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TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE
VITORIA-GASTEIZ + TARTU + SONDERBORG

Deliverable 4.3: Building retrofitting completed
WP4, Task 4.4

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Author(s):	Jaanus Tamm (TAR)

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
SEC	SmartEnCity
WP	Work package
TAR	Tartu City Government
TREA	Tartu Regional Energy Agency
IBS	Insitute of Batic Studies
UTAR	Tartu University
ET	Telia
PV	Photovoltaics
RES	Renewable energy source
KredEx	National foundation providing financial solutions

Table 1: Abbreviations and Acronyms

0 Publishable Summary

The objective of building retrofitting is to implement the ‘smartovka’ retrofitting model in the demo area of the Tartu Lighthouse based on the procedures developed within the project. The main aim of the retrofitting model is to significantly increase the energy efficiency of the buildings, provide a stable interior climate through temperature control and ventilation, increase the aesthetic appeal of panel buildings and thus create a sustainable and healthy living environment for citizens.

In the field of retrofitting, the project seeks to tackle one of the greatest challenges of Europe’s existing building stock – quickly deteriorating precast panel apartment buildings that were quickly produced in response to housing shortages. In case of Tartu, hrustsovkas make up a panel building type that was designed in the end of 1950’s during the reign of Nikita Hrushchev and which were constructed in the 50’s - 70’s. With an average life cycle of 30-40 years, many of these buildings have already outlived their time, meaning that the shortcomings in quality are becoming increasingly evident and might even pose a threat to their residents. Hereby, the project proceeds from an understanding that new buildings are constructed according to high contemporary standards and are thus energy-efficient anyways – the true challenge is how to retrofit the old panel buildings that have great energy saving potential. The market and replicability potential of respective solutions is enormous, evidenced by the variety of panel buildings in different countries, especially in Eastern - Europe.

Within the pilot in Tartu will be tested different novelties – CO_2 based ventilation, low-temperature district heating and cooling, Smart Home solution and others. Piloting of these solutions will be accompanied by an in-depth e-monitoring application (based on smart meters) that collects real-time data on energy consumption and encourages to save. The full effect of the planned actions will come from the innovative combination of green technologies, ICT solutions and the empowerment of citizens.

The aim of the investments is to create a high-quality living environment that inspires the pilot area community to make environmentally aware decisions and change their patterns of behavior. A smart and participative community in combination with integrated and innovative technological solutions will create a new experience that can also be replicated elsewhere.

Figure 1: Retrofitted apartment housees

1 Introduction

Tartu, with its population of 100,000 is the second largest city in Estonia. Lying 185 kilometers south of Tallinn, Tartu is also the centre of South-Estonia. Tartu is known as a green, innovative and environment-friendly city. The slogan of Tartu is "The City of Good Thoughts". Tartu is a city of education and well known for the University of Tartu founded in 1632.

Figure 2 : Location of Tartu City

The aim of the environmental policy of Estonia and of Tartu is to reach climate neutrality at latest by 2050. According to Tartu´s Energy and Climate Action Plan “Tartu energia 2030” the vision of Tartu City is:
Tartu is a smartly developing community with good energy, and a green pioneer.

Pilot area

According to statistics, ca. 6,500 people lived in the city centre of Tartu, making up ca. 7% of all citizens. The pilot area includes a part of the city centre with about 4,000 citizens. The population density of the city centre is about 3,600 people/km2. The pilot area includes the University of Tartu Library, the Vanemuine Theatre, a big shopping mall, offices as well as several residential areas.

In the city centre, there are 42 hrushchyovka-type apartment buildings which were mostly built in the 1960´s. The inhabitants are socially mixed and diverse. The apartments are privately owned and, in many cases, rented out (e.g. for students).

The pilot area makes up the part of Tartu that was completely destroyed in World War 2 bombing. This left the city centre of Tartu empty and under the Hrushchev housing scheme, it was decided that the area be filled with panel buildings. With little aesthetic appeal and low construction quality, the city has now taken the aim to renovate and smarten up these ‘relics’ of the past.

There are 42 panel buildings in the pilot area, out of which 18 are smartened up with help of the project. The total area of these panel buildings in the pilot area is 79,000 m2, out of which 35,216 m2 is renovated. Altogether, ca. 1,620 residents of the pilot area (out of ca. 4,000) have been affected by renovation activities.

Figure 3: Location of the project pilot area in Tartu

1.1 Purpose and target group

The purpose of this deliverable is to document the details and processes made by TAR , TREA, IBS, UTAR and ET related to implementation of task 4.4 – building retrofitting within the SmarEnCity project. The details include a description of the technical details process and also first results and lessons learned so far.

Target group include other partners of SEC project but also target groups interested in retrofitting of existing buildings into low energy buildings.

1.2 Contributions of partners

The following
Table 2 depicts the main contributions from participant partners in the development of this deliverable.

Participant short name	Contributions
TAR	Overall & general content
IBS	Engagement and Smart Home system
TREA	Retrofitting in general and results so far
UTAR	Social innovation
ET	Monitoring

Table 2: Contribution of partners

1.3 Relation to other activities in the project

The following Table 3 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the SmartEnCity project and that should be considered along with this document for further understanding of its contents.

Deliverable Number	Contributions
D4.1	This deliverable provides the overall description of the current state of the lighthouse city area and will provide a comparison in future after demo actions have been implemented
D4.11	This deliverable connects all demo actions into ICT platform. Data will be easily used for evaluation and replication purposes
D4.12	Citizen engagement and replication
D4.13	This deliverable summarizes all demo actions in the Tartu Lighthouse project.
D7.8	This deliverable provides the overall description of the KPI's and therefore the measurements to be implemented in building retrofitting

T4.2	Citizen engagement actions. This task seeks to develop and test social innovation models for changing citizen behaviour and their adaptation to new technologies in Tartu. The sub-tasks include studying socio-economic conditions, consumption levels and community behaviour (e.g. databases, ICT solutions and sensors, questionnaires); the theoretical and methodological development of social innovation models (e.g. theoretical work, focus groups, experimental research, development of motivation schemes) as well as testing and evaluating social innovation models, followed by data analysis and improving the overall citizen engagement model.
T4.3	District integrated intervention. This task will develop detailed management procedures and deployment plans for implementing the demo actions in all of its pillars (building retrofitting (i.e. the 'smartovka' model), integrated infrastructures and sustainable mobility) and carrying out the ICT deployment in a coordinated way so that synergies and economies of scale can be harnessed, coordination problems can be solved and the underlying potentials can be fully exploited.

Table 3: Relation to other activities in the project

2 Objectives and expected Impact

The energy performance of the un-renovated apartment buildings of the pilot area is worse than the Estonian average. This is not surprising when considering that these buildings are from 1960´s. Buildings have a low heat retention of the external walls that are of poor construction quality and were built using inferior insulation materials. Most of the buildings have never been renovated. In many cases, the windows have been changed for modern isolated plastic-frame windows. This has improved the energy performance but reduced the ventilation capacity. The weighted average of the energy consumption of this kind of buildings is between 250 and 300 kWh/m^2 a year.

The objective of the retrofitting plan is to drastically reduce the energy usage of the demo area hrushchyovkas. The average energy consumption of these buildings was about 270 kWh/m^2 annually and the target level is 90, reducing energy consumption as minimum by 60%. This ambitious goal is not achievable by only using regular insulation technologies. A combination of different measures is needed, including ventilation with heat exchangers and using local energy production. All of the technical solutions are accompanied with modern ICT technologies for the best outcome.

As a result of the renovation of the buildings, annual energy savings of over 6 000 000 kWh and CO2 savings of 922 tonnes per year will be achieved. In addition to energy savings, renewable energy is produced by PV- panels installed on retrofitted buildings about 471 000 kWh annually.

The smart home solutions introduced during the renovations, together with engagement and social innovation activities, have increased residents' awareness of energy use and raised the sense of community cohesion.

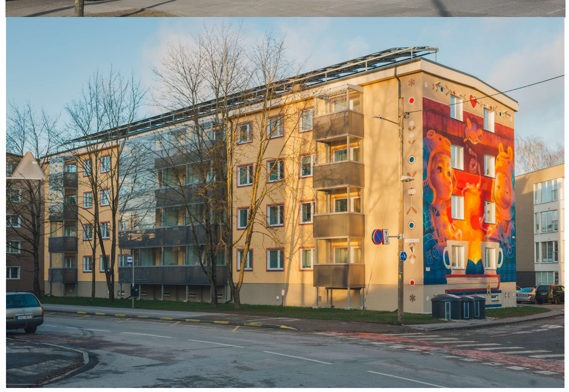

Figure 4: Retrofitted buildings before and after (Tähe 2 and Lutsu 16)

2.1 Objective

The main objective of this deliverable is a deep renovation of high-energy consuming apartment buildings into energy-efficient, near to zero energy buildings. The further goal is to achieve zero carbon urban environment.

2.2 Expected Impact

The expected impact of building retrofitting is quite wide and it appears in several areas as reduction of CO_2 emissions, as boosting a production of green electricity, as benchmark for future retrofittings in building sector and as a role model of sustainable living environment. Building retrofitting is offering for society many benefits and opportunities on the way to climate neutrality - cleaner city environment, change of energy consumption patterns of citizens, better health of citizens etc..

The reduction of usage of fossil fuels and thus reduction of CO_2 emissions is the main expected impact. Currently, most of consumed electricity in Estonia is generated from oil-shale, making the national energy mix one of the most carbon intensive in the EU with 2,898 kgCO2/toe. PV-plants installed in renovated buildings increase the production of green electricity and have a positive effect on the energy mix.

The estimated annual reduction of energy is about 6 000 000 kWh and CO_2 emissions about 922 t.

This wide-scale renovation is also seen to have a strong effect on the local construction market. With almost as much as 2 million euros planned for labour costs, it is expected that ca. 25-30 new jobs will be created with the renovation activities alone.
The retrofitting activities will contribute to the city climate policy targets – increasing the total capacity of privately owned PV power plants and consumption of locally produced electricity.

3 Overall Approach

Ambition of TAR in SEC project is to turn hrushchyovkas into 'smartovkas' with accompanying innovative solutions in public transport, street lighting and monitoring. The aim of the investments is to create a high-quality living environment that inspires the pilot area community to make environmentally aware decisions and change their patterns of behaviour. The main idea of Tartu's lighthouse project was to turn hrushchyovkas (a type of panel buildings that were constructed during the reign of Nikita Hruschchev starting from the 1950s) into smartovkas (i.e. high-quality living environments that inspire the community to make environmentally aware decisions and to change their patterns of consumption behavior) with a drastic reduction in the energy use of the buildings. With an average life cycle of 30-40 years, many of the hrushchyovkas have already outlived their time, meaning that the shortcomings in quality are becoming increasingly evident and might even pose a threat to their residents. Hereby, the SmartEnCity approach proceeds from an understanding that new buildings are constructed according to high contemporary standards and are thus energy-efficient anyways – the true challenge was how to retrofit the old panel buildings that have great energy saving potential.

Figure 5: Process model of retrofitting

As a response, Tartu piloted a series of retrofitting solutions in 18 hrushchyovkas in the city center. Increasing the energy performance of the demo area's housing stock through the smartovka renovation package reduced energy consumption from the ca. 270 kWh/m2y to 90 kWh/m2y (i.e. meeting class A requirements). The solutions included:

- Insulating all outer walls of the buildings (weighted average level U≤0.22 W/(m2*K));
- Replacing all windows with triple-glazed windows (integrated thermal transmittance level U≤1.10 W/(m2*K)) and adding an insulation layer;
- Replacing all front doors to reduce heat loss;
- Insulating and reconstructing the roofs (heat transfer coefficient U≤0.12 W/(m2*K));
- Installing a ventilation system with heat exchangers;
- Reconstructing the central heating system and installing thermostatic valves that allow to adjust room temperature in the range of 18-23°C;
- Adding low-temperature cooling systems to complement the district heating system;
- Installing 400-500 kWp PV panels to provide additional energy for the buildings;
- Applying art solutions on the facades to increase the aesthetic appeal of the buildings (see more under citizen engagement solutions);
- Setting up a smart home system

Renovation activities are funded in combination of Commission funding, a national support scheme (KREDEX) and additional loans taken by the dwelling owners

Smart Home ICT system, linked to the city's open information platform (CIOP) developed in the frame of SmartEnCity project, will yield additional benefits for diverse stakeholders: public, private (business opportunities) and ultimately citizens. Data collected from building retrofitting activities will be made through CIOP available for third parties for research purposes and for creating new business solutions/models. New arising business opportunities will increase a novelty of the system.

4. Task 4.4 / Building retrofitting completed

Within the framework of SmartEnCity project, 18 apartment buildings were renovated in the pilot area of the project in the centre of Tartu. The retrofitting included renovation of all technical systems of buildings and, at the end, every building received an original artwork.
Retrofitting activities have been the most complex and time consuming for the Tartu pilot project. Renovations with such an approach and scope have not been carried out in Estonia before, which is why in some cases the methodology and technical solutions had to be created during the operation. The project team and other Estonian partners made significant contributions to the development of various technical solutions (especially building ventilation solutions and smart home solutions) and to the involvement of residents in the renovation process.

Renovation process

Renovation process was started from rising awareness among potential beneficiaries in pilot area by info days, announcements and meetings with citizens and building associations. All together 42 buildings was defined to be eligible as beneficiaries.
The aim was to retrofit buildings mostly from 1960ś -1970´s and had certain type - called „hrushchyovkas“. Selection of that type was chosen by several practical reasons - the energy consumption of such type buildings is very high and replication potential is huge. There has a lot of same type buildings in Tartu, in Estonia and even in whole Eastern Europe.
During the pilot was tested a deep renovation and mixed financial models, to break the barriers of renovation wave in Tartu and how to achieve high energy efficiency targets (more ambitions then national) through deep (and smart) renovation. Renovation model was worked out by the Estonian project consortium.
Thank to project activities was boosted a development market of renovation and especially in technical designing and construction works processes. For this reason the procurements for technical design and construction works was made separately by every apartment association (apartment association is legal body formed by apartment owners in every multiapartment buildings in Estonia).
Retrofitting works were funded by mixed financing model where national grants (from foundation Kredex) were mixed with European funding (SmartEnCity grant) and private money (owners of apartments).
Renovation has been a rather complicated process with many details, but here are the main process activities:

- ❖ Awareness rising among beneficiaries. In addition of announcements and info days for beneficiaries we had local meetings (often several) with inhabitants in every building of the pilot area. Our team introduced the renovation package, energy calculations and financial side of renovation works.
- ❖ Gathering and managing applications form housing unions for support. Finally 18 buildings were approved for piloting with grant of 102 Eur/m^2.
- ❖ Pre-monitoring of energy consumption of buildings.
- ❖ Preparations for renovation - technical design. Support from project team for drafting the initial task for designing works. Every housing union procured designing documentation separately.
- ❖ Technical designing works. Consultation and support from project team.
- ❖ Application of housing unions for funding to Kredex for national grant.

- ❖ Procurement for construction works. Support from project team for drafting of contracts.
- ❖ Acceptance of construction works and certification of buildings. Check of technical systems (installation and operation).
- ❖ Training of residents - energy use and smart home system.
- ❖ Post-monitoring of energy consumption of buildings.

The retrofitting works in Tartu covered practically all parts of the buildings. The largest part in terms of volume was the insulation of various parts of buildings and the renovation of heating and ventilation systems. The following illustration shows the main construction works in the renovation process:

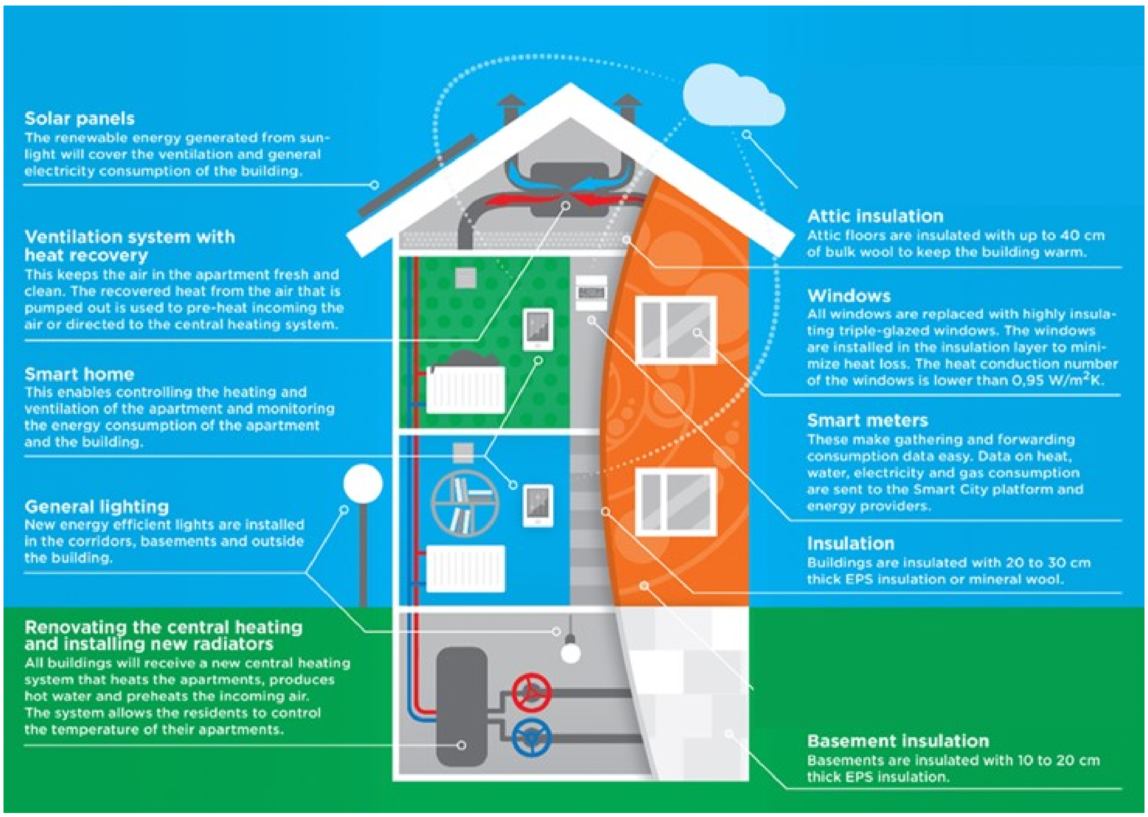

Figure 6: Renovation interventions in Tartu.

All apartment buildings renovated in the Tartu pilot project applied for additional funding from KredEx. The requirement for state support is that the building must be renovated to at least energy class “C”. In the SmartEnCity project, we took on a much bigger challenge - to renovate buildings of at least energy class “A”. The table below shows the main differences between the national requirements and the requirements for the renovation of buildings in the Tartu pilot project:

Measure/	National requiremets	SmartEnCity requirements
Energy performance label	< 150 kWh/m² a, „C“	<90 kWh/m² a, „A“
Windows	U= 1,1	U= 1,0
Wall insulation		Ca 10% better of „C“
PV	Not obligatory	Installed 24-50 kW on each building
Ventilation	with heat recovery	with heat recovery demand based (CO2)
Smart home	not obligatory	Installed
work of art on exterior walls	not obligatory	installed
Training for residents	not obligatory	Done, several meetings and info days (twice a year)

Table 4: Differences of scope and targets of renovation

Summary so far

The renovation of the buildings has been successful on the example of the Tartu pilot. According to preliminary data, the target (at least 60% energy savings) in energy use was met and the target for on-site production of renewable electricity was exceeded. The amount of renovated m^2 was somewhat smaller (less than 10%) than originally planned. However, the project is likely to exceed its CO^2 reduction target. This is mainly due to the increase in renewable energy production. The project convincingly proved that the renovation of similar apartment buildings into a high "A" energy class is completely feasible and the renovation practice in Tartu can be transferred to other European regions as well.
The figure and tables below illustrate the results so far of the renovations.

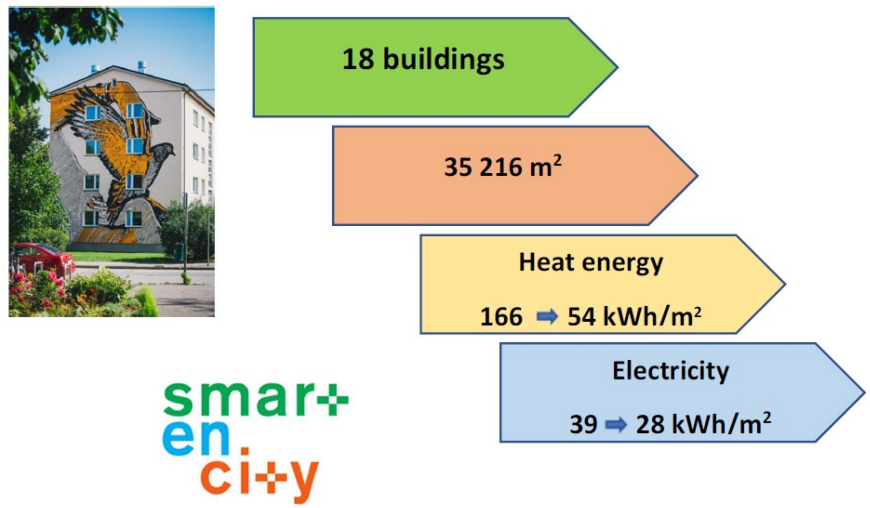

Figure 7: Summary of renovation results in Tartu.

The table below shows the preliminary monitoring results by building. As the renovations were completed at different times, unfortunately not all data are fully comparable, but we can still make a preliminary summary. It should be noted that in most cases the energy impact of renovations will not be felt until the second year after the end of the renovation. This is mainly due to the moisture stored in the structures during construction work.

Building	EPC before, kWh/m2 a	EPC after, kWh/m2*a	EPC reduction, %
1	227	128	44%
2	254	122	52%
3	267	89	67%
4	279	91	67%
5	244	162	34%
6	259	82	68%
7	237	103	57%
8	254	101	60%
9	234	97	59%
10	264	X	X
11	269	75	72%
12	300	65	78%
13	272	141	48%
14	246	91	63%
15	239	X	X
16	245	80	67%
17	271	103	62%

18	257	81	68%
Average	**257**	**101**	**60%**

EPC - Energy Performance Certificate

Table 5: Summary of results of renovation so far

The project originally planned to install 253 kWp of solar power plants on the buildings to be renovated. Largely due to the fact that the capacity of solar panels has increased over time and newer technical solutions were used in the renovated buildings (especially in the case of ventilation) it was possible to install solar power plants with higher capacity than planned. A total of 554 kWp. The table below shows the installed capacity of the solar power plants by buildings.

Building	Installed PV-panels (ETA), kW	Expected production (ETA), MWh/y
1	51,6	43,0
2	25,0	19,2
3	30,0	23,0
4	20,0	17,3
5	23,9	17,8
6	25,0	22,7
7	30,0	23,0
8	30,0	27,6
9	25,0	19,2
10	33,6	33,5
11	27,1	25,1
12	27,1	25,1
13	23,4	19,8
14	46,5	35,7
15	67,0	54,7
16	15,0	19,8
17	24,0	18,4
18	30,0	25,9
TOTAL	554,2	471,0
AVERAGE	30,8	26,2

Table 6: Installed PV-panels and expected electricity production

Smart home system

The smart home system for Tartu apartment buildings was procured by public international tender in 2018. The best offer was made by a local company EnLife OÜ, whose bid was the only one within the budget limit. The system and devices were installed to all 18 buildings

and each of the 691 apartments. The house associations could choose between radio (11 buildings) and cable (7) installations. From the project perspective it was important to test out different solutions and bring them to the market – at the time, there were no existing smart home solution providers for retrofitted apartment buildings.
Smart home installation scheme:

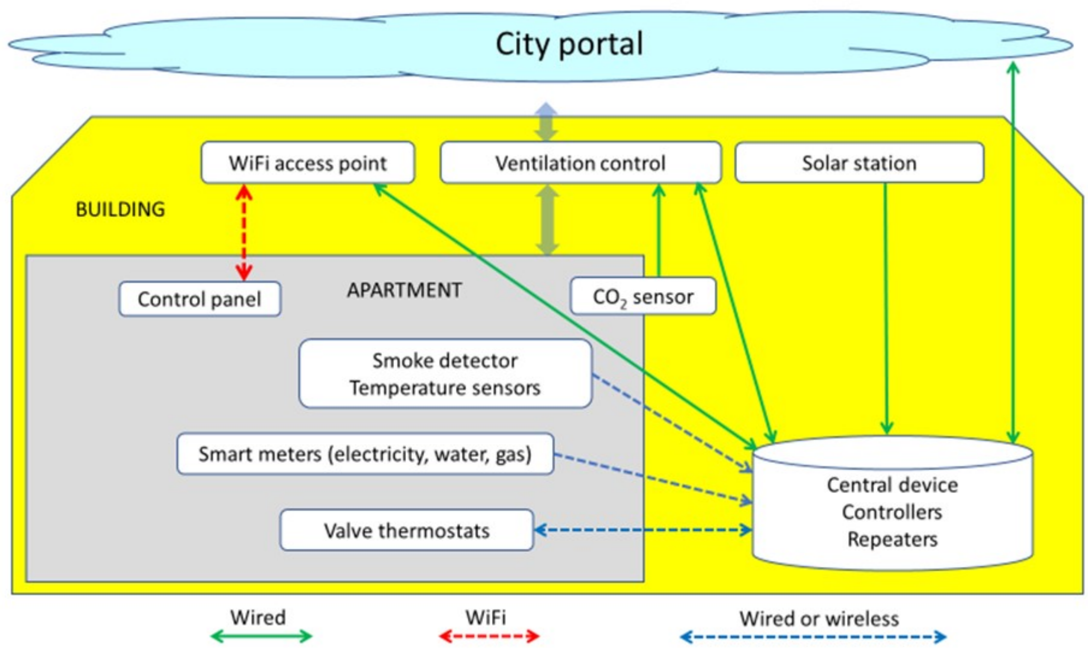

Figure 8: Smart Home installation scheme

Every apartment was equipped with smart electricity-, water- and gas meters, temperature and smoke sensors, CO^2 sensors and valve thermostats (to control the rooms' temperature). On the wall close to the apartment entrance door was mounted a tablet to allow the residents to monitor their energy consumption and building's PV panels production, apply energy saving rules, control ventilation and temperature in rooms and open the building's front door to visitors. In addition, the system allows to use videocall with visitors at the building's front door.
In every building, there is a central device which stores sensors data, controls rooms temperature, communicates with the ventilation device and PV inverters, provides information for home tablets and mobile apps. The aggregated energy data is sent to the central city portal. Hardware and software for central device, controllers, repeaters, access points, cable sensors and impulse meters were developed by EnLife OÜ.
The smart home system can be used both via the smart home tablet in the home or a mobile app.

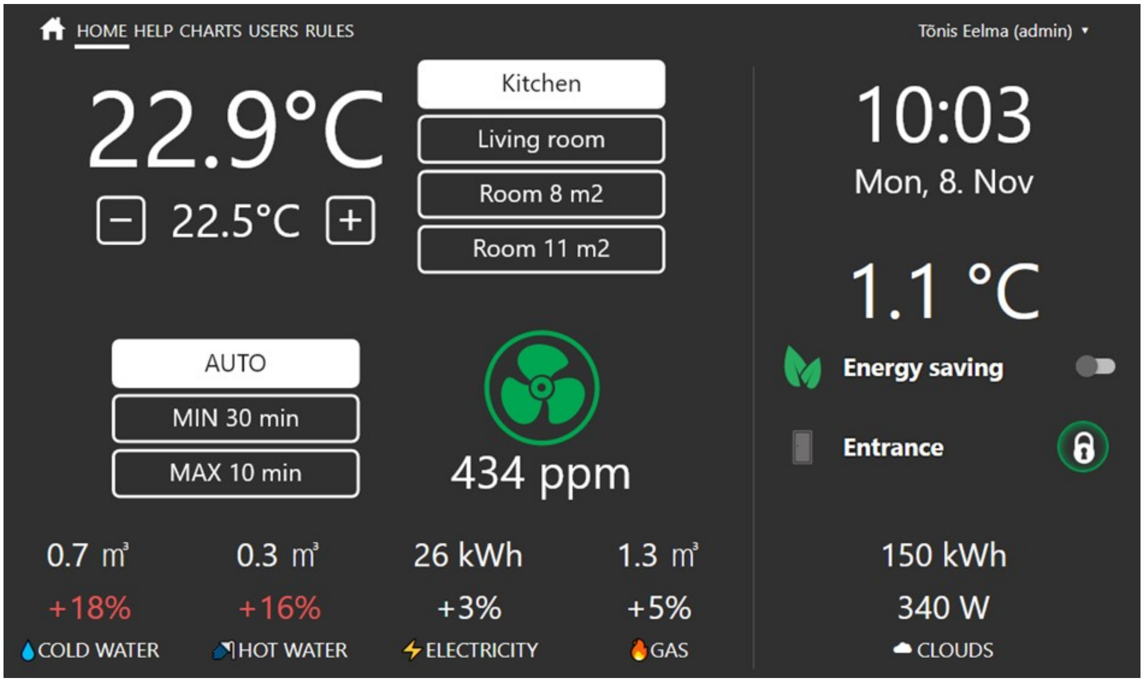

Figure 9: Smart Home system application view

Smart home printed user manual was delivered to all apartment residents and made available also on web https://tarktartu.ee/nutikodu-juhend .
As a result, building residents got a tool to control and optimize their everyday energy consumption. The house associations can gather consumption data (this was done manually before) and make billing automatic, also they have better general view of the energy consumption of the building. Individual temperature and ventilation control was enabled for residents, and separated ventilation system and CO2 level monitoring was especially useful and welcome during the COVID period.
Some problems were encountered in terms of technology - radio devices had connection problems in several places and extra efforts had to be made to get the system to work properly.

Engagement activities in Tartu during renovation

There were three main goals on engagement in the pilot area in Tartu:

1. To motivate the housing associations to join the SmartEnCity project and renovate their buildings;
2. To introduce the project and its activities to both the pilot area and other citizens, and to get them engaged and active;

3. To conduct social innovation experiments and offer educational events and programs in order to increase acceptance and awareness of new technologies, solutions and smart living.

To engage residents and housing associations in renovation, the engagement working group was formed in Tartu of key local partners who had the most tasks related to engagement and who were most necessary for the regular coordination and implementation of engagement activities. These partners are:

- The Institute of Baltic Studies (IBS; working group leader);
- Tartu City (TAR);
- The University of Tartu (UTAR);
- Tartu Regional Energy Agency (TREA);
- Smart City Lab (SCL).

The engagement working group started working and regularly meeting every two to three weeks once the project was officially launched. The first and foremost goal of the engagement target group was to reach out to housing associations to introduce the new renovation opportunity.

The engagement working group also compiled the Communication and Engagement Plan, an internal working document that includes the local goals and actions of communication and engagement, a description of the pilot area, project milestones, social innovation goals, indicators and a risk assessment. This document has been important in guiding and recording engagement activities in the pilot area.

For more information on all three goals and how they have been achieved, see deliverable 4.12: Citizen Engagement and Replication.

Engagement during renovation

The engagement process to introduce the new renovation opportunity and to help housing associations in reaching a decision to renovate in Tartu had five stages:

1. In the initial stage, the housing associations were contacted to introduce the renovation possibilities.

The technical partner of the project that is most responsible for the technical consultations with housing associations is TREA. Since the start of the project, TREA with support of other local partners, has supported the housing associations in building up the necessary knowledge for entering into the renovation process. It was important for residents to understand the benefits and risks of the renovation. All the representatives of the pilot area housing associations were contacted, and the renovation possibilities introduced. This included different funding models for energy efficient renovation, quality requirements for the renovations and specific requirements of the SmartEnCity project. At the same time, TREA and Tartu city contacted KredEx – the state funded national body offering grants for energy efficient renovation in Estonia. TREA also contacted stakeholders responsible for the technical aspects of the renovation process - engineers, designer, building experts, etc. - to discuss the technical end economic feasibility of the energy efficient renovation. All the potential service providers and contractors were contacted and invited to the discussion. The first stage is supported by the dissemination work in local media done by Tartu City and the engagement working group to create a positive image of the renovation and to encourage the housing associations to participate in the process.

2. *In the second stage, the housing associations had an internal discussion and made the final decision about renovation.*

During the second stage, the TREA experts, sometimes accompanied by Tartu city representatives as well, visited the internal meetings of the housing associations to explain the planned renovation process in detail, collected feedback and suggestions and tried to convince the housing associations to participate in renovations. Internal meetings are the local 'battle ground' for the members of the associations who may have different and sometimes conflicting interests in the renovation. TREA supported these discussions with technical knowledge. If a consensus was reached, TREA helped the associations to plan the next steps of the renovation by contacting designers, engineers, advising them on how to submit an application for the funding from SmartEnCity and KredEx, preparing an official tender process and contracting the service providers.

3. *In the third stage, the associations together with building designers designed the building plan.*

During the third and fourth stage, TREA supported the housing association as a Technical expert on developing the renovation project designed by the contracted engineering company and on implementing this project in the process of renovation.

4. In the fourth stage, the building companies contracted by the contractors renovated the buildings.

The fourth and fifth stages of the project also included choosing and realizing the artwork. For this, the project art coordinator, supported by three expert curators, mapped the initial wishes of the housing associations regarding their desired artwork, suggested suitable artists based on that and helped the residents to choose a sketch from the chosen artist. In this process, tight cooperation and communication with the residents was necessary with IBS (the partner responsible for coordinating the artworks) and Tartu city often visiting the internal house meetings of the housing associations. The residents and housing associations had the freedom to choose the artwork they wished, supported by an assigned expert art curator with specialized knowledge on murals and art in the public space.

5. In the fifth and final stage, the associations started using the renovated buildings.

During the fifth stage, TREA, Tartu City, IBS, SCL and UTAR provided knowledge to the people of renovated houses on the possibilities and ways of conserving energy in their everyday life. As numerous studies from all over the world indicate, the energy efficiency potential of renovated houses can only be realized if the residents themselves are actively aware of these possibilities. This includes monitoring personal energy consumption via the smart home and making environmentally friendly decisions in everyday life as well. For this, UTAR with the support of the engagement working group developed and implemented the social learning program “Smart house training program”. Additionally, the engagement target group developed an innovative tactile tool (“energy disc”) to compare energy savings before and after the renovation, and much more.

Numerous different communication and engagement tools were used during and after the renovation period to 1) stay in touch with the residents, 2) inform them of upcoming events and activities, 3) to gather feedback, 4) to raise awareness of the project.
The most important of these were:

- Local project webpage and Facebook page
- Public information events for pilot area residents on project progress and renovation
- Information events for housing association representatives on project progress and renovation, and more specific topics, e.g. ventilation, the smart home, etc.
- Smart home trainings for pilot area residents
- Public art tours and art exhibition on the pilot area murals and artworks
- “Smart house resident’s handbook” and a smart home system instruction manual
- Flyers, stickers
- Illustrated map of the pilot area which shows the locations of all the renovated houses
- Regular newsletters and emails via the mailing lists
- Local project videos
- Articles in local media (newspapers, magazines, radio and TV)

Figure 10: Public open-air event for inhabitants of pilot área

Figure 11: Meeting with representatives of housing unions of pilot area

Figure 12: Smart Home training session

Social innovation – Ambassador program

Peoples' everyday life practises are difficult to alter, however, the technical transformations of the buildings and apartments may affect occupants' everyday life practices. For example, in non-renovated hrushchyovkas, a common practice is to open windows when ventilation is insufficient. In fact, according to a pre-renovation survey of residents in the pilot area, three-quarters of residents opened their windows at least once a day (SmartEnCity pre-renovation survey report, 2018). However, once the new ventilation systems were installed, this practice has to change to enable the normal functioning of the sensor-based ventilation system. Research has shown that social interaction, namely communication and dialogue, is crucial in adapting to interventions to retrofit buildings (Chiu et al., 2013; cit. Lowe et al., 2018) and social learning, i.e. learning from others (Bandura, 1977) can help to diffuse knowledge, competence, and therefore affect the technology and retrofit acceptance rates in general.
Based on social learning concept, Ambassadors program was developed as a social innovation experiment. This program aimed to raise awareness about retrofitted buildings, indoor climate, smart home system and consumption among pilot area residents. The training program was developed to encourage pilot area residents to learn from each other by training so-called Ambassadors in every pilot area building who would be able to help and support their neighbours in various aspects of smart house and smart city living.
The program consisted of five face-to-face trainings, each focusing on an important smart living area: home expenses and how to live in a smart apartment; indoor climate, ventilation and environmentally friendly interior design solutions; waste, recycling and sustainability; smart home system and the rights of an apartment owner and green mobility solutions. The trainings took place every other Monday from 8 April to 29 May. All in all, nearly 40 people attended the trainings with 8 people attending at least 4 out of 5 trainings. These eight

Ambassadors were awarded with a diploma and practical prizes at the pilot area summer event on 29 May 2019.

Figure 13: Smart Home training session

Figure 14: Smart Home training session

References

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Chiu, L., Lowe, R., Altamirano, H., Raslan, R., 2013. Post-occupancy interview report: key findings from a selection of Retrofit for the Future projects. Institute for Sustainability, London.

Lowe, R., Chiu, L.F., Oreszczyn, T., 2018. Socio-technical case study method in building performance evaluation. Build Res Inf 46, 469–484. https://doi.org/10.1080/09613218.2017.1361275

SmartEnCity pre-renovation survey report (2018). http://tarktartu.ee/wp-content/uploads/2018/05/K%C3%BCsitlusuuringu-raport-2018.pdf

Monitoring

Deliverable “Building retrofitting complete” will be monitored within the project during the period 01.08.2019 – 31.07.2022. Monitoring will be carried out with help of smart city platform (Cumulocity) developed within the project by company Telia Eesti AS.

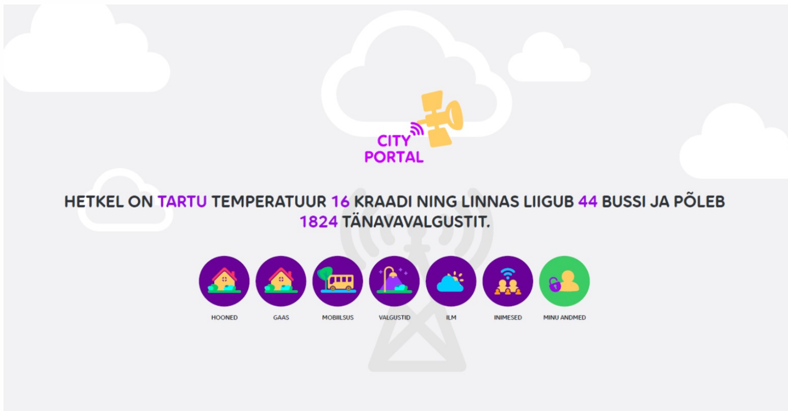

Figure 15: Smart City platform

Data on the energy use (heat, electricity, water consumption, gas consumption) and renewable energy production of all renovated apartment buildings have been collected on the city platform. There is both pre-renovation and post-renovation data on the buildings. The illustration below shows an excerpt from the data on the platform.

Figure 16: Energy data on the platform (renewable electricity production in Lutsu 16 building)

Awards received so far

The project activities have received active attention in Estonia since the beginning of the project. In addition to active media coverage, the project's activities have won various awards. In the field of building renovation, Tartu objects have been awarded by the Estonian Union of Co-operative Housing Associations twice:

> ***Most successful retrofitting project – Tähe 2 apartment building***
>
> ***Special prize for roof solution (PV panels) and renewable energy production in heritage protected area – Lutsu 16 apartment building***

4 Lessons Learned

Retrofitting of buildings in Tartu has been a rather long and complex process. When we started with planning of renovations at that time, there was no experience in Estonia of renovating similar apartment buildings to energy class "A". In particular, there was a lack of knowledge on how to deal with ventilation and other technical systems and ensure in the same time a minimum energy consumption. The introduction of a smart home solution on this scale was also innovative. Both the designers and the residents lacked knowledge and experience.
On the renovation process, it becomes increasingly important the prior in-depth planning by owners (apartment association, inhabitants) in cooperation of technical consultants and technical designers. Great help in the preparation phase was from the side of KredEx (national grant provider) who carried out comprehensive expertise of the technical projects of renovated buildings.
During the renovations, a number of modern integrated technical systems were installed in the buildings (ventilation, heating system, smart home solution, etc.). The perfect integration of these systems is essential to ensure a high-quality indoor climate in buildings and to optimize energy use. Experience after renovations shows that such systems require constant monitoring and maintenance and thorough tuning. Qualified assistance is needed here and the corresponding requirements must also be laid down in construction contracts in order to avoid future problems.

While engagement was very successful in a sense that the required number of housing associations made the decision to renovate and have by now, as of November 2021, been successfully renovated,
There were several good practices that helped achieve the goals of engagement in Tartu:

• Regular working group meetings and dedicated members are key, i.e. the engagement working group has been meeting regularly every 2 to 3 weeks, which has been important in having an overview and the planning of all engagement processes in the project.
• Consistent and personal communication are crucial for success, e.g. TREA's personal approach and technical support for housing associations; personal communication during the choosing of artwork, etc.
• Negative attitudes are not permanent, i.e. at first the project seemed too ambitious for local housing associations; however, attitudes quickly changed thanks to constant encouragement and awareness raising.

Although we estimated that a social innovation measure implemented in the renovation process - energy ambassadors, was a successful project, nearly half of the retrofitted buildings did not end up with an Ambassador. There were various reasons for this and three main themes emerged that need to be emphasized in future renovations:

- more appropriate variety of dates should be chosen;
- input about possible topics should be also gathered from the residents;
- the enrolment in the program needs to be more attractive as it is very common for Estonians to be rather passive.

Some major conclusions from retrofitting process:

- Delays at the start of the project due to the novelty of the undertaken task.
- Shortage of building designers and construction companies, which resulted in delays and rising prices.
- More concrete communication with the financing institution KredEx, which was also co-funding renovation: agreements regarding financing should have been reached at the start of the project.

In general, it can be added that modern renovation processes can be much more complex than it first appears. In order to achieve a high-quality end result, it is necessary to thoroughly plan activities and involve a wide range of parties.