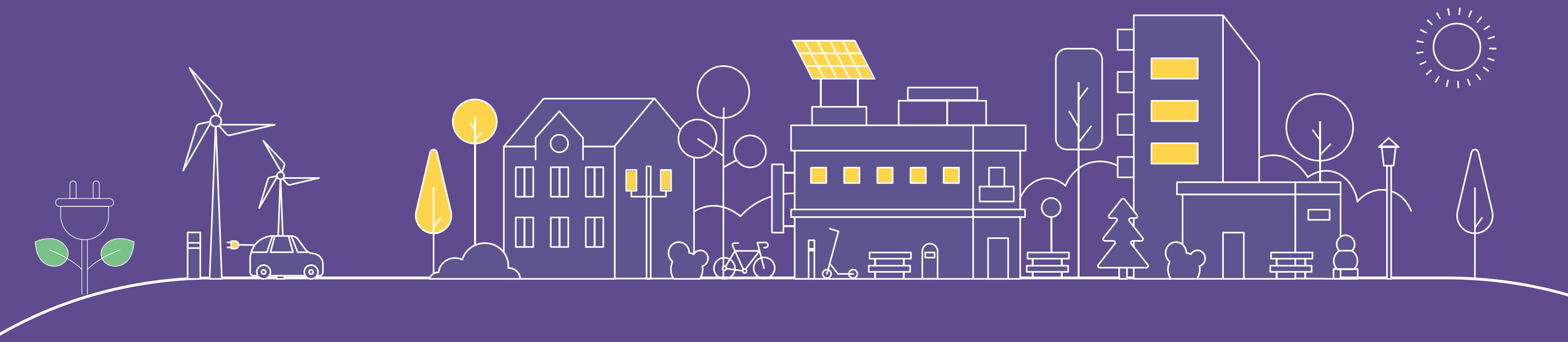
SPARCS



Kera's **Energy Playbook** – Lessons and Application Opportunities for **Kera** from **SPARCS**

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ESPOO
ESBO

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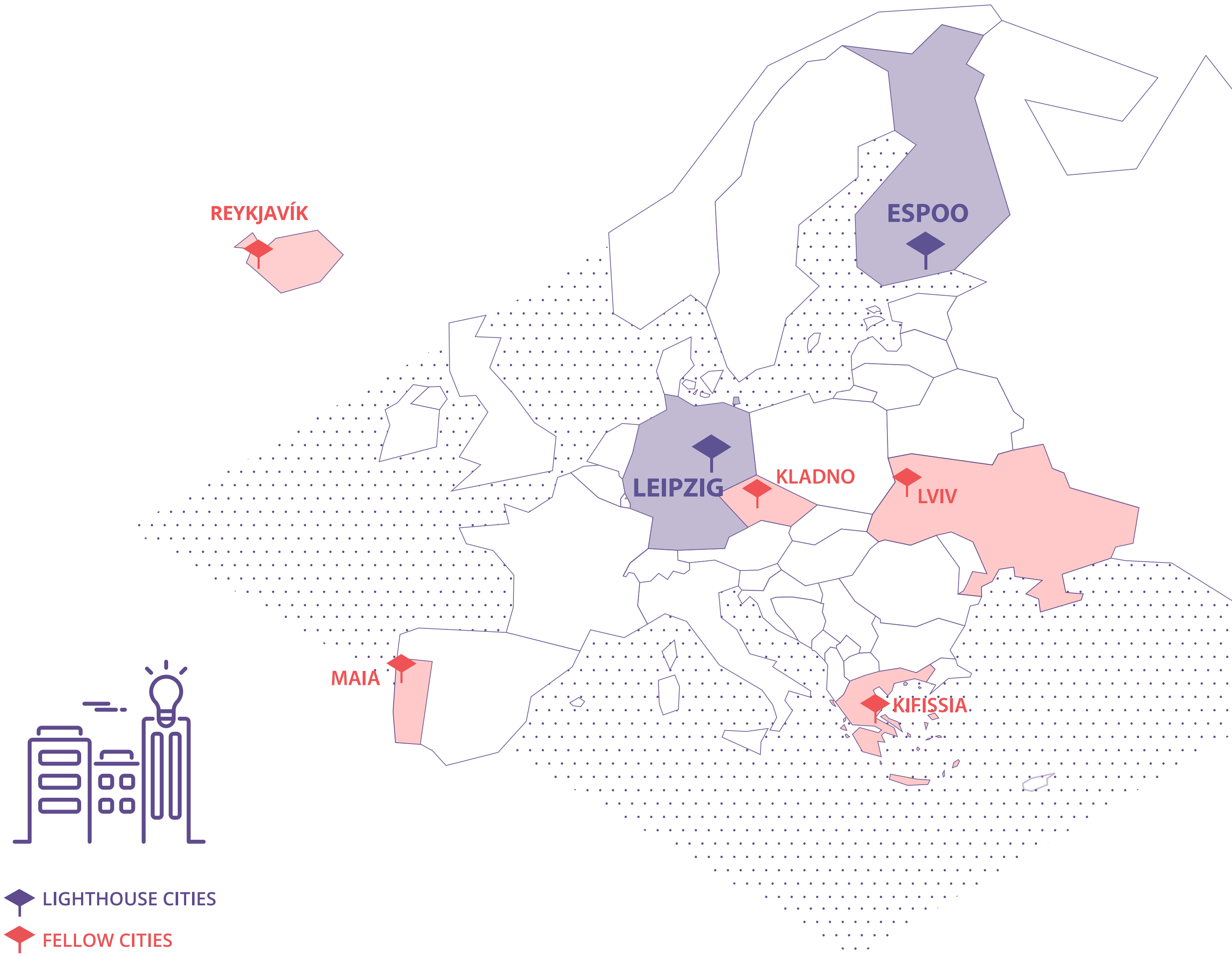
Texts: Joni Mäkinen, City of Espoo

Solution icons retrieved from Flaticon.com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FELLOW CITIES

1 Introduction

The energy sector, including energy generation, distribution and consumption, is currently the largest source of emissions in the Espoo region. Heating and electricity consumption account for around 70% of the total emissions in the Helsinki Metropolitan Area[1]. In the future, heating emissions are expected to decrease significantly in Espoo due to the joint commitment of Fortum and the City to Espoo to achieve carbon-neutral district heating by the end of the 2020s. However, electricity consumption in the Espoo region will increase, largely due to the electrification of transport and heat generation. The increasing consumption will require significant investments in the electricity grid and sustainable electricity production. Strategic collaboration between the City of Espoo and Caruna to advance the electricity grid and energy transition provides a foundation for implementing several significant sustainability measures by enabling increased electricity grid capacity in the Espoo region to meet future needs.

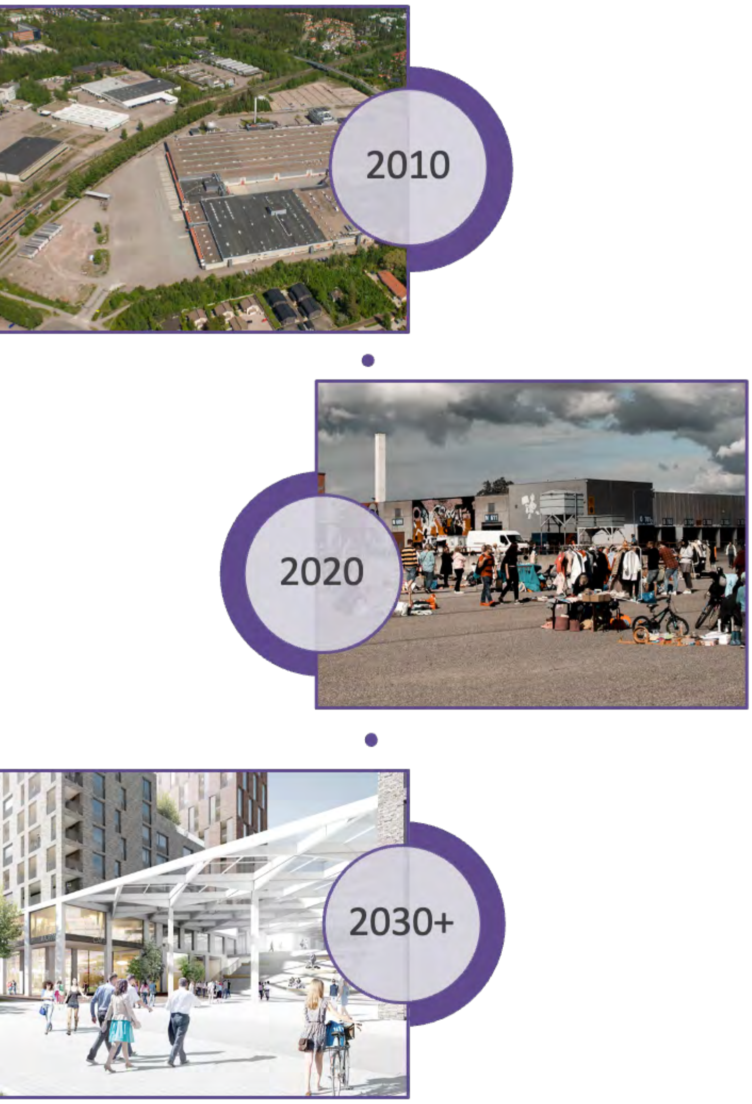
The Horizon 2020 SPARCS (**Sustainable energy Positive & zero cARbon CommunitieS**, 2019–2024) project explores and demonstrates innovative solutions for the design and implementation of smart and sustainable energy systems. The goal is to guide the City towards carbon neutrality and energy positivity. The project focuses on smart and local energy solutions, co-creation, promotion of a sustainable lifestyle and positive energy districts. In energy solutions, the focus is on the regional level rather than individual properties. The goal is for the City's handprint, i.e. new innovations, to have global significance. The development of solutions together with companies, partners and residents plays an important role in the project.

This document compiles key highlights and insights from the demonstrations carried out in the SPARCS project in the Espoo region and studies conducted for the Kera area, with the aim of promoting the development of Kera. Kera is a new future district along a commuter train line, designed in accordance with sustainable development principles. Regarding energy, the main goal in Kera has been to create a carbon-neutral regional heating solution for the area, enabling the utilisation of waste heat and two-way energy solutions for properties. The properties in the area use energy-saving and generating technologies, and solutions are sought for the profitability of investments, through means such as energy communities. The content compiled in this document may also be used in other urban areas, particularly those that are currently being built and further developed.

The text is based on a thematic report of the project, as well as other documents created during the project and in the context of Kera's development. The work is part of the project's WP3 Espoo Lighthouse Demonstrations work package.

1 . Source: HSY, Greenhouse emissions in the Helsinki metropolitan area, Available: Greenhouse emissions in the Helsinki metropolitan area - HSY

2 The KERA context



Images: City of Espoo material bank

Kera is a former logistics area in the greater Leppävaara region, which is to be transformed into a new urban district over the coming decades. Homes for around 14,000 residents and facilities for 10,000 workplaces are planned for the area. The aim is to develop the area into a model district for sustainable development, where various circular economy solutions, in particular, are at the forefront. Kera is being actively developed in close cooperation with various operators, such as organisations, companies, associations, landowners, research institutes and (present and future) residents.

Furthermore, Kera is being developed through a number of functionalities, such as energy, transport, logistics, circular economy and construction. The area's planning will be carried out in three stages, the first of which is the Centre of Kera's plan, approved in 2021. The two other plan areas, Karapelto and Karamalminrinne, will be completed in the near future. The construction of streets has begun in 2023, and the construction of the first new buildings has begun in 2024. Many development projects have developed and piloted new solutions with different stakeholders, including SPARCS. Additionally, a number of businesses and a university of applied sciences operate in Kera, making the area an interesting learning and development platform for new solutions.

In recent years, Kera has also become known for its diverse temporary use of facilities, with former logistics halls, Keran Hallit, located in the main structure of the area, gaining particularly widespread attention. The area has hosted various sports facilities, microbreweries, workspaces, event venues, art exhibitions and more. Furthermore, empty facilities have been used as test sites or «living labs» for various sustainable and smart circular economy solutions, including urban food production, autonomous transport, 5G data connections and inclusive street design. The plan is to demolish the halls around the middle of the decade as the area is built and developed. You can find more information about Kera here.

3 The Kera development commitment

The goal of Kera's development is to make it a model area for sustainable urban development. Kera aims to be a carbon-neutral district, thereby supporting Espoo's objective of becoming carbon neutral by 2030. The work in Kera is carried out through extensive collaboration between the City of Espoo, local landowners, developers and builders, thus establishing Kera as a national and international reference site.

Local development goals have been defined in Kera's development commitment. Kera's development commitment requires that the developers operating in the area present a development plan, taking into account and demonstrating the achievement of the following objectives:

1. **Kera will be developed through close collaboration.**
2. **Kera aims to achieve carbon neutrality by 2030 through low-emission and carbon-sequestering solutions.**
3. **Significant circular economy solutions will be created in Kera.**
4. **Kera will be a national and international reference site as a sustainable district.**

The development commitment also highlights themes and indicative measures that Kera developers can take into account when drawing up their own plans. These themes and measures are linked to Kera's development objectives and are illustrated in Table 1.

Kera's development commitment can be found in more detail here.

TABLE 1: Kera's development commitment measures in different themes

THEME	DEVELOPMENT MEASURES
Cooperation	Open exchange of information, call for new operators during projects.
Clean energy	Local heat pump-based network, utilisation of waste heat, energy efficiency and generation within properties, energy communities.
Circular economy services	Innovative food production solutions, circular economy services, temporary use of buildings, recycling centre.
Housing and easy everyday life	Diverse housing production, participatory measures, solutions promoting functional living.
Design and construction	Circular economy-based design solutions, use of recycled materials and products, carbon-sequestering materials, coordination and centralised services, fossil-free worksites.
Demolition and earthworks	Maximised material efficiency and high recycling rate. Use of recycled soil in construction work. Use of demolition materials as close to the demolition sites as possible.
Transport and logistics	Favouring walking, cycling and public transport, shared-use mobility services.
Smart urban solutions	Application of digital solutions, use of local data, open use and sharing of data where possible.
Communications and brand	Kera as a sustainable, smart and community-oriented district. Taking art into account in the construction of outdoor spaces and buildings.

4 The Kera development commitment – Energy

Kera's development commitment also addresses the theme of energy and proposes indicative measures to promote sustainable energy in Kera. The purpose of the measures is not to bind local operators to using specific technologies or solutions, but to generate ideas for possible development directions. The measures of the commitment can be found in the table on the right and are as follows:

1 The aim of the region has been to create a regional and carbon-neutral heating solution. Progress has been made in this respect, and the properties in the area will have the opportunity to connect to the regional heating network, which offers locally produced heat.

2 Waste heat generated in the area will be utilised as far as possible in local heat production. The regional heating network is designed to enable two-way energy solutions for properties, such as the sale of surplus heat to the network.

3 The energy solutions of properties in the area take advantage of technologies that conserve and generate energy.

4 Shared solutions can be examined in the area to facilitate profitable electricity production. Potential solutions include energy communities, among other things.

The above measures aim to enable the sustainable production and use of energy in Kera, both during and after the construction phase. Additionally, these measures will promote the energy-positive nature of the area, allowing Kera to support a sustainable change of the surrounding city, wherever possible.

TABLE 2: Kera's development commitment measures under the energy theme

DEVELOPMENT MEASURES — CLEAN ENERGY
The aim is to create a regional and carbon-neutral heating solution. Properties will have access to heat produced in the local heat pump facility for the district heating network.
Waste heat generated in the area is utilised, as far as possible, in heat production.
The energy solutions of properties will take advantage of technologies that conserve and generate energy.
Shared solutions are sought together for profitable electricity production, for example through energy communities.

5 Kera's plan areas

5.1 CENTRE OF KERA'S PLAN

- A former logistics area, focused on the logistics centre owned by SOK
- The district heating network extends to the area and locally generated emission-free heating will be utilised in the area in the future
- A low-temperature network will enable efficient utilisation of waste heat
- The plan enables the use of solar power and green roofs on roof surfaces. However, the amount of roof space suitable for solar power will be small compared to the floor space
- More information about the plan and its current status can be found here

Picture: City of Espoo

5.2 KARAPELTO'S PLAN

- **An existing and former industrial, storage and office area.** Most of the buildings have been unused for years
- **The district heating network** extends to the area and **locally generated emission-free heating** will be utilised in the area in the future
- **A low-temperature network** will enable efficient utilisation of waste heat
- The plan enables the use of **solar power** and **green roofs** on roof surfaces. However, the amount of roof space suitable for solar power will be small compared to the floor space
- More information about the plan and its current status can be found here

Picture: City of Espoo

5.3 KARAPELLONLAITA'S PLAN

- The plan is linked to the larger plan amendment area of Karapelto. The plan allows **a local heating facility** to be located in the area
- The aim is for the facility to provide **local carbon-neutral heating** for the needs of the entire Kera area
- The facility promotes Kera's aim to be **a positive energy district**
- More information about the plan and its current status can be found here

Picture: City of Espoo

5.4 KARAMALMINRINNE'S PLAN

- **A diverse area for business.** The area is home e.g. to Nokia's HQ, visitor centre, data centre and several office buildings. The area also has the temporary premises of Leppävaara General Upper Secondary School and Metropolia University of Applied Science
- **The district heating network** extends to the area and **locally generated emission-free heating** will be utilised in the area in the future
- **A low-temperature network** will enable efficient utilisation of waste heat
- The plan will enable the use of **solar power** and **green roofs** on roof surfaces. However, the amount of roof space suitable for solar power will be small compared to the floor space
- More information about the plan and its current status can be found here

Picture: City of Espoo

6 Studies commissioned for Kera & Kera's development projects

Espoo will develop and test sustainable solutions in Kera through extensive project collaboration with partners. Additionally, several studies and reviews have been carried out for Kera, aiming to promote Kera's goals by producing the necessary background material. This and the following page discuss studies linked to energy development.

A carbon neutrality roadmap has been created for Kera, giving users an overview of how various measures contribute to achieving carbon neutrality in Kera in the broader context. A roadmap allows for the identification, understanding and communication between different stakeholders on how actions are scheduled and what their combined effects are. The roadmap also highlights energy measures that promote carbon neutrality in the area.

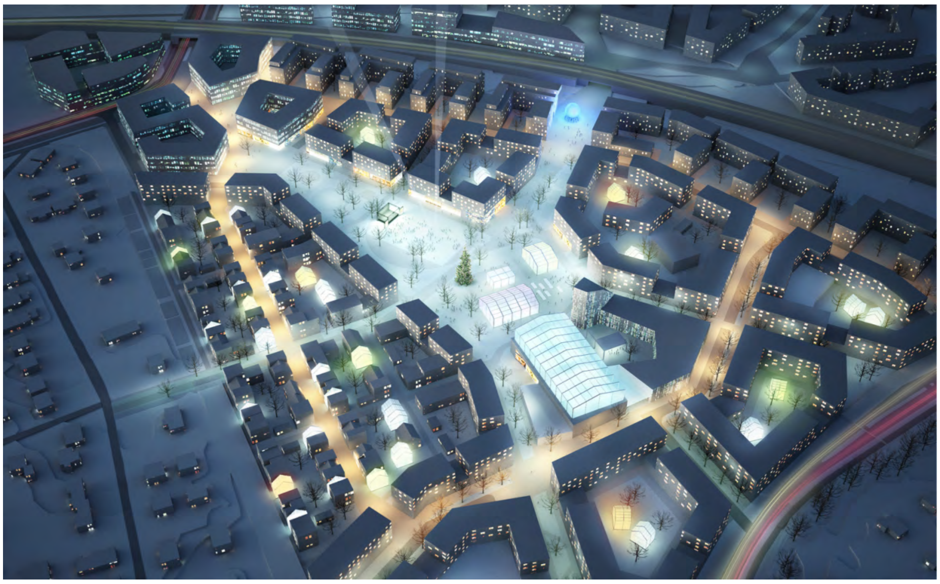
An emission assessment (in Finnish) for Kera provided an estimate of the emissions in the area over the next 50 years, including the effects of housing and infrastructure construction, energy use, and transport. An **energy ecosystem assessment (in Finnish)** of Kera's positive energy district established the steps for the concrete implementation of Kera's local energy services and solutions.

A survey of natural values (in Finnish) carried out in Kera in spring 2022 examined actions to secure and improve the area's natural values as the former logistics and industrial area is transformed into an urban centre of 14,000 residents. The survey also commented on the effects of Kera's energy measures on the area's natural values.

The Implementation Pathway for Environments that Accelerate Sustainable Growth (KETO) project boosted cooperation between businesses, schools and research organisations, creating genuine development environments that promote the green transition and digitalisation. Both quickly deployable solutions and demonstrations were implemented in the project, and suitable conditions were secured for future jobs and competitiveness. For Kera, the project included a Kera design competition, among other things, seeking innovative concepts for the reuse of building components in the area. Additionally, the project compiled **an information package on energy community studies (in Finnish)** that can also be used in planning the Kera area.

The RAKKE project strengthened collaboration between the public and private sectors, innovation and business operations connected to the development of low-carbon transport, energy, circular economy, and clean and smart urban solutions. The aim of the project was to build effective ecosystems together with 100 companies and developers, and form a foundation for increasingly effective project and development work. In the project, Kera served as one possible testing ground for the operation of an expanded functional ecosystem, contributing to the development of themes and operational models.

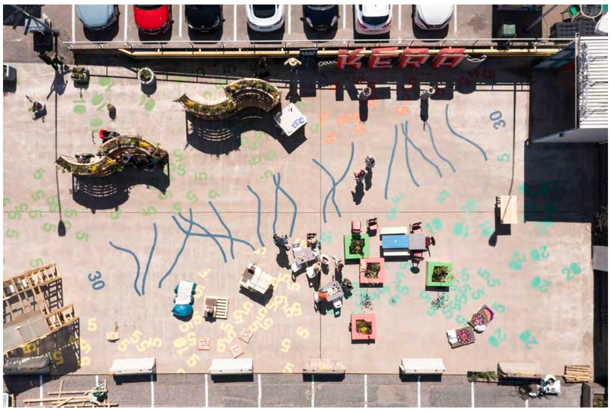
One of the goals of **the SPARCS project**, coordinated by VTT Technical Research Centre of Finland and funded by the European Union, is to promote the energy positivity of Kera through renewable energy production and energy-efficient solutions. Kera is one of the demonstration sites for the project, focusing especially on the design and planning of positive energy districts. The aim is to utilise lessons learnt from other demonstrations and studies in Kera. Additionally, a co-creation model for developing sustainable and smart urban areas has been created for the district. In this model, Kera's collaborative activities have been turned into a toolkit, which can be used for ongoing operations and in other areas of Espoo.



Images: Kera Development Plan - Arkkitehtitoimisto Stefan Ahlman Oy (source Espoo)

The Smart and Clean – Collaborative Kera project was an urban development initiative coordinated by the City of Espoo. It strengthened the emergence of Kera as a carbon-neutral, circular economy-based district through new partners, collaborative measures, approaches and solutions. In addition to expanding and strengthening collaboration models, the project solidified Kera's role as a pilot platform for climate-neutral circular economy solutions. Experiments were conducted during the project, such as **a future street environment pilot** at Keran Hallit. PÄYKE continued the Smart and Clean Kera project, which promoted the initiation of Kera's transformation together with regional partners.

Image: ESPOO / Kera New Street - Keran Hallit



7 Energy solutions in Kera

Since the beginning, the development of Kera has emphasised the possibilities of organising the area's energy supply in a way that is as environmentally, ecologically and socially sustainable as possible for the residents. The main aim regarding heating and cooling has been to introduce a carbon-neutral and local heating solution for Kera. To achieve this goal, a local heating facility will be built in Kera, generating carbon-neutral heat for the area's needs. This solution is linked to a regional low-temperature network that allows waste heat to be efficiently utilised. This way, recovered heat from office, commercial and service buildings in the area can be effectively used. The entire regional heating solution is connected to a wider district heating network, enabling the transmission of excess heat and making Kera's heat production energy-positive. Cooling, in turn, can be provided either on a district level or on a building-by-building basis. Additionally, the plans for the Kera area allow a passive reduction of cooling needs, e.g. with eaves, sun protection and vegetation.

At the core of the energy system's sustainability are solutions related to energy efficiency and sustainable energy consumption. The main goal in an area being planned should always be to minimise energy consumption before assessing production choices. Therefore, Kera's development commitment takes into account energy-saving solutions for properties, and developers in the area can incorporate energy-efficient solutions into their development plans.

In addition to energy efficiency solutions, operators can promote the sustainability of Kera's energy supply by increasing local renewable electricity production. Production can be increased either by integrating renewable energy sources into local buildings and their immediate surroundings or by investing in renewable production outside the area, either independently or collectively. The plan descriptions for the Kera area give special consideration to the integration of solar power into the area's buildings, and Kera's development commitment highlights the option of promoting sustainable electricity production through collaboration amongst the area's developers.

Since renewable energy sources are partially irregular in production and waste heat sources often do not align perfectly with consumption, realising the full potential of sustainable energy requires smart consumption control and development of storage solutions. Through flexible solutions for electricity and heat, it is possible to balance consumption peaks, shift consumption closer to hours when production is higher and provide financial benefits to the residents and stakeholders in the area. Storage solutions enable better utilisation of renewable forms of energy and waste heat by balancing differences between supply and demand. The plan descriptions for the Kera area have made considerations for the option of piloting services that enable a smart energy system, such as demand flexibility pertaining to electricity and heat, in the area.

The number of electric vehicles has increased significantly in Finland in recent times, which has also had an effect on the power system. The rising number of electric cars has been particularly significant in Espoo, which has historically ranked amongst the leading municipalities for electric cars in Finland. The proliferation of electric cars and their charging units means that electricity consumption is increasing while simultaneously providing additional opportunities for flexibility and storage. Solutions based on electric vehicles must consider the area's reliance on efficient public transport, walking and cycling.

8 Compiled solutions from the SPARCS project & other studies

The following pages describe sustainable energy solutions developed, piloted and studied in the SPARCS project. They illustrate the key lessons and observations, highlighted as part of the solution description. Additionally, each solution has been examined through the Kera viewpoint, meaning that key observations have been highlighted on how the solutions can be applied to a new developing area like Kera. In the analysis, special attention has been paid to the area's long-term development, specific conditions and requirements during construction, and the goals determined for Kera in the plan, envisioning work and the area's development commitment.

The solutions have been divided into four themes: technologies, concepts, engaging stakeholders and urban development. Each theme presents essential perspectives for a sustainable energy system, ranging from technology to new co-created concepts and design solutions. The total number of solutions presented is 16. In addition, connected pilot solutions of the SPARCS project are presented next to the solution in question.

Information about the solutions and their demonstrations during the project in the blocks of Espoonlahti's Lippulaiva and Leppävaara's Sello can be found in the project report, on which this document is also party based: **Deliverable D3.4 Interoperability of holistic energy systems in Espoo**.

TECHNOLOGIES

- Electricity demand response and Virtual Power Plants
  - Ilmatar Areena's flexibility pilot
- Electricity storage and battery solutions
  - Lippulaiva battery storage and smart power system
  - Battery storage simulation in a block of flats
- Heat storage
- Utilisation of waste heat
- Digital twin
  - Sello's digital twin and AI solutions
- 5G and blockchain technology

CONCEPTS

- Energy communities – energy community internal to a property
- Energy communities – property-crossing energy community
- Energy communities – decentralised energy community
- Vehicle-to-Grid – two-way charging of electric cars
- New business models
- Power-to-X – use of surplus electricity in manufacturing synthetic fuels

ENGAGING STAKEHOLDERS

- Engaging residents
  - Sponsor school class activities
- Engaging housing companies

URBAN DEVELOPMENT

- Co-creation
  - Co-creation model for sustainable and smart urban areas
- 3D model as part of energy planning and local optimisation
  - 3D model for designing positive energy districts

8.1 SOLUTIONS I: TECHNOLOGIES

Electricity demand response and Virtual Power Plants

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Realising the full potential of renewable energy also requires smart consumption control so that the energy system can balance energy supply and demand in a cost-effective and reliable manner, as necessary. Furthermore, demand flexibility will play a role in balancing the electricity grid in the future because the increasing adoption of sustainable solutions in the energy sector, industry and transport will require an increase in the grid's capacity. By leveraging their own flexible energy loads, energy consumers can optimise their consumption and shift it to times of more cost-effective power production, thus reducing consumption peaks. Additionally, consumers will be able to operate as part of Fingrid's reserve market, providing themselves with monetary value and opportunities to further optimise the power system. The requirements for joining the reserve market will depend on the chosen market. Demand flexibility benefits building owners, energy providers and the entire society.

Participation in flexibility markets requires meeting the capacity requirements of the specific market in question. For large-scale consumers and big landowners, these requirements may be straightforward, but small-scale operators might need to form alliances to meet the requirements. Aggregator services enable consumers to collaborate as flexibility providers through a service provider. By making use of these services and with the support of local collaboration, it is possible to join reserve markets collectively. Virtual power plants are a technological solution for controlling multiple distributed energy production or consumption sources as a unified entity, acting as a single virtual power plant. They can include production sites, but they can also focus on directing and aggregating flexible consumption.

During the SPARCS project, the potential of a virtual power plant service was studied in 100 buildings directly owned by the City that had the highest electricity consumption. Although the flexibility potential of an individual public building may not be sufficient to participate in the demand flexibility markets, the flexible loads of multiple municipally-owned properties can be combined through a virtual power plant. The potential of connecting a building to a virtual power plant is site-specific and depends on the total power of the loads, their controllability and external influences. For example, ventilation is a typical load with potential for flexibility if the building's automation system allows external control. Short-term adjustment of ventilation is usually possible without deteriorating the indoor air conditions. A potential future source of increased flexibility is electric vehicle charging points, whose usability as part of a virtual power plant service was demonstrated during the SPARCS project.

Further information

Description of a virtual power plant in the BABLE database

8.1 SOLUTIONS I: TECHNOLOGIES

CASE KERA

Demand response and flexibility solutions are central to the goals of Kera's development commitment, and flexibility solutions are mentioned, for example, in Kera's energy assessment report as one of the solutions enabling a sustainable energy system in Kera. These solutions make it possible to save energy by optimising consumption and provide an opportunity for joint value creation for the area's operators. A virtual power plant is a service that can simplify the utilisation of flexibility and facilitate local operators' participation in electricity reserve markets.

In order to understand the potential for demand response in the area, it is necessary to assess the flexibility potential of Kera's building stock during the area's development. Based on the area's consumption profile and building types, the most relevant sites can be prioritised for the virtual power plant service. However, a more detailed study would require a building-specific review and an understanding of their loads and automation system capabilities, to name a few elements. Improving future buildings' readiness in Kera for demand response could be significantly enhanced by taking it into account from the planning phase onwards, even if the solutions are not implemented immediately. This would mean, among other things, the readiness of automation systems for remote control or, alternatively, the readiness of building automation to measure the grid frequency, allowing flexibility to be offered independently without outside control. Additionally, enabling flexibility solutions may require factoring them in when designing a building's metering. For more information on the possibilities, see the «How to turn your property into a virtual power plant» guide (in Finnish) produced by the Energy Wise Cities project.

The increase in electric vehicles can highlight a new source of flexibility offering great potential in the Kera area. Furthermore, the use of flexibility solutions can reduce the need to increase electrical connection capacity when building charging points for electric cars in the area. Using charging points as sources of flexibility should be assessed when making procurement decisions.

Further information

How to turn your property into a virtual power plant (in Finnish)

SPARCS PILOT SOLUTION: ILMATAR AREENA'S FLEXIBILITY PILOT

Ilmatar Areena, located in Matinkylä, serves as a pilot building for electricity demand response in the project. The goal of the pilot conducted in the ice skating hall was to demonstrate the potential of electric vehicle charging stations in smoothing consumption peaks and balancing the power grid. The goal was also to show that demand side management enables the deployment of charging stations without increasing the electricity connection capacity. For the pilot solution, nine charging points were installed at the hall. These were connected to the Siemens Power Manager software along with electricity metering and devices integrated into building automation. Siemens Power Manager controls the charging power of the charging points based on the building's overall consumption. Charging power is restricted when the total consumption is high to prevent exceeding the connection capacity.

Since the reservations required by charging points for electric cars have been taken into account at Ilmatar Areena, completed in 2021, the physical limitations of the electrical connection are not a direct problem in the pilot. Instead, the pilot has focused on testing the functionality and adaptability of the system. As a result, the system can be scaled to almost any building where the connections allow it, enabling charging points for electric cars without the need for expensive increases in electrical connection capacity.

Image: Siemens

8.1 SOLUTIONS I: TECHNOLOGIES

Electricity storage and battery solutions

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Electricity production and consumption levels must be balanced at all times. As renewable energy production increases, maintaining this balance becomes increasingly difficult because these production methods often vary according to the weather. Thus, renewable electricity production does not always align with consumption in a timely manner and not all production can be effectively utilised. This variation in production also increases the fluctuation in price and affects the power balance in the grid. The relationship between electricity production and consumption can be improved with regulating power (such as hydroelectric power), flexible consumption and storage solutions. By utilising electricity storage solutions, such as batteries, customer-specific electricity costs can be affected by shifting procurement towards the low-cost hours, which also contributes to the stability of the power grid. Short-term storage of electricity can mean intraday storage that is already feasible through battery solutions, to name one option. Battery storage is a increasingly common and cost-effective form of short-term storage that can be used for both electricity storage, and maintaining grid stability and electricity distribution in the event of disruptions, depending on the operator. Battery storage enables a connection to electricity reserve markets similarly to demand flexibility, allowing the charging and discharging of batteries to be adjusted based on the grid frequency, which provides additional income for the battery owner. So far, investments in Finland have included both separate and property-specific battery solutions. Property-specific battery solutions have been piloted, for example, at the shopping centres Sello and Lippulaiva, which also serve as demonstration sites in the SPARCS project. Small residential buildings can also invest in solar panels, for example, which also include a battery solution for storing electricity and serving as a backup system. The energy stored in batteries can either be used in the building itself or, if necessary, sold to the electricity grid. However, battery pilots are seldom run in small residential buildings or blocks of flats in Finland. Currently, the main obstacle to buying battery systems for homes and other lower-consumption sites is the cost of these systems and the long payback period compared to high-consumption sites. Additionally, the capacity of batteries suitable for small-scale household use is often insufficient for connecting to Fingrid's reserve market due to the capacity requirements of the market.

During the SPARCS project, the possibility of including a battery solution when acquiring charging points for electric cars in blocks of flats was also examined. Based on the research, a comprehensive solution that includes car charging points, solar panels and a battery storage system can increase the opportunities for households to build charging points with shorter payback periods.

Further information

Description of energy storage in the BABLE database

8.1 SOLUTIONS I: TECHNOLOGIES

CASE KERA

Electricity storage solutions are central to the goals of Kera's development commitment, and they are mentioned, for example, in Kera's energy review as one of the solutions enabling a sustainable energy system in Kera. These solutions make it possible to save on energy costs and optimise local electricity production, and they allow local operators to create value together.

Property-specific battery storage systems can be used in Kera in connection with renewable energy production, with a focus on promoting solar panel investments in the area. Additionally, batteries can be used at properties to shift electricity consumption more to the cheap hours of the day. Separate battery solutions, on the other hand, may be unsuitable for the area due to its upcoming city centre-like building stock. Battery solutions are rarer still in buildings such as blocks of flats, offices and service buildings, but the increasing use of renewable energy and electric cars while the cost of batteries decreases may boost interest in such locations as well, shortening the payback periods for the systems. At the moment, however, the price of battery systems may still be an obstacle to many of Kera's operators, particularly if a site cannot join the reserve markets due to capacity constraints.

SPARCS PILOT SOLUTION: LIPPULAIVA BATTERY STORAGE AND SMART POWER SYSTEM

A review was carried out during the SPARCS project on the potential of minimising the cost of electricity in the new urban centre of Lippulaiva. The study covered, among other things, optimisation of electricity consumption, local electricity production and connection to the reserve markets through battery storage. As part of the study, the optimal size of the battery storage was also determined.

Based on the findings, Citycon decided to invest in a 1.5 MW/1.5 MWh battery storage, and an electricity consumption optimisation system. The battery storage has been installed, and Lippulaiva has been part of the reserve market since July 2022. In addition to the battery storage, a total of 577 kWp of solar panels have been installed on the roof and the facade of Lippulaiva. Both the batteries and solar panels have been connected to the electricity consumption optimisation system, together with the other electrical systems in the buildings, to reduce costs and consumption peaks. As the geothermal heating system of the urban centre also uses a lot of electricity, the automation systems can be integrated, which further optimises the system.

Lippulaiva is a prime example of how new smart energy systems can be used in service buildings, creating both environmental and economic benefits.

Image: Schneider Electric

SPARCS PILOT SOLUTION: BATTERY STORAGE SIMULATION IN AN APARTMENT BUILDING

A profitability study was carried out during the SPARCS project on battery storage solutions in apartment buildings. The aim of the study was to assess the profitability of different battery capacities and calculate the payback period for the installation of car charging points combined with solar panels and a battery storage. The study used the following parameters:

- 18 and 49 electric vehicle charging points;
- 50–200 kW battery storage capacity;
- 45 kWp solar panel array based on the example building's roof area;
- The example site's electricity consumption based on its hourly consumption rates.

Based on the analysis, a 200 kW battery storage is optimal for both charging point numbers, if the system's payback period is calculated without the installation of solar panels. In this case, the price also drops below the installation cost of charging points without the implementation of the battery system. However, the payback period is long, almost 20 years. The system's payback period decreases to nine (9) years for 18 charging points and eight (8) years for 49 charging points, when the installation of solar panels is included.

This SPARCS project study shows that the profitability of battery storage should be considered, especially for blocks of flats, if the plan is to install a high number of car charging points at the buildings. The solutions for a site should be viewed as a whole, as charging points, solar panels and electricity storage support each other and offer a payback period of under ten (10) years for the entire system.

Image: City of Espoo

Heat storage

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

The aim of heat storage is to ensure a better balance between heat production and consumption by storing produced heat, waste heat or solar energy passively in the summer, for example. Heat can be stored either in the short or long term. Currently, the most common form of heat storage is the so-called sensible thermal storage, which involves storing heat by changing the temperature of a substance, usually water. In this way, heat can be stored in the ground and structures as well. In addition to traditional storage solutions, various other storage methods are being piloted. They are based on new types of storage materials, such as sand or salt, changes in the state of matter and thermochemical reactions.

Short-term heat storage refers to the daily balancing of heat production and consumption. For example, hot water tanks on a small scale and heat storage tanks connected to district heating networks on a larger scale are common solutions for short-term heat storage. For instance, the water tank of a district heating battery can be heated with electricity during times of low consumption to meet the needs of consumption peaks, which reduces heat production costs and replaces fossil fuels in production.

The aim of long-term or seasonal heat storage is to smooth out seasonal variation between heat production and consumption. For example, waste heat generated in the summer could be better utilised through long-term storage during the highest heat consumption period in the winter. Long-term heat storage in Finland is still limited, and it typically involves underground locations. For example, thermal wells (so-called regenerative thermal wells) or energy piles can also be used for storing heat during summer. Alternatively, heat can be stored in underground water basins, as long as the size and insulation of the basin allow for storage with minimal heat loss.

Heat energy storage is used at sites such as the urban centre of Lippulaiva, which is also participating in SPARCS. The waste heat from the area is utilised as efficiently as possible as part of the centre's energy system by using regenerative thermal wells. Over 50 km of thermal wells have been drilled under the shopping centre, and they are loaded with thermal energy from the condensation heat of the centre's supermarkets, for example.

CASE KERA

It is important to assess the role of short and long-term storage in Kera as part of the local heating solution. Using waste heat as part of this solution can be significantly facilitated by increased opportunities for storing excess heat generated in the summer so that heat can be used in the network during higher consumption periods. Short-term storage can optimise the operation of the local heating network. In this case, a solution similar to the heat storage tank in Suomenoja, Espoo, could serve as a smaller-scale storage option.

Further information

Description of energy storage in the BABLE database

8.1 SOLUTIONS I: TECHNOLOGIES

Utilisation of waste heat

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Use of excess heat, known as waste heat, aims to reduce the amount of energy lost in activities by taking advantage of it on site or in the district heating network, for example. Large amounts of waste heat is generated, for example, in energy-intensive industries, but through technological advances, the number of available waste heat sources for utilisation is also increasing. According to the Ministry of Economic Affairs and Employment, some 130 TWh of waste heat is estimated to be generated in Finland, which is significantly more than, for example, the total use of district heating in the whole country (34 TWh in 2022). About 35 TWh of the waste heat is estimated to be recoverable, of which roughly 3 TWh has so far been utilised in district heating networks. So, at present, about 8.5% of the waste heat potential is being used. However, there are still risks related to the economic viability associated with the remaining utilisable portion. These are likely to diminish as technology advances, especially as the temperatures in the district heating networks decrease in accordance with the updated regulations of Finnish Energy. Potential waste heat sites in urban areas such as Espoo include industrial properties, data centres, commercial properties, office buildings that use cooling systems, indoor ice skating rinks and waste water. However, this potential must always be assessed on a location-specific basis.

Waste heat is already being used in Espoo, both in individual buildings and the district heating network. Individual buildings take advantage of their own excess heat sources, such as condensation heat in supermarkets and ice skating halls, to minimise their own heat consumption. Meanwhile heat is produced for the district heating network from excess heat sources such as wastewater, data centres and hospitals.

CASE KERA

The local low-temperature network to be built in Kera will allow waste heat to be better utilised. Therefore, for the area’s sustainability, it is important to identify the potential of the waste heat sources as part of the local solution, thereby optimising the entire system. In the future, a significant source of waste heat in Kera may be the cooling of buildings as commercial and office spaces develop in the area. Additionally, Nokia has a data centre in the Karamalminrinne plan area, and its use as part of the local heating network is recommended.

8.1 SOLUTIONS I: TECHNOLOGIES

Digital twin

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

A digital twin refers to a virtual copy of the physical world, such as a product, building, district or transport system. Digital twins are already commonly used in industry to allow products to be tested without the construction of physical samples. This mindset has rapidly expanded to larger contexts, aimed at creating real-time models of the surrounding world. At the moment, modelling urban areas and buildings, for instance, is already common, and Espoo too has an open 3D model of the city, among other things. However, a digital twin requires that information is integrated into a static model, which turns the virtual version into a more holistic entity than just a geometric model.

The role of digital twins in the energy sector depends highly on the application of the technology, such as in district heating networks, buildings or district development sites. At building level, digital twins can assist in streamlining design processes, and analysing and visualising energy data for the building. When a building's energy data is linked to a visual model, the energy consumption in different areas can be examined over different time spans, helping to spot faults. In a district development project, a digital twin can assist in tasks such as traffic planning, infrastructure placement, and assessing the potential for energy savings and production. Where possible, the tool can be used for communication and engagement, allowing residents and other interested parties to follow the area's development virtually and express their opinions on the area's future based on a realistic 3D perspective.

A digital twin requires and relies on extensive and efficient data collection. The development of IoT technology and the increasing number of sensors serve as the basis for the data needed by the digital twin. On the other hand, the development of AI enables the use of existing data in predicting the future state of a site, providing information for decision-making. This makes the use of data and, subsequently, the personnel's work more efficient.

CASE KERA

Plenty of local-level data modelling has already been carried out in Kera, and digital twins have been piloted in projects such as LuxTurrim5G. Kera's data model can be expanded with data and information from various stakeholders in the area, which will enhance the virtual model's accuracy and real-time capabilities. Furthermore, it also makes it possible to examine the role of digital twins in urban planning and the role of virtual models in communication and engagement. Local operators can also use new digital solutions in their activities according to their needs and abilities.

Further information

Description of a digital twin in the BABLE database

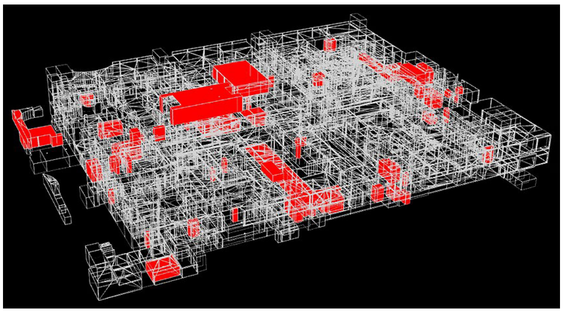
SPARCS PILOT SOLUTION:
SELLO'S DIGITAL TWIN AND AI SOLUTIONS

A study was carried out during the SPARCS project on the role of AI in optimising a building's energy system. Data generated by shopping centre Sello was used to predict the future energy consumption, production and flexibility of the centre by using forecasting models created by VTT. These models also served as a basis for the digital twin created by VTT during the project.

The purpose of Sello's digital twin is to behave and look like the real building, while only existing as a digital copy of it. The digital twin currently includes Sello's electricity and heat consumption, local solar power production, electric car charging points and HVAC system. The visual model of the digital twin utilises a 3D BIM model of Sello.

The digital twin can visualise the consumption and operation of selected heating, ventilation and air conditioning equipment in almost real time. A web-based application developed by VTT also allows users to examine both real-time and historical energy data in different parts of the building. This allows, for example, the examination of the operation of individual radiators and air handling units.

Sello's digital solutions prove that AI can be used to predict the future operation of a building's energy system. By combining historical information and forecasting models with a virtual copy of a building created using a BIM model, it is possible to make the building's energy system virtually accessible to those responsible for the building's operation.



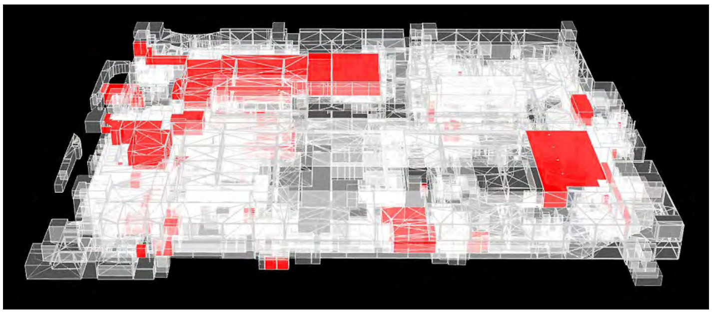


Image: VTT

5G and blockchain technology

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

During the SPARCS project, the role of 5G and blockchain technology has been investigated in the development of sustainable urban districts. These technologies and themes are closely linked to the use of data, fair data economy and data sharing or trading amongst regional operators. The wider utilisation of data in urban development has also been a lively topic of discussion especially in the energy sector, but there are still many unanswered questions related to issues such as data ownership. In Finland, Sitra, among others, promotes fair data economy, and data markets are promoted through the development efforts of companies and research institutions.

Recent benefits of 5G technology have been highlighted in the transport sector, in particular. A faster mobile network can facilitate applications related to autonomous transport, as autonomous vehicles need to be constantly aware of their surroundings and potential safety risks. They must also be capable of communicating with the surrounding world to ensure smooth and safe traffic. 5G can also support new applications in the smart energy sector, even though the energy sector is less favourable to 5G applications due to its static structure. In the energy sector, the continuously increasing intelligence of power grids, and the growing number of renewable energy sources and prosumers (producer-consumers) offer a suitable market for 5G applications. More information on the suitability of 5G technology for the energy sector can be found in the suitability study conducted during the SPARCS project (see below).

Blockchain technology has been highlighted in the energy sector as an enabler of peer-to-peer markets in renewable energy, in particular. Blockchain technology may, thus, contribute to the emergence of prosumers and adoption of decentralised renewable energy. Additionally, blockchain technology has been commonly piloted for verifying logistics chains. In the energy sector, the possibilities of blockchains have been utilised in the procurement of renewable energy certificates, for instance. By recording data about renewable energy production in a blockchain, this production can be linked to the consumption location, thereby verifying the origin of the energy produced more accurately in terms of both time and geography. More information on the suitability of blockchain technology for the energy sector can be found in the suitability study conducted during the SPARCS project (see below).

CASE KERA

Kera already has ongoing 5G development work through the LuxTurrim5G pilot environment, which explores the role of 5G smart poles in smart urban development. Linked to the LuxTurrim5G project, the NeutralPath initiative has also developed a data marketplace that operates using blockchain technology. As Kera has been a central district in Espoo's smart city development through the work of local companies and ongoing development work, continuous progress in the utilisation of ICT technologies and data will also be natural, going forward. However, focusing only on a limited selection of technologies is not natural, and development work should be based on the needs and abilities of the local operators.

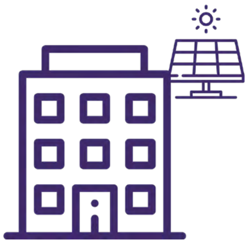
Further information

A study of the suitability of blockchains for the energy sector in Espoo

A study of the suitability of 5G technology for the energy sector

8.2 SOLUTIONS II: CONCEPTS

Energy communities – energy community internal to a property



SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Solar power is one rapidly growing method of generating electricity locally in urban areas and increasing personal production. This is evident in factors such as the number of solar power systems in the Espoo area, which, according to the latest statistics, are increasing at a considerable rate. Under Finnish legislation, it is now possible to better utilise self-produced electricity among residents, taking into account any legal restrictions, by leveraging so-called energy communities. An energy community refers to a community of operators that utilises its own energy production and shares energy between the community members. It can be, for example, internal to a property, transboundary across properties, or geographically distributed. More information on energy communities can be obtained from a study produced during the SPARCS project (see next page*). This playbook examines the feasibility of energy communities in Kera within the framework of the latest regulations. The Ministry of Economic Affairs and Employment has continued to investigate the need to further develop regulations by appointing a working group in autumn 2022, particularly pertaining to the expansion of the energy community definition and use of separate lines. The working group published its report on the development needs in spring 2023.

An energy community internal to a property is one that shares electricity generated at the property amongst the residents. The sharing can be done, for example, through reimbursement calculations, where locally produced solar power is shared amongst the housing company residents based on a chosen allocation. This model has been available for housing companies since the start of 2021, depending on the local distribution system operator (DSO), and since early 2023 throughout the country, when the calculations were transferred to the transmission system operator (TSO) Fingrid. An energy community can also be established through so-called back metering, where the property owner is responsible for metering and distributing the financial benefits amongst the shareholders

Further information on creating an internal energy community and adopting reimbursement calculations can be obtained from Motiva and local distribution network companies, among other sources. Additionally, HSY offers a course on solar power-based energy communities in housing companies and how to establish these communities.

CASE KERA

Local renewable energy production and energy community models are central to the goals of Kera's development commitment, and they are mentioned, for example, in Kera's energy assessment as one of the solutions enabling a sustainable energy system in Kera. Energy communities provide local operators with an opportunity to invest in local production and gain more value from it within their own community.

In Kera, the ratio between the building area and floor area is not favourable for solar power production. Nevertheless, in an area dominated by blocks of flats, energy communities internal to properties offer residents new opportunities to use renewable energy. This type of an energy community is the easiest form of energy sharing offered by the legal amendments, and local operators are already able to take advantage of it. Examples of these communities can be found in Espoo, enabling an assessment of the benefits and drawbacks of this model for housing companies. Additionally, many information packages and training materials produced by various operators are available to the area's housing companies on forming energy communities.

Energy communities – property-crossing energy community

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Under current legislation, energy communities can produce electricity at a separate site and connect it to the usage location with a separate line. In this case, the value distribution and community operation function in practice the same way as if the production took place within the same property, similarly to the internal community model. At the moment, it is not possible to form energy communities that cross property boundaries in Finland, except through this separate line. A separate line cannot connect consumption locations to one another, and is not connected to the distribution network. Otherwise, the activities of an energy community would be considered licensed distribution network operations. This type of activity would require, for example, a closed distribution network operator's electricity grid licence from the Energy Authority, and obtaining a licence is limited to geographically defined industrial, business or other service areas where electricity is not supplied to consumers.

CASE KERA

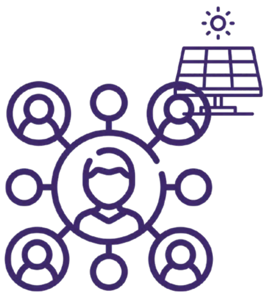
Forming a property-crossing energy community by using the separate line model will require a separate space for the production unit in the area, which may be challenging in the densely built Kera that mainly consists of blocks of flats. For instance, the roofs of car parks could be used to increase the solar power consumption of residential buildings, but in this case, the electricity generated by the panels could probably not be used directly at the parking facilities themselves. In practice, the current legislation limits these types of energy communities to situations where roof-mounted solar panels are replaced with ones installed on a separate plot. Otherwise, an energy community would require an electricity grid licence, which cannot be obtained for an area such as Kera.

Further information

* Energy community report on the SPARCS website

8.2 SOLUTIONS II: CONCEPTS

Energy communities – decentralised energy community



SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

It is also possible to form an energy community in a decentralised manner as a so-called virtual energy community. This model allows the production and consumption to be anywhere in Finland in relation to one another. One example of a virtual energy community is a situation in which a consumer wants to utilize the production of their summer house's solar panels at home outside of their summer leave period. In this case, the energy community has to pay network fees and taxes as usual but saves on energy costs when their summer house's production is subtracted from the customer's energy consumption. The community's revenue will naturally decrease compared to other models with similar production sites. However, this type of energy community allows for larger investments in production facilities when local operators make joint purchases, such as a solar panel array or wind turbine. Production resources can also be leased, if necessary.

Based on research, the legal issues surrounding participation in a virtual energy community or a service model formed around it are still partially unresolved. The constraints also include evolving practices in implementing this energy community model and questions about the monetary value to be gained. As a result, services for virtual energy communities remain limited.

CASE KERA

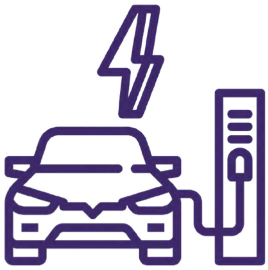
In addition to property-specific energy communities, a virtual energy community is the simplest and most functional way to implement communal energy activities in Kera, because it allows the production site to be placed outside the area, if needed, and consumers to be involved seamlessly in the operations without major physical arrangements. For local energy communities, the virtual model is the solution that offers the most potential for the area under existing legislation. However, this type of solution will serve as a pilot if adopted to the area, which is why there is still little information about the value it creates for stakeholders and the most suitable operating models. The activities will require engaging local consumers, whether housing companies or other entities, in addition to contacting the local grid company and choosing an electricity supplier to ensure the energy community's functioning, among other steps. Forming a community would also require finding a suitable production facility or plot, which could be either in Espoo or elsewhere in Finland.

Further information

Energy community report on the SPARCS website

8.2 SOLUTIONS II: CONCEPTS

Vehicle-to-Grid – two-way charging of electric cars



SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

The term Vehicle-to-Grid, or V2G, refers to a two-way charging system where energy can also be transferred from a vehicle battery back to the power grid. V2G can be used as part of smart charging, where the charging time and power can be adjusted automatically, avoiding various negative effects on the energy system, such as network overload during peak times (e.g. mornings and afternoons). Two-way charging also allows a car battery to be used as electricity storage, meaning that electricity can be temporarily stored in the car battery and fed back into the network or for local use later. The importance of energy storage will increase because energy production and consumption will not always match as weather-dependent renewable production increases. The value generated by an individual vehicle is relatively small in the overall picture due to the limited battery capacity of vehicles. However, when considered on a broader scale as a collection of multiple vehicles, the value generated by storage and flexibility also increases.

To individual consumers and operators, V2G presents an opportunity to participate in the electricity market through charging, storage and selling back to the grid, but the effects of two-way charging on the lifespan of car batteries are still unknown. Private cars are parked most of the time, creating a significant timeframe for usage cases that benefit from V2G. However, in addition to actual charging points, the active use of the V2G solution would require charging points for long-term charging as part of the parking solutions, allowing energy to be charged to or discharged from cars when it is most beneficial for the grid or the user, which increases the level of resources needed for the infrastructure. It should also be noted that the use of two-way charging requires both a suitable charging system and suitable vehicles. At the moment, their availability is still limited.

CASE KERA

Kera uses a centralised parking solution. Multi-story car parks could facilitate V2G-based solutions, particularly if a large proportion of vehicles are connected to the grid for long periods of time, but the real economic benefit of this approach may be limited, and it might not be an optimal option in terms of resources. With regard to shared-use electric cars, the option can be considered and its role in the cost-effectiveness of the service, for example, can be assessed. For any shared-use cars and charging stations, it is advisable to consider V2G readiness for the future so that the opportunities offered by the technology can be utilised.

Further information

[Description of two-way electric car charging in the BABLE database]

8.2 SOLUTIONS II: CONCEPTS

New business models

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

The energy transition and increasing presence of new sustainable energy solutions in the urban landscape both require and facilitate technological, social and economic changes in society. New business models will be at the core of the economic changes due to an increased need to invest in sustainable energy, and expanding investor profiles as the number of so-called prosumers increases. Two-way energy networks enable these prosumers to sell their surplus electricity or heat back to the grid, increasing the returns on investments during times when their own consumption does not cover all production.
For example, various service solutions (Energy-as-a-Service) and ESCO (Energy Service Company) projects may enable new financing models for energy investments. Energy-as-a-Service (EaaS) projects refer to solutions where the customer procures the entire energy solution from a separate service provider. That way, the customer does not have to take on the risk of investment costs, maintenance or upkeep, to name a few. The entire solution remains the property of the service provider, and the provider finances their investment through service fees. For instance, flexibility solutions, energy efficiency management, the charging of electric cars and the production of renewable energy can be procured as a service solution. In ESCO or Energy Performance Contracting (EPC) projects, the investments required for energy-efficiency solutions are covered by the service provider through guaranteed energy cost savings. In ESCO projects, an investment may be either owned by the service provider or the customer, depending on the contract. ESCO projects have been a part of the energy sector worldwide since the energy crisis of the 1970s, and they have gained prominence in recent years due to the increasing need to promote energy efficiency.

In addition to energy production, new business models also enable the generation of value through flexible energy consumption. Aggregator services allow operators whose own consumption is insufficient to capture the full value of flexibility solutions. This is possible, for example, in cases where joining reserve markets can only be achieved by combining multiple consumption locations into a single entity.

The study and development of new business models is one of the key themes in the SPARCS project and, at the end of the project in particular, business models will be actively developed. So far, the project has produced guidelines for holding start-up competitions, for example. Additionally, the project partner BABLE has produced a comprehensive online package of smart city solutions and their implementation, from which examples have been highlighted in the solution sheets of this playbook.

Further information

Comprehensive online package of smart city solutions created by BABLE

8.2 SOLUTIONS II: CONCEPTS

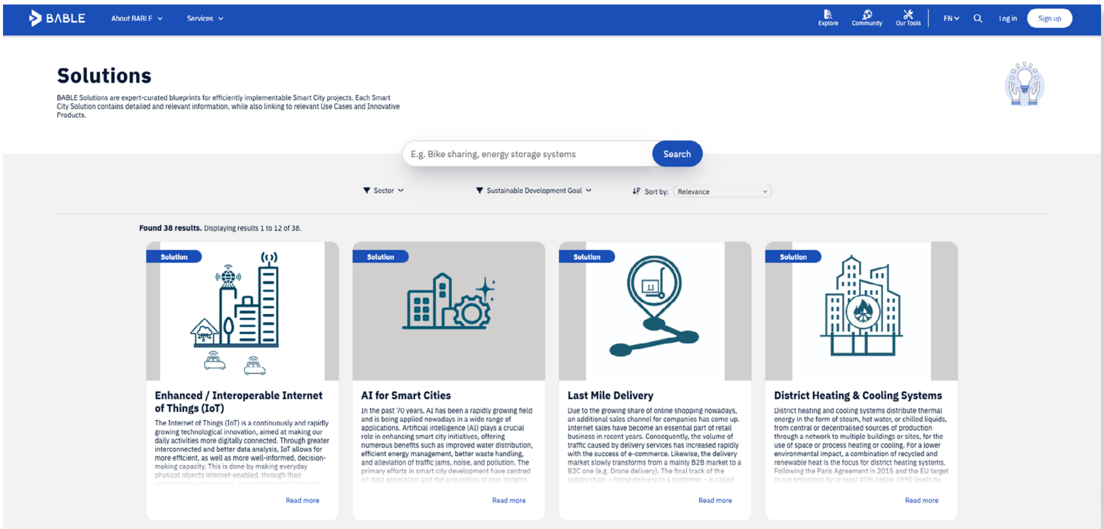


Image: Online package of smart city solutions created by BABLE

CASE KERA

Developing business models are central to the goals of Kera's development commitment, and EaaS services are mentioned, for example, in Kera's energy assessment as one of the solutions enabling a sustainable energy system in the area. These operating models facilitate the necessary investments for promoting the area's sustainability, supporting existing solutions and models.

New business models can allow Kera residents and operators to make investments in sustainable and smart energy solutions. EaaS and ESCO services can enable investments in solar energy, for example, without substantial initial capital, and joint aggregator service acquisitions can create added value from flexible consumption.

A low-temperature district heating solution to be constructed in Kera enables a broader utilisation of local waste heat sources. Operators should assess their waste heat locations and the economic viability of selling their surplus heat together with the grid operator. Small-scale electricity production can also be sold back to the grid, provided that the production equipment's connectivity has been ensured with the distribution system operator, and a sales agreement for surplus power has been made with an electricity retailer. As most of the residential buildings in Kera are blocks of flats, it is worth considering a compensation calculation service when investing in solar power. This allows a larger portion of the electricity generated to be used at the property by sharing it between the residents.

Further information

Guidelines for start-up idea competitions on the SPARCS

8.2 SOLUTIONS II: CONCEPTS

Power-to-X – use of surplus electricity in manufacturing synthetic fuels

SOLUTION DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

The term Power-to-X (P2X) refers to the use of excess electricity in manufacturing synthetic fuels, such as hydrogen, methane, liquid fuels and chemicals like ammonia. P2X solutions can help to balance electricity production and consumption, store surplus energy and promote the use of sustainable fuels, for example in transport and industry. To ensure the sustainability of Power-to-X (P2X) solutions, it is crucial to ensure that the electricity used in the process is sustainably produced. The key term around P2X solutions is sector integration, which involves the increasing transfer and conversion of energy between different forms. This will play a significant role in promoting sustainability and emission reductions, both in the energy sector and other sectors. The Ministry of Economic Affairs and Employment's sector integration working group has produced a final report, which highlights hydrogen solutions, in particular, as a key measure to promote sector integration. The Finnish government approved a decision in principle on hydrogen on 9 February 2023. According to a government decision, Finland aims to be a European leader in the hydrogen economy, and the country would be able to generate at least ten per cent of the Union's emission-free hydrogen. Cities will also play a major role in this, if and when the manufacturing and distribution of synthetic fuels becomes a larger part of urban infrastructure.

Espoo has extensive expertise in hydrogen and P2X technology, with contributions from universities, research institutions and businesses. For example, the local energy company, Fortum, is planning to pilot hydrogen production near the Loviisa nuclear power plant, and Aalto University has set up a hydrogen innovation centre to promote a sustainable hydrogen society. The City of Espoo has considered the use of biogas in its fleet of lorries. If needed, the use of synthetic methane instead of biogas in the City's vehicles may also be an option. In addition to Espoo, the opportunities afforded by the hydrogen economy and P2X solutions have also been noted elsewhere in the Helsinki Metropolitan Area. For example, with the support of the Energy Authority, the first hydrogen refuelling station in Uusimaa is being built in Järvenpää. Additionally, Vantaan Energia and Wärtsilä have entered into an agreement for the preliminary planning of a Power-to-Gas plant that produces synthetic methane at Vantaa's waste incineration plant.

CASE KERA

The transport arrangements for the centre of Kera emphasise the promotion of walking and cycling, as well as functional public transport through rail infrastructure. However, fuels produced through P2X solutions can be a means of promoting the sustainability of other forms of transport, such as logistics and private cars. Therefore, P2X solutions may play a role in Kera's development into a carbon-neutral urban area. In that case, however, production and distribution infrastructure may be located outside the area, because Kera will not be a major industrial site in the future. Currently, the role of P2X solutions in Kera is mainly focused on the opportunities for utilising end products in the transport sector, as hydrogen economy and other services in Finland develop.

8.3 SOLUTIONS III: ENGAGING STAKEHOLDERS

Engaging residents

DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Residents have been a part of urban planning measures for decades, and consulting them at certain stages of planning is a legally mandated part of a city's operations. However, it is important to view residents not only as part of the daily work, but also as a resource in urban development, as future residents will have the closest interaction with the future residential areas. Therefore, Espoo has produced a participation model with a vision that states: «All Espoo residents can participate and influence the development of their home city.» This vision is also being implemented in the City's sustainable development work, including projects focusing on Kera and other parts of Espoo. Many participatory solutions have been implemented in Espoo's projects, including buddy class activities, workshops and resident groups. In addition to this, participatory work has been carried out city-wide, such as in Espoo's master plan for 2060, the Our Espoo 20X0 event series and the My Espoo survey. All of these serve as examples of potential participatory work in Kera, now and in the future.

Engagement of residents has become more prominent under the energy theme, particularly due to the changes caused and enabled by the energy transition. New energy solutions, operating models and goals will provide residents with new opportunities to live sustainably, while being increasingly economically sustainable options. As the use of renewable solutions has increased, energy production has moved closer to cities and their residents. And as solar power investments, for example, have become easier, residents are more able to invest in renewable production. Furthermore, residents can produce and commercialise flexibility for the energy system, depending on the potential. For instance, the increased use of electric cars enables flexible charging and ultimately also the use of electric car batteries for electricity storage.

The SPARCS project has trialled various resident engagement and communication measures, both within and beyond the energy theme, including activities such as buddy classes, the Following the Carbon Footprint ("Hiilijalanjäljillä") event series, sustainable mobility test runs and 1.5-degree workshops for residents. The inclusion of young people in the project activities has been a particular focus during the work.

CASE KERA

Kera will evolve over the years, even decades, and currently only a fraction of the final population live in the area. The lessons of the participatory work can be used continuously throughout the development, taking into account the target groups and latest best practices.

Although the role and opportunities of young people under the energy theme will be limited in the near future, it is important to keep the area's long lifecycle and young people as future residents in mind. Young people's increased

Further information

Description of citizen engagement in the BABLE database

Espoo's participation model on the City's website (in Finnish) awareness of the energy theme and their role will benefit young people themselves, the City and the local operators. The buddy class activities of the SPARCS project provide a replicable concept for engaging young people in sustainable development as part of their school activities. In addition to the comprehensive schools to be built in the area, Kera houses students from general upper secondary schools and universities of applied sciences in temporary facilities. Engaging them is beneficial and allows them to influence their own environment.

SPARCS PILOT SOLUTION: BUDDY CLASS ACTIVITIES

The aim of the SPARCS project has been to develop means of participation and find the best tools to reach and engage different resident segments. One important segment, highlighted during the project, is young people. The project's aim has also been to identify factors to consider when engaging young people and find effective solutions for longer-term participatory work. The project has promoted the engagement of young people through buddy class activities. This method is a research-based and participatory way to act, and to reach young people as part of their everyday activities. School offers an ideal place to reach young people and initiate a dialogue. The SPARCS project has two separate buddy classes, one that operates under the City of Espoo and the other under Citycon. The activities carried out with both classes are similar, but the desired outcomes vary when reflected against the goals of the public sector and a commercial enterprise.

The first meeting with the pupils and their teacher took place in autumn 2020. After that, meetings with the buddy class children were held four times per academic year, between spring 2021 and spring 2023. Themes supporting the introduction of a sustainable lifestyle were discussed during the meetings. The young people's own interests and questions were taken into account when picking discussion topics and meeting-specific themes. The meetings provided an opportunity for reflection and sharing information on a sustainable lifestyle, and they inspired young people to make sustainable choices and participate in social debate.

The meetings consisted of various interactive features, such as visits, lectures, workshops, surveys and discussions. During the visits, the young people were acquainted with various ways to live sustainably in practice, and learnt, for example, what sustainable energy solutions are and how circular economy works. Above all, they learnt about the importance of sustainable development themes and actions, and how they too are active agents in achieving these goals. The lectures and workshops, on the other hand, enabled a more in-depth study of sustainable development themes and problems.

Engaging young people in the sponsor class activities and the related research requires ethical consideration and appropriate permits. In these activities, it is important to recognise the involvement of minors in research and ensure compliance with all ethical guidelines and GDPR regulations. Before initiating buddy class activities, the pupils' parents were informed of the upcoming events, the project and the buddy class themes, and the necessary permits were obtained, ensuring the safe participation of pupils.

The buddy class activities of the SPARCS project serve as an example of a method that can be used to engage young people in project work and other urban development. The aim of the project is to make these activities a replicable and disseminable concept.

Image: City of Espoo

8.3 SOLUTIONS III: ENGAGING STAKEHOLDERS

Engaging housing companies

DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

In addition to energy production and distribution, energy efficiency plays a vital role in promoting sustainable energy. As the new building stock is already highly energy efficient, the most significant potential for reducing energy consumption is in existing buildings. By investing in energy efficiency measures both environmental and economic benefits are possible, because a more energy-efficient building is also a more cost-effective building. When it comes to improving the energy efficiency of the existing building stock, the housing companies play a key role as bodies deciding on their investments and energy renovation projects. During energy renovations, housing companies can also examine and introduce other solutions, such as solar power production, alongside the promotion of energy efficiency.

As the competence of housing companies is dependent on the abilities and interest of the board members and building managers, collaboration, advice and support mechanisms can help with the implementation of measures. One possibility, also piloted in Espoo, to enhance the implementation of energy efficiency measures, and other guidance and collaboration is to establish local housing company networks. As housing companies vary in size and available funds, the network can provide advice, but also create opportunities for joint procurement and scaled investments. The City's goal is to create an operating model that guides housing company boards towards systematic maintenance and introduction of energy efficiency measures. Housing company networks are currently being piloted in Matinkylä, Espoo.

CASE KERA

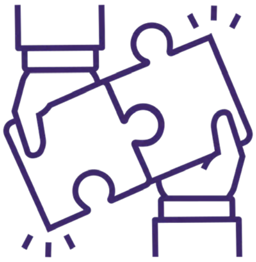
As Kera is mostly a re-developing area of housing and workplaces, the energy efficiency and implementation of new energy solutions in local building stock will, as expected, be more advanced compared to Espoo's districts that have older buildings. During the construction phase, the developer will hold the decision-making authority regarding implemented solutions, but the authority will shift to the residents during the transfer of administration. However, housing companies will be important actors in the area as the construction progresses and will make decisions as the need for energy renovations becomes topical in the future. Systematic maintenance throughout the entire lifecycle of the district, and thus also the advice and engagement of the housing companies, is important from the start. Housing company forums can facilitate local networking and a sense of unity, ensuring an easier adoption of sustainable solutions going forward. Information distribution and cooperation between housing companies should be promoted according to the interests of the local residents.

Further information

Description of energy renovations and an energy-efficient renovation in the BABLE database

8.4 SOLUTIONS IV: URBAN DEVELOPMENT

Co-creation



DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

Co-creation involves equal and network-like efforts between individuals to achieve a common goal. Its methods offer a networked, multi-stakeholder approach to work and organisation that enables the handling of large elements such as regional sustainability goals. District development is a demanding co-creation application due to the number of stakeholders involved and the inherent scope of the work, but successful efforts offer significant and long-lasting positive effects both locally and at City level.

Co-creation can be used to achieve sustainable, smart and communal urban areas where local operators work to achieve a common goal. Long-lasting and effective collaboration methods also provide an opportunity to create a flexible and more resilient urban structure that can withstand the challenges of the operating environment. Involving residents throughout the process creates a more user-centred area, giving residents an opportunity to influence their local environment and everyday services.

In 2022, the SPARCS project created a co-creation model for sustainable and smart urban areas to describe and promote the City's co-creation work. This model allows collaboration methods that have proven successful in the Kera area to be replicated in other parts of Espoo. During the model's implementation, special emphasis was placed on the challenges related to energy and mobility from the perspective of co-creation. The model is openly available online and can be accessed via the QR code see below.

Cooperation with local operators is an important part of district-level development in Espoo and, for example, the collaboration methods used in Kera have served as the basis for the SPARCS co-creation model. Additionally, Espoo strongly promotes business collaboration and other partnerships at City level, through services focused on supporting businesses and strategic partnerships that have already been established with several companies. Furthermore, the City of Espoo has signed a joint commitment towards a carbon-neutral city by 2030 with 25 partners. The Climate City Contract is part of the EU Mission for Climate-Neutral and Smart Cities.

CASE KERA

Co-creation with the area's landowners, developers, energy companies and other operators has been ongoing in Kera for years. In fact, the co-creation model of the SPARCS project has been created partly on the basis of the well-functioning work in Kera. For Kera, the key is, therefore, to actively continue, expand and replicate co-creation in other areas where similar work could be beneficial. The model serves as a good foundation for the continued work in the area.

Further information

Website of the co-creation model produced in the SPARCS project

8.4 SOLUTIONS IV: URBAN DEVELOPMENT

In terms of energy, the district-level solution and the opportunities it provides are highlighted in Kera. In order to achieve the goals set for the area, new flexible and circular solutions must be sought through co-creation as part of the local system. Shared solutions may also facilitate profitable electricity generation in or outside of the area for the needs of local actors. For example, energy communities are an interesting, evolving operating model that offers an opportunity for sustainable joint generation of electricity. However, current legislation limits existing energy community models.

SPARCS PILOT SOLUTION: CO-CREATION MODEL FOR SUSTAINABLE AND SMART URBAN AREAS

Developing future energy systems at a district level requires collaboration between operators and stakeholders. For example, the goal of positive energy districts or other similar sustainable district-level energy concepts refers to a broader perspective beyond individual buildings. The focus is on a more in-depth understanding of individual aspects and the area as a system, where various factors interact with and depend on each other. The links and connections between actors play a crucial role in the development of the area, enabling shared functions and practices, especially from the perspective of solution optimisation and resource efficiency.

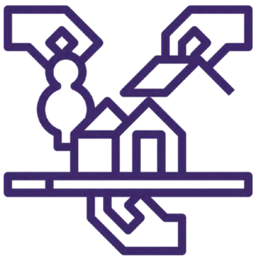
In Kera, the tradition of co-creation is deeply rooted in the area's identity. Kera has been developed through collaboration between various operators, including businesses, organisations, landowners, residents and the City. These and other lessons learnt from co-creation elsewhere have been gathered and condensed into a functional co-creation model for sustainable and smart urban areas as part of the SPARCS project. The model, or toolkit, aims to address the question of how new sustainable and smart urban solutions can be collaboratively introduced to urban areas with various actors, and how these solutions can be used to develop urban areas towards sustainable development goals. During the model's preparation, the focus was on energy and mobility, in particular, but urban services and green infrastructure were also discussed.

To form the model, the City of Espoo and the model's constructors, WSP Finland and Korkia Consulting, organised three virtual design sprint sessions, one workshop for the City's representatives and four presentation webinars in 2022. A total of 130 individuals from 40 organisations took part in the process. Residents participated in the model's creation through a resident survey, webinar and workshop.

The model's creation process produced a co-creation toolkit, which can be openly viewed and used online. At present, the aim is to share the model and the toolkit within and beyond the City in order to make the lessons learnt from the work more widely applicable.

Images: WSP Finland and Korkia Consulting

3D model as part of energy planning and local optimisation



DESCRIPTION AND LESSONS LEARNT FROM THE PROJECT

3D city information models, where a city's geometry is combined with various forms of information, depending on the model, are increasingly common applications used in city planning and visualisation. A 3D model alone refers to the digital modelling of the geometry of urban elements, such as buildings, infrastructure, vegetation or terrain. A 3D model can remain at this visual level or information can be included in the objects it contains, boosting the model's usefulness to the City's employees, other stakeholders and residents. This turns a simple geometric model into a more comprehensive city information model.

City information models are already in use in Espoo, both at city level and locally, but the applications used may vary according to area. The City of Espoo's 3D city model is also openly available via an interface, and it can be viewed in the Espoo map service. Locations where city information models could be used in district development have been studied and piloted in the SPARCS project and Kera's development. The main goal of SPARCS has been to assess the city model's role in energy planning, and work in Kera has aimed to pilot opportunities offered by the city information model in visualising the area and calculating carbon footprints, for example. Efforts have also been made in Kera, based on the information model and using the information available, to create an information package to visualise the area's development on a timescale.

More information on the use of 3D models in local energy planning can be obtained from a study produced during the SPARCS project (see below).

CASE KERA

The piloting of city information models in Kera has progressed considerably and simultaneously with the SPARCS project, providing new opportunities for testing the project's lessons in the area. The opportunities afforded by the model for energy and transport planning are particularly interesting. Any review and piloting needs should be identified in these themes with the area's developers. For example, a visualisation of the solar power potential could promote the adoption of renewable energy solutions in the area.

The city information model for district development also offers a possible channel for visualising and communicating the progress made in the area, both amongst the developers and towards the residents. The long lifecycle of the development work in Kera and the major change in the urban landscape require new applications for communicating the outcome of district development to current and future residents.

Further information

Report on the role of 3D models in energy planning on the SPARCS website

SPARCS PILOT SOLUTION: 3D MODEL FOR DESIGNING POSITIVE ENERGY DISTRICTS

The SPARCS project has examined ways to utilise Espoo's 3D city model in planning sustainable urban areas and making block-specific or district-level energy analyses, with the aim of designing positive energy districts. The City of Espoo, together with VTT, chose Espoonlahti sports park as the pilot location for the study. Seven different types of buildings at the sports park, two schools, a daycare centre, a swimming hall, an indoor ice skating rink and a fire station were selected for analysis.

The following technologies to be investigated were selected for the area's energy analysis:

- Energy efficiency measures;
  - Energy-efficient windows (all buildings except the ice rink);
- Local energy production;
  - Roof-mounted solar panels (all buildings);
  - Geothermal heat and heat pumps for heating (swimming hall)
  - Separate solar panel arrays.

Based on the energy analysis, the introduction of energy-efficient windows (U value up to 0.8 W/m^{2}K) would reduce energy consumption in the target area by 5.5%. Roof-mounted solar panels would produce 28% of the electricity consumed in the area, while geothermal heat would cover more than half of the area's heat production but double its electricity needs, also affecting the proportion of locally produced electricity. Covering all local electricity consumption would require 19,600 m^2 of solar panels. However, due to the differences between production and consumption, only about 40 percent of the electricity generated could be simultaneously consumed in the area. Similarly, covering the area's heat consumption would require the construction of another geothermal plant, which in turn would further increase local electricity consumption. Based on these results, it can be concluded that covering all local energy consumption annually is theoretically possible but unlikely due to significant investment requirements and the space needed for the solar panels. Moreover, as the production and consumption are not balanced, the local production will only cover a portion of the energy consumption over a shorter period as well.

Image: VTT

By utilising data produced by the City of Espoo on the geometric shapes of buildings, the results of the analysis were visualised on a map, aiming to create an easy and straightforward description of the results. However, for a detailed analysis of the results, traditional tables may be a simpler representation method than map-based visualisation.

SPARCS Project Partners

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