IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

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Vaasa North-Eastern Europe Implementation Guideline

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Disclaimer

Preface

The City of Vaasa is a mid-sized coastal university city in Finland, committed to be carbon neutral by 2030. The Vaasa region is known for its global energy cluster, Energy Vaasa (www.energyvaasa.fi), a world leader within different technologies, such as smart electrical solutions, sustainable energy, flexible power generation and digitalization.

The City of Vaasa is an energetic proof, that a mid-sized city can be an international frontrunner. We have set goals and we have a strong development approach and with an excellent triple helix and engaging mindset, we have created a successful way of working with stakeholders, companies, politicians, employees and citizens. The city strategy focuses on three areas, wellbeing and education, attractiveness and carbon neutrality. With the help of the city strategy, the energy and climate program and the replication plan and the stakeholder, we are working towards our goals according to the roadmap.

I advise you to set your goals for climate neutrality, create a roadmap and a smart city plan, engage your stakeholders and citizens and benchmark solutions used in other cities. In a fast-changing world, it is also of great importance to be flexible and able to act fast when needed.

I hope this "Vaasa North-Eastern Europe Implementation Guideline" will inspire you and help you in your work toward climate neutrality.

Tomas Häyry
Mayor,
City of Vaasa

Executive Summary

The IRIS smart city project was initiated in 2017 and lasts six years, until 2023. There are three IRIS Lighthouse (LH) cities in Europe: in Netherlands, Sweden and France. Vaasa (Finland) is one of the four follower cities (FC). During the IRIS project, the LH and FC cities are integrating and implementing innovative and modern measures towards energy efficiency and smart energy transition, as well as applying sustainable mobility schemes and services, and interactive citizen engagement.

At its core, the idea of IRIS is that cities can learn from lighthouse cities and then replicate the solutions. IRIS concentrates on cities, as urbanization is a global megatrend, and cities have tremendous potential to evolve and become smarter, cleaner and more sustainable. The IRIS smart city project consists of five Transition Tracks: 1 Smart Renewables and Closed-loop Energy Positive Districts, 2 Smart Energy Management and Storage for Grid Flexibility, 3 Smart e-Mobility Sector, 4 City Innovation Platform (CIP; digital transformation and services) Use Cases, and 5 Citizen Engagement & Co-creation. Each Transition Track includes integrated solutions, for example IS-2.2: Smart multi-sourced low temperature heat networks with innovative storage solutions.

The aim of this deliverable is to present the fellow city Vaasa's journey in becoming a smart city during the IRIS project and to work as a guideline to Nordic region cities on their path to becoming smart cities. Overall, the aim of this deliverable is to inform, inspire and guide. The paramount goal of the IRIS project has been to improve urban life, and to ensure sustainable, secure and affordable mobility and energy for living for all citizens and businesses.

The scope of this deliverable includes three sections: smart cities on a general level (**chapter 2**), the smart city journey of the FC Vaasa (**chapter 3**), and lastly guidelines for smart city concept implementation for the Nordic region (**chapter 4**). Chapter 3 presents FC Vaasa's researched and realized Transitions Tracks (all 1-5), and ambitiously numerous solutions (21 in total). Chapter 3 also includes lessons learned for Vaasa region. The context of this document is the mentioned IRIS smart city project within Europe. This deliverable is the last report of Vaasa North-Eastern Europe Implementation Guideline.

Recommendations to specific audiences, namely to North-Eastern European cities and SMSTs (small and mid-sized towns) are presented in **chapter 3.4** Lessons learned for Vaasa region and in **chapter 4** Guidelines for smart city concept implementation for the Nordic region. In short, we recommend linking smart city solutions to the city strategy, co-operating with relevant stakeholders, interacting with IRIS LH and follower cities, being flexible and incorporating citizen engagement from the beginning.

Referral to relevant inputs and outputs from other deliverables: D8.4 Vaasa replication plan and D8.3 replication toolbox, as well as the list in **Annex 1** about inputs. Annex 1 includes referrals to reports from three Lighthouse cities: Utrecht (WP5), Nice (WP6) and Gothenburg (WP7).

IRIS Vaasa team concludes that during IRIS project we have successfully trained ourselves to shift from solution to system change. One concrete example output of IRIS project was, for example, hiring of new resources with new titles, e.g., energy and climate expert. It can be concluded that the aims of the deliverable and IRIS project in case of City of Vaasa have been met, as IRIS has improved urban life in Vaasa, and it has helped to ensure sustainable, secure and affordable mobility and energy for living for

all citizens and businesses. In truth, some effects will be better seen in the future, but progress and development can already be witnessed nevertheless. Contacts, project results and tools created during IRIS project, as well as the system change mindset will continue to bear fruit in the future.

The expected and desired impact of this deliverable is the spreading and multiplication of smart cities across Europe. The estimated beneficial effects include energy transition, quickened pace of transition, new smart city replication plans, and the improved ability to share ideas and knowledge. One further beneficial effect is the improved ability to recognize other necessary measures on the smart city journey.

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List of Abbreviations and Acronyms

Abbreviation	Definition
BESS	Battery Energy Storage System
BEV	Battery electric vehicle

BIPV	Building installed photovoltaics
CHP	Combined heat and power
CIM	City Information Model
CIP DESS DG	City Information Platform Distributed energy storage solutions Distributed generation (power)
DH	District heating
DSO	Distribution service operator (electricity)
e.g.	*exempli gratia* ("for example")
ESS	Energy Storage System
EU	European Union
EV	Electric vehicle
FC	Fellow/follower city
HV	High voltage
HEV	Hybrid electric vehicle
HKU	University of the Arts Utrecht
ICT	Information communication technology/-gies
i.e.	*id est* ("in other words")
IoT	Internet of Things
IRIS	Integrated and Replicable Solutions for Co-Creation in Sustainable Cities
IS	Integrated solution
LH	Lighthouse city
LTDH	Low temperature district heating
LV	Low voltage
MaaS	Mobility as a Service
MV	Medium voltage

PHEV	Plug-in hybrid electric vehicle
PV	Photovoltaic
QoL	Quality of Life
RES	Renewable energy systems
Smart City	a city which incorporates sustainable & smart & co-creation solutions in the fields of energy, transport and mobility, resource utilization and/or preservation, all for achieving carbon neutrality
TT/T.T.	Transition track
V2G	Vehicle-to-grid
V2X	Vehicle-to-anything
WP	Work Package

1. Introduction

The purpose of this deliverable is to present the fellow city Vaasa's journey in becoming a smart city during IRIS smart city project. Lessons learned, knowledge gained and how the process of starting replication projects based on the demonstrations in the lighthouse cities are described. Additionally, the background of how Vaasa decided to work towards implementing smart city solutions is introduced. The importance of stakeholder engagement, smart city ecosystem development and citizen engagement are presented, supporting the overall process of Vaasa's work. The deliverable focuses on giving guidelines to cities located in the Nordic region.

Ultimately, the goal is more sustainable and well-functioning urban surroundings, with the ability to provide better quality of life to the citizens by efficient, secure and sustainable mobility, energy technology and ICT solutions.

The deliverable 8.5 is structured into three sections. The first section describes smart cities on a general level; what the concept of smart cities is, and which smart city solutions typically exist. After this smart city solutions which are typically specific for the cities located in the Nordic region are presented. Finally, a list describing the smart city solutions implemented in the LH cities of the IRIS project is examined. The second section, or the main section of the deliverable, presents the smart city journey of the FC Vaasa, describing the background and reasons behind the decision for Vaasa to start its demanding smart city journey. The challenges faced and the replication projects the city has initiated, as well as the lessons learnt throughout the IRIS project are presented and summarised. The final, third, section presents guidelines for the cities in the Nordic region, based on the knowledge gained and lessons learnt in Vaasa during the project.

This deliverable is part of the documentation of the replication actions carried out in the FC Vaasa and should also serve as a guide for other cities in the Nordic region who want to work with becoming a smart city. The FC Vaasa has presented a replication plan based on the demonstrations in the LH cities of the IRIS project in the earlier deliverable named D8.4 Vaasa replication plan. Both deliverables are connected to the replication actions of the IRIS project and are part of the work package named WP8: Replication by Lighthouse regions, Follower cities, and European market uptake.

These similar deliverables by three other FCs in the IRIS project can be of interest to the reader:

D8.6 Alexandroupolis replication plan, and D8.7 Alexandroupolis South-Eastern Europe implementation guideline.

D8.8 Santa Cruz de Tenerife replication plan, and D8.9 Santa Cruz de Tenerife South-Western Europe implementation guideline.

D8.10 Focsani replication plan, and D8.11 Focsani South-Central Europe implementation guideline.

2. Smart Cities and the IRIS project

The IRIS smart city project was initiated in 2017. The project is funded by the European Union's Horizon 2020 program, with duration of six years (2017-2023). IRIS Lighthouse cities are Utrecht (Netherlands), Gothenburg (Sweden) and Nice Cote d'Azur (France).

During the project, these cities have been acting as living laboratories for demonstration, integration and implementation of innovative energy efficient areas, flexible smart energy solutions and applications. They have been incrementing the utilization of renewable energy solutions (RES) and energy storage solutions (ESS), e.g., battery-energy storage solutions with first and 2nd life batteries, heat energy-storages, and electric vehicles' (EVs') energy storage capacity via vehicle-to-grid (V2G) or vehicle-to-anything (V2X) and photovoltaic (PV) integrated systems. Additionally, the lighthouse (LH) cities have striven for intelligent use of state-of-the-art information communication technology (ICT) solutions, sustainable mobility schemes and services, and interactive citizen engagement. The paramount goal has been to improve urban life, and to ensure sustainable, secure and affordable mobility and energy for living for all citizens and businesses. To achieve this, a coalition of universities, research organizations, innovation agencies, local authorities and private expertise joined forces in collaboration. To enforce this, the LH cities have been cooperating actively with the follower cities: Alexandroupolis (Greece), Focsani (Romania), Santa Cruz de Tenerife (Spain) and Vaasa (Finland).

2.1 Introduction to smart cities

Currently, more than 50% of the world's population is concentrated in large cities, or in their proximity. It has been estimated, that by 2050 the amount of people living in these mega cities has risen by additional 20%.

An EU report estimates that around 70 per cent of Europe's population live in cities. However, what is often left out of consideration is that a significant percentage, around 56 %, of this urban population live in small and medium-sized towns (SMSTs). This puts small and mid-sized cities in an important position.

Urbanization is a global megatrend, which has direct effects on the climate change, rising emission and pollution levels, as well as on the energy production, distribution and consumption. Additionally, urbanization bears direct impacts on urban infrastructure requirements, land use, residential and transport requirements, and sustainability on all its levels: environmental, economic, social, and cultural.

The accelerated urbanization and growing environmental awareness have risen concerns and demands for cities to become "smarter", with the ability to be constantly evolving. There is a grave need for ambitious sustainability strategies and projects, which can aid cities intelligently and comprehensively in this task. By promoting innovative, efficient, far-reaching and replicable solutions, from the fields of smart energy production and consumption, traffic and mobility, information communication technology, and citizen engagement, the objectives of the strategies can be achieved.

Smart city development promotes innovative energy solutions, smart grid and RES development, and strives to advance sustainable transport modes, thus affecting on economic and social levels, and enhancing quality of life (QoL). A smart city utilizes ICT to reach more efficient and intelligent standards in achieving carbon neutrality. It preserves natural resources and reduces land use by mature and jointly executed coordination and planning of infrastructure and transport design. A smart city strives for implementation of green and innovative technical solutions, leading to savings in costs and energy, and promoting better service delivery.

The smart city advancement should have a holistic approach on sustainability. Measures to reduce a city's impact on environment and to expedite the integration of intelligent and efficient use of technologies with the urban infrastructure outright form the backbone of environmental sustainability. Economic sustainability signifies attempts to develop a city's economic potential, new financial and business models and innovations, and advance more efficient and annexed service and infrastructural solutions. A smart city's attractiveness for people, businesses, and capital improves the overall employment, business, and service possibilities, when social and cultural sustainability levels are functioning properly. Thus, cost reductions, higher stability and security, and enhancement of quality of life can be achieved.

In order to plan, capitalize, and implement the best operating smart city solutions, new methods, technologies, and innovations are required. These include efficient and affordable energy production based on RES, and promoting sustainable mobility solutions, smart charging and innovative energy storage schemes, and advanced ICT and digital solutions. Additionally, key stakeholder engagement is relevant, including political leaders, government and city officials, organizations, service operators and solution providers, investors and consumers. Indeed, local level citizen engagement has a paramount role in any smart city development strategy. By these means, the continuance of the smart city development can be secured, including the optimal end-result of citizen-awareness and attractive city environment.

2.1.1 Smart city concept - Vaasa

The smart city concept for the City of Vaasa is based upon not only the demonstrations and experiences of the IRIS lighthouse cities but upon several other smart city project demonstrations. These examples and valuable knowledge and competence gained from them support us and provide much needed direction in various aspects of our city development, e.g., in sustainable mobility, smart energy and smart mobility solutions, renewable energy solutions' utilization, energy transition, and in exploiting the potential of various digital and intelligent technology solutions.

In many of the City of Vaasa smart city solutions' development, one of the major challenges is to find a way to initiate and proceed with the project so that heavy up-front investments could be avoided, and the payback periods could be kept as short as possible. Additionally, piloting new solutions, their swift implementation, gathering relevant data, and gaining and sharing knowledge, networking and collaboration with various stakeholders, communication and seeking external funding for smart city solutions' project development and investments, is important.

Picture: City of Vaasa

The City of Vaasa has in the last years put quite a lot of focus and effort on a centralized internet-of-things (IoT)-platform development for the city. The City of Vaasa's objective is to strive towards one holistic IoT-platform implementation, which would eventually be able to gather and provide data from the city's various data sources as traffic (emissions, modes, and optimization), climate and weather, lighting, energy efficiency and various energy solutions, and data from smart charging infrastructure. However, we realize that we do not currently possess enough competence and knowledge in how to most optimally gather, analyze, exploit and utilize the real-time data available to us via such data platform. Thus, we aim to proceed by using different pilots and use cases, and by collaborating and engaging different user groups that could provide us more knowledge and insight about their specific needs concerning targeted data analytics, visualization and/or simulations.

We consider that the best approach with which to provide the most prominent results on how to build up the IoT-platform for Vaasa is to bring different stakeholders together and go through our ideas of real-time data collection and a joint IoT-platform. We have been able to form a large consensus within the city administration, academia and many private companies, all supporting that real-time data collection and a joint IoT-platform is indeed needed in Vaasa. It would be an essential tool for the city to achieve its carbon neutrality goals by aiding our energy efficiency measures, technologies as well as smart mobility development. This collaboration, networking and engagement measures are something we see as an important part of all smart city activities we do here in Vaasa.

2.1.2 Smart city solutions

Smart Grid and Energy Solutions

Infrastructures of power systems, from electricity generation to utilization industrially, commercially and residentially, are currently in a state of significant change. The power systems, i.e., grids, are required to evolve, to become smarter. Today's power grid needs to be reliable and efficient, resilient and flexible, secure and technically advanced, controllable and customer friendly. The main drivers for these requirements are the rising global population, urbanization, and environmental issues, e.g., climate change, global warming and increased emission levels. They all have an influence on international and national energy and environmental policies, laws and regulations around the world. Additionally, advances in technology, and increased utilization of renewable energy sources steer the development of the power systems towards a new age.

A modern power system's ideal requirements are high reliability, quality, flexibility and efficiency in energy supply. Active monitoring and fast reaction to any changes in the power delivery system are also unconditional qualifications. Reliability is needed in balanced electricity supply, improved energy efficiency, and constant voltage and frequency control. Moreover, increased integration of renewable power generation, electricity storage systems, e.g., battery-energy storage solutions (BESS), and the rising number of EVs, set their own demands for power grids. Furthermore, digitalization and the increased impact of new technology, wireless communication, and new generation security threats, raise the level of requirements for the functionality of current power systems even higher. Modern power grid is required to be self-healing in case of power disturbances, and resilient to stand all attacks, both physical and cyber.

Unfortunately, the traditional electric power system infrastructure is not designed to meet these vast requirements. It is designed on the operating model in which electricity flows primarily in one direction, from HV (high voltage) generation sources to MV and LV level consumption (medium voltage and low voltage, respectively). It has limited cross-border interconnections, relying on centralized control. The traditional power systems are dependent on non-renewable energy sources (coal, gas, petroleum), which cause approximately 40% of the global carbon dioxide (CO_2) emissions, thus having severe negative impacts on the environment. Furthermore, traditional power systems are technically optimized for regional power adequacy and have limited capability for automation and situation awareness. They lack customer-size data to manage and reduce energy use sufficiently for today's standards.

Smart grids provide enhancements and expansion to the traditional power grids, their maintenance and operations, by being flexible, optimal and bidirectional. Smart power generation is coordinated, and locally managed, having full integration of distributed energy generation (DG) with RES (wind, solar (PV), hydro, wave, geothermal, bio and waste-energy), alongside large-scale centralized power generation. Smart grids provide enhanced sensory and control capacity, designed to deliver and perform at high-speed, in near- or real-time, in order to adjust to integrated DG, RES, energy storage units, EVs, direct consumer participation in energy management (consumption and production), and efficient communication appliances.

Smart systems aim to provide user specified secure, high-quality and reliable power supply for the digital age. The customers are provided with better tools to manage their energy consumption, not only to act as consumers but having the ability to perform as energy producers as well. With improved economic productivity, high-class demand side management (DSM) and customer-driven value-added services, consumers can benefit from cost savings and increment in quality of life.

Minimized environmental impact can be achieved by maximizing safety and sustainability. Smart grid's operation and technology are designed to meet the demands of modern cyber security, and to assure long-term operation of the whole power system. The latest advances in wireless communication technology and intelligent information management systems are utilized, in order to secure the most robust and dependable operation, control and monitoring.

Smart Mobility Solutions

Some of the biggest transport related challenges in today's growing cities are congestion, pollution, accidents, noise and scarceness of public space. Enhancing the development of diverse transport systems and technology requires deployment of Mobility as a Service concept (MaaS), urban mobility governance, and real-time data collection and management. Thus, better traffic and infrastructural planning and management can be achieved. Additionally, there are matters of social nature to be considered, such as enhanced ability to improve traffic safety, enhance environmental performance and attractiveness, and advance information management and decision-making. Ultimately, the goal is more sustainable and well-functioning urban surroundings, with the ability to provide better quality of life to the citizens by efficient, secure and sustainable mobility, energy technology and ICT solutions.

Through state-of-the-art energy technology, sustainable transport and ICT solutions, a smart city benefits from improved and precise quality and quantity measurements, aided by real-time big data management, analytics and modelling. Consequently, gained development in knowledge capacity building, transfer and lessons learned, enable and amplify the city's smart aspirations. Smart transport, both individual mobility and public transport, seek to support and exploit ways of e-mobility systems, continuous mobility chains and new mobility services, which are not only efficient and user-friendly, but cost-effective as well.

Private and public transport's transition from internal combustion engine (IC) vehicles to electric, gas and biofuel vehicles help to decrease fossil fuel consumption, hence helping to achieve carbon neutrality in smart cities. Transmission from private car ownership towards car sharing, i.e., car-pooling, and enhanced smart public transport services and increased connectivity, result in more sustainable transport in general, with decreased volume and emission levels, optimized to meet the demands and requirements of inter-modality. Smart public transport systems are highly flexible, providing consumers more versatility in transport modes, routes, schedules, service providers and payment systems.

Utilization of advanced EV technology and related solutions, e.g., smart charging and V2G schemes, with the option of combining RES and/or remote energy storage systems, are all part of a smart mobility's structure and integrative solutions. Functioning MaaS concept provides attractive and sustainable alternative for private transport and vehicle ownership. It uses intelligent mobility systems, e.g., data management, ICT and real-time information access. Costs concerning traffic and travel can be decreased, congestion be mitigated, and time used in travelling reduced. Additionally, the safety factors of traffic can be enhanced, and pollution and noise levels reduced. Furthermore, smart mobility contributes to the overall design of smart cities by transport network's efficiency, better management of parking spaces, and advancing public transport's usage rate and its supporting policies.

2.2 Nordic region-specific smart city solutions

Partly due to the weather conditions, partly due to development of smart solutions, the Nordic region has some specific smart city solutions that you will find in most projects in cities in the Nordics. Weather conditions include the four seasons and overall cold climate in the Nordic region. These affect the choosing and implementation of smart city solutions, as they directly affect construction and digging (main season during warm season; difficult and expensive during wintertime), heating and energy production (seasonal and annual fluctuation), and transport.

Picture: Winter view from Vaasa, family walking on the ice.

District Heating

The most common being perhaps district heating. The district heating systems in the Nordic countries have been built since the 1950's. District heating has a dominant position as a form of heating in all the Nordic countries except Norway. In Iceland, which has abundant access to cheap geothermal energy, about 90% of all heat used comes from district heating. In Denmark, Sweden and Finland, around half of the homes are heated with district heating, and in cities usually about 90% of the multi-story buildings are connected to district heating. In Norway, where electric heating from cheap hydropower dominates, district heating accounts for only a few percent of the heating market. The old infrastructure of district heating systems in the Nordics creates a lot of possibilities for innovative new systems to be implemented.

Energy efficiency solutions of buildings

Buildings in the Nordic countries use a lot of energy for heating because of the cold climate, and because of this, solutions for energy efficiency in buildings have always received a lot of attention. The Nordics have developed a lot of know-how when it comes to buildings and heating systems, implementing a lot of advanced optimization and management systems. There are large savings that can be achieved regarding energy and carbon footprints when it comes to the building stock in the Nordics, which is also identified as one of the most important areas when it comes to fighting global warming and climate change.

Decision making & citizen engagement

The Nordic countries have a strong history and culture of social democracy with interaction with citizens having been a big part of creating the modern Nordic societal structure. New smart city tools for citizen engagement are making it possible to take this engagement to a completely new level and have become something that is naturally interesting to countries in the Nordics.

Smart grids

In the Nordic countries, traditionally the energy solutions have been centralized; especially based on waterpower and industry side streams. This is very much due to the sparsely populated countries with big-industry dominated (steel, pulp & paper) economies, where basically everybody is actively working outside their homes. The population in the Nordics also lives close to nature and thus is maybe relatively sensitive to green movements. Especially wind power interests many, and wind conditions are generally good.

Society's clock speed causes energy usage tops for industrial daytime usage and inhabitants' mornings and afternoons; nights are usually quiet. Add volatile wind power, reduction of the amount of big industry units, and the many small power outages due to snow or fallen trees on the cables to the equation, and it is clear, that the grid as a whole (energy production, energy use, energy storage, pricing) must be managed in a smart way. The Nordic countries have thus been among the first areas to develop automated grid shield relays (SCADA – supervisory control and data acquisition) and telemetric real-time usage measurement devices, which help a lot in the management of these grid and storage systems.

Mobility solutions

The usage of EVs for personal mobility differs very much in the Nordic countries. Norway has supported the acquisition of EVs and charging systems heavily; the other Nordic countries rely on market demand. Due to long distances and cold winters, the market forces only can renew the fleets slowly. Although more EVs are currently bought than ever before, it may well be that fuel-driven cars are in use in big numbers still after 2050. The nations are planning various ways to speed up the transition to electricity-based mobility.

Waste management

Various recycling stations and waste-to-energy solutions, often connected to district heating, have replaced already in the 1990s most landfills in the Nordic countries. Often the inhabitants and industries are expected to sort their waste and the waste is then collected fraction by fraction and treated, e.g., biowaste and wastewater treatment sludges to biogas.

Circular economy

The next steps in waste management include planning of complete cycle circular systems that would also convert the CO2 emissions to synthetic fuels, through adding green hydrogen (from the ample wind power and water) and by using the rest product from biogas production as fertilizers. Waste household appliances, furniture etc. are collected, repaired and sold as second-hand – or recycled as materials.

2.3 The IRIS smart city solutions

The IRIS project consists of five Transition Tracks, which all include various integrated smart city solutions (IS). Once a Lighthouse city has successfully demonstrated an activity of an innovative smart city solution in their environment, a follower city is able to create a replication plan for the chosen integrated solutions. FC can then determine their schedule, resources, partners, all of which are the requirements for successful implementation. Not all the solutions demonstrated by the LH cities are required or even can be replicated by a follower city. Each participating city, a follower and a Lighthouse, has its own baseline, needs, framework and goals when starting the IRIS Smart City endeavour, determining which integrated solutions form its replication plan.

The five IRIS project's transition tracks and the included integrated solutions are:

2.3.1 Transition Track 1

Smart Renewables and Closed-loop Energy Positive Districts:

- IS-1.1 Positive energy buildings
- IS-1.2 Near zero energy retrofit district
- IS-1.3 Symbiotic waste heat networks

2.3.2 Transition Track 2

Smart Energy Management and Storage for Grid Flexibility:

- IS-2.1 Flexible electricity grid networks
- IS-2.2 Smart multi-sourced low temperature heat networks with innovative storage solutions
- IS-2.3 Utilizing 2nd life batteries for smart large-scale storage schemes

2.3.3 Transition Track 3

Smart e-Mobility Sector:

- IS-3.1 Smart solar V2G EVs charging
- IS-3.2 Innovative mobility services for the citizens

2.3.4 Transition Track 4

City Innovation Platform (CIP) Use Cases:

- IS-4.1 Services for urban monitoring
- IS-4.2 Services for city management and planning
- IS-4.3 Services for mobility
- IS-4.4 Services for grid flexibility

2.3.5 Transition Track 5

Citizen Engagement & Co-creation:

- IS-5.1 Co-creating the energy transition in your everyday environment
- IS-5.2 Participating city modelling
- IS-5.3 Living labs
- IS-5.4 Apps and interfaces for energy efficient behavior

3. Smart City Journey of Fellow City Vaasa

This chapter presents how and why the City of Vaasa started working towards becoming a smart city and implementing smart city solutions. The chapter explains the reasons and background to Vaasa's decisions and actions that led up to becoming a part of the IRIS project. Current and coming needs, challenges and prioritizations of Vaasa are explained. In addition, the replication projects that the city has been working with are explained in detail: what has been done and how, but also the reasons why these projects were important and got started.

3.1 The reasons FC Vaasa started to work with smart city solutions

The Vaasa region is known for its global energy cluster, Energy Vaasa (www.energyvaasa.fi), which is the largest energy technology hub in the Nordic countries and a world leader within different technologies, such as smart electrical solutions, sustainable energy, flexible power generation and digitalization. The region is known for innovation, entrepreneurship and smart energy solutions.

The City of Vaasa has committed to the Covenant of Mayors and set targets for carbon neutrality. The City of Vaasa has for decades developed, tested and used innovative solutions, such as zero energy residential areas, energy efficiency in buildings, as well as successful circular waste to energy solutions.

The city board has set a target for carbon neutrality, and in order to reach the target, even smarter solutions needed to be put into use.

3.2 Needs, challenges and prioritizations of FC Vaasa

Despite the wide knowledge and the already developed, tested, and integrated smart city solutions in Vaasa, the city had a need to take even further actions, as well as streamline the activities and work in a more systematic way. At the same time, a continuous need for benchmarking and development was needed.

One of the biggest challenges for Vaasa has been its relatively small number of resources, in this case especially the small number of employees within the city organization working with energy and smart solutions related issues. The knowledge of Horizon funded projects was also new for the city. Hence, we also needed to develop our knowledge concerning Horizon funding - in the preparation phase of the project application, and for future, in order to be more prepared for coming external funding applications for smart city solutions.

3.3 Replication projects in FC Vaasa according to transition tracks

During the application process, the City of Vaasa, due to its broad development work and demanding targets regarding energy and climate related issues, expressed its keen interest and strong attempt to replicate most of, if not all, the available solutions. As our smart city journey progressed, more specified possibilities and needs for replication activities became evident – solutions most suitable, required and beneficial for the region of Vaasa.

3.3.1 Transition Track 1 – *Renewables and energy positive districts*

The activities of Transition Track #1 in Vaasa strive to increase our energy grid's flexibility by new positive and near zero energy districts, as well as retrofitting old buildings to become more energy efficient. Higher energy efficiency, lower consumption, and own energy production lead to lower energy costs for both property owners and residents. In addition, adoption of renewable energy sources (RES) and energy storage solutions (ESS) for the building stock's electricity and heating demand, support in achieving the city's energy efficiency and carbon neutrality objectives.

In terms of positive energy districts, the City of Vaasa's focus has been much rather on the whole energy system development and not so much on single buildings. The reasons for that are many. First, the investment cost to renovate a building energy positive in the very North of Europe is substantially high. The reasons for this are twofold: *costs*, and *weather conditions*. The Nordic countries are all quite small and far away from the bigger markets. Finland, especially now due to the Ukraine war when commerce with Russia is on hold, is basically and island which forces us to utilize multimodal transports. The after-pandemic demand in the USA, and restrictions to import from Russia and Ukraine, have raised the price of construction steel by about 300 % in a couple of years. Even if the first image is that these countries are mainly forests, the truth is that about 25 % of construction wood is also imported, and all increases in logistic costs raise the prices of the products. Simultaneously, lots of construction activities are difficult to conduct on the outsides of houses (the extra isolation is typically done on the outer facades of the houses) when the weather is either rainy, of very cold - the construction season is quite short, so availability of skilled workforce can be problematic. Additionally, we still need to take carefully into account the energy availability when our energy consumption is at its peak on cold winter days. Thus, in Vaasa we have addressed and overcome the issue of how to store renewable energy for mid- and long-term usage. The solution for Vaasa has been constructing vast heat-storages and production of hydrogen with excessive renewable energy (mainly wind but also solar).

The second reason is the aspect of how installing a lot of PVs (BIPV) on a building increases the building's carbon footprint quite considerably, since most the PVs sold in the market are being produced with energy from coal power plants and in countries with lesser interest in sustainable production methods. Calculations made in other Nordic countries have shown that energy positive buildings may have even 30% higher carbon footprint than buildings with the same energy efficiency. Nevertheless, it should be borne in mind that although BIPV may increase a building's carbon footprint, consequently it increases the carbon handprint as well – the buildings positive climate impact.

The third reason is that Vaasa can utilize waste heat sources in the city's district heating system, thus rapidly replacing the need for heat production from fossil fuels and enabling our district heating system to achieve carbon neutrality by 2025. This means that we do not have as grave a need for positive energy building-development as do cities where this possibility is not available.

When it comes to Vaasa's CO_2 emissions, we have a very positive trend in their reduction as far as heating and electricity production are concerned. Our utility company and the distribution service operator (DSO) Vaasan Sähkö Oy (Vaasa Electricity) has an investment plan to make the district heating carbon neutral by 2025 and the electricity production carbon neutral by 2029 at the latest.

3.3.1.1 IS-1.1: Positive Energy Buildings

In the City of Vaasa's replication plan, the positive energy-building project of Wasa Station was introduced. The building's project plan described a new urban event center, which would be both multifunctional complex and a pioneer construction of highly energy-efficient piece of real estate. Wasa Station was planned to have a congress- and music center, a hotel, a shopping center, apartments and a sports and multipurpose hall – providing an urban meeting place for both business and pass-time.

Wasa Station was preliminary designed to have an innovative and cost-effective energy system, which would not only make the building itself but also the surrounding district virtually energy self-sufficient. Energy solutions such as geothermal heat, waste heat, solar heating, solar power and smart charging solutions are part of the building's plans. Wasa Station's produced surplus energy could be traded with the district's other buildings or with the DSO.

Wasa Station's impacts on sustainability and energy efficiency would be potentially prominent. The complex would be able to decrease the amount of electricity imported from the grid, thus resulting in cost savings. Moreover, the degree of increased self-sufficiency would aid in enhancing the expertise of the usefulness and benefits of novel and sustainable energy systems, which would possess plenty of the elements of a well-functioning micro-grid. Such a micro-grid would be capable of enabling a higher level of flexibility and ability to choose when to import energy to the building, and when and how to utilize the possibly produced excess energy. Hence, the building would help in reducing peak loads of the power grid and CO_2 emissions.

The project of Wasa Station progressed slowly due to some challenges in financing, city planning and political support. Yet, the project seemed to be heading in the right direction and the construction was supposed to start in 2020-2021. However, the Covid-19 pandemic and the 2022 Ukrainian conflict have had significant effect on material prices, delivery times, resource availability and project prioritization. Thus, Wasa Station is currently on hold and its future is somewhat unclear.

Figure 1. Illustration of the planned Wasa Station - a multifunctional and energy efficient complex

3.3.1.2 IS-1.2: Near zero energy retrofit district

Vaasa's aim is to achieve the highest possible level of energy independence. Additionally, one of the City of Vaasa's primary strategies and climate objectives is to achieve carbon neutrality before 2030. These aspirations are to be taken into consideration, when planning retrofitting solutions.

In general, the effectiveness of building insulation materials (U-values) of Finnish residential building stock is already relatively good, compared to average European buildings. For example, windows with more than two panes have been a standard in Finland since 1970s. Hence, to produce an impact, the interventions of solution 1.2 are focusing more on improving the overall energy performance of the buildings, rather than on renovation solutions of the building structures (e.g., insulation of the envelope or glazing).

As for initiating the activities, Ristinummi district and other suitable targets from single buildings to entire city blocks around the city were considered. The retrofitting analysis of the current building stock was already carried out during the project preparation phase. At that time, the areas considered for retrofitting were located mostly in Ristinummi and Suvilahti districts. However, these areas proved to be challenging and time consuming to act as locomotives for the retrofitting due to their size, ongoing city planning and reserved budgeting. Eventually, more single targets suitable for retrofitting were found in other parts of the city, enabling swifter initiation of retrofitting.

When it comes to social housing, a significant potential and benefit can be gained from retrofitting activities, especially from the improvement of energy and heating self-sufficiency and efficiency by increased utilization of photovoltaic panels (PV), thermal energy, heat pumps, smart charging and smart home technology implementation, e.g., smart metering and thermostats, sensor technology etc. Well-executed retrofitting activities would potentially influence in the amount of electricity purchased from the grid, thus resulting in cost savings. Moreover, the degree of increased self-sufficiency would aid in enhancing the expertise of the usefulness and benefits of novel and sustainable energy systems, aid in reducing the peak loads of the grid and decrease CO_2 emission production.

Measures

In the City of Vaasa, the building owner organizations have formed a group that together researches and evaluates different innovative solutions for energy efficiency, optimization and databased management of the buildings. In the future, this group might be able to create collaborative pilots and demonstrations, leading to joint procurements of retrofitting actions.

3.3.1.3 IS-1.3: Symbiotic waste heat networks

District heating system

Most of the buildings in Vaasa are connected to the district heating network owned by the city utility company Vaasan Sähkö Oy (DSO). Heat is produced mainly by a combined electricity/heat power plant (CHP) in Vaasa and by waste heat from waste incineration plant of Westenergy Oy.

Additionally, the new and one-of-a-kind heat storage located in Vaskiluoto district, will help Vaasa to achieve carbon neutrality in heat production by its set deadline 2025. The heat storage enables enhanced flexibility of utilization of RES. Thus, it enables district heating consumption peak shaving, and simultaneously reduces energy costs significantly and acts as back-up for oil and coal production in district heating.

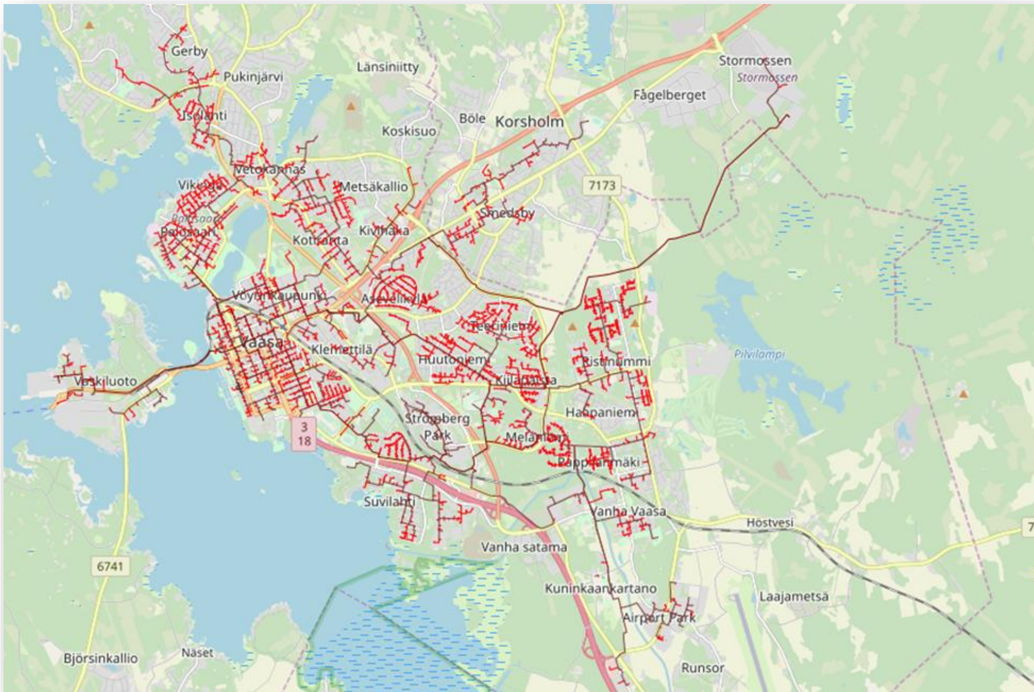


Figure 2. The district heating network of Vaasa

To achieve carbon neutrality in heat and electricity production by 2025, the importance of heat storage is paramount. It enables the optimal utilization of excess heat from Vaasa's Vaskiluoto districts CHP plant, as well as the integration of renewable energy and different waste heat sources into the district heating network. Vaasan Sähkö Oy has planned and implemented the development actions of the district heating in collaboration with stakeholder companies:

- EPV Lämpö (EPV Energy) and Vaskiluodon Voima Oy, which currently produces 60% of the district heat in the CHP plant in question.
- Vaasan Voima Oy, which takes care of the heat storage located underground near the CHP plant.
- Westenergy Oy, which has an agreement with Vaasan Sähkö Oy of feeding the excess thermal energy produced at their waste incineration plant during summertime into the district heating network. This heat can then be stored and utilized more efficiently, when there is a heat demand during colder periods of the year or during power outages.

The thermal energy storage in question includes two massive caves approx. 30 meters below the ground level, near the CHP plant in Vaskiluoto. The caves were initially built during the 1970's for storage use of oil, but were emptied and cleaned in the late 1990's.

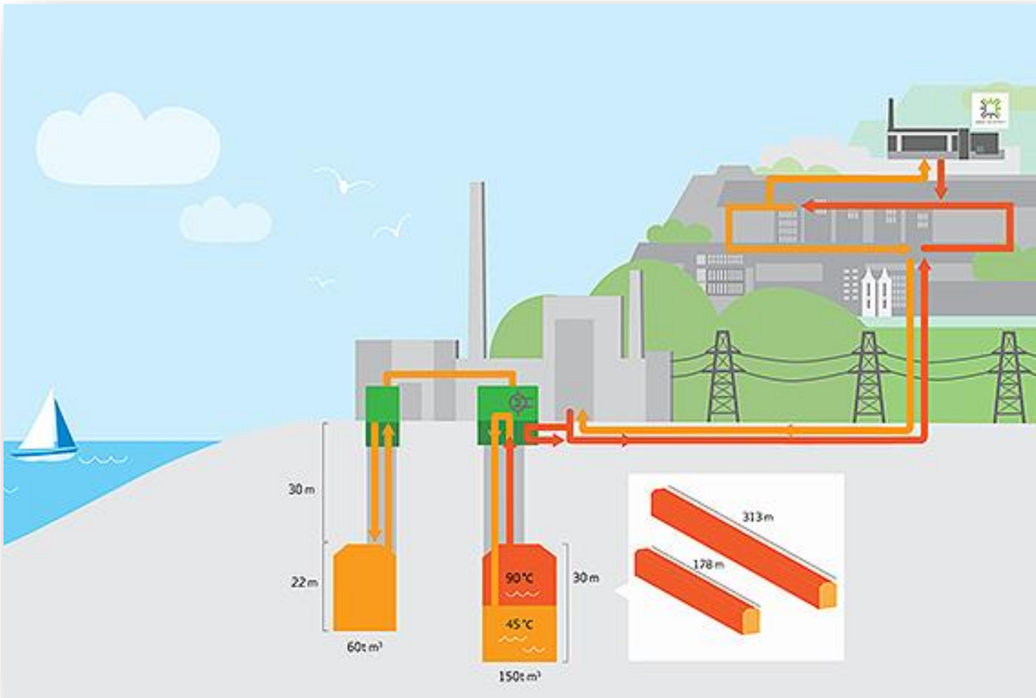


Figure 3. Basic concept of Vaskiluoto heat storage

Some specific details of the storage:

- Volume of the caves: 150.000 m³ and 60.000 m³, in total 210.000 m³
- Charging and discharging capacity: 100 MW
- Duration of the stored energy: 4-20 days depending on the discharging capacity and time of the year
- The energy storage capacity: 7000–9000 MWh
- Size: height 22 and 30 meters, length 178 and 313 meters

The energy storage makes it much easier to integrate RES and waste heat into the district heating network. Through these measures, more flexibility and security can be provided for the energy grid and energy efficiency, and further, carbon neutrality goals can be better addressed.

Interconnecting Vaskiluoto heat storage with the co-generation plant used for the Vaasa's district heating system has been successful and proved to be very efficient. The storage increases flexibility and security of the energy supply, and financial revenues of the district heating companies. The main advantages of the heat storage implementation in the district heating system are:

- A higher energy efficiency of fossil fuel utilization
- Optimal, close to full load, operation of co-generation equipment
- Reduced environmental impact

- Electricity generation during high tariff periods
- More stable operation of district heating networks

3.3.1.4 IS-1.4: Engagement

For Ravilaakso district and the objectives for it to achieve a completely new level of sustainability, the following matters have been discussed: planned LT network, energy efficiency methods in general combined with various smart city and renewable energy solutions, as well as energy community and prosumer activity engagement. These have been discussed not only within the city organization but also with the DSO and the constructor companies building the area. Engaging these stakeholders has been vital for the robust planning and development of the new district.

Since the Ravilaakso district is a brand new residential area, there are no current residents in the specific area. Hence, there is no primary target group of citizens, for citizen engagement activities related to the development of the area. Thus, engagement activities focusing on a citizen perspective must target potential future residents of Ravilaakso and/or residents living in residential areas in close connection to Ravilaakso. An experiment related to citizen engagement was implemented in Vaasa in 2018, which focused on the use of gamification techniques in urban planning processes as a participatory tool. The Ravipeli game (see Kopecká 2019[1]) was tested with citizens in Vaasa to collect feedback and ideas related to the development of the Ravilaakso area.

3.3.2 Transition Track 2 - Flexible energy management and storage

The activities of Transition Track #2 in Vaasa strive as well to increase our energy grid's flexibility, but by introducing different energy storages, low temperature district heating, and smart grids. These actions also improve the safety and reliability of the grid, plus, sustainability, as energy storages further allow utilization of renewable energy outside of peak production times. Actions done in Transition Track 2 also support in achieving the city's energy efficiency and carbon neutrality objectives.

3.3.2.1 IS-2.1: Flexible electricity grid networks

Sundom district Smart Grid project and smart grid development

Intelligent and flexible electricity grids are very important concepts for Vaasa. Several Energy Vaasa Cluster companies are world leaders in smart grid technology, as well as in grid security development and solutions. Companies such as ABB Oy, Ampner Oy, Arcteq Relays Oy, BTB Plaza Oy, Comsel System Oy, Danfoss Oy, Gambit Labs Oy, Hitachi Energy Finland Oy, Schneider Electric Vamp Oy, The Switch Engineering Oy, VEO Oy, Wapice Oy and Wärtsilä Oyj, form the very core of the cluster. They produce a variety of products for smart and flexible grids: AC drives, power converters, protection relays,

[1] Kopecká, Karolina (2019). Gamification as a Tool in Urban Planning. Master Thesis, Tampere University, Finland.

switchgear, transformers, smart metering systems, monitoring systems, drive trains, electrification solutions, IoT and data platforms etc.

Additionally, local higher education institutions, e.g., University of Vaasa, Vaasa University of Applied Sciences (VAMK), NOVIA - University of Applied Sciences and Åbo Akademi with active occupational training keep a keen focus on smart and flexible electricity grid operations and development. The universities' electrical and technological laboratories include facilities for electrical power distribution, power transmission, power generation, electrical machine and drives, electrical automation, and for IEC 61850 electricity-grid communication. The laboratories are in Technobothnia facility, and in the Vaasa Energy Business Innovation Centre, Vebic.

Upcoming amendments to Finland's Electricity Market Act will come into effect in 2028. They will restrict the maximum limit for power outages, putting increased pressure on providers to ensure a consistent power supply. At the same time, overall energy consumption is increasing and there is a national need to become as energy self-sufficient as possible.

Technology Centre Merinova prepared and coordinated Sundom region's Smart Grid project, which was active between 1.6.2014 – 31.08.2016. The Project provided a living laboratory for testing and piloting the use of smart grid technology coupled with decentralised means of energy production, such as wind and solar power. The smart grid detected faults in the grid and provided real-time data to the project partners through a fibre-optic network.

ABB Oy tested Sundom automated fault management technology with four intelligent substations, which reported the network fault situations directly to Vaasan Sähköverkko's control room, where transformer substations were also remote-controlled. The University of Vaasa explored underground cabling network automation, optimal combination of power grid security, and the economic point of view of an investment in the pilot.

Part of the smart grid pilot project in Sundom district were 130 solar panels, which together provided a nominal power output of 33kWp, an estimated 14% of the annual consumption. The panels were installed on the local school's roof. The City of Vaasa used solar panels to increase children's awareness of energy. Kindergarten and schoolchildren could follow how much energy the panels produced at any given time, as well as, how the electricity consumption could be affected on by their own choices.

The goal of the globally unique Sundom Smart Grid pilot project was to make electricity delivery more reliable, and to establish the preconditions for solar and wind power utilization in the region's households. The project also delivered a more affordable electricity supply to residents, as well as opened possibilities for utilizing green energy more efficiently. Eventually, the pilot project ended, but the installed equipment had created a living laboratory in Sundom, where the research work could continue. The data collected from the smart grid is used by both the University of Vaasa and ABB's research laboratories.

For flexible electricity grid networks, Vaasa wants to research, develop, pilot and implement new ideas and solutions, especially for/of the following:

- Changes and impacts of power tariffs
- Requirements for PV inverters

- Demand response
- Energy community and prosumer activity
- Overall optimization of the energy system
- Second generation smart energy meters and thermostats, and their utilization, e.g., in demand response and low voltage network management
- Utilization of wind models, e.g., for adjacent forest management and network design
- New measurement centre solution
- FLIR (Fault detection, Location, Isolation and supply Restoration)
- Promotion of adaptive / dynamic charging systems for electric cars, e.g., smart charging, PV-charging, vehicle-to-grid (V2G) and vehicle-to-everything (V2X) charging, and interconnecting battery energy storage solutions (BESS)
- IoT- and City Information Platform (CIP) / data platform, and digital twin technology and development

3.3.2.2 IS-2.2: Smart multi-sourced low temperature district heating with innovative storage solutions

Ravilaakso is Vaasa's new residential area of 83 apartment buildings and 45 townhouses, which will be inhabited by 2500 people once its construction is ready. The district is an extension to the city's current grid pattern. Ravilaakso used to be a horse racetrack area, before it was decommissioned in 2016. Civil engineering work began in 2019, and the construction of buildings began in early 2022. The whole district will be constructed in 3-4 phases, depending on the district's housing needs. First the northern part of the district will be constructed, its infrastructure and buildings of the city blocks. To finish this workload will take the next 2-4 years. After that, the work for the southern part of the district can begin. During the construction phase, the main principle is to use free areas as temporary public spaces, thus developing a participatory, co-creative approach on the district's planning, construction and land use. Once the whole area is finished the total living area of Ravilaakso district will be approximately 135 000 m^2.

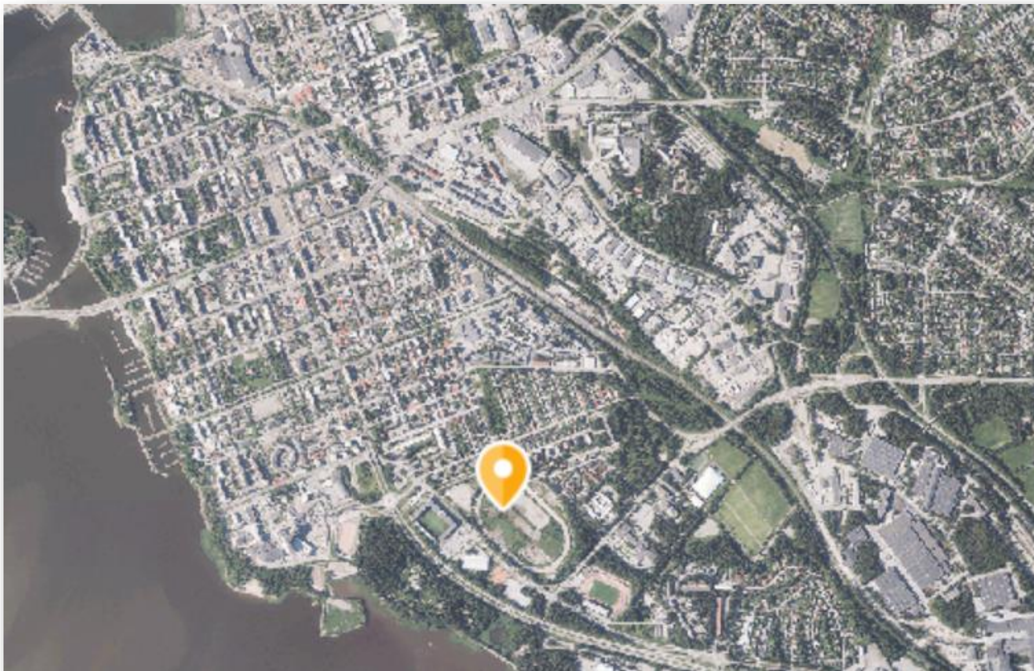


Figure 4. The location of Vaasa's Ravilaakso district

Figure 5. Illustration of Ravilaakso district once ready

Figure 6. Another illustration of Vaasa's Ravilaakso district once ready

An important objective of Ravilaakso district's development is to achieve the highest possible level of energy independence, carbon neutrality and sustainability. These goals must be considered as energy solutions for the district are planned. While a solution can be low carbon and cost effective at the district level, it may not be as beneficial for the whole city, e.g., solar panels. In the summer when the PV energy production is at its highest, there is already heat over-production at the city level, due to the operation of the waste incineration plant of Westenergy Oy.

Low-temperature district heating (LTDH) will be implemented in Ravilaakso area. The DH will be based on heat power from the waste incineration of Westenergy Oy's plant, and heat power from Vaskiluoto district's heat storage. Additionally, it is preliminary planned that Ravilaakso will have its own middle-size borehole system, enabling additional heating/cooling capability and heat storage, if a business model is found viable. Whether the planned borehole system will be constructed or not is still unclear.

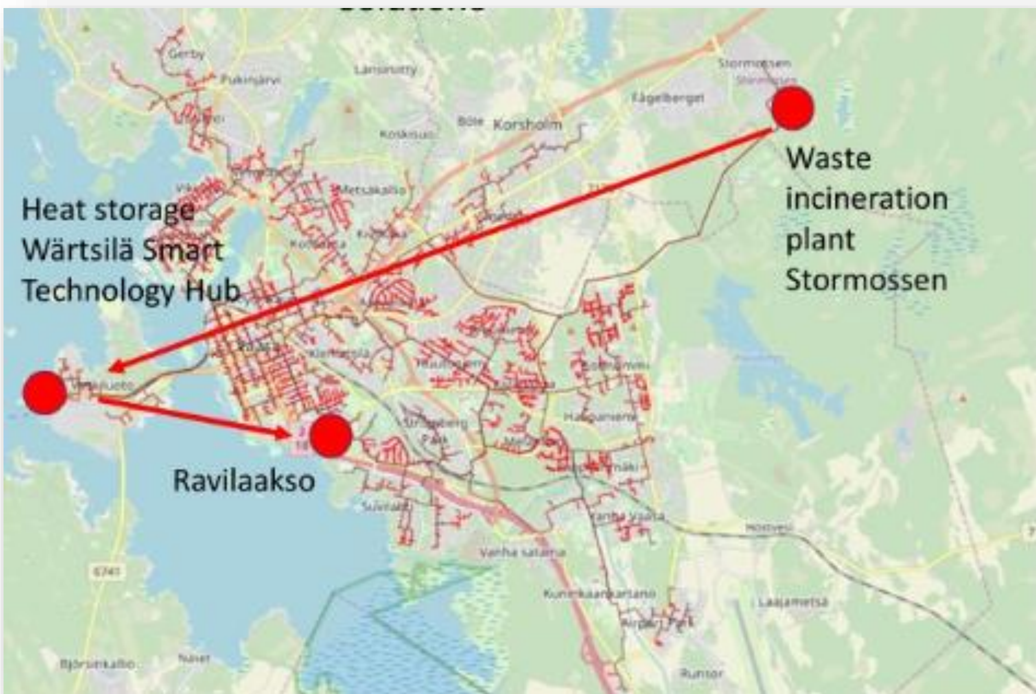


Figure 7. Main elements of Ravilaakso's low temperature DH

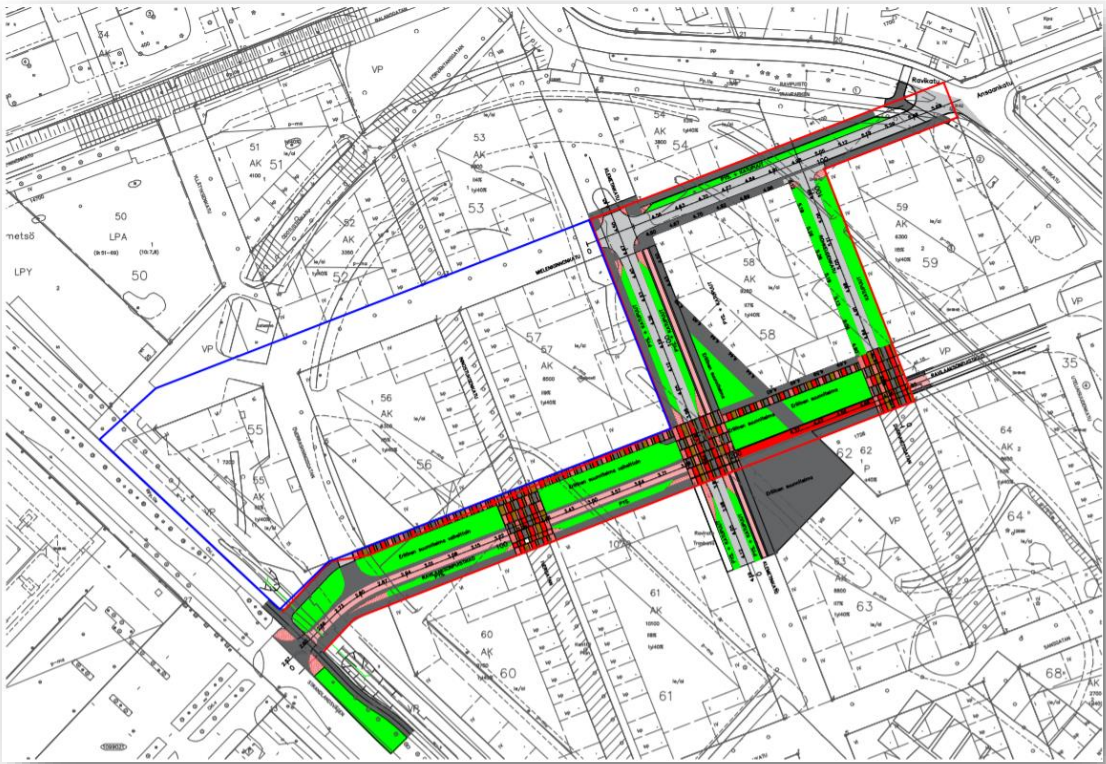
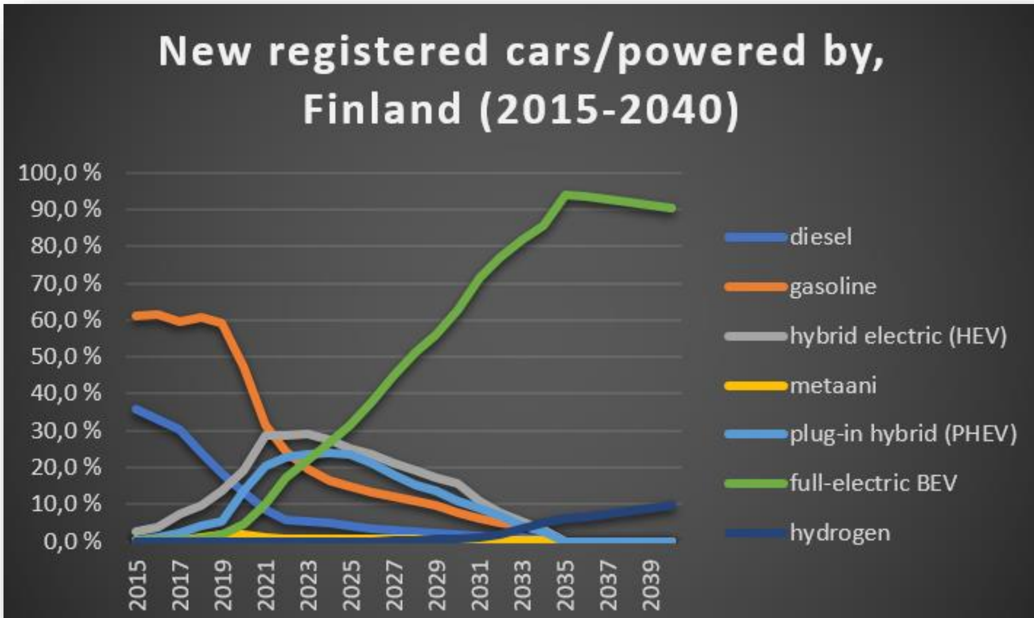


Figure 8. The first phase of Ravilaakso district's low temperature DH network

3.3.2.3 IS-2.3: Utilizing 2nd life batteries for smart large-scale storage schemes

Currently, there are no energy storage solutions in Vaasa applying 2nd life batteries. The concept of 2nd life Li-ion batteries for energy storage solutions is an interesting one, and showing a lot of potential, but in terms of future energy solutions in Vaasa area the limiting factor still is the relatively limited level of adoption of plug-in electric vehicles (PHEVs) and Battery Electric Vehicles aka (also known as) full-electric vehicles (BEVs). However, the market share of e-cars out of newly purchased and registered vehicles is in steep climb.

Table 1. Battery electric vehicles (BEVs) will dominate the market of new sold cars in Finland next decades



The utilization of 2nd life batteries and their development into a viable market in Finland requires strong progressive development of e-cars and e-buses sold for private and public sector, and utilization in traffic among all vehicles. Thus, eventually the stock of 2nd life batteries will grow, and the development of their utilization can start. In addition, the scarceness of charging infrastructure and smart charging solutions to exploit 2nd life batteries in smart energy solutions, e.g., interconnection with RES, and lack of battery energy storage solutions, e.g., acting as energy storages for buildings, hinder the utilization of the 2nd life batteries.

Although 2nd life batteries for stationary applications are not applicable currently in Vaasa, such energy storage solutions do represent possibilities for Vaasa region subsequently. Nevertheless, more investigation, research, testing and piloting is required on the subject before the utilization of 2nd life batteries becomes commonplace. The conclusion is that the market needs to mature, and more research and pilot testing is necessary.

Table 2. The matters of potential and challenges of utilizing 2nd life batteries in Vaasa

Matters of potential:	**Challenges:**
National and regional policies and goals support measures striving for energy efficiency, use of sustainable energy sources and solutions of energy storing.	Investments in 2nd life batteries are not yet economically viable. Without subsidies, it is very challenging for new business models for 2nd life battery solutions to emerge. Legal and financial circumstances need to be changed as well.
Many of the international studies indicate that the utilization of 2nd life batteries is cheap. The expenses of the batteries largely concern the batteries' "first life".	Knowledge of the utilization of 2nd life batteries is limited and may cause prejudice.
The technology for the utilization of 2nd life batteries is available. However, certain solutions may require more examination and research, depending on the case.	Security issues, e.g., fire safety, concerning the utilization of 2nd life batteries is a serious concern and requires further investigation.
2nd life batteries have 8-10 years of capacity left and are environmentally safe and sustainable energy storage/source, if examined properly and handled correctly. Recycling a battery after its first life is more expensive, and disposal may possess environmentally dangerous issues.	More regulatory framework is needed in the utilization and trade of 2nd life batteries, not only at the national level but internationally as well. Existing regulation does not support enough the commercialization of 2nd life batteries in wider perspective.
There are several potential and researched ways of utilizing 2nd life batteries: in buildings, e-mobility, MaaS and ancillary services for the local power grid.	The market is not mature yet for 2nd life batteries' usage in most countries. More time must pass for EVs to increase their share of vehicles in use.
The utilization of the 2nd life batteries adds more length and value for the life cycle of a battery, which can benefit the battery manufacturer, grid operator and the battery owner.	The biggest hindering factors learned from the LH cities demonstrations were surprising. The price of the utilized 2nd life batteries was high. Additionally, in order to build a sufficient battery pack inside an apartment building for its energy use, a substantial amount of work and investment was required, and the feedback from the inhabitants was not always positive.

3.3.2.4 IS-2.4: Engagement

As described in section 3.3.2.1 above, the City of Vaasa used the solar panels of the Sundom district Smart Grid project to increase children's awareness of energy as a part of the Energy Education Path program (see section 3.3.5.4). Kindergarten and schoolchildren were able to follow how much energy the panels produced and how the electricity consumption could be influenced by their own choices. In the planning and development of the Ravilaakso district, the engagement of constructor companies and energy researchers from the Vaasa HEIs has been an important objective in order to achieve the low/zero carbon objectives and to look for innovative energy storage solutions. The companies selected to start the building of the new district and city blocks are obliged to commit themselves to low carbon mentality and objectives, concerning building materials and procedures. Additionally, they are to utilize carbon footprint calculation software (e.g., One-Click LCA) in order to measure the buildings' lifetime carbon footprint. As for the 2nd life batteries and their required engagement activities, it will become relevant in wider aspect if/when used EV batteries ever become considerable measure of utilization for smart energy solutions and schemes. Thus, no engagement activities have so far been initiated related to the use of 2nd life batteries.

3.3.3 Transition Track 3 - Intelligent mobility solutions

The Lighthouse cities' demonstrations indicate that intelligent mobility solutions have significant potential and importance for developing smart and innovative e-mobility and EV charging solutions, Mobility as a Service concept and battery storage schemes. The demonstrations promote the development of smart charging, utilization of V2G model, introduction of innovative e-mobility solutions, and exploitation of 2nd life batteries. In addition, the demonstrations can express that the solutions mentioned do have the potential to create substantial financial value from creating new business opportunities, while promoting sustainable carbon neutral development.

The integrated solutions belonging to the IRIS Transition Track #3, Smart e-Mobility are considered important factors to support Vaasa's strategy to achieve carbon neutrality by 2030. The integrated solution *Innovative mobility services for the citizens*, possesses the highest potential value, including Mobility as a Service concept, enhancing sustainable public transport and car sharing, and development of continuous mobility chains. Moreover, the development of cycling and walking infrastructure are part of MaaS concept in broader sense, although these ways of mobility were not part of IRIS replication plan.

3.3.3.1 IS-3.1: Smart solar V2G EVs charging

The main stakeholders for the IS 3.1 Smart solar V2G EV charging, are the DSO, being responsible for the technical infrastructure and services related to possible V2G solutions, a company providing shared EVs, and the constructor companies responsible for building district houses. IS 3.1's biggest challenges are the lack of knowledge related to consumer behavior, and the sustainability and economic feasibility of the solution in question. It is relatively challenging to identify the available EV stock in the Vaasa region. Thus, it is also challenging to identify reliably the exact number of EV owners capable of utilizing V2G service, if such a service existed. Additionally, currently only a few vehicle manufacturers allow V2G readiness. However, a growing number of EV manufacturers are constantly developing V2G enabled EVs, and some progressive car brands are ready to introduce first production V2G e-cars for automotive markets in the next couple of years.

Moreover, is it challenging to draw exact conclusions on what extent the local power grid would benefit from the possible local V2G charging infrastructure, or what kind of impact would the solution have on the durability of the EV batteries. Additionally, not enough knowledge exists on what would be the true economic benefits of V2G solutions for the EV owners. For the IS-3.1, there is a need to improve the knowledge of the development of the V2G solutions and services, and to examine the financing options for developing such services for a city such as Vaasa where V2G customer base is small, compared to the regular charging infrastructure required. There is also a need to gain more knowledge about customer behavior concerning V2G solutions.

The integrated solution 3.1 is closely linked to Transition Track #2 Smart Energy Management and Storage for Grid Flexibility, both to its integrated solution 2.1: Flexible electricity grid networks, and 2.2: Utilizing 2nd life batteries for smart large-scale storage schemes. In addition, IS-3.1 is connected to the Transition Track #4's IS 4.4: Services for grid flexibility.

Smart charging and capability of interconnection with PV are expected to play an important role in smart grid operations in the future. When the EV penetration rate reaches the level where the DSO and the flexibility and robustness of its operations will need the adoption of additional smart energy technologies, e.g., involvement of RES, V2G and RESS, V2G will obtain high potential for required ancillary services. Through vast number or fleet of EVs, smart charging and management, providing extra electricity to the system when needed is possible. Moreover, V2G can provide valid function as a distributed energy storage or a network of energy storages, not only on regional but on national level as well.

Currently the City of Vaasa has no intent to replicate the IS 3.1, since the demand for smart solar V2G EVs' charging is negligible in Finland in general, i.e., there is no V2G service available and smart charging infrastructure is yet to be developed. However, when EVs become increasingly popular, and viable technological solutions and business model/-s for V2G operations and services shall eventually emerge, implementing the solution to Vaasa's ecosystem can gradually take place.

Table 3. The matters of potential and challenges of utilizing V2G schemes in Vaasa

Matters of potential:	**Challenges:**
The EU expresses a strong political commitment towards e-transport and MaaS concept.	The City of Vaasa has already made an investment in biogas buses and required infrastructure for local biofuel production. Transferring to e-transport requires a new investment plan.
The investment cost of a bidirectional adjustable charging system is higher than in G2V system. However, it is the most cost-effective and	In order to utilize EVs' batteries in the existing energy system, a new implementable and lucrative business model must emerge.

economically profitable alternative once utilizing V2G in full extent becomes widespread.	
The required technology is already available.	EVs are more expensive than IC powered vehicles. E-buses demand charging infrastructure, for example fast charging stations at each endpoint of the route. These stations can be very expensive. Well-functioning, effective and full electrification of the city's bus fleet requires fast charging infrastructure capacity, manageable in size as well.
The rising number of EVs and reduction of fossil fuel driven cars in traffic, will lead to reduction of CO_2 emissions, improvement of air quality, and reduction of noise levels.	User acceptance of smart charging can prove to be a barrier for quite some time. For many of the end-users such a service, and their awareness of its full potential, requirements and effects, can be relatively limited.
The contribution EVs have to the reduction of air-pollution might convince citizens to favor the adoption of e-mobility and shared transportation, such as shared EVs.	However, for V2G solutions, only a few vehicle manufacturers exist currently, who allow the use of EV batteries in the V2G operating model. Many of the available EV models, and charging infrastructure models, have too low technical performance and capacity, to manage detailed V2G schemes.
V2G operating model enables EVs to be utilized as distributed storage system for the grid, and in various ancillary services, providing more grid flexibility.	The main identified technical barriers related to the power infrastructure and e-charging stations are the compatibility of the charging stations with the local power network, and availability of power of the local network.
V2G enables attractive means for economical profitability, concerning the DSO, aggregators, service operators, and the EV owner.	As the number of EVs increases, it is important that the charging activity and infrastructure are managed intelligently, to avoid power peaks, and the need for additional power caused by charging. Components for implementing smart charging at the property level already exist, but only at the higher grid network levels.
	A more defined, detailed and well-constructed regulatory framework is required as V2G schemes become more current.
	Lack of wide smart charging infrastructure network.

EVs and Mobility as a Service reduce consumers' carbon footprint and open new types of business opportunities. The energy storage potential provided by e-cars and e-buses via V2G solution, combined with smart energy and charging management, have the potential to aid, or even optimize the energy self-consumption of buildings, reduce grid stress, and unlock the financial value of grid flexibility. After the development of more advanced V2G systems takes place, and enough information about suitable business models and technical requirements are available, the City of Vaasa can investigate the solution's potential anew and make decisions for further V2G schemes. Prior to that, a local pilot project should be carried out, since more research is required on the subject.

3.3.3.2 IS-3.2: Innovative mobility services for the Citizens

Traffic is the biggest single source of CO_2 emissions in Vaasa, consisting of 31% of emissions outside the trading sector. To achieve a dramatic reduction of traffic related CO_2 emissions, various new methods of technology and emission mitigation are required. The main challenges are that private car ownership is very high in Vaasa, and the utilization degree of public transport has not been high enough. This challenge should be better tackled with the new bus service *Lifti* launched in July 2022.

3.3.3.2.1 Public transport

In order to decrease the emissions from the traffic drastically, significant changes have been planned concerning public transport. The measures concerned are, e.g., increasing the number of biogas buses in use. Additionally, the bus routes have been planned anew and the schedules of the routes have been improved to be more advanced, efficient, based on reliable regularity, and covering districts later in the evening hours and weekends as well. It is hoped that the service level and usage of public transport would increase, thus decreasing the level of private car utilization. The new public transport service is called Lifti and it started its operation in July 2022.

Figure 9. The new public transport service and line-up Lifti started its operation in July 2022, introducing new routes, schedules and more biogas buses for the existing bus fleet

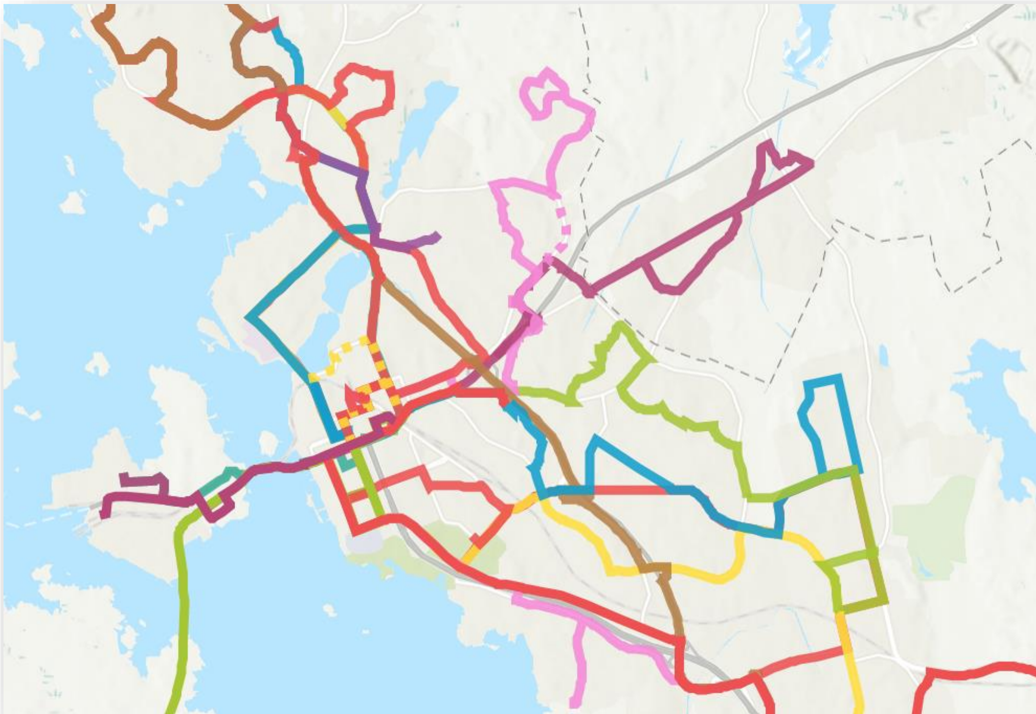


Figure 10. The new public transport service Lifti's new and improved routes in and around Vaasa region

3.3.3.2.2 Cycling

The share of cycling in Vaasa is approximately 12%, presenting good potential for growth. Distances in the city are short, the terrain is relatively flat, and for example the number of students who utilize cycling extensively is vast, approximately 13 000. Nearly 80% of the citizens of Vaasa live within cycling distance of the city's center, which is a maximum of 5 km. However, more decisive methods and heavier investments have been planned to lift Vaasa's cycling infrastructure and culture to a new level. New cycling routes and a network are planned to be constructed within the next 6-8 years. This does not only mean the development of better and wider cycling lanes and connecting routes but substantial enhancements in year-round maintenance and services (particularly wintertime), interconnected digital solutions and services and safety issues.

Additionally, to further improve and advance biking services in Vaasa, a new service has been recently started: free-of-charge, secure and monitored bike garage with 156 spots next to the railroad and bus station. Currently the garage is on a trial run, but it is planned to be taken into full usage in the near future. The aim is to encourage citizens to utilize biking instead of other services as part of their mobility chain. The aim is also to support the shift towards utilization of e-bikes, as one of the key challenges in the shift is secure storage of valuable e-bikes. After successful introduction more bike garages are planned to be installed, to meet the demand.

Hence, with these actions, and particularly by paying attention to the network's quality and condition as well as to the intersections and their traffic lighting optimization, and secure storage options, the level of safety can be well addressed.

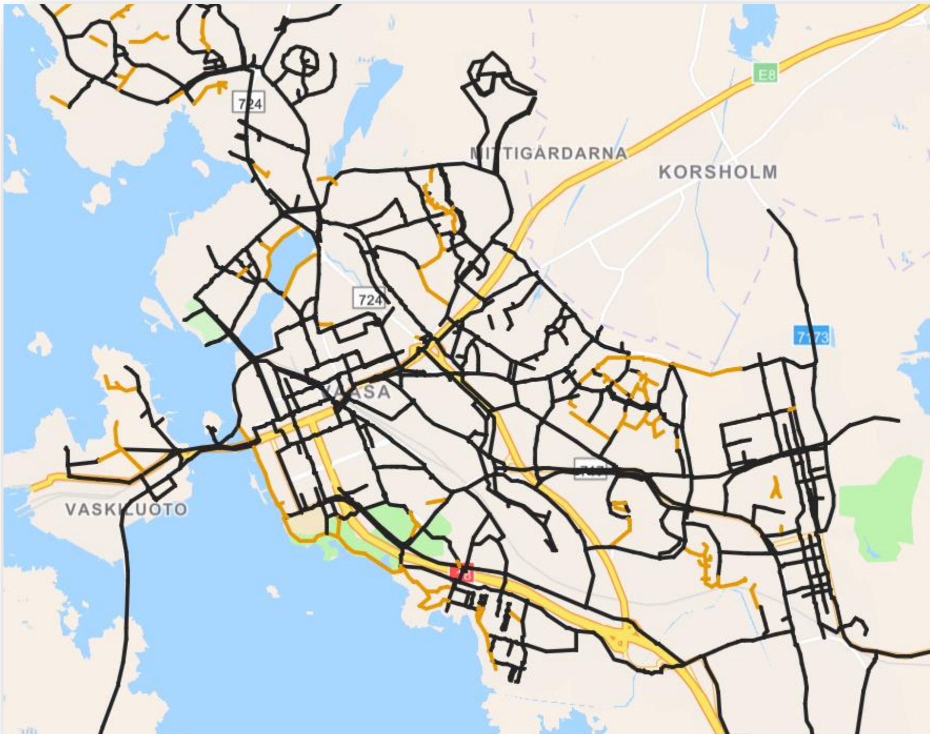


Figure 11. Vaasa's existing cycling routes

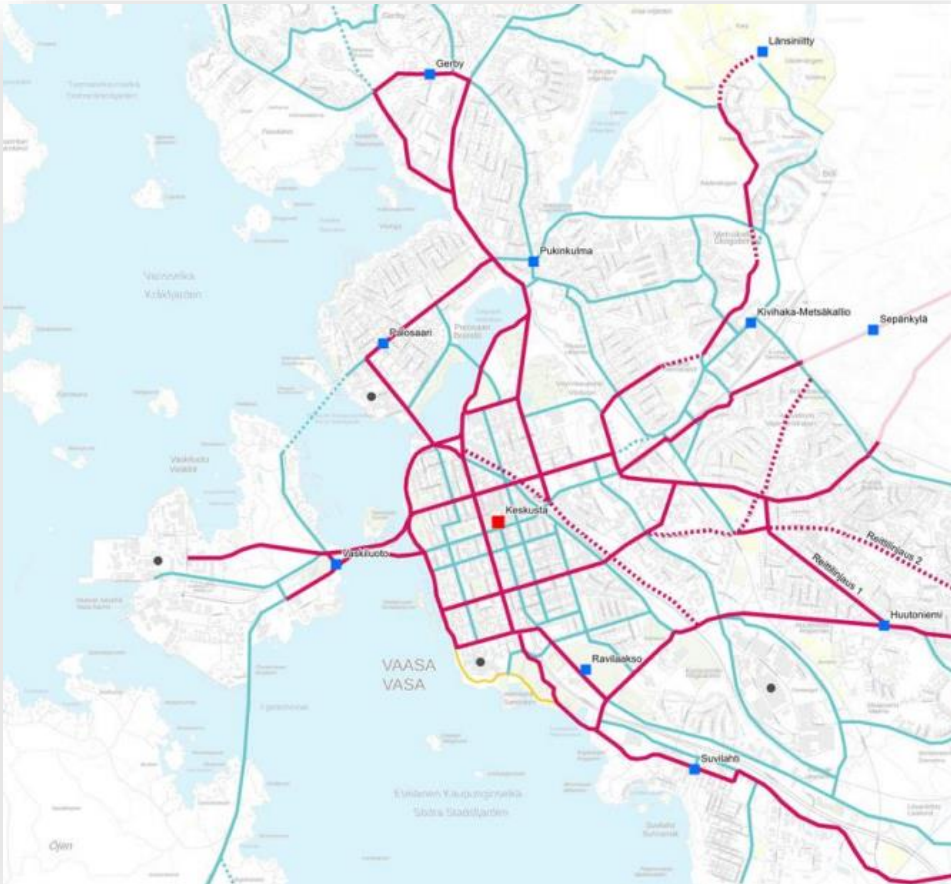


Figure 12. The planned (dashed line) and improved (continuous line) new cycling network to be constructed in Vaasa during the existing decade. Red = main route, blue = regional route, yellow = scenic route.

3.3.3.2.3 Car-sharing services

Car-sharing has proven to be in academic research and in practice a valid and highly valuable part of sustainable mobility. It provides an alternative mobility form for private car usage, thus mitigating traffic, congestion, emissions and the need for parking spaces. Additionally, a well-planned car-sharing scheme supports the utilization of public transport and other sustainable mobility modes, promotes the planning and realization of more attractive and safe urban development, and aids in the implementation of mobility hub and Mobility as a Service (MaaS) concepts.

In Vaasa, car-sharing first came into discussions in the planning of Ravilaakso district. Since the district has been planned from the beginning to be as carbon neutral and energy efficient as possible, traffic and mobility naturally have a great role in achieving these goals. Once the district is constructed, it will have a large parking facility which will be taken care of by a City of Vaasa owned company. This company will also oversee the district's car-sharing operation, which all the area's housing companies will take part in. This procedure will aid in promoting the introduction of the car-sharing service to the district, support its sustainable mobility development, lower the number of cars parked in the streets (with regulated parking norms) and boost the overall attractiveness of the district. The number of fully electric car-sharing vehicles in Ravilaakso will be approximately 2 cars per a city block.

However, since it will take a couple of years before Ravilaakso-north is even ready, the city has planned to introduce car-sharing services to the citizens earlier. The first step will be the car-sharing pilot project launched in September 2022. The pilot will include three battery electric vehicles, which the employees of the City of Vaasa can use as their primary means of motor-transportation during work hours (07.00-16.30), and at other times, the cars can be utilized by anyone. The cars will be situated at the city's technical service's parking area, where they will have designated parking lots and 22kW charging stations. The cars are required to be returned after use to their place of origin.

The City of Vaasa's car-sharing plan is to promote two-way service model, not one-way aka free-floating model. The service itself will be branded as *Mini-Lifti* associated with the public transport service *Lifti.* In addition, each car will have its own name reflecting Vaasa's reputation as the happiest city in Finland.

Figure 13. The planned look of the new car-sharing system Mini-Lifti's BEV in June 2022

Figure 14. The final look of the Mini-Lifti car-sharing service becoming reality. One of the three Nissan Leaf Visia BEV's which started successfully their operation on the 8th of September 2022

Hopefully the pilot will be successful, thus levelling the way for the service's continuance in Vaasa. The city has sought external funding, in order to develop further car-sharing schemes. The development would include more car-sharing stations around the city for central mobility junction points, where it would best support the public transport service, cycling infrastructure and people's mobility in general. Moreover, the expansion of the service has been planned to ignite the development of mobility hub and MaaS implementation and to be able to interconnect PV-charging, BESS and V2G technology, at least at some point in the future.

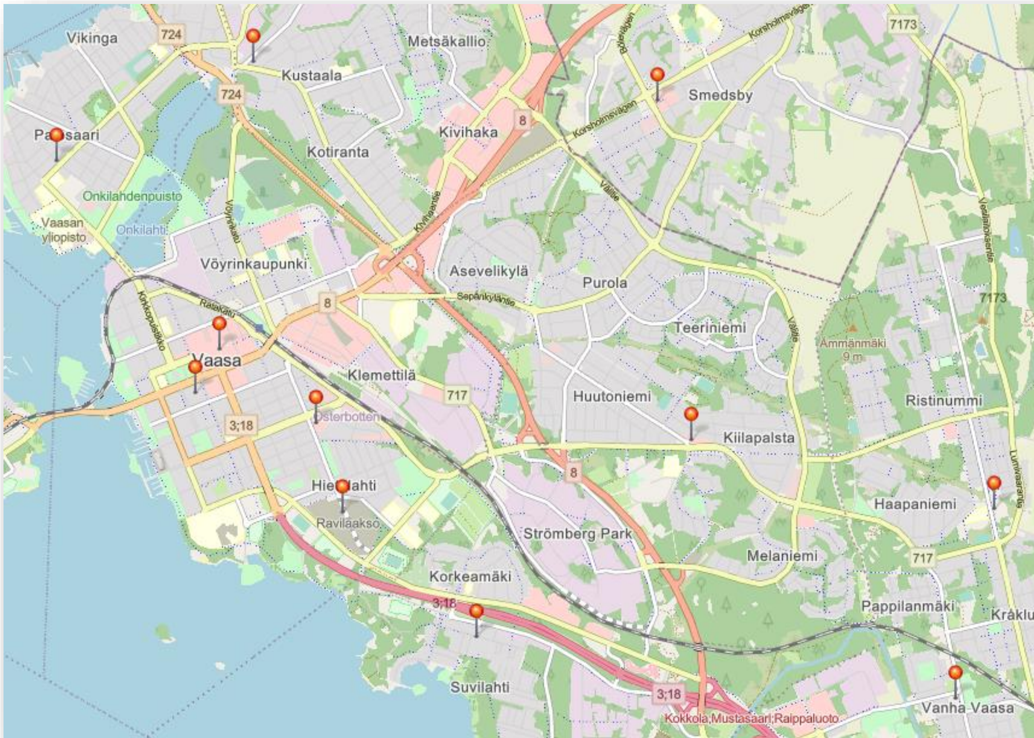


Figure 15. Tentative plan of locations of future car-sharing stops around Vaasa

3.3.3.2.4 Duo-rail-train

Duo-rail-train is an energy-efficient and low-emission mode of transport, based on the most efficient utilisation and further development of the existing rail infrastructure. This sustainable mobility mode combines tramway and railway transport models, allowing their rolling stock, infrastructure and technology in tandem to enable increasingly efficient utilization of the existing rail network for regional needs. The duo-rail-train enables direct and non-interchangeable connections between urban centres, thus advancing accessibility to a city's key locations. Additionally, it will also increase the modal share of public transport, thus, reducing the number of private cars, congestion, emissions from car traffic and the need for parking spaces. The duo-rail-train is not only safe and visually striking mobility mode, but it also strengthens the image and comfort of the city. The most common driving force in duo-rail-train traffic is electricity from over-head wire, but battery operation is also possible over short distances. Finnish legislation does not prevent duo-train-rail traffic.

The City of Vaasa is currently examining the potential of the duo-rail-train model for Vaasa's needs. The aim is to investigate and model the development, demand, service and mobility needs of duo-rail-train traffic within Vaasa's city limits based particularly on a tramway traffic model. An investment and cost estimate related to these issues, as well as a roadmap for the transport model's long-term development has been planned. The aim is also to model the effects of the duo-rail-train traffic model on land use and development of various city areas, and to study the possibilities of different rail routes. The tentatively planned rail route would extend from the harbour area in the western part of Vaasa to the GigaVaasa area and the airport, located in the south-eastern part of the city. The route would follow through the city, linking many important development areas together along the way, such as Vaskiluoto, Onkilahti, South-Klemettilä, Strömberg Park and the Huutoniemi hospital area. The development of all these areas is of great importance to the City of Vaasa, for obtaining new jobs, services and residents.

Modelling the number of potential users and studying the needs of key stakeholders are also among the important objectives. The implementation of the project's analysis and modelling work is planned to take place through a procurement process of an external expert/consulting service.

Figure 16. Duo-rail-train model combines the utilization of train rail and tram rail infrastructures/networks and services. Duo-rail-train can be operated in both networks, and it enhances a city's public transport system, sustainable mobility and MaaS

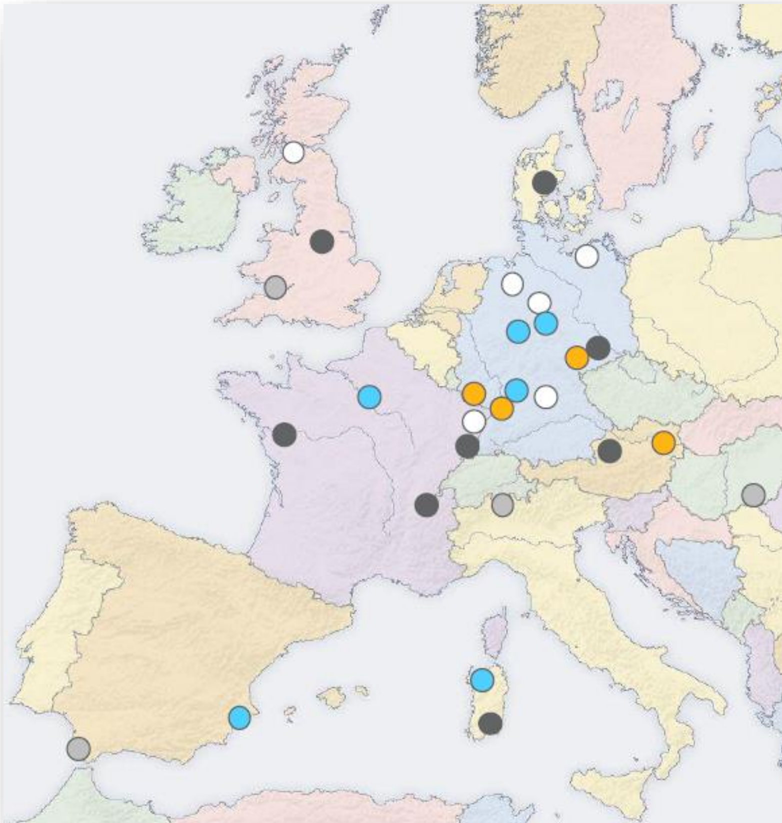


Figure 17. The duo-rail-train model is relatively popular is Western-Europe. Already eighteen cities are relying on the new mobility mode's services (orange, blue, dark grey) and ten cities are in the development phase of the mode (light grey and white)

3.3.3.2.5 Mobility as a Service (MaaS)

Concerns over urbanization and climate change, increased environmental awareness, and latest advancements in digitalization, vehicle, internet, and ICT, have affected strongly to transport and mobility markets. Mobility as a Service (MaaS) concept aims to transform the purely operational transport model to comprehensive, sustainable and user focused mobility service assortment, resorting to modern bottom-up approach instead of traditional top to bottom. The objective is to provide all MaaS users an unbreakable mobility chain possibility, enabling one-step mobility within a MaaS' region, i.e., in a city.

The main objective of MaaS is to advance the energy efficiency and fluency of urban transport and mobility, prioritizing constantly the end users' benefit. MaaS joins the public and business sectors with the users, striving to increase the attractiveness of public transport and enhancing the operability of unbreakable mobility chains. It promotes cycling and walking as an alternative-first choice of mobility to vehicle ownership. In addition, the development and utilizing innovative mobility solutions are part of MaaS, e.g., car sharing and utilizing EV fleets' power supply potential in V2G solutions and smart charging schemes. Furthermore, the concept can aid in traffic congestion mitigation, and reduce the need for parking spaces, thus affecting to urban attractiveness and land use. Moreover, organizations can benefit from MaaS by being able to improve their logistical services more efficiently.

Successful and well-functioning Mobility as a Service does more than just develops transport and mobility. It has wide economic and environmental scopes. By enhancing the utilization of digitalization and ICT, collaboration of its stakeholders, and dismantling unnecessary regulations and bureaucracy, MaaS improves the compatibility of all different actors being part of its operating model. Hence, it aids new business models to break into markets, and improves the service environment. The main objective is to develop user friendly, market oriented and high-quality mobility services, which operate seamlessly as one economically and environmentally sustainable, digital and constantly evolving system.

3.3.3.2.6 Engagement

Engagement of the key target groups and stakeholders, and co-creation with them in the planning phase of sustainable mobility solutions, is an essential part, or the very missing piece of truly effective and successful planning, implementation and utilization of sustainable mobility modes and development of MaaS. For a modern smart city, aiming for the demanding climate objectives and enhancement of liveability and quality of life of its citizens, no longer the traditional “top down” planning and implementation of solutions and services is the most valid one.

The discussions and meetings with representatives of other Horizon Europe smart cities or IRIS Lighthouse cities (particularly Utrecht) have made one thing abundantly clear: behind the greatest success stories of smart cities is engagement and co-creation from early on, cherishing the bottom-up approach. This concerns especially those smart cities with well-functioning, smart and sustainable mobility systems (e.g. public transport, cycling, walking, shareable mobility etc.), to make the whole system truly work with high utilization rate and end-user satisfaction. By this manner, the target groups can be best involved and interested in the developed system/solution/-s, and stakeholder groups such as politicians and decision-makers are obliged to hear their voice and acknowledge their opinions and needs.

Although the City of Vaasa is gradually accepting the importance of engagement and co-creation in the planning and development of the city and its solutions and services, much more should and could be done. Engagement is much more than just contests arranged for a few target groups or occasional workshops to present already planned out solutions or projects and hear about the feedback. No, to reach the level of plan and develop the city in collaboration with the target groups is an ongoing process, which takes effort but eventually gives stronger and more pervasive end-result.

In the planning and development phase of public transport service Lifti and cycling infrastructure collected feedback from the citizens and local stakeholders and collaborative organisations were considered. The name *Lifti* was selected based on the name competition held for the citizens of Vaasa. In consequence, the car-sharing service was named Mini-Lifti. Each of the cars will have their own individual name, which will be selected based on a name competition held for the citizens. When/if the service expands, citizens will determine the given names to the cars. In addition, if the car-sharing service continues and expands, the next stations for the cars will be planned and determined with the target groups (citizens, organizations, universities etc.).

3.3.4 Transition Track 4 - Digital transformation and services

One of the City of Vaasa's main strategic objectives is to reach carbon neutrality before 2030 (Carbon Neutral Vaasa 202X). In order to achieve this goal, decisive planning and measures are required of the city. In addition, strong collaboration with local organizations, institutions and stakeholders is essential. The city's climate strategy bears an affect not only on everyday actions and projects but on piloting and testing new technologies and solutions as well.

One paramount requirement in order to the City of Vaasa to reach its carbon neutrality objectives, and plan relevant measures, is to be able to constantly monitor and measure the development of emissions' levels in real-time. Currently it is not possible for the City of Vaasa to monitor and analyse the CO2 development nor the impact of executed climate measures in near-real-time nor in real-time. Real-time monitoring requires the creation of Internet of Things (IoT) -data platform, which enables the gathering of essential and relevant data for further analysis and utilization.

Primary objective for the IoT-platform, is to gather data from the city's energy systems - from energy production and consumption. Furthermore, the city's traffic system would benefit greatly from a reliable and scalable real-time data platform for its traffic planning and project implementation and the evaluation concerning low-carbon mobility.

However, the City of Vaasa has no previous experience in the operation of an IoT-platform and what can be combined with it, and where and how exactly the platform could be utilised. Building up this knowledge and experience is a necessity and should be addressed in collaboration with the local universities (University of Vaasa, Vaasa University of Applied Sciences, Novia and Åbo Akademi).

The long-term goal is that the IoT-platform can be created and studied, its operation is proven safe and reliable, and all the requirements, interfaces and considerations related to it have become familiar to all stakeholders and collaborators involved in the data platform development. Thus, the city can develop the certainty to deploy the platform further and more widely.

3.3.4.1 IS-4.1: Services for Urban Monitoring

The City of Vaasa is starting an IoT-platform development project during 2023 in the centre of the city in collaboration with the city centre real estate owners, shop owners and service providers. The objective of the project is to monitor the consumer behaviour and movement (GDPR compliance) with camera sensors and edge computing, and with mobile data utilization.

The engagement aspect is pivotal in this project. The service providers and shopkeepers, who have their stores and facilities in the centre of the city, are interested in benefiting from the gathered and analysed data giving more insight about crowd and consumer movements from one location or address to another. In addition, more detailed data about customer demography, and 'reaction & action' to marketing campaigns, product visibility, opening times and various aspects of sales promotion and their effectiveness are of interest.

The City of Vaasa and the collaborating real estate owners, shopkeepers and service providers are all joined under one common cause, which the project is hoped to enhance: to strengthen the liveability and attractiveness of the city's centre, to make it more appealing and approachable and capable to offer for people of all ages and background, whether they may come by their own car, by public transportation, by bike or walking.

3.3.4.2 IS-4.2: Services for City Management and Planning

The city already has a spatial feedback system, but the goal is to proactively collect information about operations and the environment, e.g., traffic and mobility, energy efficiency and solutions, charging infrastructure, climate and emissions, so that it is possible to react better already at the planning stage. The most valid data to aid planning and decision-making is real-time data or at least near-real-time data.

The objective is to collect data that assists planning and can describe and predict trends and changes in the city's structures and human behavior. Trends can be confirmed with the collected data. The aim is to create analyses and visualizations, i.e., *dashboards* of the collected data, to illustrate changes and needs in the city. This is also a vital measure to succeed in the engagement activities of target and stakeholder groups.

A data platform providing real-time data from valid sources supporting the city's carbon neutrality and climate goals, could potentially save huge sums of money for the City of Vaasa, due to improved quality of planning, with the help of comprehensive data from a district.

3.3.4.3 IS-4.3: Services for Mobility

The objective is to identify, collect, analyse and visualize relevant data from traffic, various mobility modes, crossroads and traffic light system and emissions caused by traffic, for the data platform by utilizing sensor technology and edge computing. The aim is to use the information in various use cases, from planning and decision-making to engagement and procurement activities. The goal requires a broad network of cooperation, in which the City of Vaasa plays a guiding role and acts as the primary (or if not the sole) owner of the data. Additionally, stakeholder involvement and access to the relevant gathered data is extremely relevant. Implementation of solutions and technology will take place through projects.

3.3.4.4 IS-4.4: Services for Grid Flexibility

Since the grid flexibility services, e.g., peak shaving, load balancing, energy arbitrage, voltage and frequency control, can include and benefit from various RES, EV and e-mobility, V2G and V2X, smart charging, BESS, smart energy management, smart house and smart metering solutions (e.g., sensor technology, thermostats etc.), different services for grid flexibility will become relevant in Vaasa soon. These will particularly be relevant in the development of Ravilaakso district, where also digital twin, energy community and prosumer activity has been planned. Additionally, the retrofitting activities could benefit from previously mentioned measures. In consequence, a data platform and AI development with required reliable technology for data gathering, analysing and presentation will become essential.

3.3.4.5 Engagement

As described above in section 2.1.1, the City of Vaasa has in the last years focused on investigating a centralized internet-of-things (IoT)-platform development for the city. The City of Vaasa's objective is currently to strive towards one holistic IoT-platform implementation, which would eventually be able to gather and provide data from the city's various data sources. This is an objective with a large potential for citizen engagement activities including the involvement of citizens in different phases of the development of the platform as well as keeping up a constant dialogue with the citizens once the platform has been established. So far, first potential use cases and pilots have been further investigated and planned. The best approach on how to build up the IoT-platform for Vaasa is via active stakeholder engagement from the early start, and it is clear that collaboration is needed between the city administration and local universities, industry, private companies as well as citizens to create a solution for real-time data collection and a joint IoT-platform in Vaasa.

A pilot taking this direction is the IoT-platform development project described above in section 3.3.4.1 starting in spring 2023, which will monitor consumer behaviour and movement. The project has been developed in close collaboration with different stakeholders, i.e. city centre real estate owners, shop owners and service providers. Another engagement activity to be mentioned in this context is the "Huld Design Award design competition – an intelligent spatial data solution for the city of Vaasa" arranged in 2020 as a collaboration between the technology design house Huld, the City of Vaasa and the IRIS project. The aim of the competition was to look for innovative design solutions to develop the City of Vaasa's understanding of urban mobility by searching for new ideas from city service users on how to utilize the knowledge of people's movement. The outcomes of the competition were several innovative digital solutions tackling different aspects of urban mobility.

3.3.5 Transition Track 5 - Citizen engagement & co-creation

Throughout the IRIS project, the implementation of citizen engagement and co-creation activities have been considered as crucial drivers and enablers in the urban energy transition. Transition Track #5 in the IRIS project integrates citizen engagement and co-creation in the Transition Tracks 1–4. Thus, engagement related aspects have already been presented and elaborated on in the previous sub-sections of chapter 3. In this section, some general aspects related to citizen engagement and co-creation as well as aspects regarding the specific integrated solutions within IRIS Transition Track #5 are presented.

The City of Vaasa has a tradition of involving citizens in the city development and decision-making processes. On a strategic level, this work has been visible in Vaasa's participation program. So far, the focus of the participation program has been mainly on participation in social and health sector related issues and not on transition related areas. However, as mentioned earlier in this deliverable report, the City of Vaasa is gradually acknowledging and accepting the importance of engagement and co-creation in the planning and development of the city and its solutions and services related to energy transition as well. In the implementation of the IRIS project, it has become clear that a stronger focus on citizen engagement and co-creation activities demands a lot of resources. Citizen engagement and co-creation requires time and knowledge; knowledge in terms of methodological skills and understanding of the local context, where the activities have been implemented.

The IRIS project offers a valuable methodological approach for citizen engagement and co-creation called the Citizen Engagement Ladder, which is outlined e.g., in the IRIS deliverable report D1.6. The Citizen Engagement Ladder offers, on one hand, a common and shared language related to engagement and co-creation and, on the other hand, a tool for mapping the current stand and planning future activities. Collaboration with other IRIS partners, especially the experts from HKU (University of the Arts Utrecht), has been very useful for taking engagement activities related to energy transition onwards in the City of Vaasa. This has provided both academics and practitioners from the Vaasa ecosystem a possibility to attend P2P meetings to come together to discuss and share knowledge and experience.

For implementing engagement activities, the restrictions due to the Covid-19 pandemic formed an additional challenge, since citizen engagement initiatives in the Vaasa context typically involved face-to-face activities of various kinds in pre-pandemic times. During the pandemic, the competences related to fostering engagement and co-creation in an online environment have increased both on an individual and organisational level enabling actors in Vaasa to carry out this kind of activities also in a fully digital setting. Even though the readiness for implementing engagement activities in a digital setting has improved on the way, certain aspects, such as building trust between participants and engaging with citizens from more vulnerable societal groups, remain particularly challenging in an online environment.

3.3.5.1 IS-5.1: Changing everyday energy use

Related to IS Changing everyday energy use, the City of Vaasa has piloted the Community building by Change agents approach in the frame of the BothniaTM project funded by the European Regional Development Fund (ERDF) 2017-2019. In this project, the local community building of change agents in Vaasa was supported by implementing a transition arena focusing on future mobility Vaasa implemented with a group of staff members at the City of Vaasa and key stakeholders. The transition arena was methodologically set up based on the Transition Management approach and was supported via collaboration with the Dutch Research Institute For Transitions (DRIFT) and the Finnish Smart Energy Transition project. In the BothniaTM project, transition pathways related to the envisioned mobility future were developed focusing on 1) increasing the usage of public transport, 2) increasing the bicycling modal share, 3) decreasing traffic emissions, and 4) increasing the coordination of planning. The pathways and transition arena outcomes are further described in the BothniaTM project report (Available in Finnish). The transition arena resulted in several immediate actions to take further in Vaasa. One of them was the development of a Sustainable Urban Mobility Plan (SUMP) for Vaasa, which was in a further step – in the context of a project funded by the Finnish Transport and Communications Agency Traficom 2019 – developed and formulated. One main aspect in the development of the SUMP was the engagement of different stakeholders in the City of Vaasa context. The contents of the SUMP were co-created in a series of workshops involving staff members of the city organization, politicians, and stakeholders representing different sectors. In addition, the development of the SUMP was supported by responses to a survey, which was generally open to citizens, and all interested stakeholders. In the SUMP (Available in Finnish and Swedish), several of the actions are described, which have in the last years been implemented, and which have been described above in Transition Track #3. As has been pointed out in previous sections of this report, further efforts are needed to get the citizen and stakeholder engagement to become a natural element in smart city development activities based on an ongoing dialogue with citizens and stakeholders.

3.3.5.2 IS-5.2: Participatory city modelling

As presented and elaborated on in earlier sub-sections of this deliverable report, the City of Vaasa has in the last couple of years been investigating different possibilities related to the implementation of a centralized internet-of-things (IoT)-platform for the city. The city is currently striving towards a holistic IoT-platform implementation. In this context, a participatory city modelling approach and digital participatory tools are considered. There is currently a need to develop e.g., the City of Vaasa's feedback system in a more interactive direction allowing for a dialogue with the citizens. In addition, online enquiries including map-based tools, online workshops and question times should be developed as well as further ways to utilize and communicate the information gained via these tools. The ambition is to develop all these aspects simultaneously. For this, the results from the IRIS project demonstrations e.g., in Gothenburg and pilots in other Smart Cities projects are inevitable.

3.3.5.3 IS-5.3: Living labs

The City of Vaasa has gathered some experience of citizen engagement in connection to Living Labs as this approach is defined in the IRIS project context, i.e., user-centered, open-innovation spaces to shape social, technical and political innovation and dialogue. In the project Lähiö-Inno (2020-2022) funded by the Finnish Ministry of Environment, Living Labs or Community Urban Planning Labs (CUPL) were established in two city districts in Vaasa.

The aim is to via the Living Labs engage the district citizens in Olympia and Ristinummi in innovation activities supporting district development and preventing segregation. Although the development of these districts is different in many respects, they are facing similar challenges due to risks of societal exclusion and poverty. In the Ristinummi district, the activities are further supported by the project Ristinummi district development plan (2020-2022), also funded by the Finnish Ministry of Environment. Thus, the Lähiö-Inno project has a strong focus on social innovation and not as such only a Smart City focus. However, in the Lähiö-Inno project, some of the issues raised and further elaborated on in the Living Labs are related to the smart city approach, such as the availability of public transport related to smart mobility initiatives. The Living Labs were established, and the experiences gathered in the Lähiö-Inno project are forming a good basis for further Living Lab activities targeting Smart City and energy transition objectives.

Due to the Covid-19 pandemic, the Living Lab activities in Vaasa – as the Living Lab activities in the IRIS Lighthouse City Utrecht – had to take place in an online setting instead of the initially planned face-to-face setup. For this, the IRIS P2P meetings involving both academics and practitioners were valuable for sharing knowledge and experiences gathered from a methodological and practical point of view.

3.3.5.4 IS-5.4: Behavior changing information

The City of Vaasa is motivated to raise awareness and improve citizens' knowledge and skills in energy transition related matters to foster behavior change. The city has collected experience in educating pupils and students in energy-related matters in the context of education on different levels: Connected to the Energy Vaasa Cluster, the Energy Education Path (www.energiapolku.fi) has been carried out in Vaasa since 2017. The program covers all levels of education from early childhood to university level education. In other words, it encompasses all forms of education, including elementary, vocational and upper secondary school as well as polytechnic and university education. The Energy Education Path's main aim is to increase pupils' and students' awareness and competence in energy-related issues. Although this primarily affects students and pupils, the effects are likely to involve the social context of each actor as well, such as friends and family. The program is summarized in Figure 18.

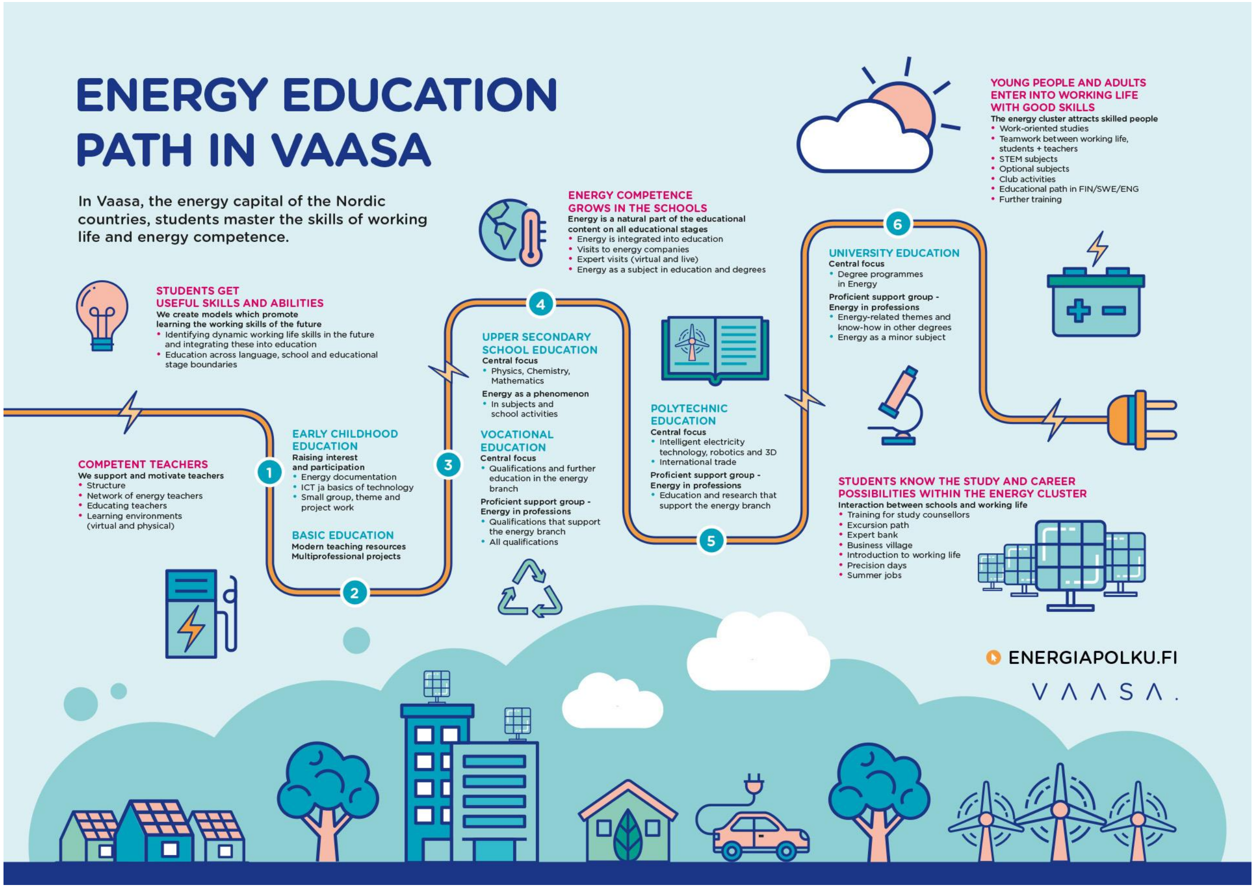


Figure 18. Overview of the Energy Education Path in Vaasa (full-size: Annex 2)

Raising awareness is emphasized throughout the path, since energy is a core theme and a natural part of the educational content on all levels. Throughout the educational path, more specific knowledge and abilities are introduced on the way, but it's important to note that the objective is to increase interest and stimulate engagement already from early childhood education. In addition to the contents provided by the schools' teachers, invited experts are visiting the schools and the pupils and students participate in different site visits. There is a special need for qualified teachers in Vaasa to improve the energy competence in the schools. By providing the Energy Education Path program as a framework and educational resource for the teachers, the project aims to support and inspire them. This is facilitated through virtual and physical learning environments. In addition, when teachers collaborate, they create a network of energy teachers enabling interaction and experience sharing. The program has some further aims in addition to increasing awareness and competence among pupils, students and teachers: The pupils and students can gain knowledge, skills, and abilities of importance for future working life, and they can familiarize themselves with the studying and career opportunities within the Energy Vaasa Cluster.

In order to meet the various goals of the Energy Education Path program and keep up to date with new changes, there is a need for continuous monitoring and development based on e.g., insights from the IRIS demonstrations in the lighthouse cities Nice (Public awareness campaign Energy – School & Collège; Youth & Family) and Utrecht (Campaign District School Involvement). These demonstrations have a similar scope and are an opening for e.g., international collaboration possibilities connected to the Energy Education Path in Vaasa.

3.4 Lessons learned for Vaasa region

Working in a mid-sized city in Finland, the Vaasa team had restricted resources, and therefore encountered some restrictions regarding time (time possible and necessary to invest), regarding knowledge (sometimes we were lacking certain knowledge or expertise), and regarding resources - as a mid-sized city we were very sensitive to staff changes. During this process, we realised that the city had already been a frontrunner in many cases when it came to smart city solutions. Still, creating the replication plan was the first time a summary of potential smart city solution projects was done in the city. During the process, a reflection was made concerning solutions being realized.

It became clear to us that when attending a project, it is not the project itself, which is important; it is the solutions and the added value that can be created for the city, for the stakeholders and for the citizens.

In our opinion, it is of great importance to have the smart city solutions connected to the city strategy. Communication of smart city benefits, targets and solutions needs a lot of effort, both within the city organisation, with the politicians, as well as with the citizens. Even though it might be difficult to know how to engage citizens, it is of great importance for successful implementation to learn this, and something that needs to be part of the process or project from the very beginning.

Picture: Part of the VAASA Team

Another important thing to do, from our perspective, is to map from the beginning the baseline of the city and on-going projects that can support development of solutions. The development of local smart city ecosystem as well as successful cooperation are key factors in order to be able to do any kind of implementation. The understanding for and interest in applying for funding from new and different sources has increased.

We also realized that the global development is very fast, and that things can change very quickly, which means certain amount of flexibility is needed. The interest towards a smart city solution can therefore shift very rapidly, e.g., CIP and V2G charging solutions. On the other hand, we realized that energy community legislation is yet not in place, so spontaneous citizen-founded energy communities are not possible as of today.

We found that it is of great importance to benchmark, study solutions and interact - visit other cities, with stakeholders. The global pandemic Covid-19 did influence on these actions and therefore less study visits could take place, but instead, more webinars, and meetings on certain solutions took place. In any case, it is important to find ways to interact.

4. Guidelines for smart city concept implementation for the Nordic region

There are a lot of websites, tools and guidelines available for smart city strategies and concept development. For implementation of a smart city concept, the City of Vaasa has collected some short guidelines, especially suitable for the Nordic region:

- *Network* with and *benchmark and learn from* other cities, national and international, that have smart city experiences
- *Investigate* smart city solutions that could be suitable for your city (e.g. Smart City Marketplace solution booklets)
- *Create a baseline* of the city (emissions, energy, data, traffic)
- Define the *targets* of the city and connect them with the *city strategy*
- *Use national research institute* (VTT, RISE, SINTEF, e.g.) regarding smart city solutions
- Map available and unavailable *data* in the city
- Create a *local energy and climate program*
- *Map funding programs*, national and EU level, or use your local EU-office
- Map important *stakeholders*
- Join Covenant of Mayors and create a SECAP (=Social, Environmental and Climate Assessment Procedures)
- *Involve citizens* from the beginning, engage and *inspire employees and politicians*
- Be flexible when opportunities arise
- It is never too early to start with *communication* actions
    - Communicate the idea of what the will of the city is (not just the decisions of the city)
    - Internal communication within the city organization is of utmost importance
    - Visualize solutions for better communication
- There might be a need to set up new departments (data platform, energy efficiency, digitalization, etc.) within the city organization

Some regional aspects are important to be taken into consideration, due to the climate but also due to other factors. It is important to analyze every solution, how it would be possible to implement the solution in your area, and what is needed to adapt and consider. Here are listed some regional aspects to take into consideration.

Regional considerations:

- The cold climate in the Nordic region (construction, digging, heating, energy production, transport)
- Seasons (summer solutions do not work in winter, etc.)
- District heating (can be found in most Nordic cities)
- Traffic (suitable modes of transportation for Nordic cities)

- Small towns but big distances
- Cultural and behavioral aspects (car culture, mobility, consumer demands & wishes)
- Legislation and taxation
- Technology usage and maturity level
- Degree of digitalization in the infrastructure
- Price category – prioritization (Nordic countries are expensive)

5. Conclusions

The possibility to take part in a Horizon project, successful as the IRIS Smart Cities, a project engaging and including all partners, has been an excellent experience. It has been an interesting journey, to learn from other cities, to interact and to reflect on own city's actions and ambitions, and to create our own replication plan and implement it. It can be stated that no city is too small to have a smart city strategy; no city is too small to be a frontrunner. Although hardly anything can be replicated fully out, "copy-pasted", lessons can still be learned and ideas can be found, and they can be shared. The found practical solutions can be adapted and modified to suite other cities.

5.1 Conclusions of the findings

It can be concluded that the City of Vaasa took an ambitious decision to try to "replicate most of, if not all, the available solutions" of IRIS transition tracks and LH cities' solutions. This has been due to our "broad development work and demanding targets regarding energy and climate related issues".

In the beginning, we decided that we wanted to follow almost all transition tracks and solutions, and in the end, we only replicated the relevant ones.

And how did we fare? Due to unpredictable reasons (covid-19, Ukrainian conflict) some planned actions have been put on hold (Wasa station), whereas some have been successfully piloted (Mini-Lifti pilot) or implemented (Vaskiluoto heat storage) already. Some are still in the planning phase and some actions are still on the working table, future steps unknown. The Ravilaakso project was also affected, and its development decelerated by the world situation, but the planning and development of the project has resumed.

During IRIS project, we have trained ourselves to shift from solution to system change. Instead of merely replicating or copying IRIS / LH / FC / solutions, we have looked at the process as a whole and found or modified the solutions to fit the City of Vaasa. One concrete output of IRIS project was, for example, hiring of new resources with new titles, e.g., energy and climate expert.

During IRIS project, we have had key personnel, who have frequently got together, worked for IRIS and smart city solutions, and therefore strengthened co-operation, streamlined processes, in the City of Vaasa. Due to IRIS project, we now have a platform for smart city operations. Some themes and actions have not been created strictly because of IRIS (e.g., carbon neutrality, city strategy theme programs), but they have been developed during IRIS journey and IRIS has helped to speed up and streamline the development.

It can be concluded that the aims of the deliverable and IRIS project in case of City of Vaasa have been met, as IRIS has improved urban life in Vaasa, and it has helped to ensure sustainable, secure and affordable mobility and energy for living for all citizens and businesses. In truth, some effects will be better seen in the future, but progress and development can already be witnessed nevertheless. Contacts, project results and tools created during IRIS project, as well as the system change mindset will continue to bear fruit in the future.

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Annex 1 - Referral to relevant inputs and outputs from other deliverables

D8.4 Vaasa replication plan and D8.3 replication toolbox, as well as the list below about inputs (mostly based on demonstrations in LHs).

WP5: Utrecht Lighthouse City demonstration activities

- D5.1 Report on baseline, ambition & barriers for Utrecht lighthouse interventions (Updated version)
- D5.2 Planning of Utrecht integration and demonstration activities
- D5.3 Launch of T.T. #1 Activities on Smart renewables and near zero energy district (Utrecht)
- D5.4 Launch of T.T.#2 activities on Smart energy management and storage (Utrecht)
- D5.5 Launch of T.T.#3 activities on Smart e-mobility (Utrecht)
- D5.6 Launch of T.T. #4 activities on CIP and information services (Utrecht)
- D5.7 Launch of T.T. #5 Activities on Citizen Engagement and motivating feedback (Utrecht)
- D5.8 Preliminary report on Utrecht lighthouse demonstration activities

WP6: Nice Lighthouse City demonstration activities

- D6.1 Report on baseline, ambition & barriers for Nice lighthouse interventions (Updated version)
- D6.2 Planning of Nice integration and demonstration activities
- D6.3 Launch of T.T.#1 activities on Smart renewables and near zero energy district (Nice)
- D6.4 Launch of T.T.2 activities on Smart energy management and storage for flexibility (Nice)
- D6.5 Launch of T.T. #3 activities on Smart e-mobility (Nice)
- D6.6 Launch of T.T. #4 activities on City Innovation Platform and information services (Nice)
- D6.7 Launch of T.T. #5 Activities on Citizen Engagement and motivating

WP7: Gothenburg Lighthouse City demonstration activities

- D7.1 Report on baseline, ambition and barriers for Gothenburg lighthouse interventions
- D7.2 Planning of Gothenburg integration and demonstration activities
- D7.3 Launch of T.T.#1 activities on Smart renewables and near zero energy district (Gothenburg)
- D7.4 Launch of T.T. #2 Activities on Smart energy management and storage for flexibility (Gothenburg)
- D7.5 Launch of T.T. #3 Activities on Smart e-mobility (Gothenburg)
- D7.6 Launch of T.T.# 4 activities on City Innovation Platform and information services (Gothenburg)
- D7.7 Launch of T.T. #5 Activities on Citizen engagement and motivating feedback (Gothenburg)
- D7.8 Preliminary report on Gothenburg lighthouse demonstration activities.

Annex 2 – Energy Education Path in Vaasa