Innovation Action

H2020-LC-SC3-SCC-1-2018

D2.1 Oulu PED (Kaukovainio) interventions detailed design

WP2, Task 2.1

November 2020 [M24]

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Abbreviations and acronyms

Acronym	Description
AC	Air Conditioning
CHP	Combined Heat and Power
CoM	Covenant of Mayors
COP	Coefficient of Performance
DH	District Heating
DHW	Domestic Hot Water
EMA	Energy Management Agent
HP	Heat Pump
HR	Heat Recovery
Km	Kilometre
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt Peak
kWth	Kilowatt Thermal
L	Litre
LED	Light-emitting diode
LoRA	Long Range
LT	Long-Term
NZEB	Near Zero Emission Building
OEN	Oulu Energy
OUK	Oulun Kaupunki (City of Oulu)
PCM	Phase Change Material
PDA	p.17
PED	Positive Energy District

Acronym	Description
PV	Photovolatic
RES	Renewable Energy Source
SECAP	Sustainable Energy and Climate Action Plan
SIV	Sivakka
SME	Small and Medium Enterprise
T	Temperature
UOU	University of Oulu
WP	Work Package
YIT	Yleinen Insinööritoimisto (General Engineering Office, now a building company)

Executive Summary

This is a description on the actions in Oulu, being completed bit by bit as the actions are proceeded.

The actions are done in Kaukovainio, which is a suburb of about 3000 inhabitants, while in the whole Oulu area there are 200 000 inhabitants. Oulu is the largest city in Northern Finland and thus the centre of many services for a geographically large part of Finland.

Kaukovainio suburb was built mainly in 1960s and 1970s. It is located about 3 km from the city centre. Like many of its peers in Finland and elsewhere, it has had a bit downward direction at least what comes to the reputation and the general willingness to pay for the flats in the area. When new, the flats were seen as fancy and comfortable. But when the general standard of living rose, people wanted to move to e.g. detached houses and on the other hand to the new flats closer to the city centre. The suburbs like Kaukovainio were left mainly for people with low income. In Finland this segregation is not that bad that in some countries, but however existing.

The City of Oulu and private companies have started a kind of program to make the reparation of Kaukovainio better and to have more mixed social structure in the area. The perquisites are quite good, since there is however for example a green environment with a lot of trees and there are no severe social problems like violence in public places or so. Thus, there is a new private-owned block of flats under construction (building company YIT) and also new rental housing (built by city-owned company Sivakka) with high technical quality is built. In addition, Sivakka renovates one apartment block. More, the old shopping centre was replaced by a new one by Arina, a local member of S-group retail chain. All of these are also a part of the MAKING-CITY project.

In the above mentioned buildings renewable energy technologies are demonstrated. PV panels are installed both in the roof and also onto the wall of an apartment house. The vertical position is favourable since it produces more in spring and in autumn, which is good for the system since the electricity consumption in Finland in winter is about one third more than in the summertime.

The grocery store has CO2-refrigerant-based heat pumps which supply heat from the refrigerated spaces in the shop to the district heating (DH) network, which exists in the area and in Oulu in general. The store has also PV panels on the roof and boreholes to store the excess heat in the summertime to be used later. The DH system is owned by Oulu Energy. The store with these equipment is up and running. The cooling equipment is supplied by Jetitek, now a part of Caverion.

In apartment blocks there is a good insulation and different kinds of heat recoveries. In new buildings there are air-to-air heat recovery systems for ventilation, which is a standard solution in new buildings in Finland. But the heating system in those is a new solution. It is a heat pump, which takes its heat from the DH return water. In Oulu DH system this makes sense, since e.g. the cooler return flow makes it possible to produce more electricity for the same heat load in the CHP plants and more energy is gained from flue gas scrubbers in those plants. The buildings with that kind of heat pumps are to be completed in 2020-2021.

Another heat source demonstrated in the project is exhaust air from the apartments. It is here and also in general used in existing buildings with no original ventilation heat recover system. The speciality here is that the system is modular. It is versatile, so different kind of heat sources can be added to the same system. In then possible future applications this is a significant advantage, since the best sources are very context-specific.

In addition to conventional water-based heat storages in the system, there are also those based on phase-change-material (PCM) demonstrated. This far the work has been identifying different materials and the suitable place for the installation. This has been done by VTT.

To control the HP and other systems the single equipment units have their own controls as native properties. In addition to that there is a “top level” control system over those. This may be needed e.g.

to control the overall situation, regarding to energy production balance in larger networks etc. Parts of the control-related issues are also the visualization units in the flats. They help the inhabitants to have an idea of their energy and water consumption and by this way hopefully reducing it. However, to have the good physical and mental feelings, there are no strict set values of e.g. room temperatures, but rather “soft” measures. E.g. University of Oulu is involved in these, as well as urban planning process studies and its development.

As a result of the experiences got from these demonstrations and the existing knowledge, we have started to establish a City Vision 2050, from the City of Oulu side and had some internal workshops about the issue. The target may not be to set one exact path, but rather scenarios or steps towards the target, which is emission-free future with moderate cost and social sustainability. This work includes the gathering of the data of the energy consumption breakdown and possible future trends.

1 Introduction

1.1 Purpose and target group

The purpose is to give an overview of the actions in Oulu, both in substance and project point of view.

Target group is wide: citizens, politicians, authorities in our own organization and elsewhere, companies.

1.2 Contribution partners

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

Table 1: Contribution of partners

Partner nº and short name	Contribution
13-OUK	Main author, most of the texts.
14-UOU	UOU contributed to the sections related to the in-home display and the web interface for residents of the PED: section 3.1 part A7, A14, A47
15-OEN	Comments on actions, where they have a significant role.
16-SIV	Provided information about their buildings and equipment there.
17-YIT	Provided information about their buildings and equipment there.
18-JET	Provided information about cooling equipment in Arina store. Currently a part of larger company, Caverion.
20-VTT	Wrote most of A13, A20, A26, A28, and A33.

1.3 Relation to other activities in the project

This is related to all other WPs. There are at least some elements in each WP that are related to engagement, directly or indirectly. It varies depending action by action.

The following table depicts the main relationship of this deliverable to other activities (mainly deliverables) developed within the MAKING-CITY Project and that should be considered along with this document for further understanding of its contents.

Table 2: Relation to other activities in the project

Deliverable / Task nº	Relation
D2.20 - D2.9	Services and Modules for Oulu ICT Platform. Action A7 and A14 rely on the data gathering structure presented in this deliverable.
D 2.23	People engagement. A 50 and A 51 are directly related to this, but also “upper level” actions like A38 and A40, about future governance policies, have an impact on engagement and vice versa. Also for example A41, single desk for energy retrofitting, is in practice very important for engagement as well as in big picture the technology behind.

2 Oulu Description

2.1 Oulu as lighthouse city

2.1.1 General description of the city

Oulu is the capital of northern Finland, with over 200,000 inhabitants. It is one of the growing cities in Finland, with an area of 3,818 km^2, and is also the oldest city in Northern Finland. It is located in the Gulf of Bothnia in the Oulujoki River delta with good access from anywhere. The city has the highest population in Northern Finland and the fifth highest population in Finland. The city was founded by King Charles IX of Sweden in 1605, and in the nineteenth century the city was Finland's leading exporter of tar, and was a favorite destination for thousands of domestic and international leisure and business travellers.

Oulu provides good opportunities for studies, work and R&D, especially in the hi-tech sector. Nowadays, the region is well known for its technology, with the hi-tech growth being quite prominent after the establishment of the University of Oulu in 1958, which gave room for development and innovation. In addition to the University of Oulu, there are there are several research institutes, including VTT Technical Research Centre of Finland and the University Hospital. There is also the multidisciplinary Oulu University of Applied Sciences.

There are two science parks in the region: Technopolis Plc, which was Scandinavia's first science park, and Medipolis Ltd., as well as a technology centre, Ii Micropolis Ltd. The region is home to many hi-tech companies, due to it possessing a well-established ecosystem for wireless technologies. This is further emphasized by its being one of the first constructors of the 5G test network. Examples of companies investing in Oulu include Nokia, Bitwise, Spent, MediaTek, and Kionix. The sector currently employs over 10,000 people. In addition to this, there is also traditional large-scale industry in Oulu like pulp and paper mill and chemical industry and a port, which serves them. There has however been a normal Western European transition from heavy industries to smaller, knowledge- and service-based companies as employers.

Transport connections are direct and fast, regardless of the means of transport or direction. Oulu railway station is one of the busiest in Finland, and it is operated by state railways VR. Considering active transportation modes, Oulu contains over 800 km of pathways for pedestrians and bikers and is quoted as an "excellent city for cycling". On speciality about cycling is the lanes which are routed not on the side of the motor traffic roads, but fully separated for example into the forest. This makes cycling a pleasant experience, close to the nature. The transport mode share of cycling is one of the highest in Finland.

Oulu has an international airport, which is the second largest in Finland by passenger volume. In road traffic, even if there are some minor traffic jam during morning and afternoon rush hours, there are normally no remarkable congestion problems. By local bus service it is possible to get round the city in 5 to 30 min intervals. The bus service quality has been made better during recent years and the development is still going on.

Oulu consists of the cultural life of a modern business and tourism city. It also has extensive shopping opportunities as well as the northern arctic nature exoticism. The uniqueness of the city is based on the fact that the hustle and bustle of the city centre areas, for example, make it easy to deviate to the peace and the greenery of the park, the sandy beach or the frozen sea. The Oulu Region also has a lively cultural climate, both in established and DIY-scenes.

2.1.2 Geographical and Climatic Characteristics

Oulu's climate is considered subarctic continental, where winters could be cold, snowy, and dark, while summers are quite warm and short. The lowest temperature was recorded to be -36^{O}C in January, while the highest temperature was recorded to be 32 ^{O}C in July. Precipitation is low compared to many peers outside Finland close to coast.

2.1.3 Urban structure and Land Use

The area of the city of Oulu covers 3818 km2, of which only a small portion is built or habited. The center of Oulu can be considered small in relation to the population. The terrain of Oulu is flat and the natural height differences are small.

The urban structure of Oulu is fragmented compared to some other European cities. The urban sprawl has been there, but the aim of the city is now strongly towards densification. The future need for refurbishment is particularly strong in the city center, in the old suburbs and around public transport routes. About half of the apartments are in blocks of flats.

Two simultaneous developmental processes have occurred in Finland: on the one hand, the regional structure has been concentrating when the population has been moving from the countryside to the cities; on the other hand, the urban structure of growing urban areas has dispersed. Only 2% of Finland's land area is urban, but the urban areas cover 80% of the population and 72% of the workplaces.

During the last decades the urban area has grown several times faster than the population. At the same time, the population in the centers of cities has decreased. The same trend has taken place in all major cities in Finland. However, there is also a countertrend that new blocks of flats are built in the city centres.

2.2 Kaukovainio as Positive Energy District

2.2.1 Description of Kaukovainio district

The Kaukovainio district is located about 3 km southeast of the center of Oulu. The residential area consists of high-rise apartment buildings on the eastern and southern sides and low terraced and detached houses on the western side. Services include a school, a library, a grocery store and kindergartens.

The district was built very quickly between 1965 and 1974. The population peaked in 1974, when the area was inhabited by 8,100 people. Subsequently, the population began to decline, with 7500 inhabitants in 1980 and today around 4500 inhabitants. Over the last 20 years, the number of children and people of working age has declined faster than the general population.

The change in the demographic structure reflects the trend of regional migration: the population is shrinking and aging in old suburbs. The average size of a household in Kaukovainio is about 1.6 people, compared with about 2.0 for the entire city.

2.2.2 Summary of interventions and actions

A1: Residential building 1. New insulation windows

A2: Heat recovery in buildings one and two

A3: Thermal energy storage in building one

A4: Connection of building one to DH

A5: Smart control in building one.

A6: eCar parking

A7: Visualization units in building one.

A8: Heat recovery in building two

A9: Solar PV panels in buildings one and two

A10: Heat recovery in building two

A11: Thermal energy storage in building two

A12: Heat recovery in building two

A13: Smart control and metering in building two

A14: Visualization units in building two

A15: Residential buildings three and four

A16: Heat recovery in buildings three and four

A17: Connection of buildings three and four to DH

A18: Smart control in buildings three and four

A19: New Arina mall

A20: Geothermal energy in Arina.

A21: CO2-based heat pump in Arina

A22: Thermal energy storage in Arina

A23: 50 kWp in Arina

A24: Solar thermal panels in Arina.

A25: Heat recovery in Arina.

A26: Smart control in Arina.

A27: Charging points in Arina.

A28: Seasonal storage in Arina.

A29: Low T regional transfer pipeline

A30: Solar PV panels in local power plant

A31: Advanced heat pumps in buildings

A32: Waste heat recovery from return pipeline

A33: Phase transfer liquid heat tank

A34: Wireless data transfer network.

A35: Control system of heat pumps.

A36: Smart Lighting

A37: LoRA wireless network.

A38: New 2050 Oulu Vision

A39: SECAP monitoring and update of action

A40: City Policies Update: taxes, subsidies

A41: Single window/desk for energy retrofitting

A42: PED Renaissance Strategy

A43: Shared private-public investment models for sustainable energy consumption and production

A44: Business model for charging stations

A45: Energy efficient design of the real estate

A46: Smart City Crunching Hackathon

A47: Demand management living lab

A48: Assessment of legal barriers & solutions

A49: Standardization of PED and energy balance in districts

A50: Citizen and stakeholder engagement

A51: Education, Co-design and Co-creation in Oulu

A52: Local toolkit for renewable energy production and storage at the district scale

A53: Local toolkit for development of Near Zero Emission Buildings

A54: Thermographic and energy production mapping or end-users engagement

A55: City mentoring

A56: Policy forum on energy transition

A57: Collaboration with Covenant of Mayors Office to communicate SECAP experiences

3 Detailed conceptual design of the actions

3.1 Actions in High Performance Buildings

A1: Residential building 1. New insulation windows

Technical Description

GA: "The building is a rental house, currently populated, and includes 56 apartments distributed in 7 floors and the basement. The total area is 2,900 m^2 and the volume is 8,930 m^3. The energy consumption before the renovation is 414 MWh/year (357 MWh for heating and 57 MWh in electricity). The annually estimated energy consumption after this renovation is 241 MWh (heat+electricity), which means 83 kWh/m^2yr, below the Finnish goal of 140 kWh/m^2yr for renovation buildings." The impact is due to also other renovation measures than only the window renovation.

Windows have been changed already earlier. Instead, roof insulation is increased. Heat recovery (HR) from exhaust air, district heating (DH) return water and sewage water have been added to the building. COP of exhaust air HR is about 3 and that of DH about 5, according to the experiences this far. HR from sewage water saves DHW heating energy by about 25%. These are in line with the expectations. As a new action concerning the building envelope, the roof insulation is increased. 10 kWp PV to the façade (see the figure) and on the roof will be installed in the end of 2020.

Figure 1: The renovated rental housing in Kaukovainio, building 1

Technical Figures [1]:	Heating + DHW estimated 60 kWh/m^2/a (incl. DH and el. for HPs)	Other liked actions:	A2, A4, A5, A7
Technical Figures [2]:	Window U-value 1.4, roof about 0,08.		
Design phase			100%
Equipment selection			100%
Installation			100%
Starting up			100%

Monitoring			75%	

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	OE, OUK
Other key stakeholders involved:	GST Högfors, Wasenco Ltd, solar panel supplier

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	Windows changed already earlier with own cost.	MAKING-CITY budget:	-

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)

C2: Payback time	Years

PESTEL Analysis (Barriers / Enablers)

Political	Largely supported by politics
Economic	Long pay-back time, but low risk
Social	Especially in this case the rents must be kept low. Long-sight investments help in this.
Technical	No major barriers, partly new technology, however. Components, materials and solutions have a good availability in general.
Environmental	At some point the increase in e.g. insulation or building new buildings may override the savings. I.e. embodied energy may be larger than net energy consumed during use.
Legal	No remarkable barriers. “The spirit of the laws” concerning building support this.

A5: Smart control in building 1

Technical Description

GA: "The building will be fitted with a wireless sensor network which monitors indoor air quality (Temperature, humidity, CO2, pressure) and operates heating, ventilation and lighting. It also monitors the energy consumption (heat and electricity), and operates as a demand response control unit. The data from the consumption will be collected to a common database with the local high-speed network."

These are under planning (concerns all smart controls). Concerning all smart controls, first there are trials to find out the response of the system. These trials are also to be continued during the whole project, since this is a very important issue to have the system working properly in practice.

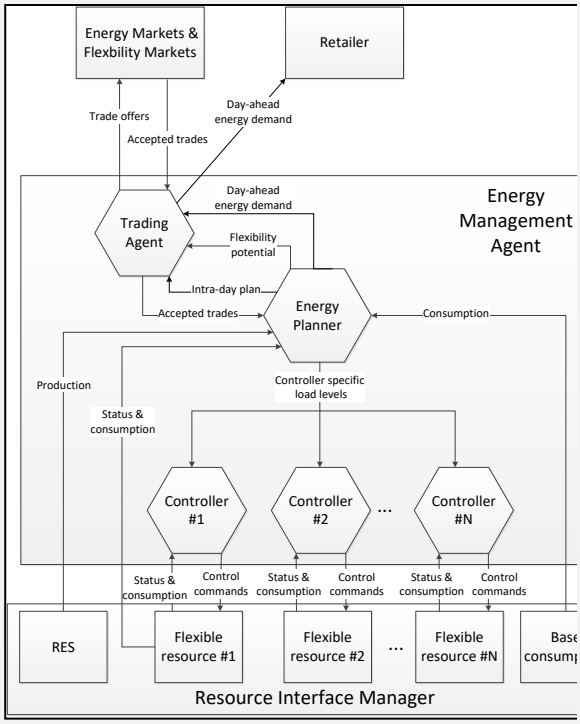
In heat pumps and district heating substations there are their own control systems in every case. They could handle the operation without extra equipment, but for now there is a remote operation possibility.

The idea to develop this further is to have all the subsystems operating so that the whole system works optimally and is controllable. For example, the heat production distribution between heat pump and district heating should be controllable or in fact automatically controlled in an optimal way in different situations.

A schematic figure shows one possibility for the controller, possibly this one and also the others. The properties are the following:

- Novel solution for energy optimization and bottom-up based demand response,
- Energy Management Agent (EMA) automates flexibility management on building-level,
- EMA provides a load plan and flexibilities for each site,
- Supports peer-to-peer and aggregation based flexibility management,

Deep learning technologies utilized for learning building dynamics and optimal control policies.



Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection		50%		
Installation		50%		
Starting up		50%		

Monitoring	25%			

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	SIV, OE
Other key stakeholders involved:	GST Högfors

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV. GST (HP manufacturer) and Ouman (automation manufacturer) apps are there to be included in the system.

Financial Plan & Business Models

Action Cost:	47 500	MAKING-CITY budget:	43 500

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

Concerning the controls, it is essential that people have power over the e.g. room temperature setting. This is maintained, in certain, normal limits.

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)

PESTEL Analysis (Barriers / Enablers)

Political	Follows the trends, even if not very political issue

Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously. The system must not override the control possibilities of the inhabitants, concerning e.g. temperature and ventilation rate.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

A7: Visualization units in building one

Technical Description

GA: "56 display modules (PDA) will be installed in building 1 to assess how human behaviour is affected by different information from the system. People living in the SIV buildings will have very comprehensive information of the local resources and energy balance. The assessment of human behaviour in terms of energy usage from both groups of people will be carried out."

Figure 2: An example of the useir interface view of the visualization unit as a mobile phone application

A prototyped version was released for both Android and mac version of the application. The online database behind, to process the data, is in its initial phase. VTT shall develop the tool based on the prototype input.

A digital application is the most appropriate method to reach out and involve citizens in their homes and increase their awareness regarding energy issues. The digital application is to be available on in-home displays as well as on mobile devices. To this matter, the MAKING-CITY project has developed an interface in which participants to the MAKING-CITY project can access their energy consumption, water consumption, evaluate their climate comfort and provide feedbacks on it, as well as information on their environmental impacts. The application shall also provide alternative and advice on how to act on the different topics, such as carbon emissions compensations, energy reduction and so on.

On top of the web interface accessible publicly, the interface of the digital mobile application allows following the status of the PED even if you are not a participant of the project nor have login information. Furthermore, the solar production, energy and environmental status of the electricity network are made available. These are functionalities that can be toggled in or out to make it possible to have a simpler interface.

The information can also be visible on the display on the staircase of the building.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection		50%		
Installation	25%			
Starting up	25%			
Monitoring				

Management structure	
Action Leader:	UOU
MAKING-CTIY partners involved:	SIV, OEN, OUK, VTT
Other key stakeholders involved:	Tenants

SIV owns the building and is responsible for the changes, using also subcontractors. VTT makes the realization of the app, based on UOU plans and demos.

Financial Plan & Business Models			
Action Cost:	4 480	MAKING-CITY budget:	4 480

Discussion was held if this should be as a separate display or if people would use it with their smartphones. Now the smartphone alternative is to be realized and thus no equipment cost will be there at least for the end user devices. We'd like to have however reserve for the possible future needs for this. As the sum Is in every case small and the devices simple, no complex procedures are thought but the needed equipment jus bought from the capable supplier.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

This interface is engagement itself. In the future we see, if there is need for e.g. meetings in which the individual consumption amounts can be discussed and further the saving potential also.

KPIs for the Evaluation of the Action	
(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	
S2: Consciousness of residents	No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness

PESTEL Analysis (Barriers / Enablers)	
Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

A8: Residential building 2

Technical Description

GA: "A new rental building will be constructed (total area 5,300 m2), consisting in 50 apartments distributed in 7 floors. It will be built according to the latest energy specifications, so the annually estimated consumption is 414.3 MWh (heat+elecricity), which means 78 kWh/m^{2}yr, large below the Finnish reference for category C buildings (120 kWh/m^{2}yr)."

The technical properties are the following:

- Ceiling U=0,08 W/m^{2}K
- Wall U=0,14 W/m^{2}K, insulation 180 mm PU
- Windows and doors U=0,6 W/m^{2}K
- Floor U=0,011 W/m^{2}K
- Exhaust air heat recovery (air-to-air), pre-heating and -cooling from soil layer under the building
- Heat recovery with heat pump from district heating return line
- Heat recovery from sewage water with water-to-water heat exchanger
- Solar panels
- Metering (temp, moisture, pressure difference in mech. ventilation)
- Ventilation rate adjustable by inhabitant
- Moisture-controlled ventilation in bathrooms

Figure 3: New rental housing, building 2.

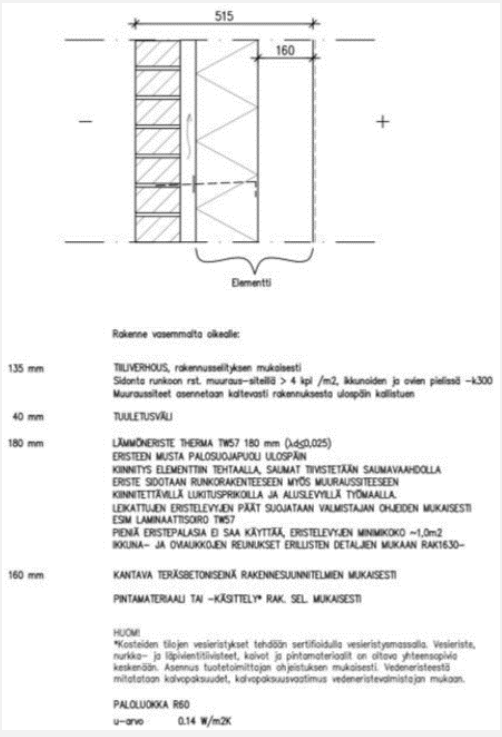


Figure 4: Cross-cut of the wall structure

Technical Figures [1]:	U-value, wall 0.14	Other liked actions:	
Technical Figures [2]:	PV max. 45 kWp		
Technical Figures [3]:	Heat + el.for building technology 78 kWh/m2/a, estimated		

Status of the action

Design phase				100%
Equipment selection				100%

Installation			75%	
Starting up	25%			
Monitoring				

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	OEN, UOU
Other key stakeholders involved:	Tenants, OUK

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	About 13 Me	MAKING-CITY budget:	-

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)

E5: RES production	kWh/month; kWh/a; % of final energy consumption

PESTEL Analysis (Barriers / Enablers) (new solutions)	
Political	Politically favourable, as potentially decrease the energy consumption and emissions
Economic	Pay-back time may be quite long, especially in system level. However, if properly implemented and used feasible investment in long term.
Social	No significant impact. May help to keep the living cost tolerable.
Technical	Readily available technology, even if there are still details which can be still improved. In this case the target is a turn-key delivery.
Environmental	Depends on the ratio of emissions from electricity (for HP) and the alternative heating method. Especially when used as a "smart", i.e. timely flexibly used component, potentially decreases the emissions.
Legal	No major barriers. Building legislation gives benefit for the well-designed systems of this type.

A15: Residential buildings 3&4

Technical Description

GA: "2 new residential buildings will be built according to the latest regulations. The 2 buildings will be equal and include 45 apartments distributed in 7 floors with an area of 2500 + 2900 m^2. Annually estimated consumption is about 350 MWh (heat+elecricity)."

There will be heat recovery from the district heating return pipe to supply heat and domestic hot water for the apartments.

The construction has started and building 3 will be ready in November 2020. The old shopping centre, which was earlier on the site, has been demolished (Arina store replaces that) and the construction is going on. At the point of writing this (20 Jan 2019), elements for the first floor are in place.

Figure 5: The new apartment block, for inhabitant-owned housing, built by a private company. Buildings 3 and 4.

Technical Figures [1]:	Heat + el.for building technology 80 kWh/m2/a, estimated	Other liked actions:	
Technical Figures [2]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation			75%	
Starting up			75%	
Monitoring	25%			

Management structure

Action Leader:	YIT
MAKING-CTIY partners involved:	OEN, VTT
Other key stakeholders involved:	Apartment buyers and investors, OUK

YIT has a comprehensive responsibility over the building process. Subcontractors are used, but most of the work is done by YIT.

Financial Plan & Business Models

Action Cost:		**MAKING-CITY budget:**	

Private funding by YIT. The selling price of the apartments can be seen here: https://www.yit.fi/asunnot/myytavat-asunnot/oulu/kaukovainio .

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As these apartments are on sale on the free market, the potential customers are those who can be said to do the final choices. The decision to build must be done before all the apartments are sold, so quite a lot of decisions must be done by YIT. As there is central heating and DH, also these decisions must be taken in advance.

The upcoming inhabitants in turn can impact a lot on the electricity and water bills, since there are individual bills for each apartment for these. Space and DHW heating are included in the fixed, monthly fee, but the inhabitants however can adjust their room temperature and ventilation rate quite a lot and of course use water up to their decision.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)

PESTEL Analysis (Barriers / Enablers) (new solutions)

Political	Politically favourable, as the new solutions potentially decrease the energy consumption and emissions
Economic	Pay-back time may be quite long, especially in system level. However, if properly implemented and used, feasible investment in long term.
Social	No significant impact (concerning the new solutions). May help to keep the living cost tolerable.
Technical	Readily available technology, even if there are still details which can be still improved. In this case the target is a turn-key delivery.
Environmental	Depends on the ratio of emissions from electricity (for HP) and the alternative heating method. Especially when used as a "smart", i.e. timely flexibly used component potentially decreases the emissions.
Legal	No major barriers. Building legislation gives benefit for the well-designed systems of this type.

A13: Smart control and metering in building two

Technical Description

GA: "The building will be fitted with a wireless sensor network which monitors indoor air quality (Temperature, humidity, CO_2, pressure) and operates heating, ventilation and lighting. It also monitors the energy consumption (heat and electricity), and operates as a demand response control unit. The data from the consumption will be collected to a common database with the local high-speed network."

These are under planning (concerns all smart controls). Concerning all smart controls, first there are trials to find out the response of the system. These trials are also to be continued during the whole project, since this is a very important issue to have the system working properly in practice.

In heat pumps and district heating substations there are their own control systems in every case. The idea is to have all the subsystems operating so that the whole system works optimally and is controllable. For example, the heat production distribution between heat pump and district heating should be controllable or in fact automatically controlled in an optimal way in different situations, related to outside temperature, electricity and DH prices etc.

A schematic figure shows one possibility for the controller, possibly this one and also the others. The properties are the following:

- Novel solution for energy optimization and bottom-up based demand response,
- Energy Management Agent (EMA) automates flexibility management on building-level,
- EMA provides a load plan and flexibilities for each site,
- Supports peer-to-peer and aggregation based flexibility management,
- Deep learning technologies utilized for learning building dynamics and optimal control policies

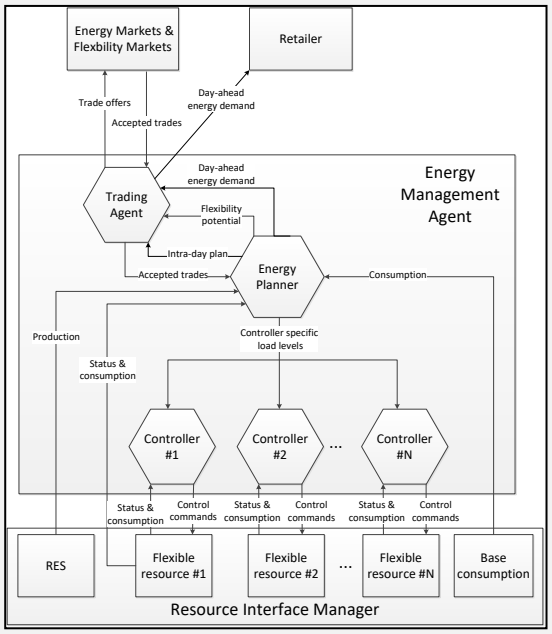


Figure 6: A chart showing the principle of the smart control in building 2.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection		50%		
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	OEN, SIV
Other key stakeholders involved:	OUK

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	47 000	**MAKING-CITY budget:**	47 000

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously. The system must not override the control possibilities of the inhabitants, concerning e.g. temperature and ventilation rate.

Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

A14: Visualization units in building two

Technical Description

GA: "50 display modules (PDA) will be installed in building 2 to assess how human behaviour is affected by different information from the system. People living in the SIV buildings will have very comprehensive information of the local resources and energy balance. The assessment of human behaviour in terms of energy usage from both groups of people will be carried out."

Figure 7: An example of the useir interface view of the visualization unit as a mobile phone application.

A prototyped version was released for both Android and mac version of the application. The online database behind, to process the data, is in its initial phase. VTT shall develop the tool based on the prototype input.

A digital application is the most appropriate method to reach out and involve citizens in their homes and increase their awareness regarding energy issues. The digital application is to be available on in-home displays as well as on mobile devices. To this matter, the MAKING-CITY project has developed an interface in which participants to the MAKING-CITY project can access their energy consumption, water consumption, evaluate their climate comfort and provide feedbacks on it, as well as information on their environmental impacts. The application shall also provide alternative and advice on how to act on the different topics, such as carbon emissions compensations, energy reduction and so on.

On top of the web interface accessible publicly, the interface of the digital mobile application allows following the status of the PED even if you are not a participant of the project nor have login information. Furthermore, the solar production, energy and environmental status of the electricity network are made available. These are functionalities that can be toggled in or out to make it possible to have a simpler interface.

The information can also be visible on the display on the staircase of the building.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase			75%	
Equipment selection		50%		
Installation				
Starting up				
Monitoring				

Management structure	
Action Leader:	UOU
MAKING-CTIY partners involved:	SIV, OEN, OUK
Other key stakeholders involved:	Tenants

SIV owns the building and is responsible for the changes, using also subcontractors. VTT makes the realization of the app, based on UOU plans and demos.

Financial Plan & Business Models			
Action Cost:	4 000	MAKING-CITY budget:	4 000

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

This interface is engagement itself. In the future we see, if there is need for e.g. meetings in which the individual consumption amounts can be discussed and further the saving potential also.

KPIs for the Evaluation of the Action	
S2: Consciousness of residents	No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness

PESTEL Analysis (Barriers / Enablers)	
Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap.

	The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

A19: New Arina mall

Technical Description

GA: "The shopping mall will be commissioned by October 2018 and will be built to meet very low 228.5 kWh/m²yr total consumption. It will have a total area of 2,000 m², distributed in a single floor. Arina will have a singular heating and cooling system based on heat pump and geothermal energy, connected to the district heating, with a thermal energy storage tanks (phase transfer liquid) and PV panels in the roof. A special type of low-temperature hybrid heat collectors will provide extra heat even in cold winter temperatures. The mall also houses an advanced control system based on wireless sensors and charging points for eCars."

The building and the basic energy technology is in place. The following steps related to this are connection to DH network and the control system to optimize the system functions, in addition to the existing equipment-wise controls. Also, thermal solar collectors are to be added.

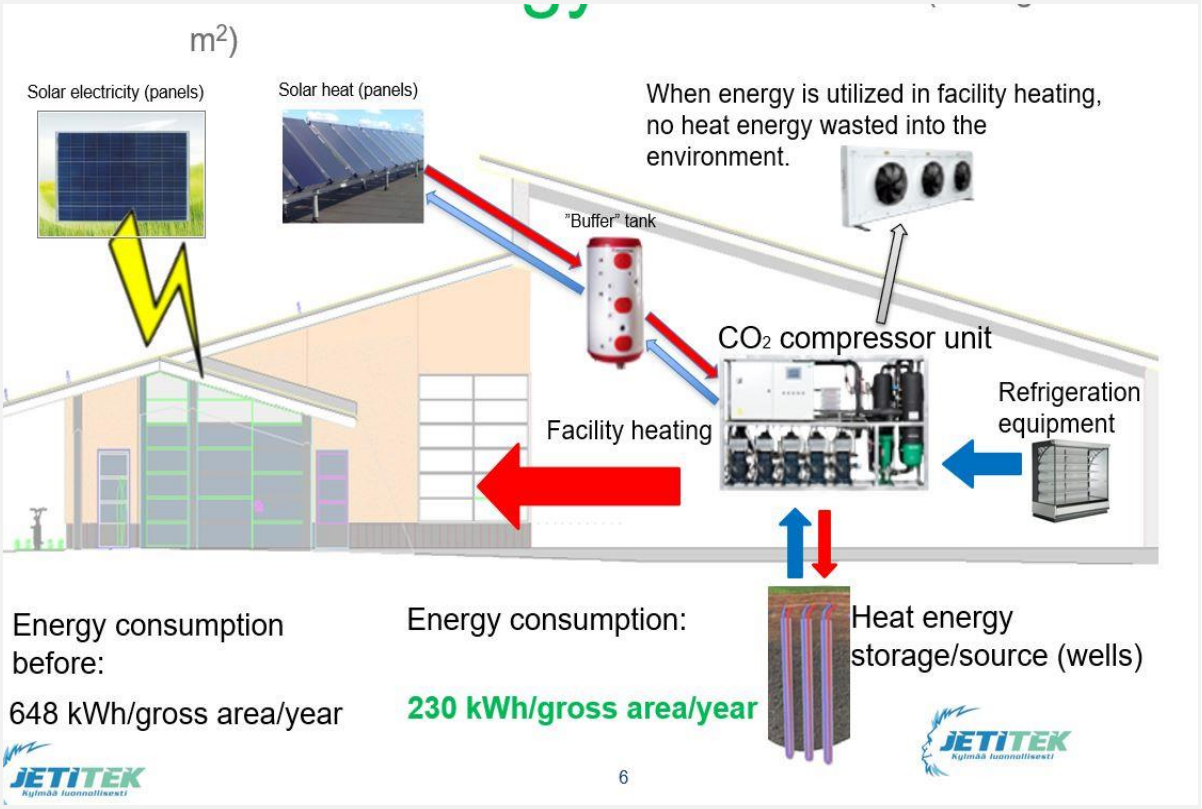


Figure 8: Main components of the cooling and heating system in the store.

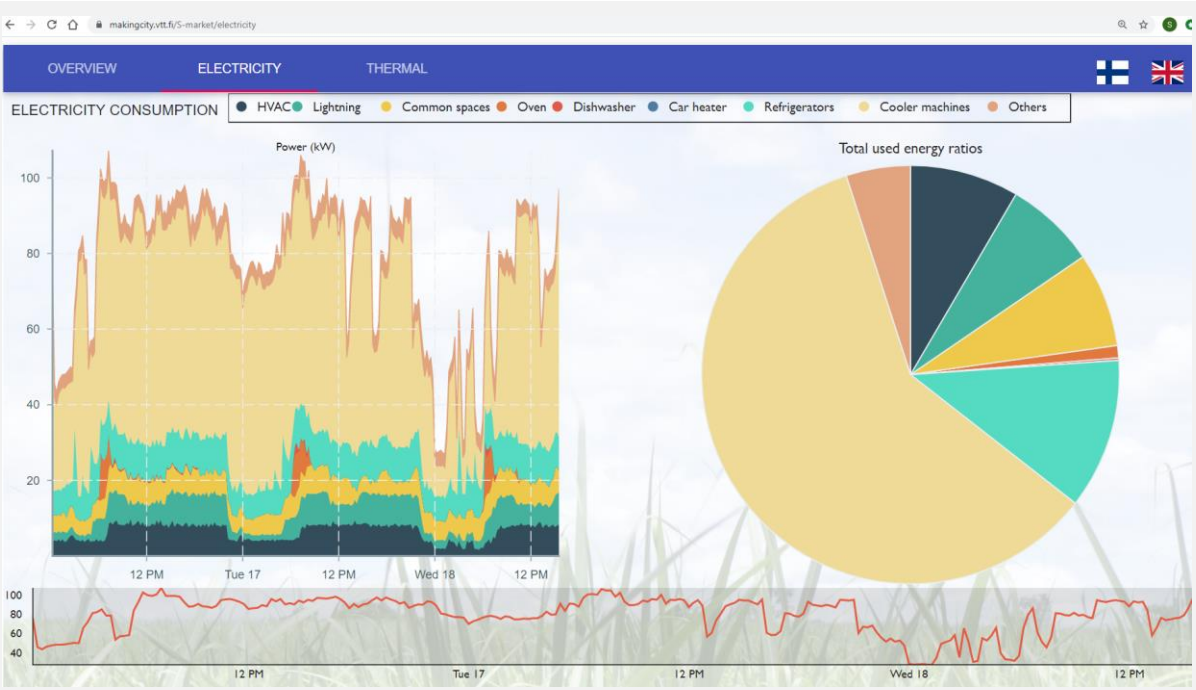


Figure 9: Electricity consumption example from Arina, from real-time measurements.

Technical Figures [1]:	Electricity consumption/m2 reduced to 1/3 of previous, 648->230 kWh/m2/a	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase				100%
Equipment selection				100%
Installation				100%
Starting up				100%
Monitoring			75%	

Management structure	
Action Leader:	ARI
MAKING-CTIY partners involved:	JET, OEN, VTT, OUK
Other key stakeholders involved:	Customers of the store and owners of the S-group (=customers also).

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:	Not known	**MAKING-CITY budget:**	-

Private funding by Arina. EU funding is used for additional installations, like measurements etc.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

The customers own the S-group, the part of which Arina is. Thus, the customers/owners of the co-operative have also decision power. This is one way of engagement. Also, in earlier phases in the Kaukovainio renovation project, the inhabitants had workshops and the new store is one result of those. Technical details and structures etc. are of course designed by experts.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit

PESTEL Analysis (Barriers / Enablers) (concerning the energy solutions)

Political	Heat recovery has a good political support as an idea. Transition to CO2 refrigerant is also politically strongly supported.
Economic	CO2-based refrigeration machines have quite short pay-back time, may be even only two years. Excess heat utilization in DH network depends on the production cost of the alternative supply. In places like Oulu with cheap heat available especially in the summertime, the profitability is not the best possible, but may still make sense.
Social	No significant impacts. Socially well accepted or even supported.
Technical	A part of the system is in the demo phase, others represent mainstream or are close to it. No significant barriers in sight.
Environmental	Net CO2 savings depend on the emission ratio between electricity and DH. In general a favourable solution as a whole, due to the high COP of feeding excess heat to DH network. CO2 refrigeration as such is a very good solution also from environmental point of view.
Legal	No major issues.

A26: Smart control in Arina

Technical Description

GA: "Arina will be fitted with a wireless sensor network, which monitors indoor air quality (T, humidity, CO2, pressure) and operates heating, ventilation and lighting by means of a smart power management unit."

These are under planning (concerns all smart controls). There are ideas, but not ready drawings etc. yet. Concerning all smart controls, there are trials to find out the response of the system. These trials are to be continued during the whole project, since this is a very important issue to have the system working properly in practice.

In heat pumps and district heating substations, there are their own control systems in every case. The idea is to have all the subsystems operating so that the whole system works optimally and is controllable. For example, the heat production distribution between the heat pump and district heating should be controllable or in fact automatically controlled in an optimal way in different situations.

Below are examples of visualisation, which gives an idea on what the system is going to optimize. It has the following properties:

- Measures energy data and the state of the environment from the site
- Sends the energy data and environment state to the centralized data base
- Provides both technical and non-technical visualization user interfaces for monitoring the data
- Data pipeline for intelligent control

The control is done using a common VPN network. Technically it is not necessary to use wireless solutions.

Figure 10: An example of the carpet chart of the energy consumption

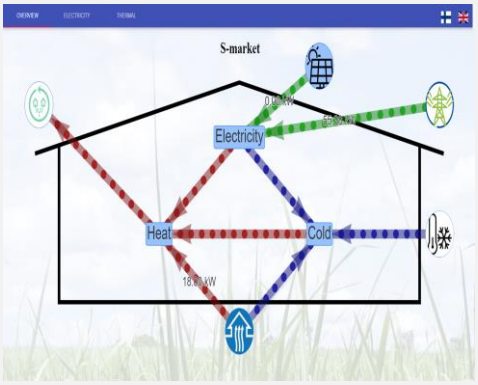


Figure 11: A simplified scheme of the energy system in the store.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection			75%	
Installation			75%	
Starting up			75%	
Monitoring			75%	

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	ARI, JET, OEN
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:	24 900	MAKING-CITY budget:	24 900

The customers own the S-group, the part of which Arina is. Thus, the customers/owners of the co-operative have also decision power. This is one way of engagement. Also, in earlier phases in the Kaukovainio renovation project, the inhabitants had workshops and the new store is one result of those. Technical details and structures etc. are of course designed by experts.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data (see figure) on display inside the store. It is also visible in internet:

https://makingcity.vtt.fi/S-market/overview

The same continuously updating picture will be shown also in other energy displays in the area.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	No significant barriers. Positive publicity can be gained.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	No significant barriers.

A18: Smart control in buildings three and four

Technical Description

GA: "The buildings will be fitted with a wireless sensor network which monitors indoor air quality (T, humidity, CO2, pressure). The control system will optimize the energy consumption (heat and electricity) and also collect necessary data for verification and performance analysis with the local high speed network".

These are under planning (concerns all smart controls). There are ideas, but not fully ready drawings etc. yet. Concerning all smart controls, first there are trials to find out the response of the system. These trials are also to be continued during the whole project, since this is a very important issue to have the system working properly in practice.

In heat pumps and district heating substations there are their own control systems in every case, here GST Fiksu (GST Smart in English). The idea is to have all the subsystems operating so that the whole system works optimally and is controllable. For example, the heat production and distribution between heat pump and district heating should be controllable or in fact automatically controlled in an optimal way in different situations.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection			75%	
Installation		50%		
Starting up				
Monitoring				

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	YIT, OEN
Other key stakeholders involved:	Apartment buyers and investors

YIT has been a builder, but the apartments are sold to private people or investors. Control systems are a part of the DH exchanger-HP-system. This and other equipment are also owned by the shareholders of the apartments, on behalf of whom the board of the housing co-operative makes the decisions. There is usually also a separate service, property management, which is bought from companies specialized on that. Property managers take care of the practical, technical issues and small maintenance jobs of the building. All in all, the control system must be designed so that the people mentioned here can use it, i.e. it must be easy and intuitive enough to use.

Financial Plan & Business Models			
Action Cost:	10,190	MAKING-CITY budget:	10,750
This is to be finally defined later. A part of the control system is included in the supply and price of the DH exchanger and HP, as a part of their normal composition.			

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action
See "Management structure"

KPIs for the Evaluation of the Action	
(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)	
Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously. The system must not override the control possibilities of the inhabitants, concerning e.g. temperature and ventilation rate.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

A35: Control system of heat pumps

Technical Description

GA: "The control system of the local heating plant is combining the heat production on site with the production available from Arina. It also manages the storages on different buildings and makes production planning taking in the weather information and estimated consumption of the inhabitants on the area. The heat production can be adjusted to match to consumption or if needed a surplus heat can be delivered also outside the area."

These are under planning (concerns all smart controls). There are ideas, but not ready drawings etc. yet. Concerning all smart controls, first there are trials to find out the response of the system. These trials are also to be continued during the whole project, since this is a very important issue to have the system working properly in practice.

In heat pumps and district heating substations there are their own control systems in every case. The idea is to have all the subsystems operating so that the whole system works optimally and is controllable. For example, the heat production distribution between heat pump and district heating should be controllable or in fact automatically controlled in an optimal way in different situations.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase			75%	

Equipment selection			75%	
Installation			75%	
Starting up		50%		
Monitoring	25%			

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	VTT, OUK
Other key stakeholders involved:	HP and automation suppliers

See previous texts about control systems. (A5, A13, A18, A26).

Financial Plan & Business Models

Action Cost:	50,000	MAKING-CITY budget:	33,333

Rest of the funding is own financing from the partners.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously. The system must not override the control possibilities of the inhabitants, concerning e.g. temperature and ventilation rate.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

3.2 Actions in Renewable Energy Systems Onsite

A2: Heat Recovery in building 1

Technical Description

GA: "The heat recovery system from AC and sewage water will be based on heat pump technology and also heat transfer without heat pump (sewage water HR and AC in B2). Estimated net energy saving is 2-3 kWh of heat /apartment daily and this heat is used to domestic hot water or heating."

Heat for heat pump (HP) is gained from DH return water and exhaust air, which is extracted mechanically, using fans, from bathrooms, toilets and kitchens. One heat pump handles both sources.

In new buildings, the heat in exhaust air is recovered by air-to-air heat exchanger to incoming fresh air, but if that system lacks in existing buildings, it is expansive to install afterwards. Thus, it may make sense to take the heat out of the exhaust air with HP and increase the temperature so that it can be used for heating and domestic water (min. 55 C for DHW). Here, this kind of HP is implemented. The system is modular, i.e. built using modules, which are easy to install and replace when needed. The whole installation includes also the heat exchanger from DH network together with HP. The system optimizes the parallel use of these sources. Coefficient of performance (COP) is around 4, when heating water from 10 to 60 C and air source has a temperature of 20 C. It may be even 6, when the source is DH return water.

Sewage water from apartments is led through a large-diameter pipe spiral, which is in the water tank. In the tank, there is another heat exchanger, from the tank water to fresh, incoming water, for hot tap water pre-heating. The whole installation is made of stainless steel. The tank with exchanger inside is located in the lowest point of the sewage system in the building, to avoid pumping. The efficiency of the recovery is about 20%. In other words, the incoming water is heated by about 10 degrees. In this case, there is no HP in sewage water heat recovery, but HP is also possible.

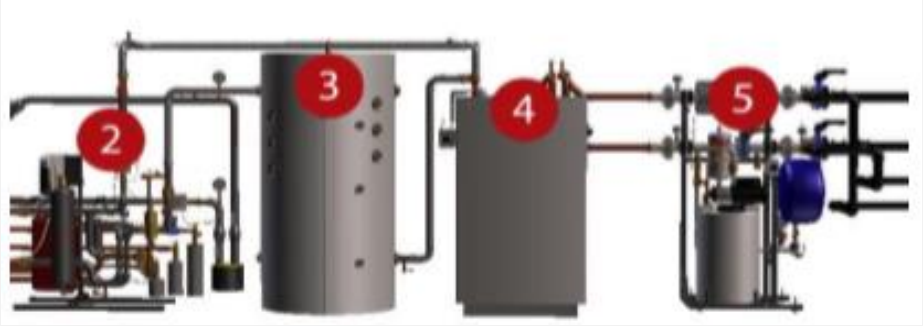


Figure 12: Exhaust air heat pump system.

2=DH exchanger, 3=buffer storage, 4=HP, 5=connection to heat collector.

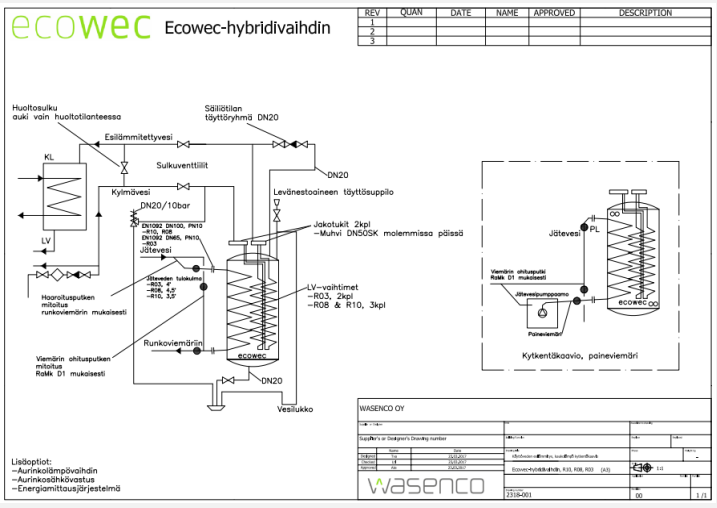


Figure 13: Exhaust air heat collector, a hood place over the exhaust air fan in the roof.

Figure 14: Sewage water heat exchanger.

Figure 15: Connections for sewage water heat exchanger.

Technical Figures [1]:	Exhaust air HP COP 4	Other liked actions:	
Technical Figures [2]:	DH return water HP COP 6		
Technical Figures [3]:	Sewage water heat recovery efficiency >20%		
Technical Figures [4]:	Exhaust air and DH return water HP, max. 14 W/m2		

Status of the action

Design phase					100%
Equipment selection					100%
Installation					200%
Starting up				75%	
Monitoring		25%			

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	OEN
Other key stakeholders involved:	OUK, GST Högfors, Wasenco

SIV owns the building and is responsible for the changes, using also subcontractors. OEN is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	65 000 (for AC HP)	MAKING-CITY budget:	37 143 (for AC HP)

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

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The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action	
E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)	
Political	Politically favourable, as potentially decrease the energy consumption and emissions
Economic	Pay-back time may be quite long, especially in system level. However, if properly implemented and used, feasible investment in long term.
Social	No significant impact. May help to keep the living cost tolerable.
Technical	Readily available technology, even if there are still details which can be still improved. In this case the target is a turn-key delivery.
Environmental	Depends on the ratio of emissions from electricity (for HP) and the alternative heating method. Especially when used as a "smart", i.e. timely flexibly used component potentially decreases the emissions.
Legal	No major barriers. Building legislation gives benefit for the well-designed systems of this type.

A3: Thermal energy storage in building one

Technical Description

GA: "In building 1, a heat tank is planned to have a capacity of 200 kWh (delta T 50ºC). The volume of this kind of heat tank with water is typically 3500 L. The temperature range for operation is from 30ºC to 80ºC and this makes the use very difficult. In MAKING-CITY Project, conventional water will be replaced by a fluid with a phase transfer temperature of 60ºC, so the whole capacity of the heat tanks will be available on a narrow temperature range (from 55ºC to 65ºC). This makes these components an ideal solution to be used together with heat pumps and low temperature heat distribution networks."

Phase-change material storage is demonstrated in laboratory by VTT and it is close to be ready for demo phase. It is to be installed in one of the Sivakka buildings and also to the grocery store.

The efforts for this kind of storages will be concentrated in Arina store, and thus the rest is described there, A22.

Technical Figures [1]:		Other liked actions:	A11, A22, A33
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection	25%			
Installation				

Starting up				
Monitoring				

Management structure	
Action Leader	SIV
MAKING-CTIY partners involved:	VTT, OEN, OUK
Other key stakeholders involved:	

Financial Plan & Business Models			
Action Cost:	18 000	MAKING-CITY budget:	18 000

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

KPIs for the Evaluation of the Action	

PESTEL Analysis (Barriers / Enablers)	
Political	
Economic	
Social	
Technical	
Environmental	
Legal	

A11: Thermal energy storage in building two

Technical Description

GA: "In building 2, a heat tank is planned to have a capacity of 200 kWh (delta T 50ºC). The volume of this kind of heat tank with water is typically 3500 L. The temperature range for operation is from 30ºC to 80ºC and this makes the use very difficult. In MAKING-CITY Project, conventional water will be replaced by a fluid with a phase transfer temperature of 60ºC, so the whole capacity of the heat tanks will be available on a narrow temperature range (from 55ºC to 65ºC). This makes these components an ideal solution to be used together with heat pumps and low temperature heat distribution networks."

Phase-change material storage is demonstrated in laboratory by VTT and it is close to be ready for demo phase. It is to be installed in one of the Sivakka buildings and also to the grocery store.

The efforts for this kind of storages will be concentrated in Arina store, and thus the rest is described there, A22.

Technical Figures [1]:		Other liked actions:	A3, A22, A33
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection	25%			
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	VTT, OEN, OUK
Other key stakeholders involved:	

Financial Plan & Business Models

Action Cost:	18 000	MAKING-CITY budget:	18 000

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

KPIs for the Evaluation of the Action

PESTEL Analysis (Barriers / Enablers)	
Political	
Economic	
Social	
Technical	
Environmental	
Legal	

A22: Thermal energy storage in Arina

Technical Description

GA: "In Arina, a phase transfer liquid heat tank will have a capacity up to 300 kWh (5000 L). The operating temperature is between 50ºC - 60ºC. This tank is used together with the heat pump and high pressure heat collector on the roof. The heat tank is reducing the peak capacity for heat and also serves as a short term storage in 24 hours operating cycle. It will also reduce the duty cycles of heat pumps in the winter time when they are used for heat generation."

The storage vessel of about 300 kWh capacity is installed. It is waiting for the phase change materials to be filled in, in the beginning of 2021. VTT has studied the properties of the different materials and calculated the possible storage capacities, savings etc.

Technical Figures [1]:		Other liked actions:	A3, A11, A33
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection			75%	
Installation			75%	
Starting up				
Monitoring				

Management structure

Action Leader:	JET
MAKING-CTIY partners involved:	VTT, OEN, ARI, OUK
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:	30 000	**MAKING-CITY budget:**	30 000

The customers own the S-group, the part of which Arina is. Thus, the customers/owners of the co-operative have also decision power. This is one way of engagement. Also, in earlier phases in the Kaukovainio renovation project, the inhabitants had workshops and the new store is one result of those. Technical details and structures etc. are of course designed by experts.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

https://makingcity.vtt.fi/S-market/overview

The same continuously updating picture will be shown also in other energy displays in the area.

See also "Financial Plan & Business Models".

KPIs for the Evaluation of the Action

F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	May be quite unknown in politics. Electricity storages have more hype around them, but substance-wise thermal storages are in most of the cases far more profitable, since they are much cheaper per energy unit.
Economic	Profitability is better than that of electrical batteries, but still may be bit so-and-so. To have the full advantage, electricity taxation and transmission pricing principle should be changed towards more effect than energy based and in addition to dynamic one, i.e. dependent on the system balance. This kind of development is in fact ongoing.
Social	No significant impacts
Technical	In the development phase. Simple principle, but in earlier examples e.g. the durability of the PCM has been a bit problematic, i.e. to have the phase change properties to be maintained for long enough time and the overall system simple enough, with all the auxiliary equipment.
Environmental	Beneficial, since gives timely flexibility and thus helps in integrating variable renewables in the system.
Legal	No significant impacts

A33: Phase transfer liquid heat tank

Technical Description

GA: "The local heating plant will have a local storage for heat (estimated capacity 500 kW). This storage can be used in several ways. In spring and autumn, the heat pump will operate with solar power and produce heat. The extra heat not consumed in the daytime can be stored and fed into the system in the night. This storage works together with the other storages in the buildings (1, 2 and 5). In summer, the power plant can also feed energy to the neighbouring areas. The other option is to stop heat generation and feed the solar energy (electricity) to the buildings. In this scenario, Arina would be feeding the heat to the pipeline."

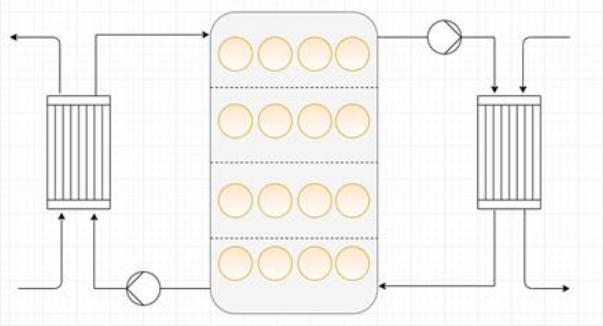

Figure 16: A phase transfer heat storage located between heat exchangers.

Latent heat thermal storage is placed in the heating network with a heat pump for example and it can be charged during night time, or times when heat is not required. Heat is released during the peak hours to increase the life time of the heat pump by reducing its start times. Latent heat storage can also be placed for storing heat from CO2 cold cycle in markets and release it to DH network. Water acts as a heat transfer fluid between PCM and heat exchangers. PCM is encapsulated to ensure better heat transfer rate.

Phase-change material storage is demonstrated in laboratory by VTT and it is close to be ready for demo phase. It is to be installed into the grocery store.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection			75%	
Installation		50%		
Starting up				
Monitoring				

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	VTT, OUK
Other key stakeholders involved:	ARI

VTT does the trials, OEN gives support especially from the system point of view.

Financial Plan & Business Models			
Action Cost:	70 000	MAKING-CITY budget:	35 000
The rest covered by the own funding from the corresponding partners.			

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action
As PCM development needs technical expertise, this is not directly connected to citizen engagement.

KPIs for the Evaluation of the Action	
Indicators about PCM storage are better suited to A22, since in that action the storage is located in the real world conditions.	

PESTEL Analysis (Barriers / Enablers)	
Political	May be quite unknown in politics. Electricity storages have more hype around them, but substance-wise thermal storages are in most of the cases far more profitable, since they are much cheaper per energy unit.
Economic	Profitability is better than that of electrical batteries, but still may be bit so-and-so. To have the full advantage, electricity taxation and transmission pricing principle should be changed towards more effect than energy based and in addition to dynamic one, i.e. dependent on the system balance. This kind of development is in fact ongoing.
Social	No significant impacts
Technical	In the development phase. Simple principle, but in earlier examples e.g. the durability of the PCM has been a bit problematic, i.e. to have the phase change properties to be maintained for long enough time and the overall system simple enough, with all the auxiliary equipment.
Environmental	Beneficial, since gives timely flexibility and thus helps in integrating variable renewables in the system.
Legal	No significant impacts

A9: Solar PV panels in buildings one and two

Technical Description

GA: "10 kWp PV panels will be made by new materials (flex cell). They will be installed on the roof of the building 2. Flex cell is an innovative material developed by VTT. During the MAKING-CITY Project, the durability and production capacity of this material will be tested on the site."

When maximising the production of solar, vertical panels should also be used. This gives not only more area, but also a favourable monthly gain of solar power. In Nordic climate, energy is needed the most in the wintertime or, to better define this case, outside summertime. Vertical panels may have e.g. 10% lower annual total gain than the "usual ones" with 45…60 degrees angle, but especially in springtime, the production of vertical planes may be even manifold compared to angled ones. In this case, solar power is directly used in the heat pumps of the buildings. Picture below shows the placement in building 1, the renovated Sivakka apartment building.

Figure 17: The planned wall placement of solar panels in building, a rental housing block.

Technical Figures [1]:	150 m2 vertical PV, 10 kWp	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection			75%	
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	OEN, VTT, OUK
Other key stakeholders	

involved:	
SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.	

Financial Plan & Business Models

Action Cost:	53 000	MAKING-CITY budget:	18 200

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat punp installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	Subsidies available in many countries, i.e. PV has political support
Economic	Long pay-back time
Social	Positive and visible image from panels
Technical	Fastening the panels to the vertical plane requires some special attention, but if skilfully done, no special barriers
Environmental	Vertical installation is advantageous in terms of system impact and emission reduction (more production in cold seasons)
Legal	No major issues

A10: Heat Recovery from AC and sewage water in building 2

Technical Description

GA: "The heat recovery system from AC and sewage water will be based on heat pump technology. Estimated net energy saving is 2-3 kW of heat /apartment daily and this heat can be used to domestic hot water or heating."

AC heat recovery in new buildings in Finland is usually handled with air-to-air heat exchangers and in this case also. The air handling machine is centralized, which may be a bit cheaper solution than one machine per apartment-alternative. The big advantage of the centralized machine is also that the change of the filters (2 times per year or so) gets properly done, in time. On the other hand the air ducts need their space.

Despite the centralized air handling solution, the inhabitants have a possibility to adjust the air exchange rate by themselves. There is also a moisture sensor in bathroom, which gives a signal to the exhaust valve to be opened up more, when needed. Having the air rates adjusted to the needs saves both heat and fan electricity.

Sewage water from apartments is led through a large-diameter pipe spiral, which is in the water tank. In the tank, there is another heat exchanger, from the tank water to fresh, incoming water, for hot tap water pre-heating. The whole installation is made of stainless steel. The tank with exchanger inside is located in the lowest point of the sewage system in the building, to avoid pumping. The efficiency of the recovery is about 20%. In other words, the incoming water is heated by about 10 degrees. Heat pump could also be connected, but in this case it is not used, since the advantage is quite small.

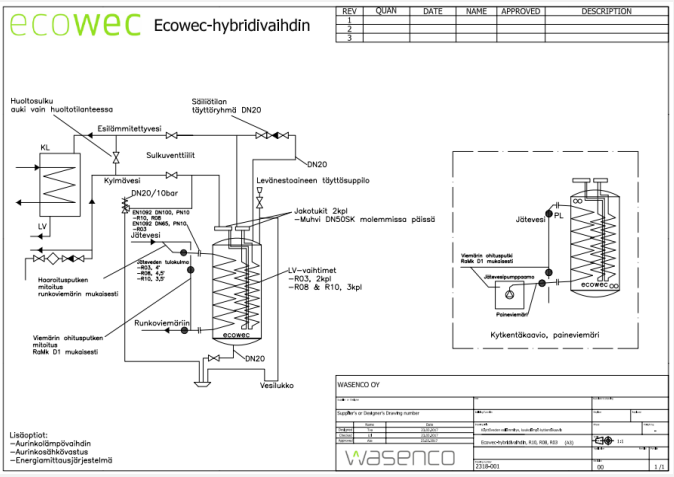

Figure 18: A cross-cut of sewage heat exchanger.

Figure 19: Sewage heat exchanger seen from outside.

Figure 20: The connections of sewage heat exchanger.

Technical Figures [1]:	Sewage water heat recovery efficiency >20%	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				
Starting up				

Monitoring				

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	
Other key stakeholders involved:	

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	45 000	MAKING-CITY budget:	13 500

Funded by Sivakka, OEN and MAKING-CITY-project.

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Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

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The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

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KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	Promotes energy efficiency and is thus politically supported

Economic	Long pay-back time, about 20 years, but also a long lifetime
Social	No major barriers/enablers
Technical	Simple and robust design, movable parts minimised (sewage water HR)
Environmental	Saves about 20% of hot tap water heating energy (sewage water hr)
Legal	No major barriers. Tight energy regulation gives benefit to also this kind of solutions.

A16: Heat recovery in buildings 3 and 4

Technical Description

GA: "The heat recovery system from AC and sewage water will be based on heat pump technology. Estimated net energy saving is 2-3 kW of heat /apartment daily and this heat can be used to domestic hot water or heating."

In buildings 3 and 4 (built by YIT) heat recovery is done by air-to-air heat exchanger and with HP from DH return water.

AC heat recovery in new buildings in Finland is usually handled with air-to-air heat exchangers and in this case also. The air handling machine is centralized, which may be a bit cheaper solution than one machine per apartment-alternative. The big advantage of the centralized machine is also that the change of the filters (2 times per year or so) gets properly done, in time. On the other hand, the air ducts need their space.

District heating connection is usually used so that the heat only-boiler or combined heat and power plant feeds heat into the network and consumers are connected by heat exchangers between heating water circuit in the building and primary circuit, i.e. the one which consists of underground DH pipes between heat production and buildings. The heat in common solution is taken from supply side and the cooled flow is fed on the return pipe.

In this case also return pipe heat is used, mainly by heat pump that increases the temp so that it is suitable for heating and domestic hot water. In addition, in milder weather excess heat is fed from the building (grocery store) to the DH network. The prequisite is that supply temp is below about 85 C, which may take in about 0 degrees outside.

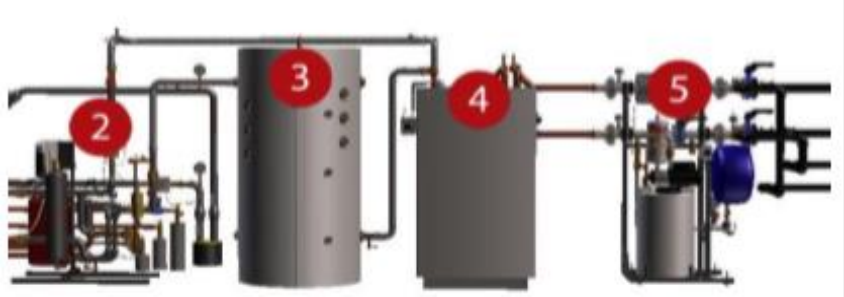

Figure 21: A heat pump system, an example.

2=DH exchanger, 3=buffer storage, 4=HP, 5=connection to heat collector.

Technical Figures [1]:	DH return water HP COP 6	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				100%
Starting up		50%		

Monitoring	25%			

Management structure

Action Leader:	YIT
MAKING-CTIY partners involved:	OEN, OUK
Other key stakeholders involved:	

YIT has been a builder, but the apartments are sold to private people or investors. Contol systems are a part of the DH exchanger-HP-system. This and other equipment are also owned by the shareholders of the apartments, on behalf of whom the board of the housing co-operative makes the decisions. There is usually also a a separate service, property management, which is bought from companies specialized on that. Property managers take care of the practical, technical issues and small maintenance jobs of the building. All in all, the control system must be designed so that the people mentioned here can use it, i.e. it must be easy and intuitive enough to use.

Financial Plan & Business Models

Action Cost:	50 000	MAKING-CITY budget:	15 000

Financed by YIT and/or OEN.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See “Management structure”.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	Promotes energy efficiency and is thus politically supported
Economic	Long pay-back time, about 20 years, but also a long lifetime
Social	No major barriers/enablers
Technical	Simple and robust design, movable parts minimised
Environmental	Saves about 20% of hot tap water heating energy
Legal	No major barriers. Tight energy regulation gives benefit to also this kind of solutions.

A28: Seasonal storage in Arina

Technical Description

GA: "Heat dwells are located under the parking area of Arina. There are 10 dwells and 250 m deep. Each dwell can supply about 10-15 kWh making the peak up to 150 kWh. The storage capacity is about the same, but the long-term capacity depends of the soil & structure (sand, clay, rock etc.)."

A pipeline connects these dwells to the supermarket cooling/heating system. The cooling energy of the freezers and cold storages (i.e. heat) is used in the heating of the building when this is needed. If heating is not necessary, this energy goes to the surrounding buildings with the LT regional heating pipeline. If this heating is not needed the heat is stored either in the (local) heat tanks for short storage or to the heat dwells for long-term storage. The supermarket has a heat surplus for 10 months of the year. During the coldest winter period the heat dwells are used to give extra boost to the heating system of the building."

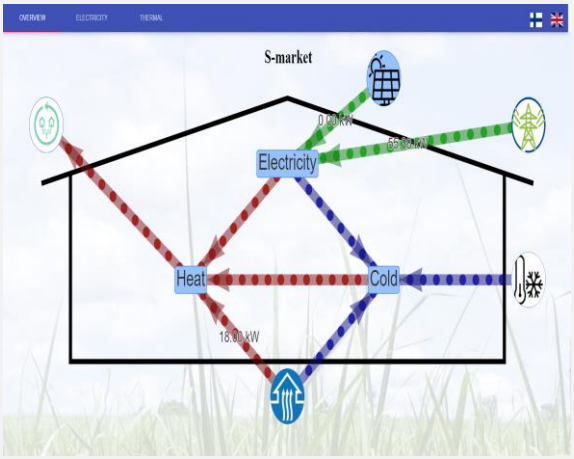

Figure 22: A simplified scheme of the energy system in the store.

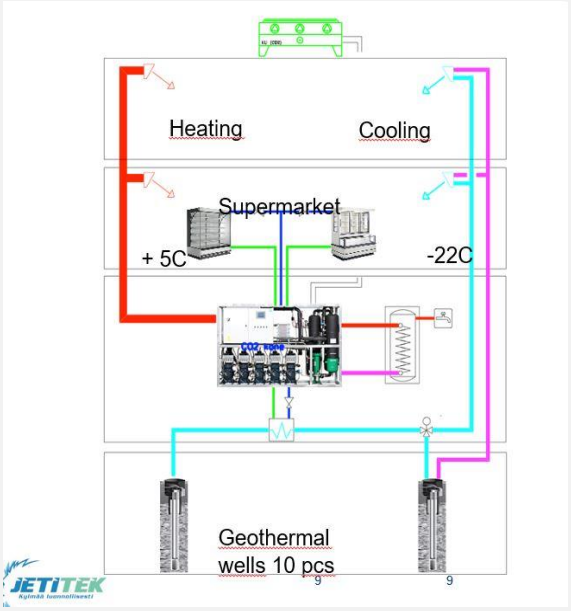

Figure 23: A scheme of cold flows in the store.

There are 10 heat dwells or boreholes drilled under the building, total length of the storage is 2,5 km. Energy balance measurements from several points have started from autumn 2019 on. This action is in practice the same than A20.

Technical Figures [1]:	Borehole thermal storage total length 2500 m	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				100%
Starting up				100%
Monitoring			75%	

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	JET, OEN, VTT
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Funding comes from Arina.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

https://makingcity.vtt.fi/S-market/overview

The same continuously updating picture will be shown also in other energy displays in the area.

KPIs for the Evaluation of the Action

F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	May be quite unknown in politics. Electricity storages have more hype around them, but substance-wise thermal storages are in most of the cases far more profitable, since they are much cheaper per energy unit.
Economic	Profitability is better than that of electrical batteries, but still may be bit so-and-so. To have the full advantage, electricity taxation and transmission pricing principle should be changed towards more effect than energy based and in addition to dynamic one, i.e. dependent on the system balance. This kind of development is in fact ongoing.
Social	No significant impacts
Technical	The technology has been known for decades and there are some well-working examples. The key issue is probably to have the suitable bedrock quality, to prevent the loss of heat with ground water. However, even in this case the system works, but then just as usual ground heat source, without recharging with waste heat.
Environmental	Beneficial, since gives timely flexibility and thus helps in integrating variable renewables in the system.
Legal	No significant impacts

A20: Geothermal energy in Arina

Technical Description

GA: "In Arina, heat dwells are located under the parking area (Action 28). During summer, the heat in the dwells is increasing by 20ºC (up to 20 - 25ºC) and this temperature is needed in the winter period. The heat pump system is able to take back the heat with a good COP down to +10ºC. This temperature is reached in January - February. From February onwards extra heat is also available from solar heat collectors (Action 24) on the roof of the supermarket."

10 heat dwells are under the building, total length of the 2,5 km, are in place and measurements collected. Energy balance measurements are taken from several points from autumn 2019 on. Process to log all the points is going on. Some temperature measurements and set value iterations are to be finished. The cooling of cold storages used temperatures from +10 to -22 C

These temperatures are created with heat pumps using high pressurised CO2 (100 bars). The excess heat in the summertime is transferred to the heat dwells into the ground.

Each dwell has a pipe looping down from the surface, these pipes are connected together with a collector pipeline and this pipeline has a heat exchanger. This heat exchanger separated the heat collecting liquid from the highly pressurised CO2.

See A28 for figures about the installation.

Technical Figures [1]:	Borehole thermal storage total length 2500 m	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				100%
Starting up				100%
Monitoring			75%	

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	JET, VTT
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Funding comes from Arina.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

https://makingcity.vtt.fi/S-market/overview

The same continuously updating picture will be shown also in other energy displays in the area.

KPIs for the Evaluation of the Action

PESTEL Analysis (Barriers / Enablers)

Political	May be quite unknown in politics. Electricity storages have more hype around them, but substance-wise thermal storages are in most of the cases far more profitable, since they are much cheaper per energy unit.
Economic	Profitability is better than that of electrical batteries, but still may be bit so-and-so. To have the full advantage, electricity taxation and transmission pricing principle should be changed towards more effect than energy based and in addition to dynamic one, i.e. dependent on the system balance. This kind of development is in fact ongoing.
Social	No significant impacts
Technical	The technology has been known for decades and there are some well-working examples. The key issue is probably to have the suitable bedrock quality, to prevent the loss of heat with ground water. However, even in this case the system works, but then just as usual ground heat source, without recharging with waste heat.
Environmental	Beneficial, since gives timely flexibility and thus helps in integrating variable renewables in the system.
Legal	No significant impacts

A21: CO2-based heat pump in Arina

Technical Description

GA: "In Arina, a very innovative 260 kWth heat pump will use CO2 instead of Freon, achieving COP 6. Compared to conventional heat pumps based on Freon, CO2 is a better environmental option and has good properties for the system (not aggressive compound, cheap, lower vapour temperature). The only problem related to the use of CO2 is the higher pressure in the system up to 100 bars. This means that all components in the cooling systems must be redesigned and tested properly."

Carbon dioxide is used as refrigerant, instead of F-gases. The advantage of CO2 as a refrigerant is that it allows high temperature difference between source and sink, with good coefficient of performance, i.e. the ratio between output heat and input electricity. The hot gas coming from compressor is cooled down gradually (due to its transcritical state), which allows different temperatures taken out of the flow. Even if the carbon dioxide is a greenhouse gas, the warming effect of that per mass unit is significantly lower than that of F-gases. This has importance, if there are leakages in the cooling system. The system is installed and running. The maximum heat output to DH network is about 100 kW.

Figure 24: Compressor of CO_2 HP in the store.

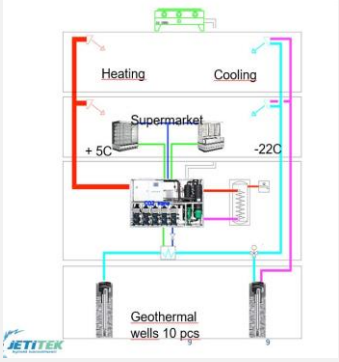

Figure 25: A scheme of cold flows in the store.

Figure 26: Heat storage tank and HP rack in the machine room of the store.

Technical Figures [1]:	Output from cooling to DH network max. 100 kW, 50 W/m2	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				100%
Starting up				100%
Monitoring			75%	

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	JET, OEN, VTT, OUK

Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

The investment cost is a bit higher than that of heat pump using F-gases, but the lifetime cost may be lower even if the environmental benefit is not counted. The concept is planned to be replicated bit by bit to other Arina stores, too, which indicates that the system is beneficial also from business point of view.

Funding comes from Arina.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

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The same continuously updating picture will be shown also in other energy displays in the area.

KPIs for the Evaluation of the Action

E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	As an energy-saving concept supported by common policy
Economic	A bit more expensive than system based on F-gases, but pays off quickly
Social	No significant impacts
Technical	CO2-refrigeration is an old system in principle, but only recently it has been developed to reliable level. E.g. high pressures must be taken into account.
Environmental	Many benefits, no major barriers
Legal	Legislation favours CO2 refrigeration, as F-gases get more and more restrictions

A23: 50 kWp PV in Arina

Technical Description

GA: "50 kW of conventional silicon crystal panels (275 m²) will be used to supply power to the CO2-based high-efficiency heat pump in Arina."

Installed. The effect is higher than what was expressed in GA. The realized effect is about 70 kWp. Production data is collected from about beginning of November 2019.

Figure 27: Solar panels on the roof of the store. They can be seen from their a bit inclined side profile.

Technical Figures [1]:	PV 75 kWp, roof-mounted	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				100%
Starting up				100%
Monitoring			75%	

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	VTT
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Funded by Arina.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

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The same continuously updating picture will be shown also in other energy displays in the area.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	Subsidies available in many countries, i.e. PV has political support
Economic	Long pay-back time
Social	Positive and visible image from panels
Technical	Fastening the panels to the vertical plane requires some special attention, but if skilfully done, no special barriers
Environmental	Vertical installation is advantageous in terms of system impact and emission reduction (more production in cold seasons)
Legal	No major issues

A24: Solar thermal panels in Arina

Technical Description

GA: "Low temperature heat collectors will be used in Arina (Action 19) to collect heat even from very low temperatures (-20ºC). The normal vacuum tube type of heat collector is able to harvest energy only when the sun is shining. A new type of heat collector is using high pressurized CO2 to collect heat also in the night time. The new collector is made by open end technology and can collect heat from radiation and from surrounding air. This type of heat collector is efficient because it collects energy 24 hours a day."

Under planning. There are some technical problems to solve. The principle is simple (an uncovered pipe system, exposed to the weather). In practical realization it is crucial that e.g. the freeze melting from pipe surfaces Is done in efficient and economical way.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	JET
MAKING-CTIY partners involved:	VTT
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:	28 000	MAKING-CITY budget:	28 000

Financially these a part of the whole system.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

https://makingcity.vtt.fi/S-market/overview

The same continuously updating picture will be shown also in other energy displays in the area.

KPIs for the Evaluation of the Action	
E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)	
Political	Subsidies available in many countries, i.e. PV has political support
Economic	Long pay-back time
Social	Positive and visible image from panels
Technical	Fastening the panels to the vertical plane requires some special attention, but if skilfully done, no special barriers
Environmental	Vertical installation is advantageous in terms of system impact and emission reduction (more production in cold seasons)
Legal	No major issues.

A25: Heat Recovery in Arina

Technical Description

GA: "The heat recovery system in Arina is based on combined cooling/heating cycle. When cooling the cold storages, the heat pump produces heat equal to the amount of cooling + electricity used for the pump operation. This energy does not evaporate to open air but is used for heating and hot water production. When needed, the heat energy is stored to the heat dwells. It can be restored in winter time when extra heat is needed in the building."

Carbon dioxide is used as refrigerant, instead of F-gases. The advantage of CO2 as a refrigerant is that it allows high temperature difference between source and sink, with good coefficient of performance, i.e. the ratio between output heat and input electricity. The hot gas coming from compressor is cooled down gradually (due to its transcritical state), which allows different temperatures taken out of the flow. Even if the carbon dioxide is a greenhouse gas, the warming effect of per mass unit is significantly lower than that of F-gases. This has importance, if there are leakages in the cooling system.

DH connection is under construction.

Figure 28: Heat storage tank and HP rack in the machine room of the store.

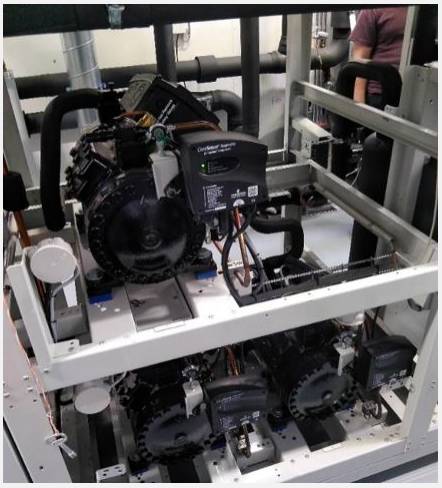

Figure 29: Compressor of CO_2 HP in the store.

Technical Figures [1]:	Output from cooling to DH network max. 100 kW, 50 W/m2	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation				100%
Starting up			75%	
Monitoring	25%			

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	JET, OEN
Other key stakeholders involved:	

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Financial Plan & Business Models

Action Cost:	45 000	MAKING-CITY budget:	18 000

Funded by Arina and OEN.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

There are plans to put the energy data on display inside the store. It is also visible in internet:

https://makingcity.vtt.fi/S-market/overview

The same continuously updating picture will be shown also in other energy displays in the area

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	As an energy-saving concept supported by common policy

Economic	A bit more expensive than system based on F-gases, but pays off rather quickly
Social	No significant impacts
Technical	CO2-refrigeration is an old system in principle, but only recently it has been developed to reliable level. E.g. high pressures must be taken into account.
Environmental	Many benefits, no major barriers
Legal	Legislation favours CO2 refrigeration, as F-gases get more and more restrictions

A30: 71 kWp in local power plant

Technical Description

GA: "71 kW of conventional silicon crystal panels (400 m²) will be assembled to supply electricity from RES to the local heating plant."

As the plant is distributed in the buildings, this not realised as such. The PVs are located in the buildings 1,2 and 5 instead.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	
Other key stakeholders involved:	

Financial Plan & Business Models

Action Cost:	51 800	MAKING-CITY budget:	38 850

The rest of the cost is funded by OEN.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

KPIs for the Evaluation of the Action	

PESTEL Analysis (Barriers / Enablers)	
Political	
Economic	
Social	
Technical	
Environmental	
Legal	

A31: Advanced heat pumps in buildings

Technical Description

GA: "The heat pump system (250 kWth) is matched to give a very high COP of 3.5 on the specified temperature range. Heat pumps are not doing very well over a range of 60ºC rise between input and output. This is avoided by dropping the secondary circuit temperature to 60ºC and working over the comfortable 30 - 40ºC temperature difference in the primary circuit. The heat pump is optimized to operate on this narrow temperature range and thus gives very good efficiency rate.

The input is coming from the cold water return pipeline of the regional heating (Action 32)."

Heat is gained here from DH return water and exhaust air, also ground is possible. DH and mechanical ventilation are commonplace solutions in Finland and there is bedrock quite close to the surface, so all of these are relevant options. One heat pump can utilise heat from all sources.

In new buildings the heat in exhaust air is recovered by air-to-air heat exchanger to incoming fresh air, but if that system lacks in existing buildings, it is expansive to install afterwards. Thus it may make sense to take the heat out of the exhaust air with heat pump (HP) and increase the temperature so that it can be used for heating and domestic water (min. 55 C for DHW). Here this kind of HP is implemented.

The system is modular, i.e. built using modules, which are easy to install and replace when needed. The whole installation includes also the heat exchanger from DH network together with HP. The system optimizes the parallel use of these sources. Coefficient of performance (COP) is around 4, when heating water from 10 to 60 C and air source has a temperature of 20 C. It may be even 6, when the source is DH return water.

Carbon dioxide is used as refrigerant in the store HP, instead of F-gases. The advantage of CO2 as a refrigerant is that it allows high temperature difference between source and sink, with good coefficient of performance, i.e. the ratio between output heat and input electricity. The hot gas coming from compressor is cooled down gradually (due to its transcritical state), which allows different temperatures taken out of the flow. Even if the carbon dioxide is a greenhouse gas, the warming effect of per mass unit is significantly lower than that of F-gases. This has importance, if there are leakages in the cooling system.

Figure 30: DH exchangers for space heating and DHW¨

Figure 31: Heat storage and HP rack in the machine room of the store.

Figure 32: Compressor of CO_2 HP in the store.

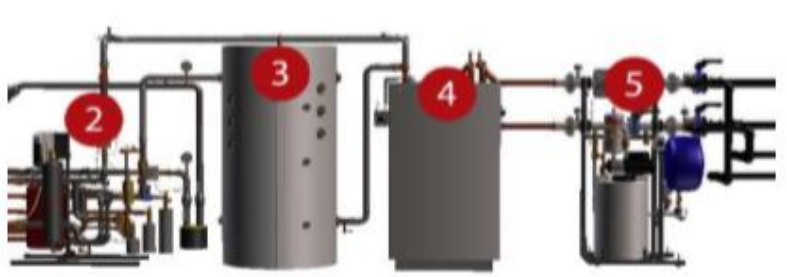

Figure 33: A heat pump system, an example.

2=DH exchanger, 3=buffer storage, 4=HP, 5=connection to heat collector.

Figure 34: Exhaust air heat collector, a hood place over the exhaust air fan in the roof.

Technical Figures [1]:	Exhaust air HP COP 4	Other liked actions:	
Technical Figures [2]:	DH return water HP COP 6		
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation		50%		
Starting up		50%		
Monitoring	25%			

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	JET, ARI, OUK, VTT
Other key stakeholders involved:	

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	226 000	MAKING-CITY budget:	226 000

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump

installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a
E5: RES production	kWh/month; kWh/a; % of final energy consumption

PESTEL Analysis (Barriers / Enablers)

Political	Politically favourable, as potentially decrease the energy consumption and emissions
Economic	Pay-back time may be quite long, especially in system level. However, if properly implemented and used, feasible investment in long term.
Social	No significant impact. May help to keep the living cost tolerable.
Technical	Readily available technology, even if there are still details, which can still be improved. In this case, the target is a turnkey delivery.
Environmental	Depends on the ratio of emissions from electricity (for HP) and the alternative heating method. Especially when used as a "smart", i.e. timely flexibly used component potentially decreases the emissions.
Legal	No major barriers. Building legislation gives benefit for the well-designed systems of this type.

A32: Waste heat recovery from return pipeline

Technical Description

GA: "Combined with Action 31, heat recovery is done by using the return pipeline of the regional heating. This pipeline carries the cold water back to the thermal power plant of the city. The water temperature is low but it still contains energy. The water is led through a big low temperature heat exchanger and heat pump primary input is connected to this. The same technique can be used to harvest energy from seawater of river if there is one nearby."

District heating connection is usually used so that the heat only-boiler or combined heat and power plant feeds heat into the network and consumers are connected by heat exchangers between heating water circuit in the building and primary circuit, i.e. the one which consists of underground DH pipes between heat production and buildings. Heat is usually taken from supply side and the cooled flow is fed on the return pipe.

In this case the return pipe heat is used, mainly by HP, that increases the temp to 40…60 C. Then it is suitable for heating and domestic hot water. As the temperature lift is low, the COP of HP is high, e.g. 6. The connection can be done either by cooling the return flow in the secondary circuit inside the building or district heating water in the primary circuit, which connects heat production and buildings together. Primary circuit connection (so-called three-pipe installation) gives the most advantage, but requires more work in especially existing buildings.

The solution is the more feasible, the more there are the following in the DH system:

- CHP plant. Increases the electricity production due to the lower condensing temperature (which partly compensates the electricity used by heat pump)
- Heat pump. COP increases, i.e. electricity consumption decreases, when the incoming water is cooler.
- Flue gas scrubber. Cooler return water cools the flue gas to lower temperature, which heat is used as DH.
- Solar heat. Lower incoming water temperature to solar collector means more solar gain per m^2.
- Industrial waste heat. The lower is the incoming water temperature; the higher is usually the waste heat potential.
- Bottlenecks in the DH network. Decreasing the return water temperature increase the temp difference between supply and return and thus increases the pipe heat transfer capacity.

Figure 34: CHP plants in Oulu, Toppila. 185 MW electricity, 320 MW district heat. Fuels peat and wood.

Figure 35: DH pipe, a "district level" size. Supply and return inside the same polyurethane insulation. Steel pipes.

Figure 36: DH exchangers for space heating and DHW

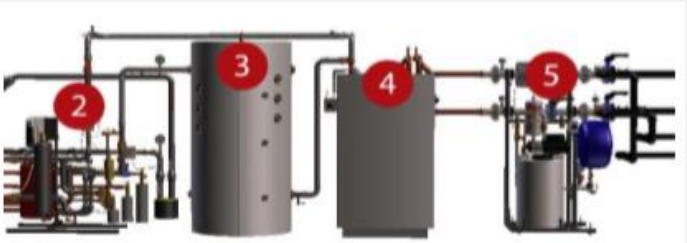

Figure 37: A heat pump system, an example.

2=DH exchanger, 3=buffer storage, 4=HP, 5=connection to heat collector.

Technical Figures [1]:	DH return water HP COP 6	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation			75%	
Starting up			75%	
Monitoring	25%			

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	SIV, YIT, OUK, VTT
Other key stakeholders involved:	

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	25 000	MAKING-CITY budget:	12 500

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	If well described, may be have positive value in politics (energy saving and CO2 emission reduction)
Economic	Depends very much on the DH system configuration
Social	No major barriers or special enablers
Technical	Some technical question marks, like the possible changes in DH water flows after implementing this. Separate components are well-known and commercial technology, but the whole solution is not common.
Environmental	Depends very much on the DH system configuration
Legal	No major barriers or special enablers, as far as we know

3.3 Other Technical Actions

A6: eCar parking

Technical Description

GA: "In building 1, the eCar parking area would have 10 charging stations for eCars. The facility will be located in the close walking distance from SIV and YIT buildings. Half of these are reserved for public use (car sharing and eCar charging) others can be rented for eCar private owners who need a parking facility. SIV will be responsible to build the parking facility and OEN to build the charging stations and taking care of the facility and management. The facility will be part of the local energy system. Local electricity will be used to charge when possible."

As there is currently no need for this in the original location, there is now to be charging stations in the parking lot of the shopping mall. Electric cars are currently so expensive, that people in rental houses (Sivakka buildings) are not purchasing them. Thus the location is changed.

In smaller scale the chargers are however in place. There are normal Schuko-type sockets outside, one for each parking lot, for most of the places. The fuses are 10 or 16 amperes, so the maximum output is 2300 or 3680 watts. This is less than that for special EV chargers, but can be used for plug-in hybrids. For combustion engine cars, the idea of these sockets is to give power for engine and car interior pre-heating in wintertime.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	SIV (->ARI)
MAKING-CTIY partners involved:	
Other key stakeholders involved:	

Financial Plan & Business Models

Action Cost:	-	MAKING-CITY budget:	-

Original sockets funded by Sivakka.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

KPIs for the Evaluation of the Action	

PESTEL Analysis (Barriers / Enablers)	
Political	
Economic	
Social	
Technical	
Environmental	
Legal	

A4: Connection of building 1 to DH

Technical Description

GA: "Low temperature heat exchangers will be installed in the buildings to provide the connection to the LT local pipeline. If these components fail, the buildings would be cold in winter and there will not be sufficient amount of domestic hot water. Local heat storage in buildings 1 will be installed to prevent this situation, cut down the peak load and offer recovery time for the heat distribution system."

District heating connection is usually used so that the heat only-boiler or combined heat and power plant feeds heat into the network and consumers are connected by heat exchangers between heating water circuit in the building and primary circuit, i.e. the one which consists of underground DH pipes between heat production and buildings. Heat is usually taken from supply side and the cooled flow is fed on the return pipe.

In this case also return pipe heat is used, mainly by heat pump that increases the temp so that it is suitable for heating and domestic hot water. In addition, in milder weather excess heat is fed from the building (grocery store) to the DH network. The perquisite is that supply temperature is below about 85 C, which may take in about 0 degrees outside.

Heat pump in the DH return side increases the water temperature to suitable level for space and hot tap water heating. Temperature lift is low (under 20 degrees), which may give COP of e.g. 6, i. e. very high.

The connection can be done either by cooling the return flow in the secondary circuit inside the building or district heating water in the primary circuit, which connects heat production and buildings together. Primary circuit connection (so-called three-pipe installation) gives the most advantage, but requires more work in especially existing buildings.

The solution is the more feasible, the more there are the following in the DH system:
- CHP plant. Increases the electricity production due to the lower condensing temperature (which partly compensates the electricity used by heat pump)
- Heat pump. COP increases, i.e. electricity consumption decreases, when the incoming water is cooler.
- Flue gas scrubber. Cooler return water cools the flue gas to lower temperature, which heat is used as DH.
- Solar heat. Lower incoming water temperature to solar collector means more solar gain per m2.
- Industrial waste heat. The lower is the incoming water temperature; the higher is usually the waste heat potential.
- Bottlenecks in the DH network. Decreasing the return water temperature increase the temperature difference between supply and return and thus increases the pipe heat transfer capacity.

Figure 38: CHP plants in Oulu, Toppila. 185 MW electricity, 320 MW district heat. Fuels peat and wood.

Figure 39: DH pipe, a "district level" size. Supply and return inside the same polyurethane insulation. Steel pipes.

Figure 40: DH exchangers for space heating and DHW

Figure 41: Heat storage tank and HP rack in the machine room of the store.

Technical Figures [1]:	DH return water HP COP 6	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase				100%
Equipment selection				100%
Installation				100%
Starting up				100%
Monitoring			75%	

Management structure	
Action Leader:	SIV
MAKING-CTIY partners involved:	OEN, OUK
Other key stakeholders involved:	GST Högfors

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	20 000	MAKING-CITY budget:	8 000

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	May be seen as old-fashioned or vice versa, depending on the country and observer. Requires some central planning. If well described, may be have positive value in politics (energy saving and CO2 emission reduction)
Economic	Expensive to implement. High capital cost and risk of getting customers and keeping them. However, cheap energy sources can be used, i.e. low operating cost. Depends very much on the DH system configuration
Social	Price setting, its variability depends on the markets. If the system has different kind of production methods (e.g. CHP and heat pumps with high capacity), the price may be quite stable.

Technical	Well-known parts mainly, but also some new solutions exist. Some technical question marks, like the possible changes in DH water flows after implementing this. Separate components are well known and commercial technology, but the whole solution is not common.
Environmental	Varies a lot. Depends very much on the DH system configuration. If properly set with a multiple set of energy sources, a flexible and environmentally sound system, potentially the best one. But can be also the opposite, in extreme when burning coal directly for heat (which is however nearly non-existent in Finland currently).
Legal	Techno-economically it is of advantage to have obligatory joining to the network, but this of course is a reason for complaints and dissatisfaction. Generally legal issues are well arranged, with a lot of experience, in Nordic countries.

A12: Connection of building 2 to DH

Technical Description

GA: "Low temperature heat exchangers will be installed in the buildings to provide the connection to the LT local pipeline. Local heat storage in buildings 2 will be installed to prevent this situation, cut down the peak load and offer recovery time for the heat distribution system."

District heating connection is usually used so that the heat only-boiler or combined heat and power plant feeds heat into the network and consumers are connected by heat exchangers between heating water circuit in the building and primary circuit, i.e. the one which consists of underground DH pipes between heat production and buildings. Heat is usually taken from supply side and the cooled flow is fed on the return pipe.

In this case also return pipe heat is used, mainly by heat pump that increases the temp so that it is suitable for heating and domestic hot water. In addition, in milder weather excess heat is fed from the building (grocery store) to the DH network. The perquisite is that supply temperature is below about 85 C, which may take in about 0 degrees outside.

Heat pump in the DH return side increases the water temperature to suitable level for space and hot tap water heating. Temperature lift is low (under 20 degrees), which may give COP of e.g. 6, i. e. very high.

The connection can be done either by cooling the return flow in the secondary circuit inside the building or district heating water in the primary circuit, which connects heat production and buildings together. Primary circuit connection (so-called three-pipe installation) gives the most advantage, but requires more work in especially existing buildings.

The solution is the more feasible, the more there are the following in the DH system:
- CHP plant. Increases the electricity production due to the lower condensing temperature (which partly compensates the electricity used by heat pump)
- Heat pump. COP increases, i.e. electricity consumption decreases, when the incoming water is cooler.
- Flue gas scrubber. Cooler return water cools the flue gas to lower temperature, which heat is used as DH.
- Solar heat. Lower incoming water temperature to solar collector means more solar gain per m2.
- Industrial waste heat. The lower is the incoming water temperature, the higher is usually the waste heat potential.
- Bottlenecks in the DH network. Decreasing the return water temperature increase the temperature difference between supply and return and thus increases the pipe heat transfer capacity.

Figure 42: CHP plants in Oulu, Toppila. 185 MW electricity, 320 MW district heat. Fuels peat and wood.

Figure 43: DH pipe, a "district level" size. Supply and return inside the same polyurethane insulation. Steel pipes.

Figure 44: DH exchangers for space heating and DHW

Figure 45: Heat storage tank and HP rack in the machine room of the store.

Technical Figures [1]:	DH return water HP COP 6	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				100%
Equipment selection				100%
Installation		50%		
Starting up				
Monitoring				

Management structure

Action Leader:	SIV
MAKING-CTIY partners involved:	OEN, OUK
Other key stakeholders involved:	GST Högfors

SIV owns the building and is responsible for the changes, using also subcontractors. OE is responsible for connection changes in DH network and solar PV.

Financial Plan & Business Models

Action Cost:	20 000 + 20 000	MAKING-CITY budget:	4 000 + 6 000

Funded by Sivakka, OEN and MAKING-CITY-project.

In Finland there is currently energy efficiency improvement subsidy of 4…6000 euros or max, 50% for housing co-operatives. It does not fit in this case, however. This subsidy is provided by ARA and set by the Finnish government. For detached houses there is the same subsidy, but with reduced amount. These subsidies are applied for very much and thus they can be seen effective.

Time by time there has been quite similar instruments. Otherwise the main instruments for financial steering are carbon emission trade and energy taxation, which guide towards renewable energy sources and energy efficiency.

For PV there are city-set rules for e.g. how the PV installations should look like. This concerns also some heat pump installations. Being connected in DH network is voluntary. In general, legislation is not a barrier but rather encourage for energy efficiency or renewable energy projects. The question is more about the financial profitability and pay-back times.

In addition, the Finnish building legislation is quite strict for new buildings. Also, when renovating old buildings, a study about feasible energy efficiency improvements must be done and the profitable measures must be carried out.

The law about public procurement gives some possibilities for giving priority to environmentally friendly solutions, but in practice the investment price is still in many cases the definitive issue. However, discussions about changing the point of view are continuously under debate.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the measures described here require technical expertise, the inhabitants' role is limited. However, the installation is realized so that the uncomfort due to the installation is as short as possible. The acceptability of the measures is increased by meetings with the inhabitants. On the other hand, the acceptability of this kind of interventions is good already in the first place.

The main concern seemed to be that if the investments would increase the rent. The investments however are for long time and in fact may decrease the total cost. The long-term nature of the investments has been emphasized in public discussions, also the fact that EU project funding covers helps us to decrease the demo investment from the perspective of the tenant.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	May be seen as old-fashioned or vice versa, depending on the country and observer. Requires some central planning.
Economic	Expensive to implement. High capital cost and risk of getting customers and keeping them. However, cheap energy sources can be used, i.e. low operating cost.
Social	Price setting, its variability depends on the markets. If the system has different kind of production methods (e.g. CHP and heat pumps with high capacity), the price may be quite stable.
Technical	Well-known parts mainly, but also some new solutions exist.
Environmental	Varies a lot. If properly set with a multiple set of energy sources, a flexible and environmentally sound system, potentially the best one. But can be also the opposite, in extreme when burning coal directly for heat (which is however nearly non-existent in Finland currently).
Legal	Techno-economically it is of advantage to have obligatory joining to the network, but this of course is a reason for complaints and dissatisfaction. Generally legal issues are well arranged, with a lot of experience, in Nordic countries.

A17: Connection of buildings 3 and 4 to DH

Technical Description

GA: "Low temperature heat exchangers will be installed in the buildings to provide the connection to the LT local pipeline. If these components fail, the buildings would be cold in winter and there will not be sufficient amount of domestic hot water. Local heat storages in buildings 1 and 2 will be installed to prevent this situation, cut down the peak load and offer recovery time for the heat distribution system."

District heating connection is usually used so that the heat only-boiler or combined heat and power plant feeds heat into the network and consumers are connected by heat exchangers between heating water circuit in the building and primary circuit, i.e. the one which consists of underground DH pipes between heat production and buildings. Heat is usually taken from supply side and the cooled flow is fed on the return pipe.

In this case also return pipe heat is used, mainly by heat pump that increases the temp so that it is suitable for heating and domestic hot water. In addition, in milder weather excess heat is fed from the building (grocery store) to the DH network. The perquisite is that supply temperature is below about 85 C, which may take in about 0 degrees outside.

Heat pump in the DH return side increases the water temperature to suitable level for space and hot tap water heating. Temperature lift is low (under 20 degrees), which may give COP of e.g. 6, i. e. very high.

The connection can be done either by cooling the return flow in the secondary circuit inside the building or district heating water in the primary circuit, which connects heat production and buildings together. Primary circuit connection (so-called three-pipe installation) gives the most advantage, but requires more work in especially existing buildings.

The solution is the more feasible, the more there are the following in the DH system:

- CHP plant. Increases the electricity production due to the lower condensing temperature (which partly compensates the electricity used by heat pump)
- Heat pump. COP increases, i.e. electricity consumption decreases, when the incoming water is cooler.
- Flue gas scrubber. Cooler return water cools the flue gas to lower temperature, which heat is used as DH.
- Solar heat. Lower incoming water temperature to solar collector means more solar gain per m2.
- Industrial waste heat. The lower is the incoming water temperature; the higher is usually the waste heat potential.
- Bottlenecks in the DH network. Decreasing the return water temperature increase the temperature difference between supply and return and thus increases the pipe heat transfer capacity.

Figure 46: CHP plants in Oulu, Toppila. 185 MW electricity, 320 MW district heat. Fuels peat and wood.

Figure 47: DH pipe, a "district level" size. Supply and return inside the same polyurethane insulation. Steel pipes.

Figure 48: DH exchangers for space heating and DHW

Figure 49: Heat storage tank and HP rack in the machine room of the store.

Technical Figures [1]:	DH return water HP COP 6	Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase					100%
Equipment selection					100%
Installation				75%	
Starting up				75%	
Monitoring		25%			

Management structure

Action Leader:	YIT
MAKING-CTIY partners involved:	OEN, OUK
Other key stakeholders involved:	GST Högfors

YIT has been a builder, but the apartments are sold to private people or investors. Control systems are a part of the DH exchanger-HP-system. This and other equipment are also owned by the shareholders of the apartments, on behalf of whom the board of the housing co-operative makes the decisions. There is usually also a separate service, property management, which is bought from companies specialized on that. Property managers take care of the practical, technical issues and small maintenance jobs of the building. All in all, the control system must be designed so that the people mentioned here can use it, i.e. it must be easy and intuitive enough to use.

Financial Plan & Business Models

Action Cost:	40 000	MAKING-CITY budget:	12 000

YIT and Oulu Energy cover the rest of the investment.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See “Management structure”.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	May be seen as old-fashioned or vice versa, depending on the country and observer. Requires some central planning.
Economic	Expensive to implement. High capital cost and risk of getting customers and keeping them.

	However, cheap energy sources can be used, i.e. low operating cost.
Social	Price setting, its variability depends on the markets. If the system has different kind of production methods (e.g. CHP and heat pumps with high capacity), the price may be quite stable.
Technical	Well-known parts mainly, but also some new solutions exist.
Environmental	Varies a lot. If properly set with a multiple set of energy sources, a flexible and environmentally sound system, potentially the best one. But can be also the opposite, in extreme when burning coal directly for heat (which is however nearly non-existent in Finland currently).
Legal	Techno-economically it is of advantage to have obligatory joining to the network, but this of course is a reason for complaints and dissatisfaction. Generally, legal issues are well arranged, with a lot of experience, in Nordic countries.

A27: Charging points in Arina

Technical Description

GA: "5 eChargers for public cars will be deployed in the Arina. The charging points are mid speed, which means that a normal eCar having 30 kW battery capacity can be charged in 3-4 hours."

Arina will build 3 places on their own cost. The charging points are concentrated here in the public space, because currently e-car users are not so many.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection		50%		
Installation	25%			
Starting up				
Monitoring				

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	
Other key stakeholders involved:	

Arina plans, finances and operates the points.

Financial Plan & Business Models

Action Cost:	6 000 (+chargers) (->0)	MAKING-CITY budget:	2 400 (->0)

In new plan Arina finances the chargers bt own funding.

Arina has the responsibility for the whole building project, in addition to EU subsidy for demo equipment. Subcontractors are used when needed. Financing comes also from Arina, from the business itself. The turnover of the S-group as a whole is about 12 billion euros per year. The group is owned by its customers, so it is a large co-operative organization.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

These are in public use, so the from the experiences can be drawn conclusions about usage patterns etc.

KPIs for the Evaluation of the Action

M1: Number of public EV charging stations	# of installed stations
M2: Energy delivered for EV charging	kWh/month; kWh/a; charging time; # of charges
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	A strong political support for EVs. How much and by what means this should be supported, is under discussion.
Economic	The price of EVs is a barrier for many. The average value of a car in Finland is about 3500 euros, thus the new EV is out of reach in many cases. It cannot be thought that the state would give large sums for purchasing EVs, due to corona etc., other urges for "savings" and also because supporting even EVs is supporting private car-based mobility, which is not sustainable. The popularity may increase strongly, when there begins to be second-hand EVs in the market.
Social	See "Economic". Not a solution for everybody yet, but the market is developing.
Technical	No major barriers.
Environmental	EVs are very probably a better alternative than fossil-fuelled cars, but they are not fully harmless either. Manufacturing of the car itself, batteries and infrastructure require (also) scarce resources, and electricity production especially outside Nordic countries relies still a lot on fossil fuels. See also point "Economic".
Legal	

A29: Low temperature regional transfer pipeline

Technical Description

GA: "This system, that will operate with Action 31, uses lower temperatures (<60ºC) compared to regional heating (<110ºC) in heating and hot water production. Lower temperature means better economy in production, less losses in distribution and lower cost in building the distribution pipelines (plastic instead of steel piping). Using the lower temperature will also improve the COP of heat pumps. The extra investment in supplies (more powerful heat exchangers – Actions 4, 12 and

14), heating system) is paid back by the savings in energy cost."

Not needed, as was planned originally, in newly configured implementation. The advantage of a bit higher COP of heat pumps would not cover the price of double DH network in the area. Suits best for new areas,, where DH is built from scratch. In the new solution this actually consists of internal heating water networks in the buildings and their connections via heat exchangers to larger district heating network.

Technical Figures [1]:			

Status of the action

Design phase				
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	
Other key stakeholders involved:	

Financial Plan & Business Models

Action Cost:	46 000 (new)	MAKING-CITY budget:	18 400 (new)

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

KPIs for the Evaluation of the Action

PESTEL Analysis (Barriers / Enablers)

Political	
Economic	
Social	
Technical	
Environmental	
Legal	

A34: Wireless data transfer network

Technical Description

GA: "This network will cover the whole area, it is used both for control and data aggregation. The data network will be used in order to control both electricity and heat management. It also serves the people by delivering online data of the energy balance thus improving the energy awareness of the inhabitants. Third function of this network is to store data for learning, verification and documentation purposes."

This is under discussion. The ordinary 4G/5G mobile or cable data transfer network seems to be enough, since in Finland they have high capacity as default. It is enough for e.g. watching streamed videos, capacity being 50…1000 Mbit/s.

Originally there was an intention to build a separate low-temperature DH network. The cable could then have been installed in the same earth canal than DH pipes. Now when low-temperature DH is rejected for technical and economic reasons, i.e. being not profitable in this case with already existing DH network, the cable installation is thus also dropped out.

However, referring to the topic, there would also be a wireless part. So, it is also possible to establish a local Wi-Fi-network still as unchanged action. Therefore the original idea described in GA can still be maintained. The manner or details of technical realization are in fact not that important, concerning the end result.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase				
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	
Other key stakeholders involved:	Equipment suppliers

VTT represents here the citizens, the mobile operators supply the equipment and take care of the maintenance.

Financial Plan & Business Models

Action Cost:	20 000	MAKING-CITY budget:	10 000

[Detailed definition of the financial plan to support the interventions. Different public procurement possibilities will be studied and outlined. The different municipal regulations, normative, procurement procedures will be also analysed]

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

[Description of the local social strategy deployed in relation with the action described cross-cutting subtasks 2.1.1 and 2.1.2. Co-creation spaces will be organized, where co-design processes will be launched to ensure that citizens are the core of the urban energy transition and to ensure that the PED concept is a valid pathway for the citizens and stakeholders].

KPIs for the Evaluation of the Action	
(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)	
Political	No major issues.
Economic	A wide coverage with separate network is not economically feasible, since there is already a common 4G network in place. However, smaller Wi-Fi or similar network with cheap equipment may make sense to avoid more expensive wirings.
Social	No major issues.
Technical	See "Economic".
Environmental	No major issues.
Legal	No major issues.

A36: Smart lighting

Technical Description

GA: "A new lighting system of the area will be installed in order to reduce the energy consumption. The technology deployed will be high power LED. The lighting control will be smart, so it will dim the lighting scene when no activity is detected on the area. Power supply may cut down to 50% of the maximum. Ambient lighting sensors are also used to keep track on the daylight so the lighting will adapt to the daylight as well."

The LED lights are already in place. The possible supplier for the dimming system is known and the discussion about the installation is going on.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection	25%			
Installation	25%			
Starting up				

Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	VTT
Other key stakeholders involved:	

[general description of the management structure]

Financial Plan & Business Models

Action Cost:	40 000(Power management)	MAKING-CITY budget:	11 250(Power management)

The LED lights were installed already earlier. City of Oulu paid the costs , which was estimated to be 260 000 euros.

[Detailed definition of the financial plan to support the interventions. Different public procurement possibilities will be studied and outlined. The different municipal regulations, normative, procurement procedures will be also analysed]

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

[description of the local social strategy deployed in relation with the action described cross-cutting subtasks 2.1.1 and 2.1.2. Co-creation spaces will be organized, where co-design processes will be launched to ensure that citizens are the core of the urban energy transition and to ensure that the PED concept is a valid pathway for the citizens and stakeholders].

KPIs for the Evaluation of the Action

[Compile the KPIs from WP5 used for measuring the success of the action]	

PESTEL Analysis (Barriers / Enablers)

Political	No major issues.
Economic	Due to the low consumption of LEDs as such, the smart dimming equipment should have a moderate investment cost
Social	Street lights may be seen as a positive issue to have at least some light around, even if there were no people traffic or pedestrians, but there is no exact information about this. If dimming is activated, it must be quite moderate so that no sense of unsecurity is perceived.
Technical	No major issues
Environmental	Positive impact, even if limited when the consumption is already low thanks to LEDs.
Legal	No major issues.

A37: LoRA wireless network

Technical Description

GA: "Power LED will be combined with smart lighting controller using LoRa (Long Range) wireless network (50 controllers) and activity sensors (50 units) to optimize the lighting level in evening and night time. LoRa based sensor network is used to have seamless control over the "private" and city owned lighting systems. The idea is to send control signals over the area to ensure safe travel and adequate level of lighting in all circumstances. Wireless activity sensors will also be used to provide intelligent control for the lighting."

The study about the feasibility of different solutions is going on.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection	25%			
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	VTT
Other key stakeholders involved:	

[general description of the management structure]

Financial Plan & Business Models

Action Cost:	35 000	MAKING-CITY budget:	35 000

[Detailed definition of the financial plan to support the interventions. Different public procurement possibilities will be studied and outlined. The different municipal regulations, normative, procurement procedures will be also analysed]

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

[Description of the local social strategy deployed in relation with the action described cross-cutting subtasks 2.1.1 and 2.1.2. Co-creation spaces will be organized, where co-design processes will be launched to ensure that citizens are the core of the urban energy transition and to ensure that the PED concept is a valid pathway for the citizens and stakeholders].

KPIs for the Evaluation of the Action

[Compile the KPIs from WP5 used for measuring the success of the action]

PESTEL Analysis (Barriers / Enablers)	
Political	[Generic Info of the solution in terms of PESTEL data]
Economic	
Social	
Technical	
Environmental	
Legal	

3.4 Non-Technical Actions

A38: New Oulu 2050 Vision

Technical Description

GA: "Oulu will face the challenge of developing the long term 2050 vision, to guarantee a seamless city transformation, from planning to implementation and further upscaling. Working with this 30-years-ahead plan will require the use of appropriate tools to support the city in the planning process, in the implementation and in the evaluation and monitoring phases throughout their whole plan's lifetime. In order to better organise cities' activities, a specific Oulu Urban Planning department will be proposed in advance, to foster internal coordination. Once created, the extended tools for modelling the demand-side and supply-side in combination with impact estimation procedures will be integrated in the decision making procedures."

We have just started making this together with Oulu Energy. It is the key stakeholder here, since they have electricity and DH networks in the city area. The idea is to make use of all the energy surpluses from refrigeration, ice rinks etc. and also to take into account the DH network capacities in different places, see if there is suitable places for external heat pumps or boreholes etc. This of course added with ordinary urban planning targets.

The City of Oulu sets biennially a land-use implementation plan for the next five years. From now on, energy production, consumption and capacity will be evaluated in greater detail, as the implementation and construction order has a great effect for the functionality of the energy network.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OUK, OEN, SIV (=city-related actors)
Other key stakeholders involved:	Potentially Arina and other stores, industrial actors etc.

Done mainly by OUK and OEN. Connected very strongly to other work done in these organizations.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
E8: GHG emissions	kgCO2-eq/ (m2month); kgCO2-eq/ (m2a) kgCO2-eq/ (kWh a)
E9: Reduction of emissions	kgCO2-eq/a; %
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a
F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit
S1: Energy poverty	% of households, or % share of income
S2: Consciousness of residents	Likert scale: No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness
S3: Resident engagement / empowerment to climate conscious actions	Likert scale: No engagement – 1 – 2 – 3 – 4 – 5 – High engagement

PESTEL Analysis (Barriers / Enablers)

Political	There is mainly consensus towards quick reduction of emission, but there are also voices that are not in favour of these. The role of peat is one disputed issue, but in practice the use has decreased quickly and very likely the trend is to continue, due to climate and economic reasons. This will happen, even if especially one party is afraid of losing the countryside jobs of peat production. E.g. OEN is however re-training peat entrepreneurs to overcome that problem. Transportation is also (always) a hot topic, many people do not like the idea that they had to decrease their car use and/or change for EV or so. However, cycling is popular in Oulu and there are improvements in cycling routes and also in public transport, so the practice favours the here desired goals. EVs are more a national and even global issue, namely the price development of those. In general the political atmosphere can be seen quite enabling for the vision, since the discussion has moved more and more towards what exactly should be done, not if something should be done at all. This said, contra-arguments still exist.
Economic	See “Political”. The price of the measures is discussed a lot. One personal point of wondering (SR) is that discussion about reducing the consumption in general and thus saving money, has been quite little. Corona has however changed the situation a bit. On the other hand less consumption means less jobs and less taxes to be used for common

	good, which may be a difficult equation. Circular economy may be one big answer, but there are barriers on the way, like the high appreciation of everything brand new and the path dependency around that phenomena. And more, then there is the question if the needed technical development slows down too much if the urge for new is decreased.
Social	See previous. One important point of view is different identity policies, or in other words, in more personal, the ways by which self-esteem is maintained.
Technical	See previous. Technical solutions mainly exist or are just conventional engineering, the challenges are more on social side.
Environmental	Even if there are above mentioned challenges, it seems well probable that at least the energy production can be made environmentally sound in the next couple decades. The keys are wind power, HPs, DH with updated wood-CHP, increasing energy efficiency of the buildings (and not bad for even now) and possible new technologies. Transportation and general consumption may be the most difficult issues.
Legal	In principle the existing laws are in favour of the actions. The general consumption dilemma is probably the one that would require some radical changes, to favour more recycling and thinking in long sight.

A39: SECAP monitoring and update of actions

Technical Description

GA: "Oulu is the only Finnish city that has signed the Covenant of Mayors, Mayors Adapt and Covenant of Mayors for Climate & Energy. Furthermore, Oulu is one of the first 21% of European cities with results already monitored (report in year 2017). Oulu Municipality is committed to continue the process of monitoring and updating their brand new SECAP, following the commitments acquired to the new CoMs for Climate and Energy. This monitoring and update will be based on the monitoring of the actions and the Upscaling plan respectively. All the insights acquired during this process will be shared with CoM Office."

This is in practice considered in e.g. the brand new environmental program, which in turn is one of the starting points of our City Vision 2050.

All subdivisions of the city administration are responsible for implementation of the environmental program. The implementation of the targets is monitored on a quarterly basis by boards and the city council. The achievement of the targets is reported in the annual environmental account.

The Environmental Program Monitoring Group monitors and develops the implementation of the environmental program. The implementation will be evaluated also by an external evaluator in 2022. On the basis of the evaluation, the necessary changes will be made to the program for the remaining period. The environmental program includes a great number of indicators, which are monitored and calculated biennially.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OUK, OE, SIV
Other key stakeholders involved:	In principle all in the city, at least indirectly

Done mainly by OUK and OEN. Connected very strongly to other work done in these organizations.

Financial Plan & Business Models

Action Cost:		**MAKING-CITY budget:**	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
E8: GHG emissions	kgCO2-eq/ (m2month); kgCO2-eq/ (m2a) kgCO2-eq/ (kWh a)
E9: Reduction of emissions	kgCO2-eq/a; %
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a
F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit
S1: Energy poverty	% of households, or % share of income
S2: Consciousness of residents	Likert scale: No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness
S3: Resident engagement / empowerment to climate conscious actions	Likert scale: No engagement – 1 – 2 – 3 – 4 – 5 – High engagement

PESTEL Analysis (Barriers / Enablers)

Political	Mainly the same concerns than in A38, New Oulu 2050 vision, applying to all PESTEL points of view.

Economic	
Social	
Technical	
Environmental	
Legal	

A40: City policies update: taxes, subsidies

Technical Description

GA: "Throughout the whole project, discussions in expert panels consisting in SME, industry, public authorities, science and research institution representatives will be made, to prepare fertile ground for these new policies in Oulu. Oulu will discuss the subsidies and loans policy on the national level with the Ministry of the Environment and the Housing Finance and Development Centre of Finland to target more subsidies and funds to energy-efficient construction projects."

Taxes and subsidies in Finland are set on national or EU level. We in the city have just started internal discussions, what could be our wishes about the issue. There are e.g. some underlying issues like the taxation of the land use, which indirectly may have a large impact on the solutions. Before that, in the background there are earlier experiences about the issue, which contain a lot of discussions with the groups mentioned above. During the project there has also been several official and unofficial meetings about this. In addition to taxes and subsidies, it is important to think the overall design of things. Should we do in this or that way and how to promote doing things in a certain way, which benefits the project goals, i.e. carbon neutrality, resource efficiency, social sustainability etc.

There is just about to be launched a new subsidy for energy renovations, so the target mentioned in GA is about to be realized. In November 2019, the Ministry of the Environment published a plan to reintroduce the energy subsidies for residential buildings, now with revised qualifications. According to the draft decree on energy subsidies for residential buildings, subsidies would be granted for projects to improve the energy efficiency of all residential buildings, totaling EUR 20 million in 2020 and EUR 40 million per year in 2021 and 2022. The subsidy would be 20 % of total cost of the renovation, including design and planning costs. To qualify for the grant, the only requirement would be that, at the end of the renovation project, it can be demonstrated that the building's energy performance has been sufficiently improved. Additional subsidy would be granted for projects that renovate buildings to almost zero energy levels or more energy-efficient than the existing legislation requires. If accepted, the subsidies will become available in 2020 and granted by The Housing Finance and Development Centre of Finland.

The energy subsidies are thought to increase innovations in energy. More renewable energy will be produced and emissions generated by housing will be reduced. There are also other issues that should be promoted. Especially those with system level impacts are on our scope, since they may get too little attention in public discussion.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure	
Action Leader:	OUK
MAKING-CTIY partners involved:	OUK, OEN
Other key stakeholders involved:	
Done mainly by OUK and OEN. Connected very strongly to other work done in these organizations.	

Financial Plan & Business Models			
Action Cost:		MAKING-CITY budget:	
OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines. In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.			

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action
See PESTEL analysis on A38.

KPIs for the Evaluation of the Action	
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)	
Political	See here also A38.
Economic	
Social	
Technical	
Environmental	
Legal	The city has very limited possibilities on setting taxes and subsidies, they are mostly national or even in the EU level.

A41: Single window/desk for energy retrofitting

Technical Description

GA: "A new platform that comprises a major simplification of the refurbishment process concerning technical, administrative and funding aspects will be implemented to reach a high potential for local individual initiatives. The idea is to create a support system labelled by Oulu that offers professional help to citizens how to optimize the heating system in residential and non-residential housing and advice how to use solar energy."

This is partly already realised. The building supervision of the city gives this kind of guidance, among the other institutions. We are discussing how to further develop the service. The marketing should be furthered, for example. Information and advices about the possibilities is still quite scattered around locally and nationally.

As a distinctive solution, the city has a wide DH network and thus when DH is produced sustainably; the customers are doing so automatically. We try to find the optimum for different kind of buildings, regarding if they are in DH coverage area or not, what is the insulation level in the first place etc. These background thoughts have also an impact on retrofitting optimization guidance and this process development is on-going.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OUK, OEN
Other key stakeholders involved:	Professionals and citizens, interested in the issue

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Funded by normal budget of the city.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

A direct, personal (if possible) guidance to the citizens, so empowering as such.

KPIs for the Evaluation of the Action

S2: Consciousness of residents	Likert scale: No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness

S3: Resident engagement / empowerment to climate conscious actions	Likert scale: No engagement – 1 – 2 – 3 – 4 – 5 – High engagement

PESTEL Analysis (Barriers / Enablers)	
Political	Limited resources are provided for this from political side. On the other hand, increasing awareness on the importance of the renovations.
Economic	The personnel giving advice could be more, but due to the aim to decrease the sum of city salaries, not very good possibilities for that. Giving good advices for renovation and for new buildings is economically highly useful, since there is in most of the cases question about large sums of money.
Social	The Finns may be quite self-acting, but help is often welcome. If the help can be given unbiased, for free and with good knowledge on the issue, the better. This can be done.
Technical	A very large set of technical issues should be handled here, so it requires a good technical expertise to be able to do the job.
Environmental	This is highly beneficial from environmental (and also economical) point of view, so at least the substance speaks for the action.
Legal	The Finnish building legislation is quite comprehensive and done with professionals, which eases the task.

A42: PED Renaissance Strategy

Technical Description

GA: "City of Oulu will adopt, based on the existing solutions and lessons learned from MAKING-CITY interventions, a model and strategy for district-level energy renovation for Oulu. The model considers technical interventions as well as urban planning interventions like densification and mobility planning. Results of this action will be considered in the Action 45."

Energy production, consumption and capacity will be evaluated in greater detail for the future biennially revised implementation program on land-use. The implementation and construction order has a great effect for the functionality of the energy network. The representatives of Oulu Energy will take part in the planning process more intensively from now on.

This is a part of City Vision 2050, which work is in progress. Densification and mobility planning (promoting walking, cycling and public transport) appear in many everyday processes and separate projects. In the future we are trying to establish a more integrated planning, in which the energy issues are taken into account in a holistic way.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OEN
Other key stakeholders involved:	

OUK is responsible for the whole, remembering democratic process behind.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
E8: GHG emissions	kgCO2-eq/ (m2month); kgCO2-eq/ (m2a) kgCO2-eq/ (kWh a)
E9: Reduction of emissions	kgCO2-eq/a; %
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a
F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit
S1: Energy poverty	% of households, or % share of income
S2: Consciousness of residents	Likert scale: No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness
S3: Resident engagement / empowerment to climate conscious actions	Likert scale: No engagement – 1 – 2 – 3 – 4 – 5 – High engagement

PESTEL Analysis (Barriers / Enablers)

Political	See A38.
Economic	

Social	
Technical	
Environmental	
Legal	

A43: Shared private-public investment models for sustainable energy consumption and production

Technical Description

GA: "Different residential and commercial buildings will be used as demonstrators of innovative business models. The data collected on performance, saving and other related benefits (e.g. jobs generation) together with the real case definition of joint public-private investments along the different actions implemented will be abstracted to provide business models to be replicated and scaled up by other districts (or cities). For instance, the Arina shopping centre will be analysed as an ambitious and complex business ecosystem in which public private (shared) clean energy investments and savings/benefits will be translated to new agreements and/or policies to reward responsible consumption, renewable energy and circular economy."

The shopping centre owner (Arina) is co-operating with Oulu Energy to have the solution demonstrated in Kaukovainio to be replicated to also other stores of Arina. And, if the experiences are good, also wider in Finland. As a part of the ecosystem Jetitek (Caverion) and also other companies are involved in the target.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	ARI
MAKING-CTIY partners involved:	JET, OEN, UOU, VTT, OUK
Other key stakeholders involved:	SIV, YIT and other building constructors and users, stores etc. All who buy or potentially sell power or heat.

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

ARI and OEN are having a consult work to be done about the issue. The work is just about to start (11/20).

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

As the question is about agreement of two companies, no direct co-design by citizens is the first option. Both are however "special" companies, i.e. ARI is a retail co-operative and OEN owned by municipality, so there is a kind of co-design. Not directly, but via the decision-making process.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	Political discussion is going on (can be said forever), how much the companies should be on the other hand taxed or governed, on the other hand subsidized or given permissions. In the best case the profit of the company and that of the community go hand in hand, when it is easy to go further. E.g. some of the excess heat uses may fulfil these criteria.
Economic	One question may be how to think about the fixed and variable cost or the price of supply security, which takes care of it. Possibly these division lines are the most crucial, when thinking about the profitability from different points of view. When possible, transparency helps in getting to the optimal solution. In Finland one may not be that worried about monetary corruption or so, but business secrets are one thing that may limit transparency, for understandable reasons.
Social	See "Political".
Technical	No major issues. However, in this case, the exact performance of the equipment is to be seen, since the solution is still a demo more than well-known technology.
Environmental	In general beneficial for the environment, thus support from that side of the issue.
Legal	There may be some juridical concerns, i.e. how to make a contract that is good and fair for both sides of the agreement and indirectly also for all customers. As the solution (two-way DH network) is quite new, the exact contract details wait still to be found and formulated in practice. For example, there has been a general discussion who "owns" the excess heat.

A44: Business model for charging stations

Technical Description

GA: "Grid bottlenecks that will become a challenge in urban areas can be reduced or even avoided via the integration of charging stations into the PED (Actions 6 and 27). A modular platform enables customer specific Apps with individual business models. Storage batteries can assist in improved load management of supplier and possibly improve economics of charged electricity by making use of time periods with excess supply and/or without local grid bottlenecks. Charging station can also be used as flexible components for demand/response control of electricity in the local grid."

Under planning. As the issue is very much dependent on the national decisions, we are waiting what is to happen.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase	25%			
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure	
Action Leader:	OEN
MAKING-CTIY partners involved:	OEN, OUK, UOU, ARI
Other key stakeholders involved:	Housing associations, Finnish state

The city has not very many possibilities in the issue, or in other words, the most crucial decisions and developments are done elsewhere. Thus our role may for now be just to follow the development.

Financial Plan & Business Models			
Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action
This depends also how the whole issue is preceded.

KPIs for the Evaluation of the Action	
(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)	
Political	A high will to promote EV infrastructure.
Economic	Some concerns how to divide the charging cost. There are however commercial charging services, and as far is known, this is not a significant issue. More problematic may be who pays the stations if there are no commercial organizations to establish them to some pre-defined place.
Social	See previous. Investment cost may be a problem in e.g. housing co-operations. Should also those who do not own a car pay for charging place?
Technical	No major barriers. Different charging stations area available at market.
Environmental	EVs are better than petrol cars by emissions, but on the other hand also they require resources for manufacturing and need urban space that could be used for other purposes also. So, not a totally clear issue. However, in suitable places, promoting charging places, can be seen beneficial for the environment.

Legal	Land use is quite much decided by the cities in Finland, so in own hands mainly. Other legislation do not cause any significant barriers, as far as it is known. On the contrary, there are obligations for new housing to have a certain number of charging points.

A45: Energy efficient design of the real estate

Technical Description

GA: "Development of a business model for energetic transformation of the real estate with guarantee of energy cost savings. The implementation will consist on the analysis of current energy state of existing buildings followed by the definition of actions and finally the large scale modernization of building energy technologies with energy-saving contracts, monitoring, controlling, energy consulting and performance optimization."

The basic solutions in new buildings in Finland are in high level already now. Still there is possibilities to improve, e.g. by introducing heat pumps in different configurations. And, by HPs flexibility, making DH system better to react to the fluctuations in electricity price (which in turn reflects the production-consumption balance). Especially the flexibility issue is quite new and not well-established yet.

The "traditional" energy efficiency is promoted of course, but in addition to that, we see it important to have flexibility as a topic. In more general, the optimization of the whole system performance so that the emissions and cost are minimised, is the target. This must be translated to the language understood by the real estate owners and that's what we try here.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	OUK, OE, YIT, SIV
Other key stakeholders involved:	

Equipment and material suppliers (for background information about product properties)

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

The issue is quite complicated, since for some of the operations highly specialised skills are needed. The structural issues and for example building physics need expertise to be realized safely. For these reasons the possibly best strategy in this case may be to take close look to the surveys about the housing preferences of the citizens. Of course, the market development shows the way also.

The crucial and to some extent "new" area (in energy efficiency) is the consideration of the whole energy system and more, the predictable future development with a lot of wind power etc.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	years

PESTEL Analysis (Barriers / Enablers)

Political	Politically favourable, as the new solutions potentially decrease the energy consumption and emissions
Economic	Pay-back time may be quite long, especially in system level. However, if properly implemented and used feasible investment in long term.
Social	No significant impact (concerning the new solutions). May help to keep the living cost tolerable.
Technical	Readily available technology, even if there are still details which can be still improved. In this case the target is a turn-key delivery.
Environmental	Depends on the ratio of emissions from electricity (for HP) and the alternative heating method. Especially when used as a "smart", i.e. timely flexibly used component potentially decreases the emissions.
Legal	No major barriers. Building legislation gives benefit for the well-designed systems of this type.

A46: Smart City Crunching Hackathon

Technical Description

GA: "A hackathon will be held for developing further ideas for a Smart City ranging from business solutions for sustainable mobility, smart energy etc. Attention will be paid to tourism, environmental issues and retail. Open Data will form a crucial input in the form of traffic data, data from tourist organization and retailers/central super malls."

This in initial phase. The responsible organization may well be Business Oulu, which promotes new businesses in the Oulu region. They have experience in designing and organizing hackathons. The wishes from technical content may come from OUK and OEN. Also UOU, their business school, can be involved.

This has not proceeded, due to corona.

Technical Figures [1]:		**Other liked actions:**	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase	25%			
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure	
Action Leader:	OUK
MAKING-CTIY partners involved:	UOU
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models			
Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

To be defined later. See A45. The problem (or challenge) is the fact that a lot of technical expertise is needed. Thus special attention should be put on the right questions, i.e. what are the areas in which the citizens or participants can give their insights. On the other hand “all” ideas are welcome, if we (OUK) just have time and expertise to value them.

KPIs for the Evaluation of the Action

PESTEL Analysis (Barriers / Enablers)	
Political	Good in gaining publicity for the renewables, energy efficiency etc.
Economic	Can be arranged with low budget.
Social	A good possibility to express also wild ideas. However, it seems to be that in this kind of events the group phenomena lead to the result, where the trendy ideas are selected and the “hidden gems” may remain hidden.
Technical	Many of the solutions require technical expertise. On the other hand, it is easy to pick out not feasible ideas (if there is expertise for that).
Environmental	Depends on the results In every case, there is possibility to have new ideas.
Legal	No major issues, if no GDPR or IPR constraints etc.

A47: Demand management living lab

Technical Description

GA: "Demand management is one of the most important of the total efficiency issues affecting energy use. It is also easier for social acceptance as long as affirmative financial and economic business cases can be demonstrated. Demand management in building energy utilization is recognized as a leading energy efficiency intervention with user-friendly interfaces of consumption, creating the energy saving behaviour. The same is true for EV's and charging and the user in this case is fleet managers and individual citizens. The living lab will once again be a testing ground for the social acceptability of technical solutions as well as testing of the technical solutions themselves"

See also A45. The difference is that in A47 the flexibility is increased by behavioural changes, but A45 relies more on "invisible" technologies in the background, like flexible switching of the heat production method depending on the fluctuating prices, heat storages etc.

In practice this has been started when implementing the solutions to residential buildings. Especially we are waiting for the displays to come to use, when we begin to see what results giving the information can achieve.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OEN, UOU, VTT
Other key stakeholders involved:	

VTT does this as their own process, but OUK is also of course involved. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

KPIs for the Evaluation of the Action	

PESTEL Analysis (Barriers / Enablers)	
Political	Follows the trends, even if not very political issue
Economic	The system price compared to the advantages may be questionable. On the other hand, many parts of the system are in every case in place and replication of digital stuff is cheap. The most expensive is the development work.
Social	Privacy and safety issues against hacking must be taken seriously. The system must not override the control possibilities of the inhabitants, concerning e.g. temperature and ventilation rate. Also, in Finland it is a habit that the dwellings have constant temperature and if this is changed more than, say, 1 or 2 degrees, the comfort is sacrified too much very probably. Other purposes than heating may be even more difficult, since they intervene in everyday life.
Technical	In principle no significant technical barriers.
Environmental	If the environmental burden of manufacturing the equipment itself is tolerable, gives good opportunities to add for example flexibility to the system, which in turn is advantageous in integrating variable renewables in the energy system.
Legal	GDPR issues must be taken care of.

A48: Assessment of legal barriers & solutions

Technical Description

GA: "Research on current barriers for the implementation of PED and identify solutions, facilitators and recommendations to overcome the legal and regulatory barriers as well as to guarantee the data security and protection."

Here the building supervision of the city has probably a large role, as well as the urban planning department. The barriers and solutions exist in many different stages and topics. We concentrate on solutions, so what should be done to overcome the barriers rather than in barriers themselves.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase		50%		
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OEN, UOU
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

In this case also, one probably feasible method is to take a look at the surveys made about the legal barriers citizens and companies see. Also it must be considered that many laws are compromises between perhaps contradictory targets.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	Highly political issue, both barrier and enabler itself.
Economic	Related also to economy, see above.
Social	Whether some law is barrier or enabler, depend in many cases from which point of view it is seen. Or from whose perspective.
Technical	Requires good technical knowledge.
Environmental	See previous.
Legal	See previous.

A49: Standardization of PED and energy balance in districts

Technical Description

GA: "This action aims to deploy the concept of positive energy blocks in a standardized concept as well as the calculation of the annual energy balance through the primary energy factors, taking into account local and country level specificities."

Primary energy factors have already been deeply discussed. This is continued. We try to present the logic suited to context, remembering also the hourly variations, which is crucial when optimizing the wholeness, not only just parts.

If possible, we use different background scenarios of e.g. the electricity production, since they have a very big impact on the result. These have been done during the last months. This is work is also related to many more actions. The idea is simply to have a functionable real-world system with moderate cost, social justice and close to zero emissions.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OEN, VTT
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

This belongs closely to A38, it is a part of City Vision 2050. The existing surveys on the citizens' preferences are studied. We are also planning to make a new one, with about the same manner than was done in Groningen (seen in D3.23).

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)

E3: Energy imported to PED	kWh/15min(/day); kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E4: Energy exported from PED	kWh/15min(/day); kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
E6: PED energy balance	kWh/month; kWh/a; (surplus + or deficit -); %
E7: Energy savings in the PED	kWh/(m2a); %
E8: GHG emissions	kgCO2-eq/ (m2month); kgCO2-eq/ (m2a) kgCO2-eq/ (kWh a)
E9: Reduction of emissions	kgCO2-eq/a; %
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a
F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh

PESTEL Analysis (Barriers / Enablers)

Political	The possibilities of the city are limited, since people cannot be forced to do something. However, some energy efficiency measures are set by law, in fact quite many especially in new buildings.
Economic	The profitability of some investments, in some places, may be weak. On the contrary there are also good investments. In general thinking in long sight is needed.
Social	See “Political”. Democracy and citizens’ right to do their own decisions must be respected. However, many measures are also desired and the only barrier is lack of knowledge and examples.
Technical	The same solutions are not suitable everywhere, one size fits not all. But, tailoring is not a problem, if the customers accept it.
Environmental	See “Technical”.
Legal	See “Political”.

A50: Citizen and stakeholder engagement

Technical Description

GA: "A user-centric approach will be followed in all the MAKING-CITY Project. For that, the smart city services will be co-designed with citizens, guaranteeing that the implemented innovations respond to their needs. Education and transparency about city plans is needed for effective participation. From one side, the city should delimit the extent of the input required from the community. A model for citizens' active participation in public life will be developed at the beginning of the project. This model will turn citizens into active actors of the sustainable change of the city via social networking

(Facebook, LinkedIn, twitter, YouTube), city app, public consultations and participative workshops in the neighbourhood (social media strategy) in line with the overall dissemination, communication and citizens' engagement activities foreseen in the project (WP1, 2, 6, 7 and 8). In all this process, special attention will be paid to include in this entire process vulnerable people living in the district, in order to guarantee that they also participate and share their opinion. With this aim, printed materials, FAQs, and in-person visits will be developed to neighbours to explain the project and to empower them."

The rental housing company in Oulu, Sivakka, engages its tenants in various ways. Tenant activity is obligatory according to the Act on Joint Management of Rental Buildings. In addition to the mandatory activities, Sivakka organizes various kinds of events for its tenants. Monthly coffee break in a changing location with complimentary coffee and buns together with a possibility to discuss with Sivakka's workers and other tenants has been a success. Sivakka Day is organized annually in a newly built rental house. Sivakka Day will be organized also in Kaukovainio area when the new apartments are completed.

In some Sivakka's rental houses there is already a volunteer environmental expert who helps residents to monitor their energy, water and electricity consumption and thereby save money and environment. An environmental expert works together with a property manager and property management to make the property's energy consumption as efficient and economical as possible. Every year Sivakka organizes environmental expert meetings, which are open for all.

Sivakka represents here a good example of how to engage also people, who may otherwise get their voice heard too little.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase			75%	
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OEN, SIV, YIT, UOU
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning

for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

The existing surveys on the citizens' preferences are studied. We are also planning to make a new one, with about the same manner than was done in Groningen (seen in D3.23).

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	The solutions in Oulu are quite centralized by nature (DH and electricity), which is both barrier and but to large extent also enabler. In the best case citizens can pick the solution they find best, from a set of good alternatives. The situation is very different compared to e.g. Groningen.
Economic	The profitability of some investments, in some places, may be weak. On the contrary there are also good investments. In general thinking in long sight is needed.
Social	See "Political".
Technical	The same solutions are not suitable everywhere, one size fits not all. But, tailoring is not a problem, if the customers accept it. Technical expertise is needed in many cases.
Environmental	See "Technical". Due to DH and electricity networks, changes there have an immediate impact on very large group of people and their emissions.
Legal	See "Political".

A51: Education, Co-design and Co-creation in Oulu

Technical Description

GA: "An important part of the engagement processes will be based on the analysis of the data collected from the PED. The data obtained will contribute to the understanding of the consumer behaviour of their citizens and offer workshops and awareness raising campaign to change their actions to sustainable behaviours. These trainings will be offered to different profiles (children, young people, families, business owners, CEOs, etc.) in different settings (schools, universities, chamber of commerce, etc.). Other training activities will be developed to engage with young and unemployed inhabitants and former workers from the construction sector living in the district to develop their eco-construction and refurbishment skills, with a special emphasis on the energy efficiency towards high-performance or near zero emission construction.

Furthermore, a social innovation activity like an innovation camp will be delivered. A dedicated 1-2 day event will be organised during the last six months of the project to boost engagement, raise awareness and help solve the challenges that European cities are experiencing when implementing PEDs. This "Innovation Camp" will gather policy-makers, city representatives, technology providers, local citizens and other stakeholders that are considered necessary, such as representatives from the project's 6 follower cities. They will work together, share experiences and perspectives, and provide input to co-design a toolkit aimed at the project's follower cities and other cities that are considering the implementation of PEDs.

This action will connect clearly with the refurbishment of building 1 (Action 1), that will be used as well as opportunity to involve the trainees in the restauration of their neighbourhood and provide economic (jobs) and social benefits (inclusion).

The impact of the training in the participants' behaviour will be assessed.

Finally, co-creation spaces will be organized, where co-design processes will be launched to ensure that citizens are the core of the urban energy transition and to ensure that the PED concept is a valid pathway for the citizens (and stakeholders).

These co-creating processes will be linked with events with high interest in the neighbourhood to attract participation.

Virtual tools will be additionally implemented to support the citizen participation processes. This strategy will be strongly linked with the policy actions."

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OUK, OE, SIV, YIT, UOU
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be rememered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

The existing surveys on the citizens' preferences are studied. We are also planning to make a new one, with about the same manner than was done in Groningen (seen in D3.23).

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)

Political	The solutions in Oulu are quite centralized by nature (DH and electricity), which is both barrier and but to large extent also enabler. In the best case citizens can pick the solution they find best, from a set of good alternatives. The situation is very different compared to e.g. Groningen.
Economic	The profitability of some investments, in some places, may be weak. On the contrary there are also good investments. In general thinking in long sight is needed.
Social	See "Political".
Technical	The same solutions are not suitable everywhere, one size fits not all. But, tailoring is not a problem, if the customers accept it. Technical expertise is needed in many cases.
Environmental	See "Technical". Due to DH and electricity networks, changes there have an immediate impact on very large group of people and their emissions.
Legal	See "Political".

A52: Local toolkit for renewable energy production and storage at the district scale

Technical Description

GA: "Actions of RES production and storage will be promoted (at different scales) for the citizens and institutions in Oulu. Best practices will be identified and a toolkit will be developed for the development of local renewable energy production and self-consumption projects adapted to each specific context. The tool will analyse the best business cases in renewable energy production, storage and will provide a decision support process to promote these actions. The Municipality will act as the information exchange medium in this topic".

These kinds of tools already exist to quite large extent. E.g. the Finnish building legislation and the building supervision of the city of Oulu have made them. Also there is a lot of literature about the issue. An additional Excel tool (for example) could here be brought to public to help the energy choices. Adding the system level information and scenario thinking would be something quite new. It is challenging, but we take a try what is possible in reality.

One important target of this action is to take a closer and generalized look what can be done with MAKING-CITY technologies, or in other words, what they can give as a part of the whole energy system.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	VTT, OUK, OEN
Other key stakeholders involved:	

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

We discuss this with our (OUK) building supervision, since they are doing this in their everyday work. For example the existing, numerous leaflets about the energy choices and energy renovation could possibly be added with the PED experiences. This channel would possibly be the easiest way for someone who needs hints in the real situation, when doing energy-related choices in the building or renovation project. See e.g.

https://www.ouka.fi/documents/486338/18477137/Improving+natural+ventilation/bdf98b62-92d7-401e-8f77-2de9f34ce1b7

The existing surveys on the citizens' preferences are studied. We are also planning to make a new one, with about the same manner than was done in Groningen (seen in D3.23).

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a
F1: System flexibility for energy players	%; kWh; Likert
F2: RES storage usage	%; kWh
F3: Peak load reduction	%; # of peaks (congestion), duration of peaks and size of peaks; MHDx maximum hourly deficit

PESTEL Analysis (Barriers / Enablers)

Political	The solutions in Oulu are quite centralized by nature (DH and electricity), which is both barrier and but to large extent also enabler. In the best case citizens can pick the solution they find best, from a set of good alternatives. The situation is very different compared to e.g. Groningen.
Economic	The profitability of some investments, in some places, may be weak. On the contrary there are also good investments. In general thinking in long sight is needed.
Social	See "Political".
Technical	The same solutions are not suitable everywhere, one size fits not all. But, tailoring is not a problem, if the customers accept it. Technical expertise is needed in many cases, especially when some general rules or guidance are given.
Environmental	See "Technical". Due to DH and electricity networks, changes there have an immediate impact on very large group of people and their emissions.
Legal	See "Political".

A53: Local toolkit for development of Near Zero Emission Buildings

Technical Description

GA: "Best practices will be identified and a toolkit will be developed on the development of near Zero Emission Building adapted to the local context to comply with the requirement of the EU regulation on NZEB by 2020. The analysis will not only identify and describe best practices in building and retrofitting, but will also provide a simple decision support tool based on clear social, environmental, technological and economic criteria, detailing possible funding sources to develop such projects. These guidelines will be translated to the local authority for their integration in the local planning documents and regulation. "

See A52. More, the retrofitting is very much context-dependent, which causes additional challenges here. The cost is difficult to generalise, since the starting points may be very different. However, there is e.g. a book about the average estimated renovation costs in Finland, in details. This can be used as a basis.

Also the Ministry of Environment has launched a new subsidy for renovations, in conjunction with which there is an intention to collect data about the realized renovation costs. We try to follow these results as much as possible and also take part in the discussions around the issue.

In practice the result can be some kind of software or internet page, or simply elaboration of current toolkits. They are now mainly guidance leaflets. PED points of views can be added to those.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase		50%		
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure

Action Leader:	VTT
MAKING-CTIY partners involved:	VTT, OUK, OEN, SIV, YIT
Other key stakeholders involved:	

Manufacturers of the materials and equipment, information about product properties.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See A38 (PESTEL) and A52.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E2: Primary energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E5: RES production	kWh/month; kWh/a; % of final energy consumption
C1: Total investments	€/m2; €/kW(h)
C2: Payback time	Years
C3: Economic value of savings	€ / saved kWh (or reduced kgCO2-eq)/a

PESTEL Analysis (Barriers / Enablers)

Political	The solutions in Oulu are quite centralized by nature (DH and electricity), which is both barrier and but to large extent also enabler. In the best case citizens can pick the solution they find best, from a set of good alternatives. The situation is very different compared to e.g. Groningen.
Economic	The profitability of some investments, in some places, may be weak. On the contrary there are also good investments. In general thinking in long sight is needed.
Social	See "Political".
Technical	The same solutions are not suitable everywhere, one size fits not all. But, tailoring is not a problem, if the customers accept it. Technical expertise is needed in many cases, especially when some general rules or guidance are given.
Environmental	See "Technical". Due to DH and electricity networks, changes there have an immediate impact on very large group of people and their emissions.
Legal	See "Political".

A54: Thermographic and energy production mapping or end-users engagement

Technical Description

GA". This engagement action will used smart energy auditing based on aerial thermographic mapping and sustainable energy production at district scale to engage household on retrofitting and new RES projects based on their own house/building characteristics. First, an aerial thermographic survey of the district will be performed to have a visual and personalized assessment of heat losses from the different buildings of the neighbourhood in an efficient way. Apart from that, a map of potential energy production in the district will be developed. These maps will provide to each end-user a picture of his house with colours indicating heat losses in a very impacting way and complemented with the potential energy generation from RES. All this data will be integrated into the Urban Platform. Individual information campaigns will be launched, based on the individual building information will be realized to engage with local stakeholder on energy efficiency issue based on individual and personalized tailored information."

This is under planning. We are thinking of e.g. the need to use expensive, high resolution equipment. It is also possible to start with consumer-grade infrared cameras in land level and use more special equipment only when needed. This to maximize the impact. If this is a right way to proceed, is discussed and tested.

On the other hand the aerial IR-photos using drones may be very quick to take and save labour cost. It must be noted, however, that the pictures should be taken from a certain angle sidewards, not directly downwards. The building roofs represent only very small proportion of the total heat losses. Also in most of the cases the upper roof temperature is practically that of outside air, since there is an open, well ventilated space under the upper roof.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	OEN
MAKING-CTIY partners involved:	OUK
Other key stakeholders involved:	

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

The possibilities to give advice for the building owners this way is thought about. It could be useful, but the needed resources may be the problem. In practice this should be done outside the demo buildings, since the buildings in the project are in a good condition.

KPIs for the Evaluation of the Action

E1: Final energy consumption	kWh/month; kWh/a; kWh/(m2month); kWh/(m2a)
E8: GHG emissions	kgCO2-eq/ (m2month); kgCO2-eq/ (m2a) kgCO2-eq/ (kWh a)
E9: Reduction of emissions	kgCO2-eq/a; %
S2: Consciousness of residents	Likert scale: No consciousness – 1 – 2 – 3 – 4 – 5 – High consciousness
S3: Resident engagement / empowerment to climate conscious actions	Likert scale: No engagement – 1 – 2 – 3 – 4 – 5 – High engagement

PESTEL Analysis (Barriers / Enablers)

Political	No major issues.
Economic	Thermographic imaging takes time and thus money if done in a detailed way. However, a light version of this can be a relatively quick exercise.

Social	No major issue, if done in blocks of flat. In detached houses there may be a bit nasty situations, when the house owner is "blamed" for mistakes in construction.1
Technical	Thermographic mapping or infrared pictures are a bit limited in their use. They are best suited for showing heat (air) leaks or thermal bridges. Technical expertise is needed to interpret the pictures and especially what to do with the result. If properly done, this is a handy aid for e.g. quick repairs to prevent air leakages and draught.
Environmental	At best an easy way to improve energy efficiency and living comfort by showing from where to begin.
Legal	No major barriers, if privacy is taken care of, e.g. who and when occupy the flat etc.

A55: City mentoring

Technical Description

GA: "In the course of WP1, and partially in WP8, the most important insights acquired during the project execution in Oulu will be selected for a mentoring campaign that will be promoted among the rest of cities participating in the project (Groningen, Bassano del Grappa, Trenčín, Kadıköy, Vidin, Lublin and León). This action aims at fostering the activities of the existing energy working group of the municipality, integrated by staff of different services, to take advantage of the project to develop their capacity in terms of energy innovation though the exchange with other partner cities. Not only the Municipality, but also other members of Oulu local team will be selected as mentors so that they can explain in detail their experience and guide about the application of these topics that were identified in the other cities. "

It is very important to think the context. This is closely related to WP4, and is done is close collaboration with that. There are some quite detailed thoughts how to take the context into account in practice. It may be done "traditionally" by decomposing the whole to smaller, more easily measurable parts. The challenge is at the same time maintain the overview for the whole, remembering the impact of each part to the others.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection				
Installation				
Starting up	25%			
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OUK, VTT, OE, SIV, UOU, JET
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models			
Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action
See PESTEL analysis on A38. As sensitivity for the context is essential, we can try to formulate some typical cases and solutions, respectively.

KPIs for the Evaluation of the Action	
(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)	
Political	Giving guidance to some others may be irritating from some points of view, namely for those who do not favour the changes and so on. The opposite view is also possible, i.e. it is fine to get help from outside.
Economic	No major barriers (if not in realization). On the contrary, this can be seen positively as a "free consultancy".
Social	See "Political".
Technical	Differences between cities must be carefully considered.
Environmental	Potentially very positive impacts, if the different contexts are remembered.
Legal	Also here the differences country by country must be considered carefully.

A56: Policy forum on energy transition

Technical Description
GA: "The outcomes from the different recommendation on energy policy analysis developed in the policies updated in the actions described above will be delivered to local decision makers and stakeholders (incl. citizen) through the development of local policy forum on energy transition where the experiences learned from the project will be transmitted to a wider audience at city scale. Moreover, municipality staff will communicate these insights in international forums." The dissemination part has already been done to some extent in conferences and that work will continue. More, this is closely related to City Vision 2050, the creation of which has started. This is very much connected to also other work in OUK and OEN.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action				
Design phase		50%		
Equipment selection				
Installation				
Starting up		50%		
Monitoring				

Management structure	
Action Leader:	OUK
MAKING-CTIY partners involved:	OEN, UOU
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models			
Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

KPIs for the Evaluation of the Action	
(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)	
Political	See A38.
Economic	
Social	
Technical	
Environmental	
Legal	

A57: Collaboration with Covenant of Mayors Office to communicate SECAP experiences

Technical Description

GA: "As explained in Action 39, Oulu will monitor and update the SECAP. During this process, guidelines to support cities in this monitoring and update process, which will be based on the upscaling and replication plans will be developed. Oulu, as Groningen will offer collaboration to Covenant of Mayors Office, for which one of its main objectives is the encouragement of mentoring activities within the cities participating in the initiative."

As the experiences are gained, this will proceed step by step.

Technical Figures [1]:		Other liked actions:	
Technical Figures [2]:			
Technical Figures [3]:			

Status of the action

Design phase	25%			
Equipment selection				
Installation				
Starting up				
Monitoring				

Management structure

Action Leader:	OUK
MAKING-CTIY partners involved:	OUK
Other key stakeholders involved:	

OUK has the leading role, but the other actors are actively heard. It must also be remembered that this is a part of the democratic process with city, country and EU behind. This gives us guidelines.

In OUK organization there also other quite similar things going on, like circular economy project and planning for large housing fair in 2025. We participate on those also.

Financial Plan & Business Models

Action Cost:		MAKING-CITY budget:	

Social Innovation Strategy. Citizens' empowering, Co-design and Co-creation in the action

See PESTEL analysis on A38.

KPIs for the Evaluation of the Action

(Direct impact on e.g. energy consumption is very difficult to measure; this is more a part of the whole system)	

PESTEL Analysis (Barriers / Enablers)	
Political	See A38.
Economic	
Social	
Technical	
Environmental	
Legal	

Conclusions

This far the conclusions are mainly from planning phases. The conclusions are added more later, when the equipment is installed and we have more experiences.

The already made technical solution is the CO_2-based cooling and heating system in the grocery store. It has worked like planned. As a conclusion from the good experiences, the technique is to be used possibly in all stores of the chain, where possible, i.e. where DH is network available and so on. The recovered heat from all stores could cover roughly estimated about 2% of the space heating and DHW consumption in Finland. Even if this is not very much, it is likely to be one part of the future energy system among the other heat sources.

From the planning one lesson is that there must be possibility to alter the plans, when the specific properties of the installation place are better known. For example, in one building here it was found that the heat pump size (physical and thermal output) had to be changed due to the wall and door placement in the building.

A bit like the same observation is the one that the design should be to some extent “design for the undesignable world”. This means that e.g. the energy prices or market situation of the apartments cannot be known exactly in advance. Thus there must be flexibility in a form or another in the plans. This can be done technically in the good case. Here for example the multi-source heat pump represents this kind of flexibility. Of course there are quite stable issues like the demand for a certain heat comfort and DHW use. Even they may change, but slowly, however.

One lesson, which actually is known already in advance, is that in the Finnish weather conditions using only solar energy throughout the year is not possible, since there are 3-4 months that the sun doesn’t shine practically at all. This is not that bad problem as it may look like by the first glance, since in the system calculations it can be seen that the multiple renewable energy resources (solar, wind, bioenergy, hydro…) can well complete each other. This may require a bit larger area than just one district, but in practice it is not serious. The good news is that in a quite limited area and with moderate energy networks the balance with nearly or fully 100% renewables could be achieved.