Chapter 17
Retrofitting Soviet-Era Apartment Buildings with 'Smart City' Features: The H2020 SmartEnCity Project in Tartu, Estonia

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Abstract The retrofitting and renewal of modern-era socialist housing estates is a prominent issue throughout the world. There are different political choices to deal with dilapidated socialist housing estates. The transformation of such estates in post-socialist cities has so far focused primarily on improving their physical conditions and increasing the energy efficiency building-by-building. However, an integrated and area-based regeneration approach would have greater potential to influence the entire neighbourhood, as well as the inhabitants' environmental behaviour. The Smart City is a concept that can achieve environmental sustainability ambitions as well as large housing estate regeneration goals. This chapter describes the implementation of the Smart City concept to the renovation of a Soviet-era apartment buildings area, based on the example of the SmartEnCity project in Tartu, Estonia.

Keywords Retrofitting · Socialist housing estate · Area based · Smart city · Estonia

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D. B. Hess and T. Tammaru (eds.), *Housing Estates in the Baltic Countries*,
The Urban Book Series, https://doi.org/10.1007/978-3-030-23392-1_17

17.1 Introduction

Socialist housing estates are obsolete, often stigmatised as socially problematic neighbourhoods that face issues of vacancy, social decline and crime (Musterd and Van Kempen 2007; Kovacs and Herfert 2012). Buildings erected in the post-WWII era are nearing the end of their service life. Many of these structures no longer meet the needs of modern lifestyles, or requirements of technological progress and environmental sustainability (Serrano-Lanzarote et al. 2016; Guerra-Santin et al. 2017).

There are various political choices to tackle the issues of such estates for application in the modern era. First, there is the option to take no action and let the estates continue to deteriorate. Second, it is possible to demolish the apartment buildings, as is planned in Moscow: in Russia's capital, authorities want to raze about 4,500 buildings that are home to around 10% of the city's population. [If the plan is realised it will be Moscow's largest urban resettlement programme in recent history (Watson et al. 2017).] Third, there is the possibility to demolish old apartment buildings and replace them with new construction, such as in St. Petersburg, Russia (Trumbull 2014). Fourth, there is the option to renovate, refurbish or retrofit old apartment buildings.

Most socialist housing estates have a high share of owner occupation following widespread privatisation in the 1990s. The estates have diverse social structures: in many cases, inhabitants are of lower economic earning power and more vulnerable, e.g. pensioners, young people and lower income earners (Martinaitis et al. 2007). Buildings designed at a time when energy was inexpensive are often now characterised by problematic energy performance. Despite low-priced living spaces, the heating costs are relatively high (Martinaitis et al. 2007). The different social structures and issues can complicate retrofitting processes. Tenants and owners can be resistant to changes and providing the investments needed for undertaking major work.

Engineering and technical challenges also contribute to the difficulty of retrofitting and modernization processes. Renovation is often more complicated, and therefore more expensive, than building new structures. Renovations in post-socialist cities have followed a similar path to Western countries during the 1980s, where the physical conditions of the buildings receive upgrades (Tosics 2005; cit. Muliuolytė 2013). However, this costly upgrading only provides a temporary relief to larger problems. This process revealed that refurbishing the housing structures is insufficient if the goal is to improve the living environment of the area's entirety (Muliuolytė 2013). An integrated approach to retrofitting that focuses on the district holistically can yield better results (Muliuolytė 2013).

Smart City is a concept that is gaining popularity for its holistic and cross-sectoral approach to urban regeneration. This concept focuses on the use of technologies and social innovation to develop a more creative society and better living environments. The Smart City concept in use has created new urban spaces (e.g. Songdo, South Korea) and transformed existing spaces (e.g. Barcelona, Spain).

A new challenge worldwide is the use of this concept in retrofitting housing stocks, such that it can contribute to achieving sustainability goals and improving living environments.

This chapter describes the implementation (planning, design, and financial scheme) of the Smart City concept to the renovation of Soviet-era apartment buildings based on the example of the SmartEnCity project in Tartu, Estonia. The SmartEnCity (‘Towards Smart Zero CO_2 Cities Across Europe’) project is an EU Smart Cities and Communities initiative, through which city districts and neighbourhoods in Vitoria-Gasteiz (in Basque County, Spain), Sønderborg (Denmark) and Tartu (Estonia) will be transformed into lighthouse demonstrations. In Tartu, 22 khrushchëvka-type apartment buildings will undergo renovation to become energy-efficient, modern dwellings, i.e. “smartovkas.” Khrushchëvki are a specific type of apartment building constructed in the 1950s and 1960s, during the rule of Nikita Khrushchëv (and continuing into the 1970s). The terms of reference established by Tartu are ambitious and focus on energy performance in residential premises. The goal is to reduce energy consumption in dwellings of this type in the Tartu pilot area from the current 270 kWh/m^2/y to a nearly zero-energy building (nZEB) level. This means a maximum energy consumption of 90 kWh/m^2/y, which therefore achieves the energy efficiency rating ‘A’. Achieving the project’s goal will require establishment of construction technology requirements and surmounting of several social barriers, with people actively engaged and trained throughout the process.

17.2 The Smart City Approach

Although the Smart City concept has no single definition (Angelidou 2015; Caragliu et al. 2011), its key elements are the use of information and communication technologies (ICT), increased energy performance, reduction of greenhouse gases and boosts to social innovation, new business models and creative industries. One premise is that the smart city technologically integrates the concepts of a creative city with sustainable development (Ahvenniemi et al. 2017).

The EU’s approach to smart cities focuses primarily on implementing technology to address environmental challenges and reduce greenhouse gas emissions (European Commission 2017). The use of innovative (green) technologies assists with resource conservation and precise data collection, ultimately informing and improving planning decisions. This provides information and feedback on the urban environment and its services, as well as individuals’ consumption patterns (Khansari et al. 2014). Such that environmental problems are partially rooted in individual consumer behaviour (Vlek and Steg 2007), increasing and influencing Europeans’ environmental awareness and understanding the motivations of people’s behaviour is vital. Technological solutions are unlikely to solve environmental problems alone; individuals must contribute through social solutions, such as reducing consumption, developing environmental consciousness, and taking action to make informed decisions (Abrahamse et al. 2005; Alfredsson 2004; Steg and Vlek 2009).

The renovation of the Soviet housing estate in Tartu city centre follows an area-based approach utilising the Smart City interventions and solutions. The regeneration approach stresses that to achieve its goals development must incorporate elements area-wide, beyond the physical upgrading of buildings. These elements include the modernisation of public and private transportation systems; upgrades to outward appearance; neighbourhood adaption to new lifestyles; creation of new uses and activities; and place-making (Muliuolytė 2013). The realisation of this strategy relies on the incorporation of integrated planning practices. Integrated planning is holistic, cross-sectoral and participatory-process oriented (Rotmans et al. 2000; Hull 2005), whereby stakeholders jointly resolve relevant urban problems. The processes are often interdisciplinary in nature involving participants from different sectors, spatial scales, stakeholders, technologies and finance instruments.

Integrated planning in smart cities pools resources from both hard and soft domains. Technology is a tool that can help resolve problems fast and effectively to raise the quality of life in cities. For example, big data from sensors and intelligent solutions is an important dynamic input for various urban services (Kitchin 2014; Hashem et al. 2016). Regarding soft domains, the integrated planning framework stresses the importance of cooperation between various parties (the so-called 4P: Public–Private–People Partnership) and creates favourable opportunities for social innovation. 'Social' in this context refers to the nature of the value generated by innovation: this value relates to topics such as quality of life, solidarity and well-being as opposed to profit (BEPA 2010). Social innovation benefits society by increasing its capacity for learning, to become more knowledgeable and take informed action to resolve social problems.

17.3 Retrofitting the SmartEnCity Housing Estate Districts in Tartu

17.3.1 Overview of the SmartEnCity Project in Tartu

In the SmartEnCity project, plans to renovate khrushchёvki use an integrated and sustainable urban regeneration approach that will tackle energy efficiency in apartment buildings, while jointly developing integrated infrastructure solutions that address building energy performance and sustainable mobility. Figure 17.1 displays an example of a building to undergo the retrofitting process.

The project area covers the city centre of Tartu. The pilot area in the Tartu city centre is 0.39 km^2 (Fig. 17.2). There are 43 khrushchёvka-style apartment buildings in the pilot area (1,779 flats total), of which retrofitting plans address 22 buildings or approximately 800 flats. The pilot area is home to nearly 4,000

Fig. 17.1 A khrushchëvka apartment building in Tartu, Estonia prior to renovation (Tiigi 7, Tartu): a 4-storey, 32-unit building with 1,350 m^2 total floor space (an estimated 80 inhabitants live in the building). *Source* Photo by authors

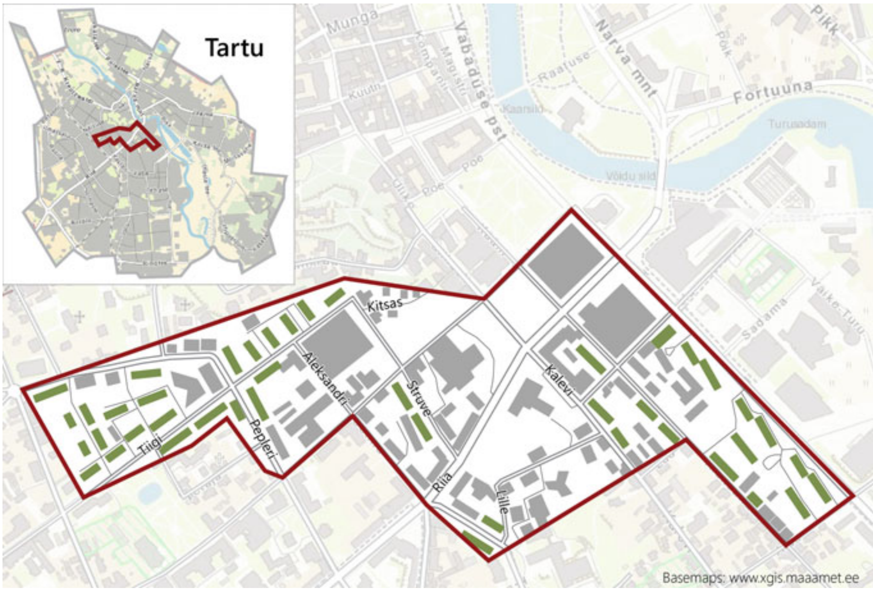

Fig. 17.2 Project pilot are in Tartu, Estonia. Green buildings: there are approximately 40 apartment buildings (khrushchëvki) in the pilot area, among which approximately 20 are being retrofitted (although not all area khrushchëvka-type buildings)

inhabitants. Retrofitting efforts will directly affect about 2,100 inhabitants. The planned timespan of the project is five and a half years during which retrofitting of the apartment buildings will occur with simultaneous energy consumption monitoring for two years. The project began in 2016 and the expected completion date is 2021.

An integrated urban planning approach is crucial for developing a smart city. Most Soviet housing estate districts are densely populated. Combined with the largely planned interior areas of estate districts, this limits the ability to make major changes to the physical environment, such as developing buildings and infrastructure. The project activities in Tartu, shown in Fig. 17.3 and outlined in Sect. 17.3.2, reflect this limitation. The activities focus primarily on retrofitting buildings and their surroundings pursuant to modern norms, as well as supplementing and renewing the transportation infrastructure that will extend beyond the pilot area. For example, transportation initiatives attempt to solve the shortage of parking spaces in prefabricated housing blocks, congestion and the decrease of urban air quality due to the growth in private car use. The transition to natural-gas-powered buses is an important step in Tartu, where there is intent to purchase 64 new gas buses; the electric car-charging network will be upgraded with 5 fast chargers in the city centre; including the development of a bike sharing

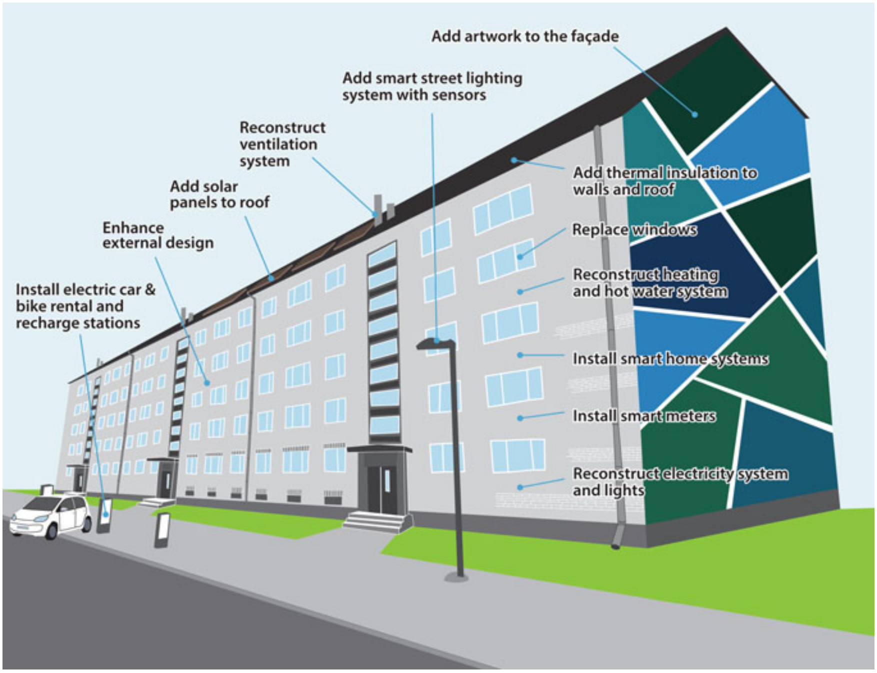

Fig. 17.3 Apartment building renovation plans in the Tartu pilot area: retrofit, mobility improvements and street lighting

system for a new network of 750 public electric and regular bikes and 69 stations. Tartu's aim is to transition the city's bus fleet to 100% natural gas fuel in 2019. The bike sharing system will include public city bikes, parking lots with safety locks and a software system for managing the bike rental system. These efforts will address electric car battery recycling, as well. H2020 sources will assist to fund the development of electric car charging stations and, in part, the bike sharing system.

Furthermore, the development of a district cooling system that returns residual heat from cooling to the district heating network will contribute to the infrastructure solutions. In 2016, with support from SmartEnCity, Estonia built its first district cooling plant in Tartu city centre. SmartEnCity will also see a move to an intelligent street lighting system that uses wireless mesh technology. More than 300 LED luminaires installed throughout the pilot area expected to generate an energy savings of 138,730 kWh per year. Additionally, infrastructure projects will include installation of various sensors, such as movement detectors with cameras, noise and road surface sensors, and environmental sensors, to monitor CO_2, NO_x and PM.

As part of the SmartEnCity project in Tartu, development of a City Information Open Platform (CIOP) will enable traditional and IoT-based data exchanges. The sensor technologies and CIOP will enable environmental monitoring, data collection and the control of the smart system. The platform concerns the buildings that will undergo retrofitting (e.g. monitoring energy use), district cooling, street lighting and transport systems. The platform must be flexible for integrating and implementing different sensors and control systems and be compatible with other systems.

Several parties shoulder the financial scheme of the retrofitting of the apartment buildings: funding for the activities is a combination of H2020 funding, a national support scheme for renovation activities (KredEx) and loans taken by the dwelling owners themselves. The estimated price of 1 m^2 of space in these flats before renovation is 1,400–1,900 EUR and a 2-room 38 m^2 standard apartment costs 60,000–80,000 EUR. The estimated cost of retrofitting is 400 EUR/m^2. The city of Tartu supports retrofitting the pilot area buildings by a total of 3,978,000 Euros (i.e. 102 EUR/m^2) from EU H2020 funds. Additionally, apartment owner associations can apply to KredEx for a financial grant of up to 40% of the total cost of renovation provided. KredEx is a financing institution that, besides providing financial support to enterprises, helps Estonians improve their living conditions by offering loans, guarantees and grants for energy efficiency action. The KredEx reconstruction grants receive financing from the European Union Cohesion Fund for the period 2015–2020. Third, apartment owners represented by the apartment associations must invest individually. Apartment owner associations will likely cover their own contribution by taking a bank loan with a repayment period of 15–20 years. Theoretical calculations show that post-retrofit building utility costs will presumably decrease by 60% and the apartment price will rise by up to 10%. In comparison, B-level renovations of apartment buildings in Estonia cost on average 300–350 EUR/m^2. The maximum KredEx grant is 40% of the price and therefore apartment owner associations must pay 60% of the costs. In the SmartEnCity project, self-financing is about 30% of the cost.

17.3.2 Retrofit Plans for Apartment Buildings

The SmartEnCity retrofitting of apartment buildings is technically 12 different categories of activity, as shown in Table 17.1. These stem from the project's terms of reference and the SmartEnCity objectives to achieve a nearly zero-energy level, increase life quality and encourage more sustainable consumer behaviour. The EU Directive 2010/31/EU on energy performance of buildings defines an nZEB as a building that has a very high energy performance. Energy from renewable sources should cover to a significant extent the near zero or very low amount of energy required, including energy from sources produced on-site or nearby (EU Directive 2010/31/EU Energy Performance of Buildings). According to the best construction practices in Estonia, a nZEB requires construction using technically reasonable, energy efficient and renewable energy technologies, with an energy performance indicator greater than 0 kWh/m^2/y and, in the case of an Estonian apartment buildings, to a maximum of 100 kWh/m^2/y (Minimum Requirements for Energy Performance Act 2015). The average energy consumption of khrushchëvki is currently about 270 kWh/m^2/y and the target level is 90 kWh/m^2/y, requiring a reduction in energy consumption of more than 66-percent. Despite an area-based

Table 17.1 Retrofit plans for apartment buildings

Activity	Details
Insulation of outer walls	Add ca. 20 cm insulation material, reinforcement, plastering, painting
Replacement and repositioning of windows	New triple-glazed energy-efficient windows installed flush with window insulation. Integrated thermal transmittance level will be $U \leq 1.0$ W/(m$^2 \cdot$ K)
Insulating the roof	Insulate attics and roofs to achieve thermal transmittance of $U \leq 0.12$ W/(m$^2 \cdot$ K)
Renovation of heating systems	Heating systems will be rebuilt as two-pipe systems that can be regulated in each room, and smart thermostat valves equipped with temperature limiters will be installed on radiators, allowing temperatures to be set in the range of 18–23 °C
Renovation of the hot water system	Will be replaced with a central system powered by district heating. Local boilers will be eliminated
Renovation of ventilation system	Installation of new system, either (a) intake–exhaust ventilation systems with heat recovery, or (b) an exhaust ventilation system with a heat pump and heat recovery, which is equipped with devices for pre-heating and filtering ambient air. The technical system must allow the ventilation to be regulated separately in each apartment: (a) automatically pursuant to the CO_2 concentration in the indoor apartment air, (b) for a limited time interval at maximum and minimum capacities, and to ensure the required exchange of air in the common areas

(continued)

Table 17.1 (continued)

Activity	Details
Installation of smart home systems	Establish preconditions for installation of smart home systems (weak-current-based). Smart home systems must be installed in every apartment to enable residents to (a) track their energy consumption, (b) modify their behaviour towards greater environmental conservation. The smart home system is planned so that homeowners can use the control panel installed in their apartments (or other smart device connected to the internet) to view dynamic energy consumption and other information, and control heating and ventilation in their apartments. Smart home systems will be procured and installed using SmartEnCity project funds, i.e. the apartment owner associations will not have to pay. However, the housing associations will have to perform the necessary preparations for installation of the system
Installation of smart meters	Automatic-read meters are to be installed in apartments and buildings to measure the following volumes: household water, heating, hot water heating, electricity for common areas, electricity for the ventilation system and gas. The meters must allow for monitoring of the energy expenditure on a running basis, transmission of data, control of building energy use and invoice preparation
Video intercom buzzers for entrance hall doors	It is recommended to install, for entrance hall doors, a video intercom system (equipped with power supply and internet cables) that is compatible with the smart home system
Building electrical systems	Electrical system will undergo renewal, controllable LED lighting will be installed in building common areas (e.g. motion detector, time relay, switch)
Solar panels	Solar panels will be installed on the buildings' roofs so that renewable energy can be generated locally, with residual energy sold to the power grid. Even in Estonia's climate, a 100 m^2 roof can on average generate 15,000 kWh of power per year
Exterior design	Visually appealing artwork will be added to the façade, designed to increase the attractiveness of the urban space. An international art competition has been carried out as part of the project and apartment associations will be able to select from artists and works chosen in the competition

approach and comprehensive goals of nZEBs, the technical outcomes of retrofitting are different, individual buildings may vary somewhat in design and material choices. It is noteworthy that external conditions, i.e. climate affect building energy performance as well. In Estonia, the average annual temperature is 5.2 °C due to a wide range of seasonal variability: the average temperature in February is −5.7 °C and the average in July is 16.4 °C.

17.3.3 SmartEnCity Stakeholders

Achieving the lofty ambitions of a project like SmartEnCity requires multifaceted organisational, technical and social engagement, and cooperation. A conclusion drawn after the first 2 years of the project is that the key to such a complicated task lies in the ability to engage various parties and harness their skills.

The first group consists of apartment owners, apartment owner associations, companies operating on the building premises, non-profits and city inhabitants. The most critical stakeholders from the project's standpoint being the apartment owners. The apartment owner association operates pursuant to the Apartment Association Act and is the legal person that represents all apartment owners in the building. The apartment owner associations organise, maintain, repair, manage and cover other everyday organisational aspects of the building. The apartment owner association functions through a collectively elected chairman, board, and often a maintenance company. Since only the general meeting may adopt major decisions, the decision regarding participation in the SmartEnCity project, contracting design and renovation work, taking a bank loan and other important decisions require adoption consideration during the general meetings of the apartment owners associations. Without interest and cooperation between residents, owners, the associations and tenants, it would be difficult to implement the project. The overall incentives for residents and homeowners to participate in the retrofitting are the increase in energy performance, lower utility costs, improved interior climate and an increase in the quality of life.

The second major group of stakeholders is the local consortium in Estonia. The team led by Tartu City Government makes a significant contribution through its legal services, public outreach and organising of the local team, and the Tartu Regional Energy Agency (TREA) that steers the retrofitting topic. In addition, the Institute of Baltic Studies, the University of Tartu, Telia Estonia and Tartu Smart City Lab all contribute to different topics from social innovation and replication to the implementation of smart technologies.

The third major stakeholder group includes technical support partners in Estonia, who contribute to their field through developing and supplying technologies. Telia Estonia provides the data communication platform, Fortum Tartu provides district heating and cooling energy solutions, and Elektritakso LTD is responsible for electric car batteries recycling solutions. TREA also serves as a technical partner, with a key role in selecting the relevant solutions, integrating them on the building level and monitoring the energy use. Technical consultants are also an important stakeholder. The technical consultants are people with relevant education and work experience whose task, based on the specifics of each building, is to assist in compiling the terms of reference and provide consultation to the apartment owner associations and design developers. The apartment owner associations hired this group to prepare the groundwork for the construction projects.

The fourth group of stakeholders is SmartEnCity's external partners from Spain and Denmark, who, similarly to Tartu, develop local solutions to fulfil the projects general goals. The international consortium had an important role in developing the ideology and technological solutions for the entire project, finding specific solutions, resolving problems that arose, providing advisory services and taking care of the exploitation, dissemination and communication of the results. Precisely the existence of the international cooperation network allows the implementation of such a project within the defined scope.

17.4 Social Considerations of the SmartEnCity Project

Residents and apartment owner associations will play a key part in achieving SmartEnCity's ambitious 90 kWh/m^2/y goal in Tartu. For this reason, a major part of the project activities ties in with social innovation, engagement and training. Three significant aspects are relevant here.

First, residents need active education and training. Energy performance and ease of living in buildings retrofitted with smart solutions depend greatly on the residents' user skills and consumption patterns. Technology alone will not yield a significant effect; rather, behaviours and lifestyles also must change.

Engagement is additionally important because the changes related to buildings' renovations are significant and people must invest significantly themselves. Many less financially secure households may find it hard to contribute, but the building conditions are already quite poor in the 40–50-year-old structures, which inevitably require major improvements. It is important that residents understand the need for retrofitting. However, the retrofitting in general is comprehensive and long-term. Façade insulation, window replacement and the ventilation and heating systems means long and arduous inconvenience for people living in the building. Most people do not have anywhere else to move to while repairs are underway for up to a year. Experiences in Tartu have shown that residents have given negative feedback for renovations of apartment buildings that lasted an entire year. Various activities related to engagement may help people accept the renovation-related inconveniences more easily.

Finally, in the context of social learning and technical and organisational complexity, explaining the technical details of the project to residents and apartment association activists is very important to ensure they understand and can use the new technical solutions. In cooperation with different project partners from Estonia, SmartEnCity will train residents and enthusiasts whose task will be to start familiarising others on the activities and technologies. In addition, the project activities include collective experiments promoting environmental conservation principles to evaluate people's motivations for consumption behaviour. The intent is to stimulate individuals and residents toward more sustainable energy use patterns. This kind of collective learning and experimentation could be effective in spreading practical knowledge and skills for using the technology, realising the building's 'smart' qualities, and changing consumption behaviours and people's environmental conservation ethos in general. Ideally, this will stimulate intriguing and beneficial ecological or social innovations.

To evaluate sentiment regarding the project before the start of the retrofitting activities in the pilot area, a questionnaire (available both in the Internet and paperback) was conducted (213 respondents). Semi-structured in-person, in-depth interviews (15 interviewees, see Table 17.2) probed familiarity with the retrofitting process and overall goals of the SmartEnCity project among the residents of the pilot area. The authors of this chapter conducted the interviews, whilst other members of the SmartEnCity Tartu project team led the questionnaire survey. Participation in both studies was voluntary. People could receive a gift card as compensation for participating in the interviews. Despite the efforts, low levels of participation were a problem. The survey response rate was low and it was difficult and time-consuming to find the interviewees.

The predominant attitude towards the project among the residents of the pilot area leaned towards the positive. Most of the survey respondents (89%) said they were interested in the apartment association investing in retrofitting and installing the smart home system in the building. Likewise, all interviewees supported the participation of their own apartment association in the project. The positive aspects and expected results of the project fall into four categories of responses based on the analysis of interviews: personal expenses, convenience and quality of life, aesthetics and environmental conservation.

Table 17.2 Characteristics of interviewees

Gender	
Male	5
Female	10
Age group	
≤ 30	4
31–60	8
$60 \leq$	3
Employment status	
Employed	9
Self-employed	1
Student	2
Retired	2
Education	
Higher	12
Vocational	2
General	1
Flat ownership structure	
Belongs to member(s) of the household	12
Tenant	2
Belongs to relative	1

In both the survey and the interview, most people considered the project's greatest positive aspect to be the financial gains in terms of savings on utility costs. A total of 69% of the survey respondents said they were hoping for a decrease in household costs and 38% expected their real estate value to rise, as depicted in Fig. 17.4.

Well, if insulating a building from the outside has such an effect, perhaps all the expenses could become even lower. (male, 38)

"…" there would be a big leap in savings on my expenses in terms of energy saving due to smart home devices and renovation. (female, 63)

Another reason cited for the positive attitudes is an expected rise in quality of life and added convenience generated during and after the project activities. Following renovation, such citations include improvements in living conditions, rise in the quality of the buildings, rise in the level of user convenience associated with new technologies, and a reduction in the use of personal automobiles.

For one thing, my life will become much easier. I won't have to report any meter readings at the right time. It will be done for me. (female, 63)

The project is a factor promoting the development and image of the entire city of Tartu. Above all, this will be through an improvement in the exterior appearance of the buildings and the city centre, which was the third most important reason cited in the survey as well (43% of respondents).

It's a great and unique opportunity for Tartu's development, really. And for shaping the city centre's appearance. (female, 63)

The interviews revealed that only a few people who placed major value on the natural environment cited environmental conservation as a reason. The project is a

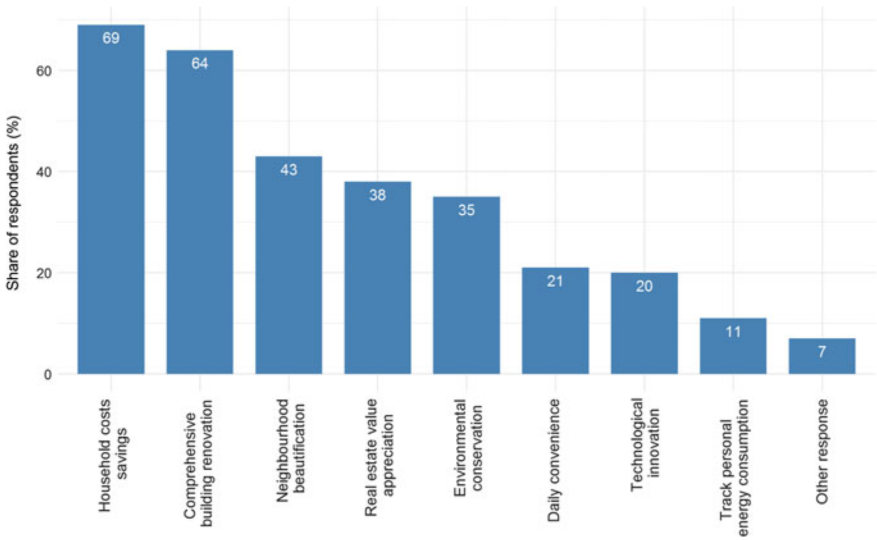

Fig. 17.4 Support for project investments: questionnaire results

way of affecting society's consumption patterns and encouraging people to lead an environmentally sustainable lifestyle. Only one-third of respondents (35%) said they prioritised environmental conservation-related aspects.

I like the general idea that we consume less and produce more. (female, 30)

Because such projects "…" can impact society's behavioural and consumption patterns in the long run. (male, 32)

Interviewees expressed a certain scepticism as to the potential increase in health risks related to technological solutions implemented in project activities (e.g. increase in electromagnetic radiation (EMR) and noise-level stemming from equipment installed and data communication), unforeseen financial costs and the technical smart home solution to be installed. Concern over the rise in the level of EMR was also expressed in the Tartu project website's forum.

Well, let's say there are ways I might die of cancer faster due to it. For example, the noise level could also grow in connection with this thing. (male, 32)

Some kind of smart home management system is being constructed. How it will exactly be realised, no one knows yet. It's a bit of a risk. (male, 39)

Overall, most interviewees view the topic of a smart home as fairly remote and unfamiliar, which is understandable, as smart home solutions are not yet widespread in Estonian households. The interviewees' knowledge about the devices installed was modest and they were vague on some aspects. People had hesitations about the nature of smart home and there was some uncertainty about their skills for using the technology: a perspective shared among adults (40–50) and pensioners. Nevertheless, most interviewed people were positively inclined toward readiness to use smart homes ('ready to use', 'ready to try'). Some were also negatively predisposed ('I won't use it') and neutral ('don't know'). Some positive aspects of using the smart home solutions cited were the increase in convenience and comfort, the possibility of monitoring one's own consumption behaviour and the possibility of adding other necessary applications, which in turn could expand the spectrum of services. People predominantly took a wait-and-see attitude to the magnitude of the effectiveness of the smart home solution, specifically whether it would have an actual impact on consumption patterns. Highlighted reasons include that the interviewees did not know the type of information collection, whether they could change their own behaviour based on the information without too much effort, whether everyone would be capable of using smart home solutions, and how the solution would function in practice.

At the moment, it seems like an exciting toy. (male, 38)

I think it depends on the information I'll get from there. Maybe something surprising will come out of it and I'll be totally willing to change my [consumer] behaviour. (female, 47)

I might consider it necessary in the short term for the project to generate feedback about itself, so to speak; in the long term, I don't see much of a point to it. (female, 30)

17.5 Discussion and Conclusion

Khrushchëvka-style apartment buildings are home to many people in Eastern Europe. Since these buildings exceed their life span or are even unsafe and do not meet the current lifestyle standards, it is evident that such neighbourhoods need change. The primary question concerns the expediency and scale of such renovations. Technically and probably financially speaking, it is questionable to renovate these 50-year-old apartment buildings. At first glance, it would be easier to demolish them and build new modern buildings. Yet, social aspects generally sway toward a path of preservation and renovation. Such estates can offer affordable living spaces for lower socio-economic groups and for the people who are at the start of the housing ladder (Kovacs and Herfert 2012). People are also, of course, sentimentally and emotionally attached to these residential buildings. However, the chosen strategy depends on the technical condition of the building and the feasibility of the retrofitting. There are cases where the structure is dilapidated, living there is dangerous and the renovation is too complicated. Besides the aspects of finance and purposefulness, stakeholders must understand in which direction the city wants to develop. As regards sustainability, socialist housing estates as compact urban settlements present a far more preferred form of European idea about sustainability than suburban low-density settlements (Tosics 2005; cit. Muliuolytė 2013).

In the case of preservation, given the age and lifespan of these buildings, a full renovation will inevitably be required in the near future. Any renovation undertaken should be major, ambitious and concurrent, as the building utility systems generally require replacement in their entirety and a patchwork approach will soon require further repairs. It is particularly complicated if the renovation has taken place at the owners' own initiatives: one apartment at a time (i.e. changing windows, radiators). Once a general, proper retrofitting begins, such people would stand to lose their investments. Thus, often they are the most ardent opponents of a full retrofitting. Yet it is not possible to retrofit a building one apartment at a time and achieve optimum energy efficiency and quality results.

The same approach is applicable on a larger spatial scale, such as neighbourhoods. A building-by-building renovation strategy has shown its incapability to resolve the bigger social issues (whether related to neighbourhood's social decline or energy efficiency etc.) in socialist housing estates in the Western countries that were already present during the 1980s (Tosics 2005; cit. Muliuolytė 2013). In addition to this, the current building-by-building policy leaves apartment associations relatively alone to deal with the vital actions necessary for efficient reconstruction, i.e. understanding the technical specificities of the building and necessary renovation, choosing a construction company, agreeing on the terms of reference and dealing with the possible consequences. For example, several cases from Estonia have shown that sometimes the retrofitting is only carried out halfway (e.g. not installing a proper ventilation system), with the aim of cutting down on expenses. Thus, apartment associations need relevant advice on which activities to pursue and which company to hire. The first examples of companies' bankruptcy while reconstruction works were still ongoing have already occurred. In such cases, the associations are in a difficult situation regarding how to manage the financing and finish the renovation works. An area-based approach more efficiently addresses these issues, where the local municipality is actively involved and can offer support in the process.

However, such area-based strategies require new implementation schemes regarding the involvement and cooperation of different stakeholders, sectors and fiscal instruments. SmartEnCity project is a good example of a realisation of such a strategy, but there is necessity for institutional changes and alternative financing schemes to sustain the spillover effect to other municipalities. Local governments need to learn how to manage the process and communication with stakeholders and to be actively involved in guiding the area-based retrofitting process and finding additional financial resources to support the works. In the SmartEnCity project Tartu pilot area, the funding originates from three sources (KredEx, H2020 and bank loans of apartment owner associations) and targets the khrushchëvki to achieve an energy efficiency rating of 90 $kWh/m^2/y$. Without the financial support of Tartu city (from H2020 funds) and KredEx, it would have been difficult to target such an energy performance level. Additionally, the integrated and area-based approach targets other complicated issues in cities such as transportation, area-based heating systems, etc., that require cooperation between stakeholders from different sectors. SmartEnCity revealed that the existence of engineers, architects and technical consultants with relevant backgrounds is extremely important. The expectation is that the competence of construction companies and other stakeholders will rise during the project within the framework of SmartEnCity, as the monitoring, design, procurement, preparation and processing takes place for 22 buildings.

Another important aspect is the active engagement and empowerment of homeowners and apartment owner associations. The Tartu project concludes that it is complicated to undertake such work without having the support of apartment owner associations. Recommendations suggest that legislators and local governments develop an organisational framework for supporting and promoting cooperative activity, a role suited for apartment owner associations or, in the case of state-owned apartments, some other institutions (e.g. housing administrations). They could include all residents and owners in the decision-making process, as the population living in apartment buildings is very diverse and the success of the retrofitting depends on everyone.

Consideration should be made for investing in the installation of smart home systems, if the aim is to achieve higher energy efficiency. Even if today's users resist the technologies now, it will be necessary to ensuring optimal energy use and indoor climate control and safety for the entire building. A central smart home system is also necessary for collecting data and analysing performance. Our experience is that residents initially question and resist smart home systems. People hesitate because of a lack of knowledge and skills and are afraid of the EMR from smart home equipment and data transmissions. When new technologies emerge, people must primarily learn to use the solutions offered, integrate them into their daily lives and change their behaviour accordingly (Zhang et al. 2016). In such cases, social learning and educating people in technology are key to keeping such projects from being a failure. Studies have shown that social learning can make people's consumption patterns more sustainable (Buenstorf and Cordes 2008). As part of the Tartu SmartEnCity project, installation of a smart home system with different sensors to measure consumption. It is important to study how people both response to and adopt to them, and what is the efficiency of these devices and systems. As a result, a smart city can bring services closer to people, but if people are unable to reach the services then it is of no use. Additionally, there might also be a negative social impact such as increasing the digital gap by integrating technological systems such. As mentioned in Sect. 17.4, interviewed people were afraid of using the smart home system due to their lack of skills. Thus, marginalisation of groups already disadvantaged (disabled people, pensioners, etc.) could increase.

People living in Soviet-era housing estates are socially heterogeneous. In Tartu, both young families and students live in the city centre buildings, alongside older people who have been living there since construction and who are now retired. There are high-income, middle-income and low-income families, as well as both international residents and locals (including ethnic minorities and majority groups). The financial investments necessary for retrofitting have different impacts on all of them. Thus, such initiatives may not be affordable to all socio-economic groups and the size of investments will certainly curtail options for the less well off. This is one possible negative social impact that requires consideration for such projects. Yet segregation is not discernible in these buildings; our preliminary study of sociodemographic data and interviews showed the buildings have a varied demographic makeup. On one hand, there is a reason to believe that the social diversity of residents will increase as retrofitted buildings in the city centre will become more attractive, and that such intermingling is beneficial for both the housing estate districts and all of Tartu. On the other hand, since the area under intervention is located in the city centre, increasing real estate prices and the value of apartments can force the outmigration of pensioners, students and low-income earners. Khrushchëvki generally were affordable residences in the city centre, but this may change following retrofitting.

The diverse population also poses a challenge in terms of teaching and training people how to live in the smart building. Achieving energy efficiency rating "A" requires more than construction foam and technologies; it requires a change in consumer attitudes and behaviours. Results from our survey and interviews showed that the basis for motivation of residents to participate in the development of smart city, above all, is the need for retrofitting and saving on costs. Very few people think about environmental problems and personal responsibility in this field, which is quite different from the noble objective of the EU-planned programme for reducing GHG emissions. Thus, there is always a possibility that people will not adapt to technological solutions aimed at decreasing the carbon footprint of buildings as expected. Because of this, education efforts will be key during this project in Tartu. This work is often complicated since the target groups are diverse and need individualised engagement approaches.

There are several ambitious goals of the SmartEnCity project and there is much to learn from both the lighthouse projects as well as from the smart city developments to sustain and spread their impact. Will technological innovation help to achieve the aims of sustainable development and environmental conservation or will it be a failure? Certainly, the condition of at least part of the city will be better and the quality of life in the district should improve. For many, this is precisely what is important.

Acknowledgements The authors of this chapter participated in preparing the SmartEnCity project proposal and are currently actively taking part in the implementation phase. This study has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691883.

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