# Learning and Energy-efficient Renovation of Residential Buildings: The user Perspective

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**Abstract**: Renovation of residential buildings has gained more attention in recent years. There are several challenges connected to energy efficient renovation of existing buildings. European Commission acknowledges the challenges and emphasizes the need to replicate best practices and learn from lessons. Several research studies have been conducted on the topic of energy-efficient renovation of residential buildings, some of which have highlighted significant aspects that are to be considered in the renovation efforts / projects. One of the aspects is user perspective that encompasses, among other things, user involvement and user behaviour. Knowledge sharing and learning play a significant role in developing and ensuring the user behaviour that is suitable for harvesting the intended benefits of energy-efficient renovation efforts. There can be wonderful energy-efficient solutions that can reduce greenhouse gas emission and promote sustainability. But, if the solutions are not used appropriately by the user, then it will hinder achieving the expected positive effect. As a result, developing and implementing the solutions in the first place will lose its very purpose. This paper looks at the user perspective in energy-efficient renovation of residential buildings and describe the learning-points associated with it. Focusing on these learning-points and the user perspective itself has its implication on wider issues such as policy making and future energy consumption. In addition, this paper summarises basic knowledge on understanding users' behaviour regarding energy and consumption, as well as briefly describes tools and examples of research projects that incorporate the users' perspective in their design. This paper is based on narrative literature study. It touches upon aspects related to the Sustainable Development Goals 11 (Sustainable cities and communities) and 13 (Climate action), at least to a certain extent. This paper is connected to an EU-project called "REZBUILD" (https://rezbuildproject.eu/), which focuses on developing decision and planning support for accomplishing near zero-emission in renovation of residential buildings.

**Keywords**: User-behaviour, Involvement, Knowledge sharing, Learning, Collaboration

## 1. Introduction

In renovation projects, we often aim to upgrade the function of the building itself so that it fits requirements for energy, accessibility or change of building use. However, experience and research show that the users are key to their success, as the use of the building may not fit for example the intentions behind the design. Halvorsen et al. (2016) has studied the rebound effect for the use of heat pump in the Norwegian households; even though heat pump is used to reduce consumption, the results showed little or no change. They attributed the effect on "higher indoor temperature and heated living space, less firewood and fuel oil use and less use of night-set-backs or reduced while away from home" (page 1114).

Similarly, Schakib-Ekbatan et al. (2015) describe the mismatch between the energy concept and the use of the building by its occupants. They looked particularly in window opening times both in winter and during the summer for an office building in Frankfurt, Germany, where they found considerable deviation from the predicted times which, in turn, can lead to higher energy demands.

Thomsen et al. (2013) draw on this misalignment of the actual use with the intended use of energy efficient buildings and investigate the causes. Although they underline that further research is needed, they found three main categories: need for control and comfort, lack of previous knowledge, and identity (being proud). Hauge et al. (2011) show the importance of evaluations of energy efficient buildings. They highlight both the mismatch between the predicted and actual use of the buildings while they point out the lack of research. They also review research that has been done on the subject. They name thermal comfort as the most researched area in relation to the users while they suggest that adaptability of the integrated systems is important to the user's experience and behaviour. They also name that having sufficient knowledge as to how to operate the systems of the building as well as training are equally important.

The above description points out the relevance of the role of learning in ensuring the accomplishment of the intended effects of renovation of residential buildings. This paper, which is connected to an EU-project called REZBUILD (https://rezbuildproject.eu/), looks at this topic. In this regard, this paper describes relevant theories and research method. And then, it presents aspects and examples of user behaviour, followed by discussion and concluding remarks.

## 2. Relevant theory

We will mainly look at sensemaking described by Karl Weick and his colleagues in connection with our discussion on the learning processes. In this regard, we will focus on the following two paragraphs as a key source for our reflection and discussion.

Weick et al. (2005, page 409) defines sensemaking as follows: "Sensemaking involves the ongoing retrospective development of plausible images that rationalize what people are doing. Viewed as a significant process of organizing, sensemaking unfolds as a sequence in which people concerned with identity in the social context of other actors engage ongoing circumstances from which they extract cues and make plausible sense retrospectively, while enacting more or less order into those ongoing circumstances".

The authors (ibid., page 409) further say: "First, sensemaking occurs when a flow of organizational circumstances is turned into words and salient categories. Second, organizing itself is embodied in written and spoken texts. Third, reading, writing, conversing, and editing are crucial actions that serve as the media through which the invisible hand of institutions shapes conduct (Gioia et al. 1994, p. 365). The emerging picture is one of sensemaking as a process that is ongoing, instrumental, subtle, swift, social, and easily taken for granted. The seemingly transient nature of sensemaking ("a way station") belies its central role in the determination of human behaviour. Sensemaking is central because it is the primary site where meanings materialize that inform and constrain identity and action (Mills 2003, p. 35). When we say that meanings materialize, we mean that sensemaking is, importantly, an issue of language, talk, and communication. Situations, organizations, and environments are talked into existence".

Sensemaking is also connected to reflection-in-action (reflecting on an action while engaging in the action) and reflection-on-action (reflecting on an action retrospectively after the action) that Schön (1998) describes. How people perceive things, events, etc., and how they interpret them individually and / or in a social context influence their behaviour.

## 3. Research method

This paper is based on a narrative literature review (NLR). NLR takes into consideration various studies of a topic, and allows the reviewer to gain an understanding of various views associated with the topic, and to make a holistic interpretation of the studies by using his / her experience as well as existing theories and models (Campbell Collaboration, 2001; Kirkevold, 1997). Jahan et al. (2016), say that NLR does not necessarily require to report more rigorous aspects that characterise structured literature review – aspects such as research methodology, search term, database that was used, and inclusion as well as exclusion criteria.

## 4. Aspects and examples of user behaviour

The role of user/owner behaviour is important in achieving the desired results of energy efficient refurbishments. Several articles point out this importance.

Sandberg et al. (2017) present an application of a dynamic, stock-driven and segmented dynamic dwelling stock model for scenario analysis of future energy demand. In this regard, they consider a dwelling stock of Norway 2016–2050. The authors emphasize the significance of user behaviour in their article. They explain the significance further by a providing some information related to one hypothesis that they use in their work. The hypothesis is: It will be possible to reduce the energy demand in the Norwegian dwelling stock by some 50% by 2050 – despite strong stock growth – by introducing currently available technology in refurbished and new buildings. The authors say, (ibid, page 230), "The results show that the hypothesis may be confirmed for the theoretical estimated total delivered energy in our most optimistic scenario. However, in this scenario, user behaviour is expected to reduce the saving potential from 51% for the theoretical estimate to 36% for the estimated 'real' energy demand from 2016 to 2050. The policy implications of this is that efforts should be made

to counteract this rebound effect. Unless such measures are taken, the hypothesis will not hold and policy targets might not be met."

Yousefi et al. (2017) look into the influence of occupant lifestyle patterns on the energy performance of the residential buildings that have various building envelopes in different climate zones. The case studied in this regard is an existing multi-family apartment building in Iran. The energy demand of the building before and after renovation was simulated with the help of EnergyPlus for different climate zones. Sensitivity analyses showed that the occupants' behaviour had a strong effect on the building's thermal energy usage. The results indicate that the interaction between the occupants' behaviours and envelope materials is an essential aspect to consider. The results point out, as a consequence of this important interaction, the occupants' behaviours can change the strategy of choosing the envelop material types.

Rodrigues et al. (2018) make as assessment of an innovative external wall insulation system for social housing retrofit in Nottinghamshire, UK. Their article suggests that gaining a better understanding of the occupants' impact on the energy consumption, is an important part of their study. Ozarisoy & Altan (2017) consider occupants' behaviour as one of the three variables to study the application of retrofit strategies to improve conditions within the residential sector in the Turkish Republic of Northern Cyprus.

One of the aspects that can influence user behaviour is users' health related issues. In this regard we will briefly present a study carried out by Underhill et al. (2020). The authors studied indoor and outdoor air quality and health impacts by investigating installation of energy-efficient retrofits in a multifamily housing unit. According to the authors, weatherization retrofits, such as air sealing and insulation, lower residential energy consumption, resulting in reduced fuel and electricity-related emissions, improved ambient air quality, and avoided climate and health impacts. However, retrofits without adequate ventilation may worsen indoor air quality (IAQ) and lead to adverse health effects and costs that offset anticipated economic benefits. Building energy management and climate action plans often omit these potential consequences. "This is a key takeaway for climate action planning – residential energy retrofits must be accompanied by plans for adequate ventilation and filtration, as strict optimization for short-term energy savings may not be beneficial from a health perspective. The substantial increases in monetized resident health costs following interventions that adversely impacted IAQ reinforces the need for holistic approaches to energy-efficient retrofits in climate action and other planning efforts" (ibid., page 7).

Sinnott (2016) looks into the relationship between envelope airtightness, how it is correlated to energy performance and occupant sensitivity pre- and post-energy efficient fabric upgrading of semi-detached social housing in Ireland. With this context, the author points out that occupants generally did little or no effort to stop heat loss through infiltration. The reason is that the occupants were not capable of carrying out the needed work or that they did not have the money to hire a professional to do the work. As a result, the responsibility lies on the local authority.

Reflecting on the occupant's perception, the author concludes that the majority of the occupants were not aware of how important adequate ventilation for their health is. And, they were also not aware of the impact of infiltration on energy use in their homes. Their prominent priority was to have house-related expenses at minimum while they can have an acceptable level of thermal comfort. As a result, they were interested in keeping the heat inside their houses, by blocking up vents or closing window trickle vents. This would in turn lead to limited airflow in the house and harm health and safety.

### 4.1 Understanding energy-related behaviour

Environmental psychology looks among others into people's behaviour that relates to environmental issues. It looks to understand, measure, and encourage environmental behaviour. Understanding is key to both measure and encourage or change behaviour. What affects it? An important factor is **values** which is defined as "desirable trans-situational goals that vary in importance and serve as guiding principles in the life of a person or other social entities" (de Groot, et al., 2018).

Environmental concerns and ecological worldviews can trigger our guiding system of what to do or not do when environmental issues arise. Social **norms** are another factor affecting environmental behaviour, which relates to people's tendency to act as their fellow others, while it is noted that people are more susceptible to norms than they think (Keizer et al., 2018). **Social identity** is also important as environmental behaviour and attitudes can

be the outcome of group membership and group processes; people can act based on the identity that is prominent (Jans & Fielding, 2018). Similarly, but on individual level, **self-identity** and **impressions** describe that environmental behaviour can be the outcome of what people think of themselves and how people would like others to think of them, which shows that environmental behaviour becomes a symbol (Gatersleben & van der Werff, 2018), a way to express ourselves. Environmental behaviour can also be affected by positive or negative **emotions** that come as a result of the behaviour (Taufik & Venhoeven 2018), as well as **habits** which define the everyday and are automatic behaviours that people do not often realise or think over (Klöckner & Verplanken 2018).

### 4.2 Need for new ways to look energy-related behaviour

Galvin & Sunikka-Blank (2017) talk about social factors that influence sustainable domestic retrofit undertakings. In this regard, they say that (page 381) "people's views, habits, practices and resources determine whether and how buildings are retrofitted, and influence how energy is consumed before and after retrofitting. Further, in buildings social factors interweave with technical factors such that the two often co-determine each other (Galvin, 2015; Lovell, 2007). Hence to understand energy-related behaviour in buildings it is not sufficient simply to apply basic principles of behavioural psychology. Shove (2014) has argued for a new paradigm to look at energy practices and transformation of consumer behaviour in the context of broader social science rather than previously dominating theories of individual attitude, behaviour and choice based on economics and laboratory psychology. A broad swathe of social theory could offer potential for more effective and legitimate policy-making and do better justice to the diverse, interlocking factors involved".

Pombo et al. (2016) present their reflection on a method called Social Life Cycle Assessment (S-LCA) with respect to dealing with social factors in the assessment processes. This method can be used to assess the social and sociological aspects of products, and their actual and potential positive and negative effects throughout the life cycle.

According to the authors, the social dimension is not fully developed. And they say that none of the studies that they received considered S-LCA. They suggest that further research is required to define the methodology and the impacts of the social analyses, and to incorporate it into life cycle sustainability assessment (LCSA). According to the authors, this would represent a significant step forward in fulfilling a significant need for an integrated methodology that takes into account environmental, economic, and social impacts from a life cycle perspective.

Pombo et al. (2016) also point out that there are other approaches that take into account the behavioural aspects; for instance, Peuportier et al. (2013) provide an approach that include a sensitivity study that deals with the influence of occupants on energy use and other environmental issues.

Several other authors also mention the need for addressing user behaviour in renovation of residential buildings from different points of view – beyond / in addition to technical solutions. Learning can be one such point of view, and it can contribute to obtaining intended effects of building renovation.

## 5. The relevance of the topic of learning

Studies show that giving adequate focus on the user perspective leads to positive results. We will look at three relevant studies, and see the role of learning in achieving the positive results.

Synnefa et al. (2017) present paper that describes a holistic energy efficient retrofit of low-income, multiple social housing located in Athens, Greece. As a part of their study, the authors applied occupant surveys. The surveys were used to collect and document the following:

- The tenants' perception of the quality of their indoor environment before and after the retrofit measures
- The tenants' views and satisfaction on the retrofit measure and the technologies and solutions that were installed in their apartments and building

Two questionnaires were sent to the occupants of the building used: One for the situation before, and one for the situation after the retrofit. Results of the survey shows that the occupants are satisfied with the retrofit measures. They evaluated all the installed technologies and solutions in terms of improving the indoor environmental quality and gave a positive rating. The occupants also mentioned that their behaviour had

changed in terms of energy and environmental issues after the retrofit. One example in this regard is, more than 90% of the occupants reported that they had used heating and cooling devices for fewer hours after the retrofit. This was also studied and verified experimentally. Reflection-in-action and reflection-on-action (Schön, 1998) could have contributed to trigger the sensemaking process (Weick et al., 2005). When comparing with the words of Weick et al. (2005), the users involve in an ongoing retrospective development of plausible images that rationalize what they are doing. Many occupants (71%) said that they were interested in knowing how they consume energy by looking at the monitors of smart meters that were installed. This interest in knowing can be compared with the words of Weick at al. (2005). That is, the interest in knowing can be seen as an instance of a process of organizing through which sensemaking unfolds as a sequence in which the users, who are concerned with identity in the social context of other actors, engage ongoing circumstances from which they extract cues and make plausible sense retrospectively, while enacting more or less order into those ongoing circumstances.

Sinnott (2016) says that even though there is a growing awareness that occupant behaviour has a significant impact on building energy consumption, there is a need to have more knowledge on how people interact with their houses and perceive their environment. The author says that designers must understand the relationship that people have with their houses and their perceptions of how the dwelling adaption influence their quality of life. Getting a new front door would make the occupants happier from the aesthetic point of view, rather than the fact that the new door could positively influence energy use and comfort. In order to maximize the positive effects of upgrading efforts, there should be several collaborative sessions with occupants before, during, and after the upgrading-work to make sure that the occupants understand why the upgrading was carried out and how they could correctly deal with the new systems or processes. The collaborative sessions could be regulatory or voluntary. These sessions and collaborations can contribute to learning through reflection and sensemaking.

Baumhof et al. (2017) investigate – through a online survey in Germany – the factors which influence the intention of owners/occupiers of single and two family houses to carry out energy efficiency refurbishment measures (EERM). This was done utilizing Vroom's Expectancy Theory. The authors compared three groups:

- "Future refurbishers": House owners who stated an intention to undertake energy efficient refurbishment measures.
- "Non-Refurbishers": House owners who stated a need for such measures but no intention of addressing the need.
- "Refurbishers": House owners who had already completed refurbishment measures.

Based on experiences from their research-work, the authors present suggestions for improving energy efficient refurbishment. Two of them are:

- Conducting campaigns to present best practices in refurbishment projects: When best practice refurbished houses are presented to "Future-Refurbishers", then it could inform as well as motivate them to implement more optimized, holistic and efficient refurbishment measures. The authors further say that this strategy could also target the potentially even more promising group of "Non-Refurbishers", convince and persuade them to carry out necessary energy efficiency measures. House owners representing the best practice refurbishment projects could participate in the best practice campaign to provide additional information to both "Future-Refurbishers" and "Non-Refurbishers", and create a trusting environment. Based on their experience, the best practice house owners could give suggestions and advice, such as financial savings due to the refurbishment measures. The authors mention that this could contribute to encourage and convince "Non-Refurbishers" or "Future-Refurbishers" to undertake (more) EERM.
- Conducting do-it-yourself workshops for low-cost measures or measures which require little effort; for example, measures such as the insulation of problematic spots-like radiator niches and cellar ceilings or checking for drafts at windows. In addition, the workshops could also offer knowledge about changes in legal requirements; for instance, regarding mandatory changes of certain heating systems according to the national / state law. Obtaining know-how, skills and information regarding EERM can unleash a potential multiplier effect among house owners, since the know-how could be spread between friends, family and the neighbourhood.

These two suggestions show the relevance of learning.

Collaboration and social settings – when applied appropriately – can induce individuals to reflect on / question their own frames of reference or mental models, and then learn. In this regard, it is relevant to look at a ladder of inference introduced by Chris Argyris and popularised by Peter Senge (1994). People perceive and interpret the reality differently. Figure 1 illustrates how our observation of something (for example, an event) is transformed into action (Senge et al., 1994) – from an individual's point of view.

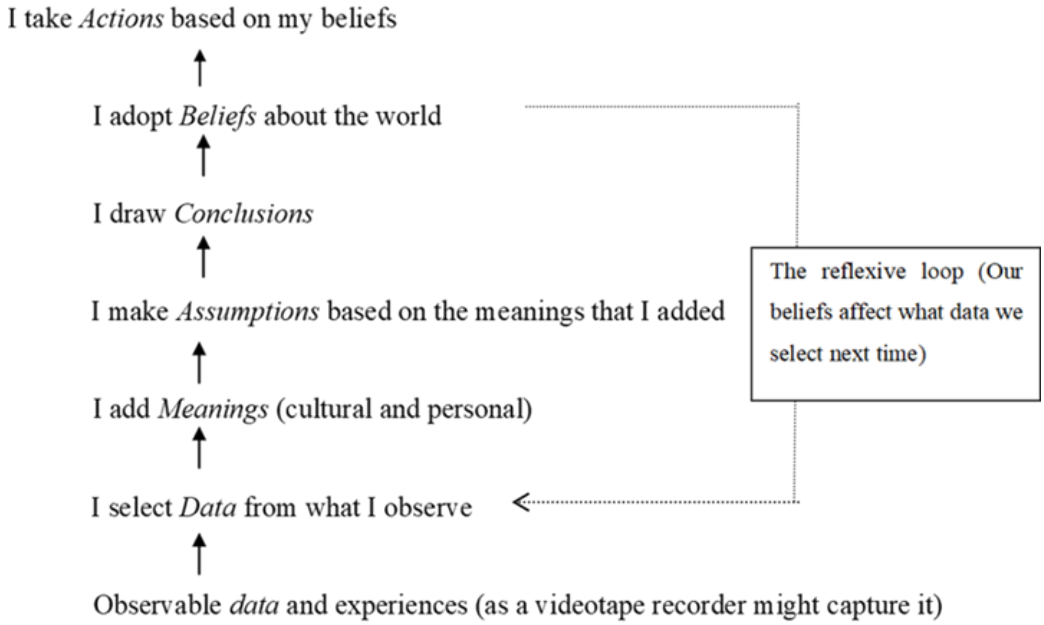


**Figure 1:** Ladder of inference (Senge et al., 1994, page 243)

What an individual selects from the observable data and experiences, what meanings that the individual adds to the experience, what assumptions the individual derives from the meanings, and so on tend to differ from other individuals who are also exposed to or witness the same experience/event. These differences can be addressed in and dealt effectively through discussions in collaborations. Open discussions can pave the way to identify underlying assumptions behind choices of behaviour. Critical questions and constructive comments can refine and concretize individuals' understanding with the help of discussion. Issues that are under concern can be looked at from different angles in order to get a wider understanding of the issues. Sensemaking is facilitated to materialise learning and knowledge development.

Learning in the design phase is also an important aspect in the user perspective. As we have seen earlier, it is important that designers must understand the relationship that people have with their houses and their perceptions of how the dwelling adaption influence their quality of life (Sinnott, 2016). In this regard, it is relevant to consider an approach called Living labs (LL) and a project where it is applied. ARV is a European project on climate positive, circular communities. Community engagement, environment and well-being is one of the work-packages aiming to integrate the users' perspectives in the project. Using Living labs (LL) as a tool, the project looks at how users respond to the energy concept of the renovation and raise engagement. "Living labs (LL) approaches are known for engaging with user groups in real-life contexts. A living lab is an inclusive space bridging the gap between the social and technical context, with focus on participatory design methodology." More about the project: https://sciencebusiness.net/network-updates/ntnu-collaborative-research-project-climate-positive-circular-communities-wins.

Syn.ikia is another European project on sustainable plus energy neighbourhoods. Novel technologies, good architecture, affordability and citizen engagement are the core of the concept. Even though users are not incorporated here as one single work-package, they are involved as sub-tasks in most packages. Following evaluation methodology and participatory design, the project aims to take the users onboard. More about the project: https://www.synikia.eu/.

## 6. Conclusion

The user perspective has gained more attention in recent years. Merely focusing on the technical aspects of building renovation may not produce the intended positive effects. Technical solutions may be very good, but how they are used, will count at the end.

Looking at this issue in connection with learning can contribute to ensure the intended positive effects of building renovation. In this paper, we described learning with aspects such as reflection and sensemaking. These aspects are significant in a learning process.

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