior in the area.

Virhe. Viitteen lähdettä ei löytynyt.

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

SPARCS

5.3 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. The subtask includes demonstration of integrating EV chargers to building management system to provide peak shaving, load management and ancillary services. The subtask will also 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 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	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. 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.
Outcome	PIT has built a 3MW charging system for electric buses. This charging system contains five (5) pcs of 350kW pantograph chargers and six (6) pcs of cable chargers. PIT has done analysis of charging needs of different vehicles in EV-mobility hubs currently and in the future. This information has also been used in Action E7-3. PIT has presented the built charging systems to multiple stakeholders and mapped out different needs.

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

	PIT has tested implemented charging system with different vehicles: electric buses, electric passenger cars and electric trucks. PIT has also studied impacts on the electrical grid of this charging system. ESP has organized two (2) SWOT (strengths, weaknesses, opportunities, threats) workshops have been organized to examine the potentials and barriers of e-car sharing development in Espoo with 1) SPARCS partners and 2) Espoo's city departments in 2021. The results of the workshops are presented in D3.5.  *Figure 24. The Leppävaara e-bus charging system. Source: Plugit*
Roles and responsibilities	PIT: Implementing the bus charging system. Gathering data and analysis. EV mobility hub charging analysis. Planning 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.
Outlook (post M36)	Monitoring and data gathering for WP2.

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

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.
Detailed plan	1) Integrate EV chargers to Sello building automation system. 2) Demonstrate peak load management of EV charger. 3) Demonstrate peak-load management on the whole building level with integrated EV chargers. 4) Gather data and analyze results for future cases.
Outcome	To enable EVs participation in peak-load management on the whole building level, understand EV load profiles, integrate EV charging infrastructure as a flexible part of Sello energy system. Sello's 24x22kW AC chargers are integrated to local building management system via microgrid controller, that integrates EV chargers to Sello's peak shaving, load shedding, and as part of the ancillary services offered to local TSO and in the future for local DSO. Solutions permit easy integration of future EV charger infrastructure extensions to energy management system. Integration was done via Open Charge Point Protocol v1.6. Integration of DC and AC chargers and management of the EV charging fleet via Modbus protocol to building's energy management system is demonstrated in E15-1. Research on business models, park and charge concept, dynamic charging and V2G applications was done in action E8-3.
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).
Outlook (post M36)	Iteration of the solution will be carried out. Monitoring of the action will continue in WP2.

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

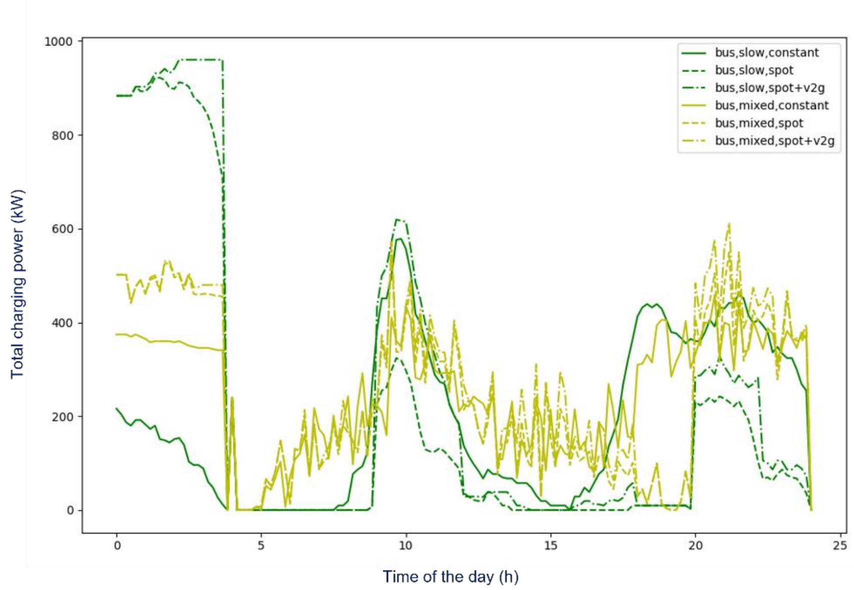
<table>
<tr><th>Action E7-3</th><th>Optimal charging strategies for commercial vehicle fleet. Utilisation of activity-based models for demand response prediction. Plugit Finland will be responsible for developing the services related to electric commercial vehicle charging.</th></tr>
<tr><td>Detailed plan</td><td>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.</td></tr>
<tr><td>Outcome</td><td>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 analyzed different suitable charging strategies with simulations based on Leppävaara area. The outcome was reached by simulating different scenarios with multiple stakeholders and analyzing the outcome.
PIT has analyzed charging needs of different vehicle fleets and mapped out relevant stakeholders in e-mobility hub. PIT has also provided some data from different sites for simulations baseline. PIT has mapped out different services related to EV charging.
VTT has built a simulation model for Leppävaara area and written a summary document based on results.
VTT and PIT have analyzed multiple simulation results and tested different scenarios.


Figure 25. Charging powers during the day for different scenarios with buses. Source: VTT</td></tr>
<tr><td>Roles and responsibilities</td><td>PIT: Analysis of charging needs of a commercial vehicle fleet. Supporting data. Support VTT creating simulation scenarios and analysing the results.
VTT: Building commercial vehicle fleet simulations and analysis of different charging strategies.</td></tr>
</table>

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

Outlook (post M36)	There is no monitoring in this action.

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.
Outcome	As the role of electric vehicles (EVs) in reducing carbon emissions becomes increasingly important, the demand for efficient charging of EVs also increases. Uncoordinated and uncontrolled charging of EVs can lead to difficulties in guaranteeing the quality of the distribution network performance. To overcome this issue, it is possible to influence charging activities by utilizing dynamic pricing based on demand. In addition, charging operation providers face uncertainties in determining charging prices due to volatility in the wholesale electricity price, nature of renewable energy generation, and spatial-temporal EV charging demand. Several dynamic pricing models were identified for an optimal electric vehicle charging strategy and addressing uncertainties related to EV charging. The study concluded that The Real Time Pricing (RTP) model would be a good fit for Sello's dynamic pricing solution for EV charging as it is able to accommodate the different customer profiles when it comes to charging behavior.
Roles and responsibilities	SIE: Do a literature review.
Outlook (post M36)	Review of implementing RTP model in Sello will be studied in further detail.

5.4 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 from a brownfield, logistics and industrial area, into a new vibrant city district during the 2020s and 2030s. This mixed-use area will comprise housing, workplaces and shared cultural and social spaces. The area is already connected by a local commuter train line to the rest of the Espoo city and the overall Helsinki Metropolitan Area which provides unique possibilities for developing the area from a sustainable mobility perspective. The new local centre of the Kera area will be developed around the train station, providing 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 (Figure 26). Kera area is developed in close co-operation between the city and different stakeholders, including landowners, companies, organizations, and citizens.

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

Figure 26. Left: The approved master plan for the southern Kera area. The (southern) station area is being developed into a mixed-use area (marked in the map as Red/C1 Blocks). Right: Kera station area in October 2021. Source: City of Espoo

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 already 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 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	Utilization of insights from the other Task 3.4 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 neighborhoods; LuxTurrim5g/Neutral Host]). Assessing successful multi-modal districts and mobility hubs globally, and the process of implementation through urban planning processes.
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 provides a platform for active dialogue. Insights and learnings for future PED areas from mobility perspective are examined in an urban planning and design context. The current development of mobility hubs in Espoo and beyond have been examined in a separate (internal) report *Urban mobility hubs - a brief review*

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

	(2022) by ESP available in the project resource bank. The report provides background, context and some theoretical and case example approaches that can be utilized in e-mobility hub development (the report also supports Actions E2-3 and E7-1). The main elements of the report are also presented in D3.5. Led by ESP, the Tasks 3.4, 3.6 and 3.8 co-organized a Workshop Series (4 workshops in total) for different stakeholders in 2021 to conceptualize e-mobility hubs and their key elements. The main insights of the workshops are presented in D3.4, see also D3.6 about the engagement process related to the workshops. The workshops examined the prerequisites, enablers and barriers of the electrification of mobility hubs infrastructure (i.e. the hub's 'backstage') as a result of the rapid future electrification of different mobility modes and shared mobility services, and examined the user experience and everyday routes utilizing such e-mobility hubs (i.e. hub's 'the frontstage'). The workshops built on another, the learnings from the previous workshops(s) used in the next one as a base material. The workshops focused on: 1) *Pilot Workshop for SPARCS Partners:* Hub user routes and needs. 2) *Workshop for Citizens/Hub Users:* Routes, habits and needs. 3) *Workshop for Mobility Service Providers:* Infrastructural requirements and needs for service operation. 4) *Workshop for SPARCS Fellow Cities:* Experiences, requirements and needs for e-mobility hubs in different geographical contexts. ESP co-organized mobility-focused working group for Kera multimodal and 'last mile' ecosystem development. The working group was co-organized with other Sustainable Espoo development projects: *Clean and Smart Kera, SixCities: Low-carbon mobility in transportation hubs,* and *Smart Stations*. The working group operated in M9-M19. The group's main task was to identify key elements for Kera mobility development with local stakeholder companies, and to form a shared vision for mobility and logistics in the area in 2030, supporting the formation of the Kera Area Development Commitment that guides the development of the area. The work included workshops-type working sessions and presentations. The learnings and insights from this work are described in D3.5.
Roles and responsibilities	ESP: Main responsibility.
Outlook (post M36)	The Action is scheduled to continue up to M60. The aim is to continue to provide new learnings and insights for the urban mobility and transportation development in Kera area in order to support the further planning and first construction phases of the area, transforming it into a new sustainable urban district with a focus on walking, bicycling and public transportation supported by market-based (shared) e-mobility solutions. The overall Kera area development timeline continues to be highly relevant for the future schedule of these activities.

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

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).
Outcome	Drawing insights from the demonstrated solutions from the other demonstration areas and assessing the implementation of prospective solutions for e-mobility hub development in Kera area. ESP organized a working group in the theme of *E-mobility in Kera*, which comprised of SPARCS partners and the City of Espoo's experts that work with Kera development, including the Kera project manager. The group had regular meetings (organized online), seven (7) in total in 2020-2022. The learnings from SPARCS demonstrations were discussed together with updates from the Kera development process: the themes included mobility probing studies (presented by KONE, also supporting E11-1 in T3.6.), Kera master plan and transportation planning process (Kera city developers), e-mobility charging hub (PIT), 5G possibilities in mobility (ESP), and Kera future mobility demand modelling (VTT). Also two workshop-type sessions were organized on e-mobility hub development and EV sharing, organized by ESP, to further generate insights about the Kera e-mobility development drivers and barriers.
Roles and responsibilities	ESP: Main responsibility. Gathering an overview on the possibilities for replication in Kera area (to support urban planning and design processes). 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.
Outlook (post M36)	The action is scheduled to continue up to M60. The replication potential of SPARCS actions from the other demonstration areas are further examined and communicated in terms of Kera development. As with E13-1, the general timeline of Kera area development (including further planning, approval of master plans, land use processes, initiation of building/block planning and construction) is highly relevant for the processes and contents of the activities here.

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

5.5 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 utilized two in-house simulation methods: activity-based transport model (ABTM) and a vehicle hub simulation model (V2G simulator) which builds on top of the two.

VTT Smart eFleet is a simulation tool aimed for commercial vehicle fleets, and it has been developed for more than 6 years. Based on the knowledge and experience from this tool, a V2G simulator was developed in order to properly model the vehicle hubs of interest in SPARCs. The V2G simulator can take into account vehicles of multiple types, both privately owned and commercial vehicles, and their interaction with the grid at a certain location can be visualised. 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 of study. The model can be adjusted to study the impact of new residential areas or modifications in the public transport network. However, answering some questions with ABTM proved to be difficult, especially due to difficulties of upgrading it for future scenarios. For example, ABTM benefits from detailed simulation of public transport, but creating a public transport schedule for year 2030 proved to above the possibilities within this project. Therefore, it was found that for a study on a general level the following V2G simulator is more useful.

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

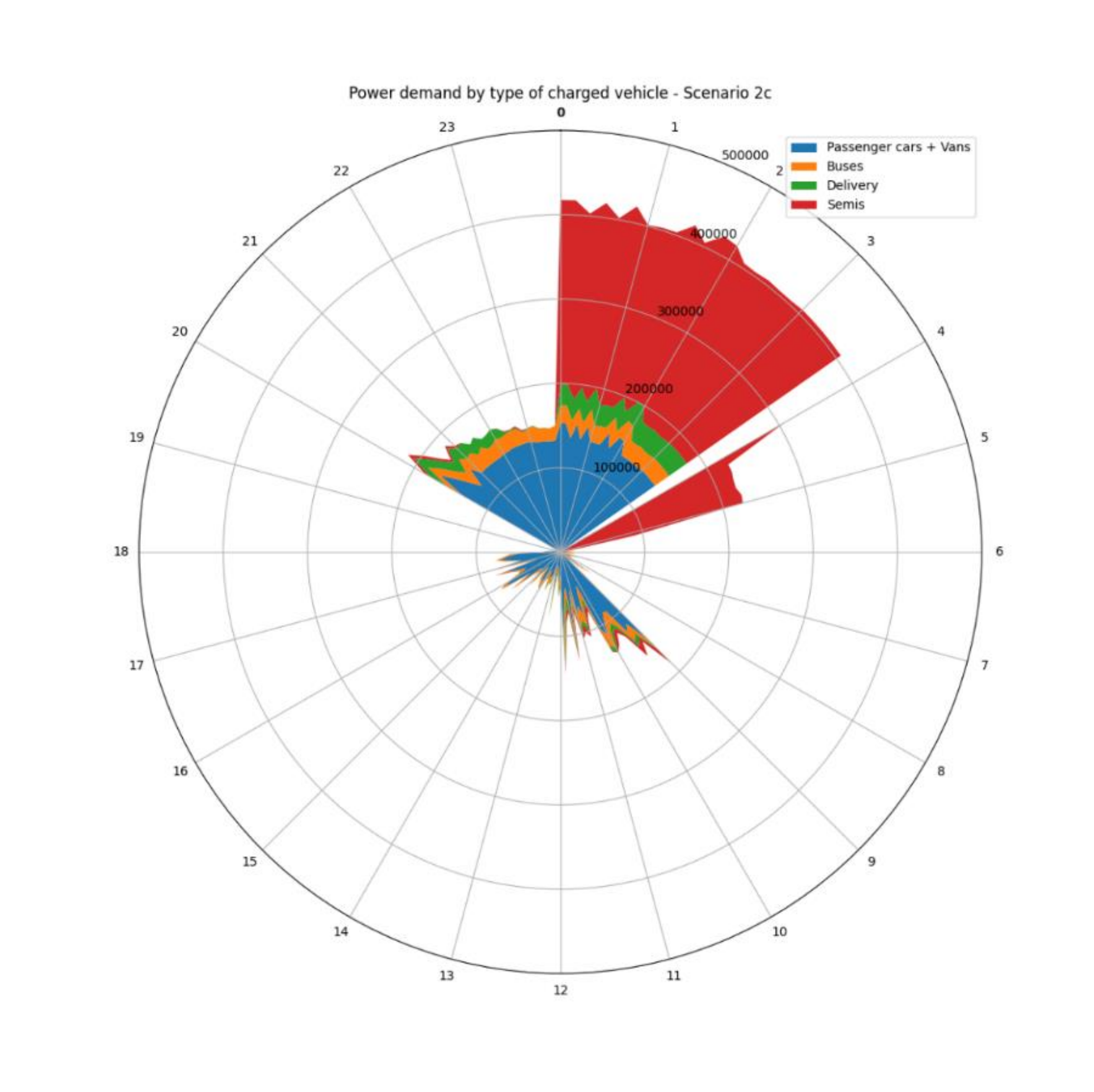
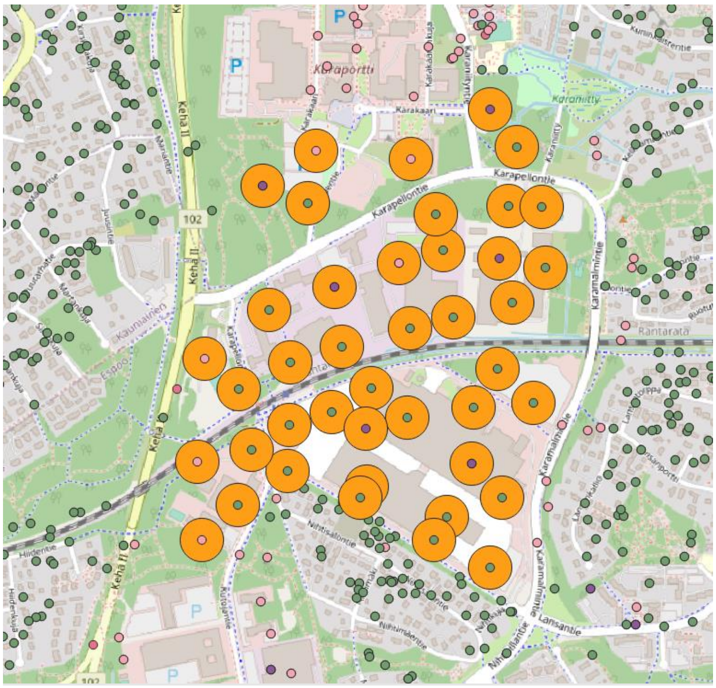


Figure 27. An example of results from the V2G simulator - charging powers for almost all e-vehicles within the Espoo city in full electrification with V2G scenario. Source: VTT

The V2G simulator has been developed to answer questions related to future scenarios about the daily demand coming from the vehicle fleet of Espoo citizen and their charging possibilities. The model also takes commercial traffic into account. The model simulates tens of vehicles at a time (which is later extrapolated to the whole fleet) and tries to find optimal charging curve given their duty cycle, charging possibilities and charging costs. An example of composed results from several model simulations can be seen in the Figure 27. More detailed results from the model are presented in Deliverable D3.5 within the same project.

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

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.
Outcome	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. Kera district in the ABTM model. Visualized with QGIS and OSM map tiles. Source: VTT* In the 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. 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

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

	generate duty cycles of the vehicles interacting with Kera and later on charging curves can be obtained from the dataset. V2G Simulator uses the Kera model simulations to gather mobility data for passenger cars and combines it with the data collected/synthetized for commercial fleets. Combining these sources it was possible to establish the model for the whole city, which given the mixed characteristics of Kera district (mix of residential and commercial/office use) can be applied there as well. From the V2G Simulator simulations the following conclusions can be made: High degree of electromobility is enabled by slow chargers at home/depot and fast chargers at other places of interest with shorter timespans. The scenarios working only with either home charging or fast charging were nearly impossible at least for some type of transport mode. Given the possibility of both slow and fast charging, flat cost for charging yields the most load on the grid, using spot prices leads to smaller peaks in the morning (9-12 in 24-hour system) and evening (20-24) with a huge spike for night charging (0-4). V2G scenario with spot pricing has consumed the most energy for charging since part of the energy has been returned back to the grid in the grid peak times (18-20 in this model). The night peak (0-4) was much more pronounced in the V2G scenario.
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.
Outlook (post M36)	Further simulations will be carried out based on updated data on the electrification rate to estimate the impact on the grid 2030 and beyond.

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

6. Planning of Positive Energy Districts in Espoo

6.1 Introduction to task 3.5

The task *T3.5 Planning of Energy Positive Districts* and its subtask 3.5.1 (Energy Positive District Planning) focus on the development of urban planning methodologies for smart city development.

When planning a positive energy district, different aspects such as: the geographical location of the district and its properties, the renewable energy environment, population, energy consumption behaviour, costs and regulations, need to be considered. Energy infrastructure like electricity distribution grids, district heating networks, renewable gases, and others lay 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. One important aspect when developing PEDs is the improvement of the energy performance of the already existing building stock. Three-dimensional illustrations of the existing building stock can help to recognize potential buildings, that are e.g. in need of an energy renovation. 3D models may also enable the development of comprehensive urban energy strategies, by localizing energy saving potentials but also by visualizing and simulating bigger building blocks or districts.

Next to energy related developments, the future urban sustainable and smart districts also need to incorporate other elements of city development, such as mobility, housing, services, green-and-blue infrastructure and public space design, to create liveable and attractive areas for citizens. Only then, these districts can operate as a functioning system of interconnected sustainable and smart city solutions. As for PEDs, active interaction between energy generation systems, energy consumers and energy storage within a district, are of great importance. Essential part in understanding the wider context of an existing urban district, identifying priorities and most urgent needs to address in designing and planning of a PED, is to include the perspective of citizens and end users of the district itself.

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

6.2 Energy Positive District Planning

The subtask *3.5.1 Energy Positive District Planning* is divided into three actions that aim to support the development and the implementation of tools for energy positive block development (mainly action E17-2) and new models and methodologies for smart city planning (mainly action E22-1). Action E20-1 focuses on identifying smart building requirements for the Finnoo district with the aim to replicate local energy solutions. Activities within the subtask 3.5.1 go beyond project month M36 and will continue until M60. The actions are presented in more detail in the following tables.

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.

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 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).
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)

[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

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

	• 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)
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 aimed to clarify how CityGML could support low carbon urban planning and block/district level energy analysis. To do so, an existing building block consisting of seven buildings was chosen to carry out a block-level 12-month simulation. The seven buildings selected are: two schools, a kindergarten, a swimming hall, an ice hockey arena as well as a rescue and fire facility. All the buildings are connected to district heating. At first, data from the existing public 3D city model as well as additional data on annual energy and water consumption were collected for each of the buildings. Next, a set of different technologies (such as: energy efficiency improvement measures and local energy production measures) supporting local PED development was identified. To carry out the block-level 12-month simulation, a simplified building energy consumption model implemented in the Apros software was adapted as python scripts. The results have been visualized on a map using the QGIS python console. The simplified model was created using the parameters contained in the CityGML files as well as the modelling parameters that are defined for each building type. To evaluate the accuracy of the model, simulated energy consumption data were compared to the actual, measured consumption data of each building. On-site energy ratios were calculated for each scenario, considering the above-mentioned measures and set of technologies. The results were also presented to the public works department of the City of Espoo. A more detailed description of the analysis and the modelling results can be found from Deliverable D3.4.

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

	 *Figure 29. Visualization of results overlaid on a map of the case area (one selected on-site energy ratio for electricity after window improvements). Source: VTT* This work provides a good practical use case for collecting and incorporating needed building and energy related semantics into the CityGML. Geographic and building data combined with energy simulation results allow not only for technical assessments but also -when combined with cost data- for economical assessments. Such assessments based on local specifics can help in all kinds of decision-making processes.
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.
Outlook (post M36)	There are no further analyses planned to be made after project month M36. However, modelling results will be validated and discussed furthermore to evaluate how these results can support future development work related to the city's 3D model and energy data base.

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.

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

SPARCS

Outcome	In Finnoo, an exemplary area for sustainable development in Espoo, sustainable energy solutions are constantly being developed. The goal is to make Finnoo a pioneer of sustainable urban construction. The construction work will be steered by low-emission, sustainable solutions, ranging from planning to energy use and building materials. Among other solutions, the area will have district heating and district cooling systems, aiming to retain the energy in closed circulation. At the same time as replication plans for the Finnoo area are being developed, plans to build Finland's first geothermal local heating network in the Finnoo-Djupsundsbäcken area were finalized. The energy solution will provide emission-free heating and cooling for a total of six apartments. Successful implementation of this solution will provide excellent basis for replication activities. Additionally, energy efficiency- as well as sustainability criteria for buildings were defined for developers of the Finnoo district. Builders selected to build Finnoo are required to commit to solutions that improve the energy efficiency of the buildings, one example of which is the measurement of their energy consumption. These requirements will accelerate the energy efficiency and the sustainable development level of the construction process above average. Co-operation between SPARCS, the city planning department, and the area project management has been intensified. Recently it was recognized that there is a need to update the already existing energy efficiency- and sustainable criteria for buildings, which have been defined for developers of the Finnoo area. The intension is to update the energy efficiency criteria in collaboration with the planning department and the area project manager of Finnoo.
Roles and responsibilities	ESP: Main responsibility. Stakeholders: Propose new solutions.
Outlook (post M36)	Continuous development of replication strategies and plans based on solutions developed and implemented in Finnoo. Updating the energy efficiency criteria for builders in the Finnoo district.

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. The model will first be made for Kera and only after that, a more general model for whole city of Espoo.
Outcome	The main goal of the co-creation model is to present ways and tools on how to develop urban districts as sustainable and smart city areas in co-operation between the city organization, companies, educational institutions, research institutes, other organizations and associations, and citizens. Instead of developing separate solutions within city districts, the model aims towards a more holistic approach to city planning, where smart and sustainable solutions are developed together as integrated, interacting and supporting parts within smart city areas, forming a larger smart city ecosystem. Developing such a smart city area as a whole required new tools, practices and processes of co-

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

	creation and dialogue to connect the different stakeholders, builders, investors, policy makers, organizations and citizens together in the city planning. This process covers the whole life cycle of the area from the initial planning to the in-depth design, construction, and use and operation phases. The actual development process to create the co-creation model was started in December 2021 (M27), after the subcontracted party (WSP Finland) was chosen through a tendering process. The co-creation model development process is planned to be finished by December 2022 (M39). By the project month M36, a total of four workshops was held in form of Design Sprints. To enhance communication and engagement activities, a steering and sparring group was formed, and regular Coffee Talks have been held. Citizens have been involved through a separate process, including a questionnaire and an organized online-event. A more detailed description of the co-creation model process, including stakeholder engagement, can be found from Deliverable D3.6. For thematic results, see D3.4 on energy and D3.5 on mobility.
Roles and responsibilities	ESP: To tender and choose the service provider for creating these models, and work together with the consult to develop the model and disseminate its results. Stakeholders: To participate in the co-creation process.
Outlook (post M36)	M39 More general model for City of Espoo finalized: the model will be further elaborated on, and it will be fitted to suit different kind of areas in Espoo (and beyond). In general, the development work will continue up to December 2022, when the final model will be ready and available on a separate web page (https://co-creatingsparcs.fi) for open use. In addition to the visualized model, the process will also result in a virtual toolkit for supporting the development of sustainable and smart urban areas. M40-M60 Internal work, communication to introduce models to different stakeholders in city organization, as well as outside the city organization.

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

7. COMMUNITY ENGAGEMENT IN ESPOO

7.1 Introduction to task 3.6

The objective of task 3.6 was to engage citizens in the energy transition in Espoo, through different channels and engagement processes focusing on diverse citizen groups. Furthermore, the task aimed to ensure a continued sustainable lifestyle, with a special emphasis on urban mobility behaviours and citizens' daily journeys. The task was 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 completion of the task followed 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 guided the user studies. The user studies provided 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 and co-design workshops were organized. The design sprints gathered all relevant stakeholders (identified through expert interviews, user studies and business model co-design) into the ideation and validation of innovative solutions for future sustainable mobility in Espoo, more precisely in Leppävaara and Espoonlahti. In addition to the aforementioned actions, a Buddy Class concept was developed, and educational workshops with young people as well as events for locals to present and test sustainable mobility solutions were arranged. The process led to two workshops on 1.5 degree lifestyles in which the citizens of Espoonlahti and Leppävaara were designing roadmaps to reduce their household's related CO_2e emissions by 2030. The results were validated by conducting a follow-up study to see how the actions planned on roadmaps were implemented by the household members. As an end-result of citizen engagement and mobility research, a sustainable mobility pilot was organized in collaboration among KONE, the City of Espoo, mobility data company Moprim ltd. and a local basketball club Tapiolan Honka. By engaging diverse stakeholders into the design thinking process of task 3.6, a bottom-up collaborative approach for creating sustainable change was enabled.

Based on the gathered knowledge as described in the sections below, a great number of scientific articles, news posts and webinars were published focusing on citizen engagement and business model co-design in Espoo. A detailed list of the results and published articles are presented in Deliverable 3.6 *Optimizing People Flow and User Experience for Energy Positive Districts.*

The Covid-19 pandemic had a great impact on the plans, for example face-to-face engagement meetings (e.g. workshops or information events for city dwellers) were cancelled and different ways to involve citizens, for example through online tools and platforms were implemented in its place.

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

7.2 People flow and daily journey

The subtask 3.6.1 *People flow and daily journey* aimed 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 was achieved through initial mobility research, starting with lead user studies and mobile probing with citizens of Leppävaara and Espoonlahti. Followed by more detailed studies on micro mobility, shared mobility and mobility hub development. Following the research findings, workshops, concept development 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 were evaluated in business co-design workshops with diverse stakeholders to form macro level conclusions and insights that were conveyed to city planning authorities and disseminated through webinars, research articles and newsletters. As final outcomes of the citizen engagement activities, Citycon and Espoo have developed Buddy Class engagement format that has been implemented with two school classes in Espoo, KONE has organised 1.5 degree workshops with D-Mat Ltd. and a follow-up study to facilitate behavioural change towards lowering household-based carbon emissions in Leppävaara and Espoonlahti areas. Final citizen engagement demonstration in Espoo included also an 8-week sustainable mobility pilot organised by KONE and implemented in collaboration with the City of Espoo, mobility data company Moprim Ltd. and a local sports club. The pilot was aiming at tracking community-related mobility behaviour and behaviour change in leisure time communities.

In Espoonlahti, the new shopping centre was opened in March 2022 and when fully finished, will include also residential buildings and senior houses. During the construction period as well as after opening of the shopping centre, 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 and local households with Lippulaiva Buddy Class and Buddy Family initiatives. Users' engagement activities were conducted in close co-operation with SPARCS Espoo Lighthouse 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 user studies 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** sustainable behaviour interventions. • 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).

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

Outcome	Through citizen involvement we aimed to engage and encourage citizens' sustainable behaviors. The following engagement activities were implemented and are reported in detail in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* (M36): ○ Mobile ethnographic user study (Espoonlahti) [M11-M15] ○ Micro mobility study (Espoonlahti) [M17-M20] ○ Shared mobility study [M11-M20] ○ 1.5 -degree workshop and follow-up study (Espoonlahti, Figure 30) [M24-M36]  *Figure 30. 1.5 -degree workshop for households in Espoonlahti. Source: D-Mat & KONE* ○ Sustainable mobility concepts [M24-M32] ○ Test day for electric vehicles [M35] ○ Buddy Families [M16-M36] (Citycon and Espoo City Library) ○ Lippulaiva virtual room [M16-M32] ○ Actions to promote PED solutions for Espoonlahti citizen: Online event “Lippulaiva LIVE”, a playground area for kids with the sustainability theme, info screens with the sustainability theme (2021-2022)
Roles and responsibilities	CITYCON was responsible for planning and conducting engagement actions in Lippulaiva and Espoonlahti area. KONE was responsible for planning and conducting the user research and design sprints/workshops and for testing the developed lead user solutions. VTT provided support in developing the user research method for different citizen target groups. ESPOO was supporting citizen engagement pilots and activities on raising awareness of new and existing solutions.
Outlook (post M36)	Buddy class meetings will continue until 05/2023. KPI data will be collected from the finished activities.

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

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.**
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).

Outcome	As an outcome eight sustainable mobility concepts were defined, identified, developed and validated to support citizens' sustainable mobility behaviours.
	The following results were implemented and are reported in detail in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* (M36):
	○ Mobile ethnographic user study. [M11-M15]
	○ Shared mobility study. [M11-M20]
	○ Sustainable mobility concepts. [M24-M32]
	    ○ Co-designing sustainable mobility concepts based on the previous community engagement studies and related insights.
	    ○ Conducting CO_2e footprint calculations in collaboration with D-mat ltd to validate the developed mobility concepts from a sustainability perspective. [M24-M28]
	○ 1.5 -degree workshop and follow-up study (Espoonlahti). [M25-M36]
	    ○ Sustainable mobility concepts were integrated to the 1.5 -degree game and validated with residents of Espoonlahti. [M25-M26] (Figure 31)
	    ○ The unfolding of (un)sustainable mobility behaviour in six households at Espoonlahti was researched through a follow-up study. [M32-M33]
	○ Test day for electric vehicles. [M35]
	
	
	Figure 31. New mobility concepts integrated to 1.5 -degree game as climate actions. Source: D-Mat

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

Roles and responsibilities	KONE was responsible for planning and conducting the user research and workshops. Citycon was responsible for arranging events for locals where sustainable mobility habits are presented. Espoo supported in organizing the activities with city stakeholders.
Outlook (post M36)	

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.

Outcome	As an outcome eight sustainable mobility concepts were defined, identified, developed and validated to support citizens' sustainable mobility behaviours.
	The following results were done and are reported in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* (M36) in detail:
	○ Lead user study [M4-M7]
	○ Mobile ethnographic user study (Leppävaara) [M11-M15]
	○ Micro mobility study (Leppävaara) [M17-M20]
	○ Peer-to-peer future e-mobility study [M12-M20]
	○ Design for Sustainable Mobility Behavior Change interventions [M15-M25]
	○ 1.5 -degree workshop and follow-up study (Leppävaara) [M25-M36]
	    ○ Sustainable mobility concepts were integrated to the 1.5 degree game and validated with residents of Leppävaara [M25-M26]
	    ○ The unfolding of (un)sustainable mobility behaviour in six households at Leppävaara was researched through a follow-up study [M32-M33]

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

Roles and responsibilities	KONE was responsible for planning and conducting the user research and workshops.
Outlook (post M36)	

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.**

Outcome	As an outcome eight sustainable mobility concepts were defined, identified, developed and validated to support citizens' sustainable mobility behaviours.
	The following results were implemented and are reported in detail in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* (M36):
	○ E-Mobility hub co-design [M17-M25]
	○ Sustainable mobility concepts [M24-M32]
	  ○ Co-designing sustainable mobility concepts based on the previous community engagement studies and related insights.
	  ○ Conducting CO_2e footprint calculations in collaboration with D-mat ltd to validate the developed mobility concepts from a sustainability perspective [M24-M28]
	○ 1.5 -degree workshop and follow-up study (Leppävaara) [M25-M36]
	  ○ Sustainable mobility concepts were integrated to the 1.5 degree game and validated with residents of Leppävaara [M25-M26]
	  ○ The unfolding of (un)sustainable mobility behaviour in six households at Leppävaara was researched through a follow-up study [M32-M33]

Roles and responsibilities	KONE was responsible for planning and conducting the user research and workshops.
Outlook (post M36)	

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

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.
Outcome	The reporting for city planning authorities of Espoo was done through regular meetings in connection to T3.4 and T3.6 by sharing results and presentation material on citizen mobility. The Espoo city planning authorities were met through regular online meetings among the KERA team and relevant city stakeholders during the project [M13-M36]. • City of Espoo organized the meetings in connection to T3.4 and KONE 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 charging and ev-charging solutions which are implemented in Leppävaara, Sello area [M19]. • Espoo presented the e-mobility hub workshop results[M23]. Presentation materials were shared with the KERA team to report the results in visual and easily sharable digital format.
Roles and responsibilities	KONE shared mobility insights from the user research and workshop activities.
Outlook (post M36)	KPI data will be collected from the city planning authorities.

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.
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.
Outcome	As an outcome this action provides holistic understanding of the most potential solutions and eight mobility concepts (presented in Figure 32) that have a balance between the user experience and sustainability aspects for macro level development. Each concept contains a description of the solution, a problem statement, user value and two use cases. The related CO_2e footprint of each concept was also evaluated in Espoo specific household types based on

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

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

today's situation and future prospect in 2030. The footprint calculation data helped to prioritize the mobility concepts, estimate their sustainability impact in Espoo and, through the 1.5-degree workshops, to validate the attractiveness of new sustainable mobility solutions among citizens.

Figure 32. Mobility concepts and themes. Source: KONE

These insights are reported in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* (M36) in detail to enable replication, further development and testing of the developed solutions:

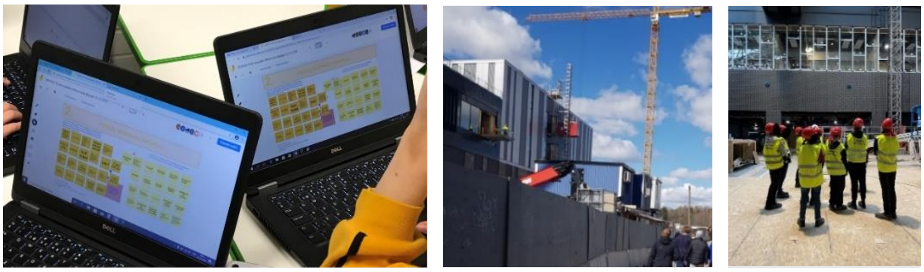
- Mobility hub study [M1-M8]
- Lead user study [M4-M7]
- Mobility expert interviews [M7-M8]
- Mobile ethnographic user study [M11-M15]
- Future material flow study [M12-M20]
- E-Mobility hub co-design [M17-M25]
- 1.5 -degree workshop and follow-up study summary [M25-M36]
- Sports community mobility pilot [M31-M34]
- Inclusive mobility study [M24-M36]

</td>
</tr>
<tr>
<td>Roles and responsibilities</td>
<td>KONE was responsible for organizing user studies and conducting workshops with different partners and citizens. Conducting a pilot with local Espoo sports community. Coordinating D3.6 reporting work, which summarizes the results in for wider replication and further development.</td>
</tr>
<tr>
<td>Outlook (post M36)</td>
<td>KPI data will be collected from the finished activities.</td>
</tr>
</table>

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

7.3 Co-creation for energy positive behaviour

This subtask 3.6.2 Co-creation for energy positive behaviour aimed to engage local citizens of Espoo into co-creation for energy positive behaviour. As part of the subtask, user interviews were conducted to identify solutions for engaging and encouraging energy positive behaviours, design sprints and co-creation workshops were arranged with diverse user groups and stakeholders of Espoo and globally. The local communities have been engaged into planning and building a future energy positive community through a Buddy Class initiative. These actions took place in Espoonlahti, Lippulaiva and Leppävaara, Sello, providing user insights and input for experimentation and piloting in Espoo. 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 chosen 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 centre".
Outcome	Citycon engaged youngsters in development of their own neighborhood with long-term time-scale. Simultaneously educate youngsters in sustainability especially in energy systems and mobility. The following actions are implemented and reported in detail in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* (M36): • Espoonlahti Buddy class [M12–M44] o Meetings with the buddy class about twice in a semester.  *Figure 33. Buddy class activities. Source: Citycon* • Co-creation of Lippulaiva with youngsters (cooperation with Discovering Youth Service) [M24 – M44] o Meetings with the youth about 4 times per year.

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

	 *Figure 34. Youth service workshop in September 2021. Source: Citycon*
Roles and responsibilities	CITYCON was responsible with arranging Lippulaiva Buddy Class action and got help from other SPARCS partners (ESP, KONE, VTT). ESPOO supported matchmaking between young citizens (local schools) and the project. VTT provided support in developing a youth engagement research plan in Lippulaiva, implementing the plan and analyzing the feedback collected.
Outlook (post M36)	Buddy class actions will continue until 5/2023 (M45). Co-creation of Lippulaiva with youngsters (cooperation with Discovering Youth Service will continue until 12/2022 (M39).

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.
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.

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

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

- Buddy class concept introduced to introduce and develop sustainable lifestyle in city of Espoo.

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

Outcome

</td>
<td>

Buddy Class activities:

- Maininki 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.
- Meetings with the buddy class twice in a semester. The goal is to introduce a sustainable lifestyle to young people.
- Actions are part of the citizen engagement plan and Espoo's engagement process.

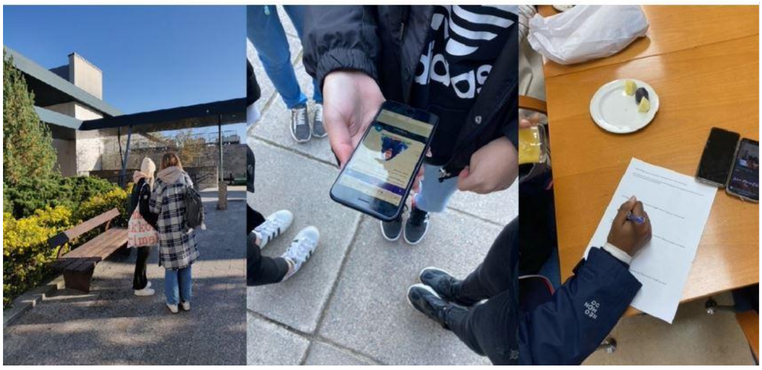


Figure 35. Buddy class actions 2/2021-6/2022. Source: City of Espoo

Webinar series:

- Sustainable lifestyle event series planning began and the survey about the topics was published for the citizens to participate in 9/2021 [M24]. Based on the answers, an event series was built that dealt with sustainable development topics that the residents found meaningful.
- Three live-events that were also livestreamed online were held in 5-6/2022 [M32-33]. Also, the recordings of the events were published in the YouTube channel of the City of Espoo.
- Events reached hundreds of citizens. Recording is the most popular arena of participation.

Figure 36. Sustainable lifestyle event series were held both live and streamed online. Source: City of Espoo

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

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

	E-mobility event • Event was supposed to be held in 8/21 [M23] but due to the pandemic situation it was cancelled and moved to 8/2022 [M34]. • Produced together with Citycon and held in citycentre Lippulaiva in order to introduce a more sustainable lifestyle to the Espoonlahti area. • Citizens had opportunity to test out e-bikes and scooters and learn more about sustainable lifestyle.  *Figure 37. E-mobility event was held in August 2022 in Lippulaiva. Source: City of Espoo*
Roles and responsibilities	ESP: Main responsibility. Engaging different stakeholders into the process.
Outlook (post M36)	Buddy class actions will continue until 4/2023 [M44]. Conceptualization of the buddy class activities 12/2023-4/2023 [M40-46]. Different surveys, articles and communication actions will take place to implement a sustainable lifestyle in Espoo until M60. Energy themed webinar targeted to citizens. Workshop about sustainable lifestyle with elderly (Activist Grannies community).

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

8. AIR QUALITY IN ESPOO

8.1 Introduction to task 3.7

The objective of task 3.7 is to ensure the availability of clean air in the demonstration districts in Espoo. In the capital region in Finland HSY (Helsinki Region Environmental Services) has several air quality measurement points. In addition to these, a measuring equipment has been placed in Lippulaiva to also monitor the local air quality there.

The two demonstration areas are Leppävaara, where Sello is located and Espoonlahti, where Lippulaiva is built. Matinkylä, which is 7 kilometres east from Espoonlahti, is used for reference until the data is received from Lippulaiva.

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.
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.
Outlook (post M36)	The data from the demonstration areas will be continuously collected throughout the project. M 60 Reporting of the air quality in Espoo.

8.2 Air quality in Finland

Air quality in Finland is generally in a good level. The most polluting single factor are the saunas heated with wood stoves. The pollution from traffic has decreased, but there is still e.g. lot of dust from the pavement, especially when winter tires are in use, ozone is formed and NOx emissions exist. To decrease these polluting factors, changing to electric cars will not make very big difference, but if the use of public transportation could be increased and hence the amount of cars on the roads decreased this would benefit the air quality. Also changing the sauna stoves from wood fuelled to electric would benefit the air quality. However, at the moment with increasing uncertainty and very high electricity prices, it might be difficult to motivate people to make this change.

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

8.3 Air quality measurements

The air quality data from HSY gives data for each hour. In the figure below (Figure 38) measurement data is shown for one week in August from Leppävaara, where Sello is located. This data can be used for comparison of the data received through the SPARCS project.

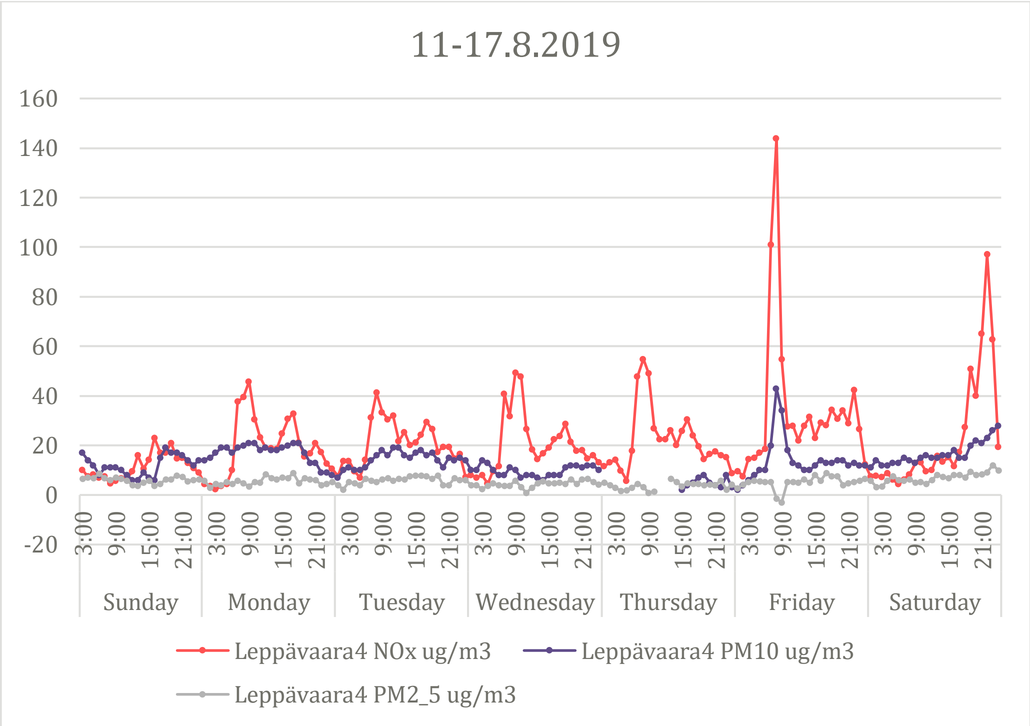


Figure 38. Sample of the baseline data for Sello gathered from Leppävaara by HSY. Data for one week in August 2019, including NOx, PM10 and PM2,5. Source: HSY/VTT

As Lippulaiva was built during the project and there was no measuring equipment, data from Matinkylä is used for the baseline, shown in the figure below (Figure 39).

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

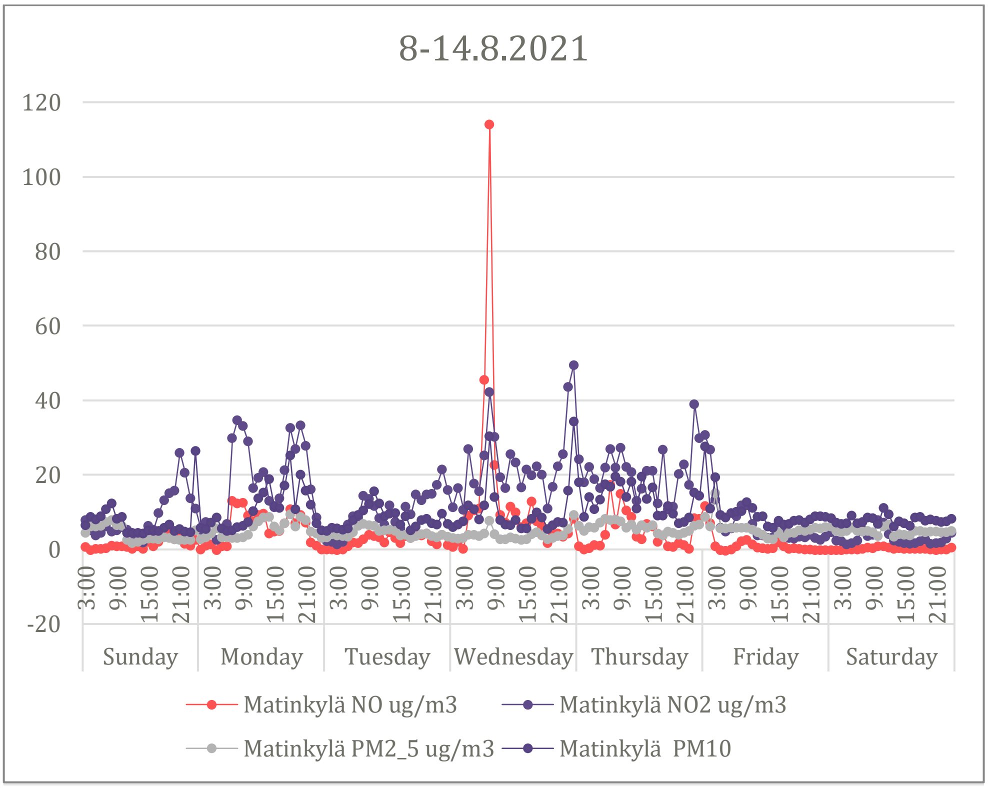
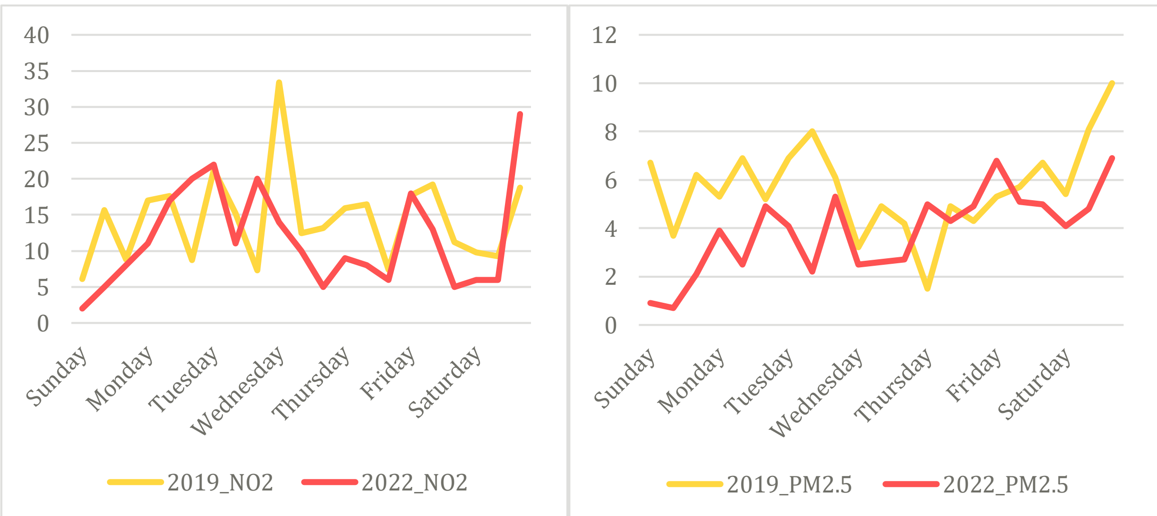


Figure 39. Sample of the baseline data for Lippulaiva gathered from Matinkylä by HSY. Data for one week in August 2021, including NO, NO2, PM10 and PM2,5. Source: HSY/VTT

To follow the air quality during the project, two sets of data are compared in the figure below (Figure 40). They are both from August, 11th to 17th in 2019 and 7th to 13th in 2022 to include one whole week from Sunday to Saturday for both years. This was to make sure weekly variations caused by commuting to work or other activities would show. For each day there are three data points, at 10:00, 16:00 and 24:00.



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

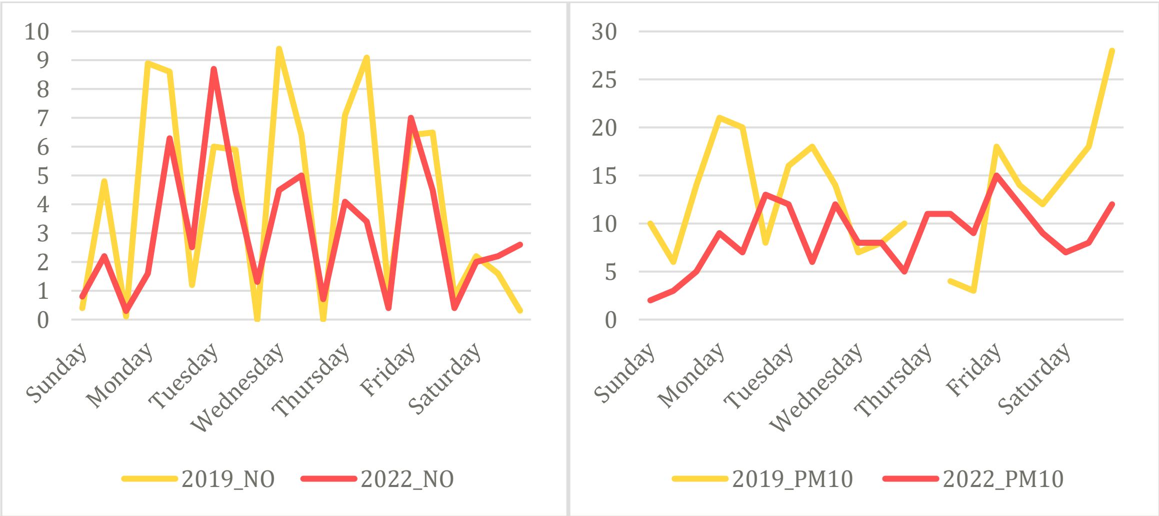


Figure 40. Air quality in Leppävaara in August 2019 (yellow line) and August 2022 (red line) during one week. Source: HSY/VTT

The current data from Lippulaiva starts from September 1st. The measuring equipment was put up in the wall when the building was just finishing is May 2022. For various technical reasons, the data started to flow only in the beginning of September. Initial data points are shown in the figure below (Figure 41).

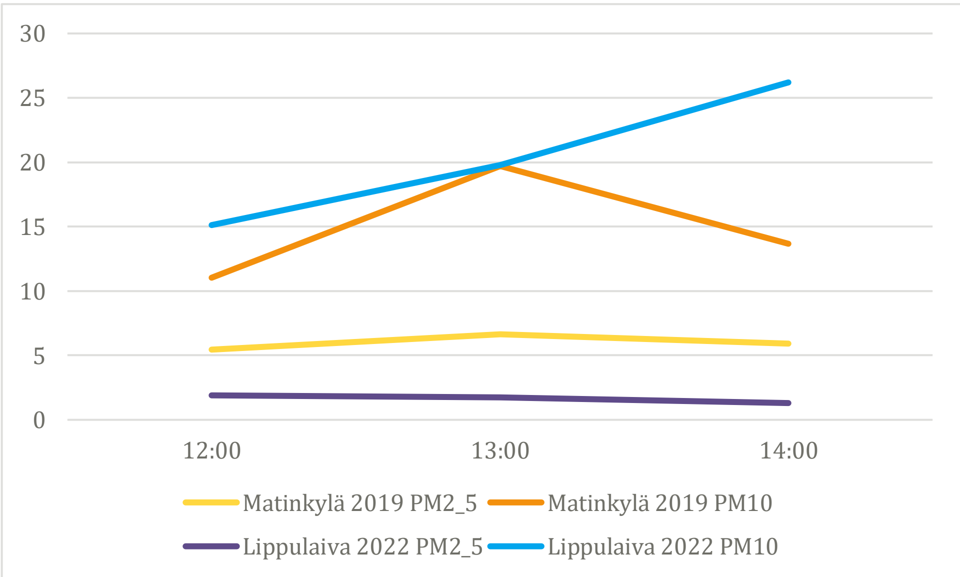


Figure 41. The datapoints from September 1st 2022 from Lippulaiva new measuring equipment and August 15th 2019 from Matinkylä HSY measuring point. Source: HSY/VTT

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

9. SMART BUSINESS MODELS IN ESPOO

9.1 Introduction to task 3.8

The objective of task 3.8 was 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 included three subtasks connected to five different actions where the objective was 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 platforms where various stakeholders are connected forming a larger ecosystem. Through different methods, such as design thinking, business model innovation and sustainable business model design, the task covers actions where the aim is to recognize and identify the elements of sustainable business models that provide new ways of creating value, both economic and social, for the city of Espoo, local businesses and other stakeholders, including citizens.

In addition, this task focused heavily on identifying relevant collaboration partners in the possible ecosystem and supported dissemination of SPARCs aiming to generate and foster new future businesses and business models. The task was thematically closely connected to the Work Package 7 (Exploitation and Business Ecosystems) and hence, partners involved were collaborating by organising a co-innovation challenge process in Espoo and aiming to wide knowledge exchange for example by exchanging best practices across lighthouse cities Espoo and Leipzig and 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* aimed to pilot ways to co-create business models together with different stakeholders. (Lead) users involved in the co-creation were both experts and businesses or public organisation representatives as well citizens. In this subtask, KONE focused especially on mobility, including both people and material mobility. Design thinking and different co-design methods were utilized to create a dialogue and foster collaboration between several stakeholders. The subtask relates strongly to KONE's actions in T3.6 *Community Engagement* and it was built on top of findings gained from the engagement activities with citizens. Due to the Covid-19 pandemic, all business model co-design activities were arranged remotely. The subtask consists of two actions that are similar but targeted for two different demonstration sites, Lippulaiva and Sello. Most of the workshop activities and co-design of new business models have been combined and conducted on Espoo level, covering both demonstration areas.

Actions E4-1 and E9-1 have examined business models from different perspectives while simultaneously engaged several different actors. One of the greatest outcomes of the work was a series of business model co-design workshops held in 2021 with SPARCS partners, multiple mobility stakeholders and citizens of Espoo. The work evolved into refined business model concepts that were validated with diverse mobility

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

stakeholders and citizens. As part of collaboration with the task T7.4 *Start-up process, a co-innovation challenge* was organized in Espoo by KONE and Gaia Consulting. The process and results of Sustainable Mobility Challenge are described in detail in D7.4 *Lighthouse Cities Start-Up Smart City Challenge Report and Lessons Learned* and D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts*.

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 around relevant topics found from user research Expert interviews to support ecosystem mapping and business model co-creation.
Outcome	By engaging users (both citizens and company / other organisation representatives) in co-creation of business models in an early phase, we have researched and developed business model concepts that create value for several stakeholders and piloted ways to co-design platform-based sustainable business models. We have also engaged a wide group of mobility and ICT start-ups and companies via Sustainable Mobility Challenge. The following engagement activities were implemented and are reported in detail in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* [M36]: • Mobility expert interviews [M7-M8] • Peer-to-peer future e-mobility study [M12-M20] • Consortium mobility ecosystem workshop [M15-M16] • Business model criteria workshop [M18] • Business model co-creation workshops with stakeholders [M19-M23] • Sustainable mobility challenge [M21-M32] • Qualitative expert interviews about the future of energy market [M21-M24] • Innovating new Sustainable Business Model concepts [M28-M39] • Moprim co-innovation process [M33-M36] to create a joint ecosystem-based sustainable business model with Moprim and KONE • Co-creation tool based on the "Four Lenses of Innovation" framework • Business model co-design playbook Engaging feedback session on developed co-creation tool in SPARCS Business models and Financing Mechanisms webinar and Start-up challenge webinar.
Roles and responsibilities	KONE was responsible for planning the methods how to engage users and organising the business model co-design work and conducting expert interviews.
Outlook (post M36)	KPI data will be collected from the finished activities.

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

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 (e.g. 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.
Outcome	By engaging users (both citizens and company / other organisation representatives) in co-creation of business models in an early phase, we have researched and developed business model concepts that create value for several stakeholders and piloted ways to co-design platform-based sustainable business models. We have also engaged a wide group of mobility and ICT start-ups and companies via Sustainable Mobility Challenge. The following engagement activities were implemented and are reported in detail in D3.6 *Optimizing People Flow and User Experience for Energy Positive Districts* [M36]: • Mobility expert interviews [M7-M8] • Peer-to-peer future e-mobility study [M12-M20] • Consortium mobility ecosystem workshop [M15-M16] • Business model criteria workshop [M18] • Business model co-creation workshops with stakeholders [M19-M23] • Sustainable mobility challenge [M21-M32] • Qualitative expert interviews about the future of energy market [M21-M24] • Innovating new Sustainable Business Model concepts [M28-M39] • Moprim co-innovation process [M33-M36] to create a joint ecosystem-based sustainable business model with Moprim and KONE • Co-creation tool based on the "Four Lenses of Innovation" framework • Business model co-design playbook Engaging feedback session on developed co-creation tool in SPARCS Business models and Financing Mechanisms webinar and Start-up challenge webinar.
Roles and responsibilities	KONE was responsible for planning the methods how to engage users and organising the co-creation sessions and conducting expert interviews.
Outlook (post M36)	KPI data will be collected from the finished activities.

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

9.3 Smart Otaniemi

Smart Otaniemi is a platform for future-bound smart city solutions that are both sustainable and commercially successful. Smart Otaniemi offer opportunities for co-creation and innovation in a forward-looking environment with top companies, evolving city and cutting-edge research organizations[6].

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 events: open clinic, virtual event, workshops and seminars.

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.
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. Smart Otaniemi was 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 project called KETO together with City of Espoo and VTT, funded with regional funding (ERDF). The Implementation Pathway for Environments that Accelerate Sustainable Growth project creates concrete development environments to promote the green transition and digitalization, Smart Otaniemi as one of the development environments. Development plan for Smart Otaniemi will be created within the project concentrating on themes transportation, energy, and sustainable construction. In addition, Zero Emission Mobility Hub in Otaniemi is planned within the project. Innovations and solutions from SPARCS partners could be part of ZemHub in the future. https://www.espoo.fi/en/kestava-kehitys/implementation-pathway-environments-accelerate-sustainable-growth-keto

[6] https://smartotaniemi.fi/

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

	- SPARCS & Smart Otaniemi webinar on EV charging infrastructure (7.4.2022)
Roles and responsibilities	VTT leading the networking, in collaboration with the City of Espoo and other stakeholders.
Outlook (post M36)	The work is scheduled to continue to M60 with continuous collaboration and seeking to identify new opportunities with relevant stakeholders.

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. The solutions are part of the city-wide and district level urban setting, and connect to local, regional and national carbon-neutrality targets and aims, sustainable mobility framework, and stakeholder engagement.

This subtask 3.8.3 assesses the opportunities for smart business in Espoo, investigates new solutions in the energy and mobility sectors, and coordinates with stakeholders to create an enabling environment for private sector participation.

The work connects also to WP5 replication activities as well as the WP7 work on business ecosystems. The activities also connect to the Task 3.5/.9 activities on developing a co-creation model for smart and sustainable urban areas (E14-1, E22-1), which provides insight on how urban district level development utilizing novel smart energy and mobility solutions can be done in cooperation between the city, landowners, companies, and citizens. Kera as a developing area can provide a fruitful base for new smart and sustainable solution development.

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, developed for the municipal council term 2017-2021 and 2021-2025. 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.
Outcome	Provide possibilities and support for new smart businesses to emerge from the Lighthouse activities.

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

	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 the project resource bank). 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. The report is available in the project resource bank, and the key notions are also covered in D3.6.
Roles and responsibilities	ESP is in charge of the Action. Practical outcomes are done in co-operation with the other relevant SPARCS partners.
Outlook (post M36)	The work is scheduled to continue to M60, and the final results will be presented in D3.7. The further development of the SPARCS demonstration actions in the monitoring phase are followed and the city's role in new business development further assessed. The work connects locally to the WP7 activities on business ecosystem development.

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

10. Replication and exploitation preparation in Espoo

Espoo is committed to achieve 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.

The city of Espoo is actively engaged in projects to support renewable energy, circular economy and low-carbon mobility solutions, with specific budgets allocated to local pilots. The City of Espoo strategy for 2021–2025 was approved by the city council with significant emphasis on sustainability, including the city's climate neutrality target in the year 2030. Espoo's City Council has recently also set the objectives for the Sustainable Espoo programme 2021–2025. Goals of the Sustainable Espoo development programme are closely aligned with the activities and main goals of SPARCS.

In January 2022 Espoo applied to become one of the EU Missions one hundred climate-neutral & smart cities and was successfully chosen as one pioneer city to strengthen the position of local operators and communities, making Espoo a key European experimentation environment for smart and sustainable urban solutions. In Espoo, the agreement will be integrated into the Sustainable Espoo programme and preparation of the roadmap for achieving climate neutrality by 2030. The objective is the long-term development of competitiveness together with companies and the research community. The Mission will help Espoo strengthen the city's role as a cooperation platform and development partner. SPARCS and its activities certainly played an influential role in the application process. The achievements and lessons learned from SPARCS will also provide important input during the ongoing climate neutrality roadmap process of the city.

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.
Outcome	The development of the Kera area 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

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

	stakeholders, including incumbent utilities improve the outlook of system optimization, reliability and replicability, as well as sustainable urban mobility. The on-site follow up of energy infrastructure solutions in Kera has been intensified, as an energy themed expert meeting group was formed. Under the direction of SPARCS, the new group is supporting the development of new energy solutions through co-creation in the Kera area. Additionally, a carbon-neutral roadmap for the Kera district was published in the beginning of the year 2022. The roadmap outlines the climate solutions needed to transform an old industrial area into an urban centre for 14 000 people. Kera and E-mobility group was organized to disseminate the replicable solutions from the other SPARCS Espoo demonstration areas for Kera planning and development in 2021-2022. Furthermore, cross-departmental collaboration with departments of the Urban Environment Division has been intensified. The opportunities on how to support Espoo's carbon neutrality goal by integrating sustainable energy solutions in the urban planning process were already discussed during several meetings and discussions are ongoing. The work on the *Co-creation model for sustainable and smart urban areas* (see E22-1) has brought together SPARCS partners, City of Espoo departments and units, companies, other cities, other organizations and citizens to develop co-creation practices for urban development. The work takes place 2021-2022. Kera has been utilized as a case area in the development of the co-working tools, methods and processes. The cooperation with local grid operators to find energy infrastructure solutions for positive energy blocks has been active. SPARCS also supported the organization of Urban Academy sparring sessions between city representatives and university researchers on sustainable lifestyles and consumption. Urban Academy is a joint network by cities and universities in the capital region. Opportunities for replication and exploitation were identified.
Roles and responsibilities	ESP, stakeholders.
Outlook (post M36)	Cooperation with local grid operators to find energy infrastructure solutions for positive energy blocks continues. Espoo is participating in the EU 100 Climate neutral and Smart cities Mission actively, selected as one of the Mission cities.

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

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.
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. In the past, the City of Espoo engaged with the UNTIL unit in Otaniemi, presented SPARCS and explored opportunities for collaboration. The city's Voluntary Local Review was published, and the City of Espoo was featured at UN High Level Political Forum. In M20 a city internal SDG sensemaking workshop for the SPARCS project group was held in order to recognize the project group's work towards reaching SDGs. Another SDG sensemaking workshop for WP3 partner organisations was held in M33. M36 Evaluation report on the SDG sensemaking workshop, the local and global impact that SPARCS can have on achieving the SDG's, and future potential of integrating SDG sensemaking to Espoo sustainable development projects.
Roles and responsibilities	ESP, VTT, Stakeholders.
Outlook (post M36)	Work to ensure the global impact of SPARCS actions through the UN SDG 2030 network will continue.

The SPARCS action E22-2 aims to coordinate, assemble, and channel the project work towards replication and dissemination on a global level by utilizing the UN Sustainable Development Goals. To achieve this, the City of Espoo assembled the SPARCS WP3 partners together to an SDG sensemaking workshop. The aim of this workshop was to analyze the role and enhanced usage of SDG's within PED development. Within the workshop, SPARCS partners utilized an SDG-Canvas developed within the "The network Strategic Management of SDGs in Cities" -project by consultant Sitowise OY, based on work already done within Espoo.

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

The workshop process is divided into four different steps, as explained below:

- Step 1: Decide upon the goal under analysis and choose one SDG that best describes your activities in achieving that goal. In addition, choose 1-4 supporting SDG's that are associated with your operations, and see what SDG's might be at risk.
- Step 2: Assess how your activities affect the different dimensions of sustainability (ecological, economic, and socio-cultural), and operating environments (local, national and international).
- Step 3: Select the most important targets from your chosen main and supporting SDG's. Write down the activities that you do in your own work to achieve the goal set in this workshop. Create a new shared target by combining the chosen SDG targets and your own activities.
- Step 4: Define concrete measures and actions towards achieving the linked target devised in step 3.

An example of the SDG canvas used during the workshop can be seen in the Figure 42. During the workshop, every participant filled their canvas individually, and the results were presented to the group afterwards. In the next paragraphs, the results of this workshop will be analyzed step by step.

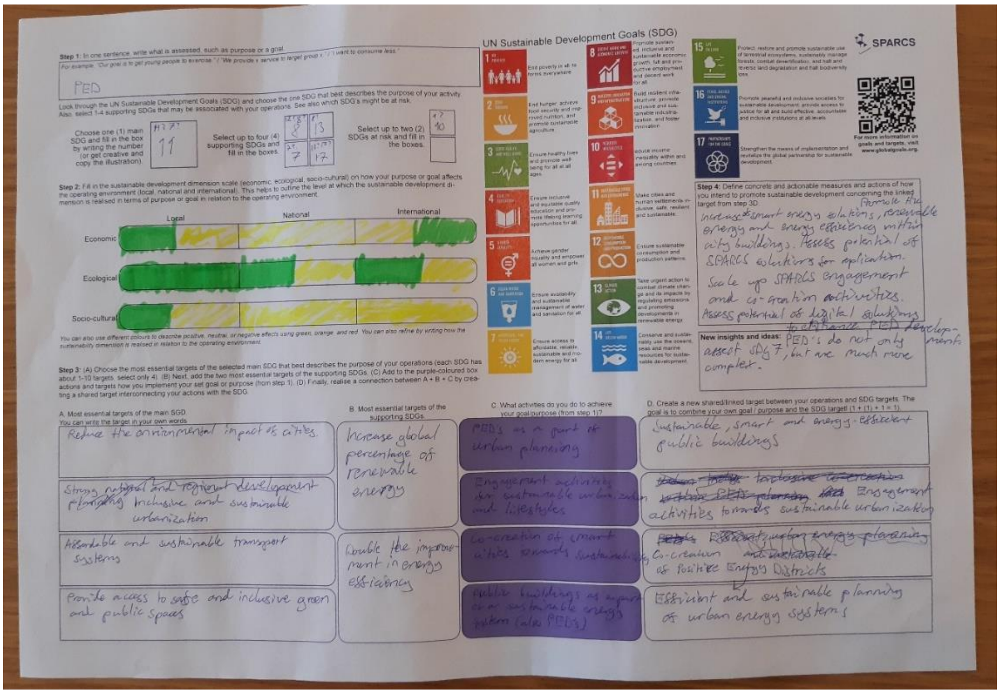


Figure 42. The Canvas used within the SDG workshop process. Source: City of Espoo

Within step 1, the participants chose the main and supporting SDG's for their activities towards achieving the goal set for the workshop. For the main SDG, the WP3 partners were almost unanimous by choosing SDG 11, "Make cities and human settlements inclusive, safe, resilient and sustainable". This shows that all partners thought of the SPARCS PED development activities as a broader concept than just piloting new energy solutions within the demonstration areas. Instead, all partners aimed to further the work towards a more sustainable urban landscape. In addition, many of the participants within the workshop work with the mobility sector, and thus might favor the

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

related targets within SDG 11. For the supporting SDG's, a lot more deviation between the participants was observed. All of the chosen supporting SDG's by the participants can be seen in the Figure 43.

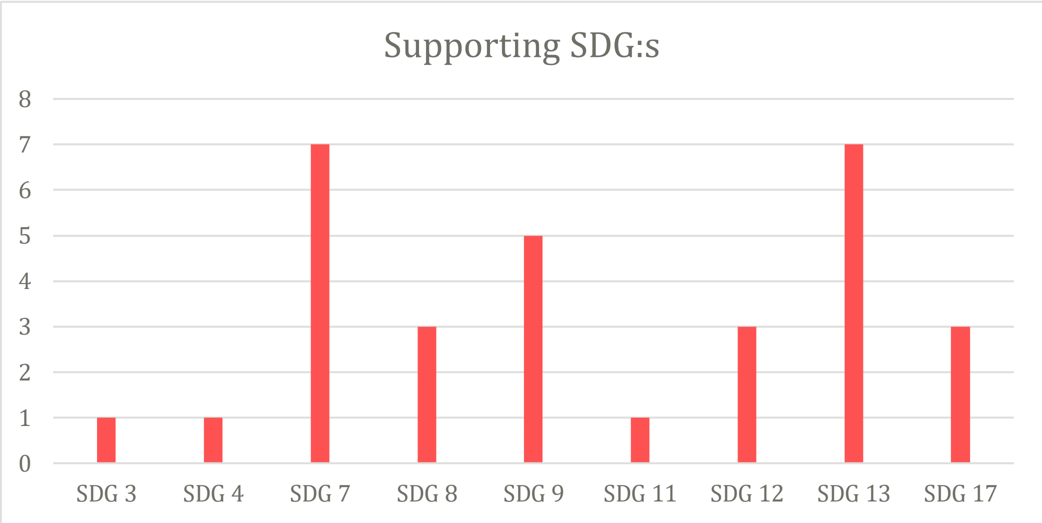


Figure 43. The number of supporting SDG's chosen by participants. Source: City of Espoo

From the figure, we can see that most of the answers preferred three supporting SDG:s:

- SDG 7, "Ensure access to affordable, reliable, sustainable and modern energy for all"
- SDG 9, "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"
- SDG 13, "Take urgent action to combat climate change and its impacts"

Thus, many of the participants saw that their actions were also associated with the work towards sustainable energy, resilient infrastructure, innovation and tackling climate change. This fits together well with the SPARCS actions. The differing choices for supporting SDG:s also shows the different roles that WP3 partners have within the project, as all participants look at the project from their own viewpoints. This also shows that SPARCS can work towards a large portion of the SDG:s through co-operation between all partners.

Within step 2, the participants assessed the positive, neutral and negative effects that their actions can have towards the three different dimensions of sustainability in three different operating environments. For this analysis, we will focus on the answers about the benefits that SPARCS actions have on these dimensions and environments. The participants saw the most positive effects on the ecological dimension of sustainability, with a focus on the local and international environments. Positive effects on the economic dimension of sustainability were also seen on the same two operating environments. However, a low amount of positive effects on the socio-cultural dimension and the national operating environment was observed.

Within step 3, the most important targets within the main and supporting SDG's were chosen. The targets chosen for the main SDG can be seen below in the figure below

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

(Figure 44). A decent spread of different answers was observed, with three targets being the most answered.

- 11.2, "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons."
- 11.3, "By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries."
- 11.6, "By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management."

The thoughts behind targets 11.2 and 11.6 are quite clear when looking into the SPARCS actions and the previous answers. However, the large amount of participants choosing target 11.3 is quite interesting when compared to the answers in step 2 of this workshop. Target 11.3 focuses on participatory, integrated and sustainable settlement planning to enhance inclusive and sustainable urbanization, which seems to have positive effects towards socio-cultural sustainability. However, a very low amount of participants saw positive effects towards this dimension within step 2 of the workshop. Thus, a focus should be had on enhancing the positive effects that SPARCS actions have on the citizens of Espoo through participatory means, to ensure that the goals seen as important by partners take action.

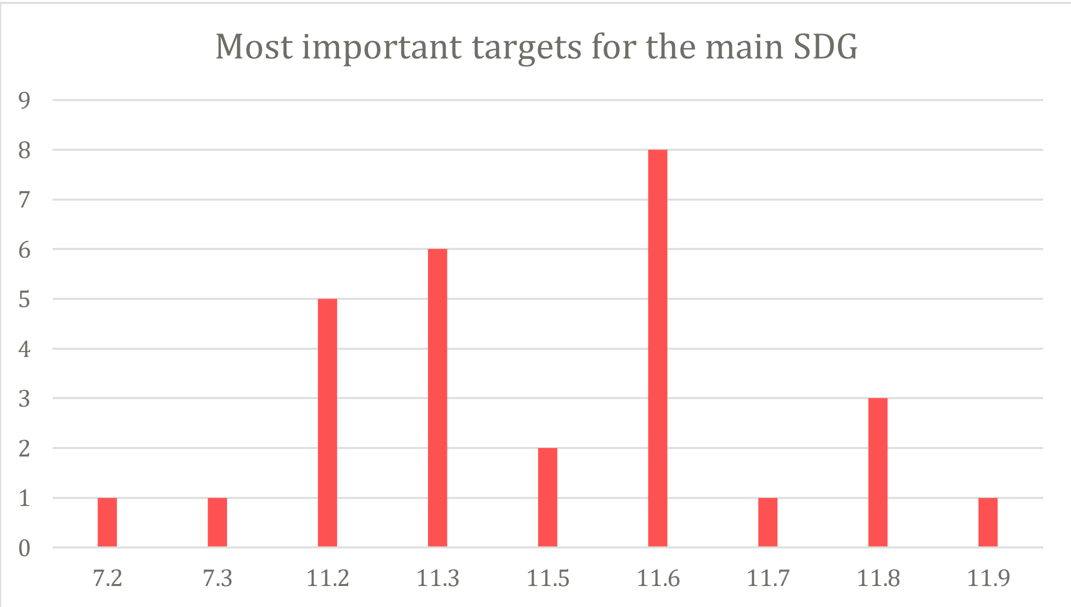


Figure 44. The most important targets of the main SDG chosen by the participants. Source: City of Espoo

The most important targets behind the chosen supporting SDG's can be seen in the Figure 44. A lower spread of different answers can be observed when compared to the different targets of the main SDG. Two targets were seen as the most beneficial towards the partners actions (Figure 45):

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

- 7.2, “By 2030, increase substantially the share of renewable energy in the global energy mix.”
- 7.3, “By 2030, double the global rate of improvement in energy efficiency”

As can be seen above, the most popular answers here focused on targets within the SDG working towards sustainable energy. This is fairly consistent with the SPARCS project work in Espoo, as all demonstration areas within the city have actions towards increased renewable operation and improved energy efficiency. However, a low amount of targets were chosen for the other main goals seen before, being SDG’s 9 and 13. Thus, the participants saw SDG 7 as the clearly most important supporting SDG for their actions.

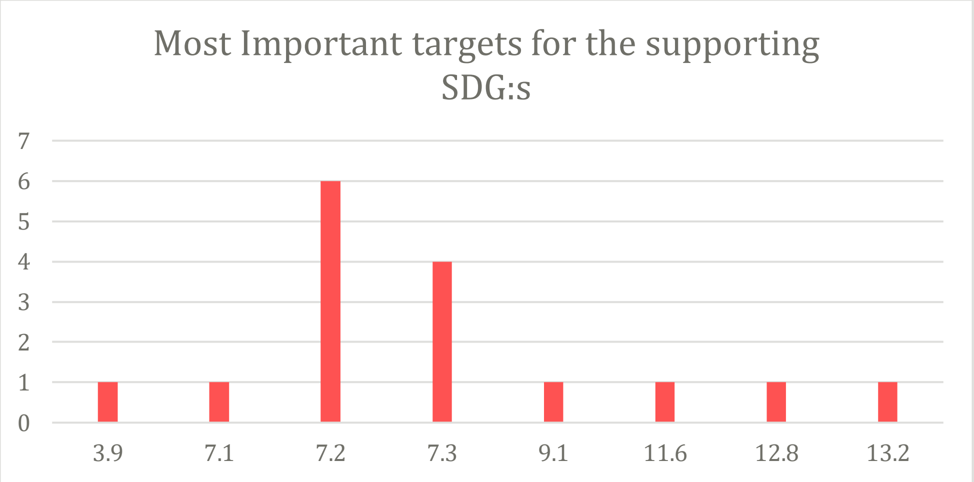


Figure 45. The most important targets of the supporting SDG:s chosen by the participants. Source: City of Espoo

Within the next parts of the workshop, participants looked into their own activities within SPARCS, connected these to the targets mentioned above, and devised future measures and actions for their work towards achieving these new connected targets. The activities written by the participants mainly fitted under three larger themes, being energy, mobility, and networking and engagement. Within energy, most of the activities were evenly divided between the increase of renewable production and energy efficiency, while the activities under mobility focused on charging solutions. These activities were also fairly well-matched to the SDG targets, meaning that it was fairly straight forward for participants to devise their new combined targets.

Finally, some ideas for future actions with SPARCS partners were devised based on these workshop results. Two main activities were seen as important for future work. Firstly, some answers already provided ideas on indicators that could be used to measure the combined targets. Future work could focus on expanding these further and combining them with the indicators already made for the related SDG’s. Secondly, many of the measures and actions devised in step 4 were seen as quite broad, and future work could focus on making more detailed measures that could be better used for the planning the next steps of the SPARCS partners’ activities.

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

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 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.

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

11. CONCLUSIONS

The objective of this report was to give an overview of the smart city Lighthouse demonstration activities in Espoo. The previous project Deliverables D3.1 and D3.2 served as the starting point for this report. The in-depth descriptions of the activities and the implementation processes, together with the gained learnings and insights from these activities, are documented in the thematic Deliverables D3.4 (*Interoperability of holistic energy systems in Espoo*), D3.5 (*EV mobility integration and its impacts in Espoo*), and D3.6 (*Optimizing people flow and user experience for energy positive districts*), also published at the same time with this report. The work on UN Sustainable Development Goals (E22-2) and air quality (E21-1) have been given here space for closer inspection and analysis, as they are not directly covered in the other reports mentioned above.

The demonstration activities overall 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. Monitoring and follow-up of the demonstrations is thus crucial for developing solutions that are also replicable elsewhere. This replication potential is relevant for both local and Espoo-wide scale, as well as on the global level. The Espoo demonstrations have been completed in March 2022, with some minor delays, and the monitoring phase and production of data has commenced in all the Espoo demonstration sites, the Lippulaiva blocks in Espoonlahti, the Sello blocks in Leppävaara, and in Kera. As the three demonstration areas are all in different stages of an urban area's life-cycle - infill, partial redevelopment and full redevelopment of the area - the demonstrations provide valuable insight to energy positive district development that is applicable in different kinds of urban areas as well as in different kinds of development phases.

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

12. ACRONYMS AND TERMS

5G	fifth-generation cellular network standard
ABTM	activity-based transport model
API	application programming interface
AV	autonomous vehicle
BIM	building information model
CAPEX	Capital expense
CHP-bio	combined heat and power production using bio fuels
CityGML	City Geography Markup Language
DH	district heating
DR	demand response
DSM	demand side management
DSR	demand side response
EV	electrical vehicle
HSL	Helsinki Regional Transport Authority
HSY	Helsinki Region Environmental Services
HVAC	heating, ventilation and air conditioning
IoT	Internet of Things
KPI	key performance indicator
LEED	Leadership in Energy and Environmental Design green building rating system
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
SDG	United Nations Sustainable Development Goals 2030
TSO	transmission system operator
VPP	Virtual Power Plant
V2G	vehicle-to-grid
V2I	vehicle-to-infrastructure
V2X	vehicle-to-everything

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