Household energy awareness as enabler of regeneration practices. Preliminary evidence from a Finnish case study

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Introduction

In terms of size, cities occupy only 2% of the world's land. However, in terms of climate impact, they are responsible of an enormous footprint. They consume over two-thirds of the world's energy and account for more than 70% of global CO_2 emissions. When it comes to Europe, hosting more than 75% of the European population, cities have a prominent role in the mitigation and adaptation processes to climate change. Besides being a multi-scale issue, facing energy and climate challenges is a horizontal priority for different sectors and societal domains (Papa et al., 2016). Among them, the key role of the building sector has been clearly recognised in energy consumption and environmental impact. In the European Union, buildings are responsible for 40% of energy consumption and 36% of CO_2 emissions.

The residential sector, with the 75% of the total energy consumption in buildings, is an important target area for energy reduction. Thanks to the energy performance regulations at EU level and at Country level, residential buildings have incrementally improved in terms of their energy efficiency during the last decade. In particular, the improvement has mainly been achieved thanks to the construction of new and more efficient buildings. However, about 75% of the residential buildings that will constitute the European housing stock in 2050 have already been built today, therefore the renovation of the existing housing stock is a fundamental step in the path to achieve the EU targets. The central role of human factor for achieving energy savings is increasingly recognised to overcome the gap between expected and actual energy consumption in buildings. Comfort preferences can vary across households and even across people within the same household. The control of indoor conditions (e.g. ventilation, temperature) could have a strong effect on the interaction between the household and the dwelling. Variations in preferences for comfort and indoor conditions have also been shown to depend on household characteristics and other socio-demographic variables, influencing energy consumption via differences in motivation and attitudes towards energy and environmental conservation. The relation among behavioural determinants is believed to be a key point in the formulation of policies and strategies to lower energy consumption through behavioural change. The lack of energy and environmental awareness among households has been demonstrated to be one of the main obstacle when it comes to the energy savings in residential buildings.

The municipality of Helsinki has ambitious targets of becoming carbon neutral by 2035, while simultaneously improving the liveability and attractiveness of the city. In the transition to a low carbon society, engaging citizens and stakeholders is a fundamental step. The paper presents the preliminary results of a Finnish case study, based on questionnaires that have been delivered to households living in selected buildings of Merihaka district in Helsinki, with the aim to understand the current situation in terms of household behaviour, attitudes towards domestic energy saving, and the willingness to implement new measures. The case study has been selected since it is part of the actions the City of Helsinki is developing in the framework of the H2020 mySMARTLife project. Its main objective is the definition of an innovative urban transformation strategy for making cities more environmentally friendly by reducing CO_2 emissions and increasing the use of renewable energy sources, with the active participation of the citizens.

Background

Many studies have investigated the behaviour of people in residential buildings, and most of them recognised that not only physical conditions influence the behaviour of building occupants. They have resulted in new understanding of household and building determinants and human behaviour patterns definition in relation to window opening, use of air-conditioning and temperature control, lighting and solar shading, depending on outdoor and indoor conditions. Among them, a consistent number of studies has adopted survey methodologies to understand household awareness, behaviour and willingness to adapt to more sustainable consumption patterns. They main consist of questionnaires (Andersen et al., 2009; Frontczak, Andersen and Wargocki, 2012; Feng et al., 2016), in-dept interviews (Gram-Hanssen, 2010; Hayles and Dean, 2015) and there have been also studies combining both (Peters, Fudge and Sinclair, 2010; Brown, Swan and Chahal, 2014). In case a disruptive change occurs, as the housing renovation to improve energy efficiency of building components, and installation of new technology systems as smart meters, scholars have highlighted the importance of performing both pre-occupancy and post-occupancy investigation (Hendrickson and Wittman, 2010).

In some cases, the questionnaire based survey are preferred for reducing the direct-personal observation effects which causes the participants to feel observed and therefore alter their responses (Wilhite and Ling, 1995; Vassileva and Campillo, 2014). In others, sending email instead of delivering the questionnaires by hand at home or by post has resulted to be effective in enlarging the target group reached (Jain, Taylor and Peschiera, 2012; Feng et al., 2016). The survey tool has also been applied at community scale rather than individual one, to determine their level of interest in the municipal Green Living Centre in London by distributing the questionnaires to visitors (Peters, Fudge and Sinclair, 2010).

Due to the time people spend in indoor environment, and considering they have the greatest freedom to act and the greatest control at home, the residential sector is the one where user behaviour has been investigated the most, since raising awareness among households on their consumption behaviour patterns at home is believed to be a crucial point in lowering energy consumption (Hayles and Dean, 2015). Therefore studies performing survey-based investigations have mostly focused on the residential sector (Vassileva and Campillo, 2014; Elsharkawy and Rutherford, 2015; Hayles and Dean, 2015; Feng et al., 2016), although the number of scholars working on assessing behaviour impact on office buildings through survey is also increasing.

The case study

The city of Helsinki has about 635,000 inhabitants, while the metropolitan area counts more than 1.4 million inhabitants, one-fourth of the total population of Finland. The population has been growing rapidly, by 8,000 annually on average in 2013–2016. Over 40% of Finnish population growth occurred in Helsinki.

When it comes to the building sector, building construction has been increasing in Helsinki, particularly towards housing. Between 2013 and 2016, around 15,500 dwellings were completed, either as new dwellings or extensions, and an additional 1,300 dwellings through change of intended use. There are considerably more people living in apartment buildings and rental homes in the city of Helsinki than in the neighbouring municipalities. About one-third of residential buildings were built earlier than 1959 (Parviainen, 2017), therefore renovating the existing housing stock is a major concern in Helsinki, as for the rest of European cities. Housing sector causes approximately 60% of Helsinki GHG emissions. Among them, 85% comes from heating and domestic hot water, while the rest comes from electricity usage (City of Helsinki, 2018). The heating consumption is a major cause of emissions. Approximately 90% of properties are part of the district heating network.

Helsinki is on the way to meet its target to reduce GHG emissions by 80% by 2035, having already achieved 25% reductions since 1990. However, to become carbon neutral in 2035, it recognises the urgency to tackle household energy behaviour as a prominent issue to effectively achieve the renovation and lower consumption of residential buildings. Therefore, the city of Helsinki is committed to raise awareness among citizens, and in particular through targeted information campaigns to households, who are believed to be the key factor for making the renovation practices effective and for activating and multiplying the urban regeneration benefits.

Merihaka district, Helsinki

Merihaka district (Figure 1a) is located right outside the East boarder of the historical city centre. The total targeted area consists of 12 buildings, resulting in more than 1,300 dwellings. Buildings in Merihaka were constructed in the 1970s and 1980s. In general, the effectiveness of the building insulation materials of this residential building stock are already relatively good compared to average European buildings. More than two-layer windows have been a standard since 1970s in Finland, and a substantial amount of the residential buildings have already been renovated by improving either the building façade and/or the HVAC system.

The project action focuses on investigating how the municipality can support and promote energy efficiency solutions in buildings to increase energy performance and decrease energy consumption. Rather than implementing solutions to improve the building materials thermal proprieties (e.g. insultation of the envelop or replacement of windows), to increase replicability the interventions are mainly focused on the installation of new technological devices. Smart thermostats for managing the heating demand at the apartment level is one of the key retrofitting interventions.

A pilot project has been conducted between November 2017 and March 2018, when one building with 168 dwellings has been equipped with a smart heating control system that includes smart thermostats remotely connected to the cloud-based intelligence and district heating system to balance thermal loads. The smart thermostats allow households to set the schedule of each room with the preferred temperature and to select the vacancy mode when not at home. At the same time, they automatically collect information on the temperature set-point preferences, the temperature of the heat distribution water in radiator and the room temperature. The collected information will be then used to provide feedback to occupants. The strategy foresees also community events where households are invited to attend to receive additional feedback, to ask questions and to co-design the awareness campaign by adding information on their expectations and preferences. Therefore, the results presented in this paper represent only the first step of the investigation the City of Helsinki is carrying on to understand awareness on energy saving, user behaviour and the usability of the solutions.

Methodology

In order to investigate preferences, interests and understandings of household energy consumption, a questionnaire was designed and sent by mail to the 168 households living in the dwellings where the pilot case described above has taken place. Participants could also choose to participate through an online version of the survey. The questionnaire based approach was chosen in order to favour a higher relationship between what the respondents answered and reality, and also due to time limits for this first round of investigation. The questionnaire based survey was also preferred for reducing the direct and personal observation effects which cause the participants to feel observed and therefore alter their responses.

Household overall energy consumption patterns have been investigated in previous research (Van Raaij and Verhallen, 1983; Guerra-Santin, 2011) combining statistical data or large scale databases on energy consumptions with survey results. In this case only a qualitative research analysis has been performed meaning that results are based on the questionnaire responses only. Although this approach embeds limitations for the exploitation of the results, it can make a difference in the local context at an early stage of the design of a renovation strategy for the existing housing stock.

Three types of questions were included in the questionnaires: the one that requires the self-evaluation of comfort choosing the value among a scale 1-7, 1 for being very dissatisfy and 7 for being very satisfy; the other that foresees a choice among multiple answers, and the last type which applies open questions for commenting or further detailing specific answers.

The topics targeted by the questions are divided into three groups. At first, questions on level of satisfaction regarding comfort of the occupants. The second part consists of information on the new thermostats setting and how it has been easy to use and to configurate. The last part intended on the one side to gather the household preferences regarding temperature setting and type of feedback to receive, on the other side to understand the awareness that households have when it comes to energy saving.

Results and discussion

Since the response rate was only 17%, the replies from households cannot be considered as representative neither for the all population living in the district, nor for the households living in the pilot building, due to potential of biased selection. Nevertheless, they provide some knowledge regarding current behaviour, awareness on energy consumption and attitude towards smart thermostats in Finnish housing stock, data that are usually particularly scarce.

Respondents were generally satisfied with the overall indoor dwelling environment. Similarly to what found by Frontczak et al. (2012), the highest satisfaction, considering the combination of the two highest scores, was observed for the air quality (49% of respondents) (Figure 1d), while the relatively lowest for the acoustic pollution (Figure 1e). The thermal comfort satisfies the 36% of households, 18% reported to be partly satisfied, while only 7% are very satisfied (Figure 1c). When it comes to the interface between privately and publicly owned spaces, households showed almost the same good level of satisfaction for the lighting of building common spaces, and for the overall community where they are living.

Households were asked to report their preferred set-point temperature in a range between 20°C and 23°C. Half of the respondents reported to choose 22°C, 2 degrees higher than 20°C, generally assumed as thermal indoor comfort temperature (ISO, 2008), chosen in this case by only one-fifth of respondents.

Results from this survey show that energy saving is considered by households a relatively important issue, with the great majority (more than 60%) stating that it is somehow important, while the 15% gave to energy saving even a higher importance. One of the reasons that could explain the rest of respondents considering this issue not important is the relatively low energy costs for end users, 15% less than the EU-28 average fuel price for domestic consumers (European Commission, 2017).

Education has been found to be significant in explaining energy consumption (Guerra-Santin, 2011; Sapci and Considine, 2014). Motivation is another important determinant of electricity consumption (Lindén, Carlsson-Kanyama and Eriksson, 2006; Vringer, Aalbers and Blok, 2007). The perception of the environment and other factors concerning the dwelling can also impact the window opening behaviour (Andersen et al., 2009). Motivation and perception could be influenced through information, feedback and other educational and economic measures.

Feedback in particular has proven to have a strong influence on occupant behaviour (Darby, 2006; Fischer, 2008; Faruqui, Sergici and Sharif, 2010). As environmental concerns increase, households take direct action to conserve energy (Sapci and Considine, 2014). In order to maintain the positive behavioural changes for longer, some scholars suggest that factors such as human motivation and energy related interest should be included in the feedback developing process (Henryson, Håkansson and Pyrko, 2000). Several studies show that most of the households do not understand much about scientific units (Jain, Taylor and Culligan, 2013; Frederiks, Stenner and Hobman, 2015), therefore feedback providing only consumption values in energy unit might not be very effective.

The results presented in Figure 1b shows that 35% of the households would prefer to receive feedback on their energy consumption either by regular mail or email, while the preferences for smart technologies such as mobile applications were lower. Interestingly, 35% of respondents would prefer to receive information on their consumption level compared with neighbours or other peers, no matter the means for delivering such information. Frederiks et al. (2015) have found that advising individuals that people similar to them (e.g. peers, neighbours) are using less energy or taking certain energy-saving actions, in addition to conveying social approval of such actions, will most likely motivate them to conform to these positive energy-saving attitudes and to reduce their consumption accordingly. Household energy consumption should not only be pre-

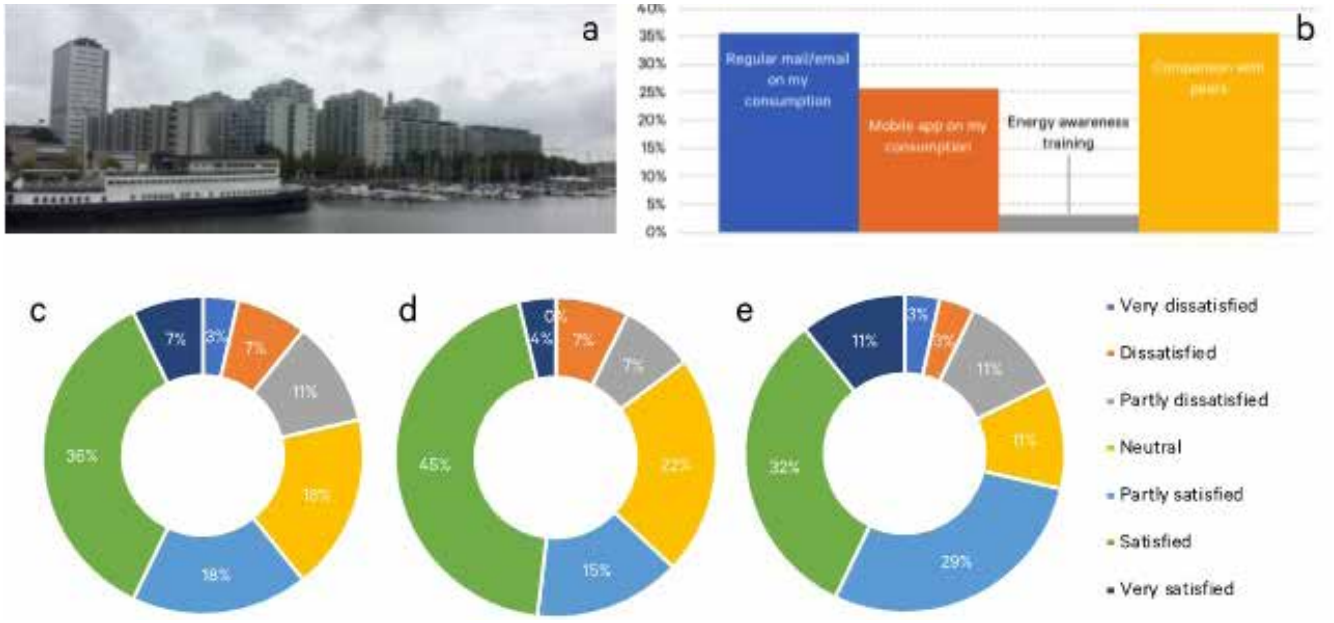

Figure 1– View of Merihaka district and overview of main results. Authors' elaboration

sented quantitatively (as monthly/annual consumption or according to the size of the household) but other values should also be included, such as comparison with similar households, environmental impact caused by the consumption, and appliance specific breakdown. To achieve long lasting effects, the feedback needs to be dynamic, as consumers preferences and knowledge can change over time (Vassileva and Campillo, 2014).

Some additional questions have been formulated to investigate household attitude towards smart thermostats. The majority of respondents reported to have experienced troubles in installing, configuring and log-in with the new smart thermostats. Although 80% have declared that they used the instructions provided by the energy company, less than 20% of them found they were clear, and the manual setting of the thermostat resulted to be difficult to understand by more than 60% of the respondents. These findings suggest that more effort is needed to make occupants able to properly use the new technology installed. An overconfidence in technology might lead to an overestimation of benefits and energy savings.

Limitations and conclusions

Whatever the technological interventions are, it is unlikely that energy saving targets for the housing sector will be achieved without a greater focus on human behaviour (Hayles and Dean, 2015). The survey conducted has been useful to gain a first insight into household awareness, attitudes and willingness to be involved in actions targeted to the reduction of energy consumption. However, identifying current behaviour is not enough, it is also necessary to identify whether or not there is a willingness to reduce consumption going forward.

Some limitations must be acknowledge. First of all, the questionnaire does not take into consideration the household characteristics of the respondents. Therefore, this issue excludes some possible findings that can explain certain behaviours. Secondly, the low response rate makes impossible to further assess the responses through statistical analysis to reinforce the conclusions. However, this study only represent the first step of the set of activity the City of Helsinki is committed to perform for the district regeneration, and more findings will be added to this first insight in the next future.

Concluding, the energy efficiency process, to be effective in achieving energy reduction targets, should be conceived as a part of an integrated and broader urban strategy fostering urban regeneration of the existing city, where the local authorities have a key strategic role in coordinating and influencing the activities of a range of actors, in defining areas and communities to focus on, and in engaging people in changing behaviours in order to reduce energy consumption (Theobald and Shaw, 2014). Therefore, investigating consumer behaviour in the framework of urban planning can provide an insight into the urban regenerative potential of cities, which relies – among others – on the one side on energy awareness of people, their behaviour, capacity and willingness to adapt, while, on the other side, on the ability of public authorities to design renovation strategies to turn occupants into active actors rather than passive target groups.

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Notes

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Politiche abitative e processi di rigenerazione urbana. Il caso del Piano per il riuso degli edifici fatiscenti del centro storico della città di Sassari.

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Introduzione

L'articolo illustra i risultati di un progetto di ricerca, condotto da un gruppo multidisciplinare del Dipartimento di Architettura, Design, Urbanistica di Alghero dell'Università di Sassari in collaborazione con il Settore Pianificazione Urbanistica ed Edilizia Privata del Comune di Sassari, finalizzato all'elaborazione di un Piano integrato per la rigenerazione urbana del centro storico della città di Sassari[1]. L'obiettivo principale della ricerca è costruire uno strumento innovativo - coerente con gli strumenti di piano convenzionali, in particolare il Piano Urbanistico Comunale (PUC) e il Piano Particolareggiato del Centro Storico (PPCS) - in grado di innescare un processo di rigenerazione urbana vera e durevole del centro storico.

Nonostante il suo valore storico-culturale e la sua localizzazione, il centro storico della città di Sassari può essere considerato una vera e propria periferia. Il quartiere, infatti, è caratterizzato dalla presenza di una serie di problematiche fortemente interconnesse: disagio sociale, scarsa qualità urbana, inadeguata presenza di servizi di prossimità, spopolamento complessivo e sovraffollamento di alcune porzioni e presenza di un numero significativo, ed in continua crescita, di edifici fatiscenti e spazi abbandonati. Queste problematiche alimentano e rafforzano il processo di segregazione socio-spaziale, che può ritenersi ormai strutturale.

Il progetto di ricerca si concentra principalmente su quelle problematiche che tendono a consolidare la condizione di marginalizzazione del quartiere e che possono al contempo essere affrontate attraverso gli strumenti di piano e progetto. Tra queste, la presenza di un numero significativo e crescente di edifici fatiscenti, molti dei quali non occupati, e di piccoli spazi abbandonati pare essere la più rilevante e urgente, anche in termini di percezione da parte degli abitanti.