IRIS

Integrated and Replicable Solutions for Co-Creation in Sustainable Cities

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Disclaimer

Executive Summary

The IRIS project is nearing completion of its 66 month-long period. In the Lighthouse City of Gothenburg, the project has resulted in many new solutions in the areas of renewable energy sources, energy storage and management, e-mobility, open data platforms and citizen engagement. These solutions have been implemented and are now in the operation and evaluation stage.

This deliverable gives an overview of the final state of the Gothenburg demonstrators and the results and data that have been gathered up to the conception of this report. It aims to present the content in an accessible and non-technical manner to serve as useful information and inspiration to other cities, organisations and individuals looking for solutions that improve sustainability, resource efficiency, democracy, and quality of life in cities.

Transition Track #1 In this transition track, the objective has been to demonstrate a Positive Energy District (PED), a district that annually produces more electricity and heat than it consumes. To achieve this, a combination of energy-saving measures, energy storages, renewable energy sources and energy management systems have been designed in the housing cooperative Viva, all of which are implemented and in use.

The results are promising although there is still some way to go towards reaching a positive energy balance for the district.

In Transition Track #2, the key message is: In future energy systems, peak power demands will cause a large part of operational costs and negative environmental impact. In this Transition Track the focus is how to store energy, both electric and thermal to reduce the power demand in the energy systems.

Main results include: PV/battery/DC network is operating and successfully cuts peaks in electricity consumption. PCM thermal storage for cooling is showing less capacity than anticipated due to material issues.

In Transition Track #3, the key message is: The mobility service has shown to be attractive and appreciated among users, it is scalable and replicable and has attracted great interest from real estate owners. However, MaaS systems offer complex challenges, both from technical integration and management of stakeholder interests in the value chain.

Main results show that in the Viva complex, MaaS usage is high, both for e-bikes and e-cars and satisfaction ratings from users are high. Private car ownership among Viva residents is significantly lower than the city average. In the campus area demonstration, results have been difficult to interpret due to the impact of the Covid-19 pandemic.

In Gothenburg the IRIS project has demonstrated two different solutions in **Transition Track #4**:

The CIM (City Information Model) pilot project which is an implementation of tools for collecting and sharing of data from building projects with support by FIWARE components. The main collected data is BIM data – Building Information data.

The Energy Cloud has been implemented and is a local version of a cloud for collecting data within the energy system. The local system has been delimited to three universities and their landlords in the Gothenburg region.

In **Transition Track #5**, the City of Gothenburg has worked with different types of civil society dialogues in various operations and processes, including Minecraft, a digital tool for engaging younger citizens

regarding for instance the development of a detailed plan for an area. The Inclusive Life Challenge is a concept developed for creating an arena were the city and its citizens can collaborate. Within urban development, a public tool/platform has been developed in 2012; Min Stad ("My City") and will be further developed to strengthen citizen engagement. The ME-model is a framework created to integrate the experience and learning from the three demonstrators: Minecraft, Inclusive City Life Challenge and Min Stad. The ERO application was developed and demonstrated in the HSB Living Lab, for nudging tenants to be aware of their energy use, and finally there is the VR/AR BIM application within the building" A Working Lab" where users can view BIM data and sensor data through a smartphone or a VR headset.

On the City level, there are numerous examples of results and impacts from IRIS that have been adopted or upscaled. For instance, IRIS results have guided the City's recently launched Energy Plan, its development of a City Innovation Platform, and adopting Minecraft as a mainstream tool for including children and youth in the urban planning process.

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List of Abbreviations and Acronyms

Abbreviation	Definition
AC	Alternating Current
AR	Augmented Reality
AWL	A Working Lab (building on the Chalmers campus)
BIM	Building Information Model
BIPV	Building Integrated Photovoltaics
Brf	Housing cooperative (Sw. ” Bostadsrättsförening”)
CIM	City Information Model
CIP	City Information Platform
CKAN	Comprehensive Knowledge Archive Network
CoP	Coefficient of Performance
DC	Direct Current
DSO	Distribution System Operator
EMS	Energy Management System
EU	European Union
HVAC	Heat, Ventilation, and Air Conditioning
KPI	Key Performance Indicator
MaaS	Mobility as a Service
ME	Citizen Engagement (Sw. “Medborgarengagemang”)
PCM	Phase Change Material
PV	Photovoltaic
REC	Real Estate Core
SAP	Sodium Polyacrylate
TES	Thermal Energy Storage
V2G	Vehicle to Grid
V2X	Vehicle to Anything
VR	Virtual Reality
WP	Work Package

1 Introduction

1.1 Scope and objectives

This Deliverable constitutes a final report on the results of the Gothenburg lighthouse demonstration activities, comparing these results with the ambitions, specifications, and planning of the Gothenburg demonstration activities. It aims to describe in a non-technical and accessible way how the Gothenburg Lighthouse demonstrations have progressed, and what results have emerged.

In the presentation of the KPI's (Key Performance Indicators) that have been used to evaluate the level of success for the demonstrators, the report seeks to put them in a context and provide background and discussion concerning their relevance and validity for the demonstrator and the overall results.

Furthermore, the Deliverable aims to serve as a "teaser" and a first step into the IRIS universe for readers looking to profit from the knowledge and experience gathered in the project, for replication, upscaling or inspiration in their own cities or organisations.

1.2 Lighthouse demonstration project

The IRIS Gothenburg Lighthouse demonstration project musters a well-rounded and multi-disciplinary team including large and small enterprises, City administration departments, real estate owners, utilities and higher education and research institutions. Together, this team addresses the challenges set out in the IRIS Description of Activities.

The demonstration activities in IRIS Gothenburg are mainly centred around the Chalmers University of Technology campus. Here, the brf Viva complex (Transition Track #1, the AWL (A Working Lab) building (Transition Tracks #2 and #5) and the HSB Living Lab (Transition Tracks #1 and #5) are situated. Outside of this area, activities dealing with the City Innovation Platform (Transition Track #4) and Citizen Engagement (Transition Track #5) take place at various locations in the city. Figure 1 shows an aerial view of the main demonstration area with the buildings highlighted.

Figure 1 IRIS Gothenburg Demonstrations

IRIS project strategy is built around 5 interdependent Transition Tracks enabling the transition towards reduced energy demand and increased shares of renewables and e-mobility in the urban energy and mobility systems. Realizing citizen engagement, cocreation of inclusive information services for citizens are regarded as a crucial drivers and enablers in the urban energy transition. Therefore, citizens play an important role in the lighthouse demonstration activities. As outlined above, the lighthouse cities face common as well as district specific challenges. The IRIS lighthouse cities will address these challenges by integrating and demonstrating solutions belonging to five both indispensable and promising IRIS Transition Tracks

IRIS Transition Track #1: Smart renewables and closed-loop energy positive districts: Integrating (a) a high share of locally produced and consumed renewable energy at district scale, (b) energy savings at building level reducing the citizens' energy bill and (c) energy savings at district level. Demonstrated solutions integrate high renewables penetration like district scale PV and biomass for district heating, near zero energy housing retrofit, energy efficient low temperature district heating and smart public lighting that is energy efficient, powered by renewables and connected to the district energy system

IRIS Transition Track #2: Smart Energy Management and Storage for Grid Flexibility: Integrating smart energy management and renewable energy storage for (a) maximum profits of renewable power/heat/gas, (b) maximum self-consumption reducing grid stress and curtailment, and (c) unlocking the financial value of grid flexibility. Demonstrated technical solutions include smart ICT to interconnect energy management systems at home, building and district level, and to integrate maximal renewables production (track 2), V2G storage in e-cars operated in car sharing systems (Track 3) with additional stationary energy storage.

IRIS Transition Track #3: Smart e-Mobility Sector: Integrating electric vehicles and e-car sharing systems in the urban mobility system offering (a) local zero-emission mobility, (b) lower household mobility costs, and (c) smart energy storage in V2G car batteries. Demonstrated solutions include extensive deployment of (V2G) e-cars, exploitation of (V2G) e-cars in local car sharing systems, and district-wide smart (V2G) charging stations powered mainly by renewables.

IRIS Transition Track #4: City Innovation Platform (CIP): Cutting edge information technology and data framework enabling (a) the above-mentioned solutions, maximising cost-effectiveness of the integrated infrastructure. Next, the City Innovation Platform with open, standards-based application program interfaces (APIs) provides meaningful data and information services for households, municipality and other stakeholders, allowing for a Data Market with new business models. A common architecture, harmonized data models and a sustainable data governance plan ensure the interoperability and replicability of the solutions, transferring them from city to city. The City Data Market and the service marketplace manage access to all data and services, with appropriate licenses and flexible pricing models in and across cities and allowing real time KPI monitoring and benchmarking of smart energy and mobility performances.

IRIS Transition Track #5: Citizen engagement and Co-Creation: Design and demonstration of feedback mechanisms and inclusive services for citizens to achieve that they are intrinsically motivated to (a) save energy, (b) shift their energy consumption to periods with redundant renewables, (c) use electric vehicles and (d) change the vehicle ownership culture towards a use or common mobility assets culture. Demonstrated solutions include game-theory based engagement methods and instruments ranging from co-creating infotainment apps, local school campaigns, offering training on the job to students living in the district by partaking in the demo activities, competitive energy games using the home energy management system, energy ambassadors creating local energy communities, to crowdfunding creating a sense of being part of the solution.

The five transition tracks focus on energy and mobility solutions that will be demonstrated by all lighthouses, but will include some specific city solutions as well, allowing the lighthouse cities to put their own accents responding to their local conditions and challenges. The demonstration results will be replicated in other districts in the lighthouse cities, as well as in the follower cities, which can mix and match the demonstrated solutions according to their needs, paving the way to worldwide replication.

Along with demonstration of integrated solutions, new business cases will be developed and tested to accelerate the worldwide market uptake of the demonstrated solutions. Beyond demonstration and implementation, extensive monitoring and evaluation of each implemented measure has been carried out in the three lighthouse cities. Energy and CO_2 savings, as well as other environmental and socio-economic impacts, benefits and lessons learnt will be quantified, assessed, and reported to accelerate replication and knowledge dissemination.

IRIS Objectives

Objective 1: Demonstrate solutions at district scale integrating smart homes and buildings, smart renewables and closed-loop energy positive districts.

Objective 2: Demonstrate smart energy management and storage solutions targeting Grid flexibility.

Objective 3: Demonstrate integrated urban mobility solutions increasing the use of environmentally friendly, alternative fuels, creating new opportunities for collective mobility and lead to a decreased environmental impact.

Objective 4: Demonstrate the integration of the latest generation ICT solutions with existing city platforms over open and standardized interfaces enabling the exchange of data for the development of new innovative services.

Objective 5: Demonstrate active citizen engagement solutions providing an enabling environment for citizens to participate in co-creation, decision making, planning and problem solving within the Smart Cities.

Objective 6: Put in practice bankable business models over proposed integrated solutions, tested to reduce technical and financial risks for investors guaranteeing replicability at EU scale.

Objective 7: Strengthening the links and active cooperation between cities in a large number of Member States with a large coverage of cities with different size, geography, climatic zones and economical situations.

Objective 8: Measure and validate the demonstration results after a 3-years large-scale demonstration at district scale within 3 highly innovative EU cities.

1.3 Relation to other activities

In the work with WP2, D2.1 and D2.3 have created a broader understanding of current networks and utilisation of these, as well as the EU's various platforms in order to find knowledge about other projects and find their way in the difficult-to-navigate map of networks and platforms that have emerged during the project period.

In collaboration with WP3, several deliverables have been given input through dialogue and texts. A valuable work within WP3 to describe the innovation chain and systems in Gothenburg was done, which in turn provided inspiration for closer dialogue with the City of Stockholm/Grow Smarter and the City of Umeå/Ruggedised regarding the benefits and impacts these two Lighthouse projects identified that gave IRIS in Gothenburg interesting perspectives.

Close collaboration with WP4 has been carried out through the related work on CIP for WP4 and CIM D7.6.

In the work with D5.2 and D6.2, close collaboration has been consistent throughout the project period for input and output. Several deliverables in these WPs have led to an exchange of knowledge dissemination in the form of study visits, workshops and webinars.

Within WP8, D8.1-3 has served as a support in our work with IRIS partners and external partners who wish to learn more about selected demonstrators in Gothenburg.

A close collaboration has been carried out with WP9 to identify and develop KPIs, as well as greater knowledge how to communicate the results of the metrics.

WP7 is responsible for the Gothenburg Local Newsdesk where the support from WP10 has been consistent for all kinds of communication within all deliverables, IRIS Magazine and the final conference in Gothenburg.

1.4 Structure of the deliverable

This Deliverable is divided in five main parts, each giving description of the aim, scope and results (where available) of the demonstration activities in each of the above-mentioned Transition Tracks. Each Transition Track chapter also touches on possible exploitation schemes and business models associated with the demonstrators.

The concluding chapter deals with the wider impact the IRIS project and its activities have had, and what tangible results have been produced on the city level.

The Appendixes contain technical information for the benefit of the reader that is looking for more details on selected subjects.

2 Final Results of Transition Track 1

In this transition track, the objective has been to demonstrate a Positive Energy District (PED), a district that annually produces more electricity and heat than it consumes. To achieve this, a combination of energy-saving measures, energy storages, renewable energy sources and energy management systems have been designed in the housing cooperative Viva, all of which are implemented and in use.
The results are promising although there is still some way to go towards reaching a positive energy balance for the district.

2.1 Overview

Together, as a sector, we must do better. The energy usage in buildings, and the resulting climate forcing must be reduced rapidly and substantially. This Transition Track showcases various measures aimed at achieving this goal through their implementation in two facilities.

The following measures are stated in the GA:

- T7.3 1) Demonstration of at least 200 kWh electricity storage […]
- T7.3 4) Demonstration of local energy storages
- T7.3 5) Demonstration of seasonal energy trading
- T7.3 6) Development and demonstration of an advanced Energy Management System

The more specific aims are to enhance the understanding of how housing and energy systems can work together. To shave peak power, reduce energy consumption and provide an increased energy system flexibility.

2.1.1 The building HSB Living Lab

In the full-scale housing lab HSB Living Lab (**Fout! Verwijzingsbron niet gevonden.**), much was already achieved when IRIS begun, albeit only shortly before, and so the demonstration included is a retrofit of façade-integrated photovoltaic panels. These panels were installed in multiple directions for evaluation purposes, including an economic comparison of using PVs as a façade material.

HSB has its Living Lab placed at campus Johanneberg. The Living Lab is the home for some 30 students, and at the same time a research, test and demonstration environment for e.g. energy efficiency, resource optimization, electricity generation, laundry habits, cooking possibilities and so on.

Figure 2 The HSB Living Lab.

Figure 3 The locations of HSB Living Lab and Viva, relative to each other

2.1.2 The building Brf Viva

In the direct vicinity of Chalmers campus Johanneberg in Gothenburg, Riksbyggen developed the housing association *Riksbyggen Brf Viva*, or *Viva* for short, with a total of 132 apartments (**Fout! Verwijzingsbron niet gevonden.**, **Fout! Verwijzingsbron niet gevonden.**). Viva is the result of an innovation process, led by JSP and Riksbyggen and has involved several local IRIS partners, e.g. Chalmers, RISE (Research Institute of Sweden), City of Gothenburg, the local energy utility Göteborg Energi, architects and consultants. The process was initiated in 2010 and two years later it was established as “Positive Footprint Housing” with all above-mentioned partners.

Viva aims at being the most innovative and sustainable housing project in the country, incorporating a range of integrated solutions designed to achieve more renewable electricity production, more sustainable transportation, peak power shaving and increased system flexibility. The aim is also to create solutions that enable a positive energy balance in districts and create an attractive, social inclusive campus and neighbourhood.

Viva's energy system consists of demonstrators with varying levels of innovation. While some are considered state-of-the-art with high level of performance, others are so novel that they were still under development when implemented in Viva.

Figure 4 Viva as seen from Johanneberg Science Park

In Viva, it is not the individual elements of the solutions but rather how they combine that will allow the future deployment of the proposed solutions in larger areas. To establish a self-sufficient energy system that is resilient and diverse (Figure 5), multiple elements have been designed and implemented.

Three principles guided the design of the system and the selection of its components:

1. *Minimize the demand for energy and power*. This was achieved through well-insulated buildings with high thermal inertia, efficient appliances, and automated lighting controls. As this is a commonly implemented practice, it is not included in the measures evaluated in IRIS.

2. *Maximize local renewable energy production*. Electricity production through PV panels on the roofs and heating and cooling provided by ground source heat pumps, all of which are included as measures in IRIS. These solutions and systems are increasingly common in the Swedish housing stock, but it is primarily their part in the system that is of interest for the evaluations done in IRIS. This includes the measures as stated in the GA:

   - T7.3 1) Demonstration of at least 200 kWh electricity storage in 2nd life automotive (bus) batteries powered by 140 kW local PV
   - T7.3 2) Demonstration of heating from geo energy with heat pumps
   - T7.3 3) Demonstration of cooling from geo energy

3. *Store or sell the excess, in that order.* The electricity storage is, to the best of our knowledge, first of its kind in the world. In collaboration with the bus manufacturing company Volvo,

batteries which have been utilized in buses for approximately three years are given a second life by being repurposed as stationary electricity storage in Viva. There, the batteries serve two purposes: to increase the amount used PV-produced electricity, since it's more profitable than selling it, under current Swedish regulations; and to balance electricity consumption over time to shave peak electricity power usage. Viva also uses accumulator tanks for thermal energy storage and the high thermal inertia of the building structure to shave peak thermal power (**Fout! Verwijzingsbron niet gevonden.**).

An Energy Management System/algorithm has been developed, implemented, tested, and demonstrated with the main goal of proving that it is technically possible to manage energy flows within a complex energy system with district heating, heat pumps, 2nd life batteries, solar panels through their algorithm.

The algorithm's purpose was to reduce energy costs from operating the energy system.

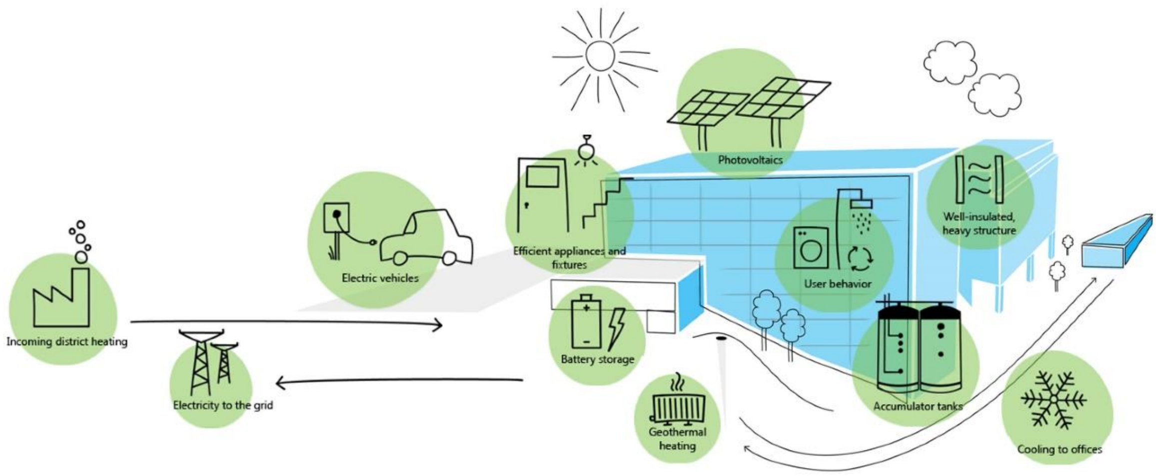


Figure 5 The components of the energy system in Viva

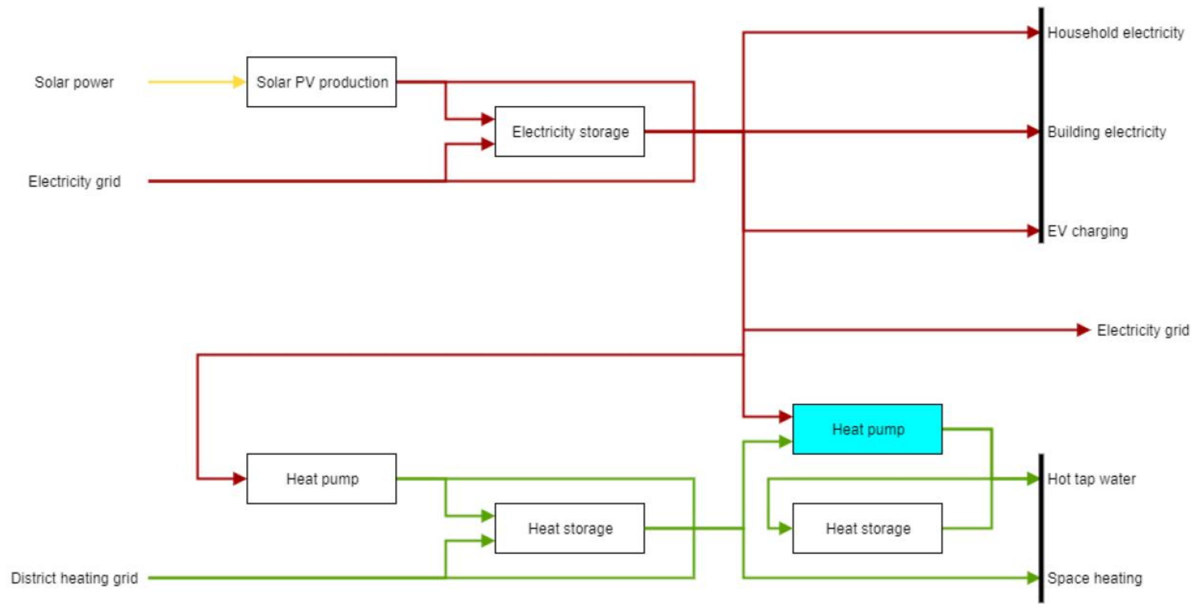


Figure 6 An overall schematic view of the energy system in Viva

When Viva now has been fully operational and with full occupancy for more than three years, the main activities revolve around two principal things; operational optimization of the measures that were expected to work better and continuous measuring and evaluation of the energy system and all its components.

2.2 Implementations

This section will describe the aim(s) and target(s) with each demonstrator and the extent of the implementation of the demonstrators.

2.2.1 Demonstration of how Building Integrated Photovoltaics (BIPV) can be used in façade renovation process.

The aim was to demonstrate BIPV as the primary screen in a building envelope in a renovation process. The economic feasibility was of particular importance. This was done in HSB Living Lab (**Fout! Verwijzingsbron niet gevonden.**) and is now fully evaluated.

A collection of photovoltaics was investigated:

- Amorphous silicon- and monocrystalline silicon cell BIPV-facade, about 3,5 m². Directed to east and west.
- Amorphous silicon cell BIPV- facade, about 140 m². Directed to south, east, and west.
- Mono-Si BIPV-roof, ca 50 m². Slanted 14° to the south.

Figure 7 The south façade of the HSB Living Lab after installation of Building Integrated Photovoltaics.

The implementation of facade integrated PVs has a big potential, by using the façade a much larger share of a building can be used for producing solar energy. In addition, the PVs can be part of the architectural expression, especially when using coloured panels. This can also make it possible to install PVs where a regular installation would not be allowed due to regulations and building permits. Also, for high rise buildings with a low roof to façade ratio this type of PVs can increase the possible area for solar panels manyfold. Last, but maybe not least, this type of solution can have a high impact on building brand recognition, showing how a company values and actively work with sustainable solutions and reducing climate impact.

But even though the potential is there, very few actual installations have been completed. This is mainly due to three factors:

- Limited demand
- Lack of suppliers and entrepreneurs
- Uncertainties regarding technology and cost

The limited demand is mainly connected to the price model and the low-cost benefit in Sweden for a building owner when selling electricity to the net owner. With a larger PV installation, the amount of over production (electricity that cannot directly be used in the building) will increase and this will either have to be stored or sold to the net. Typically, PV installations are designed to cover a percentage of the building electricity demand and to avoid over production. This leads to a cost beneficial solution for the building owner and in most cases the available roof space provides sufficient area for PVs to achieve that. This in turn reduces the demand for increasing the area for PVs and using façade integrated panels.

Another aspect concerning the demand is suitable facades for using integrated PVs. Ideally this type of PV should replace a regular façade material both in function and aesthetic expression. This limits the number of suitable facades where the solution would best be suited. This is especially so for existing buildings, for new building projects this could be included in early stages.

The next point is connected to the limited demand and that is a lack of suppliers and entrepreneurs. Today there is a very high demand for regular PVs and thereby more focus from the suppliers to meet this demand. Experiences have shown that smaller suppliers focusing on façade integrated PVs have had difficulties meeting project requirements and keeping in business.

With regards to entrepreneurs the main issue is that façade integrated PVs are more complex, requiring more working hours to install per m^2 of PV compared to a regular roof installation. For the entrepreneur they can install much larger PV installations on roofs with a higher revenue than they can get from a façade integrated installation. With a high demand for regular installations coupled and a limited number of qualified entrepreneurs getting an entrepreneur to perform the work becomes a bottle neck for façade integrated PV project.

The last item is connected to this still being a relatively new and uncommon installation. With few reference projects and (at least perceived) uncertainties regarding the PVs performance as part of the building envelope it can lead to a hesitation by building owners to go for this type of solution. This coupled with an increased investment cost both compared to a regular façade and a typical PV installation on a roof has likely contributed to a lack of new projects.

2.2.2 Demonstration of heating from geo energy with heat pumps (2-300 m deep boreholes).

The aim was to provide heating to Viva from borehole-based heat pumps. The target was to be able to cover Viva's entire heating demand with the heat pumps. This has been fully implemented with the following hardware:

- A heat exchanger of 200 kW for district heating.
- Geothermal heat pumps with a condenser power of 195 kW in total, coming from three heat pumps of 65 kW each. The Coefficient of Performance (CoP) is 3.2 on average.
- 19 boreholes reaching some 230 meters down into the bedrock.

2.2.3 Demonstration of cooling from geo energy without chillers, and Demonstration of seasonal energy trading (cooling in summer season) with adjacent office block.

The aim was to use the boreholes to provide cooling in addition to heating. This is achieved basically by exposing the bedrock to a heat medium warmer than the bedrock, so that the medium will return colder from the boreholes.

The aim of the seasonal energy trading was to connect the energy systems of Viva to adjacent office buildings using insulated pipes. This enables:

- Free cooling from the boreholes to cool the comfort system in the office buildings, which otherwise would have been cooled using electrically powered cooling machines.
- Excess heat from this comfort cooling system to heat the boreholes in Viva and in turn make the geothermal heat pumps more efficient, which means they use less electricity.

Both facilities could then potentially meet their heating and cooling demands by using less electricity.

Both facilities are entirely dependent on the connection between Viva's energy system and that of neighbouring office buildings, with an owner who is not part of IRIS. After a few years of trying, funds and forms for the collaboration are now agreed upon and the demonstrator is in service.

2.2.4 Demonstration of local energy storages consisting of water buffer tanks, structural (thermal inertia of the building) storage and long-term storage in boreholes.

The aim was to build solutions for increased thermal inertia in the energy system in Viva. These are

- A well-insulated building structure, with large amounts of concrete exposed to the indoor air, to passively smoothen the temperature curve in the apartments.
- Accumulator tanks at nodes in Viva's heat distribution system. These are actively controlled for peak power shaving during the hours with the highest hot tap water demand on a daily cycle, typically in the mornings when most residents shower.
- Recharge of heat into the boreholes to increase the longevity of their heat delivery. The continuous heat extraction of the boreholes can cause the temperature in the bedrock to drop too much which in turn has a negative effect on the efficiency of the geothermal heat pumps and the delivery of heat.

The water tanks are fully operational, and the structural storage is a passive system that always has an effect. The long-term storage in boreholes, however, was dependent on the *seasonal energy trading*, which was completed later.

2.2.5 Demonstration of at least 200 kWh electricity storage in 2nd life automotive (bus) batteries powered by 140kW local PV.

The aim was to install and demonstrate a large array of PVs, as well as a stationary electricity storage consisting of 2nd life batteries, previously used in electric or hybrid buses. Furthermore, the aim was to integrate and control the two systems to store excess electricity from the PVs in the batteries. The targets were 140 kWp of installed PVs on the buildings, and 200 kWh storage capacity in the batteries. Since this is a demonstration that is first of its kind for all parties involved, the essential aim was to learn whether this is a useful second application of automotive batteries at all, particularly regarding the degradation of the batteries.

The battery storage consists of 14 lithium-ion batteries that have previously been used to power buses in public transport in Gothenburg. The specific chemistry is called LFP - Lithium FerroPhosphate, or Lithium-Iron-Phosphate. The main ingredients are common metals including aluminium.

Figure 8 Inside the battery storage room.

The batteries are made up of a large amount of smaller battery cells which are integrated in modules, and the modules are connected to larger packs including functions like cooling, intelligent controls, and encapsulation. The battery case is built by a protective steel shell and includes electronics, cables, and cooling pads. These 14 batteries are installed in a separate room (Figure 8) and joined to form a functioning energy storage of roughly 200 kWh. Each battery is about two meters long and weighs 350 kg.

This was fully implemented, but due to some problems with the control systems, the battery storage has worked with reduced capacity during parts of the period.

Knowing the aging rates and service life in this second application of the batteries was considered a challenging and important topic to evaluate. Since the battery monitoring system was developed for vehicle usage, a custom-build capacity measurement was implemented. This was regularly set to measure the capacity and the resistance of the system.

2.2.6 Development and demonstration of advanced Energy Management System to integrate PV, DH, grid and all abovementioned storage options to achieve peak shaving and minimal environmental impact.

The aim was to plan, develop, implement, and evaluate a control algorithm in a real-time model to optimize the energy use from an economical perspective. The target was to include the following components in the automated EMS: district heating, ground source heat pumps, battery energy storage, water buffer tanks and PVs. Expected outcomes of this EMS was to reduce climate impact and energy costs as well as manage peak power, by shifting energy demand away from costly and climate intense hours in the grid.

This demonstrator has been implemented with a reduced functionality. The communication between the various control software for these components was not entirely possible, which is why the EMS did not control all intended components in the energy system.

The main goal of the Management and Optimization project has been to prove the technical feasibility of managing a complex energy system with district heating, heat pumps, 2nd life batteries, solar panels. Initially the plan was to also use thermal storage, but after consideration the idea was discarded since the tanks were not originally designed for this feature. Overriding them could temporarily jeopardize the possibility to get domestic hot water. The thermal inertia of the buildings was also considered as well as Vehicle to everything charging stations, but neither of the solutions were realized due to excessive costs. The optimization was based on variable electricity costs and the optimization did not include power tariffs for electricity and district heating.

2.3 Results

This section includes information gathered from surveys and interviews with residents in Viva, feedback from collaborators, and measured data from the demonstrators.

2.3.1 Shared targets for the transition track

Main KPI's Transition Track 1 in Gothenburg, as stated in the GA are:

(i) sub-district energy consumption (target: <24 kWh/m2/y),
(ii) peak power shaving (target: >80% reduction in peak power compared to control)
(iii) and net energy surplus on annual basis (target: >10 MWh/y)
(iv) Energy savings (67 kWh/m2/y compared to average Swedish buildings
(v) Integrated PV power (420 kW)

2.3.2 End-user experience

Much to the satisfaction for those involved in the development of Viva, surveys conducted among residents have predominantly yielded positive feedback.

In the questionnaire on indoor thermal comfort which was carried out as part of the certification for the Swedish system "Miljöbyggnad", roughly "Environmental Building", most respondents in each of the six buildings say that the thermal comfort is better than acceptable. This varies between 50 % and 78 % in winter, and from 76 % and 100% of the respondents in summer. Unfortunately, some also say that the thermal comfort is worse than acceptable, mainly during the winter period. Thorough efforts have been taken to find and fix different problems or faults that cause this dissatisfaction.

A large study of the perceived housing qualities in Viva, carried out by researchers from the architecture department of Chalmers University of technology (also a project partner in IRIS), returned similarly positive results. When asked about whether Viva is a housing project that supports a sustainable lifestyle, a majority answered in the affirmative. From their written motivations, however, most residents did not think of choosing to live in a building with an ambitious energy system as a lifestyle choice. Electrified or human-powered mobility, waste management, opportunities to repair furniture and sharing of some household appliances would be things more closely associated to lifestyle choices. One exception is individual metering of energy and water usage.

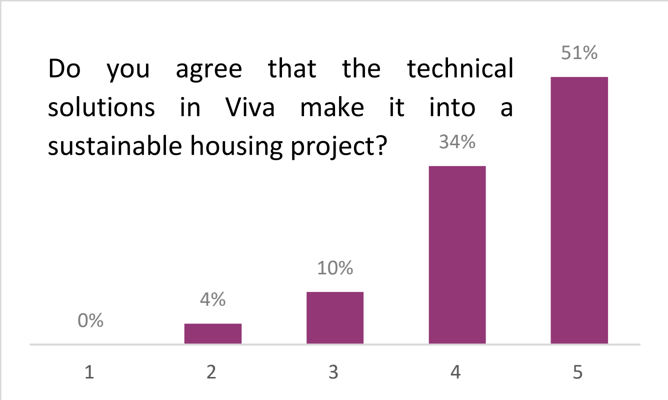


Figure 9 Survey results from end-user experience in Viva

n the same study, when asked if the technical solutions in Viva make it a sustainable housing project, the agreement was much higher (Figure 9). More than half of the answers were "5 - completely agree", and 85% were positive. When asked about this specifically, they described the solutions as "timely" or "very good". One said that these solutions make buildings "less unsustainable", and one stated that "*mentioned technologies are definitely a part of sustainable building. It is surely possible to do more, but this is a good start*". It is like it is expected of a reputable housing developer to prioritize the improvement of these often-overlooked systems, providing residents with comfort while steadily reducing environmental costs.

2.3.3 Data quality

The quality of the data is generally good, but could have been better and more readily available if desired and if kept in mind in the early stages of the Viva project. Long before the IRIS project started. When data is extracted at an hourly resolution from different platforms, it turns out to differ quite a bit. In some cases, it is a matter of the platforms retrieving data from different meters, all of which should measure basically the same thing. In other cases, it is unclear which hours corresponds to each other and how the platforms interpret the data.

Sometimes data is missing for certain hours/days, and you need to invest time and energy to get this filtered for the data to be useful and comparable with data from other platforms, or data extracted at another time. In addition to this, certain meters that were needed for certain evaluation were never installed.

Some input data to KPI-calculations overlap, making it difficult to assess the benefits of the measures one by one. Some information/lessons learned has been lost or inaccessible due to staff turnover during the project or that people are stuck with information but either lack the time or incentive to deliver it, not being a direct part of the IRIS project.

Also, some information is owned by other project partners, outside of IRIS, and some of that information could unfortunately not be delivered due to problems with the collection of data, and thus not all the data required to produce certain KPI:s is available.

2.3.4 Building Integrated Photovoltaics in façade renovations

This demonstrator has shown that PVs on facades can be an excellent idea. An important factor here is that the PV panels are used as the primary rain screen for the building, which means that it replaces another façade material, and the investment is not simply an added cost but an alternative cost. And with the long service life of the panels and the continuous values it creates in the electricity it generates, life cycle costs are quite encouraging.

Table 1 KPIs for Building Integrated Photovoltaics in façade renovation process

KPI	Unit	Definition	Target	Result
Increase in local renewable energy production	MWh	Ratio of produced energy from renewable production over a period (e.g. month, year)	(iii), (v) 14 MWh	11,5 - 12,4 MWh
Degree of energetic self-supply by RES (electrical)	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	19 %	10-15 %
Carbon dioxide Emission Reduction	tonnes CO2/year	Reduction of emissions of carbon dioxide related to measure.	0,525 tonnes CO_2 /year	0,75 - 0,80 tonnes CO2/year
CO2 reduction cost efficiency	Euro/ton CO2 saved per year	Costs in euros per ton of CO_2 saved per year		-860 – 1150 Euro/ton CO2/y

As previously reported the technical installation of façade integrated PVs was successful. Since installation, the PVs has functioned as intended both as part of the building envelope and for producing solar energy. This dual function has potential cost benefits compared to a normal façade depending on produced solar power and energy prices.

As part of the evaluation, an LCA was performed for the solar panels compared to a regular façade. The initial climate impact for façade integrated PVs compared to regular material is significantly higher. However, this is compensated for during the operational phase where the produced solar energy can replace electricity produced using fossil fuel. The results showed that over an expected lifetime of 25 years the façade integrated PVs have a lower climate impact than a regular façade. These results depend on where the panels are produced and the local energy production mix. For countries or regions with a high degree of fossil fuels in the energy mix solar panels will have a shorter climate pay-back time compared to a regular façade.

Due to the limited time of the project and few installations there is not sufficient data regarding maintenance need for this type of PVs or for possible increased costs for operation. But regular PVs have a low need for maintenance, and it is likely to be the same for a façade integrated solution. The HSB LL demonstration has not shown any increased need for maintenance or added costs.

The installation of façade integrated PVs is more complex than working with regular materials. The PVs cannot be altered at site to fit in around windows and openings. This requires additional work during the installation phase and proper competence from the entrepreneur.

2.3.4.1 KPI: Increase local renewable energy production

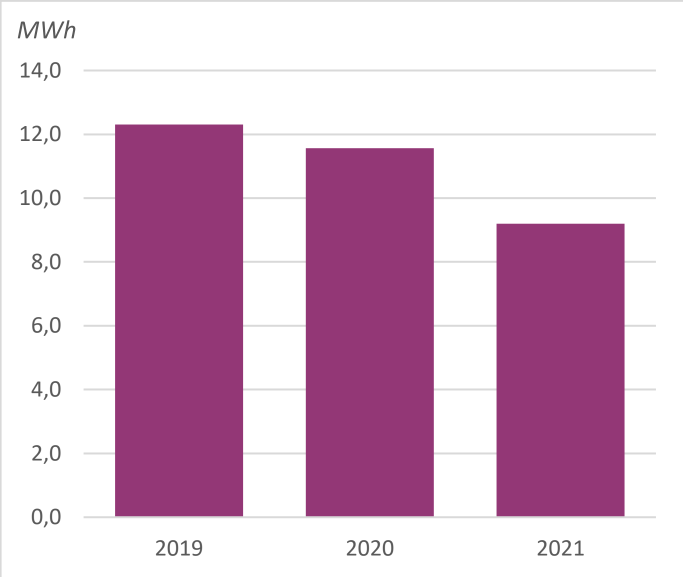


Figure 10 Increase local renewable energy production, yearly

Figure 10 shows the yearly production of solar energy from facade integrated PV panels. The difference in yearly production between 2019 and 2020 are most likely due to natural variations in terms of sunlight. The PV panels showed a slightly reduced production in practice than what was expected from the design stage but there have not been any issues with operation or performance.

For 2021 there was a fault with the central control system and data collection for the PV panels, the yearly production data therefore does not include 2 months of production. Apart from this, the production has been similar to previous years.

Since the façade integrated PV panels were already installed and in operation at the start of this project this demo does not show any increase in the local renewable energy production. However, the installation has provided an increased local production capacity for HSB Living Lab.

2.3.4.2 KPI: Degree of energetic self-supply by RES (electrical)

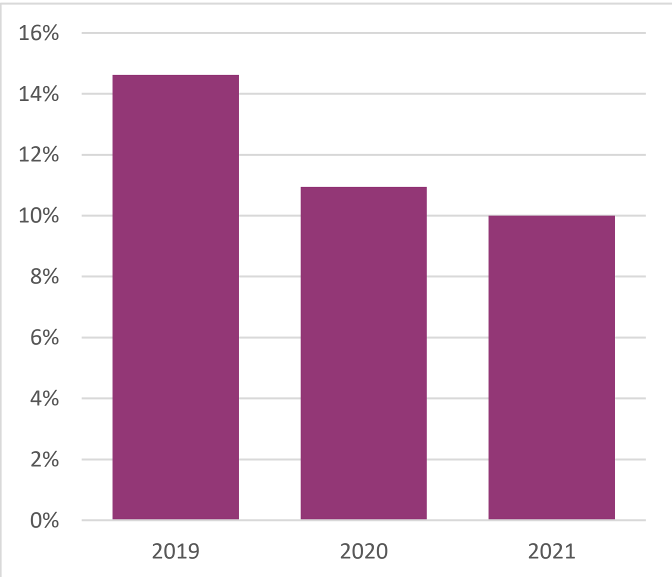


Figure 11 Degree of energetic self-supply by RES (electrical), yearly

Figure 11 shows the degree to which the local production of solar energy can cover the need for electricity in the building.

2020 was a year when the pandemic led to a large change in behavior and the residents were required to work and study from home. The electric energy consumption for the building increased by 25 % between 2019 and 2020. This explains the reduction of self-supply between these two years.

For 2021 the energy consumption was more like 2019 but since the production data misses two months the KPI is also affected and is not representative.

This shows that when it comes to degree of self-supply it is not only the production side that matters but also the energy consumption. For instance, changed behavior, colder temperatures and other factors can influence the result.

2.3.5 2nd life bus batteries and local photovoltaics

The installations have worked. However, both batteries and PVs have not been able to reach their full potential during the demonstration period, largely due to miscommunication between software and interfaces, and lack of communication between organizations.

It did not appear to be any major issues with using used bus batteries as energy storage for buildings. The first approach of the degradation investigation failed, but approach two showed a moderate degradation of 5% annually.

Table 2 KPIs for 2nd life bus batteries and local photovoltaics

KPI	Unit	Definition	Target	Result
Increase in renewable local energy production	kW	Increased amount of produced energy from RES over a period (e.g. month, year)	140 kW and 140 MWh/a	171 kW and 65-139 MWh/a
Degree of energy self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	(iii) Brf Viva's degree of self-supply for **electrical** energy is expected to vary between 10% and 60%.	16-27%
Carbon dioxide Emission Reduction	tonnes CO_2/year	Reduction of emissions of carbon dioxide related to measure.	15-20%, or 10 metric tonnes.	1,5-3,2 tonnes CO_2/year

2.3.5.1 KPI: Increase in renewable local energy production

At the time of the application for the IRIS-project, a peak power capacity of 140 kWp was expected to be installed. The final installation was instead 170 kWp (290 Wp × 589 panels). This addition came about because, additionally, one of the low buildings got its roof covered with PVs, as shown in **Fout! Verwijzingsbron niet gevonden.**. In total, the PV system is expected to produce around 160 MWh annually, on a year with normal irradiation. This was expected to cover about half of the electricity demand for the building itself, i.e., disregarding the demand of the households.

Figure 12 Brf Viva with its PV clad roofs

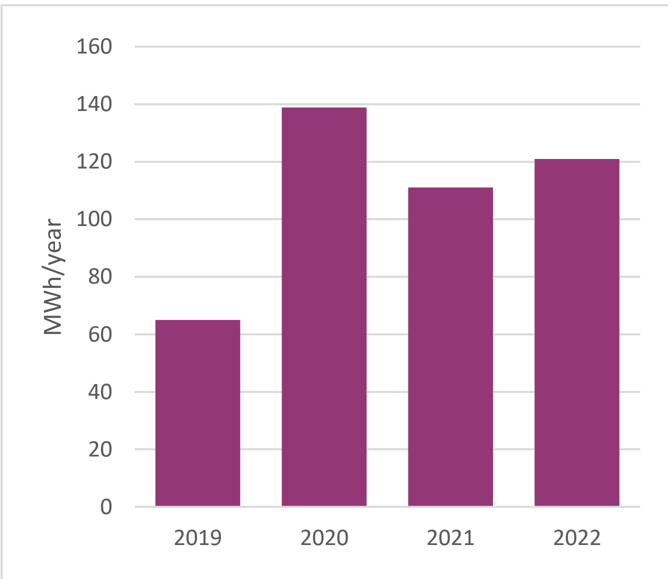


Figure 13 Increase in renewable local energy production, yearly

The PV-panels have produced less electricity than expected as shown in Figure 13. The average production has altogether been around 75% of the expected amount. As for 2019, the first 5 months are not included missing some 50-60MWh and as for 2022, the last 3 months are not included, missing some 10MWh.

One reason for the relatively low yield in 2021 is due to a safety breaker being turned off, which is assumed to be caused by a lightning strike. Without an alarm signal, it took some time for this to be noted and fixed, resulting in a reduction in production.

2.3.5.2 KPI: Degree of energy self-supply by RES

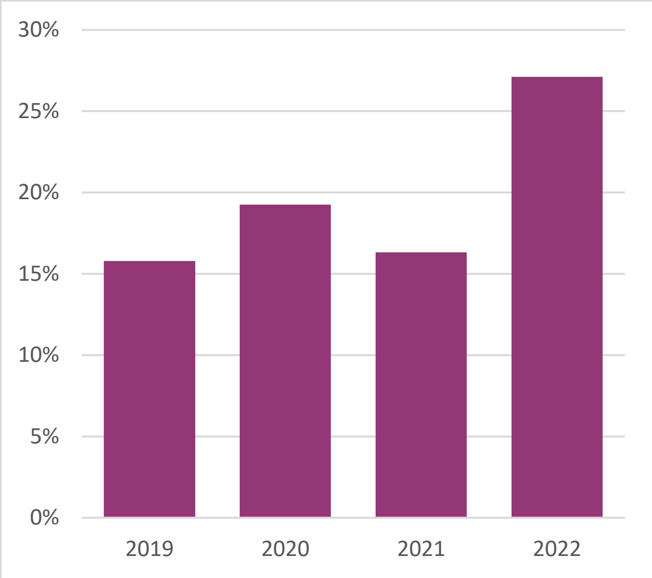


Figure 14. Degree of energy self-supply by RES, yearly

Averaging at 20% of the total electricity consumption, the PV-system in Viva makes a substantial contribution to the energy performance of Viva (Figure 14). While this might seem low for a building with such high ambitions and large focus on enabling a large PV installation, the buildings in Viva are tall and slender, making for relatively little roof area per housing area.

It should also be mentioned that PVs are only installed on the roofs in Viva, and placements on the facades were investigated but deemed to have a return on investment that was too long. Since 2018, the cost per installed power for PV panels has dropped around 30% in Sweden, while prices per bought kWh have soared, so this calculation would probably have looked different with today's input.

It is also worth noting that the energy usage and consumed electricity has been higher than expected, in addition to the fact that production of solar electricity has been lower than expected, thus, the rating between bought electricity and produced solar electricity has been much lower than expected.

The ratio of solar electricity production to total electricity consumption in the last seven months of 2019 remained roughly the same as for the whole year. As for 2022, where the data only reached until the end of September, the situation was different. In the three missing months, electricity consumption was relatively high and while solar production is used to be very low during this time of the year, it makes 2022 stand out. If the whole year was included, the degree of self-supply in 2022 would have been just over 20%. 2019 had the highest electricity consumption during the period analysed.

Thanks to operational optimization, electricity usage has decreased over time, assuming the same conditions. Additionally, in 2020 and 2021 it was decreased even further due to the use of district heating to some extent, instead the ground source heat pumps. Still, the degree of energy-self supply by RES has been much lower than expected.

2.3.5.3 KPI: Carbon dioxide Emission Reduction

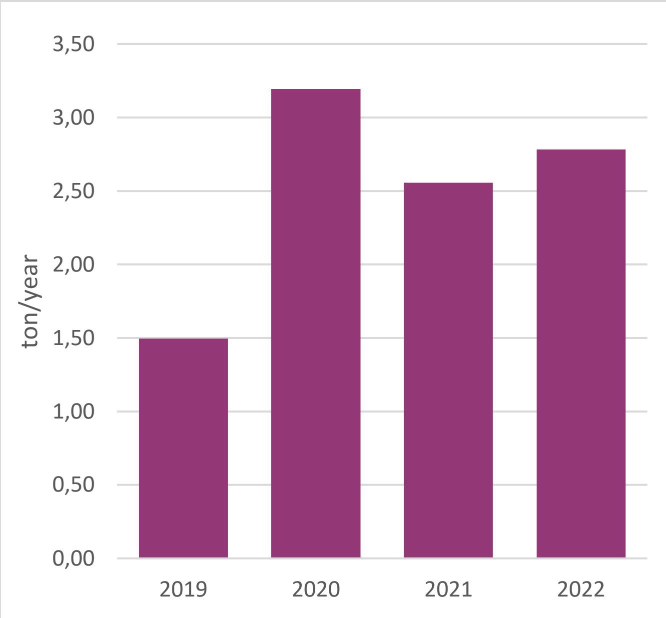


Figure 15. Carbon dioxide Emission Reduction

The reduction in carbon dioxide emissions (Figure 15) is directly proportional to the produced energy by RES. In Viva's case, the CO2 intensity of the purchased electricity which is primarily sourced from low-carbon sources such as hydro and wind power is very low by European standards, at 23 kg CO2-e/MWh. Sweden does have the lowest CO2 intensity in its the power system, compared to other countries in the EU [Statista.com]. If the C02 intensity of the Netherlands were used, the figures would have been 14 times greater. For Poland, the figures would have been 32 times higher, and for Finland, they would have been twice as high.

2.3.5.4 Storage capacity installed

This is a KPI that belongs to TT2, but since the capacity of the battery storage influences other measures in this TT, as well as it being in the title of the measure, it is included here as well.

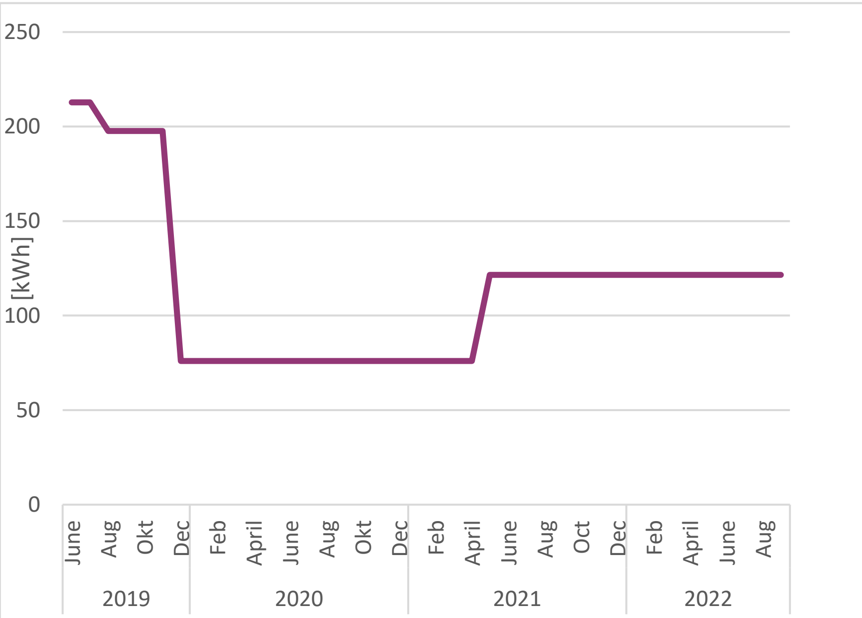


Figure 16. Active electrical storage capacity of the 2nd life batteries over time

In the summer of 2019, a battery system consisting of 14 batteries with a capacity slightly greater than the intended 200 kWh and with a SOC window of 22% - 85% was in operation. The batteries underwent occasional disconnection for adjustments. One battery stopped working due to aging in July 2019, while in November 2019, eight batteries ceased functioning because of excessively low SOC levels. The remaining five batteries in operation had their SOC window adjusted to 30% - 85%. In April 2021, three out-of-service batteries were replaced, resulting in a total of eight functioning batteries.

2.3.5.5 Stakeholder experience from Volvo's point of view

The collaboration began as an idea to test the integration of 10 batteries from Volvos first electric buses in Viva, an apartment building with solar panels. At that time, neither the final capacity of the batteries or the number of available batteries was known, and so a flexible system that could handle different amounts of batteries was designed. Volvo delivered 14 lithium-ion batteries from the first electric buses in Gothenburg. They were installed in 2018 in collaboration with Göteborg Energi and Riksbyggen. The SME Ferroamp supplied the overall control and monitoring functionalities. It was very important in the beginning to be able to follow each battery individually.

The batteries were having regular calibration sessions out of service, meaning that scheduling of the calibration impacted the availability of total capacity and the optimization of the usage. Also, fault reports were handled by the control system supplier and sent to Volvo to intervene and check on the batteries. Volvo had the maintenance support for the batteries.

A major risk is a standby discharge of the system, which could lead to a capacity depletion that below certain levels became irreversible and destructive for the batteries. Therefore, a sleep mode was introduced where all internal electronics of the batteries were shut off to prevent a slow depletion of the system. The sleep mode was to be activated at set *Safe states* at the battery level. In general, it was made clear that the batteries of type LFP (Lithium Iron Phosphate) needs maintenance charging while not used for a long time. This was a limiting factor for the storage between the bus and the house.

It was not possible to replace failed electronics or make software updates of the battery control units due to IP of the battery supplier, which was not Volvo. Therefore, there was no repurposing procedure or deep diagnostics of the battery system. This led to the need to exchange a few batteries over the years.

The mature system with follow up and capacity measurements and data evaluation required a personnel engagement from Volvo and Ferroamp. A more standardized system would probably be easier to maintain. However, manual adjustment on seasonal basis would still be needed in most cases.

The experience from this demonstration is that this kind of installation is feasible from a technical point of view.

2.3.6 Heating from geo energy

The boreholes and heat pumps have shown good results. However, the ground source heat pumps, custom built for Viva, have been out of service more than their conventional counterparts, which has led to an increased dependence on district heating purchases.

Table 3 Demonstration of heating from geo energy with heat pumps (2-300 m deep boreholes)

KPI	Unit	Definition	Target	Result
Degree of energetic self-supply by RES (thermal)	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	(iii)	66-100 %
Increase in local renewable energy production	MWh	Ratio of produced energy from renewable production over a period (e.g. month, year)	(iii), (v)	315-773 MWh
Carbon dioxide Emission Reduction	tonnes CO2/year	Reduction of emissions of carbon dioxide related to measure.	34-46	31 tonnes CO2/year
CO2 reduction cost efficiency	Euro/ton CO2 saved per year	Costs in euros per tonne of CO_2 saved per year	400	-644-404 Euro/ton CO2

2.3.6.1 KPI: Degree of energetic self-supply by RES

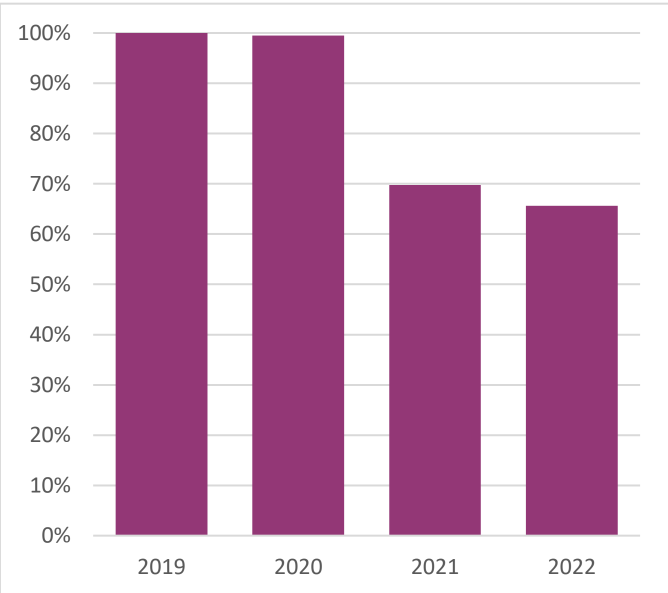


Figure 17. Degree of energetic self-supply by RES, yearly

Unfortunately, the energy performance of the buildings themselves has turned out lower than expected, resulting in more heat pumps to be in operation over time thus higher use of electricity than expected. As a result, the heat pumps have not been able to cover 100% of the heating power demand for the association during a few days/hours each year. The relatively low percentages in 2021 and 2022 were the result of the EMS opting to purchase district heating rather than utilizing the ground source heat pumps. (Figure 17)

In fact, during 2019 and 2020 the heat pumps stood for more than 99% of the delivered heat and during 2021 until the EMS was put into operation, the heat pumps could cover more than 95% of the heat demand. Speaking of power demand, it's a different story.

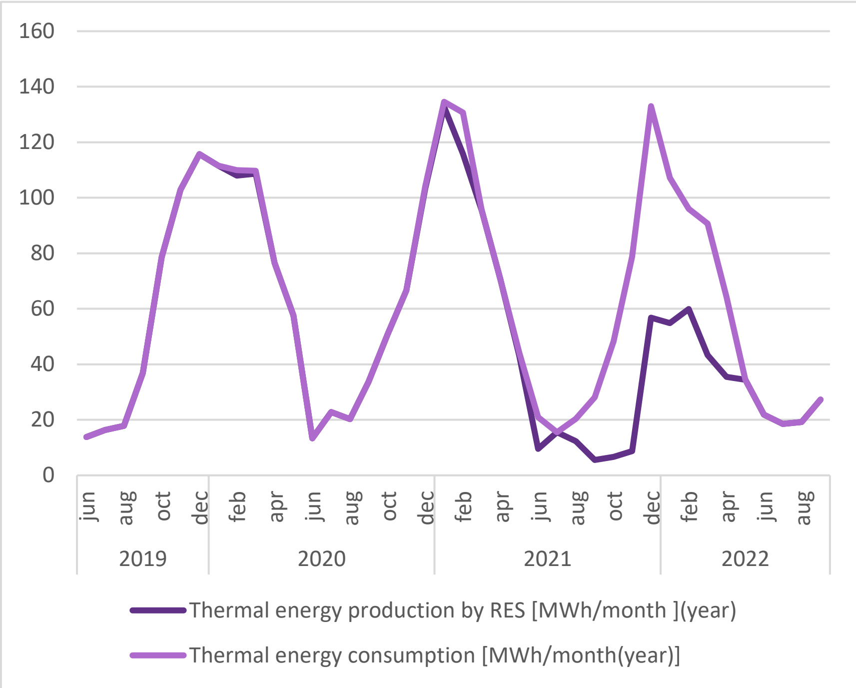


Figure 18. Thermal energy production and consumption.

Consumption fluctuates with the seasons, predictably, with varying peaks relative to seasonal temperatures. The consumption behaves normally but the production figures are dampened in the winter 21/22, since the EMS opted towards using district heat for heating. (Figure 18)

Upon closer inspection, it is evident that the thermal energy generated by the heat pumps was insufficient to meet the demand in February 2020 as well as January and February 2021.

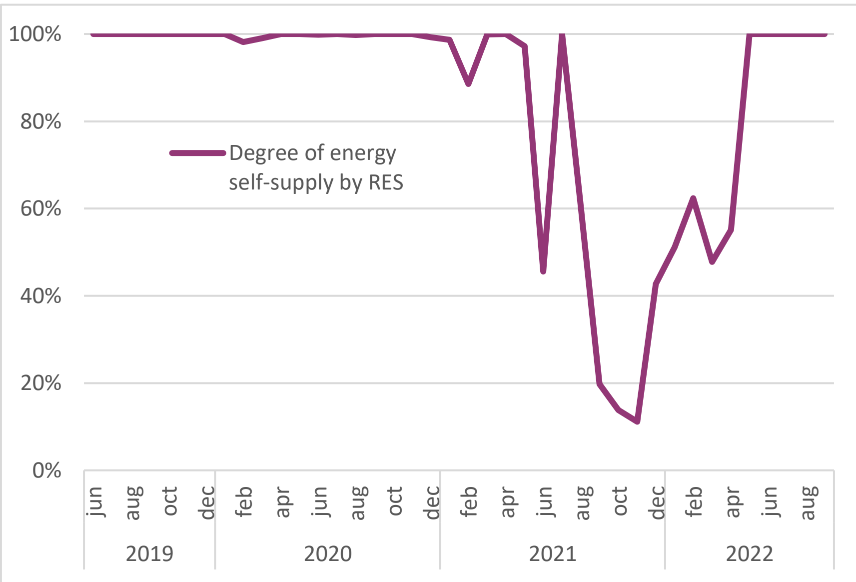


Figure 19. Degree of energetic self-supply by RES, monthly

The resulting ratio of production over consumption, with a monthly resolution instead of yearly.

When the heat pumps were utilized as the primary source of thermal energy, the degree of self-supply was consistently close to 100%. Therefore, the conclusion is that the system has performed well during operation. (Figure 19)

2.3.6.2 KPI: Increase in local renewable energy production

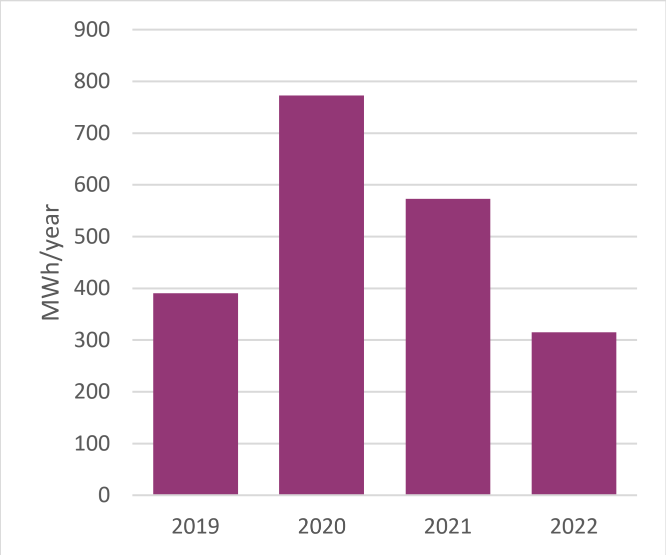


Figure 21. Increase in local renewable energy production, yearly

The increase in local renewable energy production is the thermal energy production /extraction from the boreholes and heat pumps.

The figure for 2019 is low since the full calendar year is not included; monitoring began in June that year. The figure for 2021 is lower than 2020 mainly due to district heat being used instead of the ground source heat pumps. The figure for 2022 is a combination of the above two; district heat being used instead of the ground source heat pumps and the data series reaching until September. (Figure 20)

2.3.6.3 KPI: Carbon dioxide Emission Reduction

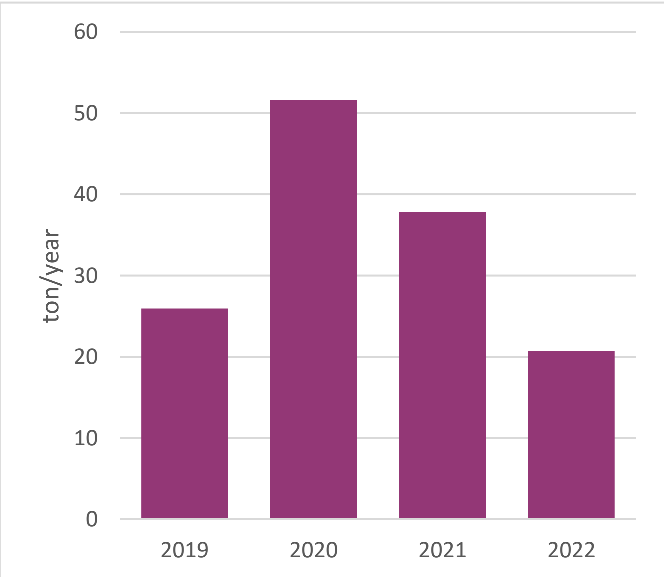


Figure 22. Carbon dioxide Emission Reduction, yearly

The reduction in carbon emissions is a directly dependent of the increase in local renewable energy production by the heat pumps, which is why the curves have the same shape in both Figure 20 and Figure 21.

The emission reduction comes from the alternative carbon cost had the same amount of energy been taken from the district heating grid, subtracted by the carbon emissions from the electricity that the heat pumps use.

The carbon intensity for the Swedish electricity mix is very low in a European comparison, at 23 tonnes CO2-e/MWh, and the same number for district heating is 75 tonnes CO2-e/MWh.

2.3.6.4 KPI: CO2 reduction cost efficiency

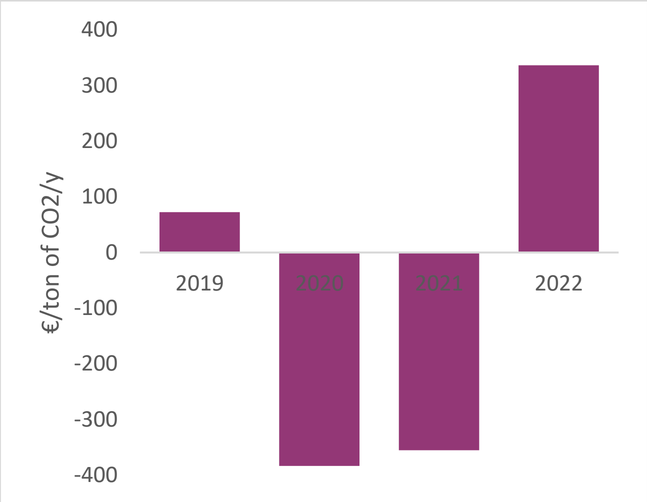


Figure 23. CO2 reduction cost efficiency

The difference between the years is mainly due to the volatile electricity prices recently, and the fact that the housing association pays for a variable electricity price per month. (Figure 22)

Since Viva's heat pumps use electricity to make heat, when electricity prices go up, the cost per reduced tonne CO2-e go up, too.

In 2019 the ground source heat pumps' annual running costs were lower than what the district heating they replaced would have cost. Taking the annualized investment costs into account the cost was 72Eur/ton CO2 reduced. In 2020 and 2021 there was a cost reduction while reducing CO2 emissions, due to lower running costs. In 2022 the price for electricity in the south of Sweden skyrocketed, resulting in even the running costs exceeding what the equivalent extra power and energy would have cost with district heating.

2.3.7 Cooling from geo energy

Table 4 Demonstration of cooling from geo energy without chillers

KPI	Unit	Definition	Target	Result
Degree of energetic self-supply by RES	%	Ratio of locally produced energy from RES and the energy consumption over a period (e.g. month, year)	80 %	42 %
Carbon dioxide Emission Reduction	tonnes CO2/year	Reduction of emissions of carbon dioxide related to measure.	1,6 tonnes CO2/year	0,84 tonnes CO2/year

2.3.7.1 KPI: Degree of energetic self-supply by RES

Manual meter readings show that BRF Viva supplied CFAB with 110 MWh of cooling from 2021-11-22 to 2022-10-25. During the same time, CFAB used 261 MWh of cooling. Due to challenges faced by CFAB with the control of their system and monitoring of energy meters, this information is the only available data. Hence, the degree of self-supply by RES is calculated to be 42%.

2.3.7.2 KPI: Carbon dioxide Emission Reduction

Based on the assumption that all the cooling supplied by BRF Viva to CFAB replaced the need for cooling from cooling machines with an average annual COP of 3, it is estimated that approximately 37MWh of electricity in theory was avoided from being purchased by CFAB. By multiplying this amount by the emission factor for electricity, the resulting carbon dioxide emission reduction is calculated to be 0.84 tons per year.

2.3.8 Local energy storages

The accumulator tanks and bore holes are operating and functioning as intended. However, quantifying the bore holes contribution to the overall storage capacity is challenging. The thermal inertia of the buildings was neither measured nor utilized by the control system to equalize the heating power demand and shave peak power, as this would have required expensive hardware that was not initially planned for in the project.

Table 5 Demonstration of local energy storages consisting of water buffer tanks, structural (thermal inertia of the building) storage and long-term storage in boreholes

KPI	Unit	Definition	Target	Result
Storage capacity installed	kWh	kWh storage capacity installed	(iii)	970 kWh

2.3.8.1 KPI: Storage capacity installed

The installed storage capacity of the tanks is determined by two variables, the amount of water stored and the maximum temperature range within which the water is allowed to fluctuate. Depending on the temperature of the water coming out of the tanks, varying over a year, using the extremes, we have calculated the capacity installed, stated in Table 6. By utilizing district heating, it would be possible to allow for a wider temperature range, and thus increase the storage capacity installed even further.

The primary purpose of the tanks in the main energy central is to serve as equalization tanks, enabling more efficient operation of the geothermal heat pumps rather than shaving peak thermal power. The tanks themselves have no power limitation. They can store and release the entire power output of the geothermal heat pumps. The power output of tanks in the energy sub-centrals depends on the house's hot tap water demand and cannot be influenced by the control system itself.

The stored capacity that is utilized on a regular basis is thus far less than the capacity listed. If that sort of capacity or more than that capacity is the be utilized, the system needs to be controlled differently.

Table 6. Details on the accumulator tanks

Tank location	Number of tanks	Volume per tank	Possible range of temperature	Resulting heat capacity
Main energy central	2	2 m^3	30-50° C	90 kWh
Energy sub-central	3*9	0,5 m^3	(6-23)-63° C	890 kWh

The long-term storage of energy in boreholes has not been measured. However, as shown in **Fout! Verwijzingsbron niet gevonden.** and **Fout! Verwijzingsbron niet gevonden.** , it is possible to see that the temperature in the heat transfer medium brought down into the boreholes has been higher than the temperature brought up from the boreholes at certain times. This indicates that there has been a recharge of energy in the boreholes during these times.

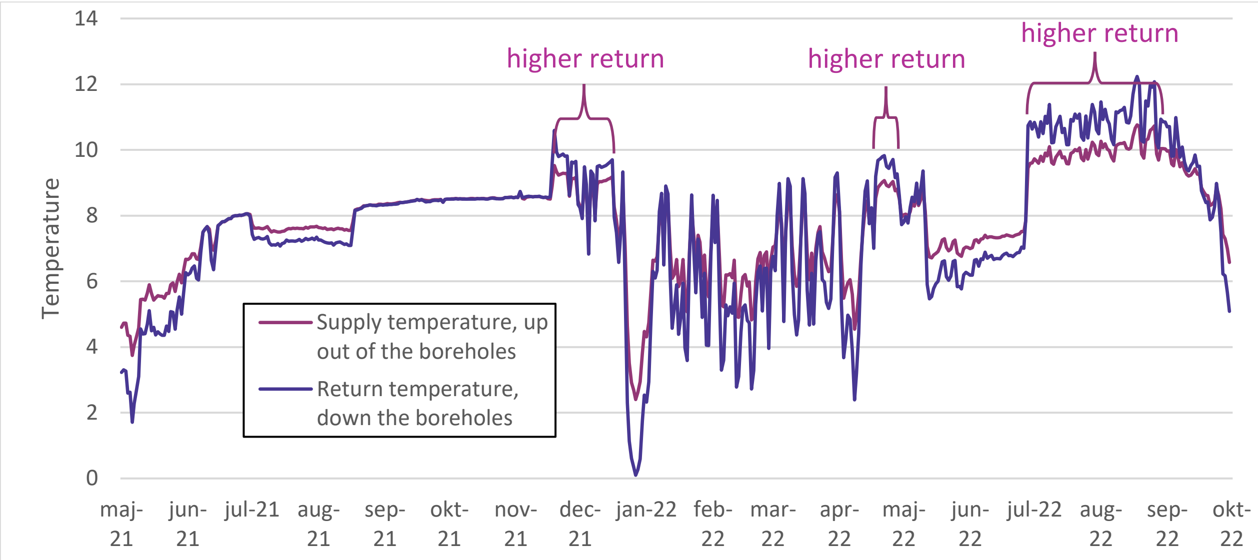


Figure 24. The temperatures returned to, or supplied from, the boreholes

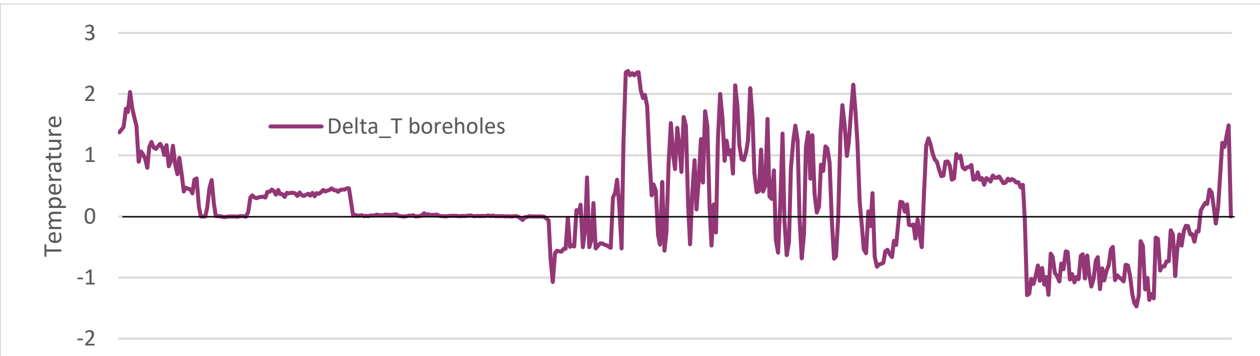


Figure 25. Difference between supply and return temperatures in the boreholes

Figure 24 shows the temperature difference of the heat transfer medium going down and coming up from the boreholes over time, specifically. A positive value implies that the boreholes have heated the water, while a negative value indicates that the water has heated the boreholes.

During the project, attempts has been made to implement the buildings' thermal inertia in the EMS to shave peak thermal power, but it was never implemented due to lack of resources. Utilizing the thermal inertia to shave peak power or for energy cost optimization purposes turned out to be hard without a certain type of smart meters. Those meters would have been necessary in each individual apartment, which would have been very costly.

The potential of the thermal inertia could have been utilized and measured if Viva was controlled differently.

2.3.9 Seasonal energy trading

Table 7 Demonstration of seasonal energy trading (cooling in summer season) with adjacent office block

KPI	Unit	Definition	Target	Result
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	(ii)	Not available.
Reduced energy cost for consumers	%	Reduction in cost for energy consumption on an aggregated level, based on energy savings and current energy prices.		68%

2.3.9.1 KPI: Peak load reduction

Sufficient data is missing to determine this result.

2.3.9.2 KPI: Reduced energy cost for consumers

During a total of 11 months of seasonal energy trading, which ran from November 2021 to October 2022, the reduced energy cost was roughly 68% using an estimated price for electricity. This significant cost reduction largely depends on the relatively high electricity prices in Sweden during this period.

2.3.10 Energy Management System

The target of the EMS measure was to control the following components: district heating, ground source heat pumps, battery energy storage, water buffer tanks and PVs. The EMS is no longer in operation.

Table 8 Development and demonstration of advanced Energy Management System to integrate PV, DH, grid and all abovementioned storage options to achieve peak shaving and minimal environmental impact

KPI	Unit	Definition	Target	Result
Reduced energy cost for costumers	%	Reduction in cost for energy consumption on an aggregated level.		No savings
Increased electrical system flexibility for energy players	%	The change in load capacity participating in demand side management before and after the measure.		64-95 %
Increased thermal system flexibility for energy players	%	The change in load capacity participating in demand side management before and after the measure.	100 %	70-95 %
Peak load reduction	%	Reduction in maximum peak load of a building or a group of buildings.	(ii)	0-20%

2.3.10.1 KPI: Reduced energy cost for customers

The EMS has not reduced the total energy cost. Instead, the total cost for energy was increased by a few percent during the year of operation and another couple of percent the following year due to an increased cost for peak power, based on the district heat grid tariff. However, Göteborg Energi has credited and cancelled the extra costs. While the EMS proved the technical feasibility of controlling a complex installation as Viva, it did not result in any financial savings for the customers.

2.3.10.2 KPI: Increased electrical system flexibility for energy players

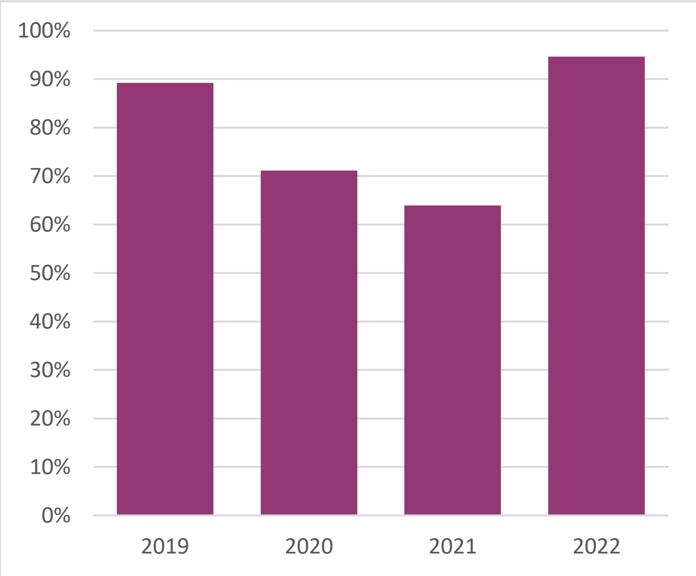


Figure 26. Increased electrical system flexibility for energy players, yearly

On the electrical side, the system flexibility was increased by 64-95% during the monitoring period. These values were obtained by dividing the sum of the peak power available in the battery storage and the peak power consumption of the geothermal heat pumps by the peak power delivered from the electrical grid. (Figure 25)

This means that the power from the electrical grid could have been reduced by this percentage by discharging the maximum available power in the batteries while at the same time switching from geothermal heat pumps to district heating.

It was assumed that all the heat power delivered by the geothermal heat pumps could have been replaced by district heating, at any time.

2.3.10.3 KPI: Increased thermal system flexibility for energy players

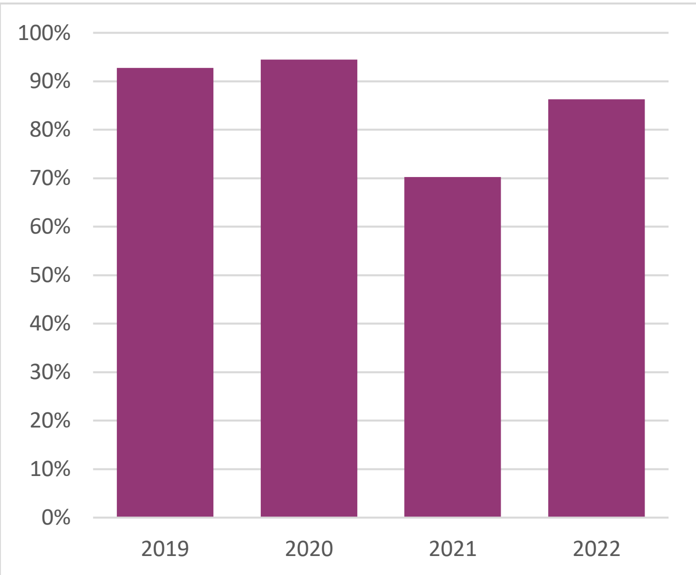


Figure 27. Increased thermal system flexibility for energy players, yearly

The thermal flexibility was increased by 67-95%. These values were obtained by dividing the peak power heat delivered by the geothermal heat pumps by the total heat power demand. (Figure 26)

This means that the delivered district heat grid power could have been reduced by this percentage while supplying Viva's heating demand from heat pumps instead.

During some of the colder days of the monitoring period or when one or more of the geothermal heat pumps were out of service, the geothermal heat pumps could not meet Viva's heating demand.

Furthermore, additional heat pumps, complements the geothermal heat pumps to make hot tap water. These heat pumps could not be replaced by the district heating.

2.3.10.4 KPI: Peak load reduction

The "Peak power baseline" is simply the curve for power consumption, and the "Peak power" shows the actual electrical power input from the grid (Figure 27). The "Peak load reduction" is the difference between the curves divided by the curve for power consumption (Figure 28).

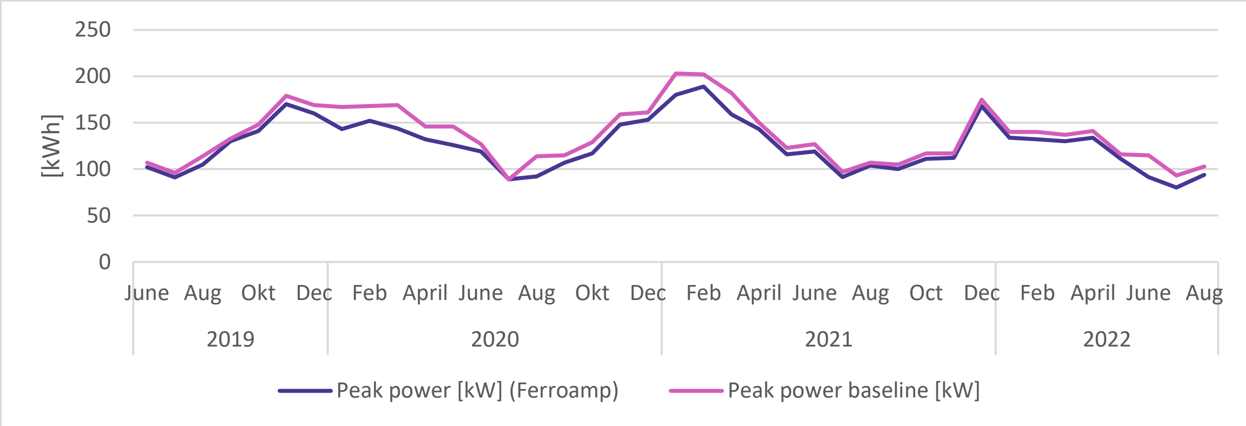


Figure 28. Peak power, actual and baseline

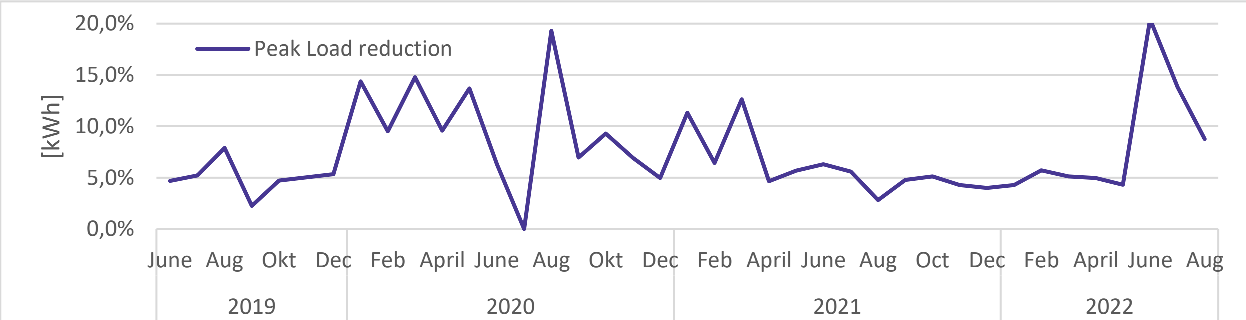


Figure 29. Peak load reduction

It appears that the battery storage's default settings reduced peak power more than the algorithm of the EMS, as reducing peak power was not the primary objective of the EMS.

2.3.10.5 Stakeholder experience from Gothenburg Energy point of view

The aim in the project was to learn about the control of building energy systems. In the project, a solution has been developed that is able to optimise the operation of electric batteries, heat pumps and district heating plants. The software is also capable of predicting solar production, heating and electricity demand using machine learning algorithms.

The main purpose of developing the control algorithm was to demonstrate how and if it is possible to control a property like Brf Viva. The control algorithm is designed to minimise a cost function that was developed to correspond to Viva's variable energy costs linked to its main power connection. The district heating price is based on Göteborg Energi's price list. The electricity price is based on Nord Pool's spot prices for the price area SE3 with surcharges for taxes and fees. The cost function can be formulated as:

$$\min \sum_{t} DH_{consumtion}(t) \times DH_{price}(t) + EL_{consumtion}(t) \times EL_{price,import}(t) - EL_{export}(t) \times EL_{price,export}(t)$$

Based on the optimisation, the model then recommends how much power should be supplied from district heating and heat pumps, respectively, and how the batteries should be run. This is then sent as an operating proposal to the Nordomatics Control Portal. For the batteries, the signal is then sent to the Ferroamp system with one of three signals: charge the batteries with the suggested power, discharge the batteries with the suggested power, or put the batteries in auto mode (e.g. to optimize self-consumption of solar).

Four battery control scenarios were developed and implemented:

1. Maximization of self-generation
   The solar energy that was not used in the internal plant was stored in the batteries. When demand exceeded production, the batteries discharged to cover the demand.
2. Time shifting
   Electricity was purchased at a cheaper time to charge the battery and then used when electricity was more expensive. In this way, power was shifted, and costs were reduced.
3. Planned discharge
   meant saving the electricity in the battery for when the electricity price was more expensive even if there was a need to discharge earlier
4. Heat source selection
   It was sometimes more profitable to use the batteries for heat production and sometimes more profitable to use district heating instead and use the batteries for the other electricity use

The model thus only considers energy costs, but not any power-related costs. For future installations, power-related costs should be included as they were found to have a larger impact on costs than initially estimated.

When would this type of management be interesting in the future from a utility's perspective?

Viva has an unusual installed base of both district heating and heat pumps, and this has allowed it to have several different operating cases, for example generating heat from district heating only or heat pumps only. If the system is not built with such a high level of redundancy, the options for different operating cases are reduced.

From a systems perspective, there is great potential in smart control of buildings that optimises for timely use of energy, e.g. when there is a surplus in the systems, or by balancing peak loads. Achieving system benefits requires a critical mass of installations. With a critical mass, the system can run more efficiently by using transmission capacities more evenly and avoiding running expensive peak load boilers to accommodate peak loads. This reduces the cost of operating and reinvesting in the system, which can deliver cheaper energy to end users and increased environmental benefits.

2.3.10.6 Conclusions on this measure

- There were issues with communication through multiple interfaces, which limited the extent of possible control. Troubleshooting required many parties involved.
- A simplified and static approximation of the installations' performance, complexity and interaction led to sub-optimal control decisions by the EMS.
- What the algorithm controlled towards in financial terms was not on a par with the price model and the contracts that formed the basis of the energy costs. The most significant factor was that the optimization/control did not take peak power costs into account, which had a greater impact than expected.

2.3.11 Summary of results on the joint KPIs for the Transition Track

Measurement	Definition	Unit	Target	Result	Related building/measures
Sub-district energy consumption	Consumed (bought and produced) energy by the buildings minus electricity consumption by the residents, per heated area.	kWh/ m2/a	<24	48-65	Viva / M1.1 – M1.6
Peak power shaving	Reduction in peak power compared to control.	%	>80	8-37	AWL / M2.1
Net energy surplus	Produced and sold energy minus consumed (bought and produced) energy by the buildings, electricity consumption by the residents not included.	MWh/ a	>10	No surplus (-373)-(-589)	Viva / M1.1, M1.2, M1.3, M1.5.
Energy savings	Energy savings compared to average Swedish buildings. BBR21	kWh/ m2/a	67	Heated with other than electricity: 34-53 Electricity heated: (-0,8)-18	Viva / M1.1, M1.2, M1.3, M1.5.
Integrated PV power		kW	420	387,5	Viva / M1.1 HSB living lab / M1.7 AWL / M2.1

2.4 Business models and exploitation

2.4.1 HSB: Living Lab

As discussed above the business model for PVs is connected to energy cost, the building energy use and possible revenue from selling over production of solar energy to the net. With the price model for electricity as of today in Sweden a building owner may get a revenue per sold kWh of solar energy that is 1/3 to ¼ of the cost when buying a kWh from the net. Note that this was during typical circumstances and not with a more fluctuating market with high prices as has been the case during 2022.

A typical housing co-operative is not likely to want to become a producer of solar energy more than to cover its own demand. Becoming a major producer can lead to more administration and a more complex technical installation. HSB mainly consists of housing co-operatives which means that in most cases it is not attractive to increase the requirements for administration and maintaining technical installations.

For larger building owners the same principle regarding business model applies. For residential buildings a regular PV installation is most likely to be more cost efficient, produce more electricity per m2 of panel and cover the needs for the building.

In order to create an attractive business model for façade integrated PVs, there needs to be either a higher demand for electricity in the building or a change in cost and revenue when selling locally produced electricity on the market.

A decision to install these PVs can also be from a standpoint of sustainability, working towards reducing climate impact and brand recognition. However, these are not directly related to economy or a business model.

2.4.2 BRF Viva

- All new development from Riksbyggen, all new housing buildings, are expected to have PVs now. This was not the case when Viva was being planned, and although many other tests and demonstrators have shown the operability of PVs, Viva was a project that many in leading positions in Riksbyggen followed closely, thereby learning a lot.
- The evaluation of the concept of second life batteries from electrical buses as energy storage in Viva is ongoing. Business models of the value chain from battery supplier to the end user to the recycling are developed together with key stakeholders (**Fout! Verwijzingsbron niet gevonden.**) and one specific model is used in the demo. Together with this a pre-study has been made for a further developed concept planned to be replicated in at least one other housing association in Gothenburg, one existing building that is retrofitting its roof and one new development. The further developed concept includes frequency regulation at two different Swedish markets (one that didn´t exist when IRIS started). Another improvement to reach bankability is a standardized container for the batteries instead of a permanent installation to reduce the investment cost and increase the flexibility. The concept is predicted to reach the market in 2-4 years when the volume of second life batteries is sufficient. The ongoing electrification of several sectors together with the increased share of renewables is also expected to increase the profit of the concept in the coming years.

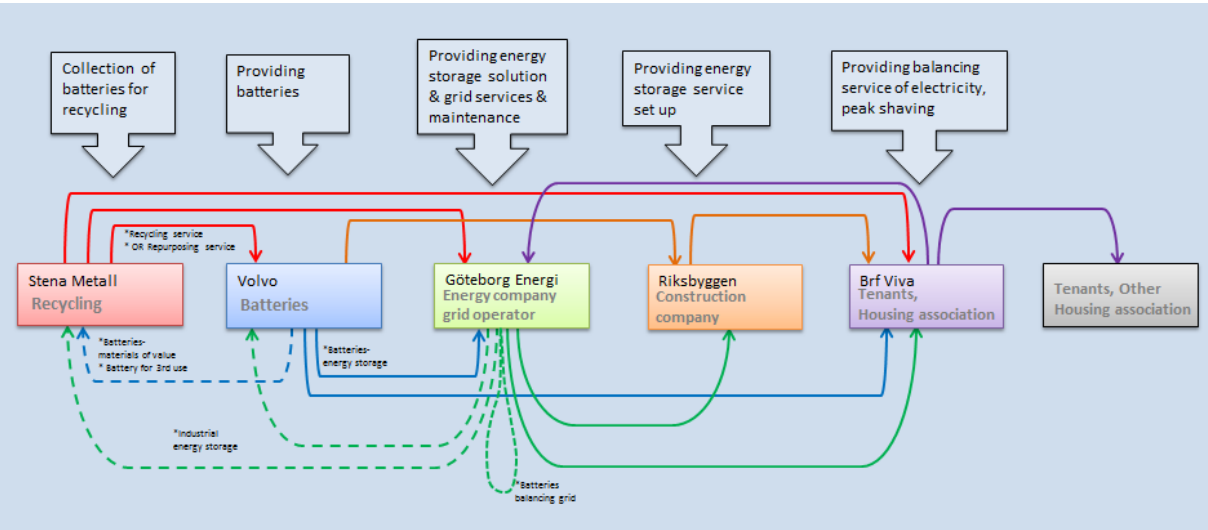


Figure 30. Relations between organisations and services, relating to the second life bus batteries.

2.5 Lessons learned

2.5.1 HSB: Living Lab

The demonstration project in HSB Living Lab has shown that it is technically feasible to install façade integrated PVs on an existing building and that the technology works. Even though there are still few installations and limited data regarding operational costs the indication is that there are no technological question marks for this type of solution. Nor have there been any indications that it will lead to higher maintenance costs than a normal PV installation. Additionally, it has been shown that this can be a sustainable solution with a large potential for increasing the amount of electricity produced by a building.

But as of now the conditions are not really there for large scale implementation of façade integrated PVs on residential buildings from a purely economic standpoint. This is further hindered by a limited market with suppliers and a difficulty in finding entrepreneurs to perform the work.

There are several trends that may change the conditions and lead to a higher demand and better profitability for façade integrated PVs:

- Higher demand for electricity – e.g due to electric vehicles and charging stations
- Higher prices for electricity
- Higher demand and requirements for sustainable electric energy production

All these trends increase the potential for PVs in general as well as for façade integrated panels.

2.5.2 Viva

The demonstrations in Viva have had their successes and setbacks. All the demonstrators were launched and have shown technical feasibility, a sort of proofs-of-concept as regards to the more novel systems. Although a project of this size and complexity comes with a large collection of conclusions, experiences, and lessons learned, some are more relevant to highlight than others. The principal lessons have here been gathered and grouped, which in some way permeates all demonstrators.

2.5.2.1 Keep your friends close, but your collaborators outside the project closer

There are many benefits to participating in a large demonstration project like IRIS. Besides the improved access to technical know-how, help with monitoring and evaluation, and direct funds to complete more installations and consult more experts, the participation unites the project partners around a common goal and a common delivery. For, even when all partners agree on the intention of completing a given demonstration, the late stages of an innovative work can challenge the individual patience. When an early assumption turns out to have been a mistake, or a component that should be reliable keeps faltering, it is sometimes tempting to cancel the whole work. Then, an agreement with a financer can work as a good motivator and keep the determination up.

This only applies to the partners in the project. Not everyone who was important for the demonstrators in this Transition Track have been partners in the project, which has been challenging. For example:

- The owner of the building CTP was not a project partner. So, when the early cost assessment for the seasonal energy trading turned out to have been optimistic, there were few reasons for them to take on additional costs or risks. This is entirely understandable from their point of view. It did however cause some difficulties for Riksbyggen, having committed to deliver to the Horizon program while being fully dependant on CTP to being able to complete the installations.

For another project, there should be a close scrutiny on what parties have major influence on the ability to complete a demonstration, and actions to either include them in the project or make strong agreements with them separately.
- The pipes with cooling water that connect the two buildings for seasonal trading (Viva and CTP) are situated in the ground owned by the municipality. This results, in this case, in a short term guaranteed lease period. This is a drawback since it brings an uncertainty to the service life of the demonstrator.
- Fire safety regulations were not up to date for systems with reuse of automotive batteries. The dialogue with fire department was reactive, not proactive. Ideally, an actor of this importance should have been a cooperation partner.

Even between the project partners, it is important to work with finding forms for collaboration and distribution of responsibilities. Some of the things that came into play for the work presented in this report were these points:

- The coordination between actors and distribution of responsibilities could have been better defined, and the need for collaboration between parties in the early stages was somewhat underestimated. For example, the role distribution for the continuous monitoring and the alarm management of the batteries was insufficient, resulting in discontinuous operations for parts of the system. It would for a future case be beneficial to have a support organization for these types of installations that has ability, tools and IP rights to replace parts and make updates or repairs of the batteries. Even exchanging single modules of the batteries, since the ageing of the individual modules might differ.
- Göteborg Energi and Volvo joined the battery installation project late, and therefore could not contribute with their preconditions in the very first stage.
- The differing interests and perspectives from the actors that together form an energy system. This resulted in different views of how to optimize the energy monitoring system and differing ideas of which rules and variables should be allowed to manage the energy system. “Good” meant different things for the different actors.

2.5.2.2 Issues of software communication and compatibility

The innovative demonstrators in Viva are partly of a software nature, meaning that they are the result of programming. And programming always happens in a specific language, out of the many hundreds of coding languages in use. An unexpectedly large issue in the IRIS-work has been making these languages talk with each other. The extent of this issue is that these problems with translation are considered the main reason for the problems noted in the operation of the batteries, and a large contributor to the EMS not being launched sooner.

For the batteries, this related to the integration between the Volvo's control system in the batteries and the control system in Viva. Dedicated code was sent to the batteries, partly to facilitate communications between the systems. It worked for a while, then a reset of a sub-system disregard said code, and communications in the system broke down, ultimately leading to many of the batteries being discharged to levels they could not recuperate from.

- A maintenance charging strategy would help ensure higher minimum battery charge levels, and programming of the batteries during their initial manufacture for their anticipated second life would help to ensure compatibility.
- To obtain the desired evaluation results, it is important to have continuous, fine-resolution operation monitoring and to promptly respond to any alarms that arise. For future attempts, it is

recommended to establish that degradation characterization can be implemented directly in the control program at the installation of the facility.

For the EMS, this came into play as it turned out to be challenging but possible to communicate through multi-layered interfaces between the technical layers of the batteries, proved surprisingly difficult to integrate. One obstacle that the project had to deal with was the extensive integration work required between the control system, decision-making algorithm, Nordomatic's control portal, and the Ferroamp system that controls the batteries. These integrations had to be developed during the project, and the unexpected amount of time required for this work resulted in a significant delay in the launch of the EMS.

2.5.2.3 Scope and control strategies of the Energy Management System

The EMS is a system that was built from the ground up. The main goal of the Management and Optimization project was to prove the technical feasibility of managing a complex installation, as in the case of Viva. The launched version includes district heating, heat pumps, 2nd life batteries and solar panels. The initial plan was to include thermal storage, but the idea was discarded after some consideration, since the size of the hot water storage tanks were designed to secure longevity of the heat pumps. Had the same tanks been used also for thermal inertia, this longevity could have been compromised. Thermal storage of the building's structure was also considered, as well as V2X charging stations; neither were installed due to high costs. The optimization was based on variable energy costs and did not include power tariffs for electricity and district heating.

For future installations, there are several lessons to be learned from Viva linked to the control algorithm.

- It is essential to consider all major cost items in the optimization. In particular, to use the same pricing rules for the optimization as the one that rules the costs.
- Taking grid tariffs which are based on peak power into account is challenging since it relies heavily on forecasts of power demand. The peak power tariff in Gothenburg, which is paid monthly, is based on the maximum power consumption over the past 12 months, which is a long period to consider in a case like this.
- The market for energy system optimization has developed rapidly during the period of the project. Quite possibly, for the next project, it would be worthwhile to scan available control software platforms on the market and spend the allotted time and resources on developing that instead.

3 Final Results of Transition Track 2

KEY MESSAGE

In future energy systems, peak power demands will constitute a large part of operational costs and negative environmental impact. In this transition Track the focus is to how to store energy both electric and thermal cooling energy to reduce the power demand in the energy systems.

In this transition track we focus on demonstration of energy storage in battery systems together with DC systems and energy storage in PCM cooling storage. The location of the demonstrator is shown in Figure 31 and Figure 32.

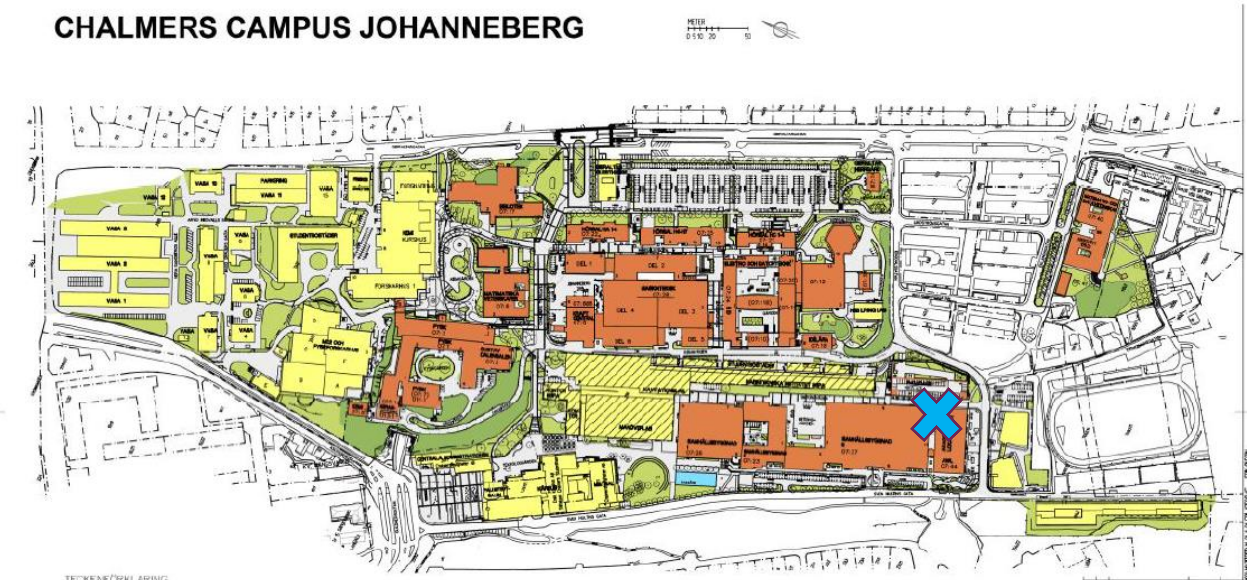


Figure 31 Map of Chalmers campus. Pilot plants located in building AWL (denoted with "X")

Figure 32 Exterior of AWL building on Chalmers campus

3.1 Demonstrator 1: Demonstration of a 760v DC building microgrid utilizing 171 kW rooftop PV installation and 200 kWh battery storage

3.1.1 Overview

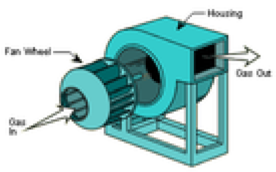
As an attempt to reduce the energy losses in combined solar PV-systems and battery energy storages a DC connected system was proposed. To further reduce conversion stages (and thus electrical losses) between AC and DC quantities, common in multiple appliances within ordinary electrical loads, some loads were connected directly to the DC system. Energy losses were calculated to reduce to 3% and on an annual basis 4 to 10 MWh. Prior to this demonstration, this was not common practice. Hence, in conventional systems solar power would be converted to AC prior to being fed to the electrical loads and the building. In this pilot system however, lighting fixtures and ventilation fans are connected to the DC link instead. This in combination with a DC connected battery allows for an improved usage of the produced solar power within the A Working Lab (AWL) building (Figure 32). Furthermore, the purpose of the pilot system was to;

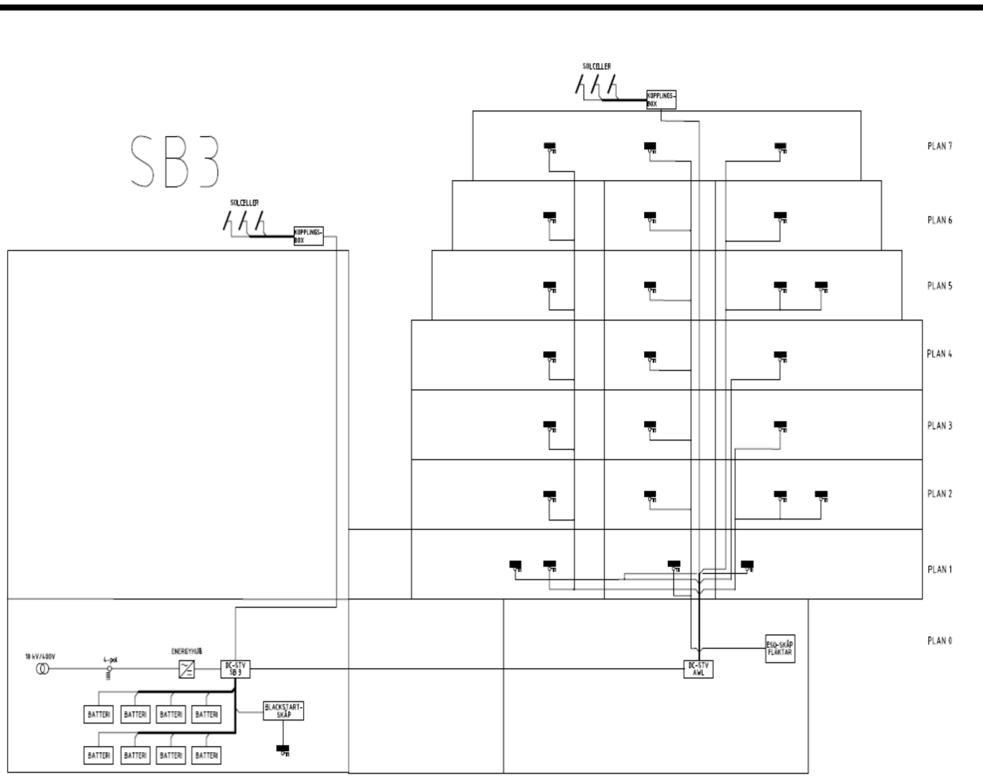
- Contribute to technology development.

- Contribute to line of business' knowledge on DC systems.
- Contribute to research.

A brief description of the DC system can be observed below in Table 8.

Table 9 DC system components and description

	Description
	Main AC/DC converter, responsible for converting power not used by battery or internal DC loads. And to supply loads and battery when no PV power produced.
	177 kWp solar controlled by 32 optimizers sectioned on 2 different roof tops.
	200 kWh/96kW Li-ion battery ($LiFePo_4$) connected to the DC side of the main AC/DC converter to allow for increased self-consumption of PV, peak shaving, and active power support to AC grid.
 	DC connected loads, 1300 lighting fixtures and 20 large ventilation fans in AWL. 20 – 50 kW power consumption depending on temperature, occupancy, and solar irradiance.

	DC switchgear and cable system, running in parallel to an existing AC system.DC connection points on every floor for possible expansion and for DC connected lighting

3.1.2 *Time schedule*

2017 Start of innovation platform for AWL building and decision to bring in the pilot demonstration of a 760V DC building microgrid utilizing 171 kW rooftop PV installation and 200 kW battery storage
2017/2018 Design and development of the system
2018/2019 Building the system
2019/2021 Testing system
2021 In operation and monitoring for KPI
2022 Operation and troubleshooting

3.1.3 *Implementations*

The system was constructed by Akademiska Hus, where information and knowledge were shared during the construction in a dedicated project group, called the DC group. This group contained representatives from Akademiska Hus, Research Institutes of Sweden (RISE), Ramboll, AFRY, SP-gruppen.
The different parties had various tasks closest to their competence area, some listed below in Table 10.

Table 10 Distribution of tasks in the PV/DC team

DC group members		
Company	**Type of actor**	**Tasks**

Akademiska hus	Real-estate owner	Project lead and project owner, coordinator, meeting leader, main contact towards the company.
SP-Gruppen	Electrical installation	Responsible for electrical installations, project managers of the build, assistance on PV-installation and quotes from providers during procurement writing.
Research Institutes of Sweden (RISE)	Research institute	Expert assignments, sizing of energy storage, loss estimation, power electronics, DC systems, detailed vendor contacts regarding DC systems, research projects, master thesis workers, system modelling, technical questions during procurement proceedings.
Ramboll	Electrical consultants	System electrical schematics, protection and fuses, electrical layout.
ÅF (now AFRY)	Energy consultants	PV generation modelling, load modelling, building certification, innovative ideas, procurement writing.

3.1.4 Results

The energy storage has two different modes of operation, preferably during wintertime the battery could be used to cut peaks in grid consumption. Whilst during summertime, the abundance of solar power suggests a control method for improving the self-consumption of solar should be used. It was noted that if the self-consumption of solar was used during winter, the battery stayed at its minimum state-of-charge since it would only be charged when the solar was higher than the load of the system.

Two examples are provided for the various controls, different years but same time period. This to indicate the two different modes of operation.

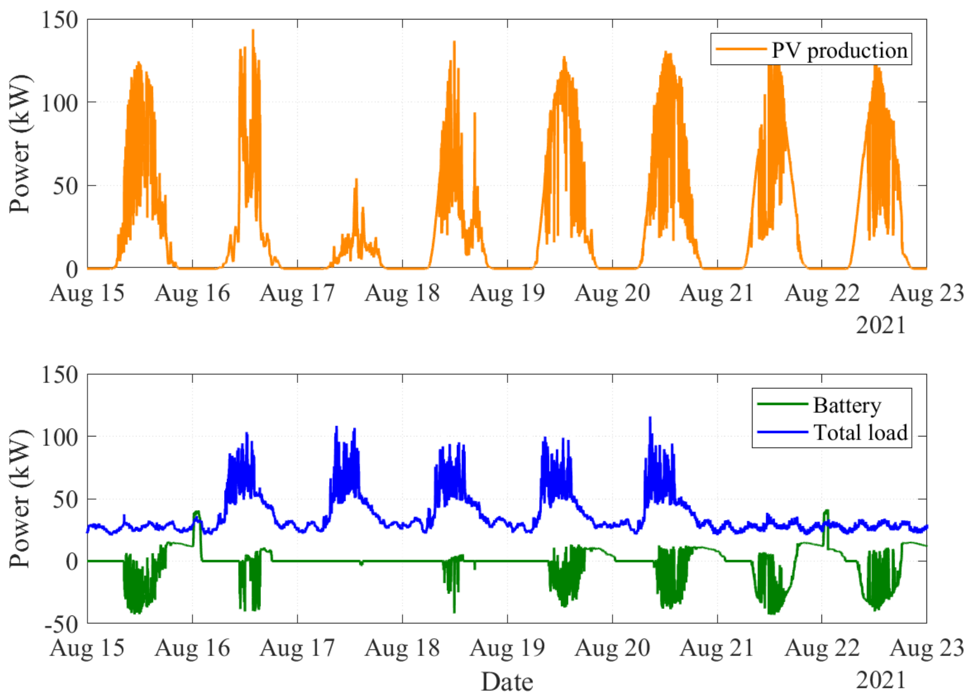


Figure 33 Battery usage during the self-consumption of solar control method during late summer of 2021.

From Figure 33 it can be observed that the battery charges during the days (negative battery power) and discharges once the sunlight has disappeared from the roof. Further tests have been made considering cut of power peaks in the system.

From Figure 34 it can be seen that the battery charges during the night and is used considerably more often and in various directions. The limits of when to charge and discharge were complicated to set, this resulted in some occasional discharges during night-time as well. Erroneous discharge can be seen for example during the night of the 21/8-2022.

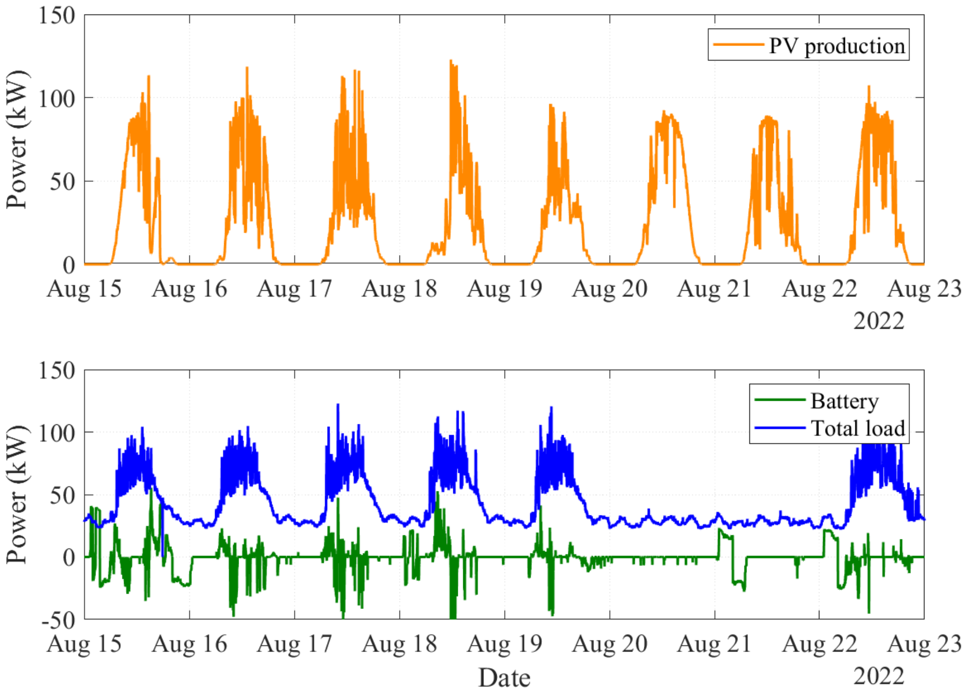


Figure 34 Battery usage during the peak reduction control method during the late summer of 2022

Finally, it was concluded that a clever method for switching between the two various control modes is needed as well as a proper setting for discharge and charge boundaries.

At blackouts in the campus system the AWL DC system can't start up automatically. The problem is that the lighting load is too high when starting up. Today lighting groups are manually disconnected to get lower power demand at start-up. During 2022/2023 we will build a new starting system to avoid the problem.

We have problems with understanding some of the equipment such as power electronics. The operating staff is depending on support from the suppliers of the parts. We need to learn more.

Figure 35 shows results for KPI10: Degree of energy self-supply by RES. The target was 10 % and the result was significantly better due to increased solar cells. For 2020 there is only data for the last two months included and for 2022 only the nine first months.

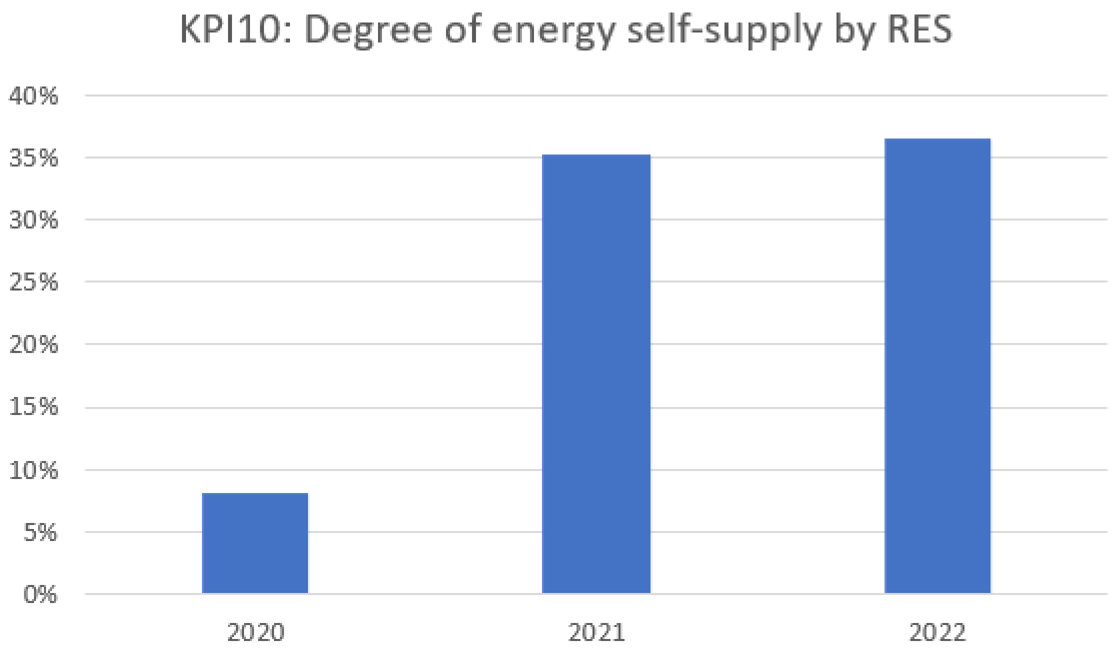


Figure 35 Results for KPI10: Degree of energy self-supply by RES. Target was 10 % and the result was significantly better due to increased solar cells. For 2020 there is only data for the last two months included and for 2022 only the nine first months.

Figure 36 shows results for KPI31: Peak load reduction. The target was 80%. For 2020 there is only data for the last two months included and for 2022 only the nine first months. The difference between 2021 and 2022 is that the plant has been further optimized and the operating staff learned more about the facility.

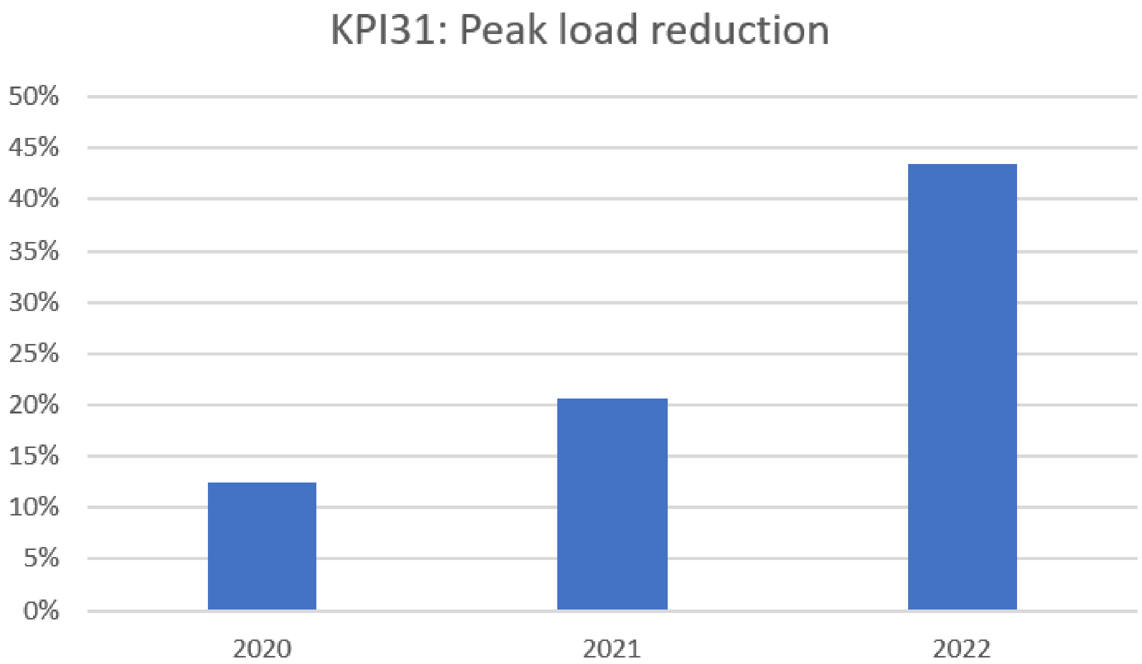


Figure 36 Results for KPI31: Peak load reduction. Target was 80%. For 2020 there is only data for the last two months included and for 2022 only the nine first months. The difference between 2021 and 2022 is that the plant has been further optimized.

Figure 37 shows the parameters used to establish KPI31: Peak load reduction. During June 2022 the ventilation operated harder for cooling the building, therefore the peak power baseline is higher than usual.

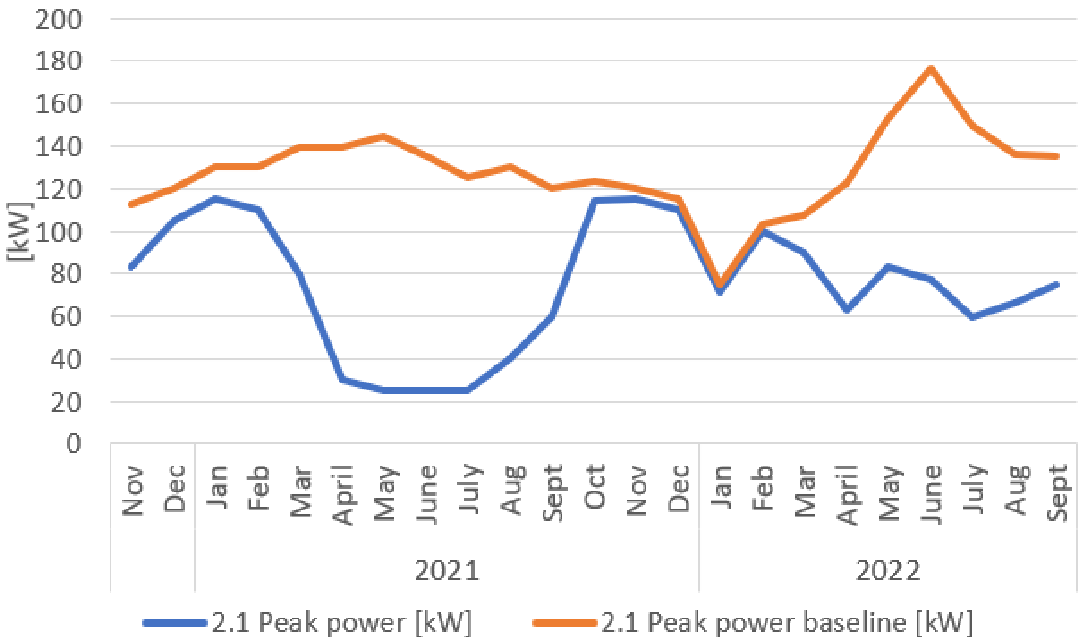


Figure 37 Parameters used to establish KPI31: Peak load reduction. During June 2022 the ventilation operated harder for cooling the building, therefore the peak power baseline is higher than usual

Figure 38 shows results for KPI42: storage capacity installed. The target was 200kWh.

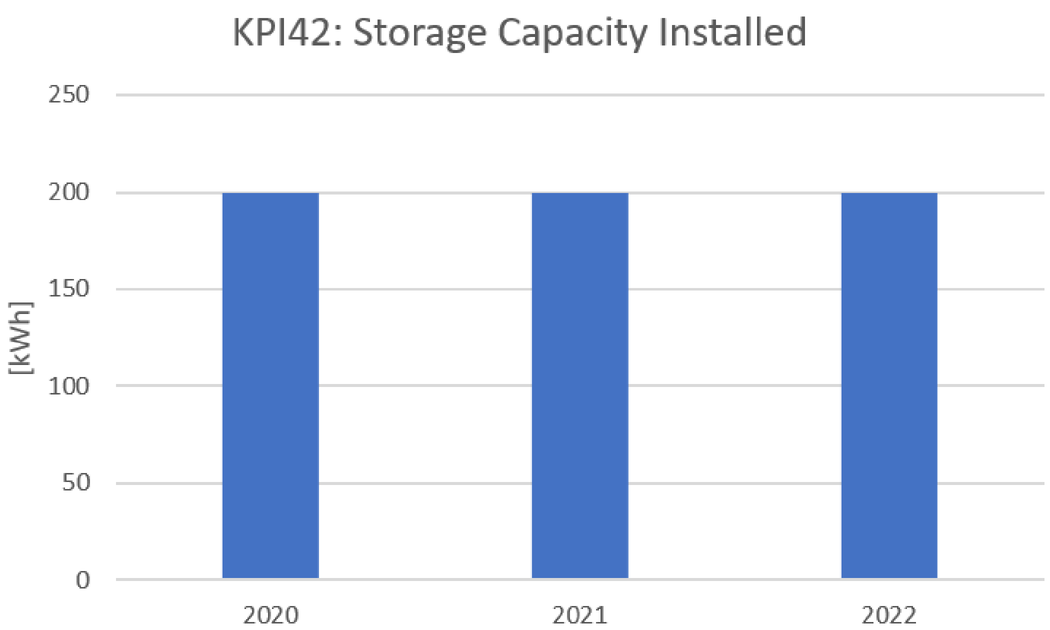


Figure 38 Results for KPI42: storage capacity installed. The target was 200kWh.

3.1.5 Business models and exploitation

3.1.5.1 Barriers

As always with new technology, there is a level of uncertainty. Some solutions may prove more difficult than planned and results may not be as expected.

There is a barrier in the work finding the right ways for the DC/PV (solar cells) and battery storage constructions. It’s also hard to obtain reference facilities that can provide support in the design. Under the project period, the development of dc and battery system has been intense. Problems with several electrical components, such as electric heating element for hot water, have caused these to be disconnected. Another problem is to find DC fans on the market. It has taken a long time because of the difficulties to get the supplier to bring in the DC product in their production. It is a problem to find DC products that normally is driven by AC. The control system for controlling battery, solar cell and dc systems has taken time to get in place. Problems with control signal interference have made installations difficult.

3.1.5.2 Market – Target market

The market is the global market for DC systems. In Sweden and at Akademiska Hus the DC products can be proposed in future renovations and new constructions within Akademiska Hus project portfolio.

3.1.5.3 Market – Competitors

To reach the market is rather difficult. There are many systems that are already optimized, and the building sector is difficult to adapt to new developments. Suppliers are in the process of launching many different technical solutions.

Likewise, one must prove to the buyers that it works. Suppliers must have more pilot test and can then scale the data. However, there are very few DC systems in operation that have good monitoring. Therefore, data of the Chalmers IRIS DC system is important and show/communicate the solutions.

Akademiska Hus’s business model is to rent out appropriate premises to their tenants, (higher education institutes) in Sweden. This includes proving the building with efficient energy systems. These systems can also act as test equipment for Akademiska Hus’s customers. The DC project is a good example of this.

3.1.5.4 DC systems strengths compared to similar solutions

The DC system strengths compared to normal AC systems are the better efficiency between PV and battery system and also to DC products. On the other hand, the DC system is significantly more expansive today. If the market for DC systems and components grows in the future the costs will go down. AC system will always be there, but DC systems will probably be competitive.

3.1.6 Lessons learned and next steps

Lessons Learned are summarised in Table 11.

Table 11 Learnings and issues from the DC system in AWL

Learnings and issues	
DC project group	Extreme spread of competences that meet in this type of one-off development project with high complexity are hard to manage.
Lack of standards	AC systems has a lot of standards that does not necessarily translate to DC systems.
Find the right people	It is sometimes hard to find the right person within a company in innovative projects, the DC project group found most use of the R&D units within various companies. Sales staff could say yes and no to questions with little or no knowledge supporting it. This could imply that a supplier left a positive reply whether their component would be suitable, but in the end retract that statement and a new product had to be found.
The procurement of energy storage	How to compare different storage solutions, cycle life, price, capacity, usable range, internal losses, safety etc. The project group proposed several metrics for the providers to supply, as an example lifetime during different C-rates (How fast the battery is charged or discharged) to be able to compare the systems. This was still not easy process.
High DC system voltage	The chosen DC voltage by the provider of the AC/DC converter was 380/760 VDC which seemed to be slightly too high for some manufacturers. Perhaps better system design could be reached with lower DC levels.
Technical issues	Issues related to Black start of the DC system; the system needs to be energized prior to the connection of the DC loads. Thus, a DC ready signal was developed that was sent to the DC loads. This signal then told the load if it was allowed to start up or not. DC Balancing of the 380 VDC system to avoid power unbalance on the AC side; this was made by external circuitry and planning by the 380 VDC loads (lighting loads) to install them in a clever way, not to overload either of the two 360 VDC systems. Such an overload would breach the 1% imbalance requirement set on the AC/DC converter by electrical guidelines. At blackouts in the campus system the AWL DC system can't start up automatic. The problem is that the lighting load is too high when starting up. Today we most manually take out lighting groups to get lower power upstart. Under 2022/2023 we will build a new starting system to avoid the problem.
Unable to remove rectifying stage	Most components had a DC rectifying stage (in order to be used in conventional AC system) that could not be removed. Efficiency improvements were still made, due to higher voltage, but would have been increased if these DC rectifying stages were removed.

3.2 Demonstrator 2: A 200 kWh PCM (Phase Change Material) cooling system

This demonstrator contributes with new knowledge about practical design and real performance of PCM-cold storage. The overall goal of the project was to secure and verify design tools and data to identify a cost-effective and environmentally sound solution of a PCM-TES. A novel, full-scale PCM-cold storage with a phase transition temperature of approximately 11°C has been designed for this purpose and put in use in the AWL-building. For deeper analyses, a smaller (pilot) cold storage tank has been designed for laboratory investigations. Since 2019, storage capacity, power output and utilization rates based on field and laboratory investigations have been systematically studied and presented to various stakeholders, including real-estate owners, HVAC designers, PCM producers, and public. Routines for planning and optimization of charging and discharging cycles have been also developed. Based on the findings, new design process and key performance criteria (KPI) for PCM-TES have been suggested. This report provides insights in the main work tasks and results.

3.2.1 Overview

In today's thermal energy systems, peak power demands stand for a large part of operation costs and negative environmental impact. Various measures can be applied to decrease, or 'shave' peak loads, and thermal energy storage (TES) is one of them. Commonly, TES are classified based on physical principles behind the heat storage, which are sensible, latent, and thermochemical. Among these, sensible TES such as water accumulator tanks and ground heat storage are the most common solutions in the heating systems for buildings. After a period of varying interest, latent TES with phase change materials (PCM) have come into the focus because of stricter climate targets and technological developments. Due to a complex technology and high costs, thermochemical TES are yet to emerge for building heating applications.

Thermal energy storage with phase change materials (PCM-TES) are more space-efficient for storing cooling energy above 0°C than traditional water-based TES. During melting and solidification, a large amount of energy is released or stored in a PCM while its temperature changes for about several degrees. In theory, the water-based TES would need to be several times larger than the PCM-TES to store the same amount of energy, within the same temperature range.

When a new building is connected to an existing cooling system, it is generally needed to add new cooling capacity. But if the existing cooling system can produce sufficient cooling when the demand is low, the surplus can be stored in a TES and used during high demand periods. The advantage is also a reduced peak power output.

The expansion of Chalmers Campus Johanneberg area with new buildings will contribute to an increase of power and energy demand in the area. Future energy systems and power loads will be a major part of the energy costs. Reducing power demand is one of the measures to achieve energy-efficient buildings.
The purpose of the PCM Cold Storage connected to AWL building is to reduce the peak cooling power demand in the building and, thereby, to avoid new investments in the cooling machinery and high costs for peak power production. Because of a small temperature span for charging and discharging of the cooling energy (2°C), the TES is designed with a PCM rather than with water.

Despite a large interest for PCM-TES in the research community, just a few PCM cold storage systems can be found in real operation. Therefore, a pilot PCM-cold storage has been developed to allow detailed studies on heat transfer processes between PCM and water (heat carrier).

In this demonstration the energy efficiency of the PCM-TES was measured under realistic operation conditions. The efficiency was measured in terms of energy storage capacities, heat loses and investment costs, by having a cooing machine as a reference. The market for PCM product is small today. Therefore, through this demonstration it was tested how the market can deliver needed products and services, and how much effort it takes.

Time schedule

2017 Start of innovation platform for AWL building and decision to bring in the pilot demonstration of a PCM cooling storage pilot plant

2017/2018 Design and development of the system

2018/2019 Building the system

2019/2021 Testing system and rebuilds

2021 In operation and KPI measurement

2022 Development better PCM material.

2023 New PCM material will be tested

3.2.2 Implementation

The main drivers for the project implementation were the concept of AWL building as an innovation arena and the innovation-oriented research about PCM-TES at Chalmers. The decision about the innovation track has been made in 2016 by Akademiska Hus in Gothenburg.

During 2017, different solutions for the PCM and of the tank design were explored. The final design of the PCM-TES was adopted in October 2017 and project planning documents were made. Construction, installation and running tests were conducted during 2018. From the spring 2021, the full-scale PCM-TES has been in operation.

In parallel, close contacts with German Rubitherm, a manufacturer of the PCM material used in the cooling energy storage in the AWL building were held.

Pilot PCM-TES

The pilot PCM-TES (Figure 39) is installed in the laboratory of the Division of Building Technology at Chalmers (building SB-II) to replicate the full-scale PCM-TES in AWL building. It comprises a transparent container of plexiglass (560 x 560 x 800 mm), heat exchanger, PCM and water as a heat transfer fluid (HTF). The tank is filled with 168 kg salt hydrate with the product name SP11 (Rubitherm), which has the phase transition temperature around 11 °C. The calculated heat storage capacity for this amount of SP11 is 4.92 kWh. The heat exchanger is immersed in the PCM and consists of narrow polypropylene tubes arranged in 18 mats. Each mat has 44 vertical capillary tubes, whereof each 2 are connected in a U-shaped channel. Water circulates through the heat exchanger by means of pumps.

The centre-to-centre distance (cc distance) between the tubes in a mat is 10 mm to ensure a thin layer of the PCM around each pipe and an efficient use of the PCM. The distance between the mats is larger, 25 mm, due to the collector pipes. The heat exchanger concept is commercially available under the product name SP.ICE (BEKA).

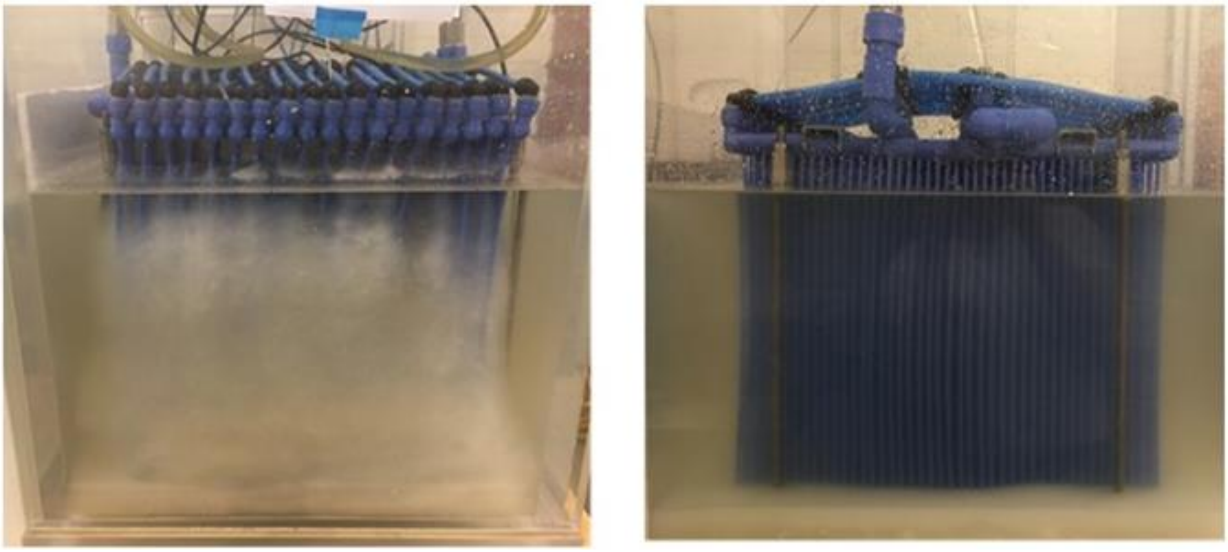


Figure 39 Pilot PCM-TES in the laboratory of the Division of Building Technology, Chalmers. Charged and discharged tank.

Table 12 Pilot PCM-TES – geometry of the tank and properties of PCM

Parameter	Values	Comments
M	168 kg	Mass of PCM in the tank
V	125,37 L	Volume of PCM in the tank
ρ	1340 kg/m^3	Density of PCM at 20 °C, based on the producer
Temp.	11 °C	Phase change temperature, based on the producer
	25 mm	center-to-center distance between mats
	10 mm	center-to-center-distance between tubes in a mat
	792	Total number of tubes. Each 2 tubes are U-coupled
	18	Total number of mats
	10.5 L	External volume of mats in contact with PCM
VTESVTES	135,87 L	Inner volume of the tank
QmaxQmax	4,92 kWh	Calculated maximum energy storage capacity of the tank
	36,21 kWh/m^3	Energy storage density = QmaxVTESQmaxVTES

Full-scale PCM-TES

The PCM cold storage for AWL building is an upscaled version of the pilot PCM-TES. It has the same phase change material, SP11 (Rubitherm), and the same construction of the heat exchanger. The tank is made of opaque plastic and insulated on the outside.

The tank is placed in the basement of the nearby building called SB-III (Figure 40, Figure 41). It is charged by the Chalmers campus cooling system through line KB0 and discharged to AWL through KB01 pipe system. Temperature in KB0 system during loading is 8 °C. Discharging from the PCM is done at 14 C to return pipe KB01 before aftercooling with KB0. The return temperatures in KB01 are 18 °C and the supply temperature to AWL building are 12C. Schematics can be seen in Figure 42.

The installed energy storage capacity is 275 kWh according to the PCM manufacturer. After a phase separation of SP11 has been observed during laboratory tests, 3 percent of the superabsorbent polymer (SAP) sodium polyacrylate (FAVOR PAC) was added as a thickener to the PCM, by the PCM supplier.

Figure 40 AWL-building on the Chalmers campus Johanneberg and the PCM-cold storage

Figure 41 A photo showing AWL and SB 3 (located behind AWL) building were the PCM plant is located

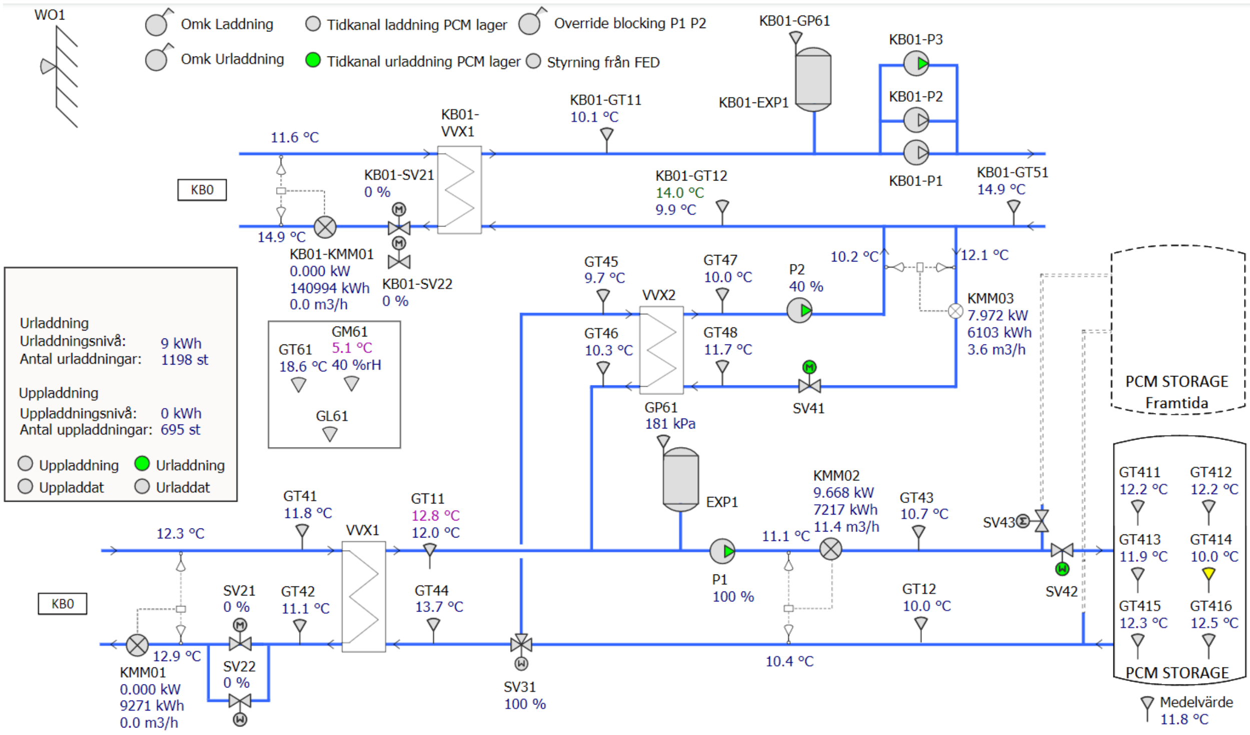


Figure 42 Coupling and control scheme for PCM-TES in relation to the AWL building and the local district cooling network. Operating parameters are taken on March 20, 2021

The control system of PCM-TES can be accessed remotely by technical personnel at AWL and by Chalmers researchers. This allows various experimentations in real-time. For example, routines for optimization of charging and discharging cycles in respect to the predicted cooling load can be tested. Besides, the control system is set up in such a way to allow virtual (cloud) connections to the smart energy network at the campus, which may lead to further innovations linked to the PCM-TES.

Table 13 Dimensions and energy storage capacity of the full-scale PCM-TES in the AWL building

Parameter	Values	Comments
M_{PCM}	9 380 kg	Mass of PCM in the tank
V_{PCM}	7 000 l	Volume of PCM in the tank
n	17 200	Total number of tubes. Each 2 tubes are U-coupled
	481 l	External volume of tubes
	7 862 l	Inner volume of the tank
	2 776 l	Volume of the insulation around the tank
	11 200 l	External volume of the tank
Qmax	275 kWh	Installed energy storage capacity, based on the producer
	50 kW	For 4 hours at 14 C

The full-scale PCM-TES has been in operation since the spring of 2019. The pilot tank was actively used during 2019-2020. Under 2021 to 2022 different testing has been done to reach the capacity. From January 2022 we have not operated the storage and have instead concentrated on developing new PCM material that better fits the Chalmers district cooling system KB0 temperature and gives more capacity.

Several improvements have been made on the full-scale PCM-TES after it has been put in use. Besides the thickener that has been added to the PCM and additional de-airing of the heat exchanger, several adjustments on the automatic control system have been made. Various control tests have been done after each intervention. Some tests were delayed due to the Covid-19 pandemic and the weather conditions (too low cooling load). Since 2020, a PhD student at the Division of Building Technology, is responsible for running the follow-up tests.

As presented in the result section, the declared energy storage capacity and power output from the full-scale PCM-TES have not been reached yet. New development meetings will be held with the material supplier Rubitherm to discuss the remaining issues. These meetings may result in new devices and implementations. The plan today is to have a new PCM material in place in the first half of 2023.

3.2.3 Results

Results of the measurements confirm that the full-scale PCM-TES reduces the cooling demand from the district cooling system. The greatest effects are seen when the discharge starts. As the PCM storage is depleted of energy, the cooling output from the district cooling increases. The discharge lasts for about 5 hours.

However, it turned out that the PCM-TES has a significantly lower charging power and storage capacity than what has been specified by the manufacturer. The installed data is: 275 kWh and 50 kW output in 4 hours. The charging time is limited to 14-18 hours because the PCM-TES operates as a daily storage. During that time only 36 percent of the theoretical storage capacity was charged, i.e., about 100 kWh instead of 275 kWh. The average charging and discharging power levels were 7.1 - 5.5 kW and 19.8 kW, respectively.

The follow-up (KPI) of the PCM plant will be done after changing the PCM material in beginning of 2023 and as mentioned earlier, the plant does not reach the promised power and energy levels. When there is low cooling power load in the cooling system, the power reduction has been up to 9 kW for approx. 5 hours. At high power outputs, the power reduction has been up to 35 kW for short time.

Figure 43 shows results of KPI31: Peak load reduction. For 2020 there is only data for the last two months included and for 2022 only the nine first months. The PCM plant has been closed during 2022 because of development of a new PCM material.

Figure 44 shows parameters used to establish KPI31: Peak load reduction.

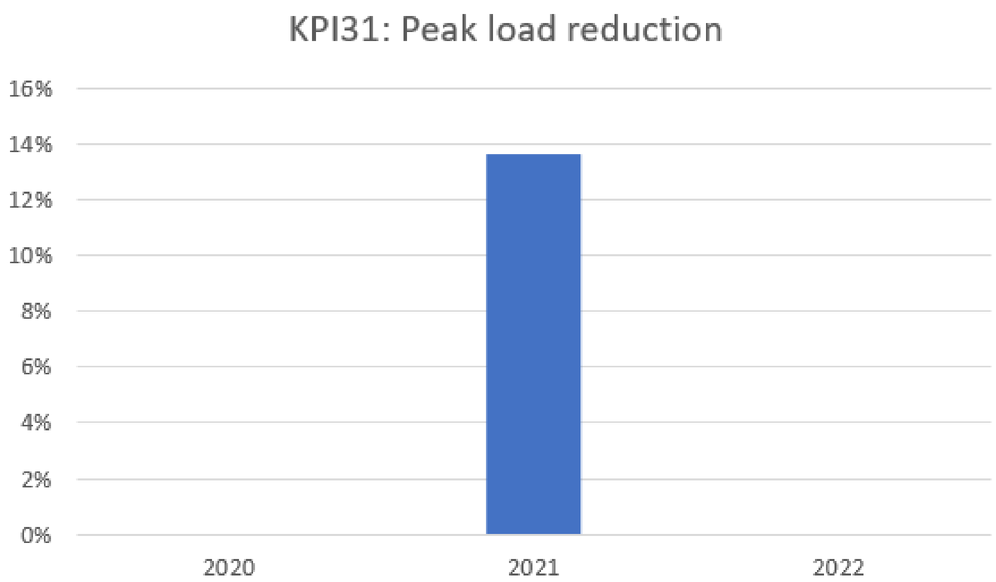


Figure 43 Results of KPI31: Peak load reduction. For 2020 there is only data for the last two months included and for 2022 only the nine first months. The PCM plant has been closed during 2022 because of development of a new PCM material.

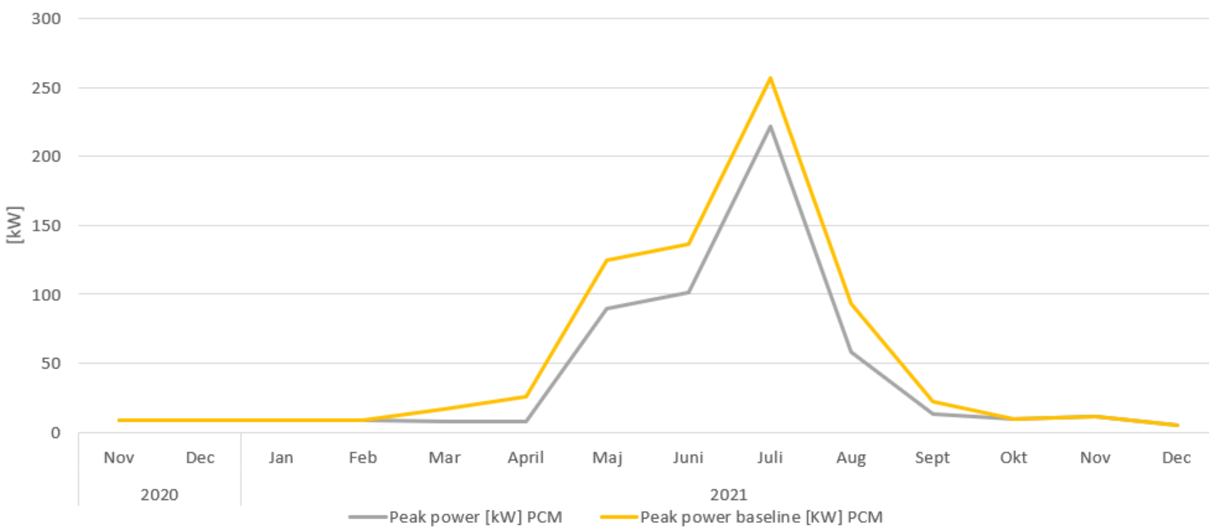


Figure 44 Parameters used to establish KPI31: Peak load reduction

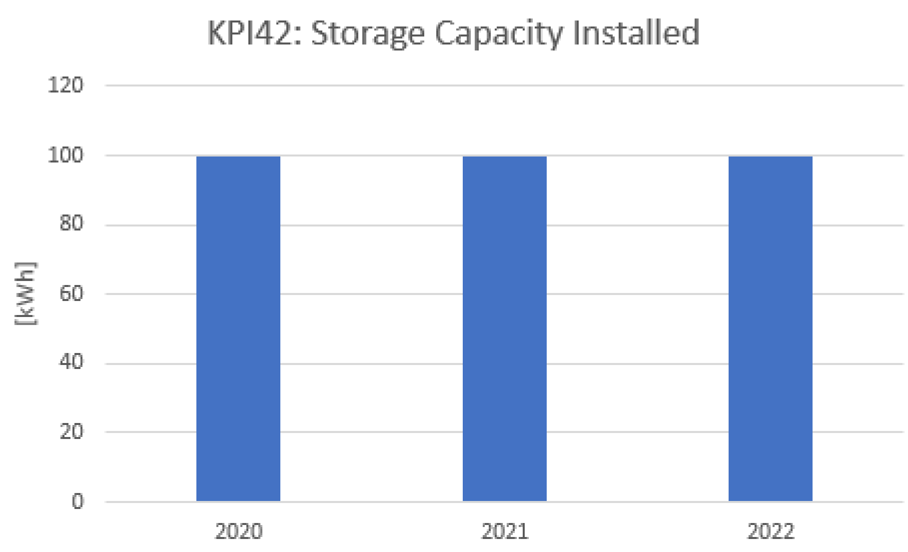


Figure 45 KPI42: Storage capacity installed

Figure 45 shows results of KPI42: Storage capacity installed. The target for step 1 was 200 kWh/50 kW for 4 h, which has not been reached. A new PCM material will be tested in the spring of 2023.

Figure 46 shows results of KPI53: Storage energy losses. During July 2022 there were problems with data, which caused the apparent negative values of energy losses. The losses during 24 hours operation should be significantly lower, approx. 2-3%. The high storage energy losses are due to long storage time >24 h governed by the problems experienced in the facility.

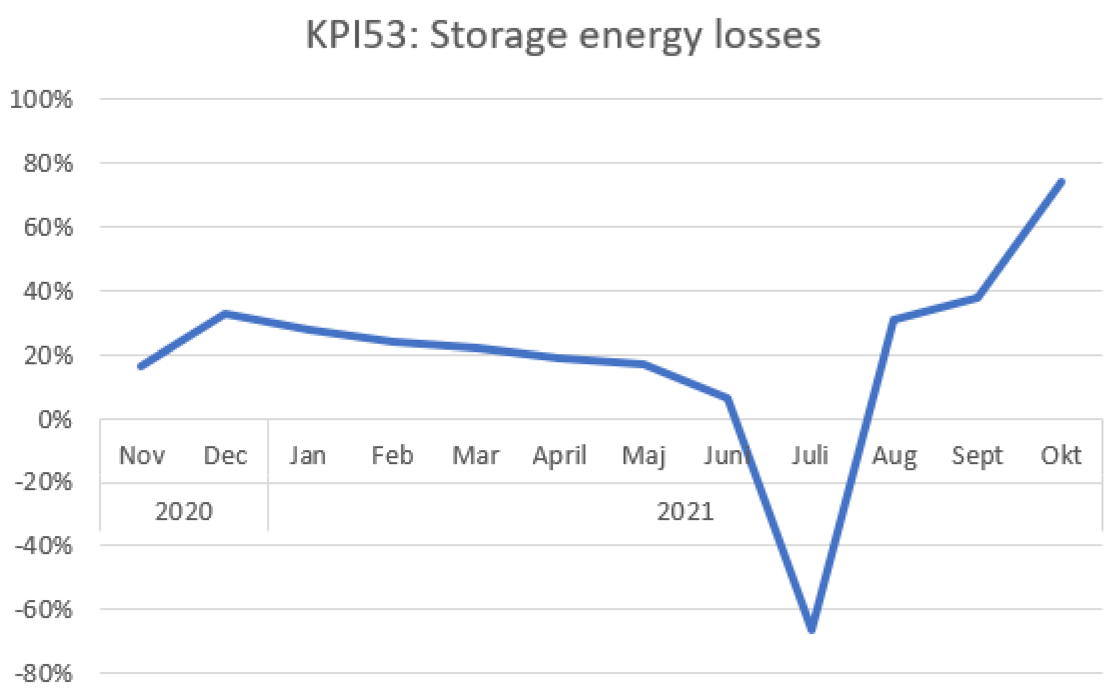


Figure 46 Results of KPI53: Storage energy losses. During July 2022 there were problems with data. The losses during 24 hours' operation should be significantly lower, approx. 2-3%. The high storage energy losses are due to long storage time >24 h governed by the problems experienced in the facility.

At present, it is still unclear why there is such a big difference between the designed and measured energy storage capacity of the PCM-TES. During 2020, various operational tests were performed including adjustment of the circulation pumps and the control system, as well as additional de-airing for the heat exchanger. Minor errors were found and fixed. New capacity tests have been made during spring 2021 to check if the correction measures have improved the energy storage capacity. During 2022 Rubitherm/Chalmers and Akademiska Hus have worked together to find a better PCM material and will change to new PCM material in the spring of 2023. A discussion on the characteristics of different Phase Change Materials can be found in Annex 2.

A practical design tool for PCM-TES has also been developed in the project. With this tool it is possible to evaluate other designs of the heat exchanger inside the PCM-TES, as well as to optimize charging and discharging cycles for one or several PCM-TES. Calculations with this tool have shown that a better utilization of the PCM inside the tank would be achieved if mats with the capillary tubes are placed denser, basically one more mat between two existing. These results indicate that the heat exchanger design is very important for the good utilization of PCM, and that the current design has potential to be improved. The latter is achieved by placing an additional mat with the capillary tubes between the existing mat. Bars (Figure 47) show how the energy storage density changes when different volumes are used as reference, ranging from the total volume of the PCM to the total exterior volume of the tank

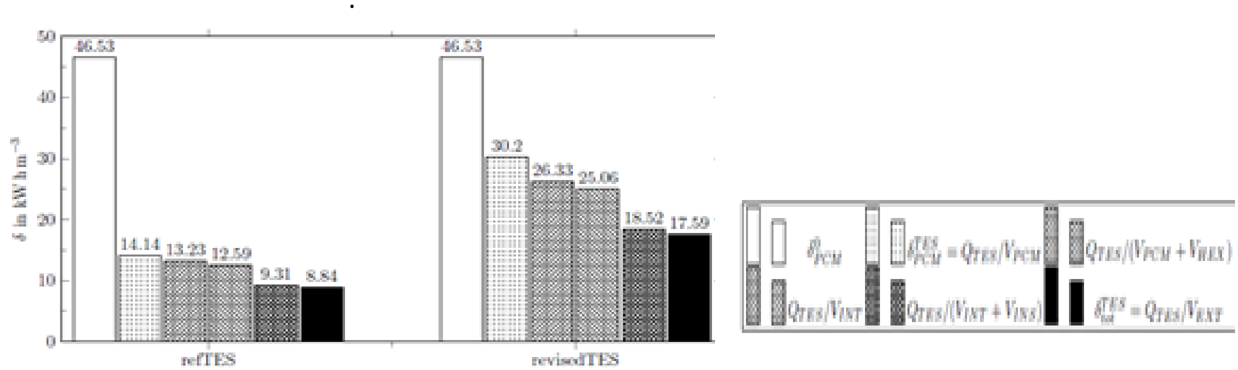


Figure 47 Energy storage density of the PCM volume inside the tank for the existing (to the left) and revised TES (to the right). The latter is achieved by placing an additional mat with the capillary tubes between the existing mat.

Figure 48 shows how peak cooling demands can be shaved in an optimal manner, if two PCM-TES work in parallel. During a warm summer day, the peak cooling demands are cut between 10 – 17 h. If the heat exchangers in both PCM-tanks are revised as suggested earlier, larger peak shaving can be achieved. These results are calculated by the design tool.

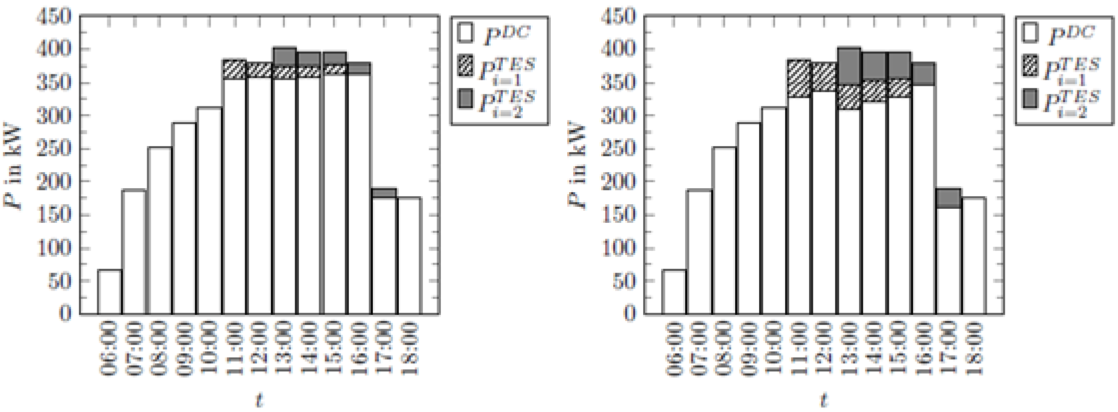


Figure 48 Optimal use of doubled PCM-TES

A cost-benefit analysis of the PCM-TES has also been performed. The purpose of the PCM-TES was to complement the capacity of the local cooling plant, composed of absorption chillers and heat pumps. The local energy utility has different prices for electricity for these types of cooling machinery. In addition, Akademiska Hus pays a monthly maximum power fee to the utility company which is based on the month's highest power peak consumed.

With the existing PCM-TES as specified by the manufacturer, a total cost reduction compared with no PCM storage, approximately 4,2 percent can be achieved. The largest cost savings (Table 14) results from the decrease of the peak electric power surcharge, and not so much due to the variable electricity price between charging and discharging. Today 2022 November when it's a big difference between day and night prices, it can be more profitable. The calculations assume a payback period of 5 years. If the energy storage capacity is increased, by adding e.g. another PCM-TES, larger cost-savings can be achieved.

Based on the financial results, a limit on investment costs can be defined as a key performance indicator (KPI) for a predetermined payback period. Investment costs for the PCM-TES in the AWL building were calculated to (The real cost is significantly higher because the project has large development costs) SEK 546 452, of which 64.5 % or SEK 352 462 was the cost for the PCM, 13.9 % for the tank and heat exchanger and the rest was for transport and installation. These costs are much higher than the calculated limit for investment costs.

Table 14 Cost saving for cooling without and with PCM-TES

Case	Cost saving for po wer, %	Cost saving for ene rgy, %	Total cost saving, %	Investment limit (SEK) for 5 years payback time
Current PCM-TES	-8,19	-0,76	-4,17	9 804
Revised PCM-TES	-13,03	-1,08	-6,55	15 421
2 x current PCM-TES	-15,10	-1,42	-7,68	18 075
2 x revised PCM-TES	-22,84	-2,06	-11,58	27 235

It is worth noting that the financial results are usually case-dependent and that other assumptions may lead to different conclusions. Therefore, the future work should focus on finding applications where a PCM-TES is profitable. Compared to water-based TES, it may be necessary to express a potentially high energy storage density of PCM-TES into an additional economic benefit, such as saving floor space. Also compared with water/ice storage the PCM can be a good investment if the temperature level in the cooling system is around 6-14 C. A PCM-TES can also be more profitable compared to purchasing new cooling machines. For a correct evaluation, a more accurate LCC analysis is needed. More information on PCM-TES durability and maintenance costs should be available from the manufacturer.

Because PCM-TESs in full operations are rare, there was an intensive collaboration between Akademiska Hus, Afry, Chalmers, and various subcontractors during the design, installation, and testing of the PCM-TES. These collaborations were important knowledge-enhancing activities for all involved partners, implying that innovations projects should be run in this or similar collaboration between the industry and academia. A rather large interested of the public has been received. Multiple interviews for national technical magazines and public seminars were given. Inquiries by interested representatives from industry and academia were also received, but many have been postponed due to the Covid-19 pandemic. Several scientific articles with the results from both the pilot and full-scale PCM-TES were published in collaboration.

3.2.4 Business models and exploitation

3.2.4.1 Drivers

A cooling system can produce cooling to a storage when demand is low in the system, the stored cool can be used in high demand periods. The advantage is also a reduced peak power output from the cooling machine.
If there is a need for more cooling and more cooling production and PCM is used as a cooling storage solution, the existing cooling equipment can be used to manage the increased need for cooling.
The market for PCM cooling storage will probably increase as will the demand of being able to produce cold when the price is low. Through the PCM cooling storage the cold production can be optimized according to the **energy price.**

3.2.4.2 "Market" – Target market

The market is the global market for refrigerated products. In Sweden and in Akademiska hus the PCM products can be proposed in future renovations and new constructions within Akademiska hus project portfolio.

3.2.4.3 "Market" - Competitors

To reach the market is rather difficult. There are many systems that are already optimized, and the building sector is difficult to adapt to new developments. Suppliers are in the process of launching many different technical cooling solutions.
This includes not only the reluctance to launch new products, but also the price surcharges imposed by wholesalers and vendors. These ensure that the product is no longer attractive to the buyer in the end.
Additionally, it must be proven to the buyers that it works. Suppliers must have and test storage and be able to scale the data. However, there are very few storage devices that have good monitoring. Therefore, data of the Chalmers IRIS PCM storage is important.

3.2.4.4 PCM strengths compared to similar solutions

To store cold can be done through several technical solutions depending on what temperature that should be delivered. The strengths of the PCM cold storage compared to other cold storage techniques is that the PCM is compact compared to alternative water volume storage and that it can deliver a more stable temperature.

3.2.5 Lessons learned and next steps

- Collaboration between industry and academia in true innovation projects like this one is needed and beneficial for both partners
- A combination of a pilot and a full-scale TES is recommended when there is a lack of expert knowledge and design references
- PCM-TES can be used for shaving of peak cooling demands
- Producers of PCMs need better methods for the characterization of their products, PCMs
- Design of the heat exchanger should be improved to increase the utilization of the PCM
- Development of better matching PCM material is still under progress. Hopefully, during the beginning of 2023 there will be a new PCM material in operation. Chalmers/Rubitherm and Akademiska hus work closely to get the new PCM in operation and look positively on the likelihood of succeeding.

4 Final Results of Transition Track 3

The MaaS concept EC2B offers customers an attractive alternative to owning/using a private car, allowing easy access to a variety of transport modes (e.g. e-cars, e-bikes and public transport) in connection to where customers live or work. The two demonstrators in T7.5 (Housing association Viva and Campus Johanneberg) have been up and running during the project as planned, even though the Covid-19 pandemic and the restrictions implemented due to it has meant that usage of the EC2B service for employees in demonstrator #2 has been low.

The key findings of the two demonstrators implemented within the IRIS project are:

- The EC2B service is appreciated among users
- The demonstrators have spurred a large interest, not least among property companies, as EC2B is unique in connecting MaaS to real estate
- The business model has shown to be replicable, with several new projects being implemented during the last years, also on commercial terms
- As expected from other similar pilots, one of the main barriers to be overcome concerns the technical integration of many different mobility services into one app
- Especially in demonstrator #2, EC2B for employees in the campus area, the complex structure with several property owners, employers and mobility service providers has proved to be a challenge, requiring time and energy to coordinate the interests of all parties involved.

4.1 Overview

In T7.5, a new Mobility as a Service (MaaS) concept called EC2B (“Easy to be” or “Easy to B”), has been implemented in Gothenburg in two different contexts. In demonstrator #1 EC2B was implemented for residents in the 132 apartments in housing association Brf Viva in Gothenburg, where no private car parking is available. In demonstrator #2, the EC2B concept was adjusted to cater for the needs of employees in the campus area of Johanneberg. See Figure 49 for the location.

Figure 49 Photo of demonstration area with Johanneberg campus area in the centre and BRF Viva to the left.

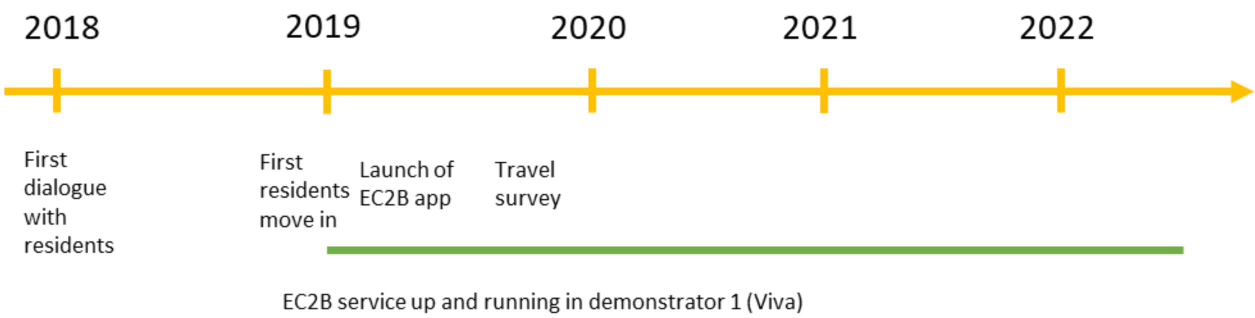


Figure 50 Timeline of demonstrator #1, EC2B in Housing association Viva

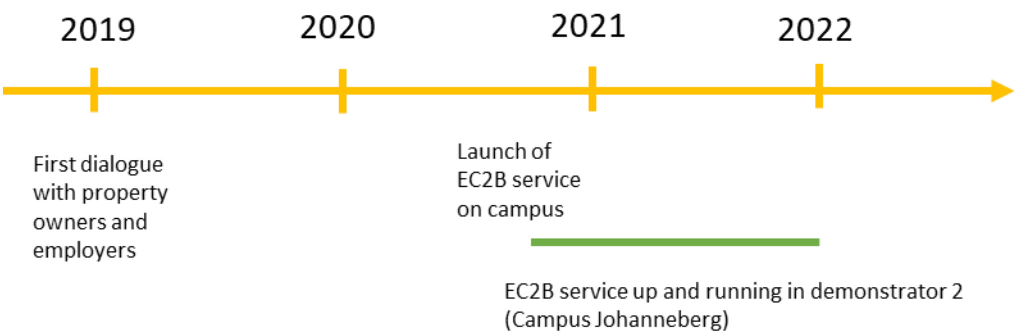


Figure 51 Timeline of demonstrator #2, EC2B on Campus Johanneberg

4.2 Implementation

Demonstrator #1, EC2B in Housing association Viva

Figure 52 Housing Association Viva in Gothenburg, view from the south. Shared e-cars can be spotted under the green roof adjacent to the middle building.

Demonstrator #1 was implemented from December 2018 (Figure 50) when the first residents moved in, although preparatory dialogue was initiated more than a year earlier. During the demonstration, residents in Brf Viva have access to three (initially four) e-cars, Renault Zoe (Figure 52). Residents also have access to three electric cargo bikes and four e-bikes, as well as charging infrastructure for all types of electric vehicles (55 recharging polls for e-bikes, 6 for e-cars and 2 for light e-vehicles) (Figure 53). During a trial, a light e-vehicle, "Zbee", was added to the pool of vehicles. The first bikes and cars were installed in December 2018 when the first residents moved in, and the number of cars and bikes were increased as more and more residents move in to reach the numbers indicated above. To access the e-bikes and light e-vehicles, an electronic key cabinet was installed which is opened using the EC2B app.

Figure 53 Shared e-cars to the top left, key cabinet for shared bikes to the top right, and below the bike garage with shared e-bikes, including cargo bikes, to the right down the green lane. To the right booking view from the EC2B app.

The EC2B app was launched in February 2019. Information activities for residents took place already during the year before they moved in but were intensified during the period when they moved in, with several information gatherings ("mobility evenings") where the mobility services were demonstrated, and residents were offered support to get started using the EC2B service. In October 2019, a travel survey was made among the residents to follow up travel behaviour, use of the EC2B service and user satisfaction. Demonstration of the EC2B app was closed in August 2022, but residents still have access to shared e-cars, e-bikes and all the bike facilities, although booking is no longer integrated in the EC2B app.

Demonstrator #2, EC2B at Campus Johanneberg

In demonstrator #2 a dialogue with property owners and employers in the Johanneberg campus area was initiated in early 2019 and continued throughout 2020 (Figure 51). The dialogue resulted in a common understanding of how the EC2B service offered in the campus area should be designed to be useful to employers in the area.

Figure 54 To the left, sign in the campus area explaining the mobility hub concept and where to find the mobility services included. To the right, shared e-bikes at one of the hubs.

Four mobility hubs (Figure 54, Figure 55) were created in the campus area, combining e-cars, e-bikes, and public transport, and the EC2B service, integrating these transport modes within one app, was launched in November 2020. Figure 55 below presents a map of the hubs. However, there have been some practical problems concerning the hubs, related to finding suitable locations for the bikes where they are safe but still available to users, and also problems with getting a charging point for e-cars in place. Due to the Covid-19 pandemic and restrictions and recommendations of working from home, avoiding physical meetings, and avoiding the use of public transport, usage of the service during the demonstration was unfortunately also very low. The service was initially planned to run until the end of September 2021, but partners agreed to let the pilot run until the end of 2021. There is an agreement among the property owners in the area to continue a collaboration on common mobility services. At the very least, the mobility hubs will become permanent.

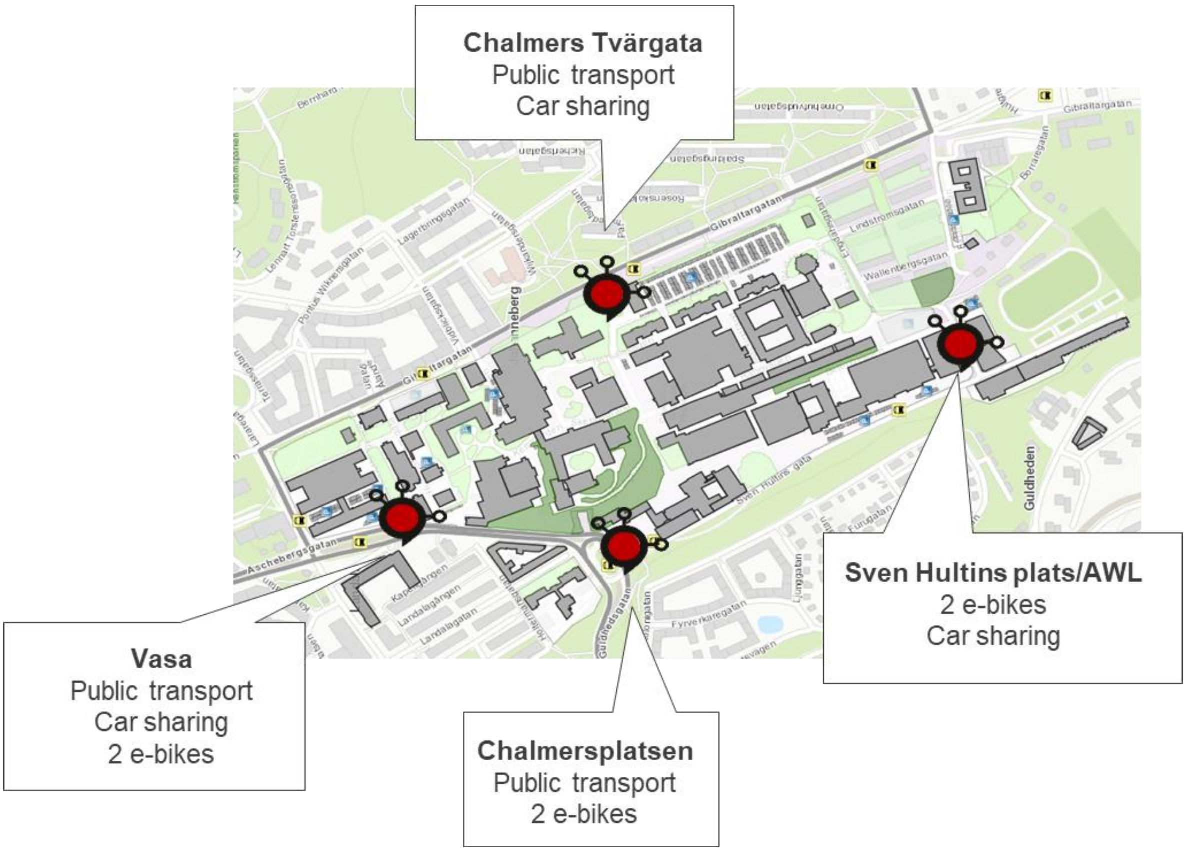


Figure 55 Map of mobility hubs in Campus Johanneberg

Mobility wallet

As a continuation of the mobility hub initiative and the experiences from the campus stakeholder dialogue, the development of a "mobility wallet" took place during 2022, using the IRIS project's opportunity to include an external solution provider to develop the digital service. The idea of a mobility wallet is to create the possibility for an employer or a property owner to offer a sum of money digitally within the mobile application which can be used to consume any mobility service included in the application, as preferred by the user. It is common for employers to provide benefits such as public transport cards or different car lease solutions, but the mobility wallet would increase the flexibility. The project wanted to explore what problems the mobility wallet can solve within the respective organisations. The goal of the project was to increase the understanding of what is important to include in the mobility wallet to further ease the use of mobility as a service, focusing on the employer perspective.

Through interviews with stakeholders on campus where mock-ups of the digital solution for the mobility wallet were presented, it was concluded that there is an interesting potential for this type of functionality. It could be used both to cover business needs to promote sustainable mobility, and to equally distribute a benefit of sustainable mobility to the employees. As for all digital solutions, the need for a user-friendly interface that eliminates some of the administrative hassles and paperwork for the organisation and at the same time is easy and preferred to use by the consumers, were highlighted.

The work resulted in the development of a mobility wallet in both the mobile app and the administrative interface. For the end-users it is mainly visible in the payment flow, and for the administrative user mainly to refill and see the use of the mobility wallet, see **Fout! Verwijzingsbron niet gevonden.**

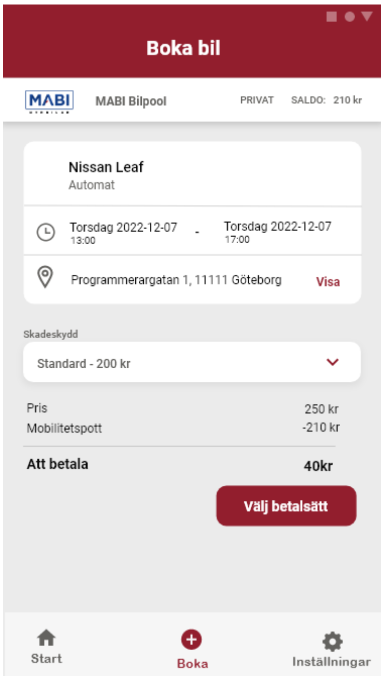


Figure A56 The mobility wallet in the EC2B mobile application is used when paying for the use of transport modes for either private use of for business trips.

4.3 Results

Demonstrator #1, EC2B in Viva

Usage and user satisfaction

When it comes to end-users' experiences, we know most about demonstrator #1, as it was up and running well before the pandemic.

The use of mobility services in Viva is high compared to ”ordinary” housing projects with only shared cars. The use of the shared cars started faster than the car sharing provider had normally expected and the occupancy of the vehicles has been relatively good, with many bookings also from users who do not live in Viva themselves. The shared e-bikes have also been much appreciated and used by the residents, possibly partly because booking the bikes initially was free.

Experience has shown, however, that heavy usage also means relatively large running costs to keep the bicycles in good condition, which needs to be budgeted for.

Purchasing public transport tickets in the EC2B app was popular during a trial when the tickets were discounted, but when the discount disappeared, most people switched back to buying tickets in the public transport company's app. It's obviously difficult to compete with the original.

An overview of number of bookings of the services included is found in Figure 57 below.

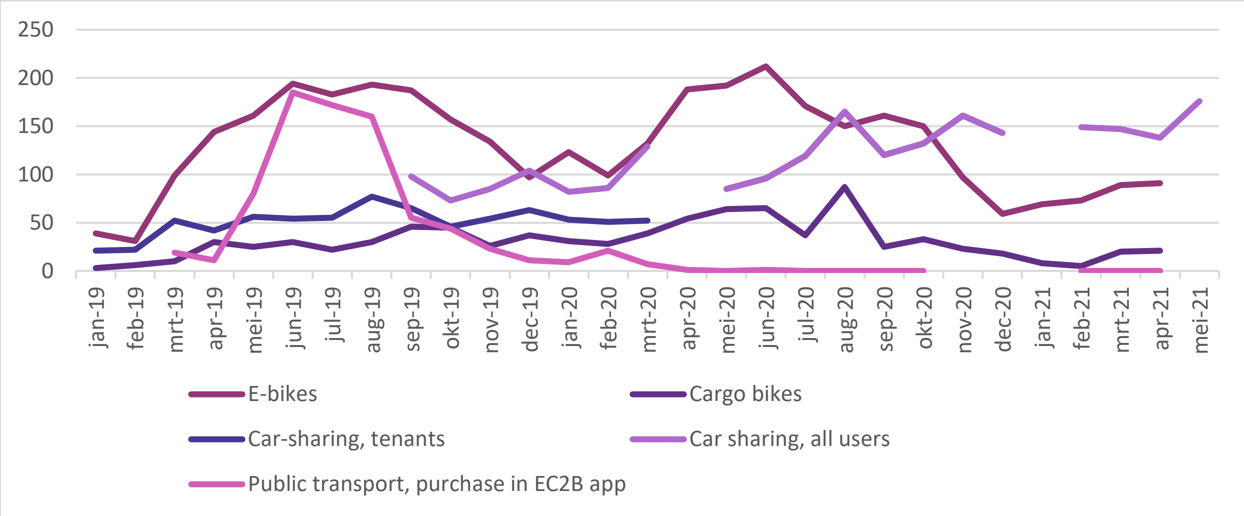


Figure 57 Viva mobility services, number of bookings/month

Overall, when it comes to user satisfaction, results show that the EC2B service is appreciated by users, see Figure 58 below.

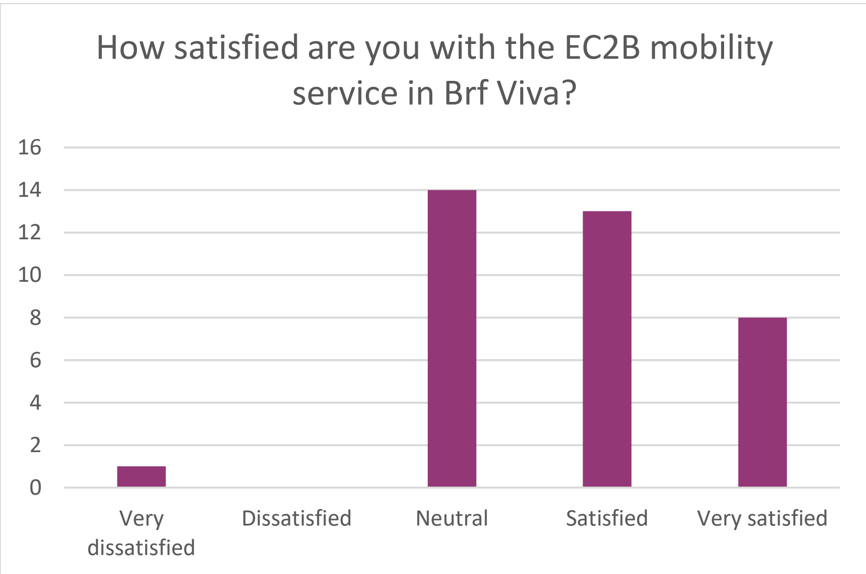


Figure 58 User satisfaction in Brf Viva, after one year of trial

Impact on travel behaviour

Our analysis indicates that many of the residents in Viva used to own a car before but disposed of it in connection with moving into Viva. One group of residents travelled sustainably already before moving in and was attracted to Viva because of its sustainability profile. At the same time, one group of residents also have kept their cars and rented parking spaces in the surrounding area, which was not anticipated on beforehand. However, total car ownership in Viva is significantly lower than the average for Gothenburg. A total of 32 cars are registered on inhabitants in Viva (KPI 38), while the expected number of cars (based on an average for the area, which is already relatively low compared to other parts of the city) would be 68 cars. In the Grant Agreement, calculations were made based on the assumption that car ownership among the residents would be zero, which in hindsight seems overly optimistic.

When it comes to the kilometres driven (KPI 39), reductions have however been larger than anticipated (Figure 59). Our original assumption was that the kilometres travelled by car would be reduced from 6470 to 4520 km/year when tenants join a carpool, which was based on a previous study from Gothenburg, but that car travel would be reduced a further 5 % due to communication activities, also based on previous studies. This meant that in total, we expected car travel would be reduced by 2387 km/person and year. This assumption was surpassed, as the calculated length of car journeys among the tenants in Viva based on a travel survey was only 3 500 km per person and year. Compared to the Gothenburg average, this is a reduction with 2 970 km per year, more than our previous assumption of 2387 km/year.

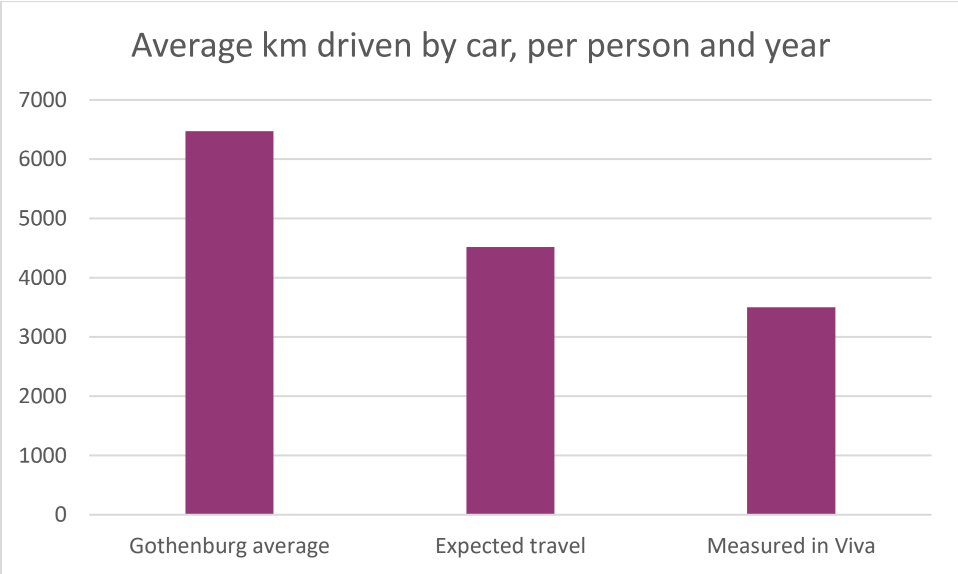


Figure 59 Results of KPI 39, kilometres driven by car

The travel survey shows that the number of car trips among residents in Viva is only about half of the average for Gothenburg, whereas the number of bike trips is somewhat higher. Public transport usage is comparable to the average for Gothenburg. Interviews with residents indicate that also those that have kept their car make fewer trips by car than before, which can be explained by the added resistance that comes from not having the car parked in immediate connection with the apartment, which means that trips are planned more actively, combining several errands in one trip. (Smith, 2022)

However, we initially expected that 100 % of tenants' car trips would be shifted to the e-cars in the carpool, but this turned out to be an overestimation explained by the fact that a share of tenants actually kept their car while moving into Viva. When the travel survey was made in October 2019, only 5 % of the total length of tenants' car journeys, 170 km per person and year, were made using the e-cars in the carpool (KPI 46) (Figure 60). The share of trips was higher, but journeys with private cars are generally longer. This can partly be explained by the fact that everyday car travel was reduced more than expected (reduced and shifted to bike), and that remaining car journeys are less well suited to car sharing (these include longer trips to summer cottages, etc, hence many kilometres in total). Nevertheless, figures from the operator show that usage of the cars has increased over the years, from 170 km/year and person in 2019 to 220 km/year and person in 2020 to 330 km/year and person in 2021, which is more than 9 % of total travel by car (see **Fout! Verwijzingsbron niet gevonden.** below for total number of kilometres driven in e-car sharing system). To some extent, this is probably an effect of the pandemic, where some trips were shifted from public transport to shared cars due to recommendations from authorities to avoid public transport. However, based on experiences from other cases, it is also likely that usage of the shared cars would increase gradually as more residents get accustomed to the service. When calculating the carbon reductions from demonstrator #1 we have made calculations for the two extreme cases that 100 % of new trips with shared cars replace trips by private (conventional) cars, or that 100 % replace trips with public transport. The truth most likely lies somewhere in between.

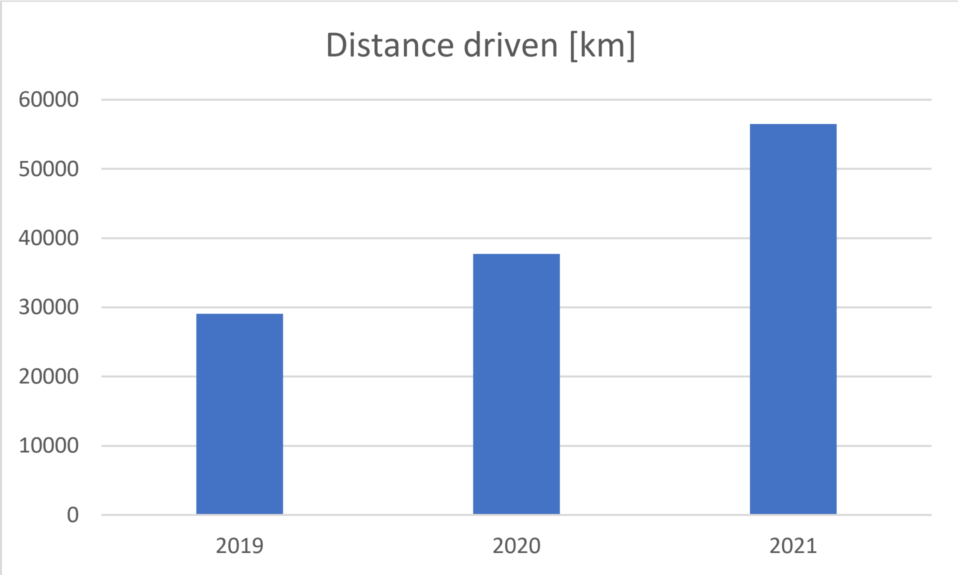


Figure 60 Results of KPI 46 for M3.1, kilometres driven in car sharing system per year.

Consequences on energy use and carbon emissions

When calculating the carbon emissions (Figure 61), we have updated the assumptions of CO_2 emissions per km for an average Swedish car and e-car compared to the figures used in the Grant Agreement. The original assumptions (from 2015) were 163 g/km for an average Swedish car and 53 g/km for e-cars, based on the European grid factor. Updated figures used in the calculations were 156 g/km (tank-to-wheel) for an average Swedish car (2019), 150 g/km (2020) and 143 g/km (2021).[1] For e-car emissions of 0 g/km were assumed due to the green electricity procured in Viva. Combined, these changes do not substantially impact the result. It is important to note that as the average emissions from private cars decrease, the potential of reducing emissions from shifting trips to shared e-cars is diminished. However, even if the vehicle fleet would be completely fossil free, the usage of shared cars still has potential to reduce total emissions, as a substantial share of carbon emissions from cars come from the production of vehicles. If fewer vehicles are needed, total emissions are reduced.

In total, the calculated reduction of CO_2 for Demonstrator 1 (KPI 5) ranges from 77 tonnes in 2019 to 75 tonnes per year between 2019 and 2021, or down to 7133 tonnes in 2021 if new trips made by car sharing are assumed to replace trips by public transport, see **Fout! Verwijzingsbron niet gevonden.**.[2]

[1] These figures were calculated based on statistics from the 2021 environmental report of the Swedish Traffic agency, report 2022:008.

[2] The fact that emission reductions are lower for each year has to do with the fact that the baseline of emissions from conventional private cars becomes lower each year.

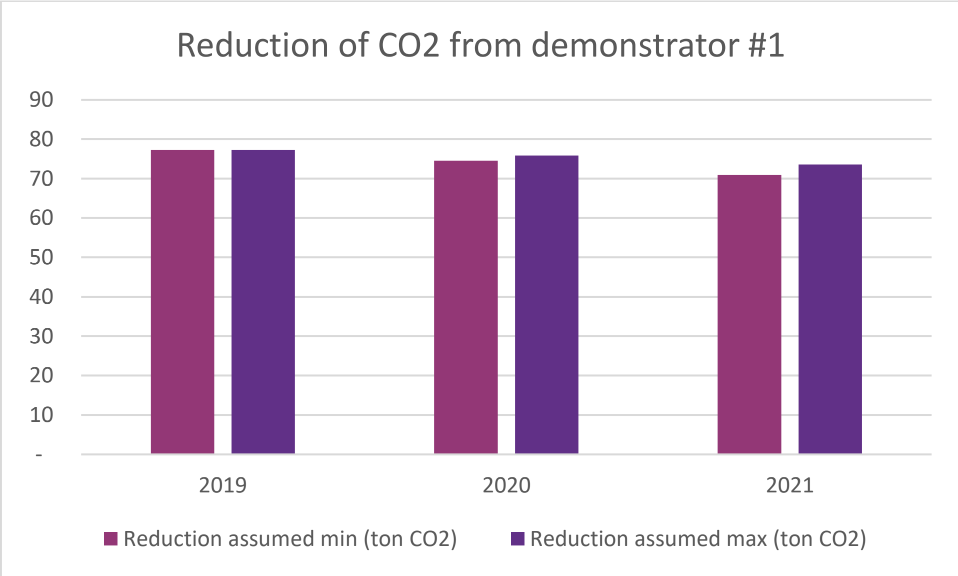


Figure 61 Results for KPI 5 for M3.1, reduction of CO2 for demonstrator #1.

This should be compared to the original assumption of 131,4 tonnes/year. The reduction in car travel counts for the main share of the reduction, 71-77 tonnes/year, while the shift to e-cars counts for 4-8 tonnes per year depending on which assumptions are made about which trips were replaced by e-cars during the pandemic. Over 5 years, the total carbon saving would be about 400 tonnes, as compared to the initial assumption of 657 tonnes per year. This is mainly due to the fact that car ownership among the residents is substantially higher than expected. However, even if the goal set out in the Grant Agreement was not fulfilled, the carbon footprint from everyday transport for the residents in Viva is only about half that of an ordinary Gothenburg citizen.

Demonstrator #2, EC2B at Campus Johanneberg

Changes in content of Demonstrator #2

Demonstrator #2, EC2B at Campus Johanneberg, took a somewhat different direction than originally planned. According to the Grant Agreement, a “lighter” version of the service would be offered to all end users in the campus area (15 000 people). However, based on the dialogue held with property owners and employers in the campus area, the partner consortium concluded that rather than launching a service open to both employees, students and residents but not being tailored at any of these groups, it was more interesting to design and implement a more advanced MaaS solution targeted specifically at employees in the campus area, where they identified a clear need. According to the new plan, a more advanced service would be launched, targeted specifically at business travel made by employees in the campus area (4 100 employees). This set-up included new or strengthened vehicle pools with e-cars, e-bikes, bike sharing, and taxi dedicated to business travel to be launched in the campus area, and a focus on establishing a permanent organization to procure a permanent mobility service on campus. An important part of this set-up was that all expenses for business trips that a user made through the EC2B service were compiled on a monthly invoice, which reduced the administrative burden for both employer and employee. The changed set-up for Demonstrator #2 made it a more interesting complement to Demonstrator 1, and also made it possible to test the business model of EC2B in a new context. This change in focus was presented to and approved by the Project Coordinator of the IRIS project.

Main results from Demonstrator #2

The most interesting results of this demonstrator was that employers on campus realised the benefits of collaborating on mobility, and that the supplier parties were able to test and discover which parts of the concept need further development to create as good a MaaS platform as possible.

Adaptation of service and business model

The EC2B platform was originally developed and tested for housing but has through the IRIS project been adapted to also offer services for businesses and business trips. In addition, the collection of experiences regarding various organisations' administrative systems and where the interface runs between property owners and mobility providers has provided a basis for adapting the service and business model. Based on collaboration with participating employers, EC2B has developed a business plan that will respond to the needs that exist in an area consisting of different types of companies such as property owners and other companies. The approach is based on an openness that enables companies that move into an area where EC2B operates to choose what works for them and to bring with them their own mobility solutions and connect them to EC2B.

Stakeholder experiences

The employers' organisations that have participated in the project themselves have stated that there is a great benefit in collaborating on mobility linked to a campus setting. Challenges have been identified, such as procurement forms and responsibilities, which has led to the dialogue between parties becoming more hands-on and solution oriented.

Stakeholder experiences have been evaluated more in detail and property owners and employer organisations have drawn some conclusions based on their experience of the demonstration. Many stakeholders connected to the campus area would prefer to set up a mobility broker solution in the long run, similar to the concept demonstrated in the project, but they are also highlighting some obstacles. One obstacle is that there are too few suppliers available that can handle the role as a mobility broker. Another obstacle identified is the difficulties to design a public procurement for such purpose. The demonstration has provided valuable experience especially regarding the complexity of the demonstrated service. An interesting result is that the stakeholders at campus now see the benefits of working together to set up mobility services for business trips.

User satisfaction and usage

Results linked to the use of the service during the demonstration period have been almost completely absent due to low usage, which can be explained by the ongoing pandemic and associated restrictions. 58 persons in total registered to take part in the trial. Of these, 39 filled out the ex-ante survey, and of these 28 persons actually downloaded the app and took part in the trial. 108 trips were made, of these 74 % were bike trips. Users appreciated the service, and mostly found the service easy to use (see Figure 62). The ex-ante survey among end users indicates that less than 50 % of the respondents were satisfied with their mobility solution before they tried the demonstration. A clear majority expressed that the service improved their access to vehicle sharing solutions (see Figure 63). The most common reason to participate in the demonstration was curiosity. Bike sharing was by far the most popular service, but it is hard to draw any conclusions on usage due to the restrictions caused by the pandemic that affect the potential for especially public transport (avoid, few business trips) and car sharing (few business trips).

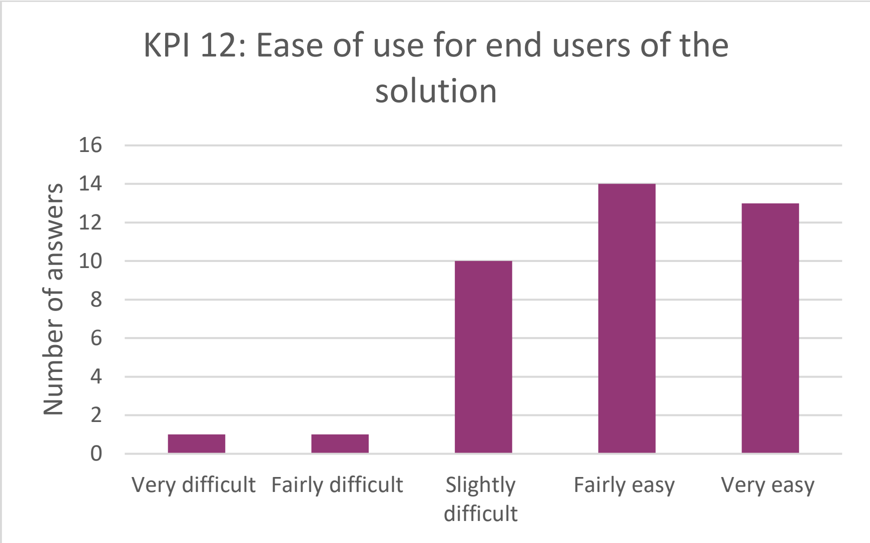


Figure 62 KPI 12, Ease of use for end users of the solution, Demonstrator #2.

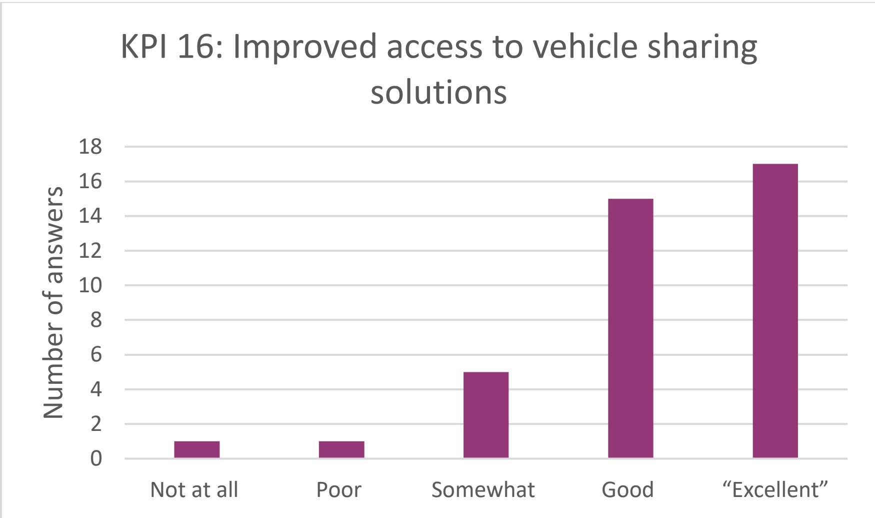


Figure 63 KPI16, Improved access to vehicle sharing solutions, Demonstrator #2.

4.4 Business models and exploitation

The main value propositions of EC2B are formulated in the following way:

- EC2B helps residents in the (larger) cities to travel sustainably without the need of owning a car. This is done through the packaging of flexible mobility services, counselling, and a community for sharing.
- EC2B helps real estate developers and employers who want to offer the market a modern, urban, and low-car housing concept, through a package solution for sustainable and flexible mobility that is attractive to both customers (residents or employees) and authorities (the municipality).
- EC2B helps mobility service providers who want to reach a large and affluent market for their sustainable mobility services. It will form part of a comprehensive service for sustainable mobility, easily available at home.
- EC2B helps cities create a more attractive urban environment and sustainable development with fewer cars and a significantly more efficient land use, as well as significantly reduced climate impact.

EC2B helps real estate actors meet municipal requirements of low-parking housing concepts through packaging different mobility services into one mobility concept which is made available to end users through the EC2B app. The real estate actor pays EC2B to set up the services, provide the EC2B app to users during a pre-defined time span, and arrange on-boarding activities to get users started, while mobility service providers get paid as their services are used. Compared to building an expensive garage to meet parking requirements, the cost of setting up and running EC2B is significantly lower for the developer.

The business model of EC2B has been tested in two different varieties within the two demonstrators of T7.5. While both concern integrating mobility services with the built environment, the set-up when it comes to the actors involved differs slightly. With EC2B for workplaces, the additional layer of the employer is added between the property owner and the end user. In Demonstrator #2, the fact that several property owners active in the campus area needed to collaborate added further complexity.

However, the EC2B service has been replicated in several different contexts since the first implementation in Brf Viva, and the start-up EC2B Mobility has been set up as a daughter company to Trivector to further develop the business model and scale up the service. So far, the EC2B service has been replicated in Lund and Västra Frölunda. The Xplorion project in Lund is similar to Brf Viva as it also a new housing project with zero parking space. In Västra Frölunda, the EC2B service has been implemented in an existing building complex in collaboration with the municipal housing agency Framtiden, who wish to reduce the number of parking lots in an existing area to be able to use the land to build new apartments.

4.5 Lessons learned and next steps

The combination of good access to mobility services and tailored information activities has made the residents in Brf Viva (Demonstrator #1) feel satisfied with their mobility situation despite the fact that they have no residential parking. On an aggregate level the residents in Viva travel more sustainably than they did before, and only half as much by conventional cars compared to the average Gothenburg citizen. However, car ownership is still far from zero, and the main part of car travel is still made in private cars, especially in terms of kilometres travelled as trips with private cars are longer. This explains why the targets for CO_2 reductions set out were not met completely. Nevertheless, the fact that those who still own a car are forced to park some distance from home has led to a sharp decrease in car travel also among car owners.

Car-free or low-car housing can make a significant contribution to sustainable transport, but it is important to have reasonable expectations of the first pilot projects. An (even more) supportive traffic environment in the immediate area, such as higher parking fees at nearby car parks, would also be clearly desirable to further reduce car ownership among residents. So far, it has turned out to be quite easy, and not very expensive, for residents to hire a parking lot in the surrounding area, which of course reduces their incentive to sell the car and start using the EC2B service. Another partial explanation is that the mobility services offered did not cover for all residents' needs, such as travel to the summer cottage. A more flexible mobility offer, potentially also including car rental, would make the service even more competitive. This is also in line with the future development of the EC2B service.

Employers in Campus Johanneberg (Demonstrator #2) see a clear interest in collaborating on shared mobility services for their employees, even though there are obstacles to overcome, and (the few) users seemed to appreciate the service. However, the Covid pandemic unfortunately meant that the trial did not at all reach its full potential, which also explains why the targets laid out in the Grant Agreement were not met.

From a stakeholder perspective, an important conclusion is that mobility as a service is not just more services, but what gives increased potential is coordination, packaging and holistic thinking. How can public transport create offers that are relevant for MaaS users, in combination with other services? What can be done to make the on-boarding process easier? What services need to be included to create an offer that covers all types of needs that users might have? This coordination and packaging does not happen by itself. Since mobility as a service is new for everyone - residents and users, employers, real estate actors, municipalities, mobility service providers, technology providers, etc. - no one can fall back on how you "usually" do things. New solutions need to be tried out. Herein lies the challenge of being able to realize the great potential that exists in mobility as a service for real estate. Here is an important role for the city / municipality to play, who set the rules for this type of solutions, integrating mobility with housing or workplaces.

5 Final Results of Transition Track 4

In Gothenburg the IRIS project has demonstrated two different solutions in TT#4:

a. The CIM pilot project which is an implementation of tools for collecting and sharing of data from building projects with support by FIWARE components. The main collected data is BIM data – Building Information data.

b. The EnergyCloud has been implemented and is a local version of a cloud for collection data within the energy system. The local system has been delimited to three universities and their Landlords in the Gothenburg region.

A City innovation Platform (CIP) in Gothenburg has been implemented and is in the process of turning into a service for citizens, business and authorities within the city (D4.8). Through the FIWARE based platform some business cases through sensor data have been implemented and start of collaboration with other FIWARE based platforms.

5.1 CIM- City Information Model pilot

5.1.1 Overview

CIM can be compared with the concept BIM, Building Information Model, used in the building process. A BIM model is a 3D model of the building where all the information about the building is collected and organised though the buildings life. CIM could be described as BIM for an entire city. The theory that was tested in the demonstrator CIM pilot in T7.6, is that if the City starts collecting BIM data from all its buildings, the City will eventually build up a CIM. The CIM pilot in T7.6 is therefore a pilot implementation of tools to collect and share data from building projects, BIM data. The ambition was that current and future city building projects in the close by area could reuse the data already produced by another project for instance to check for collisions or to find results from already done investigations etcetera. Via third party apps, citizens could view the data more easily and get engaged in projects.

The pilot has been implemented and tested with data from the reference project “Hisingen bridge” (Figure 64, Figure 65) thus it is implemented in the area where the Hisingen bridge is built in Gothenburg.

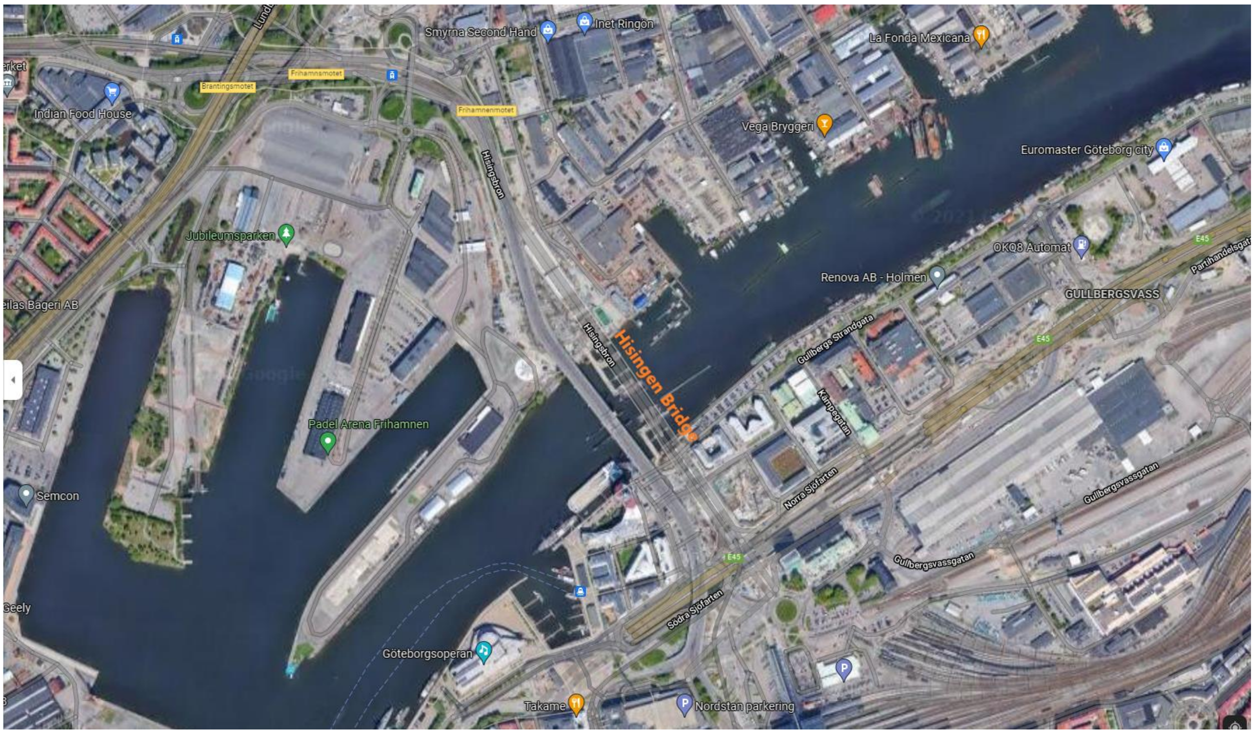


Figure 64 Map showing the area around the new Hisingen Bridge

Figure 65 An image from the visualisation of the Hisingen Bridge

The CIM pilot was ready for demonstration and evaluation Q1 2020.

From the start the plan was to have an innovation challenge based on the data in the CIM pilot. During the project it has become evident that an innovation challenge based on the CIM pilot would not have given much value, so instead of doing that activity, we documented our experiences in a report, see Annex 2. The main reason for cancelling the innovation challenge was the lack of building data to share due to confidentiality. This was a problem that we had not foreseen but nevertheless an important insight. This is addressed in chapter 5.1.3.1.

5.1.2 Implementations

The implementations in the CIM pilot are based upon infrastructure data as the pilot has been developed for the Urban Transport Authority, in the City of Gothenburg.

It is implemented from two use cases: ***Visualize your City*** and ***Kick start your project***

The use case ***Visualize your City's*** main objective is to give citizens and users an easier way to access/acknowledge projects and means to influence the planning process. The objective for the use-case ***Kickstart your project*** is to give design teams an easier way to access and reuse data relevant for their projects and thereby simplifying the design process and making it more cost effective.

To achieve the objectives of these use-cases the following implementations have been done:

- A specification of **BIM requirements**: A first version of a specification of BIM requirements usable for infrastructure projects in a city.
- The **BIM Data Collection Tool**: A pilot version of a tool that can be used by the city to collect, validate and save project data (BIM data) that follow the BIM requirements specification.
- A **test version of a CIP** based on FIWARE technology, where the project data is saved and from where the data could be downloaded from or accessed through APIs. The data in the CIP is described in a data catalogue (**CIM Data Catalogue**). The CIP also have a web-based interface where project data is listed and can be searched. Through this interface the data can be downloaded (**CIM Data Retrieval Tool**).
- An API specification over the APIs to access the project data programmatically
- **CIM Visualization Tool** is a simple test tool to test the possibilities to visualize project data uploaded to the test CIP and accessed through the API.

A simple demonstration of the CIMpilot and its components is available in Swedish on YouTube:
https://youtu.be/X5QWXwZQ64M [youtu.be]

5.1.2.1 Specification of BIM requirements

From a sustainability point of view this task has focused on information sustainability.

The most sustainable information is in fact the re-used information.

Even if we may not always realize this, the collection, production, and handling of information require resources and therefore also adds to the total footprint.

We have identified the interface between projects and asset management as the weak point where information most often is lost.

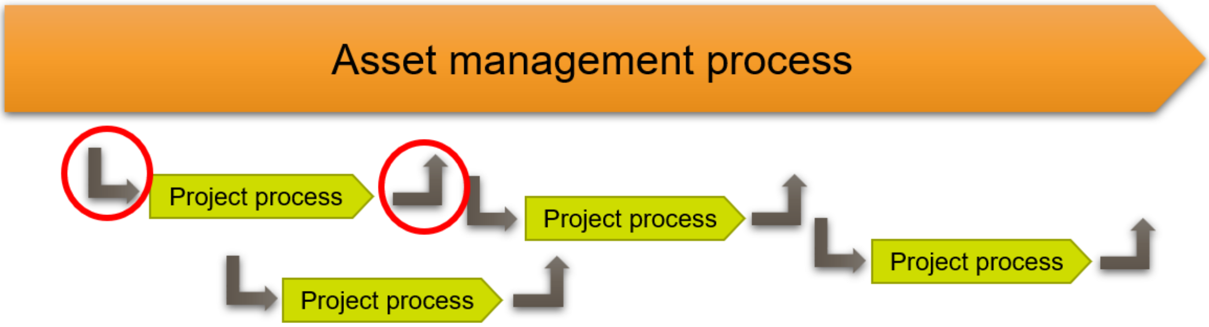


Figure 66 Asset management infinite process docking with projects. Information exchange points identified as weak points.

The purpose of the BIM requirements is to specify the interface between the Asset management process (Figure 66) and the Project processes. The requirements are governed by the Asset management process. The BIM requirements will make it clear to the project groups what to expect in terms of information from the Asset management process and what it must give back when the project is finished. The BIM requirement delivery specifications also exist in a machine-readable format to facilitate automatic validation as described in chapter **Fout! Verwijzingsbron niet gevonden.**.

If all infrastructure projects follow the same requirements the project data can more easily be saved, shared, searched, and reused. For example, in the document" Riktlinje Digitala leveranser för förvaltning" published by BIM Alliance, the organizations Akademiska Hus AB, Fortifikationsverket, Riksdagsförvaltningen, Specialfastigheter Sverige AB and Statens fastighetsverk, have concluded that common clear requirements will lead to a more effective information handling regarding building information.

The BIM requirements specify down to object detail how to classify and set attributes. The rulesets are divided into disciplines (i.e Roads, Railroads, Geotechnics).

The classification part of the BIM requirements is based on the Nordic CoClass standard, which is also used by the State Road Authority in Sweden for infrastructure buildings. The specification of requirements are described in the document "BIM-kravTK_v1_0". CoClass is from the beginning based on the SS-ISO 12006-2:2015 standard describing general classification for the built environment.

5.1.2.2 BIM Data Collection Tool

The BIM data Collection Tool (Figure 67) has been designed to automate and validate the import process from Project into the Asset management database. It is based on the delivery specification set out in the BIM requirements. The BIM Data Collection Tool should be used by the Design Teams to upload project data to the city Asset management database. The BIM Data Collection Tool has a web interface where projects can deliver infrastructure project data to the Urban Transport Administration. It is implemented as an FME sequence of operations and utilizes the scripting capabilities of FME to interpret and validate input files of building or construction work. The input data must comply to the BIM requirements. Files are uploaded as zipped packages of files in .ifc or .dwg format. The FME processes provide both evaluation documentation, processing logs and converted 3D object data files in CityGML format out of the CAD files and sends these objects to the 3DCityDB in the test CIP for separate storage. Original files are also stored in a CKAN dataset.

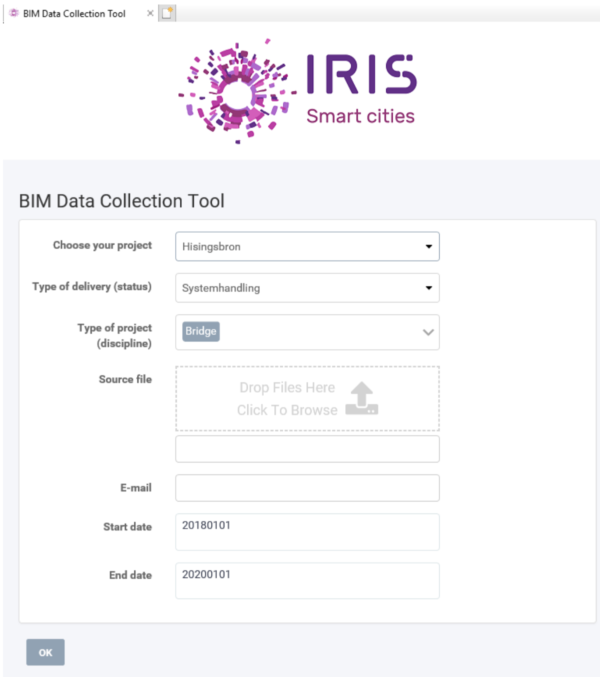


Figure 67 The web-based interface of the BIM Data Collection Tool

5.1.2.3 CIP test version for CIM pilot

The test version of CIP was developed to support the use cases of the CIM pilot only. It was based on the reference architecture described in D4.2 and the technical solution reference architecture described in D4.4. It uses a mixture of Fiware and other open software or internally developed components. The system is set up in a Docker environment with several containers. Read more about this in Deliverable 4.6.

The CIP has a web-based interface where project data is listed and can be searched, this is a styled standard CKAN web interface. Through this interface the data can be downloaded (Figure 67, Figure 68). The user can search for datasets and resources by bounding geography in an interactive map control, use buttons for the most utilized tags or keywords, select datasets by an organization or search for any dataset descriptive text content.

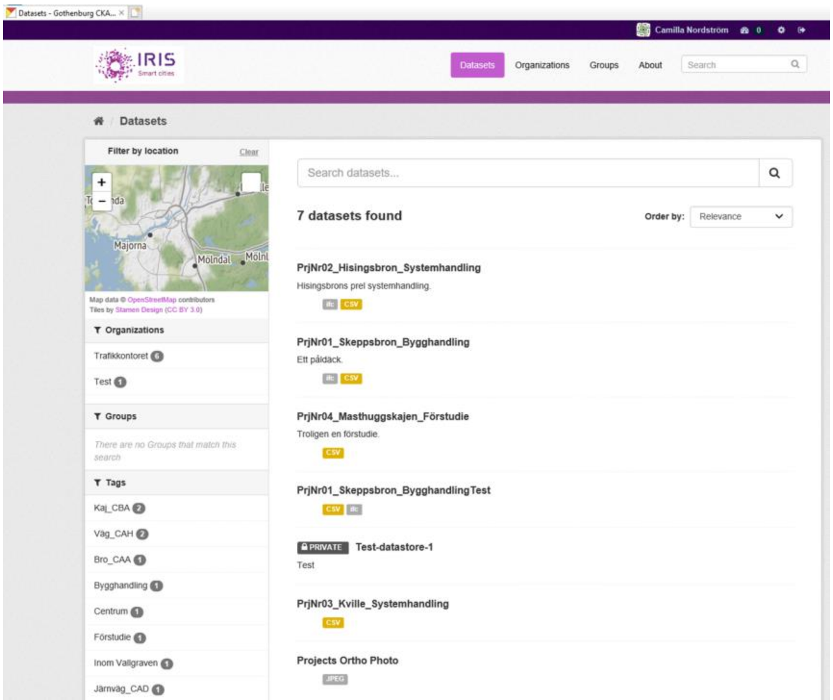


Figure 68 CIM Data Retrieval Tool

5.1.2.4 API specification

The API specification is a document that describes the interfaces to be used for input of data into the databases of the CIP as well as the interfaces, tools and access conditions for management and retrieval of data. The main part of the document is focused on how to access the data through API's, mainly the CKAN API and the 3DCityDB Importer/Exporter API, see the document "CIP Pilot API description TK Gbg".

5.1.2.5 CIM Visualization Tool

The tool is a simple visualization tool to visualize the data available in the CIM. The purpose is to test access and use of the CIM data available through the available APIs (Figure 69).

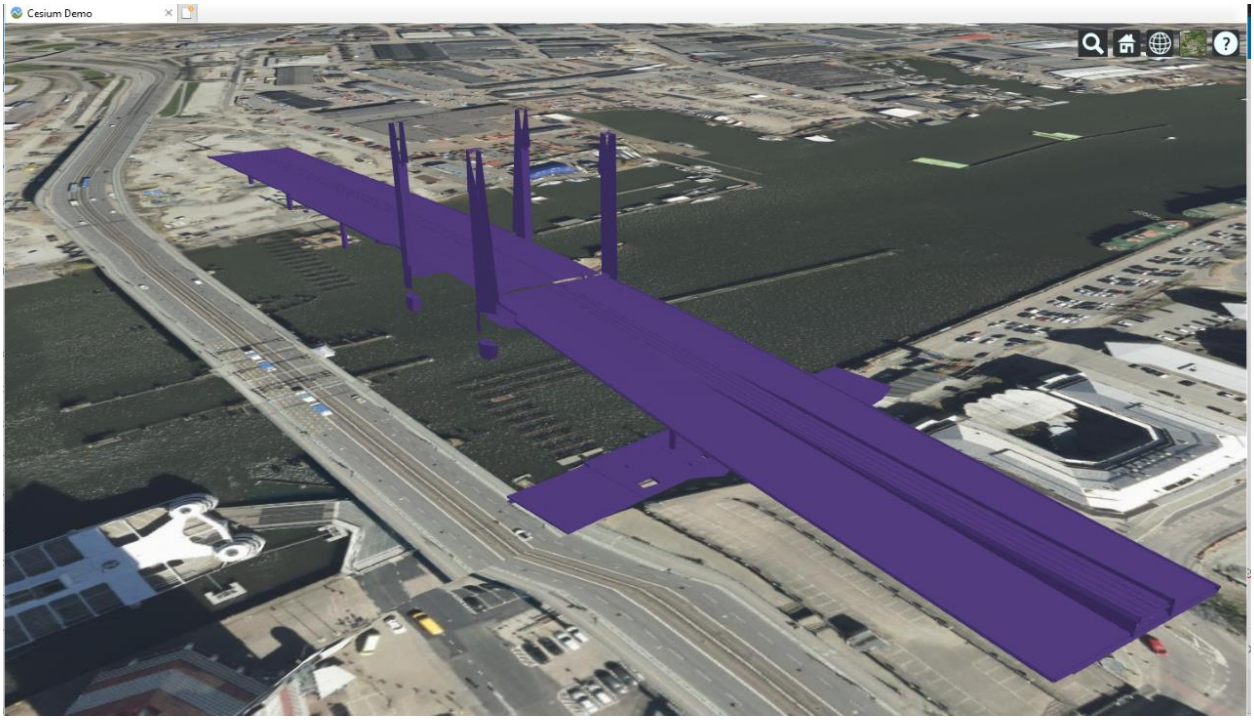


Figure 69 CIM Visualization Tool

5.1.2.6 Implementations CIM pilot, general comments

The CIM pilot is a test, and it has not reached the desired level so that it can be used for real, since the barriers for that are too high (see chapter 5.1.3.1.) Because of this there are currently no decided plans on how to proceed with implementation of the CIM pilot as such and it will be dismantled. But as shown in user evaluation, tools to collect, validate, save and share BIM data from projects, are highly needed, so it is most likely that those tools will be implemented, in some way in the future. The City of Gothenburg is now starting up the work on a BIM strategy. Material and lessons learned from the CIM pilot will be of use in that work.

The City of Gothenburg is also implementing CIP as a city-wide service. This service is based on the FIWARE framework as well as MIMs from OASC, EU Join Boost Sustain and Living In EU. The CIP will be focused on supporting sensor technology and IoT and use that as a driving force to establish CIP. This CIP will most likely not have building data to start with due to the legal complexities with information classification of the building information, as shown in the CIM pilot. Even though the Gothenburg CIP will not have BIM data to start, the first tests of the CIP in Gothenburg was done by the CIM pilot, and these tests have contributed with a great knowledgebase to the Gothenburg CIP.

5.1.3 Final results

The main ambition for the CIM pilot was to pilot automation of collection and saving of BIM data in a structured and well-defined way, to share with stakeholders via the City Innovation Platform.

A test implementation has been done as described above, but the pilot contains very little data and the data cannot be shared as planned. This is due to the high barriers for implementing the CIM pilot and is described in subchapter 5.1.3.1 below. Because of this there was no use in going through with the planned innovation challenge. As a direct result the KPI “Open Databased solutions” is 0, which is not close to the target > 5 as it was described in Grant Agreement. The whole idea with the innovation challenge was to stimulate the development of new applications based on the CIM data.

The CIM pilot has been evaluated by the personnel at the Urban Transport Authority (UTA). As a result of the workshop two more KPIs were measured “Advantages for end users” and “Ease of use for end users of the solution”. The KPIs are plotted in Figure 70 and Figure 71.

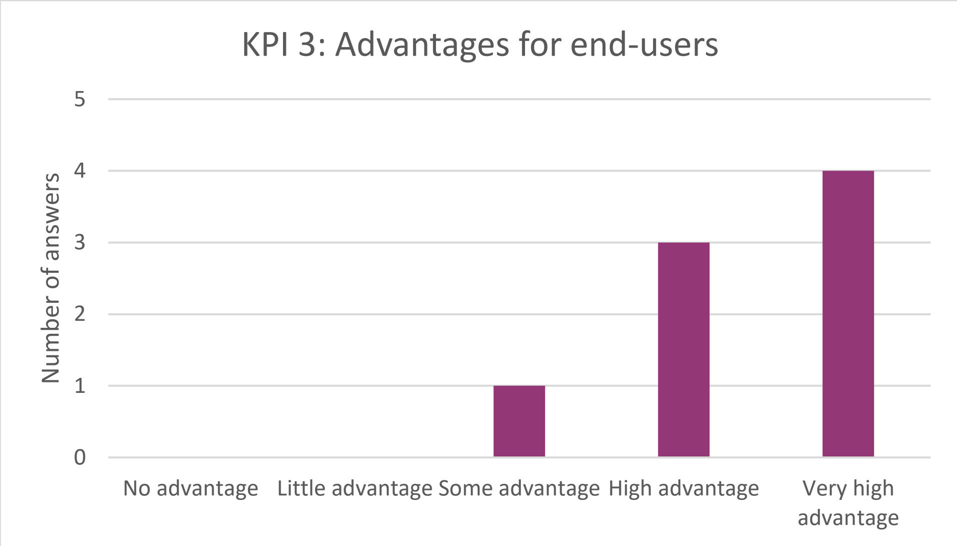


Figure 70 Results Advantages for end-users

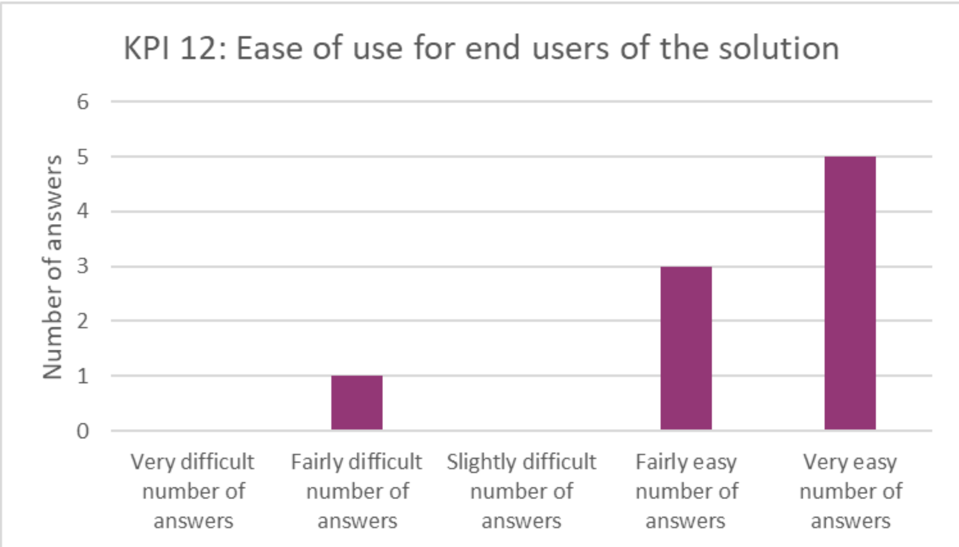


Figure 71 Ease of use for end users of the solution

The diagram shows the summed-up results. It is important to understand that the numbers of answers are more than the evaluators since the evaluators were asked to evaluate different parts of the solutions separately. Some parts of the solutions are found more valuable or easier to use than others. Se subchapter 5.1.3.2 below to fully understand what the users think. But to sum up, the users see a potential in the pilot tools, but it has some way to go before it can be usable for real.

5.1.3.1 High barriers for implementing the CIM pilot

The barriers for implementing the CIM according to the ambition initiated for the CIM pilot are very high:

Availability of BIM data:

There is not as much useable project data as we expected available. The city has not had any guidelines regarding how 3D data should be provided, so the structure of the data available are currently different for each project, which makes it hard to put in a common database. BIM requirements, like the ones produced in this project needs to be in place in order to start collecting BIM data in a structured way. These requirements will only affect the projects purchased after the requirements are in place so to build up a reasonable amount of project data in the CIM will take many years.

Sharing of BIM data:

The city has a hesitation on sharing this type of detailed data in such an easily accessible way. At first, we did not think that sharing official BIM data would be a problem or a risk, however as the project has shown how easily this BIM data could be accessed and used, the risks of malicious use also have become more evident. There is a fear that the data could be used in the wrong way. Especially for types of projects that are considered sensitive for security reasons. We have also discovered that for some projects, project data cannot be shared due to procurement reasons. Cities have barriers in sharing the data and unfortunately there are no guidelines or requirements for collecting and sharing data and therefore the processes do not move forward. There is a hesitation, and no one is willing to take the step to move further. The data is available but is only intended for use by the project. Thus, the data needs to be classed in the models so that it can be shared in the right way. The city needs to review how the digital models can be used in other phases of the project and in other parts of the administration.

These barriers have also forced the City to not go through with the planned innovation challenge, which was originally part of the scope of the project. The purpose of the innovation challenge was to encourage the usage of the shared BIM data in useful applications. But as we could not share enough interesting project information, there was no purpose in going through with the innovation challenge, as the usefulness was expected to be very low compared to the effort needed for the innovation challenge. Read more about this in Annex 2.

5.1.3.2 User evaluation

As described above the CIM pilot was evaluated by the personnel at the Urban Transport Authority (UTA). The evaluation was done in a workshop where the users responded to questions in the meeting. There were three people evaluating the CIM pilot. Two persons work with technical management of assets and one of the persons is a design project manager. The design project manager also took the role as a data supplier in the evaluation as he has recently worked in design teams in the private sector. The results from the evaluation are the following:

The BIM Data Collection tool and specification of BIM requirements

In general, the evaluators see a great value with more common, clear requirements that each project can reuse and a tool where you can deliver data from projects and that validates the data. They would highly appreciate if the UTA continues to work for an introduction of BIM requirements and a tool that validates deliveries of BIM data towards these requirements. They believe that this can facilitate the work for both management of technical assets and the project work. Management of technical assets points out that the validation part would be very valuable for them. The project management concludes that it would be easier to avoid "inventing the wheel" before each project when deciding what requirements to set. The project management also sees values in being able to share 3D models with each other between projects, especially in areas such as the Central Area, and everyone is served by getting updated information about what is going on.

The delivery requirements as such are not considered to be completely easy to understand. It could be because no one has really worked with such or with CoClass. The project management believes that most likely, the consultants who are supposed to deliver the data, will understand the delivery requirements. Management of technical assets are uncertain whether the requirements are sufficient from the perspective that the UTA is a plant owner. More details are probably needed.

The user interface of the data delivery tool is perceived by everyone as very user-friendly and easy to understand. One point of view is that you might be able to use the tool for other deliveries other than what is intended according to the pilot, for example delivery of review documents. The results of the validation were perceived as a little difficult to understand by project management but again it is believed that a consultant working in this field will understand the error codes.

Project management believes that consultants would appreciate delivering data through a simpler portal like the BIM data collection tool unless they must deliver the data elsewhere as well. It must not be too different to deliver according to the requirements, in relation to how the project work with the BIM models internally in the project. If the requirements are included from the beginning, when signing the contract, it makes it easier.

CIM data collection tool (the web-based user interface of the CIP)

In general, it is believed that this type of tool, when only containing data from the different stages of projects, would primarily facilitate the work at the UTA.

Asset management find an advantage in being able to refer people to a portal to retrieve information instead of having to look up data themselves.

Project management think it will be useful to be able to retrieve the data yourself, compared to having to find the correct persons to ask. Finding the latest data from a project's stage will facilitate when shifting stages in a project. But it is possible that an external consultant, wants to get the information from his client and may not want to download it himself from a portal. External consultants probably need more details. For example, it will not be enough to know that the construction time is from start to finish. The main benefit of the portal for projects are in the analysis and the planning phase and not so much during the implementation and completion phase of a project.

Project management sees potential in a tool like CIP being able to reduce costs and facilitate collaborations but believes the impact will be limited if the information is too general.

It is considered relatively easy to search and find data in CIP, but that may be because there is not much data. There are suggestions for improvements in the search function. Metadata about the files per project is needed.

One suggested improvement would be if you could choose to subscribe to certain projects or partial deliveries.

For future realization

Major considerations that have emerged in the user evaluation that needs to be addressed for future realization:

- how long should the models/data be saved and maintained after the construction stage
- versioning of documents
- digital maturity of all parties needs to be high enough for this to work
- level of detail, so that it does not become too general and provides the desired benefit

- how to ensure that everything is delivered as required even towards the end of the projects
- ensure that delivery requirements meet asset management needs
- user rights for consultants to retrieve data through CIP

Suggested improvements:

- ensure that the delivery requirements and validation results are more understandable
- ensure that the metadata description of the files is included in the delivery package and that the description is visible in CIP
- introduce a viewer to the data contained in CIP
- introduce a subscription service linked to the tool, to know when documents are uploaded
- multiple files should be able to be downloaded at the same time from CIP
- Small improvements in search function and also scavenging functionality

5.1.3.3 Measured KPIs

In Table 15 all the measured KPIs for the CIM pilot are presented.

Table 15 Results of measurements of CIM pilot KPIs

KPI	Parameter(s)	Baseline	Target (as described in DoW or declared)	Result
Ease of use for end users of the solution	Ratings on the Likert scale, of “Ease of use for end users”, provided by users [integer, Likert] =78	N/A – The CIM pilot is new	The ambition is that the calculated average rating given by the users should be 4 or more on the Likert scale 1-5, where 5 is very Easy, and 1 is very difficult. (Not in DoW)	4,3 Target reached
	Total number of users that have provided a rating of “Ease of use for end users” [integer]=18			
Advantages for end-users	Ratings on the Likert scale, of “Advantages for end-users”, provided by users [integer, Likert] =70	N/A – The CIM pilot is new	The ambition is that the calculated average rating given by the users should be 4 or more on the Likert scale 1-5, where 5 is very high advantage, and 1 is no advantage. (Not in DoW)	4,4 Target reached
	Total number of users that have provided a rating of “Advantages for end-users” [integer]= 16			

Quality of open Data	Number of datasets that are DCAT compliant in CIM pilot [integer] = 7	0.There is no CIM Pilot and there are no Datasets in the CIM pilot.	100% of DataSets in CIM pilot are DCAT compliant. (Not in DoW)	100% Target reached
	Total number of datasets in CIM pilot [integer] = 7			
Open data-based solutions	Number of applications using the API in the CIM pilot [integer]= 0	0.There is no CIM Pilot API and therefore there are no applications using it.	Number of applications using the API are more than 5.	0* Far below target
Usage of open source software	Number of full purchased solutions from one single company used [integer] = 1 (FME)	0.There is no CIM Pilot and therefor there are no solutions built with or without open source software.	No full purchased solution from one single company is used in the CIM pilot. (Not in DoW)	1** Below target

*The reason no Open Data based solutions based on the CIM pilot have been developed, is that we cannot share the data openly as is explained.

**We have used Open Source software as much as possible, but the FME product was needed to get the solution to work. We could not find any Open Source products that were good enough for the task.

No more KPI measuring is planned for the CIM pilot.

KPI	Parameter(s)	Baseline	Target (as described in DoW or declared)	Result
Ease of use for end users of the solution	Ratings on the Likert scale, of "Ease of use for end users", provided by users [integer, Likert] =78 Total number of users that have provided a rating of "Ease of use for end users" [integer]=18	N/A – The CIM pilot is new	The ambition is that the calculated average rating given by the users should be 4 or more on the Likert scale 1-5, where 5 is very Easy, and 1 is very difficult. (Not in DoW)	4,3 Target reached
Advantages for end-users	Ratings on the Likert scale, of "Advantages for end-users", provided by users [integer, Likert] =70 Total number of users that have provided a rating of "Advantages for end-users" [integer]= 16	N/A – The CIM pilot is new	The ambition is that the calculated average rating given by the users should be 4 or more on the Likert scale 1-5, where 5 is very high advantage, and 1 is no advantage. (Not in DoW)	4,4 Target reached
Quality of open Data	Number of datasets that are DCAT compliant in CIM pilot [integer] = 7 Total number of datasets in CIM pilot [integer] = 7	0.There is no CIM Pilot and there are no Datasets in the CIM pilot.	100% of DataSets in CIM pilot are DCAT compliant. (Not in DoW)	100% Target reached
Open data-based solutions	Number of applications using the API in the CIM pilot [integer]= 0	0.There is no CIM Pilot API and therefore there are no applications using it.	Number of applications using the API are more than 5.	0* Far below target
Usage of open	Number of full purchased	0.There is no CIM Pilot	No full purchased solution from one single	1** Below target

*The reason no Open Data based solutions based on the CIM pilot have been developed, is that we cannot share the data openly as is explained.

**We have used Open-Source software as much as possible, but the FME product was needed to get the solution to work. We could not find any Open-Source products that were good enough for the task.

5.1.4 *Business models and exploitation*

The business model for the CIM pilot is a Societal Business Model. It is described in chapter 5.2.2 in D7.6.

In general, the CIM pilot has potential of creating societal value, as time and money could be saved for the City both when managing building projects and when managing existing buildings. Also, the CIM pilot has the potential to contribute to a more sustainable society as the most sustainable information is the re-used information. To reach the potential, a lot of work and money needs to be invested, and it will take time before the benefits can be harvested. Today it is not certain that the City have the resources required to do these investments in the close future.

5.1.5 Lessons learned and activities beyond the project

There is a value and a need for collecting and sharing of BIM data. As investigated, the services demonstrated in the pilot are considered very useful, by the users responding in the user evaluation. However, the barriers for implementing the CIM according to the ambition initiated for the CIM pilot are very high as described earlier. Due to this, the CIM pilot has been dismounted.

But the work continues in other projects and forms:

- The City of Gothenburg sees the advantages with a CIM and the possibilities a complete CIM can provide the city. Work on the CIM began as an activity in the IRIS project but the potential for the future use was evident. Lessons Learned on how to integrate BIM data and on the implementation done of the 3D city database has been transferred from the IRIS CIM pilot project to the CIM project for the whole city.
- The work we have completed in IRIS provides a strong base for the continued work with BIM data. There is an expected value in being able to collect and share BIM data, but the city and UTA does not have much experience or knowledge in working with this type of data. Because of this the city needs resources to raise the knowledge base and continue the journey with BIM. The first step in this perspective is to create a BIM Strategy based on the experiences from the IRIS project. One important lesson learned from the CIM pilot is that an agreed upon BIM strategy is necessary to be able to start the journey towards collecting, saving and sharing BIM data and the work on the BIM strategy has been initiated during 2022.
- The City of Gothenburg is also implementing CIP as a city-wide service. Knowledge and experience from the work developing the test CIP in the CIM pilot has been used in this work. This service is based on FIWARE framework as well as MIMs from OASC, EU Join Boost Sustain and Living In EU. The CIP is focused on supporting sensor technology/IoT. Due to the legal complexities with information classification of the building information it will not have that type of data to start with. The reason the city is focusing on sensor technology for CIP is that it supports the desire from the different business areas to automate using IoT devices. It gives a tactical advantage to the business areas through automation as well as making the generated data available as open data where possible. Currently the City is implementing 4 business cases i.e. water temperature, freshwater consumption, soil moisture level measurements and street lighting and there are ca 30 additional business cases in a backlog for the coming years. The datasets will be published via the CIP as a part of establish as a city wide service for the different business areas and allow for horizontal integration.

- Digital Twin. In Gothenburg, many initiatives regarding digitalization are being implemented. One goal, that has been reached, is to create a digital twin (Figure 72). Virtual Gothenburg is the name of the city’s digital copy. Having a digital copy of the city, connected to real-time data, will facilitate gathering, sharing, and visualizing relevant information in one platform for planning, control and maintenance. The Digital Twin can also serve as a test bed for development and innovation striving to achieve the global sustainable development goals.

There is overall a political interest in opening data, because it increases transparency and stimulates innovation. Benefits would be improved planning and greater efficiency in execution, for instance improved logistics when building new houses or infrastructure. The major challenge is to handle security issues and abuse of certain data, which need further development.

Figure 72 The City of Gothenburg - Digital Twin

- In order to develop the concepts of CIM, digital twin and data distribution Gothenburg has deepened its understanding of FIWARE
- The Urban Transport Administration's information security work has taken several steps forward in the last few years. A permanent information security group has been established and information classification on the largest part of the information holding has been carried out. Review and classification of systems and IT applications is underway. The attention paid to the area has led to changes in the way information is shared, including the clarification of the need to protect certain information. However, before the information volumes have been classified in full by the administration, precautions need to be taken. For example, large amounts of information cannot be made available before the business has ensured that there are no parts of it that are sensitive. The business also needs to analyse how information, that is not sensitive by itself, can be used, together with other information, from other sources. This means that in short term there is a need to share less information – before full assessments have been made. In the longer term, however, it gives the administration better opportunities to share information in a secure and informed way.

5.2 EnergyCloud

Key learnings

Quality of data is usually not a topic that is highest on the agenda when starting to collect and present data. It is very common that quality of data is neglected in the beginning of these projects. However, quality of data has shown to be the biggest bottleneck in the EnergyCloud setup within the project. The local Landlords have their own systems and their own way of quality assuring, structuring and naming the data created in the buildings. To unify this and allow tenants within the ecosystem to create their own quality assurance and structure has been the biggest challenge.

Key recommendations

When applying a cloud service with data make sure that energy users can integrate and develop applications individually. The need for reports and visualization of data can change between different actors, regions, and types of buildings. Therefore, flexibility when choosing integrations and applications is very important. This has shown in the local Energy Cloud built within the project and considering all the different stakeholders there would be in applying this into a city then flexibility and ability to choose will be of high importance.

5.2.1 Overview / introduction

The transition into a smart energy system is completely dependent on data. Data needs to flow between different actors within the system in a secure and adaptable way. In the smart energy system that is currently being developed there are tenants, utility providers, renewable energy sources industries and other actors and they are all in the need of easy data access (**Fout! Verwijzingsbron niet gevonden.**). Data also needs to be quality assured so that decisions both automated and human decisions are taken based on reliable information.

The project called EnergyCloud has been aiming at creating a local version of this system to show that it is possible to share, and quality assure structured data within the energy system. The local system has been delimited to three universities and their landlords in the Gothenburg region.

By creating structured clouds of energy data all actors involved, and even entire cities will be able to utilize data in a better way and to create new value propositions. By establishing this first case where data is digitized and shared among interested actors this EnergyCloud project can work as a guiding star for other similar projects throughout Europe.

EnergyCloud has been developed in Gothenburg together with the following partners Metry (EnergyCloud), Akademiska hus, Chalmers Fastigheter (Real Estate Owners), Göteborg Universitet, Chalmers, Högskolan i Skövde (University tenants). (Figure 73). The BI consultancy company Business vision has built an application on top of the EnergyCloud platform to illustrate what can be done with structured digitized data (Figure 75).

The main activities of the project have been to:

- Set up data collections from Real estate owners.
- Validate and quality assure data, together with Akademiska hus we have identified this as the main bottleneck.
- Structure data from Real estate owners.
- Share data with university tenants.
- Workshops to get input on external application built by Business vision.

- Follow up on data collection and quality issues.
- Restructuring of the technical integration to improve quality.
- Complemented with data-knowledge and experience to Gothenburg city and their work to create an IoT platform.

5.2.2 Implementation

To allow for the benefits of digitized energy data (such as electricity, heat, water and gas) described above, Metry has within the project provided a platform where all energy data from the above-mentioned actors has been collected.

Akademiska hus and Chalmers are real estate owners measuring energy data in their buildings. Göteborgs University, Högskolan i Skövde (Skövde University College) and Chalmers are in this case tenants that are renting office and educational space from these real estate owners.

The need for data from the tenants (Universities) is based on many usage areas where the most urgent and important one is to report data within a climate initiative signed by almost all Universities in Sweden. This initiative is called the Climate Framework and more information and what Universities that has signed up to this can be found in Annex 4. Within The Climate Framework it is clearly stipulated that energy data should be followed up on and reported by the Universities on a continuous basis.

This creates a clear need for energy data, data that before this project was stuck with the real estate owners managing the buildings. In Table 16, some of the other application areas for data that was identified during the workshops are listed.

Table 16 Application areas for data

Who?	**Organisation**	**Why?**
Environmental co-ordinator	University	Environmental reports and sustainability reports creates the need for data on how much energy that has been used divided on different energy-types.
Scientists	University	Basis for scientific work where scientists need real data and real buildings for their projects.
Students	University	Basis for environmental projects and education.
Real estate owners energy controllers	Compare sustainability work and energy consumption between different universities and campus.	Raw data exports and CO2-equivalents
Environmental institutes	Other	General information about environmental impact from external actors. Raw data exports and CO2-equivalents
Politicians	Other	Use data to understand the current status and take high level decisions. Raw data exports and CO2-equivalents
Journalists	Other	Use data for reporting. Raw data exports and CO2-equivalents.

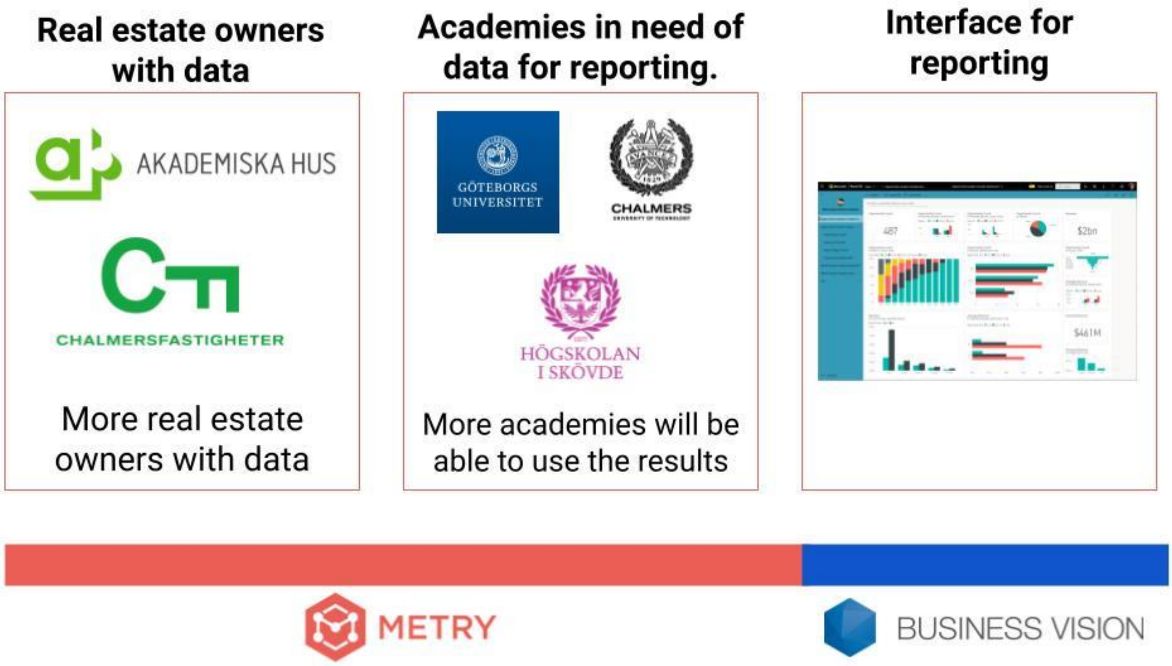


Figure 73 Stakeholder map for EnergyCloud

Based on the need to report energy data the actors within the project have set up an EnergyCloud of data with the purpose of structuring and sharing data with the University tenants.

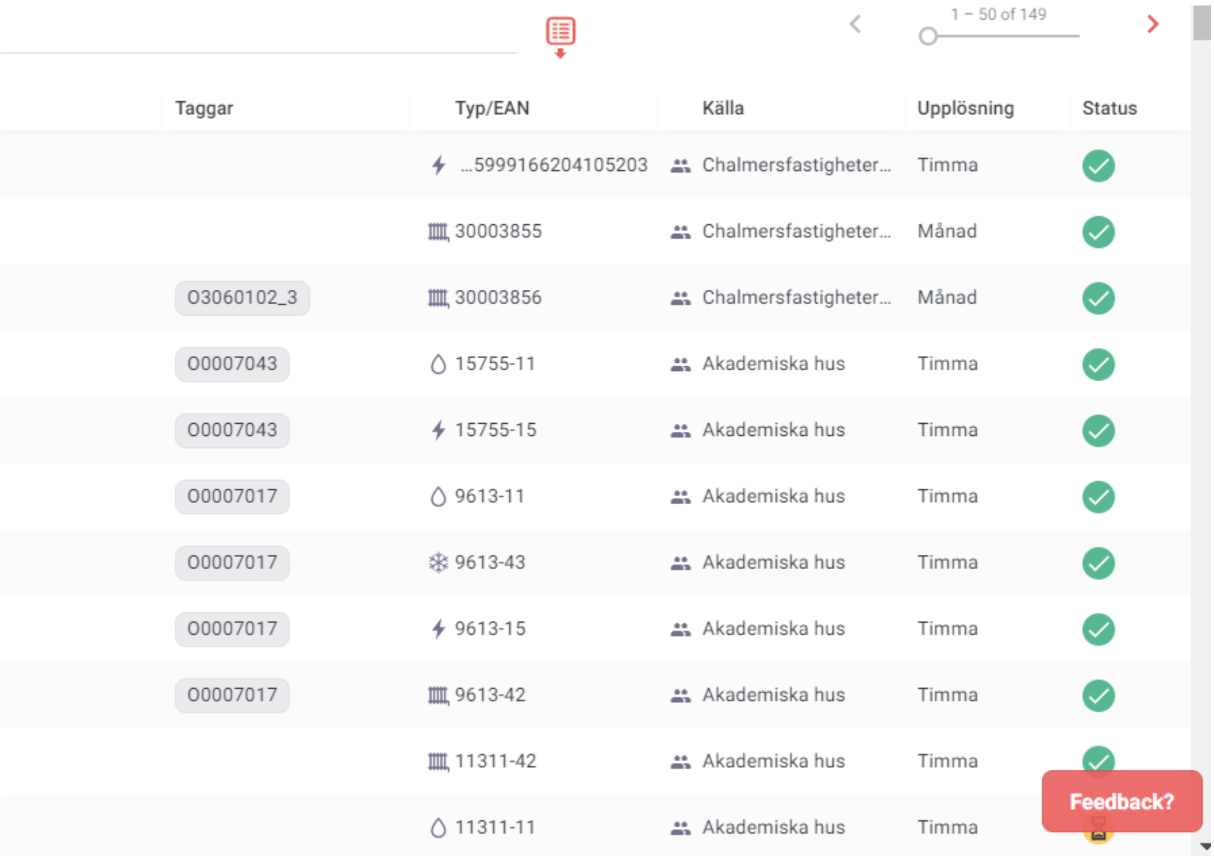
- Metry provides digital energy data and opportunity to share data between landlords, tenants, applications or even cities. Metry has connected to data from Akademiska hus and Chalmers Fastigheter within the project.
- Akademiska hus and Chalmers Fastigheter are managing a large amount of data including data from around 1 200 energy meters that have been integrated to the Energycloud platform and therefore are available to be shared with tenants.
- Chalmers, Högskolan i Skövde, Göteborgs Universitet example of HEIs (tenants) that are working on complying with the Climate Framework (Klimatramverket). With the Energycloud setup they have continuous access to the energy data that they need.

5.2.3 Results

From the real estate owners in the project the result from sharing data to the University Tenants has been that quality issues in the data have moved higher up on the agenda. When data is being used by external parties such as tenants the demand on quality increases and that puts pressure on the data providers in this case the real estate owners to improve quality of data. This has been both a positive and negative experience creating a new work-task to make sure quality issues are handled.

Quality assurance of data has been identified as the main bottleneck to scale up the Energycloud to more users. During the project the involved actors have learned that data delivered from meters are not reliable and a system to wash data and verify data is always needed. In the context of a larger volume of data such as a city or an entire country, validating data in a uniform way is crucial to be able to use it easily (benchmark, common goals or similar activities needs uniform data).

Within our local project, data has been collected for all real estate owners and shared to every tenant. This data has then been integrated to the Business Intelligence system created in Microsoft Power BI by the third-party BI-consultancy company called Business vision. Figure 74 shows a print screen from the EnergyCloud platform showing data being shared from different actors to one of the tenants within the project.



1 – 50 of 149

Taggar	Typ/EAN	Källa	Upplösning	Status
	...5999166204105203	Chalmersfastigheter...	Timma	
	30003855	Chalmersfastigheter...	Månad	
03060102_3	30003856	Chalmersfastigheter...	Månad	
00007043	15755-11	Akademiska hus	Timma	
00007043	15755-15	Akademiska hus	Timma	
00007017	9613-11	Akademiska hus	Timma	
00007017	9613-43	Akademiska hus	Timma	
00007017	9613-15	Akademiska hus	Timma	
00007017	9613-42	Akademiska hus	Timma	
	11311-42	Akademiska hus	Timma	
	11311-11	Akademiska hus	Timma	

Feedback?

Figure 74 Print screen from the EnergyCloud platform showing data being shared

Data has been shared using standard Metry API. There has been no need within the project to change the integration layer between the actors. Instead, the standard Metry API has been used when integrating data between Metry and the BI application. The actors within the project have not seen any positive effects by changing that to another format.

Within the project a BI-tool in Power BI has been developed to demonstrate how data easily can be integrated from the EnergyCloud into different services (Figure 75, Figure 74, Figure 77). The BI-tool has been developed in close collaboration with the University tenants and Real estate owners in the project.

Figure 75 Visualisation of EnergyCloud data for electricity and water consumption for a specific user.

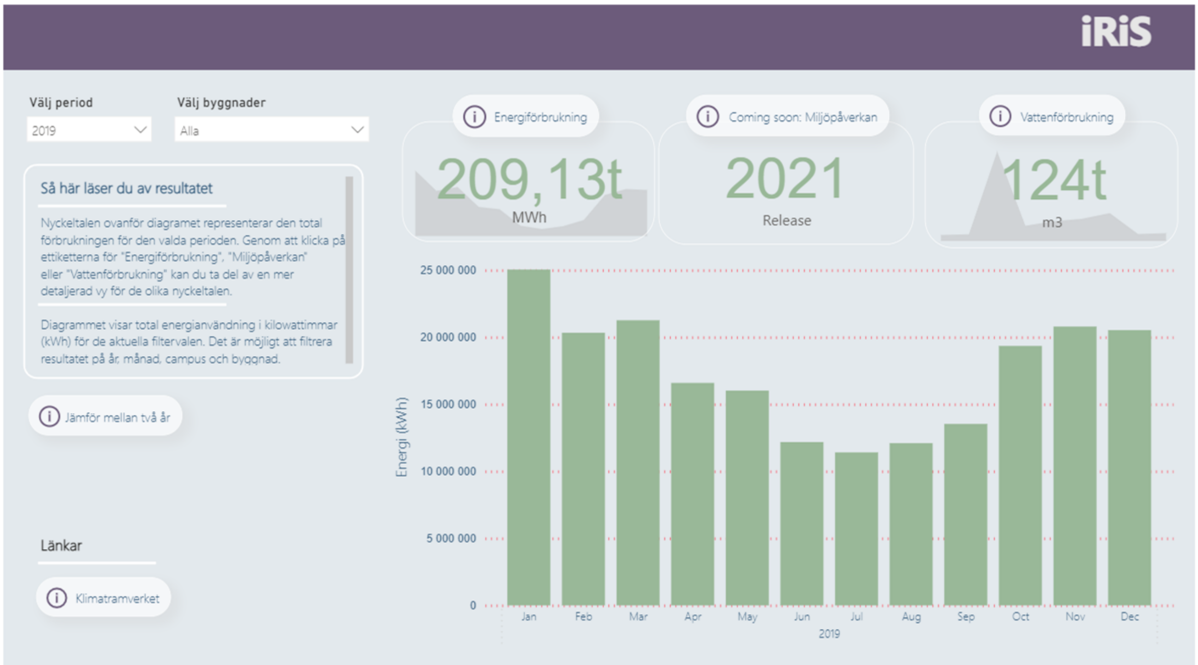


Figure 76 Visualisation of EnergyCloud data for electricity, heating and cooling for a specific user.

Figure 77 Visualisation of EnergyCloud data for electricity consumption for a specific user.

5.2.4 KPI's

Open data-based solutions and Number of services based on data

The number of services on data has within the project is one since it is only one Power BI service that has been integrated within the project. However, since data is not stored in an EnergyCloud the barrier to add new services is low. Initially, within the project the idea was that more applications from other regions would be connected to the EnergyCloud platform, but this has not been achieved.

This does not affect the demonstration that has been done and the scalability is not connected to the EnergyCloud platform but rather to the lack of quality assured data that has been described above.

Success factors within a larger project would be to not only set standards for structure but also set standards for quality of data.

Total number of datasets

The total number of datasets is not affecting the project. Reaching the level of six within the project is within expectation. In a larger scale of the EnergyCloud platform there would be a greater number of datasets and this needs to be handled by such a platform. For example, a larger volume would need datasets within not only energy but also sustainability and waste. This could include CO_2 emissions, kilos of metal, bio-waste and more.

Quality of open Data

In this KPI the quality measurement has related to using REC (Real Estate Core) standard. However, the quality issues that we have experienced in this project do not originate from any standard and are not solved by using a standard. If data have gaps, are missing or even show the wrong value there is no standard structure that will solve that. Therefore, this quality of open data measurement using 100% REC data is misleading. An example of the data structure is shown in Table 17.

A better measurement would be for example that a 100% of the monthly values within the project is collected and reliable. Or that 100% of the buildings have all datasets from the parameters available. This would better illustrate the quality of the data within the platform.

As an example, if there are 100 buildings within an Energy data platform. They can all be REC compliant but the data within this platform can still be of low quality. For examples if the meters break or constantly stop sending data. However, if the data is filtered and gaps are estimated in a standardized way the data would have high quality regardless of what standard it would comply to.

Table 17 Data Structure example

Data set	**Description**
Address	Meta information. Example: Kungsgatan 2.
Name	Meta information. Example: Bruttomätning villa.
Type	What type of consumption the meter represents. Example: electricity.
Metrics	Which metrics the meter is recording data in. Example: energy
Representation	Does this meter record energy consumption or production. Example: production.
Generation Type	Integer that represents the current meters level in a tree structure, gen 0 (root meter) is held by the owner of the meter, gen 1 is the subscribed meter held by company or person that's energy usage is recorded by the meter, gen 2 is a shared meter which has been shared with a 3rd party.

KPI's for the Energy Cloud are shown in Table 18

Table 18 Summary list of KPIs and related parameters for Measure 4.2 Energy Cloud

Parameter(s)	**2020**	**2021**
Number of services based on open data	1	1
Number of data sets using DCAT standards	0	0
Total number of datasets	6	6

KPI	**2020**	**2021**	**Target**
Open data-based solutions	1	1	Number of applications using the REC compliant datasets in the Energy Cloud demonstrator are more than 3.
Quality of open Data	0%	0%	100% of DataSets in Energy Cloud demonstrator are REC compliant.

5.2.5 Business model & exploitation

Energy-data in buildings are stuck in vertical solutions. Sharing data and integrating to third party systems is usually connected to unstructured processes and manual work. This also means that the potential value-creation that can be made from data is not utilized.

In the EnergyCloud platform all energy-related data from all vertical data sources can be collected, qualified, and structured in a uniform way. This means that everything can be stored in the same platform and same format, allowing sharing, and integrating data in a uniform way to third parties.

The platform scales in a way that makes it useful for one building but also for an entire city (Figure 76). Within this project there are discussions with the City of Gothenburg in relation to the CIP they are implementing around digital data for the city. The City has published the first datasets with sensor data and there is an opportunity to use the results from EnergyCloud within the project to implement a cloud of Energy also for Gothenburg city. Technically, this is already ready to be launched however there are organisational decisions that first have to be made within the city.

Also, other cities in Europe are investigating how to utilize data in a better way. Creating open and reliable clouds of data will be necessary for any city that wants to increase digitalization. What has been showed in the EnergyCloud project within IRIS can be scaled up to an entire city where data flows seamlessly between different stakeholders. This development is happening with energy data but also with any other data that is created within a city.

This creates several business opportunities for the results of EnergyCloud. Within the project sharing data from Real estate owners to tenants has been the use case. The USP (Unique selling point) of the results in this project is that tenants can get data shared from many property owners to the same EnergyCloud platform. A tenant usually rents offices or other facilities from more than one landlord. With the Energy Cloud, energy data can be aggregated regardless of landlord.

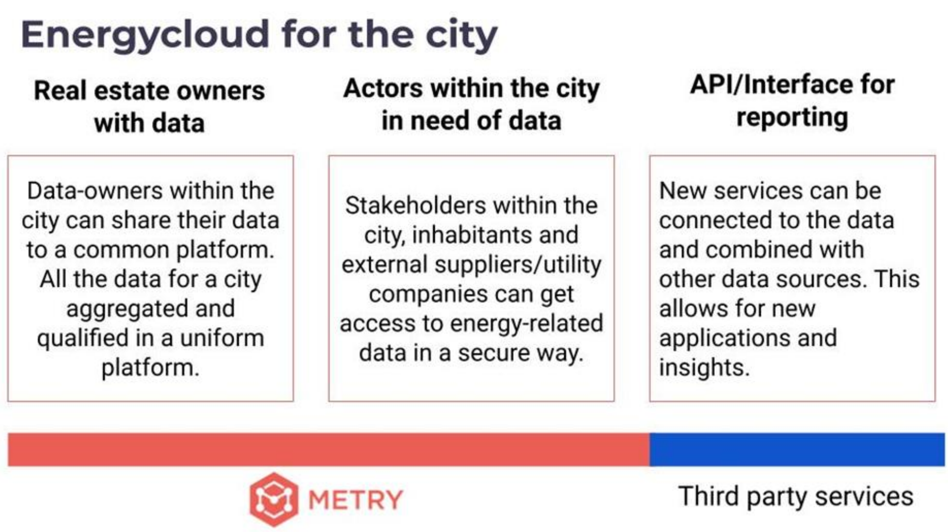


Figure 78 Business models for EnergyCloud

The business model that can be used based on this is a SaaS per meter cost where real estate owners and tenants are charged for using the SaaS platform (Figure 79).

Other value proposition that might be basis for revenue streams are for instance that the user wants an overview of what actors that can access this data, both internally and external actors. The user also wants to administrate the metering infrastructure regardless of what meters are installed in the building. All this can be done through the EnergyCloud platform.

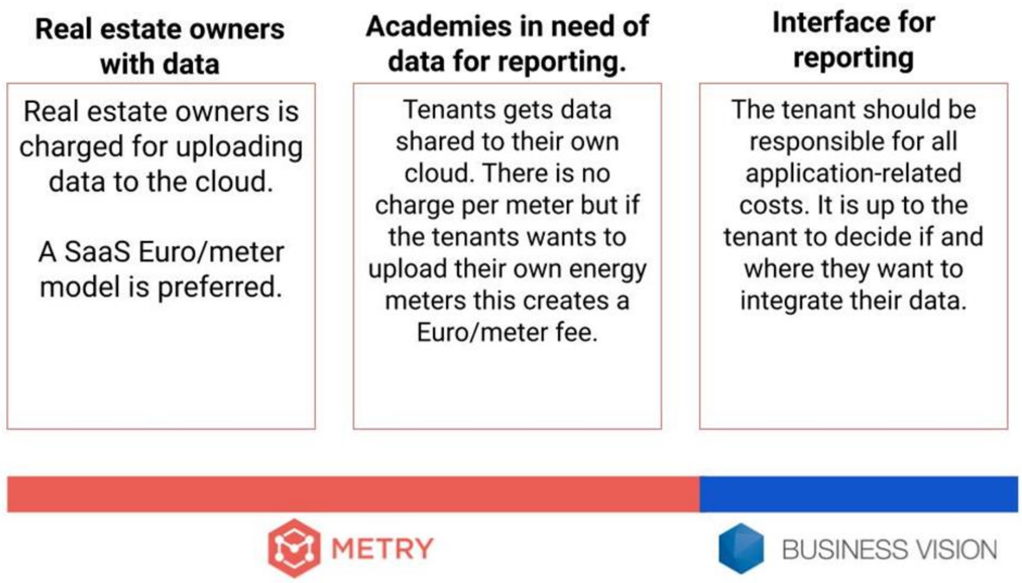


Figure 79 Business Models for Energy Cloud (2)

The business model that has been used within the project is that real estate owners are charged by the EnergyCloud provider for uploading and allowing sharing of data to tenants. When tenants want to integrate data to third party services the tenants are responsible for the cost of the third-party service.

5.2.6 Lessons Learned, recommendations and next steps

Quality of data is usually not a topic that is highest on the agenda when starting to collect and present data. It is very common that quality of data is neglected in the beginning of these projects. However, quality of data has shown to be the biggest bottleneck in the EnergyCloud setup within the project. The local landlords have their own systems and their own way of quality assurance, structuring and naming the data created in the buildings. To unify this and allow tenants within the ecosystem to create their own quality assurance and structure has been the biggest challenge.

When applying a cloud service with data make sure that energy users can integrate and develop applications individually. The need for reports and visualization of data can change between different actors, regions, and types of buildings. Therefore, flexibility when choosing integrations and applications is very important. This has shown in the local Energy Cloud built within the project and considering all the different stakeholders there would be in applying this into a city then flexibility and ability to choose will be of high importance.

5.3 Gothenburg CIP implementation

Gothenburg aspires to become a Smart City, where data from different domains can be combined to create a more vivid picture of a city. This will create new benefits for citizens, as it is the prerequisite for data-driven innovation/AI. Data sharing is central. To achieve data sharing for a Smart City, some key components have been identified: a City Information Model (CIM), which is the data model of the City data and a City Information/Innovation Platform (CIP) which is the platform used to share the data.

The earlier work done by different organisations within the City on CIM and CIP has led to a centralised project being initiated to establish a common service for CIP for all of the City. The project to establish the CIP as a service was started in the being of 2021 and is expected to have the first part of the service CIP in place during 2022. Work on CIP is expected to continue in different phases until 2025.

The CIM and the CIP of Gothenburg should not only handle static data in the form of 3D models of buildings, roads, schools, bridges, etc., but they should also be able to deal with real-time information from sensors used to measure temperature, traffic, soil moisture, bathing temperature, indoor climate, air quality, etc. Within the different areas of responsibility, the City of Gothenburg wants to create a living digital representation of the city. Therefore, a lot of data or just high-quality data within a sector is not enough. The data also needs to be in a format that makes it possible for the different systems to "talk" to each other and be scalable.

To better understand the challenges with sensor data, the City has been doing tests with technical connectivity platforms, particularly LoRaWan and 5G, to collect sensor data. For Gothenburg, the CIP will be fed with data from multiple data sources, where the first will be our IoT platform. CIP will make data available to more consumers than the original sensor/IoT solution. In other words, Gothenburg will create interoperability through CIP, maximise the value of our data by making it available to multiple consumers, make it possible to combine data with 3D models and create the prerequisites for data-driven innovation with AI, BI, etc. with standardised data models where data is interconnected. This is also an important part of the City of Gothenburg's Open Data initiative.

To meet this challenge, Gothenburg is working in both a top-down and bottom-up approach. The top-down approach is to define the requirements for CIP as a service, which will be built up of microservices, and specify how the microservices will be deployed supported and paid for. The bottom-up approach looks at different technologies to see which ones are the most capable and available for the city. In practice, this means the city needs to test different technologies to understand better how these technologies can be used to deliver the desired service described in the requirements in the top-down approach.

The first microservices to be implemented are soil moisture and bathing water temperature services. These have come a long way and will be published during 2021.

The latest developments in Gothenburg CIP and the new microservices (use-cases) are presented in detail in deliverable D4.7.

6 Final Results of Transition Track 5

Key message
In **Transition Track #5**, the City of Gothenburg has worked with different types of civil society dialogues in various operations and processes, including Minecraft, a digital tool for engaging younger citizens regarding for instance the development of a detailed plan for an area. The Inclusive Life Challenge is a concept developed for creating an arena were the city and its citizens can collaborate. Within urban development, a public tool/platform has been developed in 2012; Min Stad ("My City") and will be further developed to strengthen citizen engagement. The ME-model is a framework created to integrate the experience and learning from the three demonstrators: Minecraft, Inclusive City Life Challenge and Min Stad. The ERO application was developed and demonstrated in the HSB Living Lab, for nudging tenants to be aware of their energy use, and finally there is the VR/AR BIM application within the building "A Working Lab" where users can view BIM data and sensor data through a smartphone or a VR headset.

6.1 Overview

Within TT#5 we will present the final results of the following demonstrators in IRIS Gothenburg:

a. The City of Gothenburg works with different types of civil society dialogues in various operations and processes. Minecraft, is a digital tool for reaching the younger citizens and is being demonstrated for use of dialogue with younger citizens regarding the development of a detailed plan and a planning program. "The Inclusive Life Challenge" is a concept we have developed for creating an arena where the city and its citizens can collaborate around aspects that make citizens more included in the development of the city. Within urban development, a public tool/platform has been developed in 2012; Min Stad ("My City") (minstad.goteborg.se). It was developed for citizens where they have the opportunity to read others' or create their own contributions and suggestions for urban development and there is a need to develop it further for stronger value regarding citizen engagement. ME-model, is a framework created to integrate the experience and learning from the three demonstrators: Minecraft, Inclusive City Life Challenge and Min Stad.
b. The ERO application has been developed and demonstrated in the third generation house of HSB Living Lab, for nudging tenants to be aware of their energy use, and finally we will present the VR/AR BIM application within the office space of "A Working Lab" where BIM data and IoT data can be visualized through AR (Augmented Reality) or VR (Virtual Reality).

6.2 Minecraft, Inclusive Life Challenge and ME-Model

6.2.1 Implementation

The purpose of the application of the Minecraft tool in the planning project is to investigate how Minecraft can be used as a tool to engage children in a citizen dialogue. In the planning process that so clearly affect children's local environment and everyday life, it is of extra importance to strive to start from the children's own perspective. The hypothesis is that the application of Minecraft can facilitate dialogue with children, by the form of a computer game is both engaging and easily accessible to many children, and ultimately increase children's ability to influence the development of their local environment. The purpose of the six completed workshops is to get an idea of how the tool can create an understanding of the planning process and its different perspectives, as well as generate issues that can be used as a basis for in-depth dialogue. The workshops have not primarily aimed to acquire knowledge for the planning process, but to test and evaluate Minecraft as a dialogue tool. Overall questions from the workshops:

- Can Minecraft be used as a tool to gather knowledge for work on detailed plans?
- What information is possible to collect using this tool?
- Is this application of the tool suitable for increasing the interest and knowledge of schoolchildren in urban development issues?

Minecraft at Bergsjöskolan

- Children and youths at Bergsjöskolan were invited to participate in two Minecraft workshops during easter holiday week 2020.
- The working group for the Bergsjön workshops has consisted of the City Planning Office, the Cultural Administration, the NGO Bergsjön 2021 and the initiative Skolan in the center of the village/suburb (Skolan mitt i byn).

Minecraft at Lärjeskolan

- Children and youths at Lärjeskolan in Hjällbo has been invited to four workshops during April and May 2022, during the so called Consultation of the Planning Program for the area.
- The working group for the Hjällbo workshops has consisted of the City Planning Office (project manager, planner, and Minecraft specialist) together with Hyresgästföreningen and consultants from White architects and Göteborgsregionen (GR)

The Vice-Chancellor at Lärjeskolan approved the schools participation. The activity was performed within the Samråd and Child Consequence Analysis (BKA) for city development program for Hjällbo (**Fout! Verwijzingsbron niet gevonden.**), which aims to densify and quality-enhancing measures of the public spaces.

The activity was carried out through four workshops with 100 pupils at Lärjeskolan in April and May 2022. An architecture educator / pedagogue was leading the work. The differences from the workshops at Bergsjöskolan was to test Minecraft as a dialogue tool with a large group of children, within the education and within a greater scale of planning project.

- Time of implementation: –April-May, 2022.
- Implementation resources: Project Manager: Anna Reuter Metelius (City Planning Office), Minecraft specialist: Robin Nilsson (City Planning Office), Planner: Jesper Adolfsson (subcontracting), Architecture Pedagogue through subcontracting: Kajsa Sperling, White, Gaming Pedagogue Felix Serrao.

In April 2022, four Minecraft workshops were conducted over two days, April 7th and 28th, at Lärjeskolan in Hjällbo (Figure 80). Lärjeskolan is located in an area that is relevant for a new planning program for urban development. About 100 children in four different grades (grades 4, 7 and 9) participated in the workshops (Figure 81, Figure 82). The workshops were conducted by the City Planning Office in collaboration with the Tenants' Association, the Gothenburg Region and White Architects. On-site participants were responsible for the planning work, architecture and game educators, technical managers and class mentors. The workshops aimed to test Minecraft as a tool for dialogue with children and young people. They also aimed to gather knowledge about the children's views on the area and what they want to change. The results were exhibited during the Hjällbokalaset in May 2022, which is an event for everyone living in Hjällbo with entertainment and activities for all ages. The implementation is described in more detail in Annex 6: The Hjällbo Minecraft Method for engaging children in urban development.

Figure 80 The area Hjällbo. Aerial view.

Figure 81 Children working in Minecraft during one of the workshops.

Figure 82 Final exposition of the results of the Minecraft workshops.

Inclusive Life Challenge

The Inclusive Life Challenge is a concept developed for creating an arena were the city and its citizens can collaborate around aspects that make citizens more included in the development of the city. Inclusive Life Challenges can be carried out in various formats. In IRIS we implemented the Inclusive Life Challenges as a part of the Bachelor's degree level course *Leading in a Digital World* at Chalmers University of Technology in Gothenburg, Sweden. The course has dual purposes: 1) To teach students about strategic thinking and leadership in a global and digital world, by teaching them how to use new technology to transform value creating activities both in organizations as well as in society: 2) To help a city (in this case the City of Gothenburg) to fulfill its vision towards a Smart City (regarding circularity and sustainability). The students were expected to develop a digital innovation and accompanying business model.

In total, 100 Chalmers students divided into 18 teams, worked on their ideas in their live case projects for the City of Gothenburg over a timespan of eight weeks. The course started in January with a kick-off lecture and during March to May, the Innovation pitch videos were displayed online for public voting and the Innovation pitch posters were planned to be displayed at an exhibition area in the city. Unfortunately, the pandemic restrictions gave obstacles for the physical exhibition, and it was presented online.

Each team had to select an innovation focus area and geographical location, i.e. one of the boroughs of Gothenburg. The teams worked on ideas about reducing food waste, improved mobility and air quality, water use management, a student accommodation platform, waste sorting and connected urban farming. To develop a solution to their challenge, the teams had to collect market information, use open data provided by the City of Gothenburg and available from other sources and test their own as well as others' assumptions. This implied that students had to engage the stakeholders of their ideas to their work by having e.g., dialogues with them. Towards the end of the eight weeks the teams pitched their digital innovation solution to the City of Gothenburg's jury, the citizens of Gothenburg, the faculty, and their fellow students and tried to convince them that it is a great innovation for the City of Gothenburg and its citizens.

Min Stad and Min Stad 2.0

In order to understand the users of the digital platform Min Stad (platform provided by the City of Gothenburg with the potential to be used for city development, Figure 83) we invited a pair of students at Chalmers University of Technology to conduct a study as a part of their Master's degree on what motivates citizens to use the digital platform Min Stad and how to develop *Min Stad* as a dialogue tool. The 30 ECTS Master's thesis project was conducted August 2019 to January 2020. The Master's thesis (Report No. E2020:123) by Helldén and Zhao is attached in the Appendix.

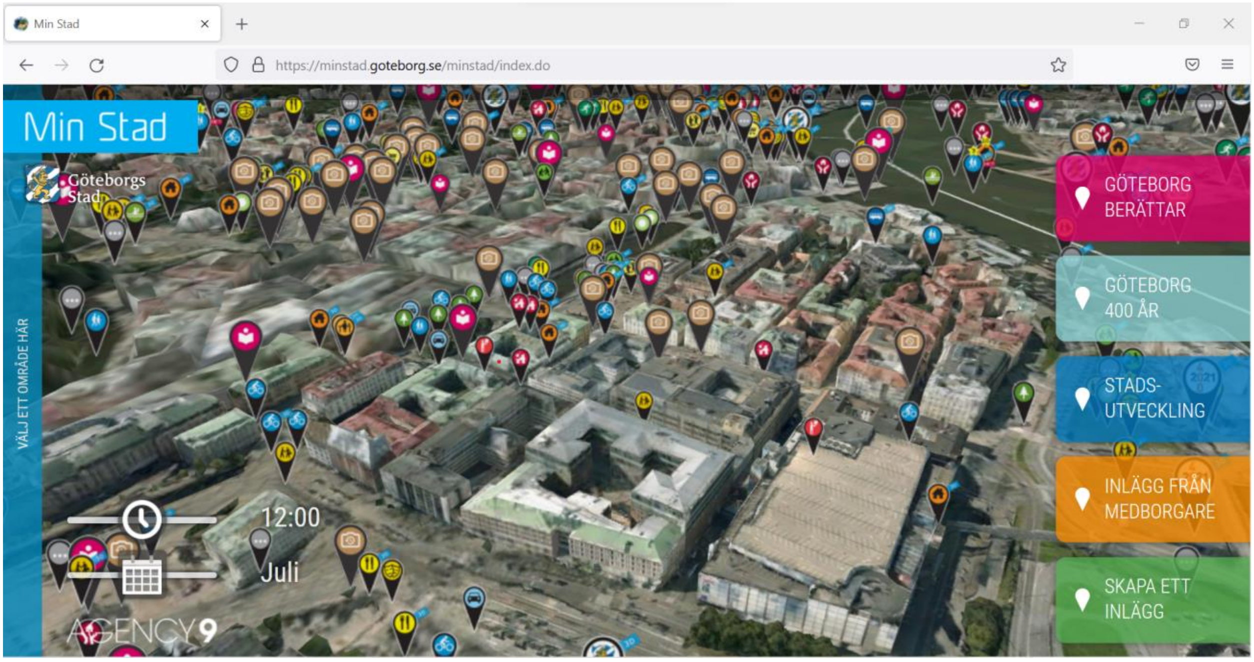


Figure 83 A screenshot of the application Min Stad

"Min Stad" (My City) was created as a website in 2012 by the city of Gothenburg and has later also been launched as a mobile application. The application was intended to serve multiple purposes for the city such as:

1) Idea inbox: citizens can suggest ideas on things that need to improve within the city and tag them with a specific subject on a specific location
2) Visual information sharing: the city can visually share information on various city development or infrastructure projects that are going on or are planned around the city
3) Story sharing: both users and the city can share stories or historical facts behind specific geographic locations within the city

The website and the app are 3D-maps over the city where users can explore all posts that other users or the city have posted throughout the city as well as post their own contributions. Min Stad has a total amount of more than 1400 posts from citizens. A post is often a short comment e.g. "this traffic light is broken" or "rebuild this city area to a large park". **Fout! Verwijzingsbron niet gevonden.** shows a screenshot from the application. Min Stad was not supposed to operate as a dialogue tool between citizens and the city in its original form. However, as became evident through the master's thesis project, citizens were lacking this aspect of the app.

During 2020 a small group of people lead by Ola Setterby at City Planning Office started to further develop Min Stad into Min Stad 2.0 to explore how the digital platform could be used as a tool in the dialogue between citizens and the city around city development. This new version of Min Stad was used during the consultation of planning program for Hjällbo. The plan proposal was made visible in 3D in Min Stad and accessible on IPads at a local Open House during five occasions April-June 2022, for dialogue at the city centre in Hjällbo. In that way citizens and planners could have a dialogue about the plan proposal while "walking around" among the planned buildings. It was also possible to zoom in and out and study the proposal from different angles in the city scape (Figure 84). The dialogue could take place both around the IPad in the room and through written comments in the MinStad application.

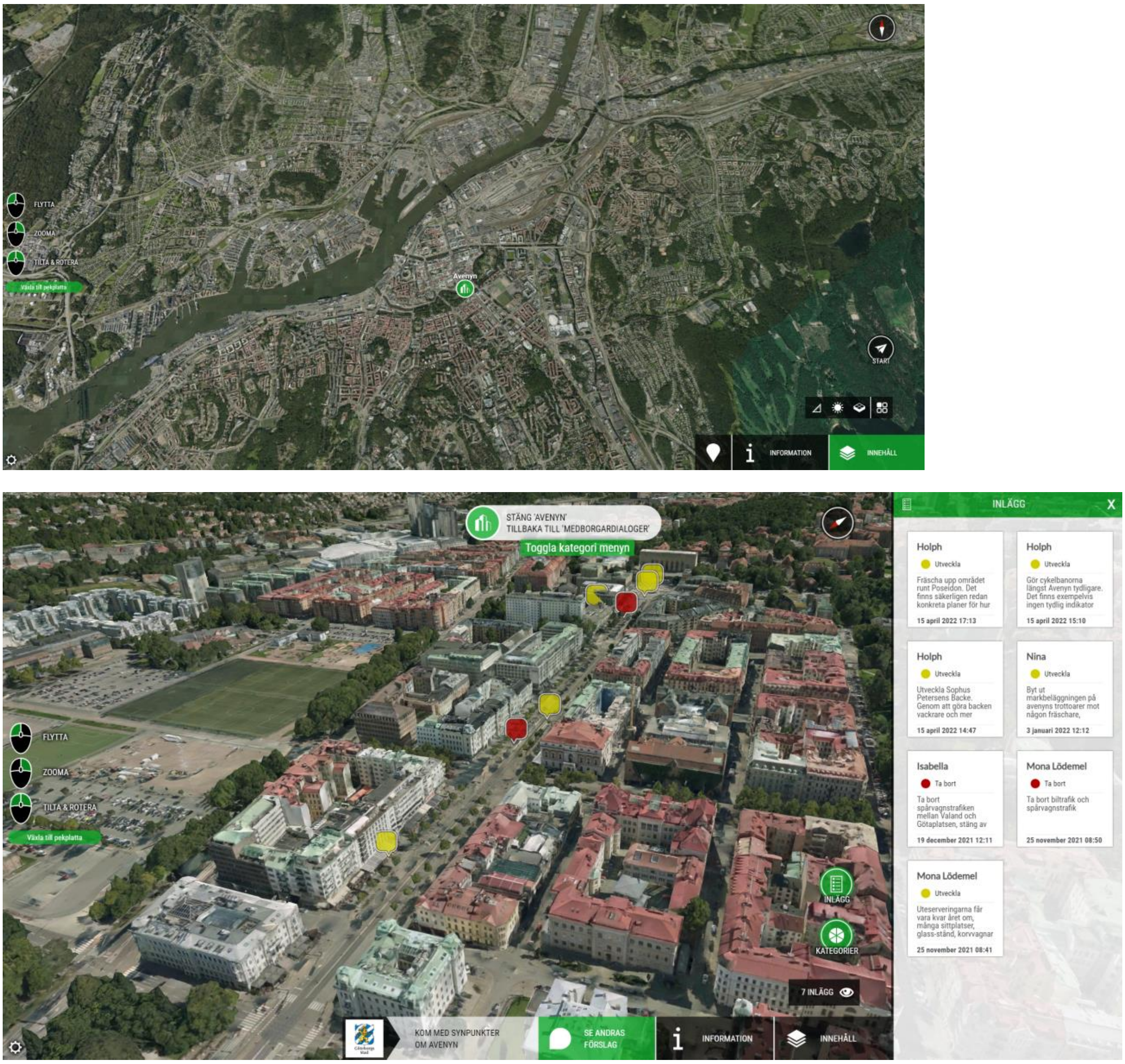


Figure 84 Screenshots from the application Min Stad 2.0

ME-model – citizen engagement model

The fourth demonstrator; the ME-model (Table 19) is a framework created to integrate the experience and learning from three demonstrators: Minecraft, Inclusive City Life Challenge, and Min Stad/Min stad 2.0. The purpose of the model is to contribute to the city's further work on citizen engagement by means of digital platforms by highlighting what rights and obligations i.e. pointing to for example expectations citizens as well as the city have when launching digital platforms to engage citizens in city planning and development. The ME-model can also be applied for discussing what kind of organization and facilitation the various types of citizen engagement require. The ME-model has been developed through a series of workshops mainly with staff within the city of Gothenburg working with tasks related to citizen engagement, democracy, and city planning.

Table 19 ME-model for citizen engagement

Method to engage citizens	**Minecraft**	**Inclusive Life Challenge**	**Min Stad/ Min Stad 2.0**
Mode for engagement	Face-to-face and digitally	Face-to-face	Digitally/Face-to-face and digitally
Purpose with engagement	Build relationships with citizens and create interest and understanding for city development and governance	Get ideas from citizens	Enable dialogue between citizens/Receive feedback and ideas from citizens
Engagement in what phase	Idea generation and implementation	Idea generation	Idea generation and complaints/ Idea generation and Implementation
Direction of engagement	City together with Citizens	Citizens to City	Citizen to Citizen/ City together with Citizens
Citizens' expectations on the City	Provide information and feedback to citizens Show need and interest	Provide information and feedback to citizens	Provide information and feedback to citizens/Provide information and feedback to citizens, Show need and interest

Type of engagement	Citizens are informed	Citizens give feedback	Citizens have dialogue with each other or the city	Citizens co-create with each other or the city
Inclusive Life Challenge	Yes	Yes	Yes	Yes But could be improved
Min Stad/ Min Stad 2.0	Yes	Yes	No/Yes	No/Yes But could be improved
Minecraft	Yes	Yes	Yes	Yes But could be improved
City engagement and role	Provide citizens with information	Respond to citizens' feedback	Provide information and respond Show interest in the citizens	Provide information and respond Show interest Provide tools for co-creation

The ME-model shows that the moderators used implies that the city was interacting with the citizens in different ways: informing them, receiving feedback from them, having a dialogue with them, or even co-creating with them. What we learnt from the demonstrators was that the Inclusive Life Challenge and Minecraft has even more potential for engaging the citizens in co-creation but the prerequisites for this needs to be improved and the city needs to improve their organizational capability to engage in co-creation with the citizens. The model also shows that the different moderators require varying levels of engagement from the citizens as well as changing types of engagement by the city, which implies that it should be clear in “the contract” what expectation the city and citizens can have on each other.

We have also thought of the demonstrators in the light of city governance issues. Hilgers and Ihl (2010) (2) have developed a framework for citizen engaged governance outlining three main types of citizens engagement – citizen ideation and innovation, collaborative administration, and collaborative democracy - that can be part of the city’s advancement towards a more open governance model were citizens play a crucial role. We mapped our three demonstrators in relation to these three types and found that they can be considered as examples of how to design citizen engagement in accordance with the Hilgers and Ihl (2010) framework. As illustrated in Figure 85, the Inclusive Life Challenge conducted with students at Chalmers University of Technology demonstrates how citizens can be engaged in ideation and innovation, the Master’s thesis based on Min Stad and the results from the use of Min Stad 2.0 in city development in Hjällbo demonstrate that a digital platform has the potential to become a tool for collaborative administration, and the Minecraft event at the primary schools demonstrate that a digital game and play can engage citizens and enable collaborative democracy.

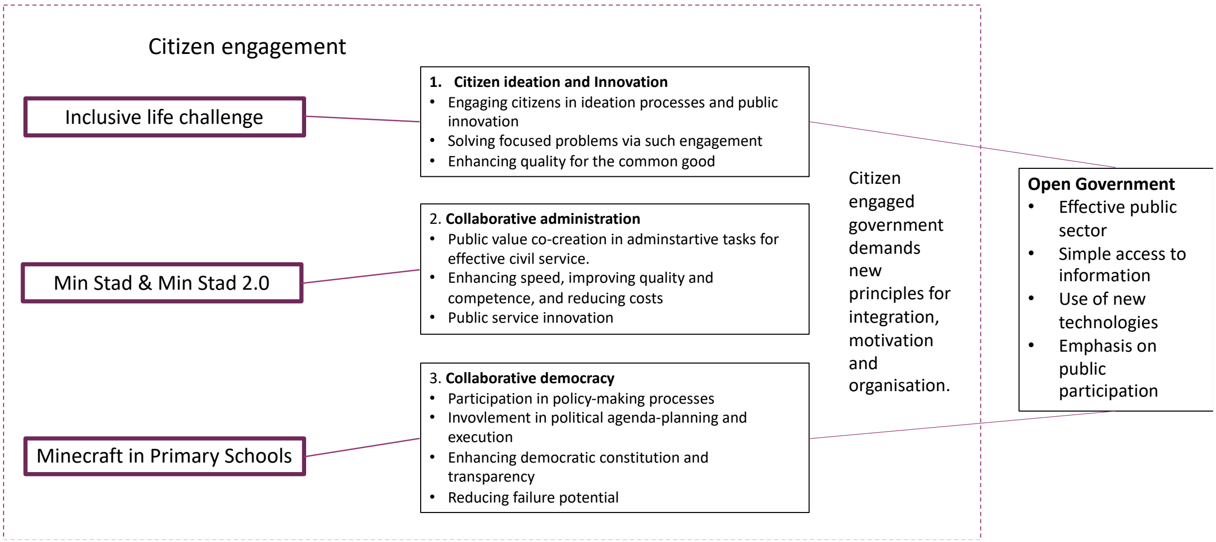


Figure 85 Citizen engagement for participatory city modelling and open governance.

6.2.2 Final results

Minecraft Bergsjöskolan, Bergsjön

Minecraft has been valuable above all in understanding the scope and volume of the changes proposed, which may otherwise be too abstract to have thoughts and opinions about. It should be taken into account that the children who participated have been invited to use Minecraft. We should therefore read the conclusions on the basis that the initial workshops have been carried out with participants who have an interest in and prior knowledge of the tool we are going to test and evaluate.

We have used several of the questions from the working group, regarding children's movement patterns, relationships with the district, etc., to have something to apply "Can we use Minecraft to extract information from children and young people in urban planning projects" on. Because we had so few participants, we can't draw such big conclusions, but the children and young people who were there have all expressed that it has been fun to play Minecraft and that it has helped them understand what the proposal for the area means.

Using the game Minecraft as a tool requires a certain structure and guidance. On the one hand, we use the play signal in the tool to engage children and young people, but on the other hand, we need to drive the investigation through the game to extract information. There are elements in the game that can take the focus away from what we want to explore. The fact that there is suddenly night and monsters appear in the district we inventory is exciting for the player, but at the same time can be distracting for the mission.

- Can Minecraft be used as a tool to gather knowledge for work on detailed plans?

Minecraft has been used in this project to contribute to a better understanding of the planning area and the suggestions available for the development work.

The game itself has not gathered knowledge but has been used as a tool to give participating children as clear information and understanding of the subject and area as possible. Based on this, the children and young people who participate can formulate questions, thoughts and opinions that can then be used as knowledge in the work with detailed plans.

The game includes opportunities to visualize ideas and suggestions, but it has not been included in this feasibility study.

- What information is possible to collect using this tool?

The definition of a tool is that it facilitates the work. The question is not whether Minecraft can be used completely independently to gather information, but the premise is that it is used in a context - educational or rhetorical.

Minecraft can be used as one (or one of several) tools in dialogue methodology to help gather whatever information children and young people might have to contribute.

In this case, Minecraft has been used in conjunction with more dialogue tools, and all participants have expressed a positive attitude towards experiencing the environments that underlie the questions in the game. The assessment is that it may feel less abstract to experience the volumes of suggestions in the living gaming environment, compared to seeing renderings, floor plans or sketches. The play aspect of exploring a topic within a digital game can also make it easier to get away from what we call the school effect - that is, that children perceive that there is the right answer to questions asked by adults, and that in the classroom they would like to answer what they think the questioner wants to hear.

- Is this application of the tool suitable for increasing the interest and knowledge of schoolchildren in urban development issues?

Schoolchildren participating in dialogue projects are generally composed in groups based on age and where they live. A class therefore consists of individuals who can be at very different levels of prior knowledge, have widely different interests and prefer different techniques both to absorb knowledge and create information.

If the objective of a project is to formulate as nuanced and comprehensive a children's perspective as possible, the dialogue tool Minecraft is appropriate to apply and include in the work on, for example, detailed plans.in a dialogue methodology that is designed based on the scope, conditions, issues and need for results of the specific project (Figure 86).

The two initial workshops have aimed to test and evaluate Minecraft as a dialogue tool, together with students from Bergsjöskolan, and to start formulating questions among participating children and young people. The goal is to understand how the dialogue tools can be used and the issues we find will serve as a strong basis for in-depth dialogue in the continued work with BKA in the planning process.

The three meetings that were carried out have been perceived as positive, and participating children and young people have enthusiastically and generously engaged in the challenges presented to them.

The experience of Minecraft as a tool is that it can be rewarding and valuable in dialogue projects with children. It is an open and adaptable tool, which can facilitate certain aspects of an investigative and creative process.

We may include questions regarding extended uses (as in this preliminary study we have tested a limited area), how the participants' existing interest in the game and prior knowledge affects their use, and what accessibility looks like as the game requires access to computer, tablet, or smart phone as well as software.

Minecraft Lärjeskolan, hjällbo

Competence Important skills for conducting workshops in a good way:

- Technology skills, how does the game work and how to create the Minecraft world.
- Pedagogical competence in the use of games in teaching.
- Class educators/mentors
- Urban planning/project competence
- Architecture/designed living environment competence with extensive experience of meeting children and young people

Structure/process. Reflections on completed workshops:

<u>The importance of how to appeal to the children:</u>

- Not judgmental and not evaluative. Focus on constructive feedback.
- Allow students to build and be creative without adults “putting words in the children’s mouths" which would have shaped their thoughts and what they are building.
- Listen to students.
- By putting the main focus on Minecraft as a communication tool, the students felt more confident and stimulated to express themselves than if analog methods were used. A tool that students are used to. The students are experts in the tool and the adults are experts in the process. Helping each other, good for the community of students.
- Good to focus on the build while the conversation is taking place compared to asking questions straight face to face.
- Good to let them get started before we asked lots of questions.
- It is important to describe in the report something about the connection to the place Hjällbo and the student base and how important the above points then become for the creative process to take place and that the students do not close themselves.

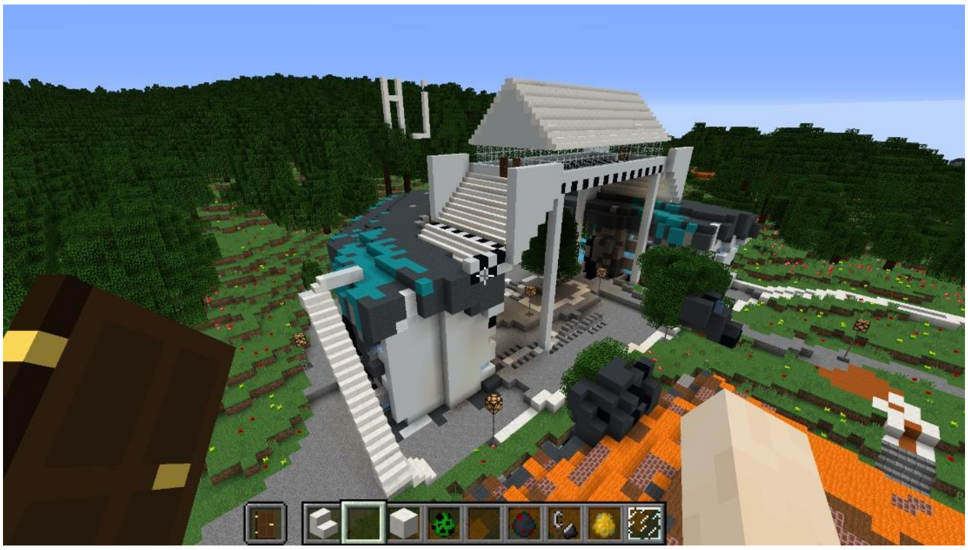


Figure 86 Screenshot from Minecraft application

<u>Equipment/Technology</u>

- One computer per two students, stimulated dialogue.
- Technology support and support in Minecraft important, many questions from both experienced and inexperienced students
- Clearly marked computers with numbers and with the possibility of being connected afterwards to maps showing where they built, demolished, and put lanterns and pumpkins.
- Clear instructions on how to control different functions in Minecraft such as time and weather.
- It would have been good if all the adults in the room could Minecraft basics so that there were no waiting times to get help. I couldn't help them with the simplest and it would have been good to know ten commands at least. How to move forward, how to remove something and how to build...
- "It would have been much easier if the students themselves had made some screenshots at angles that they think capture the most important of their builds. Then their thoughts and constructions can be more easily communicated with others, both in an exhibition and in contact with the actors who could carry out their projects together with them.

<u>Exhibition</u>

- Successful with an exhibition so that the children and young people saw that their constructions and reflections were taken care of and shown to different actors. It increases the possibility of realizing the children's ideas and increased knowledge of, for example, the city and property owners. In this way, the questions can be taken care of and landed with each actor
- Dialogue possible in connection with an exhibition on urban development issues, for example linked to the plan
- Positive to invest in the exhibition, with opening with Minecraft tablets and computers, etc. to create a meeting place and positive memory around dialogue work. But all the more important that the ideas are followed up and to some extent realized so that it did not "just" become an exhibition
- During the exhibition, there was an opportunity to look at the planning program in Minecraft and walk around in that environment and look around.

Follow-up and consequences

- It is important to have a plan for how students' ideas are taken care of and at best realized. If it turns out that it is possible to find funding for certain measures, how will young people be involved in further work? Students need to get feedback on what happened to their ideas and how the plan is moving forward. A great responsibility rests on us not to create frustration and disappointment. We want to be part of the solution, not part of the problem.
- It would have been interesting to see if it would have been different if Hjällbo hadn't been in Minecraft and if it had changed the result. Especially considering that not all cities or neighborhoods can bring out their area or neighborhood in Minecraft.
- Data from maps is very valuable to be able to partially see which parts of the district you want to influence and see what changes have been made.
- Create a model and process that can be used/ordered by several parties to be able to collect citizens' opinions and create dialogue. Is this a further development that is to be done or can it be included as part of the report?

Inclusive Life Challenge

The Inclusive Life Challenge activity engaged citizens in mainly three ways:

- Students taking part in the course: The 100 students taking part in the course and working with their live case projects in collaboration with the City of Gothenburg were very engaged as they were working with issues concerning their own surroundings, which had a positive impact on their learning as well as their understanding of the challenges that their city is having.
- Representatives of stakeholders of the ideas developed: To develop the digital solutions addressing these challenges the students had to engage citizens in the process. Although few, the perspectives collected by means of interviews were important.
- The general public: The citizens could engaged in voting for the ideas on the homepage of the city and they appreciated the opportunity to get involved in the process by showing their preference.

The winner of the Inclusive Life Challenge Matvinn (Figure 87) impressed both the general public who voted as well as the jury. Matvinn is an app to enable the saving of food waste from school kitchens by allowing students' parents to bring food boxes home with leftovers. Thus, Matvinn solves two issues simultaneously, i.e. the climate impact of food waste can be reduced while the everyday lives of families are made easier. The app was not fully developed during the course, but the team has been in contact with a school in Gothenburg, Sweden, that has shown interest in the project. The winning concept were also addressed by at least two housing companies within the city of Gothenburg that were interested of a collaboration. Unfortunately, the students were split geographically and did not have the possibilities to develop the concept together with the interested parties.

Figure 87 The poster for the winning idea Matvinn

Min Stad and Min Stad 2.0

The master's thesis based on the Min Stad app was sent to the three persons working for the city that took part in the study and were interviewed. The students put forward some recommendations:

1) the city's purpose with the platform Min Stad needs to expand beyond that of an error reporting/complaints channel or graffiti board for citizens since it has potential to motivate citizens to be engaged and responsible co-creators of the city

2) the city's purpose with the platform Min Stad needs to be clarified for the citizens to mitigate expectations, either in its current form or if developed into a platform for co-creation with the city

3) developing the platform to reach critical mass is required, and that one approach to growing could be through a beachhead strategy commonly used by other successful digital platforms.

In the master's thesis project, the citizen engagement activity on the Min Stad platform was analysed and the results show that the number of posts has steadily been declining from around 350 posts in 2012 to less than 50 posts in 2020. Interviews with users of the platform were conducted. The interviews revealed that people viewed the platform as a tool for communication, mostly with the city but also with other citizens. The users expected some sort of feedback or response on their posts and felt like their efforts were useless when they did not receive any reaction. With feedback they meant a comment from the city or a fellow citizen. The users perceived the platform as "dead" and thus trying to achieve anything on it felt pointless. They said that the value of feedback is enough to motivate their efforts on the platform even if their suggestions are not implemented. The analysis of the interviews indicates that the main reason users are not returning to the platform is caused by the lack of feedback and the low level of activity on the platform.

To contribute to the understanding of citizens' motivation to participate in the development of their city a concept called *citizensourcing two-factor motivation,* building on previous motivation research on dissatisfiers and motivators, is presented (see Table 20).

Table 20 Citizensourcing two-factor motivation (Helldén and Zhao, 2020)

City Life Conditions	Citizenship Identity
Safety	Achievement
Mobility	Recognition (by fellow citizens and politicians)
Infrastructure	The work itself
Public goods	Growth
City tax rate and fees	Responsibility
City rules and regulations	

City Life Conditions are dissatisfiers meaning that these are basic need of citizens and fulfilling them results in citizens who are not dissatisfied but not necessary engaged. *City Life Conditions* refer to the conditions of citizens' city life, i.e. their life outside of work and home. Citizens expect these conditions to meet their expectations as a citizen in the city and will not become more motivated or happy with their life even if these factors are much better than expected. However, if one of these City Life Conditions is not working as expected, they can cause a citizen to become very dissatisfied with their life as a citizen in the city. One example is that a citizen can be expected to be dissatisfied with their city if public transportation (mobility) is not working according to expectations.

Citizenship Identity are motivators meaning that they are factors motivating citizens to engage in the development of their city. However, as stated above, the City Life Conditions i.e., the dissatisfiers need to be fulfilled for these factors to function as motivators. Citizenship Identity motivators refer to citizens in a city life setting, outside of home and work. These motivators build on the idea that an individual knows that he or she belongs to a social group that holds a common social identification and thus strives to become a good member of that community to feel good about him/herself and receive status within the group of other citizens. This citizenship identity motivates them to contribute to the community i.e., the city.

Min Stad 2.0 used within the consultation of Hjällbo allowed spatial discussions about planned changes in the area without having to get to the specific location. Citizens of different ages were engaged in looking at the projects in the digital place form.

6.2.3 KPIs, social KPIs, short- and long-term effects

KPIs and social KPIs

The three demonstrators Inclusive Life Challenge, Minecraft and Min Stad are focused on citizen engagement. It is challenging to indicate higher levels/stronger citizen engagement such as trust with quantitative measures, since more participating citizens do not necessary mean more engaged citizens. Nevertheless, different aspects of the demonstrators are captured in the listed performance indicators

(Table 21) to capture the progress towards citizen engagement that each demonstrator has contributed with. None of the demonstrators covered more than 10% of the population in the city. However, the demonstrators were not designed to engage all citizens but a smaller important and critical sample, e.g., children and local community members in an area undergoing city development where the attitude towards the city and the development plans have not been positive. The activities generated high engagement from the participating citizens, which enabled dialogues building trust and understanding. These dialogues are essential for building long term citizen engagement. As shown in the table X all activities have high potential to be used for co-designing the city as well as attractive and inclusive services. However, there is space for improvement regarding the ability of the city to use citizen co-creation as is indicated in the "organizational readiness" KPI.

Table 21 KPI Table for citizen engagement activities

KPI	**Minecraft** (events outside of school hours)	**Minecraft 2.0** (events within school hours)	**Inclusive Life Challenge**	**Min Stad (from start to 2020)**	**Min Stad 2.0 (from 2020 to 2022)**
Participatory governance	1: 0-10% Available for all students at Bergsjöskolan who saw the announcement for the activity after school.	1: 0-10% Available for approx. 100 students in total four classes at Lärjeskolan.	1: 0-10% Available for everyone who saw the voting platform at City of Gothenburg's homepage	1: 0-10% Available for everyone who had a facebook account and downloaded the Min Stad app.	1: 0-10% Available for everyone who has an e-mail address and downloaded the Min Stad 2.0 app or participated in Hjällbodagen (an event in the neighborhood where the city has ideas for development) and used the tablets there.
Local community involvement in planning phase	2: Low involvement (quantity) (but high engagement from few)	2: Low involvement (quantity of the local community) but high engagement from few. / 4. High einvolvement of the ones invited.	2: Low involvement The task for the students was to involve a few stakeholders i.e., to talk to people that have an interest in their idea	2: Low involvement (quantity) but high engagement from few	2: Low involvement (quantity) but high engagement from few
Representation of concerned citizens in city development participation efforts	2: Low representation (in total) Of those who participated, the level of commitment was very high	2: Low representation (in total) Of those who participated, the level of commitment was very high	2: Low representation The task for the students was to talk to people that have an interest in their idea to understand their needs	2: Low representation (in total) But the people using the app engaged in the area they live, work or along the way between the two	2: Low representation (in total) But the people using the app engaged in the area they live in
Congruence of expected and actual outcome of local community	High congruence. The students where well informed of that the purpose was to	High congruence. The students where well informed of that the	Not applicable	1: Significant incongruence There was never a purpose to realize ideas. Min Stad is now used more	2: Some congruence Min Stad 2.0 was used purposefully at Hjällbodagen for local community

involvement in city development	conduct a test of a tool. The realization of ideas was talks about as a secondary purpose.	purpose was to conduct a test of a tool. The realization of ideas was talks about as a secondary purpose.		purposefully for community involvement in city development	involvement in the planned development ideas for the area
Potential for attractive and inclusive services through co-design	4: High potential Through management of architecture educators, planners and game educators the Minecraft app can both result in ideas for co-design and a parallel dialogue	4: High potential Through management of architecture educators, planners and game educators the Minecraft app can both result in ideas for co-design and a parallel dialogue	4: High potential The purpose of the course is not to co-design services per se (not in the in-depth involvement and designing together meaning) but rather to involve potential users and other stakeholders in the design by talking to them.	4: High potential The ideas presented by the user were insightful and relevant for the local community.	4: High potential The ideas presented by the user were insightful and relevant for the local community.
The co-creation tools' ability to engage citizens	1-2: Low-moderate ability to engage The Minecraft app demanded a special account that is not for free. The developed ideas are only taken care of when the Minecraft session is involved in a workshop and part of an ongoing planning process.	1-2: Low-moderate ability to engage The Minecraft app demanded a special account that is not for free. The developed ideas are only taken care of when the Minecraft session is involved in a workshop and part of an ongoing planning process.	2: Moderate ability to engage Given the purpose of the course engagement with a high number of citizens is limited	2: Moderate ability to engage This version of the Min Stad app demanded a Facebook account.	3: High ability to engage Can be used if having an e-mail address or at events and activities that are part of the City development plan work
Organizational readiness for citizen co-creation	2-3: Moderate to high readiness The engagement from the City of Gothenburg to set up Minecraft as a tool for dialogue was moderate to high. The demand of / needs of the tool is high. The tool is ready to use. But there is a lack of readiness / resources.	2-3: Moderate to high readiness The engagement from the City of Gothenburg to set up Minecraft as a tool for dialogue was moderate to high. The demand of / needs of the tool is high. The tool is ready to use. But there is a lack of	3: High readiness The engagement from the City of Gothenburg to set up the student projects addressing the "Inclusive life challenges" was high. Since the students came up with ideas where the City was not critical for implementing them, this course required little readiness.	1: Low readiness There was no intent and no readiness related to the Min Stad app. It was supposed to mainly be a place for dialogue between citizens.	3: High readiness Min Stad 2.0 is closely connected to city development plans.

		readiness / resources.			

6.2.4 Conclusions and lessons learned

Citizen engagement beyond IRIS

The city will:

- Continue to use Minecraft in primary schools to engage young citizens and their parents in the development of the local environment as well as public spaces in the city.
- Explore if and how Minecraft can be used to engage other “categories” of citizens in city development.
- Further explore how Minecraft can be used as a collaborative democracy tool, e.g., how it can be used to enhance democratic constitution and transparency as well as enable involvement in political agenda planning and implementation.
- Continue developing Min Stad 2.0 as a digital platform for continuous dialogue between the city and citizens as well as between citizens. It is critical to increase the number of users. This can be done by e.g., ensuring feedback is provided, using the platform for presenting city planning ideas open for feedback and further development.
- Further explore how Min Stad 2.0 can enable collaborative administration, e.g., how it can enhance the speed of engaging a broader and larger number of citizens, improve quality of ideas of plans for city development as well as improve the city’s competence about citizens’ needs.
- Further develop how the use of Minecraft as well as Min Stad 2.0 can be better integrated in the city planning processes.
- Continue engaging in activities such as Inclusive Life Challenge and similar innovation competitions, or hackathons to engage students and beyond in the development of e.g., new services that the city can provide.
- Further explore how Inclusive Life Challenge can enable citizen ideation and innovation and how it can be used to solve focused problems and challenges that the city has.

Lessons learned

- Citizens care about their city but not about all aspects and not everyone at the same time. We must help them direct their commitment at the right time. Use various activities to enable citizen engagement. Consider what type of engagement (information, dialogue, co-creation) is needed and what you are willing and capable to do to realize this. The ME-model can provide some guidance.
- Citizen engagement demands city engagement. When launching citizen engagement activities, these need to be integrated with the strategies, plans and activities of the city. Citizens providing their valuable time and effort are expecting the city to show interest and engagement as well.
- Citizen engagement is about building relationships with mutual trust. It is pivotal to have true and transparent intentions with the engagement. If citizens feel exploited or fooled e.g., if they realize or suspect that decisions are already made and their input is not valued, their trust in and interest to engage with the city will be seriously damaged.
- Digital platforms such as Min Stad 2.0 and Minecraft complement physical meetings in two main aspects: 1) since they are independent of time and space they are flexible and can be

used to reach out to a broader range of citizens, 2) they can be used to deepen the engagement from citizens that are familiar with the technology used.

Minecraft:

- Reflection is needed on working in an area where there are people who feel that they cannot influence their living environment. Perhaps there is more anxiety in "specific exposed areas" and sometimes perhaps difficult to describe their needs in words. Perhaps the previous experience of the city being planned "from above" by people "from outside" rather than responding to needs that are close in everyday life.
- In Minecraft, kids can move around their neighborhood at eye level and build spatial environments where they can easily live their way into the scale. An analog model building in a district can, on the one hand, be easy to understand but perhaps a little too abstract when there is no opportunity to experience the rooms that are created. It was clear that they could easily connect the real everyday environment to the environments they built in Minecraft.
- At the time they're going to agree on a common place to develop, they don't get any directives except to delineate the surface given the time, but maybe they could get more tools from us? Or more time? In the groups where the collaboration between the people worked well, the selection went on a common desire to develop a specific place, but in other groups, especially in the higher grades, I felt that they had a harder time choosing and lost some energy in that part.
- It is important to try to understand what is behind the words and their construction, such as the storage room that a group built that was about the fact that they needed somewhere to have all the things they need to have a fun leisure / leisure. Difficult to build a meaningful leisure time, so the storage room became the symbol of it. Competence is needed to decode what they really say, and the most important thing is what they say, not what they build.
- The younger children found it very easy to get started and find meaning in the task. Closer to the play and the imagination. The young people had a harder time getting started and there the task became perhaps a little too "big". More things that weigh into the decision of place you like or want to change.
- An interesting angle would have been to conduct a shorter workshop together with the older students where they could reflect on what urban development means and what you usually look at for different aspects when developing a city. By linking to the goals of the governing documents, teachers would see a greater benefit in working with the class. It would create a clearer focus for students once they get into Minecraft on what to build and why.
- Clear assignments and focus areas are a key to keeping students' interest and focus up. By having shorter assignments at the beginning, a mindset was created where the students became focused on the task and made them ready for the larger task that awaited at the end. Had we started with a big task right away, one consequence would possibly have been that the students lost focus and tired faster. A further development would have been to create more assignments.
- Breaks are an important part of the work as breaks create time for thoughtfulness and analysis. When students came back from their break, they were often very focused and knew exactly where to proceed because their thoughts had "landed" during the break. Breaks were also a good way to catch up with the class when it was getting a little noisy. By taking breaks at the right time, students were able to come back and be more focused.
- Feedback is important in game design and because we were many adults in the room, the students were able to quickly get help if needed. The adults were also able to give positive and

constructive criticism, which meant that the students wanted to continue to develop their ideas and thoughts in the game as they became positively motivated.

- By using a game that they know, and many people have played, they become very positive about working with and about how their district should develop. The game removes the resistance that may otherwise arise when external parties enter the school and carry out projects. The game becomes a positive tool that the students would like to take on and create through because the game itself is established as something fun and enjoyable in the students.
- Curiosity is a key that is important to use. As adults, we must be genuinely curious about what the students build and reflect on.
- People with trust capital linked to the class are important in the room as well as preparations for the workshops together with the class. Important in our case was that the teachers were so positive about the workshops and were able to motivate the students to participate and contribute. They were also an important support during the workshops even if they did not hold them. Their presence created a calm.

6.3 Personal Energy Threshold (PET)/ERO application in HSB Living Lab

Key message and learnings

- Close collaboration between researchers and IT-professionals.
- The scope was limited which meant that all key competences could be kept within the team.
- Re-use of infrastructure components. The project had the benefit of building the solution on top of a solid IT-infrastructure provided by Chalmers focusing work on the specific tasks of the project rather than building infrastructure components.

6.3.1 Overview

The demonstration of PET - Personal Energy Threshold was demonstrated in HSB Living Lab in the Lighthouse City district Campus Johanneberg. Within the PET project an application was developed for monitoring energy usage and then giving feedback to users regarding their personal energy consumption, and it was designed for a smart home system in mind that could balance the energy demand and supply. The app had a function called Personal Energy Threshold (PET), a momentary power level showing when there is plenty and short of energy in relation to the household's energy consumption. Sara Renström, PhD, studied the behaviour of users throughout the demonstration aiming at how energy functions in a smart home can be monitored, accessed, and controlled. Users of the app was people living in HSB Living Lab. Target group/groups could be any citizen with total or some possibility to control their energy usage (Figure 88). The expected impact was to develop a deeper understanding of the tenants' energy consumption at individual level, and let each individual choose what type of energy source to be used and when. Through the developed application ERO the aim was to nudge individuals to choose "green" energy such as energy from the installed PVs (façade and roof). The cost of the participants energy use was included in the rent.

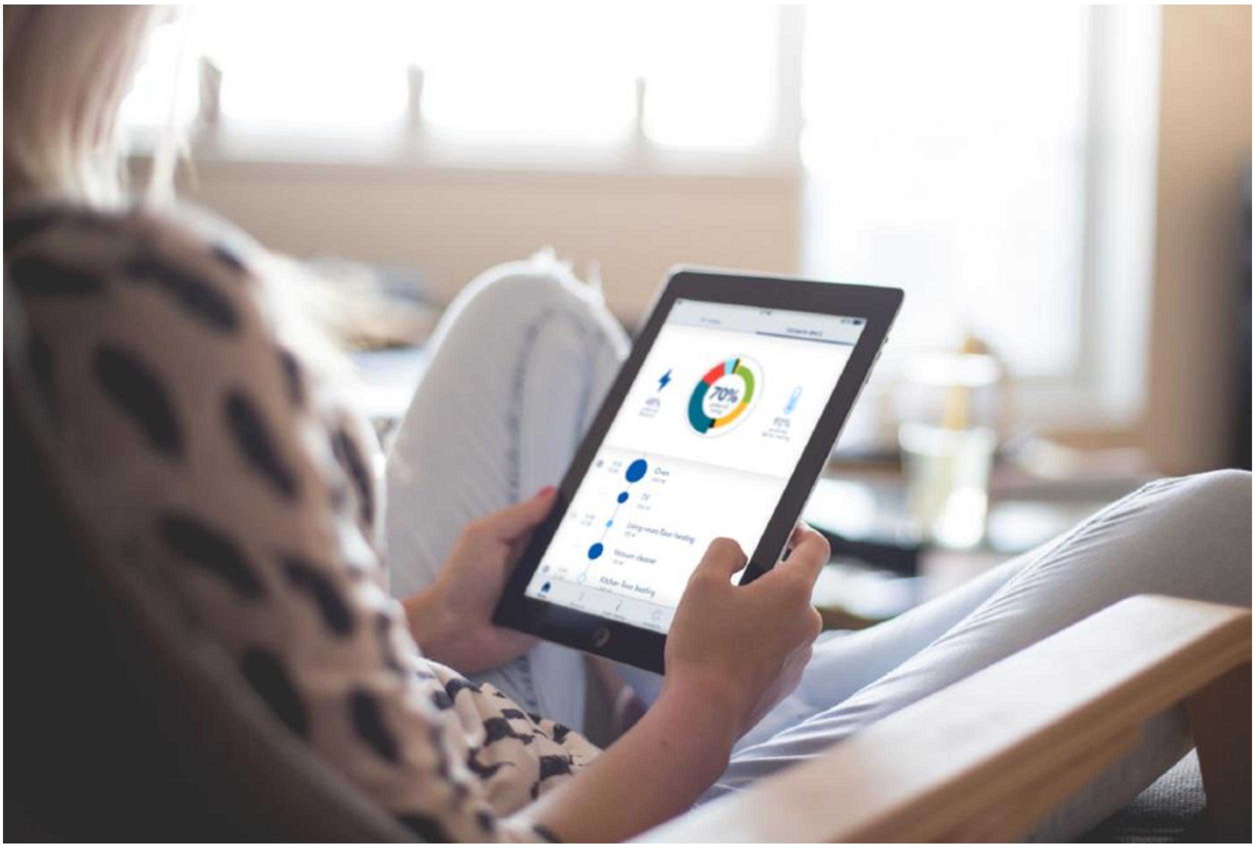


Figure 88 Tablets were used when interacting with the ERO application

The demonstration took place in 2017 and 2018 and unfortunately did not go ahead for development. Among other things, there was a lack of funds to move forward. The technical and research implementation results, have been reported in D.7.7

6.3.2 Lessons Learned and Next Steps

The overall aim was to explore what roles households can play in the smart energy networks of the future and what digital solutions are required to make this possible. In the current project, a demonstration was carried out with users and residents in HSB Living Lab.

In the future energy system, it can be of great benefit with conscious and committed end users of energy, which can help reduce power peaks and environmental impact through behavioural choices.

In the future, it will be possible to connect Ero with other projects in smart energy systems.

- It was unfortunately not possible to connect the district heating and the solar energy storage system to the PET application. The focus then, was electricity usage.
- Seven participants took part in the study and none of the participants used ERO extensively. The particpants' own experiences were that they did not use much energy and could not then optimise much energy.
- The results gave conclusions that it was possible to create a smart home system. The function the application had, to serve as an energy status lens, was anyhow appreciated by the participants.

- **ERO/PET app**

- Technically a replication could be arranged as the code is available in GIT and will in part be re-used in coming projects.
- The application was appreciated by the users, but many of them questioned the extent to which their demand shifting could contribute.
- Some positive lessons learnt was the close collaboration between researchers and IT-professionals, and the re-use of infrastructure components. The project had the benefit of building the solution on top of a solid IT-infrastructure provided by Chalmers focusing work on the specific tasks of the project rather than building infrastructure components.
- No next steps are being taken for this demonstration.

6.4 AR/VR BIM Visualisation Demonstrator

6.4.1 Overview

A modern building is a very complex entity, consisting of a multitude of components, sub-systems and materials. In order to manage and keep track of this complexity, the so-called Building Information Modelling) BIM method, has emerged as a standard mode of working for making digital representations of buildings.

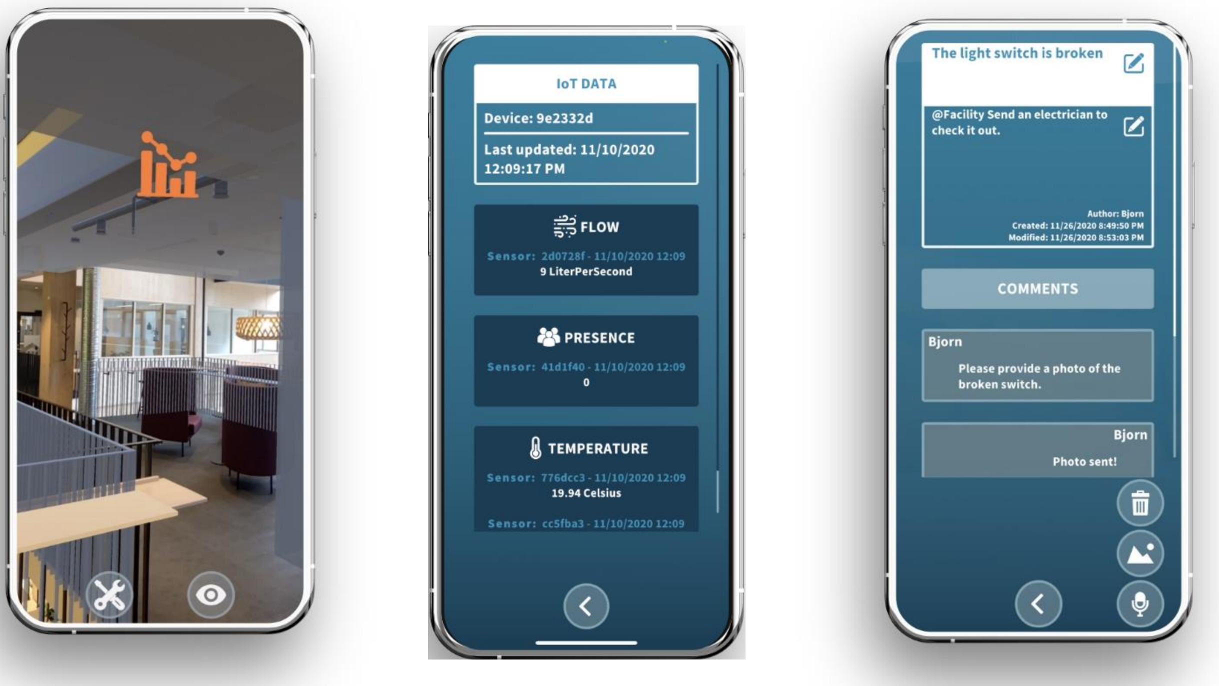


Figure 89 Screenshot from smartphone, of the AR environment in AWL (left), IoT data (middle), and the annotation feature (right)

A BIM model is a virtual model of reality. In the model, all information from a building's life cycle is collected and organized. The BIM model can contain information about both the physical and the logical composition of the objects and the building itself. The BIM model can be described as a virtual prototype. A BIM model consists of an object-based, digital representation of the constituent components.

Figure 90 The VR app is accessed through an Oculus Quest headset

Figure 91 Screenshot from VR environment in AWL building

6.4.2 Implementation

The aim for the demonstrator was to create a way for anyone to view a building's BIM components, either by interacting directly with the building in an AR (Figure 89) environment, or remotely in a VR (Figure 90, Figure 91) application. This could provide interesting insights into the "inner workings" of the building as well as to act as a tool for those working with building management and maintenance.

As an added feature, the AR and VR apps are also able to visualise IoT data from the building's sensors. All in all, 500 sensor locations are installed in the building, providing information about properties such as temperature, occupancy, air quality and noise.

For property owners, the visualisation will provide easy access to BIM data. Currently, property owners rely on third parties such as consultants or design firms to handle and provide access to BIM data. With this system, BIM data will be readily available without having to employ expert resources, providing greater understanding of the building's working and performance. The system can also be used as a means of communication with the tenants.

Maintenance and technical staff may use the system as a tool to simplify identification, specification or malfunctions and problems as well as execution of repair and maintenance tasks, for instance by using the annotation feature (**Fout! Verwijzingsbron niet gevonden.**), where the user may interactively add new data to BIM objects in the form of annotations. Annotations may thus be used to create issues and, if desirable, integrated into an issue tracking system.

Also, tenants and visitors could benefit from the app for navigation and orientation, to get acquainted with the building and its innovative features.

6.4.3 Results

The AR and VR apps were launched in M22. An upgraded version with extended functionality was released in M57. Orientation markers (Figure 90) have been set up in the AWL building to enable any user with the app to use the system.

Figure 92 Orientation marker for AR app

A number of workshops and seminars have been carried out to promote the application and spread information about its features, targeting groups such as researchers, facility managers, building maintenance staff and others.

As the Covid-19 pandemic caused most people to relocate their work to their homes, there was little use of the apps during 2020 and 2021.

In the autumn of 2022, a further workshop was carried out to disseminate and promote the app. In addition to presentations and instructions on its use, participants were invited to go on to search for virtual ol location of the treasur

Figure 93 Screen view with virtual object in "treasure hunt"

Figure 94 Participants of "virtual treasure hunt"

6.4.4 Lessons Learned and Next Steps

The AR and VR apps were launched in the autumn of 2019, but due to some initial improvement work, there was only a small amount of use in the first months. The launch of the app coincided with the outbreak of the Covid-19 pandemic, which meant that there were very few users during the first two years.

Property managers and technicians were originally seen as potential users of the app, for instance as a means to detect and track malfunctioning building components and to facilitate maintenance work. However, it turned out that the interest was not as large as expected, possibly due to the fact that there already exist similar, albeit less advanced tools for these tasks.

In order to find strong candidates for future use cases, the app must be seen to solve for a user group a problem, which is hitherto unsolved and as well as being significant. This will likely necessitate further development and further specialisation of its functionality. Work is ongoing together with the app's developer ReSpace to identify and exploit such opportunities.

Fout! Verwijzingsbron niet gevonden.Fout! Verwijzingsbron niet gevonden.**Fout! Verwijzingsbron niet gevonden.**

7 Results and Impact at the Lighthouse City Level

7.1 Introduction

7.1.1 Gothenburg's innovation strategies and activities

The City of Gothenburg has eight policy-guiding programs, a multitude of plans and several rules to work from to achieve an improved environment and improved climate work directly related to the global goals. It is however impossible for a municipality to achieve the goals by itself, and there is also a programme to support and drive innovations as a municipality needs to grow and achieve good results. Through "*Innovationsprogrammet"* (the Innovation Programme) the objective is to increase the City of Gothenburg's capacity for innovation within the City's organization, in collaboration with other sectors of society, and to increase the City's ability to contribute to a strong innovation system in the Gothenburg region. During the IRIS consortium meeting in Nice 2019, one Gothenburg City representative participated to give a presentation to this effect.

To develop and implement sustainable energy and climate policy the City of Gothenburg are connected as signatories to the Covenant of Mayors and has also signed the New Covenant of Mayors in May 2020 which extends to 2030. This contains a vision for 2050 for the connecting cities to work for climate adaptation that will lead to sustainable resilience and that carbon dioxide emissions will be reduced by 40% by 2030, through increased energy efficiency, and increased use of renewable energy sources. The accession provides an opportunity to compare oneself with other cities and to share knowledge with local and regional authorities within and outside the EU.

Climate change transformation needs a broad perspective, considering and coordinating social, ecological and economic sustainability. Therefore the City of Gothenburg and Johanneberg Science Park are part of the national Viable Cities' network who focus towards Climate Neutral Cities 2030. The network started in 2019 with nine Swedish municipalities, and from autumn 2021, the initiative involve 23 municipalities which together account for 40% of Sweden's population. Gothenburg was one the first nine cities to develop a Climate City Contract 2030. The contract is an agreement between the city, several government agencies, and Viable Cities in which all parties commit to make concrete contributions to speed up the climate transition and to ensure cooperation between the city and the state level. The contract will develop over time and is revised every year, both at local and national level.

An important step is that in 2022, Gothenburg has been selected as one of about 100 Climate Neutral Cities in the EU, where all cities that have been accepted have committed to be a hub of experimentation and knowledge, sharing experiences and solutions with other cities. Within the new Climate Neutral Cities Gothenburg initiative, the IRIS project, with colleagues in the city and other stakeholders, can thus contribute with its lessons learned to drive the work forward.

During 2022 City of Gothenburg have also joined European Scalable Cities network through the IRIS project, dedicated to build upon the learnings from the Horizon Lighthouse cities, possible future scale ups and new collaborations toward climate challenges.

7.1.2 One particular achievement example from City level perspective; E-mobility

Within IRIS Gothenburg, the partnership has not worked on operational applications for the development of electric buses or other electric vehicles. However, the project has demonstrated mobility services for residents with zero parking space and flexible energy solutions that drive development and create new incentives for the development of electric mobility. When IRIS started, there were three fully electric buses and seven plug-in hybrid buses running through Gothenburg and the IRIS Lighthouse District since 2015. The electric buses were concept buses, and in 2017 series production of fully electric Volvo buses started. The number of emission-free electric buses and ferries powered by renewable electricity is rapidly increasing in the Gothenburg region; in 2021, 145 electric buses were introduced in the municipality of Gothenburg and the neighbouring municipalities of Mölndal and Partille. The climate-related benefits have been studied and show a halving of nitrogen dioxide emissions and a reduction of carbon dioxide emissions by 10%. The nitrogen dioxide savings are equivalent to the annual emissions of over 8 000 average cars.

7.2 Impact at the Lighthouse City Level

7.2.1 IRIS Impact on Gothenburg's Energy Plan

This section of the report aims at describing how IRIS activities, demonstrations and experiences have contributed to form activities and policy development on part of the public stakeholders in the Gothenburg region, mainly the City of Gothenburg.

The starting points for the governance of the City of Gothenburg are laws and constitutions, the political will and the city's residents, users, and customers. To realize starting points, preconditions of various kinds are needed. City politicians have the opportunity through governing documents to describe how they want to realize the political will. One such governing document is Gothenburg's Energy Plan 2022-2030.

The purpose of the energy plan includes

- Promoting the implementation of measures that lead to the City of Gothenburg achieving the following goals in the City of Gothenburg's environmental and climate program 2021–2030:
    - Reduce energy use in homes and premises
    - Produce energy only from renewable sources
    - Reduce the climate impact of transport
    - Maintain and develop the city's work to have a safe and secure energy supply

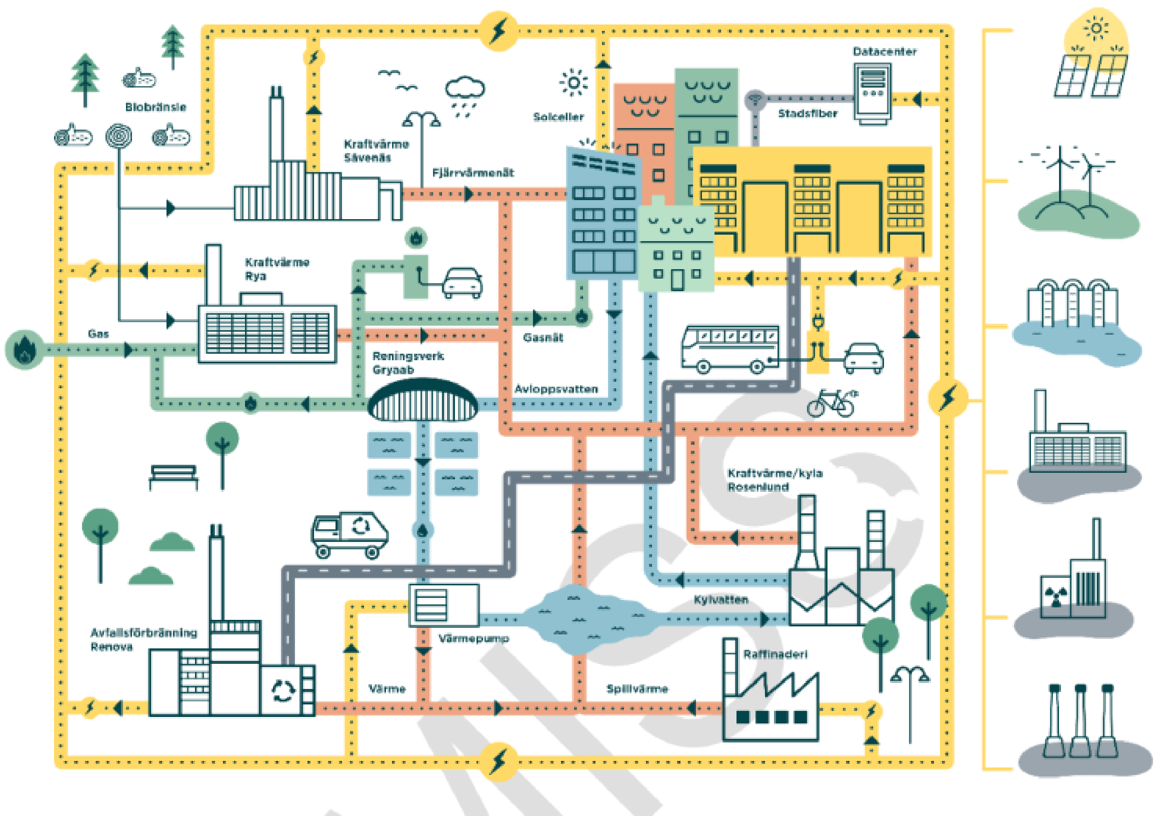


Figure 95 A schematic of Gothenburg's energy system (City of Gothenburg)

IRIS impacts in Gothenburg's Energy Plan include the following.

7.2.1.1 Flexible and capacity-secure energy system

Today, the City of Gothenburg actively participates in innovation projects and will continue to prioritize research collaboration and participation in pilot projects concerning controlled use and storage of electricity, heating, and cooling to increase the robustness of an energy system (Figure 95) that faces more and greater challenges. The energy solutions (local power generation, storage, and management) piloted in Viva and A Working Lab in IRIS TT#1 have contributed greatly to the understanding and provided the groundwork for further developments. The City of Gothenburg has also profited from learning from LHC Utrecht's V2G demonstrator. Below, some specific impacts related to IRIS are listed (text within quotation marks are taken from the Energy Plan).

Impact: Göteborg Energi AB will, together with Förvaltnings AB Framtiden, start pilot projects to develop and implement technologies for smart control of power use in the electricity grid, in combination with energy storage, to investigate the possibility of reducing electricity power peaks on a large scale. The lessons learned from the project will be disseminated to other property owners and management companies and committees within the City of Gothenburg.

Impact: "Göteborg Energi AB, together with Förvaltnings AB Framtiden, will start pilot projects to investigate the possibility of reducing heat output peaks in apartment buildings on a large scale through smart control and heat storage. The lessons learned from the project will be disseminated to other property owners and management companies and committees within the City of Gothenburg."

Impact: "Göteborg Energi AB shall, together with other relevant actors, actively work for the management of electricity power use and a stabilization of the electricity power demand in Gothenburg. This by taking advantage of the potential for demand flexibility through, for example, Vehicle-to-Everything (V2X) technology, smart power control of electric car chargers, central and local electricity storage and power control of heat pumps for residential customers", as observed in the lessons from Utrecht.

7.2.1.2 Renewable and recycled heat

"That premises and housing in Gothenburg are heated in a sustainable way is a prerequisite for the city to achieve set climate goals. As part of the work to reduce Gothenburg's climate impact, district heating in the municipality will consist of only renewable and recycled energy by 2025. This means that Göteborg Energi AB needs to decommission existing fossil fuel-powered CHP plants and replace them with renewable equivalents. This work has already begun. Based on the fossil emissions from district heating production in 2017–2019, the total emissions can be reduced by 70,000–120,000 tonnes per year through this conversion. Continuous cooperation is already underway with existing heat suppliers in order to optimize deliveries and increase the proportion of heat recovered in the district heating mix. An exchange also takes place with adjacent municipalities that have their own district heating systems."

The demonstrators in Viva have made extensive use of heat pumps, low temperature district heating, heat recovery and storage. Göteborg Energi, as an IRIS partner, have been able to profit from the results and learnings from these demonstrators.

Impact: "Göteborg Energi AB will continue to follow developments, investigate and work for, where appropriate, combination solutions where district heating and heat pump are used together for heating."

Impact: "Göteborg Energi AB will continue to develop district heating to be as long-term sustainable as possible by investigating opportunities to favour recycled heat with renewable and sustainable origins".

7.2.1.3 Energy efficient and fossil-free travel, transport, and work machines

"Gothenburg's population is assumed to grow by just over 60,000 inhabitants between 2020 and 2030. If the additional population travels with the same distribution of vehicles as today, energy use within the transport sector will grow in an unsustainable way. If fossil-free fuels and electricity capacity shall be sufficient, travel and transport need to be reduced and to become more efficient. The goal in the environmental and climate program is that road traffic work will be 25 percent lower in 2030 compared with 2020. To reach that goal, traveling on foot, by bicycle and public transport needs to be stimulated and prioritized in relation to car traffic. The role of urban planning is important to achieve this, as factors such as population density and infrastructure affect travel patterns. Too low population density (for example, large single-family housing areas) tends to create car dependency. Densification in combination with improved infrastructure for sustainable modes of transport can contribute to reducing road traffic work and the transport sector's emissions.

Electrification of the transport system also means, in addition to sharply reduced emissions, a more efficient energy use compared to internal combustion engines."

In Viva, IRIS has piloted a car-free life-style with zero private parking space allotted, where residents instead have had access to a range of transportation services such as electric vehicles, electric bicycles and public transport. The City has followed the outcome of this experiment and has stated that it is favourable towards flexible parking norms as a means to reduce private car use.

Impact: "Förvaltnings AB Framtiden will offer mobility alternatives, such as electric cars or cargo bike pools, as a complement to public transport for all residents. The purpose is to contribute to reduced car travel and to increase the probability that private individuals choose sustainable alternatives to conventional ownership of fossil-powered vehicles Measure: Förvaltnings AB Framtiden, Byggnadsnämnden, Fastighetsnämnden and Göteborgs Stads Parkering AB, shall prioritize parking spaces dedicated to carpools over private parking spaces.”

7.2.2 Open data and IoT

In the “City of Gothenburg's service plan for municipal internal services 2021-2023" it was noted that the City of Gothenburg is currently undergoing one of its most extensive digitalization periods, where it aims to develop a so-called City Information Platform (CIP). This platform aims to create an easily accessible webpage that will consist of and provide all available information regarding the city of Gothenburg. This will benefit businesses, visitors, and citizens. The city of Gothenburg makes it clear that this solution is going to be beneficial for the citizens but also for themselves. When gathering the available information in one place, it creates an internal affiliation between co-workers and an external simplicity in the communication.

“The City of Gothenburg's plan for digitisation 2022 – 2025” is now ready and applies from January 2023 where work is progressing. The city has also signed the Declaration Join Boost Sustain (Living-in.eu) and strongly supports the necessity of finding simple and holistic smart solutions for our citizens and to share knowledge and ideas.

The city of Gothenburg continues with its upscaling and implementation of the CIP that was originally conceived in the IRIS project. The city has also established a collaboration with the Swedish city of Sundsvall using an open source FIWARE based platform. This software is available via GitHub to all and is an amalgamation of the knowledge gained in the IRIS project as well as other innovation projects driven by the City of Gothenburg and Sundsvall.

7.2.3 Citizen engagement

Within IRIS, several activities using Minecraft as a dialogue tool have been carried out with children and young people in 2020-2022 in two different geographical areas in Gothenburg. The areas were selected because new zoning plans were in progress containing new housing, proposals for the location of walkways and lighting and playgrounds. There was and is a need in Gothenburg to reach children and young people and apply BKA-Child Impact Assessment in this type of planning work, and through the support of researchers, a method and process have been developed in parallel for best application and follow-up. The results have led the city to adopt a new strategy concerning democratizing the urban planning process. The impact and result is that Minecraft as a digital tool in the dialogue process now is being implemented in the regular activities.

7.3 Results at the Lighthouse City Level

As the IRIS project has just finished, it is still early to start to expect a vast bulk of concrete results at the City level, particularly considering the slow-moving nature of city planning and development. However, there is tangible evidence that IRIS is starting to deliver these concrete results in the medium to long term.

7.3.1 Flexible energy solutions and storage

In the two IRIS demonstrations Viva and A Working Lab (AWL), flexible energy solutions have been demonstrated. The need for flexibility is expected to increase in the region to handle larger share of renewables and at the same time increased energy demands due to electrification of the industry and the mobility sector. The interest of flexible energy solutions has also increased the last year due to high energy prices in Europe. Riksbyggen´s platform Positive Footprint Housing (TT#1) are considering several results from the Viva buildings for new construction projects.

7.3.2 Mobility

A mobility service has been demonstrated and produced a variety of results, such as the fact that the Maas EC2B solution has helped tenants of the car-free brf Viva housing real estates to travel sustainably without having to own a car. The real estate developer and partner Riksbyggen, which wants to offer the market a modern, urban and car-efficient housing concept, has achieved a breakthrough for further scaling up of a complete solution through the demonstration. The service has involved suppliers, municipality and market with a developed business model. This in turn have given impact and results to a more efficient use of land for housing with fewer cars and better air quality.

7.3.3 IoT & City Innovation Platform

The CIP is (during 2022) focused on supporting sensor technology and IoT as a driving force to establish CIP. The process of building the requirements specification for a CIP as a service is still proceeding with the new "Service plan for 2023-2025". These include both technical requirement and organizational requirements, which is a breakthrough for building a smart city innovation ecosystem. The testbed Sustainable Smart Parks, which is an open and innovative arena in Gothenburg, have used the CIP platform for test of the use cases (real-time):

- Soil Moisture for green areas: Used to determine if a green area needs to be watered or not, save a large quantity of fresh water and reduce vehicle transport in the city.
- Tap water to private houses: The City of Gothenburg has started to use the CIP and IoT platforms to retrieve and publish information received from tap water smart meters. The aim is for instance to identify leaks at an early stage.
- Bathing water temperature: Finalization of our bathing temperature module.

The City of Gothenburg has also carried out a test pilot of a CIM-City Information Model. This has led to capacity building within several city departments and new collaborations.

7.3.4 Knowledge exchange

Within IRIS, valuable lessons for dissemination have been learned during the cooperation- and consortium meetings organised. Other activities have been arranged such as workshops between Gothenburg and Utrecht and with IRIS follower cities. There are partners in Gothenburg who wanted to learn more about Utrecht´s demonstrations of V2G and ISO15118, roll-out strategies of sharing infrastructure, data driven roll out strategies and Smart Charging Parking (sensors). As one concrete result, the Volvo-affiliated company Polestar, Chalmers and RISE have now joined in the Horizon Europe project SCALE together with City of Utrecht, for collaborations regarding V2G.

In the autumn 2022 a collaboration with follower City of Vaasa, the Erasmus project ALLBATTS, Volvo Group and Johanneberg Science Park, a seminar was organised to disseminate knowledge about second hand batteries for storage, flexibility in buildings and more.

7.3.5 IRIS visibility

IRIS Gothenburg partners has showcased different demonstration projects, which contributes to strengthen the City and others. This adds several dimensions of value for the Gothenburg innovation system, for instance knowledge, networking and visibility locally as well as internationally.

Since the Covid-19 pandemic started, Green Gothenburg, which is now named Invest in Gothenburg, has developed a Virtual Tour in collaboration with the IRIS project as a new way of showcasing smart city solutions in Gothenburg. The focus for the first virtual tour was Innovative and Energy efficient buildings where you can discover the smart sustainability solutions in three buildings and residential blocks in the Lighthouse district; HSB Living Lab, A Working Lab and housing cooperative Riksbyggen´s Viva. The virtual study tour can be carried out individually, but also through group-shared personal guidance, which has been much appreciated and aroused great interest during the pandemic. Study tours have remained popular during 2022.

7.4 Next Steps

7.4.1 Next steps City level

The City of Gothenburg has ambitious goals in the various transition tracks that IRIS has been running for 5 1/2 years. With the relatively new Climate and Environment Plan and the mission-driven work for 100 Climate Neutral Cities, the city is showing that it is possible to pull together for the missions. However, work remains that the IRIS project can, with its lessons learned, support in and which poses continued challenges; developing the city's capacity to address and manage the complexity of climate change within the administration, which should be based on knowledge of challenge-driven innovation and the required capacity in terms of governance, financing structures, collaboration, process management and communication.

Integrated solutions are being demanded rapidly, for working towards the ambition of becoming a climate neutral city, and interventions are being demonstrated in the near future, including the electrification of large parts of the City’s own vehicle fleets, procuring transports and extending charging infrastructure for public and commercial fleets as well as residential traffic. These ambitions include light, medium and heavy duty vehicles, ferries, working machines and equipment and leisure boats. Additionally, the use of geofencing as a tool to enforce hybrid vehicles to turn on the electric mode in specific city areas are being upscaled.

Flexibility from buildings such as Viva and A Working Lab can be used to create a more stable electrical grid in the city, and on national level. The DSO Göteborg Energi has during 2022 started a new local flexibility market for this purpose. IRIS partner Akademiska Hus is one of the first participants on this market with their energy facilities on Campus Johanneberg. The plan is that Viva also will participate from 2023. On national level these buildings can participate on one or more frequency markets, this opportunity might require an aggregator depending on the size of the batteries, a role that now exist in Sweden. I the future the local flex market might support this function as well.

In Viva the evaluation of the 2nd life batteries is planned to continue to get more knowledge of the aging. A pre study has also been made regarding a new installation in another multi-family house.

During the dissemination of the results from Citizen engagement activities; Minecraft as a digital tool for city planning within the City of Gothenburg, the City Planning Office and several housing companies have shown considerable interest in both learning more and in applying the solution to broader target groups. During the winter of 2022-2023, the City of Gothenburg will start implementing Minecraft as a digital tool in its regular operations, which is a positive result and a step forward for improving young people's engagement in city planning and the concept of democracy.

7.4.2 Organisational changes in the City of Gothenburg

The City of Gothenburg is a medium-sized city in Europe but has a significant size of organisation with almost 40,000 employees and several fully and partly owned companies. In its work towards climate neutrality, challenges need to be addressed. An organisational change is currently taking place for urban development as four new boards will be created from 2 January 2023, replacing five previous ones. The aim is for the city to increase its cohesion for urban development processes and for the change to contribute to greater efficiency and transparency in relation to residents, visitors, and the business community.

7.4.3 The City Innovation Programme

The City Innovation Programme (*Göteborgs Stads Innovationsprogram)* was adopted by the City Council in 2017 and runs through 2023. It has two-year action plans, the current for 2022 – 2023. The focus in the action plan is to support governance structures in the city organisation that supports innovation in work, processes, and communication.

Presently, there is a process of defining what will come after 2023, when the programme comes to an end. It will not be replaced by a new programme, instead the intention is to develop a process tool, with structure from ISO56000, that will be more of a guideline in innovation processes. This will make it easier to cooperate between different sectors within the city, as well as with city-owned companies, as they will use the same "language". To facilitate this a pilot project, "*DINO – Demonstrator för innovation i offentlig verksamhet"*, has started that will be running in 2023 with the objective to develop this process tool. Several parts of the city administration are participating in the project. The Innovation Programme is from this year also an interlinked part of the City digitalisation strategy and current work to establish and develop the new digital platform for city information and services (CIP).

7.5 Conclusion

To build on the results and successes of the IRIS project, Gothenburg City will

- Implement the co-creation strategies and approaches developed and tested during the IRIS project in the city's planning and decision-making processes. This could involve involving citizens, businesses, and other stakeholders in the planning and design of urban projects and initiatives.
- Use the data and insights generated by the IRIS project to inform the city's sustainability goals and targets, and to identify areas for improvement in terms of environmental, social, and economic sustainability.
- Disseminate the results of the IRIS project to other cities and communities, to encourage the adoption of similar co-creation approaches and to facilitate the sharing of best practices and knowledge.
- Build on the existing partnerships and networks established during the IRIS project to continue collaborating with other cities, research institutions, and other stakeholders on sustainable urban development initiatives.

- Consider applying for additional funding to continue and expand the work of the IRIS project, either through European Union or other funding sources.

8 References

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2. Hilgers, D., & Ihl, C. (2010). Citizensourcing: Applying the concept of open innovation to the public sector. International Journal of Public Participation, 4(1).

9 Annexes

Annex 1: Support from WP3 on the x.4 Business models and exploitation sections

Annex 2: Characteristics of different Phase Change Materials

Annex 3: T7.6.1 Innovation Challenge. Change of Scope – lessons learnt

Annex 4: Climate framework for higher education institutions

Annex 5: Master's Thesis: Motivation for Participation in City Development (Helldén, Zhao 2021)

Annex 1: Support from WP3 on the x.4 Business models and exploitation sections

Exploitable results

There are several solutions within IRIS Gothenburg that have started to explore business models and/or tested them in a real environment through their demonstrations (Table 1). There is also a chain of external actors in the local, regional, and national innovation system who have taken part in disseminated lessons - results that have been communicated and packaged to arouse interest in more people who want to replicate or try an IRIS solution. In two cases, it is in very early innovation phases as actors within the city of Gothenburg and the nearby city of Mölndal, who wanted to take part in the lessons for, above all, energy and mobility solutions for potential upscaling and start projects. Colleagues within JSP, Göteborg Energi and others work as a bridge between the IRIS project's results and knowledge sharing to interested parties for upscaling within Gothenburg but also within the Västra Götaland region.

Table 1 Exploitation and replication of IRIS solutions

Year	Location	Solution/s
Planning	Mölndal Forsåker	Early innovation phase for V2G, storage in batteries, smart energy system, Mölndala/JSP m.fl.
Planning	Göteborg/Oklandsåsen	Early phase looking for smart district solutions, Gothenburg Municipal housing company Framtiden
2020	Göteborg/Västra Frölunda	EC2B has been replicated & implemented in an existing building complex in collaboration with the Gothenburg municipal housing agency Framtiden.
2020	Lund	EC2B has been implemented in the real estate "Xplorion" in Lund in collaboration with Municipality of Lund real estate company.
2020	Gothenburg/Fyrklövergatan	Energy storage with second life bus batteries from Volvo within an existing real estate, Stena Fastigheter & Battery Loop
Planning	Gothenburg house 38	Second life bus batteries from Volvo will be implemented in existing real estate, Riksbyggen/Gothenburg Energy/JSP

Planning	Gothenburg/Kviberg	Second life bus batteries from Volvo will be implemented in existing real estate, Riksbyggen/Gothenburg Energy/JSP
Planning	Gothenburg/Gibraltar	Second life bus batteries from Volvo will be implemented in existing real estate, Riksbyggen/Gothenburg Energy/JSP

D3.8 already described that an exploitation plan has the objective to make use of results for scientific, societal or economic purposes and to recognise the exploitable results and their stakeholders. The next step was to - together with WP3 leaders - arrange workshops during the spring 2021 to identify results with the use the KER template for IRIS. One workshop was carried out in 2018 together with WP3 leaders for second life batteries.

- TT#1 second hand batteries
- TT#2 PCM – Phase Change Material
- TT#3 MaaS-Mobility as a Service
- TT#4 Energycloud
- TT#5 Minecraft

Annex 2. Characteristics of different Phase Change Materials

Figures 11-14 show the different PCM materials that are being tested in the Rubitherm factory in 2022. When the test is finished in late 2022 it will be used in Chalmers full scale pilot plant.

SP11D

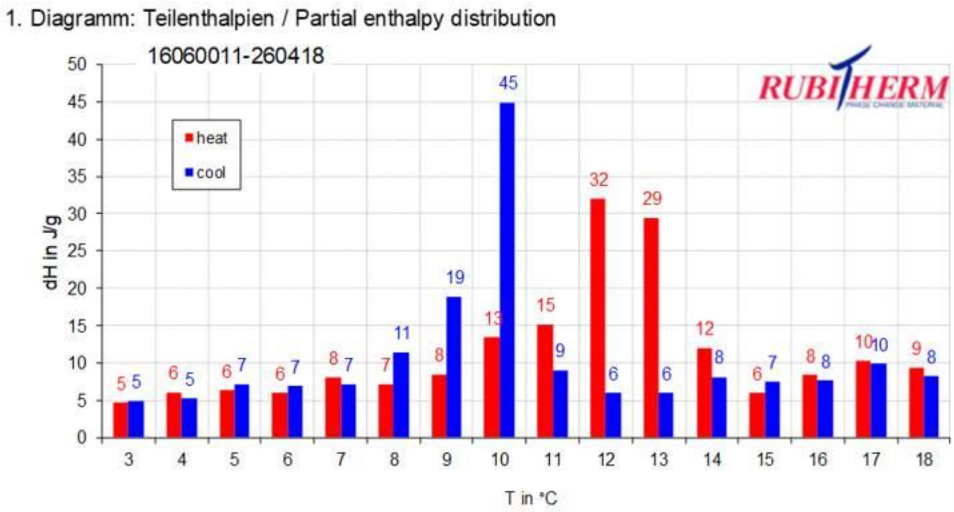

Figure 1 Partial enthalphy distribution for PCM SP11D when cooling (blue) and heating (red). Maxima in the enthalpy distribution indicate solidification and melting points, respectively.

SP11D was originally developed for the PCM plant in 2019 As shown in Figure 11, the solidification point is around 9~-10ºC (where the partial enthalpy is at its highest in the cooling (blue) phase). Considering around 1ºC of temperature difference for heat exchanger, the cold-water temperature KB0 shall be lower than 8º C to get PCM to solidify. Then, to cool/freeze the PCM, the water temperature shall be around 7ºC. However, this cannot be reached by the Chalmers KB0 system therefore a new PCM material needs to be introduced. For the melting point, the diagram in Figure 11 shows that the melting temperature is around 12~13 ºC (where the partial enthalpy is at its highest in the heating (red) phase). which will give about 14 ºC temperature to KB11.

SP11N

1. Diagramm: Teilenthalpien / Partial enthalpy distribution

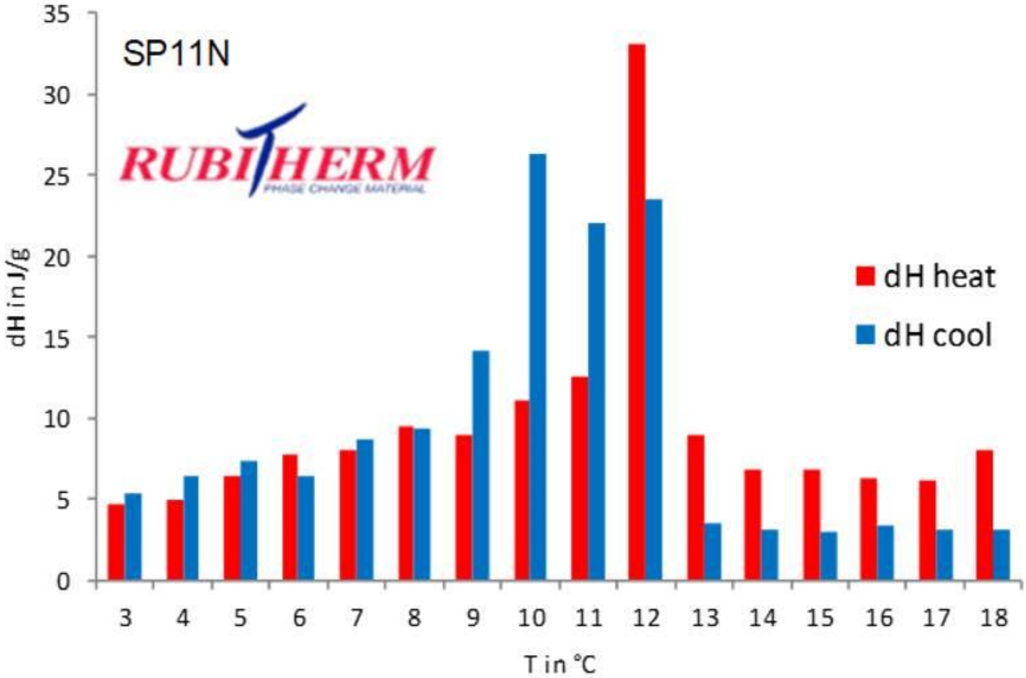

Figure 2 Partial enthalpy distribution for PCM SP11N when cooling (blue) and heating (red). Maxima in the enthalpy distribution indicate solidification and melting points, respectively.

SP11N (Figure 12) is designed to compensate for subcooling. Also, an attempt was made to adapt the melting and solidification point to slightly higher flow and return temperatures.

SP11black

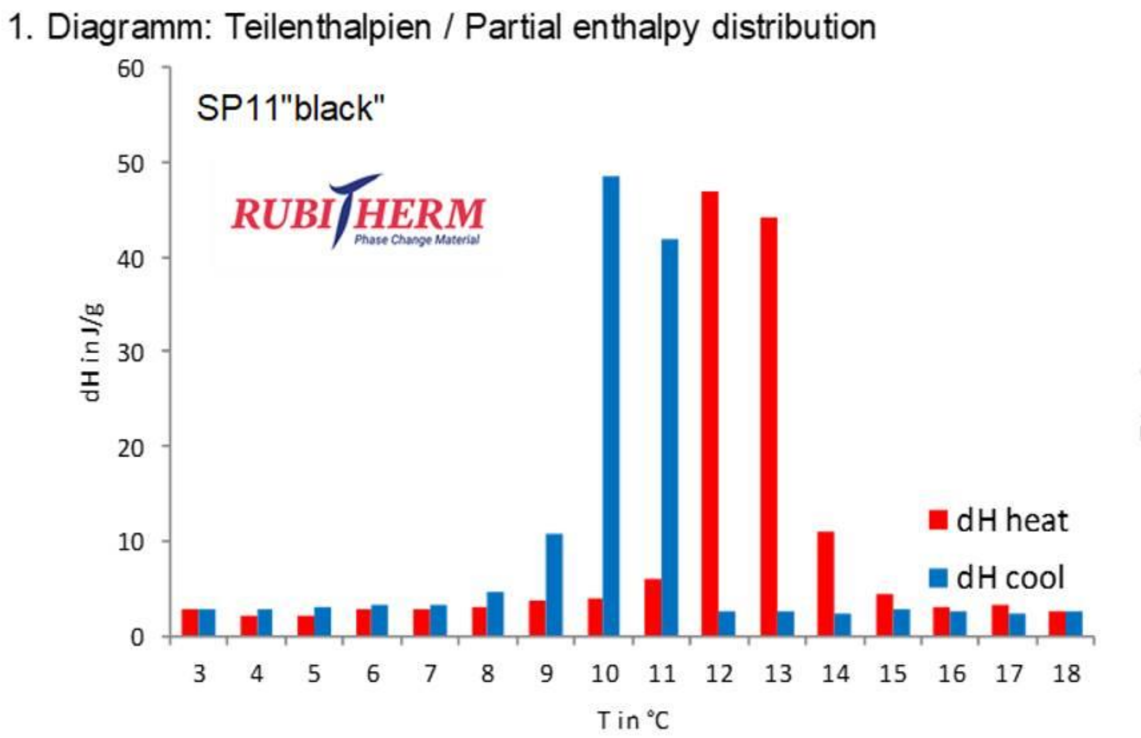

Figure 3 Partial enthalphy distribution for PCM SP11"black" when cooling (blue) and heating (red). Maxima in the enthalpy distribution indicate solidification and melting points, respectively.

In SP11Black (Figure 13), a completely new material was used as a base and thickened with carbon, hence the black color. Unfortunately, a reaction results in an increased and clearly noticeable concentration of ammonia. This makes the PCM unusable despite very good temperature curves.

SP11CCA

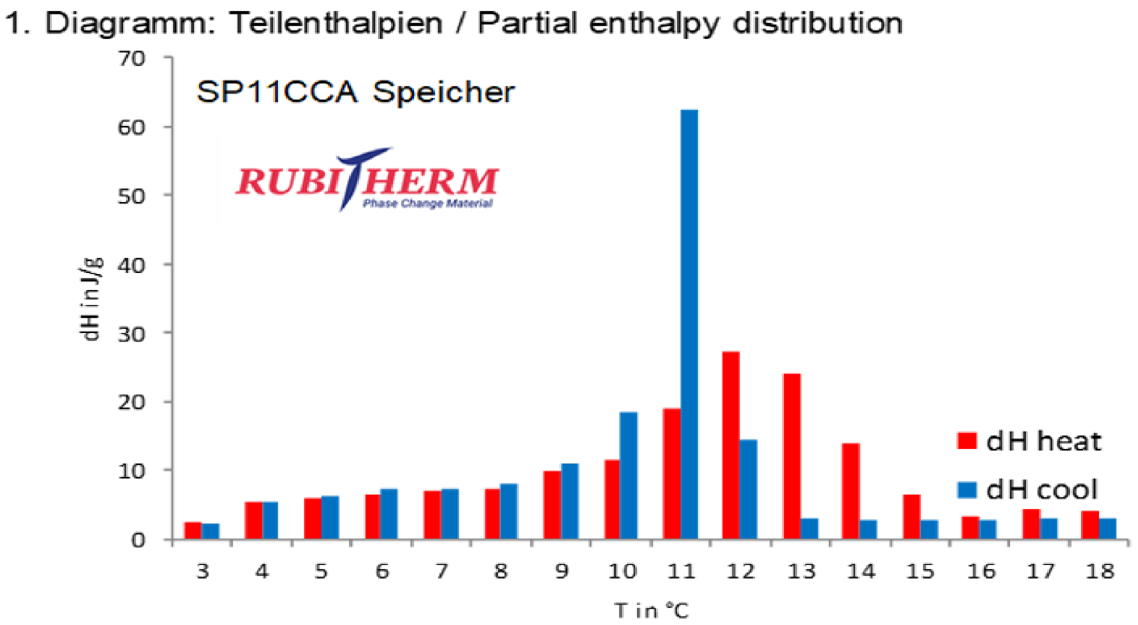

Figure 4 Partial enthalpy distribution for PCM SP11CCA when cooling (blue) and heating (red). Maxima in the enthalpy distribution indicate solidification and melting points, respectively.

SP11CCA (Figure 14) has no ammonia in the mixture. Through the experience with SP11Black and the carbon, a mixture from old trials could be used. The mixture is very thick and damaged the heat exchanger in the test in the 800 kg storage tank. Using it in this condition in the large original storage tank (Chalmers) poses great risks. Otherwise, the temperature levels are suitable.

Today we are still working on the development and hopefully we can get the new PCM material in operation in late 2022 or beginning of 2023.

The PCM material development can be summarized so far:

SP11D – deployed and is in Chalmers PCM tank now

SP11N - adapted to the temperature difference but problem with separation in PCM material.

SP11black - adapted to temperature / develops ammonia odor

SP11CCA - adapted to temperature, no separation, too thick for storage geometry

Annex 3 T7.6.1 Innovation Challenge. Change of Scope – lessons learnt

According to the IRIS Grant Agreement: "An innovation challenge will be held to stimulate the development of new applications making use of the CIM data". Unfortunately, within the framework of the IRIS project, the city of Gothenburg was not able to localise enough data to proceed with the Innovation Challenge.

This document is intended to provide an insight to the complexities of using BIM data to implement an Innovation Challenge. It will summarise the lessons the city learned from the process and will also provide guidance to cities and administrations who plan to use BIM data in future applications.

This report is an addition to the D7.6 Launch of T.T.# 4 activities on City Innovation Platform and information services (Gothenburg)

Description in Grant Agreement

Task

The task 7.6 is described in the following way in Grant Agreement:

"T7.6 Demonstrating Transition Track #4: City Innovation Platform (M13-M60) [GOT (17PM), TYRENS (25PM), METRY (22PM), CHALMERS (10PM), RB (5PM), SP (5PM), CERTH (1PM)]

Cross-cutting ICT enables the integration of the above-mentioned solutions, maximising the profitability of the integrated infrastructure. To achieve this, open ICT-system and open APIs are necessary, providing the City information platform and meaningful data services serving households, municipality and other stakeholders, together allowing for the new business models that emerge in the Gothenburg lighthouse project. Gothenburg will demonstrate the following solutions.

1) Implementation of a CIM (City Information Model) pilot that facilitates city management and planning by including building information, infrastructure, geodata and planning data in the Johanneberg district

In a digital model of the city, decisions, documents and plans can be connected to geographic locations, and forecasts, taking benefit of the visualization and planning application innovations provided by combining GIS (Geographical Information Systems) data with BIM (Building Information Model) data and 3D data in a way that captures both existing and planned structures to support the Urban area with analyses and maps. An innovation challenge will be held to stimulate the development of new applications making use of the CIM data.

2) Development and implementation an "Energy Cloud" on the Chalmers Campus. Near real-time data from energy (electricity, heat, water) consumption will be collected, integrated and made available for further analysis, thereby opening up for new applications to optimise energy supply and management on campus. For instance, setting maximum power limits dynamically adapting to varying consumption, predicting energy use automatically, analysing energy mix and calculating resulting CO2 footprint and more. This refined data platform will open up for external App developers to tap into the data and create innovative energy services for pilot implementation within and outside of the district. Additionally, a connection with Gothenburg City's open data is foreseen to further enhance the scope and usefulness of potential applications. An innovation contest will be held to stimulate the development of new application making use of the Energy Cloud.

This task is closely linked to the work carried out in WP4 and will make use of those common features and structures that are developed within that work package. Main KPIs include: Number of new applications using the CIM (target: >5) and the Energy Cloud (target: >5), respectively. Peak shaving for the Chalmers Campus Area (target >80 % peak power reduction)."

For more information on the CIM pilot please see D7.6 Launch of T.T.#4 activities on City Innovation Platform and information services (Gothenburg).

Change of scope & lessons learnt

Problems with original task scope

According to Grant Agreement: "An innovation challenge will be held to stimulate the development of new applications making use of the CIM data".

The data in the CIM pilot is based on BIM data from infrastructure projects. During the work with the pilot, it has become evident that the procedures and structures for collecting this type of data is far behind, and the data that we have been able to collect is limited to three projects. In order to be able to save the data in the CIM it is necessary that projects follow the same requirements identified in the project, but unfortunately no project follow these requirements, since this has not been implemented as requirements from the start. For the projects Tyrens must "remake" the data to make it fit in the CIM. As the requirements have not been either approved by or implemented in the city, no project data will automatically fit into the CIM. Currently the amount of project data available in the CIM is data from one project, the Hisingen Bridge.

To obtain BIM data:

At the start of the project the IRIS project requested BIM data from the city departments that work with planned, ongoing and finished projects. Unfortunately, there was not as much data as we expected. The reference projects are the projects that could provide relatively good interesting data. In the beginning we also changed the guidelines towards our entrepreneurs, so that 3Dmodels should be supplied to us when existing, however it takes time for these guidelines to give results. These guidelines will only affect projects being purchased after those guidelines were in place, which was after the start of the IRIS project. On numerous occasions during the IRIS project we have asked for project data both internally at the Urban Transport Administration and in the entire city. A lot of time has been spent searching for and investigating potential data. The little data that we have found has turned out to be of little use in the CIM in combination with too much effort to put it there.

In addition to that the City has a hesitation on sharing this type of detailed data in such an easily accessible way. There is a fear that the data could be used in the wrong way, so if an Innovation Challenge would be held, it has to be with contracted developers who are not allowed to spread the data.

To share data:

To avoid the risk of not being able to share the data, the approach was to only share what is already official data. At first, we did not think that sharing official BIM data would be a problem or a risk, however as the project has shown how easily this BIM data could be accessed and used, the risks of malicious use also have become more evident. The reference projects "Hisingen Bridge" and "Masthuggskajen" are considered sensitive for security reasons. As of the third reference project, Kville, this could also be the case. Additionally, the data from this project will not become official until after the end of the IRIS project, which means that this data cannot be used. We have investigated what guidelines there are in terms of open and shared data and looked for support in those, but it turned out that we could not get much help from those guidelines either as they are a bit unclear. Thus, the result is that we do not dare to share the data from Hisingsbron or Masthuggskajen openly. We have also considered using project data from constructions which are not as sensitive, but generally that kind of project data is not as interesting and will not be very useful to share. For this data we think the effort of adopting it will be higher than the value.

The City of Gothenburg does not believe that it is useful for the city nor the citizens to proceed with the Innovation Challenge based on data from one single project. Before start spreading the data and developing applications based on the data it would be more useful to develop the procedures, requirements and means of collecting and saving data.

In conclusion we can state

- We were not able to share the interesting BIM data we got from our reference projects and despite our efforts to obtain similar and useable BIM data, no BIM data could be made available at any levels at the city of Gothenburg to use in the Innovation Challenge. Efforts were made both at the Urban Transport Administration, other various administrations at the city as well as external partners. Thus, alternatives solutions to replace the Innovation Challenge, for example involving end-users or service providers in a different way have been investigated thoroughly.
- Unfortunately, the data that was possible to share – and to use in the Innovation Challenge - was not interesting enough to give added value to the project.
- This lack of available data has shown us that the city needs to value this need for BIM data as a priority area in the Urban Transport Administration internal development for 2021 and indeed the whole city.
- Cities have barriers in sharing the data and unfortunately there are no guidelines or requirements for collecting and sharing data and therefore the processes do not move forward. There is a hesitation, and no one is willing to take the step to move further. The data is available but is only intended for use by the project. Thus, the data needs to be classed in the models so that it can be shared in the right way. Finally, the city needs to review how the digital models can be used in other phases of the project and in other parts of the administration.
- It is clear to us now that the scope of the Innovation Challenge was too narrow from the start. Unfortunately, this could not have been foreseen.
- The innovation jam/workshop conducted as part of the IRIS project highlighted and recognised the need of sharing BIM data.
- There is possibility to explore the future connectivity to the city's digital twin. See below.
- The city has implemented necessary actions to avoid this risk of taking place, but that we are now faced with this deviation because it's unavoidable as explained above.

New scope – lessons learnt

What is needed to implement a successful Innovation Challenge based on BIM data? This document is intended to provide an insight to the complexities of using BIM data to implement an Innovation Challenge. It will summarise the lessons the city learned from the process and will also provide guidance to cities and administrations who plan to use BIM data in future applications.

The following list contains questions and problems relating to different aspects; the digitalisation of the building process (Smart Built environment), digitalisation in the city (increasing the sharing and use of models within the city), using BIM as a tool in the city (organisation, new methods of working and the handling of sensitive data) and finally the conditions needed to implement an Innovation Challenge with BIM.

- Have in place clear guidelines for open and shared data. Identify what the cities need to do to be able to as well as dare to share data.
- Have in place clear procedures and structures for data collection.
- Identify clear requirements for saving data in the CIM.
- Identify how the cities can enable that their (BIM) data become accessible, thus enabling the data to be published and communicated
- Identify how the city provides their (BIM) data:
    - Is the data classed? For example, are the different data elements in the model classified according to sensitivity? Is some data more available than other data? Not as high risk? Not confidential?
    - If not, can the data be categorized? Perhaps not all data is the same?
    - Should there be a recommendation that cities categorize their data?
- Ensure there is adequate accessible and available data from construction projects, e.g. infrastructure projects, during the life of the project to be able to implement the Innovation Challenge (if indeed the Innovation Challenge is a part of a project).
- Broaden the scope of the Innovation Challenge so that it is flexible and can accommodate unforeseen problems.
- Secure that 3D models are supplied (when relevant)
- Identify who needs to be involved (which city administrations, project partners, industry, researchers etc).
- Identify the implications of NOT doing the Innovation Challenge. What does this mean for the city and for the project?
- Have a clear strategy as to WHY the city wants to implement an Innovation Challenge, how it relates not only to the city's strategies yet also to regional, national and EU strategies. This might call for a workshop with the stakeholders to discuss the goals and the impacts.
- Have very clear goals and objective on how the results/knowledge of the innovation challenge will be used in the city and/or project. For example, will it be a part of the future planning of the city's operations? Used for replication? Upscaling? Used to apply for funding?
- Plan to do an evaluation of the Innovation Challenge.
- Identify alternatives if the Innovation Challenge in the intended form cannot be implemented. For example, can a Digital twin with its access to current data be used to implement the innovation challenge? (See below, chapter 4).
- Identify what is needed to succeed with the implementation of the Innovation challenge. Workshops? Innovation Jams? Etc.
- Identify a clear process for the whole process of the innovation challenge.

Moving forward

- This report will be spread within the city's administrations who have use of this report, partners in the IRIS project, interested cities and the European Commission.
- The city of Gothenburg sees the advantages with a CIM and the possibilities a complete CIM can provide the city. Work on the CIM began as an activity in the IRIS project but the potential for the future use was evident. The work we have completed in IRIS provides a strong base for the continued work with BIM data.
- The city of Gothenburg has an ambition to create a joint work/platform for CIP.
- Digital Twin. In Gothenburg, many initiatives regarding digitalization are being implemented. One goal is to create a digital twin of the city. Having a digital copy of the city, connected to real-time data, will facilitate gathering, sharing and visualizing relevant information in one platform for planning, control and maintenance. The Digital Twin can also serve as a test bed for development and innovation striving to achieve the global sustainable development goals. There is overall a political interest in opening up data, because it increases transparency and stimulate innovation. Benefits would be improved planning and greater efficiency in

execution, for instance improved logistics when building new houses or infrastructure. The major challenge is to handle security issues and abuse of certain data, which need further development.

Figure 1 The City of Gothenburg - Digital Twin

- In order to develop the concepts of CIM, digital twin and data distribution Gothenburg has deepened its understanding of FIWARE, which is the smart solution platform, launched by the European Commission and the major ICT players in 2011. FIWARE provides a set of public and royalty-free tools that ease the development of smart applications.
-

Impact on the IRIS project

The innovation challenge activities will need to be adjusted in the time plan in task 7.6.1 to incorporate the change of scope.

Impact on KPIs and monitoring of KPIs

The main KPI for the CIM pilot and the only KPI for the CIM pilot specified in Grant Agreement is: "Number of new applications using the CIM (target: >5)". This KPI will not be reached. Number of applications will be 0.

In deliverable D 7.6 some more KPIs have been identified. Below is a short version of the monitoring plan for all KPIs for the CIM pilot as it was described in Deliverable D7.6. An extra column is added to describe the impact on the monitoring of each KPI.

KPI (Description from D7.6)	When monitor (Description from D7.6)	How monitor (Description from D7.6)	Impact on monitoring
Ease of use for end users of the solution	Twice, M32-M33 and M45-M46	1:st time, in workshop with users responsible for new projects and users responsible for administration of data from projects. 2:nd time, through questionnaire given to third party developers	Will only be measured the 1:st time M32-M33, in the workshop

		that participate in the Innovation Challenge	
Advantages for end-users	Twice, M32-M33 and M45-M46	1:st time, in workshop with users responsible for new projects and users responsible for administration of data from projects. 2:nd time, through questionnaire given to third party developers that participate in the Innovation Challenge	Will only be measured the 1:st time M32-M33, in the workshop
Quality of open Data	Once, M45-M46	Manual check	No Impact
Open data-based solutions	Once, M45-M46	Manual check, how many applications exist after Innovation Challenge	Can be measured, but we already know that the target of >5 applications cannot be reached. We know the result will be 0 applications.
Usage of open source software	Once, M45-M46	Manual check	No Impact

Impact on Costs

The change in costs will only affect the city’s internal costs.

Impact on other Tasks

Task 9.5 will be affected since the monitoring of the KPIs will be affected according to the description of impact on KPIs and monitoring above.

Impact on the demonstration and evaluation of the two use-cases “Visualize your city” and “Kick start your project

The use-case “Visualize your city” cannot really be evaluated since we would need third party applications from the Innovation Challenge to do that. We can still demonstrate the ideas through the test implementation that has been done by Tyrens in Cesium 3D. There is no impact on demonstration and evaluation of “Kick start your project".

Annex 4: Climate framework for higher education institutions

A Climate framework for higher education institutions, with the aim of engaging universities and university colleges in Sweden to contribute to both national and international commitments to reach the so-called 1.5°C target.

Higher education institutions (HEIs) have a central role in efforts to combat climate change. We have an important task to contribute through our teaching and research, but we also need to contribute by reducing the impact of our own operations.

The HEIs that have signed this framework consider the climate to be a crucial and prioritised issue. We undertake to do the following:

- We will through education, research and external engagement help society as a whole to achieve set targets.
- We will work to reduce our own climate impact in line with society's commitment as expressed in national and international agreements.
- We will, based on our HEI-specific conditions, set up far-reaching targets for climate-related work and also allocate resources so that we can achieve these targets and conduct follow ups.
- We will clearly communicate our climate-related work in order to inspire and spread knowledge to other organisations and members of society.

The Climate Framework includes this text, and a guideline document that among other things list a number of key areas for climate impact from higher education institutions. Each institution will choose the areas they will focus on depending on their local circumstances. Each institution should however be prepared to work with the following areas: education, research, collaboration, business travels and energy use, since they are considered central for all higher education institutions.

For Chalmers, this work has resulted in a climate strategy.

The following higher education institutions are signed up to the framework

- Beckmans College of Design
- Blekinge Institute of Technology
- Chalmers University of Technology
- Dalarna University College
- Ersta Sköndal Bräcke University College
- Gävle University College
- Halmstad University
- Jönköping University
- Karlstad University
- Karolinska Institute
- Konstfack, University of Arts, Crafts and Design
- Kristianstad University
- KTH Royal Institute of Technology
- Linköping University
- Linnaeus University
- Luleå University of Technology
- Lund University

- Malmö University
- Mid Sweden University
- Mälardalen University College
- Newman Institute
- Red Cross University College of Nursing
- Royal College of Music, Stockholm
- Royal Institute of Art
- Sophiahemmet University College
- Stockholm School of Economics
- Stockholm School of Theology
- Stockholm University College of Music Education
- Swedish Defence University
- Swedish School of Sport and Health Sciences, GIH
- Swedish University of Agricultural Sciences
- Södertörn University
- Umeå University
- University College West
- University of Borås
- University of Gothenburg
- University of Skövde
- Örebro University

Annex 5: Master's Thesis: Motivation for Participation in City Development

CHALMERS
UNIVERSITY OF TECHNOLOGY

Motivation for participation in city development

A case study of Citizensourcing in Gothenburg, Sweden

Master's thesis in Management and Economics of Innovation

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CHALMERS UNIVERSITY OF TECHNOLOGY

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David Helldén & Ruibo Zhao
Gothenburg, February 2021

Motivation for participation in city development

A case study of Citizensourcing in Gothenburg, Sweden

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ABSTRACT

During recent years, the topic of Smart Cities has become increasingly relevant. Cities all around the world are faced with the challenge of utilizing technology to improve and better the quality of life for their citizens. One aspect of Smart City development involves inviting citizens to participate in development of their cities, sometimes referred to as Citizensourcing.

Citizensourcing essentially views citizens as both customers and users of public services and concerns how citizens can co-create value together with public administrations and governments. In order for Citizensourcing to be successful, governments have to be able to involve their citizens in Citizensourcing initiatives which leads to the question of how to motivate citizens to participate in such initiatives. In this study, we have studied the Citizensourcing platform Min Stad in Gothenburg using Herzberg's Hygiene Needs Theory and Vroom's Expectancy Theory to understand what motivates citizens to participate and what causes citizens to stop participating. Our results indicate that citizens are driven by both dissatisfiers and motivators, value feedback highly and are mostly interested in participating on city topics that are geographically close to home or within topics that interest them. In addition, we propose the introduction of a new framework based of Herzberg's Hygiene Needs Theory called "Citizensourcing Two-Factor Motivation" to study motivation in Citizensourcing settings. In this framework, we propose a replacement of Herzberg's so called dissatisfiers and motivators with the new terms "City Life Conditions" and "Citizenship Identity" to better understand what motivates citizens to participate in Citizensourcing initiatives. With this, we hope to encourage more studies in this field as well as getting a better understanding of how citizens can become more active in shaping their cities, and lives.

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Keywords: Smart City, Citizensourcing, motivation

1. Introduction

1.1 Background

This chapter will provide a background as well as an introduction establishing why this research is interesting and important. Firstly, a brief introduction to Smart Cities and Citizensourcing will be provided. Secondly, an introduction to motivation as a topic within Citizensourcing will be presented. Finally, the purpose and research questions of this report will be introduced.

1.1.1 *Citizensourcing in Smart Cities*

Throughout the last decade, becoming a Smart City has risen as an important challenge for cities and public administrations around the world. The interest in the transition to Smart Cities can be seen both in academic research, with the number of papers on the topic accelerating around 2010 (Dameri & Rosenthal-Sabroux, 2014), and also through the myriad of industry reports published on Smart City development such as Woetzel et al. (2018) or Deloitte (2015).One of the most cited authors within the topic of Smart Cities, Giffinger, defines a Smart City as: "...a city well performing built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens". (Giffinger & Gudrun, 2010) The term Smart City is by definition complex in its nature as it incorporates many different aspects that have become increasingly relevant during recent years. Therefore, there is no universally established definition of exactly what Smart Cities are. In general, a Smart City revolves around using technology and data to improve efficiency of processes, improve existing services or innovating entirely new services and processes. Authors such as Green (2019) and Dameri & Rosenthal-Sabroux (2014) agree that technology is the most important aspect of a Smart City.

However, it is important to note that Smart Cities is a broad term not limited to the use of

ICT-technology to digitize a city. For instance, Dameri & Rosenthal-Sabroux (2014) emphasise that Smart City definitions include a wide range of areas including environmental, social and digital components. Additionally, both Green (2019) and Dameri & Rosenthal-Sabroux (2014) agree on the importance of social aspects of Smart Cities. According to Green (2019), technology itself can act as a valuable tool, however unintended consequences can appear when using a technology-driven approach to social changes. He further explains how Smart Cities often overemphasize the role of technology. Dameri & Rosenthal-Sabroux (2014) further add that human contribution is vital to incorporate the life of people into the smart actions that make up Smart Cities. Having this in mind, a growing field within Smart City research has been to understand how to effectively incorporate social aspects and bring citizens' perspectives into the complex questions of Smart Cities.

Benefits of Smart Cities include improving the quality of life of its citizens, nurturing a sustainable economic development and creating a more inclusive environment that allows for more citizen participation (Dameri & Rosenthal-Sabroux, 2014). These types of benefits have led to many cities, such as Gothenburg in Sweden, to adopt a digital agenda to transition to a Smart City. The city of Gothenburg (also referred to as Göteborgs Stad) highlights five key benefits of becoming a Smart City: "1) Simplifying everyday life for citizens, visitors and businesses, 2) Becoming a smarter and more open administration that supports innovation and participation, 3) Creating higher quality and efficiency in its functions, 4) Contributing to the city's brand and 5) To a larger extent use and optimize external financing to increase the pace of development and pre-requisites for innovation (Göteborgs Stad, 2020).

As exemplified by point 2) from Gothenburg's official homepage, one part of developing a Smart City is transitioning towards a more open government and a new type of public governance which view citizens not only as customers, but also as co-creators of public policy (Thapa et al., 2015).

The transition toward a more open government has led to an introduction of the term "Citizensourcing", borrowed from the term "Crowdsourcing" often used in the private sector, to describe an act where public administration outsources a task traditionally performed by a public agent to an undefined group of individuals in an "open call"

(Hilgers & Ihl, 2010). Successful Citizensourcing requires cities to adapt in order to allow citizens to become more involved and participate more actively in the development of a city when compared to traditional public administration. For Citizensourcing to function properly, enough citizens have to participate in co-creation and innovation activities which leaves the question, what motivates citizens to participate in Citizensourcing initiatives?

1.1.2 *Motivation in Citizensourcing*

Motivation in co-creation and innovation initiatives organized by public administrations is thus an increasingly relevant topic, particularly within the field of Citizensourcing as it is a fairly untouched area. Previous research within the field, for instance Schmidthuber et al. (2019), has applied traditional motivation theories such as self-determination theory (also referred to as SDT) to try to understand what motivates citizens to participate in Citizensourcing. However, these studies have not been sufficient enough to fully explain the driving forces behind citizens' motivations. Studies such as Schmidthuber et al. (2019) have explored the initial motivations behind citizens participation, but have also highlighted the need to further study what causes citizens to stay motivated over time. Previous research such as Wijnhoven et al. (2015) has also highlighted that cultural factors may play a role in what motivates citizens to participate, indicating that motivation factors may differ between cultures.

Therefore, this study will attempt to add to the existing knowledge on the subject by qualitatively studying what motivates citizens to participate in a case of Citizensourcing, more specifically, a digital platform called "Min Stad'' (translated to My City) in the city of Gothenburg in Sweden. This platform was chosen as a suitable object to study for several reasons, including that the platform allows for voluntary participation on a wide range of topics and that the platform gives access to users over time, as it has been up and running since 2012. The fact that the platform allows for voluntary participation makes it interesting to study from a motivation perspective as participation is not driven by obligatory, rules based, participation or rewards. The theoretical framework used in this study is based on two motivation theories, Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964). These theories originate from work motivation in the corporate world but could prove useful in understanding motivation in a Citizensourcing setting. It is reasonable to expect some of the same aspects that motivates employees in a workplace environment to also be relevant in motivating citizens to participate in Citizensourcing initiatives such as Min Stad. Therefore, our study aims to initiate an adaptation of traditional motivation theory to a Citizensourcing setting and take the first step in this direction to better understand citizen motivation. In addition, these motivation theories provide additional perspectives on motivation which complements previous research that has used other motivation theories, such as SDT, within the field of Citizensourcing.

Furthermore, there is an increasing interest from the city of Gothenburg to engage its citizens in Citizensourcing activities. This makes this study both relevant from a theoretical perspective and beneficial to the city of Gothenburg and other cities as it hopefully provides value by aiding future management decisions on how to implement Citizensourcing activities that increases citizens' motivation to participate.

1.2 Purpose and research questions

The purpose of this paper is to study a Citizensourcing platform ("Min Stad") created by Göteborgs Stad in order to understand what motivated citizens to participate in Min Stad. By doing this, the study hopes to contribute to the field of Citizensourcing and Smart Cities by providing valuable insights on what motivates citizens to participate in Citizensourcing initiatives. Thus adding additional knowledge about the subject as well as aiding in future decisions regarding development of these types of initiatives.

Additionally, cities such as Gothenburg may also struggle to either attract enough citizens to participate, or potentially keep participation high without citizens losing interest over time. Therefore, another aim is to understand what causes citizens to stop participating in Citizensourcing projects to gain insights into how a public administration could go about motivating those citizens into staying active and participate over longer periods of time.

This study strives to answer the following research questions:

1. What motivates citizens to contribute to a Citizensourcing platform, such as Gothenburg's "Min Stad"?
2. What causes citizens to stop contributing to a Citizensourcing platform, such as Gothenburg's "Min Stad"?
3. How could the city of Gothenburg act to impact motivation and citizen engagement levels on Citizensourcing platforms, such as Gothenburg's "Min Stad"?

The paper will be structured into the following sections. In Chapter 2, previous work within the fields of motivation theory and Citizensourcing will be discussed in order to create a theoretical framework for the study. In Chapter 3, the method of the study will be described including the overall study design, data collection and data analysis methods. In Chapter 4, the results of the study will be presented. In Chapter 5, a discussion related to the results will be provided. Including a discussion of the theoretical contribution of this paper along with a proposed framework for Herzberg's Hygiene Needs Theory adapted to a Citizensourcing setting. In Chapter 6, some practical implications of this paper will be provided and finally, in Chapter 7, some limitations and potential avenues for further research are described.

2. Theory

In this chapter, the theory that forms the theoretical framework for this study is presented. To begin with, an introduction of Open Innovation and Citizensourcing is presented. This is followed by a presentation of motivation theories, more specifically, Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964). These motivation theories are then adapted and linked together with the subject of Citizensourcing. Lastly, the coding scheme developed for the analysis of this study is introduced.

2.1 Citizensourcing

Open Innovation essentially concerns encouraging and utilizing internal and external resources for innovation purposes (West & Gallagher, 2006). This term is often used to describe how private firms can use external resources such as customers, rivals or universities for innovation. By applying these principles to the public sector, one can speak about "Open Government". Open Government is described by Hilgers & Ihl (2010) as a way to integrate external actors for value creation in the governmental processes. It is described as a way to embrace more openness in terms of information and decision-making in order to improve the relationship between the government and the public. Closely related to Open Government is "Citizensourcing", which Hilgers & Ihl (2010) explain is a way to achieve participation and transparency in public sector organisations.

Citizensourcing can be seen as a new type of relationship between the government and its citizens where citizens are encouraged to aid public value-creation through different types of Citizensourcing initiatives. Their definition of Citizensourcing is as follows:

> "...the act of taking a task that is traditionally performed by a designated public agent (usually a civil servant) and outsourcing it to an undefined, generally large group of people in the form of an open call." (Hilgers & Ihl, 2010)

Citizensourcing is a way of viewing citizens as both customers and users of public services. An important aspect is therefore to provide them with possibilities to contribute with complaints and suggestions to improve these services (Hilgers & Ihl, 2010). Hilgers & Ihl (2010) propose a framework that categorizes Citizensourcing along three dimensions: 1) *Citizen Ideation and Innovation*, leveraging the citizens' creativity and knowledge through methods such as idea and innovation contest through open innovation platforms, 2) *Collaborative Administration*, integrating the citizens to enhance existing public administrative processes and 3) Collaborative Democracy, collaborating to improve public participation within public policy processes.

When it comes to previous work on what motivates citizens to participate in Citizensourcing, Thapa et al. (2015) explain that in order to increase citizen involvement, the designing of Citizensourcing initiatives has to be tailored to the task and target group due to the diversity of motivations. By tailoring the task to the right target group, Thapa et al. (2015) mean that citizen involvement can lead to a boost in innovation in the public sector. Another interesting finding of theirs was that citizens' willingness to participate increased with the level of expertise. Furthermore, Schmidthuber et al. (2019) analyzed why citizens participate in open government projects from the perspective of self-determination theory. Their study found some quantitative support that intrinsic motivation (such as the feeling of fun and enjoyment) boosted participation quality. In addition, results from this study indicated that individuals that are motivated by external pressure or rewards share fewer ideas although they may evaluate more ideas by pressing like or dislike.

However, the report also highlights the need for further research on the topic as they have a rather large unexplained variance in their results. Additionally, they emphasise that factors such as cultural differences and previous governmental attempts to communicate with the citizens could influence the results. Another study from Schmidthuber et al. (2017) analysed determinants of citizens participation through the perspective of a Technology

Acceptance Model (TAM), Intrinsic and Extrinsic motivation and Theory of Planned behavior. This study found that the perceived ease of use of a Citizensourcing platform had no significant impact on participation while the perceived usefulness did. Similarly to Schmidthuber et al. (2019), this study also found that fun and enjoyment were important motivators. In addition, the study also found that participants with experience from traditional reporting had higher activity on the online reporting platform. This study also highlighted the need to further study, not solely what causes citizens to participate initially, but also what causes citizens to keep engaging over time.

Therefore, this study attempts to add to existing research by exploring a Citizensourcing platform by using classical motivation theories. In addition, the study will also provide new insights by studying what causes citizens to stop contributing to a project. The motivation theories Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964) are used to analyse the motivation of citizens as they are both well cited and widely accepted when it comes to work motivation. The following chapter will therefore explain these theories on a general level and tie everything together with Citizensourcing in the case of Min Stad.

2.3 Theoretical framework

Motivation theories help us understand why people act and behave in different ways. It is however important to bear in mind that most motivation theories originate from work motivation and how to motivate employees (Shani et al., 2009). Previous studies, such as Robinson et al. (2016) highlights that motivation studies within digital space is rather uncommon, however some previous work using motivation theories within a Citizensourcing setting exist. In our study, Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964) are used to develop a coding scheme that is used as a framework for analysing citizens motivations to participate on Min Stad.

2.3.1 *Herzberg's Motivation – Hygiene Needs Theory*

Frederick Herzberg identified that people had two types of major needs (Herzberg, 1987). The first type of need is "hygienic needs", which essentially concerns the physical and psychological conditions where people work. Shani et al. (2009) explain that hygiene needs, according to Herzberg, were to be satisfied by hygiene factors or dissatisfiers. Dissatisfiers could be working conditions, company policy, relationship with supervisors etc. The name dissatisfiers comes from the rationale that employees expect these factors to be good. However, they will never be truly motivated if these factors are better than good.

The second type of needs is "motivator needs", which are the needs that really make people want to work. These motivator needs include factors such as recognition, the nature of the work and responsibility and are described by Herzberg to be similar to the higher needs in Maslow's Hierarchy of Needs (Maslow, 1958). These are the factors that contribute to job satisfaction. This theory is called Herzberg's Two Factor Theory, sometimes also referred to as Herzberg's Hygiene Needs Theory. According to Herzberg (1987), the opposite of job satisfaction is not job dissatisfaction, it is no job satisfaction. Similarly, the opposite of job dissatisfaction is not job satisfaction, but rather no job dissatisfaction. Herzberg (1987) states that people tend to see satisfaction and dissatisfaction as opposites, however, when it comes to understanding human behaviour, these are caused by two different human needs.

2.3.2 *Vroom's Expectancy - Valence Motivation Theory*

Vroom (1964) described how motivation can be explained as a function of three factors, Expectancy, Valence and Instrumentality. According to Vroom's theory, the three factors can be used to determine how much effort an individual will put into a task. The theory is based on an assumption that individuals weigh costs and benefits, consider alternatives and take action based on what action yields the highest utility.

The first factor, Expectancy, can be described as the individual's perceived probability that a certain level of effort will lead to a desired performance (Shani et. al, 2009). In previous research, the perceived relation or correlation between action and outcome has also been measured as Expectancy (Van Eerde & Thierry, 1996). The second factor, Instrumentality, can be described as the individual’s perceived probability that the performance achieved will lead to a desired outcome (Shani et. al, 2009). Because a certain level of performance could have several potential outcomes, Vroom (1964) states that the number of outcomes should be weighted by Valence and summed. In practice this part has received some criticism due to difficulties in measuring Instrumentality because most researches select the outcomes that are later presented to the subject for rating (Van Eerde & Thierry, 1996). This can potentially cause issues as outcomes may be of a type that the subject did actually not consider yet, thus causing the researcher to impact the subjects motivation just by studying it. The final factor, Valence, can be described as the perceived value of the projected outcomes (Shani et. al, 2009). This is generally interpreted in previous research as the importance, attractiveness, desirability or anticipated satisfaction of an outcome (Van Eerde & Thierry, 1996).

Although this theory has received much attention in the study of motivation of work, critics argue that the model is too complex and that key elements are subject to interpretation and definition issues (Shani et. al, 2009). Previous studies, such as Van Eerde & Thierry (1996) have shown that different researchers disagree on what the key components mean and how to measure them.

Despite the criticism against Vroom’s model, the theory has led to multiple new theories that have been developed upon the Expectancy Theory, for instance SDT (Self Determination Theory) (Gagné, 2005) or Porter and Lawler’s (1968) model of Intrinsic and Extrinsic work motivation.

However, Van Eerde & Thierry (1996) suggest using the Valence, Instrumentality and Expectancy components rather than the developed models.

2.3.3 *Linking Citizensourcing together with Herzberg’s Hygiene Needs Theory and Vroom’s Expectancy Theory*

In the case of Gothenburg’s digital platform Min Stad, the motivation theories mentioned above have been adapted and interpreted accordingly. Firstly, as Herzberg’s Hygiene Needs Theory (Herzberg, 1987) originates from work motivation and was developed to understand the motivation to work, some aspects of it would be less relevant than others. For instance, dissatisfiers such as “salary”, “company policy” and “supervision” that are relevant factors for motivation of employees, are most likely not directly applicable for what motivates citizens in a city. However, other dissatisfiers such as “safety” and “work condition” are more directly applicable in a Citizensourcing setting. Safety can be referred to as the safety in the city and includes factors that cause people to feel safe. An example would be when a citizen choses to report on the platform because a broken street causes an alley to feel dark and unsafe or when a bicycle lane has a sharp bend that ends in a highly trafficked car lane. Work conditions could refer to general conditions in the city environment that bother citizens but do not pose a direct question of safety. This could be when a traffic light is irritatingly slow and causes a citizen to spend a couple of minutes extra every day on the way to work. When it comes to the dissatisfiers that are not directly applicable, these could be adapted to better fit in a Citizensourcing setting. Salary could be replaced with “city tax rates and fees”, as the city (or municipality) tax rate is usually determined by the city (or the governing politicians) and also has a direct effect on disposable income in the same way that salary does. An example of this would be when road tolls or congestion fees that are higher than other cities cause a citizen to come on to a Citizensourcing platform to complain about this. Company policy could be replaced with “city rules and regulations”, meaning that citizens care that these are fair, clear and in line with other cities the same way that employees care about that for company policy. An example of this would be that citizens could be dissatisfied and comment on how long bars can stay open at night or how long cars can stay idling in the city.

In terms of Herzberg's Hygiene Needs Theory (Herzberg, 1987) in a Citizensourcing setting the motivators are mainly "achievement", "recognition", "challenge" and "the work itself".

Achievement refers to people getting a feeling of accomplishment, which is different from recognition that refers to people feeling being recognized for their contribution. In the case of Min Stad, a participant motivated by recognition could choose to contribute to the platform because the person expects his/her ideas to gain praise and be recognized as a good citizen by other citizens or city officials. Challenge refers to citizens finding the task being a challenge to them. An example of this could be when a citizen feels that developing ideas for public transportation and getting his/her suggestions good enough to be implemented is a challenging and rewarding task. Finally, the work itself refers to citizens finding the actual work being fulfilling. A citizen that is motivated by the work itself might find enjoyment just exploring the city through a 3D map and adding suggestions for fun. In general, these motivators could be closely linked to the feeling of fun and enjoyment highlighted by previous studies within the field of Citizensourcing as an important factor for what causes citizens to contribute.

InTable 1 below a summary of the dissatisfiers and motivators is presented. This table provides the framework used when developing the coding scheme.

Type	**Name**	**Description**
Dissatisfier	Safety	Factors that directly affect the

		feeling of safety among citizens.
Dissatisfier	Work conditions	Factors in the city environment that are not directly related to safety.
Dissatisfier	City tax rates and fees	Tax rates, fees or other factors that impact the citizens disposable income.
Dissatisfier	City rules and regulations	Factors that impact how rules and regulations within the city are perceived by citizens.
Motivator	Achievement	Factors that provide citizens with a sense of achievement.
Motivator	Recognition	Factors that provide citizens with a sense of being recognized for their work.
Motivator	The work itself	Factors that make citizens feel encouraged and find it interesting to post.
Motivator	Challenge	Factors that act as a challenge for the citizens to be stimulated.

Table 1. Descriptions of Herzberg's Hygiene Needs Theory adapted to a Citizensourcing setting

Just as with Herzberg's Hygiene Needs Theory (Herzberg, 1987), Vroom's Expectancy Theory (Vroom, 1964) is also adapted to a Citizensourcing context. As Vroom (1964) highlights, it is important to note that citizens can have multiple expected outcomes that impact their motivation and how much effort they will put into sharing on the platform. For example, a citizen that has reported a broken street light that makes a local alley feel unsafe, might both expect the problem to be fixed, but also that other neighbours in the local community show their support on the suggestion. Expectancy can be exemplified with factors causing people to feel that posting something requires too much effort or that the platform does not allow them to express themselves properly no matter how much they try. Instrumentality could in the case of Min Stad be factors causing citizens to feel that no matter how good contributions they make on the platform, these contributions will never reach the desired outcome. For example citizens might feel that nobody cares or replies to their posts anyway or that no suggestions ever get implemented through this platform. Lastly, Valence can be exemplified as citizens not caring about what happens to their posts, and them viewing it as a way of getting it out of their mind. Table 2 below provides a summary on the three factors of Vroom's (1964) factors adapted to a Citizensourcing setting.

Type	Description
Expectancy	The individual's perceived probability that a certain level of effort will lead to a desired performance.
Instrumentality	The individual’s perceived probability that the performance achieved will lead to a desired outcome.
Valence	The individual’s perceived value of the projected outcome.

Table 2. Descriptions of Vroom’s Expectancy Theory adapted to a Citizensourcing setting.

To summarize, some previous research exists on the topic of how to motivate citizens to participate in Citizensourcing initiatives. However, these studies also showed that the motivation theories used in those studies do not fully explain the underlying motivations of citizens. Therefore, this study aims to add to existing literature by exploring two classic theories of work motivation in a Citizensourcing setting. In addition, previous studies have also highlighted the need to study what causes citizens to stay motivated over time, and not only the initial motivations for participating.

Therefore, this study will also attempt to understand what causes citizens to stop contributing using these theories.

3. Method

The purpose of this study was to understand what motivated citizens to contribute to Citizensourcing initiatives. Therefore, a single case study based approach was deemed most appropriate to allow in depth exploration of the underlying motivations of the citizens (Yin, 2018).

3.1 Case study

“Min Stad” (translated to English: My City) originates from a website created by the city of Gothenburg in 2012, which was later also launched as a mobile application. The application serves multiple purposes in the eyes of the city. Firstly, citizens can suggest ideas on things that need to improve within the city and tag them with a specific subject on a specific location. Secondly, the application can be used by the city to visually share information on various city development or infrastructure projects that are going on or are planned around the city. Thirdly, both users and the city can use the application to share stories or history behind specific geographic locations within the city. Central to the interface of the application, and website, is a 3D-map over the city where users can explore all posts that other users or the city have posted throughout the city, in addition to putting their own contributions on the map. A post, or contribution, is generally a short text comment such as “this traffic light is broken” or “rebuild this city area to a large park” . Sometimes posts are tagged with a specific theme such as “public transportation” or “leisure”, and occasionally with an included picture. In terms of the three Citizensourcing dimensions identified by Hilgers & Ihl (2010), Min Stad could be described as mostly about Collaborative Administration, as citizens can collaborate by reporting on issues in the city and thus enhancing the quality of data for the city on where to focus its resources. However, it also has some aspects of Citizen Ideation and Innovation as citizens can provide suggestions and ideas for improvements within the city that are of a more creative nature.

Min Stad was chosen as the basis for theoretical sampling as it is a good case to study motivation in a Citizensourcing context. Firstly, the application allows users to post ideas on how to improve the city, but also stories where the user may only be looking to share something interesting with others. This is relevant from a theoretical perspective because it means that users could have a wide range of motivations for contributing on the platform. Secondly, the application targets the entire population of Gothenburg, and is not limited to a specific subject such as, for instance, traffic issues. This means that the theoretical framework and results of this study may be applicable across a wide array of other Citizensourcing initiatives. Thirdly, the platform has a significant amount of contributions, with a total of over 1400 posts from citizens, proving that the application is actually used by citizens. Finally, the application has been around since 2012, although partly only in form of a website. This is important to answer the second research question, why citizens stop contributing to Citizensourcing platforms, by having access to individuals that may have contributed in the past but have now stopped contributing. These factors contribute to Min Stad being very interesting from a Citizensourcing perspective. This, combined with the interest from the city of Gothenburg to understand the underlying motivations of participants, makes Min Stad an ideal platform for this study.

3.2 Data collection

The data collection for this study consisted of data from three main sources. Firstly, interviews were conducted with both users of the platform and staff from Göteborgs Stad who had worked on Min Stad. Secondly, activity of the users on the platform such as how many posts were admitted over time was studied. Finally, other relevant documents and websites relating to Min Stad and Göteborgs Stad’s work with other Citizensourcing platforms were reviewed. Each of these data sources will be described in more detail in the following section.

3.2.1 *Interviews with users*

The primary data source was interviews with users of the application Min Stad. Interview subjects were selected from individuals that had contributed to the platform by submitting suggestions using their Facebook profiles. As all suggestions on Min Stad require a Facebook profile, most participants were available for messaging through the Facebook platform. A few participants were however unreachable, as they had either removed the Facebook profile used when publishing the post or had their profile closed from messaging. Participants were contacted from a reverse chronological order, meaning that interviewees that had posted more recently were contacted first. In total, 52 potential interviewees were contacted, which equals all participants that had posted from 2017 except 7 that were unreachable due to factors described above. Participants who had not posted anything since before 2017 were not contacted as it was assumed that these subjects would not remember enough of their motivations to provide valuable data. Out of the 52 contacted, 37 did not respond, 4 declined to be interviewed and 11 were finally interviewed.

Moreover, all interviewees in this study have been anonymised in order to protect each individual's personal integrity. This means that all the names mentioned in the results and discussion chapter are pseudonyms and thus not the real names of the interviewees.

The interviews with users were conducted using a semi structured approach with an interview protocol intended to last roughly 30 minutes. The protocol was structured into two main parts, the first part focusing on motivation behind using the app in general and the second part focusing on motivation behind a specific post. The motivation theories introduced in the literature chapter were used as a foundation to formulate questions exploring the underlying motivations of the participants. All communication with study participants, including interviews, were conducted remotely either through telephone or digital video conference tools. The interviews were all conducted in Swedish and later transcribed.

3.2.2 *Interviews with staff at Göteborgs stad*

In addition to the interview data collected from users of the platform described above, conversation-like interviews were conducted with staff at the city of Gothenburg that had worked with the platform. The purpose of these interviews was to get a better understanding of the background of the platform, along with the city's perspective on what the purpose of the platform was. In total, three interviews were conducted with staff that had worked with, or close to, Min Stad. The interviews ranged between 40 - 60 minutes and were conducted remotely through digital conferencing tools and in Swedish. Because the purpose of these interviews were to gain background information and understanding of the general purpose of Min Stad, these interviews were not transcribed.

3.2.3 *Data on activity on the platform*

Data was also retrieved on the usage of the platform, including details on the number of contributions to the platform, along with information on which geographical areas users commonly posted in. The purpose of retrieving this data was to gain an understanding of the activity on the platform and how that had developed over time. As the second research question relates to why users stop contributing to a platform such as this one, it was important to understand whether the application was successful in retaining users over time or if activity was stagnant or declining. In addition, reviewing individual posts on the platform served as a way to gain understanding on both what users commonly posted or discussed on the platform, but also for a high level of understanding in which locations these posts were more or less common.

3.2.4 *Documents and websites related to Min Stad*

To complement the interviews and data on activity on the platform, a number of documents and websites related to Min Stad and Göteborg Stad's related work on Smart City development in general and Citizensourcing in particular were reviewed. The purpose of reviewing these sources was to gain a deeper understanding of the purpose and goals of Min

Stad and other Smart City initiatives in the eyes of the city. Public documents regarding Göteborg Stad's Smart City development in general (Göteborgs Stad, 2020) along with documents from the EU project IRIS (Integrated and Replicable solutions for co-creation in Sustainable Cities) were reviewed (IRIS Smart Cities, 2020). In addition, more application specific documents such as opinions from the city council on guidelines for the similar Citizensourcing service within Göteborgs Stad called "Göteborgsförslaget" was also reviewed (Göteborgs Stad kommunstyrelsen, 2019).

3.3 Data analysis

All interviews with the users were recorded and transcribed. To ensure a robust analysis, the transcripts were analyzed using a coding process based on Units of Analysis similar to the one proposed by Campbell et al. (2013). Using this method means identifying portions of text to be coded, called Units of Analysis, that capture the meaning and context of what a respondent says (Campell et al., 2013). An example of a Unit of Analysis would be if an interviewee says that: "I engaged on the platform because I was concerned with the safety of my area.". This sentence in its entirety, or a part of it, could then be identified as a Unit of Analysis and coded as related to safety. A high level overview of the process can be seen in Figure 1 below. This method was used in order to minimize issues that can arise when the Units of Analysis are not naturally given and thus require the subjective interpretation of the coder, sometimes referred to as issues of Unitization (Krippendorff, 1995). For instance, a Unitization issue could arise when two independent coders want to use the same code for a specific paragraph or sentence, but their defined strings of text to analyse may not be exactly the same (Campell et al., 2013). One coder may, for instance, include a sentence of background for the statement when the other coder does not. This would then lead to low intercoder reliability although the authors actually mean the same thing but express it slightly differently.

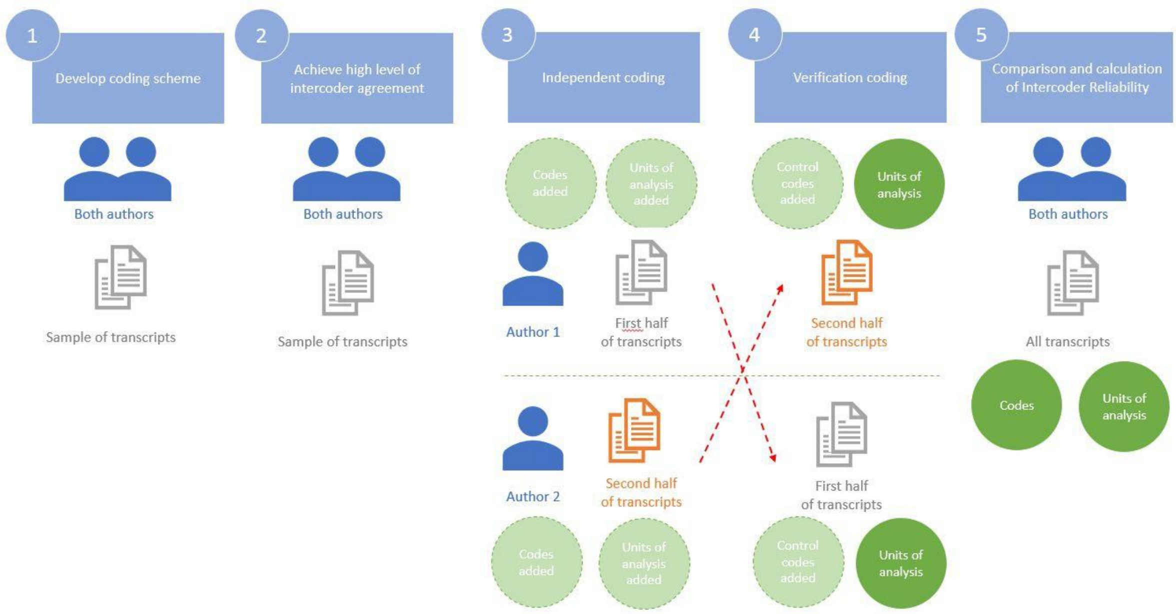

Figure 1. Overview of the coding process used in this study.

Firstly, a high level coding scheme was developed by both authors together coding a sample of two transcripts. The basis for the initial coding scheme was developed using the two motivation theories, Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964) adapted to a Citizensourcing setting. A set of questions were formulated to aid the understanding of the underlying motivations. These questions constituted the foundation for the interview questions. Firstly, to answer what motivates citizens to participate, the following questions were developed:

1. How did they discover the platform?

2. Did they contribute due to dissatisfiers or motivators?
3. What was their perceived purpose of Min Stad?
4. Why did they post that specific post?

Secondly, in terms of understanding why people stop contributing, an analysis of the platform activity was made, combined with these questions to understand why people stop contributing:

5. What was their expected outcome of the post?
6. What factors caused them to post more or stop posting?

This initial coding scheme was further developed by adding examples and more details throughout the entire coding process as suggested by Campbell et al. (2013). Secondly, the authors attempted to settle rules for any codes that were more open to interpretation in order to achieve a high level of Intercoder Agreement. Intercoder Agreement meaning settling any remaining disagreements on how to code a specific unit of text (Garrison et al, 2006). Thirdly, the first author independently defined Units of Analysis and coded half of the remaining transcripts using the coding scheme.

While the second author, independently, did the same for the other half. Once all transcripts had been coded by one author, the transcripts that were coded by the first author were transferred to the second author, together with the Units of Analysis but without the codes relating to each Unit of Analysis. The second author then coded the exact same Units of Analysis as the first author on transcripts that were initially coded by the first author. The same process followed for the transcripts that were initially coded by the second author. In addition, if the first author found a Unit of Analysis relevant (that was not coded by the second author), the second author was informed about this and had to code this before proceeding to the next step. By doing this, the risk of missing an interesting Unit of Analysis was mitigated. Finally, the authors compared coding on each transcript to calculate Intercoder Reliability and discussed any differences to reach Intercoder Agreement. In total, 122 Units of Ànalysis were identified across the 11 interviews.

3.3.1 *Intercoder reliability*

To calculate Intercoder Reliability, the proportion agreement method was used (Morrissey, 1974). This method simply calculates the number of coding agreements divided by the total number of both agreements and disagreements and does not, in comparison to the commonly used Krippendorff alpha (Krippendorff, 2018), take into account that coders may sometimes agree by chance. However, using the Krippendorff alpha was inappropriate to use in this case as it assumes that all codes have equal probability of being used (Campbell et al., 2013), which was not the case in this study. The overall level of Intercoder Reliability was 92 percent and Intercoder Agreement 100 percent. Indicating a high level of consistency between both coders.

4. Results

This section will describe the main results and insights of the study. Firstly, findings from studying the platform and the activity on it, together with findings from the conversations with staff behind the platform will be presented. Secondly, a presentation of findings from the interviews on what motivated citizens to participate on the platform will be shown. Finally, findings from the interviews on what caused citizens to stop returning to the platform will be presented. Quotes from the interviews with participants will be used throughout this section to illustrate some of the findings. As mentioned in the method chapter, all names used for interviewees in this chapter are pseudonyms and thus not the real names of the interviewees.

4.1) *Min Stad in the perspective of the city*

4.1.1 Declining activity on the platform

Figure 2 below shows the number of posts or contributions that have been made on the platform each year since the launch in 2012. As can be seen in the graph, the number of posts have been steadily declining, with the exception of a spike in 2016, up until 2018 when it appears to have bottomed around low levels.

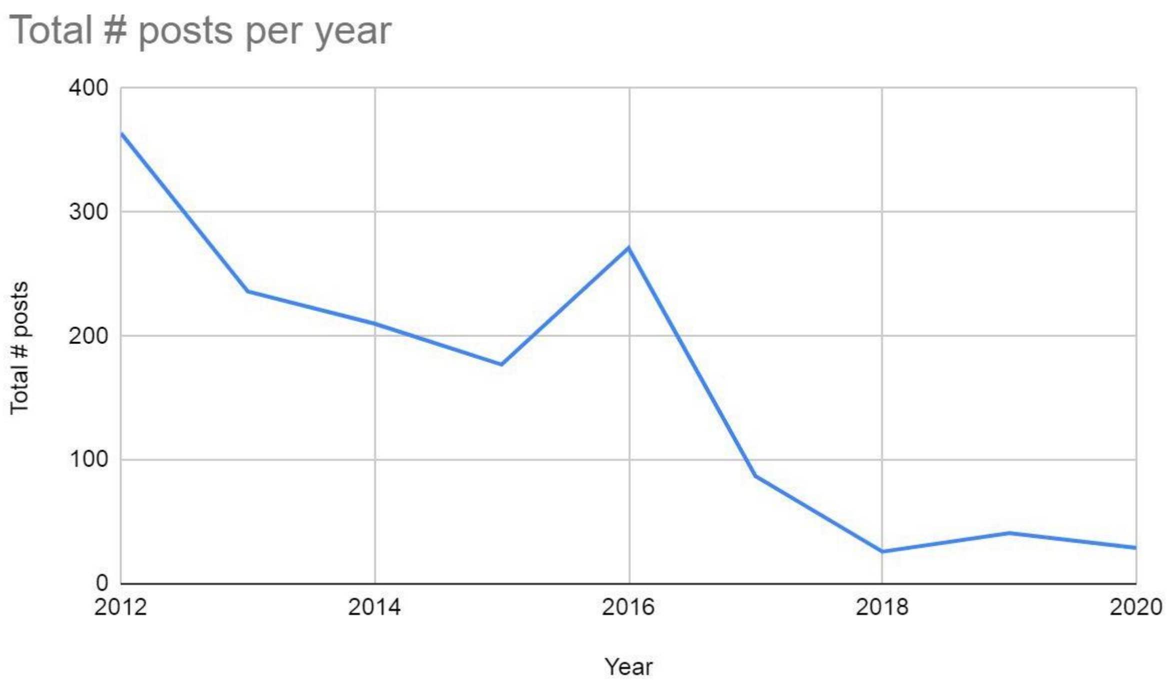

Figure 2. Total number of posts per year on Min Stad since launch in 2012.

4.1.2 Not a dialogue tool between citizens and the city

During conversations with staff at the city of Gothenburg, the staff described that they believed the most common reason citizens came on to the platform was to complain about issues. For example that a crossroad felt dangerous or that something was faulty in the city. One of the staff members working with the platform also described that sometimes suggestions of a creative kind were posted, however these posts were assumed to come from people who had a specific interest in city development and architecture. In terms of the purpose of the platform, one staff member described the platform as a graffiti board where citizens could interact and discuss issues without the city interfering. Another representative described how the platform initially was thought of as a way for citizens to make error reports and have more dialogue with the city but that they had to move away from that due to legal reasons. The main legal reason being that all suggestions would require a specific administrator and case number and go through the appropriate, formal processes which would in turn require a unsustainable amount of resources. In summary, the purpose of the platform from the representatives of the city was described as a way for the city to inform about city development and for citizens to discuss issues with each other without the city interfering, rather than a dialogue tool between citizens and the city.

4.2) *Understanding the motivations behind contributing to Min Stad*

4.2.1 Citizens discovered Min Stad primarily through government channels or friends and family

To understand the initial motivations of the participants, it could be relevant to understand how they first discovered the platform. The most common ways in which participants discovered the platform was either through government information channels, such as Göteborgs Stad's website or public advertisements, or through friends and family members that informed them about Min Stad. Others discovered the platform through social media, work or through the news.

4.2.2 Bothered by the city environment and/or motivated by recognition from others

Initially, the participants that were driven by a dissatisfier(s), motivator(s), or both, were divided into different categories. According to our study, participants were most commonly driven by both a dissatisfier and a motivator. This could for instance be where one participant was dissatisfied with safety while simultaneously wanting recognition for his contribution. One participant described how, "A post that concerns a dark tunnel that feels unsafe." followed by "...hopefully being able to contribute somehow, and that maybe somebody sees it and takes it further." (Lucas Ekerot). Some participants also described that although their initial motivation to come on to the platform might have been driven by a dissatisfier such as complaining about something in the city environment, they also found the platform to be a fun and clever way to discover and explore the city by looking at what other citizens posted about. For instance, one participant mentioned, "That is what is good about this thing, it is the visualisation that is the general strength of this application right? That I can immediately find my way to, both where I thought about putting my own suggestion, but also relating to other people's suggestions geographically. I thought that was very good." (Axel Valdemarsdotter).

The most common motivator was that participants were driven by some sort of recognition for their contribution. An example of this would be that a participant could be recognized by neighbors as an active contributor to the local society or that someone else thought that the suggestion was a good one. For instance, one participant described the following about her motivations, "...by getting more life and movement going in this location I would feel more safe. So it would affect me positively and I would be happy that someone else thought it was a good suggestion." (Camilla Björnberg). Another motivator was that some participants were driven by finding the work itself interesting or enjoyable. For instance, one participant mentioned that he had a great interest in city planning and infrastructure solutions and found enjoyment in researching and creating a detailed proposal for how a new tram stop could add value to a specific location in Gothenburg.

In terms of dissatisfiers, the most common dissatisfier was classified as “work conditions''. This included all topics where participants made a post because something in the city environment (the work environment) bothered them. Examples of this were reporting on traffic lights turning green too slowly or a bicycle renting service that had its rental stations in non-optimal locations. As one participant put it when asked why he made his post, “I made my post about a traffic light for bicycles that was very slow. It took too long before it became green.” (Rickard Knutsson). The other common dissatisfier that motivated participants to contribute to the platform related to safety. Some examples of this were a tunnel that felt dark and unsafe at night or a poorly light area that made walking there at nighttime feel unsafe.

4.2.3 Citizens perceived Min Stad as a way to communicate directly with Göteborg’s Stad

To understand the expectations and underlying motivations of the participants, understanding their perceived purpose of the platform is important. Different participants had different views on what the purpose of the platform actually was and therefore also their expectations of it.

The most common perceived purpose of the platform, from the interviewees perspective, was as a way for citizens to communicate directly with Göteborgs Stad. This meant that the participants expected the platform to be a means of communication where citizens could reach Göteborgs Stad, or a specific administration such as the traffic department, directly. Examples of this from the interviews with citizens include, “I mean, when a public institution receives a message in any way, even electronically, they are required to register that and respond to it in some way.” (Pelle Adolfsson) or “It [my post] was only directed at Göteborgs Stad so to speak. Who would receive it I do not know. If they have some system for that.” (Carl Linusson).

Several participants also perceived the platform to have an additional purpose besides communicating directly with Göteborgs Stad, which was communicating with other citizens. These participants mentioned that they also viewed the platform as a way of communicating with other citizens about suggestions in the city. For instance, “Primarily I wanted other people living in Lövgärdet to see it. Not that some politician saw what one person in Lövgärdet thought.” (Måns Zvanberg). This indicated that although many of the participants believed the main purpose was to communicate with the city, several citizens also perceived communication with other citizens as an additional value added from the platform.

Finally, several participants also mentioned that the purpose of the platform felt unclear and that they did not know exactly what to expect. Some of these mentioned that they felt this from the start while others mentioned that they initially thought the purpose was to communicate with Göteborgs Stad, but then changed their mind after they had used the platform. An example of this would be, “That kind of social engagement [that you get in local community Facebook groups] is a communication platform, this is not a communication platform. This is a well, I don’t know what this is.” (Axel Valdemarsdotter).

4.2.4 Citizens are motivated to participate in discussions that are close to home...

Another interesting aspect is to understand why participants chose to post about their specific topic. Therefore, participants were also asked to describe why they posted about a specific topic or in a specific location. Almost all participants mentioned that their post was related to something that was either close to their home or close to/on the way to work. Examples of this include, “But I have also felt a great need to say something about my living environment .... ” (Camilla Björnberg)

and “It was the biking route from my apartment to work, I had to bike on a foot road where bikes were forbidden… otherwise I had to bike on a big road with lots of traffic and several hundred meters extra just to get to work.” (Anton Axelsson). In addition to making their own posts and suggestions close to home, another interesting aspect mentioned by some interviewees was that they did not care about things that happen all over the city, but wanted to keep a close eye on what went on in their local neighbourhood in terms of what other citizens were suggesting. For instance, one interviewee described the following on what would make the application more useful and attractive for him, “Small subtle ways, yeah I see that your neighbor is also on Min Stad. He has made a post here, would you like to look at that suggestion? That would create a sense of presence, I mean feedback and presence.” (Axel Valdemarsdotter).

4.2.5 ...and/or on issues that relate to a personal interest or hobby

Almost half of the participants also mentioned that the specific topic that they posted about was related to a personal interest or hobby of some sort, with the most common being a personal interest in city planning. Examples of these include, “Then when it comes to the other suggestion about the pavilions, that is really an interest I have about city planning when it comes to architecture and so on.” (Carl Linusson) or “I have always had an interest in city planning.” (Måns Zvanberg). These results further add to show that citizens may not be interested in everything that goes on in Min Stad, but want to participate in the discussion on certain specific topics. For example, one participant described, “...play is it, the category that I [my post] is under. Then I should receive an email every time there is a ‘play suggestion’ in my part of the city. So I should know that because there is a risk that I am interested in that specific part.” (Axel Valdemarsdotter). In summary, our results indicate that citizens are more motivated to contribute or come back to the parts of the platform that relate to their home or workplace environment, and on topics that are related to specific interests of theirs.

Finally, an interesting finding was that citizens that contributed due to interest were sometimes working with related questions in their profession. For instance, “I am pretty engaged in technology and environment, and hydrogen gas, I work at AB Volvo with vehicles so it’s close to my heart.” (Mats Wahlberg) and “I’ve been working as a researcher at RISE for two years with digital innovation. I’ve had a look at a few of these solutions.” (Pelle Adolfsson). This indicates that citizens could, through platforms such as Min Stad, potentially be a valuable resource that provides help and input with expertise from their profession on city development. Ideally, a city could gain valuable input from professionals that simply want to help because they have interest in the subject. Potentially even on topics that are outside the core competencies of the city, for instance on new technology such as hydrogen gas.

4.3) *Understanding why citizens stopped coming back to the platform*

4.3.1 Citizens expected feedback and implementation

In order to understand citizens motivations with Expectancy Theory, participants were asked to describe what their expected outcome of the post was. All interviewees expected their post to be read, however whom they expected would read their post differed. For example some interviewees expected the city of Gothenburg to read it, while other interviewees expected other citizens to read it. Additionally, there were two common expected outcomes. The first was participants expecting feedback on their proposal/post in some way and the second was participants expecting their proposal/post to be implemented in the city.

More than half of the participants mentioned that they expected to receive some sort of feedback on their proposal/post, for example in the form of a comment or an e-mail reply. Some participants expected feedback to come from other citizens, such as neighbours in the area or others with similar interest. Other participants expected feedback to come directly from representatives of the city, for example that their proposal would receive an answer from the relevant department in the city as to why it was not feasible to implement. It was mentioned that they preferred having negative feedback, for example their proposal not being able to be implemented, rather than being left unheard. Finally, one participant expected that someone would provide some sort of feedback either through liking or commenting although that participant had not considered who that might be that provided the feedback.

Most participants described that their expected outcome was that their proposal could be implemented in the city through their post. Some of these participants had clear expectations that their post would lead to implementation while others hoped, and believed, there was a chance it was implemented but understood that it may not be implemented. Some participants however, did not have any expectation that their proposal/post would actually reach implementation.

4.3.2 Citizens feel disrespected due to lack of feedback

The most common reason for not coming back to contribute more to the platform was due to lack of feedback. Participants that mentioned this had some expectation that they would receive feedback from other citizens or the city and became disappointed when they discovered that no feedback was received. Some examples of this from the interviews were, “But that is simply the reason that I have not kept adding stuff, because I don’t feel respected as a contributor. I don’t feel like what I am giving is received.” (Jonathan Ljung) or “No [I have not used the application since I made my post], I gave up after I did not receive any feedback on my post.” (Pelle Adolfsson). In addition, some participants also described how the platform felt dead when they were browsing it, as they could easily spot that activity on all posts on the platform was very low. An example of this would be, “But it’s also something about the low activity on the platform. You see it instantly, if I just randomly click on this new bridge there there is a blob where it says ‘Mr.Bean was here’. But then nobody has commented, I mean nobody… It’s very short information. This makes me feel like I don’t want to go any further.” (Jonathan Ljung). These participants described that by realizing that others were not using the platform, and that no feedback was provided on other citizens' posts, their own motivation to participate on the platform was weakened. In other words, these citizens became less motivated to continue participating the fewer other users they thought were active on the platform.

In addition to the lack of feedback, a few participants described that they were not able to express themselves properly through Min Stad the way it was currently designed. An example of this was, “I think that very few understand what I am trying to say. Simply because: 1), they cannot find it [my post], 2) they don’t really have a way to understand what to do with it or how to use it”. (Jonathan Ljung). In general however, most participants felt that using the platform to share suggestions in the city was an easy to use process with a potentially valuable outcome. Interestingly, several citizens described the value of getting feedback as equally valuable compared to getting their proposal implemented. Getting feedback was described as valuable because it would make them feel noticed and having the power to make a difference in their local environment. For example some participants stated the following on how they would feel if their post would reach implementation, “...that would have made me very happy and like, oh wow, could you really make a difference using such an easy method.” (Lucas Ekerot) or “I’d be very happy, it would have felt like it was a city that was there for its citizens and developed together with them.” (Rickard Knutsson).

5. Discussion

In this chapter, the findings of the study are reflected upon and put in relation to both motivation theories and previous studies on the topic of Citizensourcing. Firstly, a discussion on the results in relation to existing theory will be presented. Secondly, the theoretical contribution of this study will be discussed.

5.1 Applying work motivation theory to a Citizensourcing setting

As previously stated, studies within motivation theories and Citizensourcing have not been sufficient enough to fully understand what motivates citizens' participation. Therefore, the purpose of this study was to explore the motivations behind citizens' choice to contribute in Citizensourcing initiatives.

5.1.1 *Both dissatisfiers and motivators drive participation in Citizensourcing*

Our findings indicate that both motivators and dissatisfiers play a part in why citizens were motivated to contribute to the Citizensourcing platform Min Stad. The most common motivator proved to be recognition and the most common dissatisfiers proved to be safety and work conditions. These results are interesting because platforms such as Min Stad, where citizens can report issues or suggestions in the city, can in the eyes of a city administration easily be viewed as a traditional issue reporting channel where citizens only report on things that bother them expecting them to be fixed. Although many of the interviewees mention that getting issues fixed were part of their motivation to come to the platform, it was not enough to fully explain their contributions.

Participants expect more in terms of getting recognition and feedback from this platform than they might from a traditional error reporting service on a city website.

In terms of studying citizens' motivation to participate on the platform, Herzberg's Hygiene Needs Theory (Herzberg, 1987) proved to be an interesting approach as it showed that people contributed due to both types of needs. However, several of the dissatisfiers that were identified and developed in the theory chapter were not mentioned as drivers behind motivation to come on the platform by any of the participants in this study. For instance, dissatisfiers such as city tax rates and fees and city rules and regulations were not mentioned by any interviewees. Similarly for the motivators, growth, advancement and achievement were not mentioned by any of the interviewees in this study. Despite the lack of complete utilization of Herzberg's Hygiene Needs Theory (Herzberg, 1987), the rationale behind distinguishing between dissatisfiers and motivators proved useful as it showed that citizens' motivations expanded beyond simply complaining. In addition, the theory could prove useful in further studies in Citizensourcing settings as our results indicate that some citizens were motivated by factors similar to those that motivate employees in a workplace environment. For instance, citizens that are motivated by some sort of recognition from the city or other citizens are similar to how employees in a workplace environment could be motivated by recognition from managers or fellow peers. Further studies could seek to expand understanding on the usefulness of the theory in this setting. For instance, Herzberg (1987) describes how catering to dissatisfiers can only serve to make a worker less unmotivated, but not make them truly motivated. In a Citizensourcing setting, it could be the case that catering to the participants motivated by dissatisfiers only serves to make them return when they have a new dissatisfier. However, catering to participants motivated by motivators could lead to encouraging participants to come back to the platform not just when they have something to complain about, but also to share entirely new ideas.

5.1.2 *Low Instrumentality caused participants to stop contributing*

Min Stad has seen a decline in activity in terms of posts for between 2012 - 2020. This is most likely an indication of two factors, 1) citizens or new users are not finding and contributing to the platform or 2) citizens that have posted once are not coming back to the platform to contribute more. Regarding what causes citizens to stop contributing to a Citizensourcing platform such as Min Stad, an interesting finding was that people viewed the platform as a tool for communication, mostly with the city but also with other citizens. This view of Min Stad as a communication platform is likely part of the explanation as to why a majority of the participants expected some sort of feedback on their contributions, and in turn why they felt like their efforts were not leading to anything when this expectation was not met and they did not receive any feedback. To put it bluntly, the platform felt dead in the eyes of the participants and therefore, trying to achieve anything on it felt pointless. This lack of feedback leading to low Instrumentality likely plays a part in explaining the declining activity on the platform from 2012 to 2020. Although citizens expect implementation of their suggestions in addition to the feedback, our results indicate that the value of the feedback is enough to motivate their efforts on the platform even if their suggestions are not implemented. This would also make sense from an Expectancy Theory perspective as Vroom (1964) describes that each outcome should be weighted by Valence and summed. Therefore, if citizens feel that they are likely to receive feedback on their suggestion (high Instrumentality for feedback as an outcome) and the feedback is perceived as valuable (high Valence for feedback as an outcome), that could motivate their efforts even if they do not believe their suggestion will be implemented (low Instrumentality for implementation as an outcome).

Furthermore, our study indicates that both Expectancy and Valence related factors were not as relevant to understanding why citizens were not contributing in the case on Min Stad. Although a few participants mentioned some Expectancy related issues with the platform, participants in general did not feel like it using the platform required too much effort from them or that the value of their desired outcome was too low to bother posting. These results further indicate that the main explanation for the declining activity on the platform was that citizens stopped contributing to the platform primarily due to low Instrumentality. Put differently, this analysis indicates that the main reason participants are not returning to the platform is caused by the lack of feedback, making participants perceive the platform as dead (Instrumentality). As opposed to being caused by issues related to citizens perceived ease of use, functionality and how citizens can express themselves on the platform (Expectancy) or that citizens simply do not care enough about potential outcomes to bother coming back to post more (Valence).

5.1.3 *Inability to reach critical mass caused citizens to stop contributing*

Another vital factor to why citizens stopped contributing was how the platform was perceived. In this case the platform was viewed as dead since not much activity could be seen. This finding is not surprising, as economic theories of platforms highlight positive network effects and reaching critical mass as vital parts in establishing successful platforms, such as described by Eisenmann et al. (2006) and Hinz et al. (2020). Essentially, a successful platform needs to have enough users active for it to become more appealing in other users' eyes. For instance, the value of being on Facebook increases the more friends I have that are also active on Facebook. If no-one else is active on Facebook, the platform is essentially useless. Our results indicate that this dynamic also exists on Min Stad, i.e. that citizens perceive the value of the platform as higher the more other citizens are also active on the platform to provide feedback and new suggestions. Because many of the participants interviewed in this study perceived the platform as dead, the overall usefulness of the platform as a communication tool also felt low. This indicates that one of the causes of the declining activity on the platform between 2012 - 2020, highlighted in the results chapter, could be that the platform has never reached the level of activity from citizens required to sustain critical mass. The platform in its current state could be described as stuck in a negative feedback loop of declining activity, where the lack of feedback leads to lower activity which in turn leads to less feedback that causes even lower activity.

5.2 Theoretical contribution

This study adds to existing studies within Citizensourcing such as Schmidthuber et al. (2019) and Thapa et al. (2015) by studying Citizensourcing motivations using Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964), theories that are more commonly used within the field of work motivation. By taking this approach, this study contributes to the topic of Citizensourcing in three ways. Firstly, we have made an attempt in adapting Herzberg's work motivation theory to a Citizensourcing setting and propose the usage of

Citizensourcing Two-Factor Motivation to study motivation in this field. Secondly, the results of this study expand on previous work by further highlighting that citizens chose to contribute due to both dissatisfiers and motivators, for example complaining about something in the city being broken and wanting other citizens' recognition, and that personal interest plays a part in explaining citizens' motivation. Finally, the results of this study provides insights on what can cause citizens to feel unmotivated and stop coming back to a Citizensourcing platform.

5.2.1 *Introducing Citizensourcing Two-Factor Motivation*

As previously mentioned, Herzberg's Hygiene Needs Theory (Herzberg, 1987) proved to be an interesting approach to study Min Stad. However, as the theory originates from work motivation its potential could not be fully utilized in the Citizensourcing setting. Therefore, we propose a new framework called the "Citizensourcing Two-Factors Motivation" based on Herzberg's Two Hygiene Needs Theory. An overview of this framework can be seen in Figure 3 below.

Herzberg's Hygiene Needs Theory (Work motivation)		**Citizensourcing Two-Factor Motivation (Citizensourcing motivation)**	
Motivators	**Dissatisfiers**	**Citizenship Identity**	**City Life Conditions**
Achievement	Company policies	Achievement	Salary
Recognition (by colleagues, supervisors)	Supervision	Recognition (by fellow citizens, politicians)	Mobility
	Relationships		Infrastructure
The work itself	Work conditions	The work itself	Public goods
Growth	Salary	Growth	City tax rate and fees
Responsiblity		Responsiblity	City rules and regulations

Figure 3. Citizensourcing Two-Factor Motivation compared to Herzberg Hygiene Needs Theory.

To begin with, we propose the introduction of using "City Life Conditions'' to replace dissatisfiers when studying motivation in Citizensourcing settings. City Life Conditions refer to the conditions which citizens are exposed to in their city life, outside of their work and home environments. This includes factors such as safety (such as feeling safe on the way home from a bar in the city at night), mobility (such as transportation of any kind within the city), infrastructure (such as public parking spots, lighting) and public goods (access to fresh air, law enforcement). The rationale behind City Life Conditions in Citizensourcing Two-Factor Motivation is similar to the rationale of dissatisfiers in Herzberg's Hygiene Needs Theory. Citizens simply expect these factors to meet their expectations in everyday life and will not become more motivated or happy if these factors are much better than expected. For instance, a citizen cannot be motivated or happy in the city life by having a well-functioning public transportation system, this is rather something to be expected, just as getting a salary for work is expected. However, if one of these City Life Conditions is not working as expected, they can cause a citizen to become very unhappy or unmotivated. An example of this would be that a citizen could be expected to feel very frustrated or unmotivated if public transportation is not working according to expectations, or that a local law on parking is unreasonably strict and disturbing their everyday city life.

Additionally, we propose using "Citizenship Identity" to replace motivators when studying motivation in Citizensourcing settings. Citizenship Identity refers to factors that motivates citizens in a city life setting, outside of their home and work environment and can be thought of as similar to a social identity. In social identity theory, a social identity of an individual is the knowledge that he or she belongs to a social category or group (Hogg & Abrams, 1988). According to this theory, individuals compare and categorize themselves and other individuals as part of, or not part of, a group that holds a common social identification. In the case of Citizenship Identity, this means that individuals see themselves as members of a community and strive to become the best possible member of that community to feel good about themselves and receive status within a group of other citizens. Our results showed that motivators were an interesting perspective to take into consideration in Citizensourcing. However, just as with dissatisfiers the motivators in the Hygiene Needs Theory were not fully applicable to the city life of citizens. Citizenship Identity on the other hand, serves the same purpose as motivators in Herzberg's Hygiene Needs Theory, with the only difference being the adaptation to city life instead of work life. For instance, the motivator "recognition" in Herzberg's theory refers to being recognized by colleagues or supervisors at work, while recognition in the city life refers to being recognized by fellow citizens or politicians.

However, it is important to note that not all factors of Citizenship Identity are necessarily inherent to Citizensourcing initiatives, which means that these factors may need to be artificially stimulated from developers of such initiatives. For instance, "achievement" in Citizensourcing settings might not exist in the initial design of a Citizensourcing initiative but could be stimulated by introducing a sort of reward system. Examples of this in the case of digital platforms could be the karma system in the massive online social forum Reddit where users can reward other users by "upvoting" posts they like to make the initial author of the post receive higher status and a sense of achievement on the platform (Reddit, 2020). A more extreme, and perhaps disturbing, example in the case of Citizenship Identity could be China's social credit system (Business Insider, 2018). This system allows states in China to rank all citizens based on their social credit and offer punishment and rewards in their city life based on this. This allows the state to incentivize “good behavior” such as donating to charity while punishing bad behaviour such as smoking in no smoking zones.

Although we do not propose a model so extreme as the Chinese one, the concept in itself is interesting. In the case of Min Stad, introducing a ranking system of some sort for citizens that provide relevant suggestions on how to improve the city could provide citizens with a sense of achievement and thus improve their motivation to contribute more.

In conclusion, just as Herzberg’s Hygiene Needs Theory helps us understand employees, we believe that the Citizensourcing Two-Factor Motivation can help us better understand citizens. By thinking in terms of the Citizensoucring Two-Factor Motivation, we believe cities can get a better understanding of what factors could impact their citizens’ motivation to participate in Citizensourcing initiatives.

5.2.2 *Addition to existing literature on citizen motivation*

The indication that motivators play a part in explaining why citizens choose to participate in Citizensourcing further add to support previous studies such as Schmidthuber et al. (2019) and Schmidthuber et al. (2017) which both found that fun and enjoyment are important factors for participation. It also adds to existing theory by showing that Herzberg’s (1987) motivators, such as recognition, could play an important role in explaining citizens' motivation to participate.

Recognition being an important motivation would also be inline with previous empirical studies on what motivates individuals to contribute to open source projects in general as opposed to Citizensourcing initiatives specifically. For instance, a study by West & Gallagher (2006) found signaling one’s own capabilities to gain respect from one’s peers as one of three classes of motivation when studying what motivates participation in open source projects.

Our findings in this study indicate that people are partially driven by finding the work itself interesting. While Schmidthuber et al. (2019) found that intrinsic motivations such as fun and enjoyment boosted the quality of participation our study found that this also holds true in terms of why people choose to contribute. Another interesting aspect brought up by Thapa et al. (2015) is that there is a positive correlation between citizens’ expertise and their willingness to participate in Citizensourcing. While our study did not include examining citizens’ levels of expertise, we did find out that citizens with a personal interest, hobby or expertise through profession in the subject of city planning were contributing to Min Stad.

In addition, we also contribute to the literature in Citizensourcing as previous studies such as Schmidthuber et al. (2019) have highlighted the need to study why citizens stop contributing in

Citizensourcing projects. This aspect is important as Citizensourcing aims to establish a new type of relationship between the government and its citizens where, as was described in the introduction through Dameri & Rosenthal-Sabroux (2014), human contribution is a vital part. Therefore, we believe that one-time contributions have to be turned into frequent communication in order for trust and belief to build betweens citizens and the government. In terms of why people stop contributing, our research showed the importance of feedback as well as meeting the citizens' expectation of the platform. Additionally, our results indicated that Instrumentality plays a larger role than Expectancy in explaining why citizens stop contributing to the platform. These results are similar to Schmidthuber et al. (2017), which found that the perceived usefulness of the platform in the eyes of participants was more important than the perceived ease of use. Perceived usefulness is closely related to reaching critical mass and benefiting from network effects that positively affects the perceived usefulness. Essentially, positive network effects can create a positive feedback loop, which accumulates the amount of users and therefore increases the perceived usefulness of the platform. As our results indicate, feedback seems to play a big part in accomplishing and reaching critical mass, specifically when citizens expect to receive feedback.

Furthermore, citizens also mentioned feeling disrespected as a contributor to the platform as no feedback was provided. As mentioned in the introduction, the city of Gothenburg mentions strengthening the brand of the city as one of the key benefits of becoming a Smart City. However, with the current state of Min Stad it seems that the opposite effect is achieved in the eyes of some citizens, i.e. Min Stad is negatively affecting the brand of the city. On a more positive note however, participants also mentioned that if the platform would work according to their expectations, this would positively impact their view of Göteborgs Stad as well as simplifying their everyday lives and making them feel like they could actually participate in the development of their city. This indicates that Min Stad has the potential to achieve at least three of the five key benefits, mentioned in the introduction, of Smart Cities that Gothenburg identifies. These would be: 1) Simplifying everyday life for citizens, visitors and businesses, 2) Becoming a smarter and more open administration that supports innovation and participation and 4) Contributing to the city's brand.

6. Implications

Our research provides insights that can be beneficial for practical implications. Firstly, we believe that the view of the platform in the eyes of the city needs to expand beyond a traditional error reporting/complaints channel or graffiti board for citizens. Secondly, we believe the purpose of the platform needs to be clarified in the eyes of the citizens, or that the platform is developed to meet the citizens expectations better. Finally, we believe that growing the platform to reach critical mass is required, and that one approach to growing could be through a beachhead strategy commonly used by other successful digital platforms.

6.1 Expand beyond a traditional error reporting and complaints channel

Contrary to what staff at the city of Gothenburg described (that most citizens post due to dissatisfiers), our study shows that citizens contributed both due to motivators and dissatisfiers. A mismatch like this could have negative consequences as it can hold back a lot of the potential of the platform. For instance, if the developers of the platform believe that the main reason participants come on to the platform is to report issues or bring forward complaints, their focus might be to develop a platform that is very good at making issues and complaints go away quickly by solving them. However, this focus might miss the fact that some participants want their suggestions to be visible on the platform so their neighbours can recognize them, thus leading them to be unmotivated if the issue is resolved and disappears from the platform quickly.

Consequently, it all depends on what way the city wants to develop the platform. If the city aims to cater to focus on City Life Conditions, the platform and its functions should be aligned for this purpose. For instance, making it easy to submit and gather error reports from citizens. However, if the purpose of the platform is to facilitate idea sharing and interaction on a wide range of topics, both between citizens themselves or between citizens and the city, a focus on catering to motivators such as recognition and achievement could make more sense. As of now the platform can be described as being in limbo, not having a clear focus on either dissatisfiers such as City Life Conditions or on Citizenship Identity aspects such as interaction and idea sharing, therefore causing confusion among citizens that use the platform.

6.2 Clarify the purpose or meet the citizens expectations of the platform

Another finding with practical implications was that almost all participants perceived the primary purpose of the platform to be communicating directly with Göteborgs Stad. Put differently, citizens expected representatives from the city to read and respond to their suggestions through the platform. This perspective from the citizens differed from what the interviewed staff of the platform described the purpose of the platform to be. These findings indicate that there exists a mismatch between how the citizens expect the platform to behave and how the city actually uses the platform. This mismatch could partly explain why several participants mentioned that the purpose of the platform felt unclear after using the platform, and in turn what causes citizens to not contribute or refrain from returning to the platform. Therefore, we identify that one area of improvement could be to clearly communicate the purpose of the platform. By doing this, Göterborgs Stad removes expectations from citizens that cannot be met and therefore reduces the occurrence of false hopes and mistrust in the city. Alternatively, but probably more difficult to implement, the city could adapt the platform to be more of a direct communication platform with the city to better meet the expectations of the citizens. This would then probably include developing functions in the application, and processes within the administration, to actively provide feedback to all suggestions that are received through the platform.

6.3 Grow usage through a geographical beachhead strategy

As discussed previously, our results indicate that Min Stad may not have reached critical mass to sustain engagement of citizens over time due to the lack of feedback. To escape this negative feedback loop when developing initiatives such as Min Stad, it could be beneficial to divide the city into smaller areas and focus on reaching critical mass in one smaller area at a time, as opposed to the entire city all at once. The rationale behind this would be that the number of citizens required to reach critical mass would be substantially lower for a portion of the platform, compared to the critical mass required to sustain activity on the entire platform. This would in turn allow the city to spend less to target and attract a subgroup that can reach critical mass and become self-sustaining, as opposed to spending large amounts on marketing towards the entire population of the city. Just as economic theory within entrepreneurship such as Aulet (2013) suggests, it could make sense to start with a niche target group and focusing on that group before developing it further. This approach has led to success stories of some of the biggest platform players such as Facebook and Amazon, where they initially focused on a small target group (Facebook initially only served Harvard students and Amazon only sold books) before expanding to broader audiences. We believe that such an approach would add more value and aid in developing stronger and more active engagement.

In terms of shaping a beachhead strategy to Min Stad, our study indicates that the importance of the topic being close to heart plays a big role when it comes to what citizens post about. Moreover, topics that lie closest to the heart of people are places they visit often, such as being close to home or on the way to work. These results are perhaps not so surprising, as one could expect citizens to have issues related to environments where they spend most of their time on top of mind when thinking about suggestions to make on the platform. Therefore, a reasonable strategy could be to develop initiatives for local communities in each urban district as this could be a way of gaining critical mass and encouraging engagement by people in that area. For instance, the value of the platform for a user living in the area Majorna is likely more dependent on the number of other users in Majorna, as opposed to the total number of users on the entire platform. Based on our results, it seems reasonable to expect this user to appreciate the platform more if there are 100 users active in Majorna, rather than 1 000 users in all of Gothenburg and only 10 of these in Majorna.

Therefore, the city administration could start by developing a well functioning platform for people living in Majorna and attempt to reach a critical mass there, before rolling out in neighbouring areas one at a time. This could also help by showing new users of the platform how the service is intended to work by showcasing an area where critical mass has been reached. Another benefit of this strategy could be to, with limited resources, showcase internally within the city administration what can be achieved from the platform if critical mass is reached. Thus creating a “quick win” and sense of achievement that can help motivate staff working on the platform. An alternative approach to going from district to district could be to instead focus on a specific area of interest, such as for instance city development. The approach could then be to achieve a critical mass of users interested in city development who view the platform as the go-to platform for everyone interested in city development in the city. The drawbacks of this approach could however be that the platform struggles to attract “regular citizens” and instead becomes a niche platform for a specific interest group that is difficult to change too much without upsetting the existing user base. In addition, the platform could then also directly compete with existing platforms that exist for that specific interest group, an example would be Yimby (Yimby, 2020) in the case of city development.

7. Limitations and further research

This study contains both some limitations and potential avenues for future research. Firstly, our study is limited by the single case study Min Stad created by the city of Gothenburg. Therefore, a suggestion for future research to gather more details could be to use the approach of a multiple case study. Just as Schmidthuber (2019) highlighted, one also has to take into consideration factors such as cultural differences and the general economic climate. Thus, conducting a similar study in a Nordic country would add great value to the work done through this paper.

Furthermore, the primary data retrieved in our study came from interviews conducted with citizens that had contributed to the platform. Contribution displays some sort of interest or experience in the platform which in itself can be susceptible to selection bias. In other words, using other sampling methods could provide additional insights that were not captured in our study.

Moreover, our study is limited by the number of participants as only 11 people were interviewed. However, as our study is of qualitative nature and aims to gain deeper understanding, along with the multiple data sources and robust analysis methods, this counterbalances this limitation.

Additionally, our study incorporated motivation theories Herzberg's Hygiene Needs Theory (Herzberg, 1987) and Vroom's Expectancy Theory (Vroom, 1964). The results proved to be somewhat mixed, indicating that motivation theories can be a good way to understand motivations from citizens. However, one might also want to dive deeper into each motivation theory and conduct studies based on the isolation of each theory to get an even better understanding. In the case of Herzberg's theory, we suggest using our proposed Citizensourcing Two-Factor Motivation to study Citizensourcing initiatives to aid the understanding of citizens in their city life.

Finally, we highly encourage and recommend more research within this topic as it is an increasingly relevant area of study. Understanding motivations of citizens is essential in developing cities for the future as it is a value add for public government, citizens and society in large.

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Annex 6: The Hjällbo Minecraft Method for engaging children in urban development

Anna Reuter Metelius and Susanne Ollila, 2023-03-24

Summary of method

1. Based on images, plans, Google Maps and other available materials, a Minecraft environment specific to Gothenburg city is produced by a geo data at the City Planning Office. An area is selected for the conduct of workshops and the specific area is prepared in Minecraft by a visualizer. The preparation of the specific area takes about two weeks for one person.

The area Hjällbo in Gothenburg in Minecraft.

2. A school is selected based on its relevance for the new planning project for urban development. A relationship is built up with the school, which accepts that Minecraft workshops are integrated into the regular teaching. One must take into account that the use of Minecraft will be fundamentally different depending on the scale and stage of the planning project. The outcome can vary from using Minecraft to just dialogue about the existing environment to using it as a pure design tool.

3. A project team with pivotal competence is created including:

- a project manager from the City Planning Office for the urban planning and project competence
- a Minecraft expert from the City Planning Office for the technological skills - how to create the Minecraft world/model and how to use Minecraft
- a planner from the City Planning Office for the city planning competence
- an architecture pedagogue for the competence on designing environments for living
- a gaming pedagogue for the pedagogical competence on how to use computer gaming in education
- teachers from the school where the Minecraft activity will be conducted for the competence on the school curriculum and teaching as well as their relationship to and knowledge about the children.

4. The project team holds meetings to prepare the workshop that will be hold with the selected group of pupils at the school in order to:

- Discuss the purpose of the activity in detail
- Discuss how the outcome of the activity will be used
- Inform the team members of the basics of Minecraft modelling
- Discuss roles and facilitation of the Minecraft workshop
- Discuss the practical conditions: classrooms, technology, snacks, etc.
- In good time before the workshops, it is advertised at the school so that the message is spread and interest is aroused.

Information poster at the school inviting pupils as test pilots for an EU project. Poster by White arkitekter

5. The project team holds the Minecraft workshop with the children including the following:

- Presenting purpose of doing the activity – inviting the children to be pioneers and experts
- Providing guidelines on how to use Minecraft
- Starting a dialogue by asking what the children consider to be needed in their local space and neighborhood
- Supporting the children in their play
- Being curious and answering questions

Interviews are conducted during the workshop.

MINECRAFT BASICS

- Styr med musen och rör dig frammåt med **w** och bakåt med **s**.
- För att se inventory: Tryck **e.**
- För att ändra till dag: Tryck **t**. Skriv sedan **/time** set day
- För att det skall sluta regna: Tryck **t**. Skriv sedan **/weather** set clear
- För att flyga: Dubbelklicka på **space**-tangenten Håll sedan inne space för att stiga och dub belklicka igen för att landa på marken igen.
- Håll inne **Ctrl** när du går eller flyger för att skynda på.

MINECRAFT BASICS

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Instruction note with 'Minecraft Basics': short instructions on how to navigate in the application. It explains how to move forward and backward, how to fly, how to change to day, remove rain, bring out your toolbox, etc.

6. The children work in pairs or small groups on one computer enabling a dialogue between them. Roles are changed regularly so that everyone gets to test. Those who don't know the program learn quickly from their friends.

The children work in pairs or small groups to encourage conversation and collaboration.

7. The workshop need to provide sufficient time for the children to develop their ideas in Minecraft. Breaks are essential for enabling a broader conversation across the pairs of children. A minimum of 2 hours in total is needed.

WORKSHOP LÄRJESKOLAN 7 APRIL

WS 1 Kl 8.30-11.30
WS 2 Kl 12.30-15.30

ANTAL GRUPPER: Ca 10 st med 2-3 i varje grupp

>> **INTRO** 30 MIN

20 min. Jesper och Anna, SBK – Bakgrund och övergripande syfte 20 min
10 min. Felix och Kajsa introducerar uppgiften samt förhållningsregler tex alla komma till tals

>> **HITTA PLATSERNA: EGEN REFLEKTION** 10 MIN

Gröna kuben: En plats jag gillar i Hjällbo (alla väljer var sin plats)
Orange kuben: En plats jag vill förändra (alla väljer var sin plats)

Genomförande. Kajsa och Felix instruerar. Först välja en plats som de gillar och när de har valt så får de intruktionen att välja en plats de vill förändra. De redovisar inte detta för oss eller för de andra grupperna.

>> **VÄLJA EN PLATS TILLSAMMANS** 15 MIN

Alla grupper väljer ut en av platserna de markerat med grönt eller orange

Genomförande: Kajsa och Felix instruerar. Gruppen enas om en av platserna som de skulle vilja utveckla. - Utveckla något som är bra eller något du vill förändra! Avgränsning: Inte för stor plats, tex inte hela torget utan en del av det.

--- PAUS --- 15 MIN.

>> **UTVECKLA PLATSEN** 90 MIN INKL FIKAPAUS

Kajsa ställer frågor till grupperna. Samma grundfrågor till alla, några kärnfrågor som är samma och jämförbara

Genomförande. Kajsa frågar: Var satte ni de andra kuberna?
Andra frågor: Varför valde ni just denna platsen? Vad är det ni utvecklar?

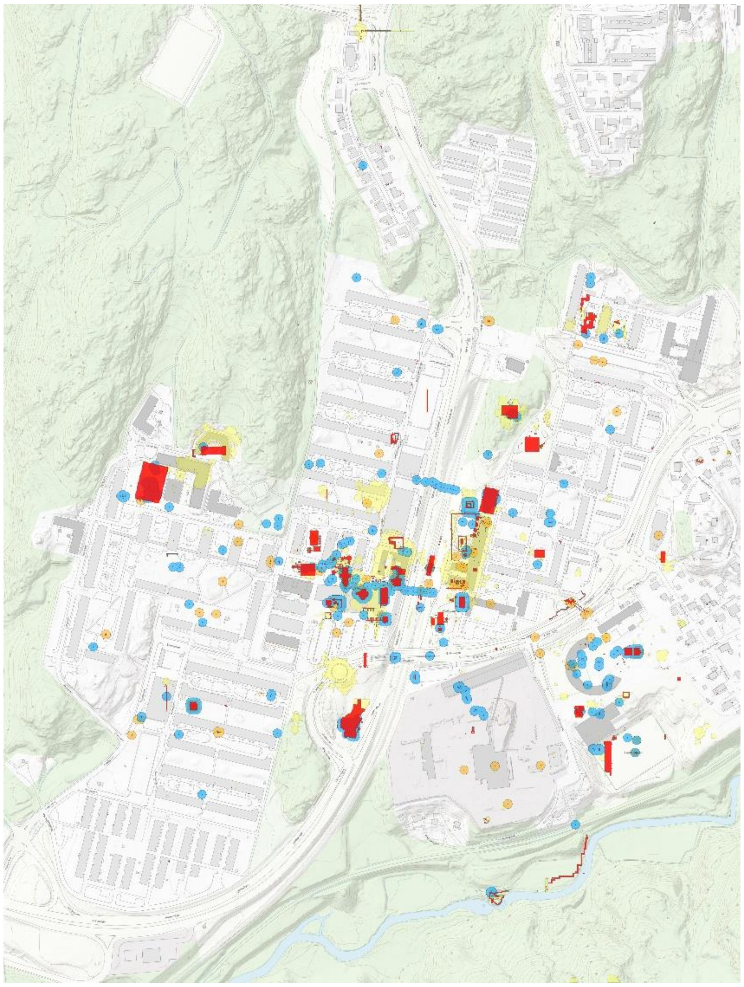
Felix går runt och peppar, svarar på frågor
Övriga gruppen lyssanar och antecknar
Anna Reuter Metelius tar bilder

>> **AVSLUTANDE REFLEKTIONER** 20 MIN

Kajsa sammanfattar lite, lyfter några findings
Felix ställer några frågor till hela gruppen om vad de tycker om verktyget och förståelsen för uppgiften .

Schedule for the day

8. The workshop results in proposals that are documented together with their respective interviews. The activities in Minecraft can also all be brought together on an area map. Project team facilitates an exhibition where the Minecraft ideas are shown to the local community and stakeholders to generate discussion.



Area map with all the Minecraft activities.

Exhibition during Hjällbokalaset. Exhibition design by White arkitekter

Exhibition during Hjällbokalaset.

9. The Minecraft proposals feed into the city planning process. Project and design proposals as well as summaries of the interviews are handed over to interested parties at the municipality and property owners.