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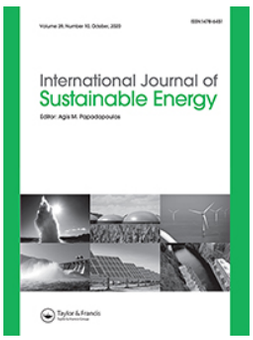

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Social acceptability of using low carbon building: a survey exploration

Sadaf Alam[a], Munjur E. Moula[a,b,c] and Risto Lahdelma[a,d]

[a]Department of Mechanical Engineering, School of Engineering, Aalto University, Espoo, Finland; [b]Department of Built Environment, School of Engineering, Aalto University, Espoo, Finland; [c]Faculty of Business, Northern University Bangladesh, Dhaka, Bangladesh; [d]Department of Mathematics and Systems Analysis, School of Science, Aalto University, Espoo, Finland

ABSTRACT

Enhancement of buildings energy efficiency has typically been approached by viewing the buildings from a social acceptance perspective focusing on multi-level stakeholders. In order to examine social acceptance in terms of public's opinion and knowledge about using low carbon buildings, a multiple-choice questionnaire was designed with four groups of questions: background information, community perspective, social perspective, and market perspective. The study showed that 59.72% of the seventy respondents' opinion were using low carbon building (LCB) can help to reduce greenhouse gas emissions. In general, more than 53% of the respondents were willing to upgrade their accommodation to LCB. However, 70% respondents were not ready to hire any consultant because majority of have the problem in paying the upfront cost for LCB.

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KEYWORDS
Low carbon buildings; net zero energy buildings; economic feasibility; energy efficiency; social acceptability

1. Introduction

Building stock is amongst the biggest cause of greenhouse gases (Zhao, Pan, and Lu 2016; Zuo and Read 2012). The EU has set an ambitious target to increase the number of 'nearly Zero Energy Buildings' (nZEBs) by 2020, which seems to be an unachievable target now. The existing ' National Plan of Finland' (Warf 2017) aimed to expand the amount of nZEBs, however, it has not yet established any detailed specifications.

Nonetheless, definitions of nearly zero-energy construction and associated specifications are underway. The variations in building culture and climate throughout Europe makes it a bit tough for the European Building Legislation (EPBD) to prescribe a uniform approach to nZEBs (Hamdy, Mohamed, and Hasan 2015; Paatero, Moula, and Alanne 2018). Perhaps, in certain countries, the building stock can contribute more than 40% of the total greenhouse gas emissions (González and Navarro 2006). Low carbon buildings (LCBs) implementations are therefore essential (Cabeza et al. 2013).

There are numerous benefits associated with the implementation of LCB. These benefits are multi-facet. Apart from environmental benefits such as pollution reduction, low carbon buildings have social and economic implications (Zuo, Jin, and Flynn 2012; Kennedy and Basu 2013; Liu, Liu, and Wang 2013). For instance, tenants of low carbon building experience a higher level of satisfaction, wellbeing, and productivity (Zuo and Zhao 2014). However, the challenges remain mainly

CONTACT Sadaf Alam er.sadafalam@gmail.com; sadaf.alam@aalto.fi
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due to the comparatively higher up-front cost associated with the sustainable features (Zuo and Zillante 2012; Yung and Chan 2012).

1.1. Low-carbon project practices

The growth of (LCB) can be seen in the improvement of theories and project applications (Shi, Yu, and Zuo 2015). The research not only established the key factor in the performance of low carbon buildings and their connection. The various critical factors for low carbon building development were highlighted.

In this context, international cooperation, macro-level management, low carbon theories and technologies growth, carbon knowledge and training, economic advantages, low carbon facilities and the structure of building energy use should be given the highest focus (Shi, Yu, and Zuo 2015).

An admirable project plays a crucial role in fostering systemic transition in the building sector towards low-carbon sustainable growth (Zuo and Zillante 2012). Low carbon initiatives have been carried out worldwide. For example, by integrating process and input-output analysis, the integrated energy usage in buildings can be estimated by a hybrid approach, based on a case study done on E-Town in Beijing (Han et al. 2013). In the same manner, successful policy mechanisms for reducing greenhouse gas (CHG) emissions are being formed in a direction to achieve low carbon development (Wang 2014). Such include the laws, carbon tax and other financial incentives.

Furthermore, Beliz Ozorhon found that corporate policy has influenced the implementation of energy-efficient technology on low-carbon projects through a series of case studies (Ozorhon 2013).

Such project activities provide useful knowledge for low carbon building and research on relevant hypotheses.

1.2. Development of low-carbon theories and technologies

The authors Dimoudi and Tompa highlighted that the developments in materials, technology, and expertise of developers in mitigating carbon pollution at this point are crucial to the reduction of building stock emission (Dimoudi and Tompa 2008).

The effect of low carbon building development on technologies and theory are of various faucets (Zhang, Skitmore, and Peng 2014). It has been argued by Zuo, Jin, and Flynn (2012) that an absence of a standardised concept of LCB poses a major challenge in the advancement of low carbon buildings.

Correct analysis of the carbon emissions of building materials enables the procurement process through the tagging of dioxide carbon labelling (Ng, Skitmore, and Cheung 2013). Conejos et al. likewise stated the value of developing sustainable reuse theories to reduce pollution and climate change emissions (Conejos, Langston, and Smith 2013). Subsequently, they built the Adapt STAR model to promote sustainable development with respect to adaption in buildings.

Figure 1, illustrates the five low carbon technologies, given by the author (Conejos, Langston, and Smith 2013), which are as follows:

(a) New energy utilization technology (which is solar, wind and geothermal), (b) Energy efficiency improvement (which is wall insulation, energy-saving windows, natural lighting), (c) Environmental load reduction technology (which contains, green reusable building materials, waste recycling), (d) Low carbon management (which contains, renovation planning and management techniques), and (e) carbon storage technology which is roof garden techniques, etc.

1.3. Societal acceptance

Societal acceptability of large-scale technologies has been argued to depend on a wide range of issues, some of which are related to safety and economics, while some issues are of cultural, social, and

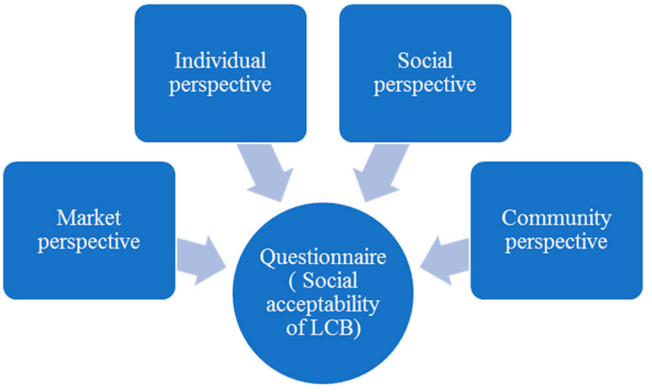

Figure 1. Low carbon technologies (author).

psychological significance. According to some studies, societal acceptance does not necessarily mean that people are willing to, capable of, or used to invest in or use the solution (Moula et al. 2013, 2017). It is, in fact, vital to understand societal acceptance and its variation among the broad spectrum of actors and stakeholders.

Table 1 sums up the public recognition of low carbon energy from a community-wide perspective. The principal contents / objectives of various research papers are indicated, and the comments are provided to indicate the research gaps.

From Table 1, in summary, we can say that the clients were ready to pay for energy efficiency. Most of the studies are focussing on low energy solutions. However, besides the low energy solutions to achieve low carbon buildings, the social acceptability of such buildings shall also be studied and is of high importance to know the social aspects.

The social acceptability of renewable technology in Finland in the communal context has been recently examined by Moula et al. (2013), Jung et al. (2016). Socio-political acceptance, community acceptance, and market acceptance of energy-efficiency and low carbon solutions have been distinguished in Ref. Wüstenhagen (2007). The author (Heiskanen, Matschoss, and Kuusi 2012) basically categorises two kinds of market acceptance as 'acceptance in principle' and 'acceptance in actual adoption and use.' On the basis of that classification, acceptance in principle does not necessarily imply that stakeholders are inclined, able or prepared to invest in or use a fixed solution. The degree of public approval in terms of actual acceptance depends on the social circumstances and/or investment actions of decision-makers, such as the house owner (E. Moula and Järvinen 2015; Moula, Sorvari, and Oinas 2017).

In the Refs (Moula et al. 2013) for example. It is recorded that 53% of Finnish interviewees agree, in theory, that it is critical to enhance RETs for energy efficient buildings at the moment. Nonetheless, only 43% of the sample shared their approval of 'real acceptance and usage' to take effective action on renewable energy technologies, e.g. the installation of solar panels on their roof. In Europe, the public awareness, and the general understanding of energy saving needs is fairly widespread. However, the public awareness is weak, when it comes in relation to the fairly complex and ambitious systems linked to near zero renewable energy and cooling and heating systems for renewables. In addition, in some countries different approaches are more appropriate and/or common and legitimised in comparison to the other countries. The definition nZEB or even energy renovation is not properly understood nor have been implemented equally across Europe and across the Globe.

Low carbon building energy technologies for low carbon generation are diverse. People's adoption of low carbon buildings increases the use of different types of renewables, and each technology utilises various natural resources in a variety of ways, and the economic, social and environmental impacts of

Table 1. Acceptability studies on low carbon building energy solutions.

Year	References	Approach/Aim/Objective	Conclusion
2010	Nair, Gustavsson, and Mahapatra (2010), Mahapatra and Gustavsson (2009)	To analyse the influencing factors of the adoption of the investment measures towards the improvement of energy efficiency.	The discomfort was present only in terms of thermal comfort
2010	Zografakis (2010)	The aim of this study is to analyse and to evaluate the citizens' public acceptance and willingness to pay (WTP), for Renewable Energy Sources (RES) in Crete	Willingness to pay for renewable energy sources.
2012	Kostakis and Sardianou (2012)	To analyse the tourist's perception of renewable energy supply	They were willing to invest in Renewable energy sources.
2012	Zalejska-jonsson (2012)	The aim of this paper is to investigate building performance from the occupants' perspective and to compare how the residents in low-energy multi-family buildings and conventional buildings, respectively, perceive the comfort of, and satisfaction with, indoor element.	This paper shows that occupants' feedback is an important part of comprehensive building performance assessment, indicating areas for improvement relevant for developers and housing managers. The presented results show that problems often identified as specific to low-energy buildings also appear in conventional buildings
2013	Stieß and Dunkelberg (2013)	Homeowners' barriers for energy-efficient refurbishments	Financial barrier were the major ones.
2013	Berardi (2013)	The perception of construction project stakeholders to energy saving in Italy	High uncertainty and the lack of information and communication among the stakeholders were the major barrier towards the energy efficiency technologies.
2014	Zalejska-jonsson (2014)	To examine stated willingness to pay (WTP) for low-energy and environmentally labelled buildings among owners and tenants living in green and conventional multi-family buildings in Sweden.	Respondents were prepared to pay more for very low-energy buildings. Willingness to pay for low-energy buildings of 5% can be considered a rational investment decision
2015	Hayles and Dean (2015)	Tenant's willingness to reduce energy and water consumption in Northern Ireland	Tenants willing to further reduce resource consumption
2015	Häkkinen et al. (2015)	To focus on the importance of having design measures during the early design phase of the building.	The importance of early phases of building projects was also confirmed by interviews which revealed that most of the decisions that affect the selection of building materials and parts are done in the preparation, concept design phase, and developed design phase.
2016	Lq et al. (2016)	To explore the occupants' perceptions about indoor environment comfort and energy-related values in commercial and residential buildings via survey.	The survey resulted that health is equally important to the Doha and Arizona respondents.
2017	Lai et al. (2017)	The survey focused on analysing the external driving factors of LCT innovation in construction enterprises	The results show that LCT (Low Carbon Technology) integration driving forces are significantly influenced by the continuous changes of a particular low carbon project as well as the number of participating enterprises.
2018	Paatero, Moula, and Alanne (2018)	The acceptability of zero energy housing for inhabitants in Finland.	It was observed that there was the willingness to pay extra for energy-efficient improvements was more munificent than that for renewable energy installations. In addition, most of the respondents willing to pay were to pay only 5–10% extra for the improvements.
2019	Ali, Miraj, and Windrayani (2019)	This study investigates stakeholder's perspective on sustainability and green building rating components	Most of the respondents only pointed out environmental issues and overlooked other significant aspects that contribute to sustainability such as social features and economic aspects. Despite their awareness of this concept, limited experience from

(*Continued*)

Table 1. Continued.

Year	References	Approach/Aim/Objective	Conclusion
			building owner and rewards are the two main barriers to the steady progress of professionals taking the green building certification in Indonesia and the adoption of green building

each technology vary (Moula et al. 2017). Thus, it is important to evaluate the social acceptance of low-carbon buildings to understand the social perceptions of the people in terms of usage of low-carbon buildings and climate challenges (E. Moula and Järvinen 2015; Moula et al. 2013).

2. Aims and objectives

The aim of this paper is to identify the level of awareness of using Low Carbon Buildings and climate change in the Finnish Society. In addition, this paper also addressed how the acceptability rate of using low carbon buildings energy technology vary especially for participant's own use in their buildings or near the environment. In this paper, we focused on public awareness and knowledge about the cost of low carbon building energy applications, willingness to pay for green energy, and low carbon buildings acceptability.

The study results provide classical knowledge in many ways. For example, (1) they provide us a new approach to know how and what kind of steps have already been taken to create awareness about low carbon building energy technology and climate change so far in Finland, and (2) they help us to analyse public perceptions towards low carbon building applicability and to acquire knowledge about what different kinds of low carbon building energy technologies they (participants) are aware of.

3. Methodology

As one of the widely assumed factors for the successful implementation of low carbon buildings, the term societal acceptance has received great importance (Hai, Moula, and Seppa 2017; Moula et al. 2017; Ekins, Anandarajah, and Strachan 2011). More clearly, the concept of societal acceptance is a major concern in energy policy in terms of implementing the principles of low carbon buildings, and in the marketing of new innovative solutions (Moula et al. 2013). Societal acceptance study contributes to the sustainable development of low carbon buildings meeting current and future-oriented societal needs. It will provide specific observations concerning the impact of low carbon buildings on society. Additionally, the study effectively addresses user's misconceptions into wider acceptance of the low carbon building applications.

User's levels of acceptance of the low carbon building systems will be considered as a part of the process optimisation. People using low carbon buildings and alternative energy sources at all levels today are forerunners, not average people. Societal acceptance study aims to find out: public awareness and knowledge about the cost of low carbon building energy applications, willingness to pay for green energy, and low carbon buildings acceptability.

3.1. Survey design and questionnaire

This study uses a survey questionnaire type of methodology that considers various users segment groups, in the financial community and among sellers, builders, and local and national and international level policymakers dealing with low carbon buildings solutions.

Questions for the questionnaire are divided into 4 different categories: individual perspective, social perspective, community, and market perspective as illustrated in Figure 2 below.

In total 27 questions are chosen. The background questions covered the demographic details of the interviewees (Q1–Q4). Questions (Q5–Q9) covered the social perspective, (Q10–Q14) covered the community perspective, and the rest of the questions covered the market perspective of LCB.

The survey questions first mapped the respondent's awareness and choice of using LCB Q8 as a first-generation (fossil fuels) or second-generation (renewables). Secondly, how important was it using LCB for them Q12. Thirdly, Q22–Q25 further highlights the respondent's understanding of LCB and its technologies and their willingness to invest in LCB Q7. A room for an open answer and the 'not known' option was available for the questions.

3.2. Data collection

An online surveying system was used to publish the questionnaire. On 27 July 2019, the public version of the survey was initiated. The question was connected to the Internet management and survey distribution network, which was used in various Internet panels to obtain the necessary amount of feedback. The target population was limited to Finnish citizens, and the research participants were divided into three classes (15–25; 26–40 and 41–60). Such groups of age were chosen to understand precisely the role of the age level towards the social acceptability of Low Carbon Buildings. Figure 3 shows the interviewee ratio for the above-mentioned data.

Approximately 46% as most respondents were the age of 45–64 followed by the age group of 25–44 by 32%. The majority of the participants (Figure 4) were employed (74%), whereas the second largest group of participants were students (10%), and few of the participants were others (11%).

3.3. Data analysis

The data collected were exported to a spreadsheet for thorough analysis from our on-line survey system after closing our online survey. Based on our survey questions, two types of variables (independent and dependent) have been chosen as follows.

(1) Independent variables through the questions: Q1–Q8, Q10–Q15
(2) Dependent variables through the questions: Q16–Q19, Q22–Q38, Q40

The open questions were analysed through a simple qualitative content analysis, by identifying certain words and calculating their repetition for each question. Using the spreadsheet calculations, the data was analysed and the selection of the statistical characteristic of the data was identified using standard statistical operations. Different kinds of statistical analyses have been used to analyse the data, for example, Co-relations, variables, and text mining analysis.

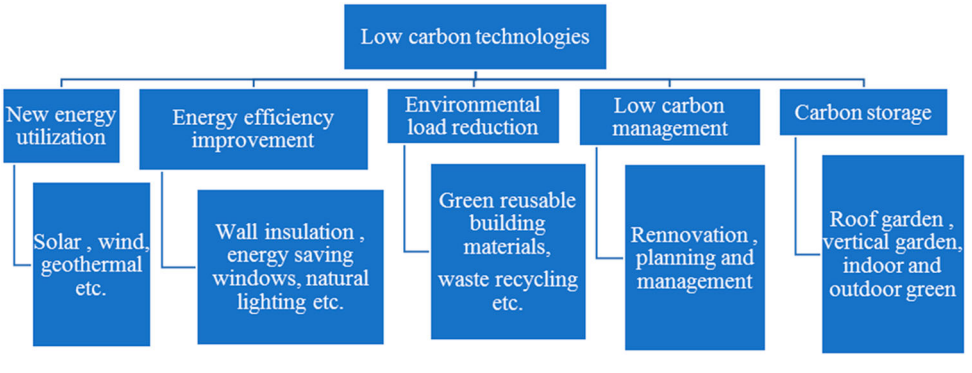

Figure 2. Questionnaire design methodology.

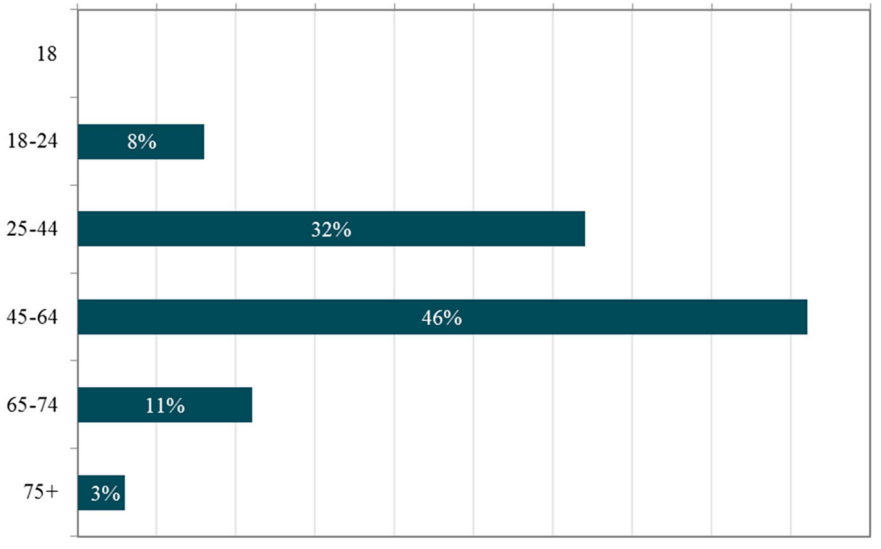

Figure 3. Percentage of the respondents by age.

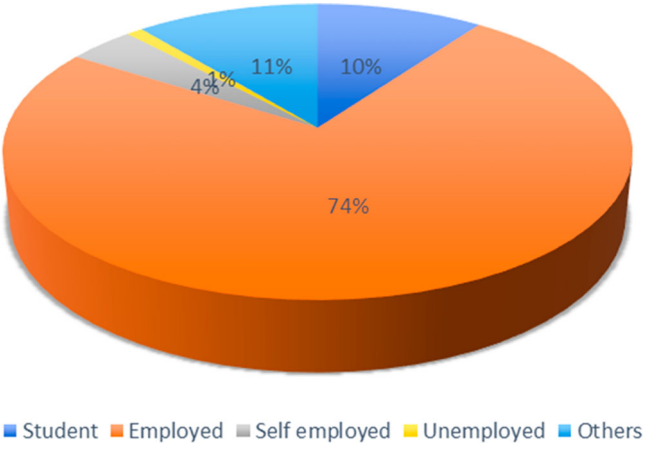

Figure 4. Percentage of the respondents by employment.

3.4. Background data

As discussed in most of the respondents were of the age of 45–64 years. Mostly living in the city side of Finland as shown in Figure 5.

Text mining analysis shows that most of the respondents are living in houses 40% followed by apartments 29.17%. Further Figures 6 and 7 below highlight the responses of Q4. Additionally, we used word mapping by hierarchical and clustering analysis to analyse the reason behind their living in such houses/apartments.

Respondents chose to live in an apartment/ house because of the following reasons as shown in Figure 6.

(i) the price (ii) location (iii) good public transportation options (iv) maintenance (v) reliable and comfort (vi) and environment friendly.

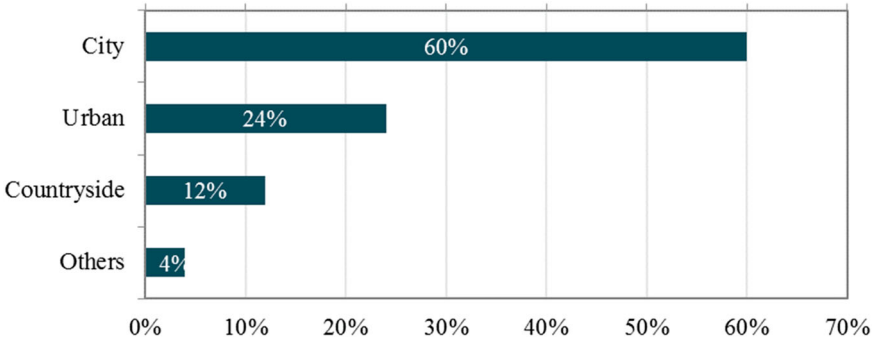

Figure 5. Percentage of the respondents by the area they live in.

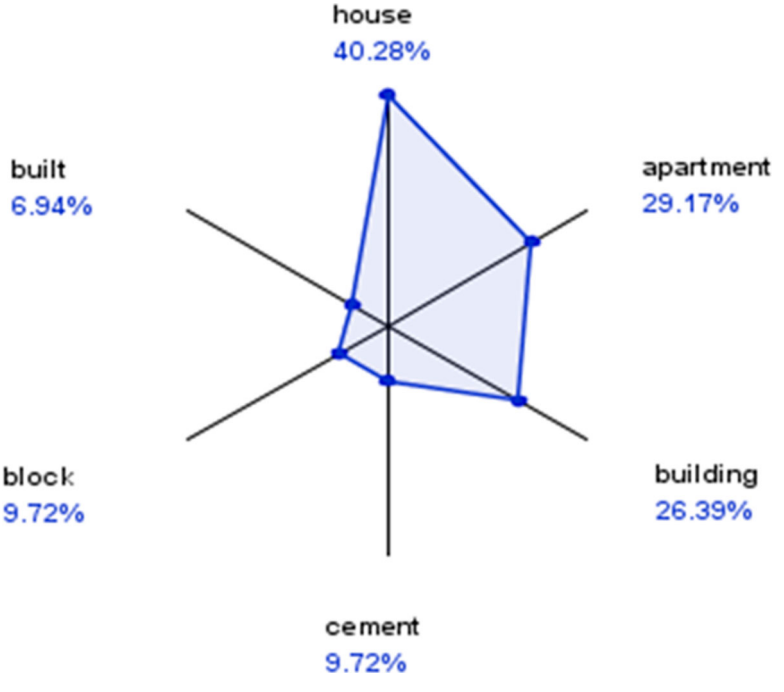

Figure 6. Percentage of accommodation in which the respondent lives.

4. Results

4.1. Users perspective/understanding of LCB

The survey highlights (refer Figure 8) that the users have a much understanding and awareness about LCB, and further they are willing to invest in it. Q8 highlights that 59.72% of the respondents have their opinion that using LCB can help to reduce greenhouse gas emissions. Respondents (Q15) are also highly equally considerate about the aspects like building price, sustainability, renewables in a building when they evaluate the building (refer Figure 9).

4.2. Willingness to upgrade to LCB

The survey shows the respondents not only have the understanding but also, they are also willing to invest in upgrading their accommodations towards LCB. Q21 (refer Figure 10) highlights that more than 53% of the respondents show their willingness to upgrade their accommodation to LCB.

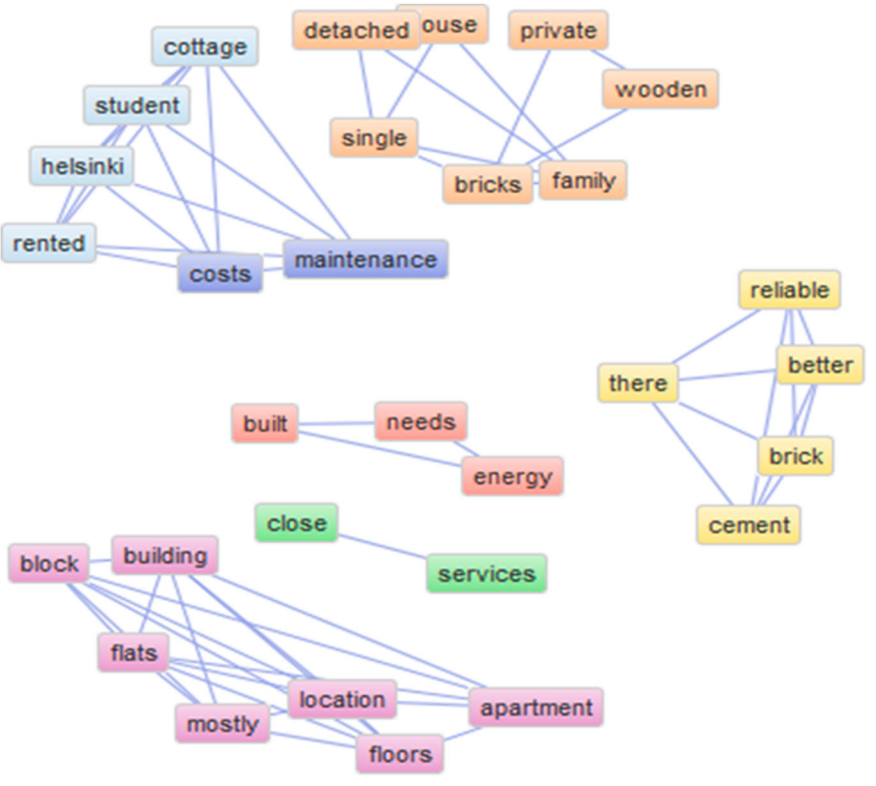

Figure 7. Clustering analysis for the Q7.

However, when asked if they want to hire any consultant to upgrade to LCB most of them don't want any consultant. Q22 (70%) were not ready to hire any consultant because a majority of having the problem in paying the upfront cost for LCB (Q23) 49% respondents, and 39% of them have the concern of payback period and rest of i.e. 25% they are not sure of the consultants, in other words, there seems to be a lack of trust on the consultants. Nevertheless, Q24 highlights even though the respondents are willing to upgrade, neither they want to hire any consultants for that, nor they want to take the loan. We can conclude from the situation that people are willing to upgrade their houses/accommodation to LCB, however, lack of trust on the consultants and financial issues seems to be a hindrance.

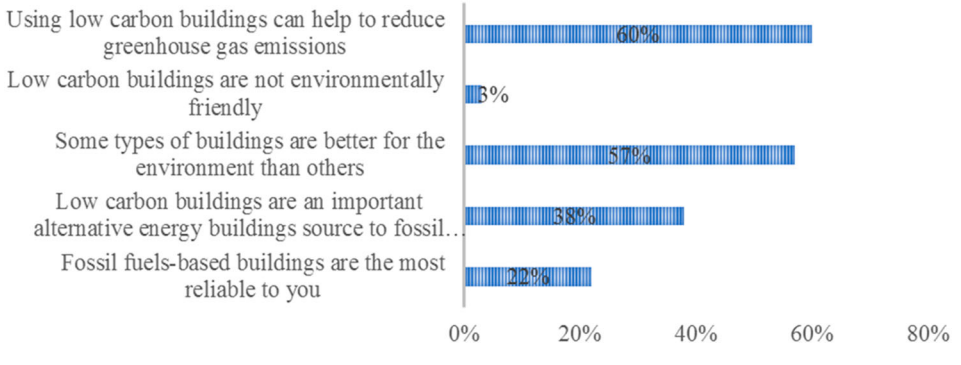

Figure 8. Respondents opinion about LCB (Q8).

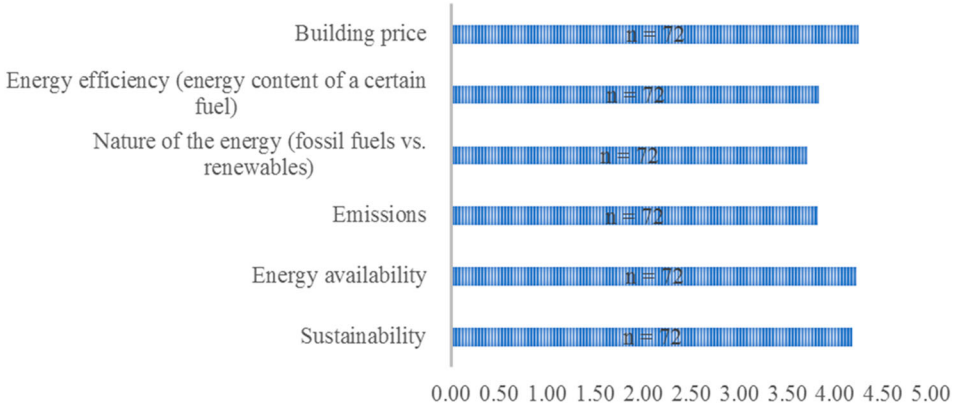

Figure 9. Aspects the respondents consider the most important when evaluating different buildings.

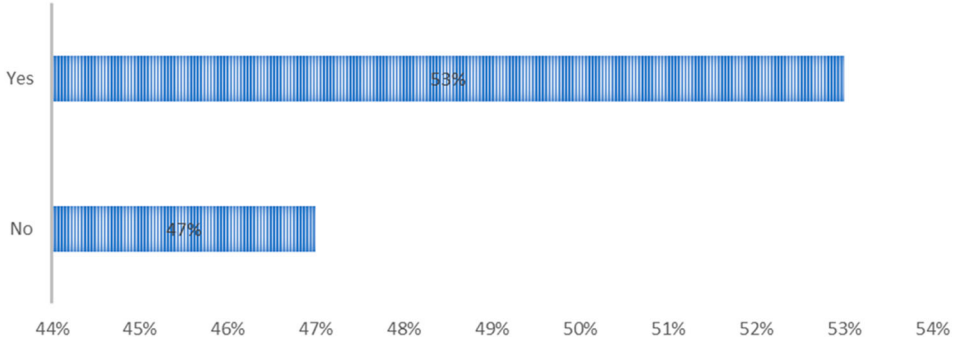

Figure 10. Percentage of the willingness of the respondents to upgrade to LCB.

4.3. Perception of energy efficiency towards LCB

When it comes to the knowledge of energy efficiency, Q25 highlighted that most of the respondents (37%) consider solar PV as one the energy efficiency among others such as solar hot water, nuclear power, power plant, wind energy, solar power plants, etc.

As mentioned in the section above we saw that the respondents are willing to invest to upgrade, however, from the Q27, they are only ready to accept a bit of upgradation in their existing building envelope. The reason could be again the lack of knowledge about LCB (Q28) and lack of trust in the consultant (Q17 and the financial constraints Q25) and, they think that LCB development is too expensive Q20.

Q28 further clarifies that respondents are not aware of the difference between LCB and Zero energy buildings. Nevertheless, they are ready to educate themselves about LCB and zero energy building. Q18 also puts a light on their willingness to know more about renewable energies in the Zero energy buildings. Also, they think that the government shall do something to increase the awareness of LCB (Q19).

5. Summary of the results and discussion

The aim of this paper is to identify the level of awareness of using low carbon buildings and climate change in the Finnish Society. In addition, this paper also addressed how the acceptability rate of

using low carbon buildings energy technology vary especially for participant's own use in their buildings or near the environment. To do so, we used an online survey questionnaire methodology that considered various users segment groups, in the financial community and among sellers, builders, and local and national and international level policymakers dealing with low carbon buildings solutions. Questions for the questionnaire are divided into 4 different categories: individual perspective, social perspective, community, and market perspective.

The total no. of the respondents was 72. Approximately 46% as most respondents were the age of 45–64 followed by the age group of 25–44 by 32%. Most of the participants were employed (74%), whereas the second largest group of participants were students (10%), and few of the participants were others (11%). The survey results convince that the people in Finland are willing to know more about LCB and Zero Energy buildings and would like to invest in these technologies in their building. The survey highlights that the users have a much understanding and awareness about LCB, However, they do not understand what the difference between LCB and Net Zero Energy Building is. Nevertheless, further, they are willing to invest in it and are also highly equally considerate about aspects like building price, sustainability, renewables in a building when they evaluate the building. However, they showed a mixed- set acceptance regarding their building up-gradation towards LCB. Knowledge, perception, fear, political beliefs are correlated with social acceptance in this regard. For example, a large number of respondents think that the government shall do something to increase the awareness of using LCB.

When it comes to the knowledge of energy efficiency, Q25 survey, highlighted that most of the respondents consider renewable energy technologies (RETs) such as solar PV as one the energy efficiency among other such as solar hot water, nuclear power, power plant, wind energy, solar power plants, etc.

6. Conclusion

When it comes to the knowledge of energy efficiency, our survey results highlighted that most of the respondents consider solar PV as one of the energy efficiency options among others such as solar hot water, nuclear power, power plant, wind energy, solar power plants, etc. The respondents are willing to invest to upgrade their existing buildings, however, they are only ready to accept a bit of upgradation in their existing building envelope. The reasons for their unwillingness from our survey results are: (1) the lack of knowledge about LCB and lack of trust on the consultant and the financial constraints, and (2) they think that LCB development is too expensive.

Nevertheless, the people in Finland are willing to know more about LCB and Zero Energy buildings and would like to invest in these technologies for their building. However, they feel financial constraints and have a lack of trust on the consultants for their building upgradation towards LCB. The solution could be that govt shall take some major steps to educate their people towards LCB and shall provide some cheap loan, or some benefits subsidy to them once they achieve LCB. Additionally, they can promote some Energy Performance contracting (EPC) business models to help them promote the upgradation of the buildings towards LCB (Alam and Keane 2019). Energy Performance Contracting (EPC) is a market mechanism provided by Energy Service Companies (ESCOs) and has been widely used as one of the most common contracting models for guaranteeing energy efficiency expectations and to improve energy efficiency, and also considered as one of the solutions to upgrade the building when there is a financial constraint from the client's side. EPC business models (Goldman, Hopper, and Osborn 2005) have emerged as one of the solutions to provide retrofitting solutions to the existing buildings. Also, EPC has been promoted by Energy Performance of Building Directive (EPBD) (2012/27/EU), and Energy Efficiency Directives (EED) to upgrade existing buildings to achieve EU energy targets by 2030.

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