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Häkkinen, Tarja; Gostik, Samo; Jung, Nusrat

Barriers for energy-efficient refurbishment at district level

ABSTRACT

This paper aims to address the need and barriers involved in the development for energy-efficient refurbishment at the district level and making conclusions about the need for improved processes. By district-level refurbishment, we mean concurrent renovation of several buildings in a same district/neighbourhood with the view to achieving cost savings, financial benefits and a more efficient use of Renewable Energy Sources (RES). Also, full optimization and performance of the nearly zero energy buildings (nZEBs) require aspects such as the consideration of load-matching and grid interaction. District-level refurbishment projects may enable a better understanding of these aspects. On the other hand there may also be significant barriers related to several factors such as legal issues regarding town planning and building permission practices; legal issues regarding practices, taxes and fees of energy generation; presence of several owners; simultaneous presence of several actors including energy companies; lack of actors able to initiate and integrate; lack of business models for profitable work in district-level projects; lack of experience in using collaborative delivery models; lack of tools for energy assessment at district level; lack of process descriptions for district-level refurbishment, and lack of design methods for optimization of grid interaction and load matching.

To understand these barriers, interviews in eight European countries were conducted. The results show that most of the questions addressed are relevant to at least to some extent. Different actors in various European regions emphasize somewhat different aspects. However, the most significant problem was found to be the involvement of many owners in district-level refurbishment projects with differing interests and their difficulty in forming an agreement. Related to this, the lack of actors who would initiate the project and motivate owners, and other stakeholders were also imperative. Besides, current legislation causes significant hindrances for refurbishment at the district level in many countries.

Keywords: Sustainable neighbourhood; Design process; Energy saving

1. INTRODUCTION

Currently, nearly zero energy buildings (nZEB) methods and technologies are implemented in a single building and not yet at the district level. To fully optimize the nZEB performance, aspects such as grid interaction and load matching are necessary since peak loads and voltage deviances require a proper synchronization of electricity consumption and production. Optimizing nZEB requires demand-side management, electric storage capabilities, and also minimization of energy delivered to the building. The presence of an existing grid or grid connection is not mandatory since district level refurbishment projects can benefit by sharing renewable energy resources, such as biomass-based micro combined heat and power (mCHP), solar for hot water and heating, or geothermal energy. They can then take advantage of load matching at a building group level to fulfil the yearly energy balance (Salom et al. 2014; Sartori et al. 2012). The focus is already shifting from single buildings towards nZEB neighbourhoods/districts. As defined by (Marique & Reiter 2014) nZEB neighbourhood is where the annual energy consumption and transportation of inhabitants are balanced by renewable energy production on site.

The main prerequisite for local distribution system as pointed out by (Salom et al. 2011) is that the energy system should be designed according to the electricity demand of the grouped buildings while considering load variations between the buildings. Load marching indicators can inform designers, architects and engineers in comparing different design options which would make use of planned integrated technology (such as mCHP), sizing of storage devices, strategies of sizing storage devices factoring in the events such as grid breakdown, etc. With a step ahead, Ala-Juusela et. al proposed positive energy neighbourhoods, where '*the annual energy demand is lower than annual energy supply from local renewable energy sources*,' aiming to support even wider generation and distribution networks. Energy positive neighbourhoods can display key performance indicators including annual mismatch ratio, maximum hourly supply, maximum hourly deficit and a monthly ratio of peak hourly demand in comparison to lowest peak power demand (Ala-Juusela et al. 2015).

Significant risks and barriers for energy efficient districts renovations include insufficient support from residents, collapse of available infrastructure, failure of new technology, not too many examples to follow, principle-agent problems, negative externalities, financing, etc. (Ahvenniemi et al. 2013; Sepponen & Heimonen 2016). The primary motivation to understand the barriers affecting refurbishment of districts is to build upon solutions such as financing possibilities, new business models such as ESCO, customer-oriented renewable model, utility-oriented model, heat entrepreneurship model, on-bill financing model, energy leasing model, etc. to support energy-efficient refurbishment at a district level.

1.1. Objective

The purpose of this study was to identify barriers pertaining successful renovation of multiple buildings in districts/neighbourhoods in seven European countries. To understanding the complex relationships between stakeholders in reference to district refurbishment in various European countries, the following barriers were

considered and assessed in (1) Legal issues regarding town planning and building permission practices; (2) Legal aspects regarding practices, taxes and fees of energy generation; (3) Presence of several owners; (4) Simultaneous presence of several actors including energy companies, designers and consultants; (5) Lack of players able to initiate and integrate; (6) Lack of business models for profitable work in district-level projects; (7) Lack of experience in using collaborative delivery models; (8) Lack of tools for energy assessment at district level; (9) Lack of process descriptions for district-level refurbishment and (10) Lack of design methods for optimization of grid interaction and load matching.

2. Method

Interviews were carried out in eight northern and middle European countries including Finland, Germany, The Netherlands, Slovenia, Lithuania, Latvia, Poland, and Austria. The aim of the interviews was to understand specific barriers preventing the district level refurbishment. We also intended to ascertain if there are significant differences or several similarities among different European countries. Such findings are further useful in the future for developing business models to attain benefits of energy-efficient refurbishment at a district level and to spike interest through collaboration among stakeholder groups in Europe.

The interviews were conducted as face-to-face meeting or teleconferences. The duration of the meeting lasted for about an hour. In total 67 stakeholders (interviewees) from the above countries participated one at a time. However, in Poland and Lithuania, the stakeholders were interviewed as a group. In those cases, the individual responses were also recorded. The number of participants per European country is presented in Table 1. The interviewees were asked to categorize themselves among eight categories based on the role of their company and their particular role in the enterprise, as categorized in Table 1 (A) Building owners with large building portfolios; (B) Designers and consultants actively engaged in district refurbishment projects; (C) Energy company; (D) Town planning and building permission authority; (E) Renewable energy technology service provider; (F) Contractors and developers engaged in district level refurbishment projects; and (G) Maintenance and building managers as illustrated in Figure 1. The interviewees were selected by the consortium teams part of 'Mobilization of innovative design tools for the refurbishing of buildings at district level' (MODER) project which is present in each of the eight European countries except in Lithuania and Poland.

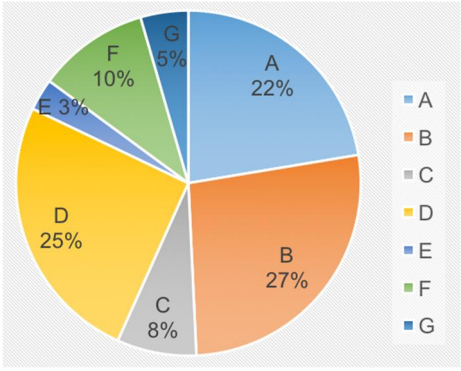

Figure 1: Percentage of respondents per category from all countries

The interviewees were provided with a set of barriers for assessing (as presented in Table 2) and the interviews were semi-structured to take advantage to document the experiences of interviews. They were also asked to determine the importance and validity of the claimed barrier on the scale of 1-5, where five was deemed very important and one as not relevant to their point of view. The list of presumed barriers is based on an extensive literature review which will be published in the future study and could not be included due to space limitation.

Table 1: Participants/ Interviewees from each European country

S.No.	Country name	No. of participants	Number of respondents per category (a.-g.)
1	Finland	23	5(A); 4(B); 3(C); 5(D); 2(E); 2(F) ; 2(G)
2	The Netherlands	6	2(A); 2 (B); 2(D)
3	Slovenia	13	2(A); 4(B); 2(C); 4(D);1(G)
4	Germany	4	2(A); 1(B); 1(D)
5	Lithuania	10	2(A); 4(B); 3(D); 1(F)
6	Poland	5	1(A); 1(B); 1(D); 2(F)
7	Austria	2	1(B); 1(D)
8	Latvia	4	1(A); 1(B); 2(F)

Table 2: List of presumed barriers presented as a set of questions to the interviewees

S.No.	List of barriers presented as questions and discussion points to the interviewees based on extensive literature review
1	Legal and institutional barriers related to town planning and building permission practices
2	Legal and institutional barriers related to the practices, taxes and energy generation fees
3	Presence of several owners
4	Simultaneous presence of several actors
5	Lack of activators or integrators
6	Lack of business models
7	Lack of proper procurement and delivery models
8	Available energy performance tools at district level
9	Designing process and methods for refurbishment at district level
10	Design methods for the optimization of grid interaction and load matching

3. Results

The cumulative results of all countries are presented in Figure 2 illustrating the importance of each barrier discussed in Table 2 and Figure 3 presents the standard deviation in the responses. This section will discuss each of the barriers selected as the most pertinent in each of the country.

The legal and institutional barriers associated with town planning and building permission process in Germany and Finland were found to be imperative. Typically, the planning processes are slow in Finland, because when a larger scale change is proposed which can influence the landscape of the site, local actors may oppose the change, which leads to further delays. The building approval process for multiple land plots at the same time is difficult to attain, but, municipalities, in general, were found to be supportive of energy efficient refurbishments. The Netherlands have strict laws protecting the rights of the tenant which are seen positively, at the same time it was found difficult for the building owner's/ housing associations to come to an agreement with the residents on needed refurbishments leading because it leads to increased rent. Similar legislation barrier was observed in Slovenia, at times 100% of the tenants/owners in a building are required to be in agreement on major renovations. Thus, we need to develop practical guidelines to support the large scale refurbishment process.

Legal and institutional barriers related to the practices, taxes, and fees on energy generation at a district level were seen as an obstacle in Finland, Germany, and the Netherlands. Most of the urban areas in Finland and Germany are connected to district heating, local energy generation in such scenario is not supported. In Finland taxation was seen as a barrier; when capacity is larger than 100kVA and the generation exceeds 800MWh. If even a part of the generated local electricity goes to national net the whole generation needs to be reported. The limit is so high that it causes no problems on building level but may decrease the profitability on district level refurbishment cases. Similar types of problems were described by the interviewees in Germany.

Legal issues on energy taxation and net metering in the Netherlands have been a significant barrier for energy generation via the photovoltaic installation of roofs which discourages the owners to share access production. The energy subsidies in the Netherland also vary from town to town each year. Increased administrative burden discourages owners to have collecting heating systems, which leads to each household having their gas boilers. The price of energy is rather low in Slovenia, leading to low interest in the implementation of renewable energy. The taxation and fees were not found to be a barrier in Lithuania and Latvia.

In general, the presence of several owners in refurbishment projects brings a lot of hindrances and barriers for smoothly proceeding processes because of different interests and financial possibilities in all countries. The availability of convincing information about the profitability of simultaneous refurbishment projects might help to solve the problem. Examples of successful projects with transparent results on costs and benefits are required.

However, the simultaneous presence of several actors was not seen as an important barrier if a leading body is presented. In the case of no one driving the process it becomes difficult from the administrative point of view for housing associations in all countries. An absence of facilitator at the district level in energy efficient refurbishment was found to be a barrier. For example, housing managers, building owner with large portfolios, ESCO companies, municipalities, etc. could play a role of an integrator or an activator for strong cases. This issue was not seen in

Latvia, The Netherlands, and Austria, mostly the housing associations, lead such processes.

Lack of business models was seen as a critical barrier in Slovenia and the Netherlands, but not in Germany. The opinion on the presence of business models was rather divided among all other countries since it was seen as very case depended on. In some cases, business models work, and in some, they don't depend on the externalities of the project leading to differing opinions. Financial models should always be presented together with the technical refurbishment plans to private owners to guide the probability of investment in long term. Lack of procurement and delivery models was perceived differently by all interviews; again it's a process driven method which varies case by case. It was seen as an important barrier and not so important at the same time. In Slovenia, implementation of pilot projects was seen as a vital step to encourage district refurbishment project mainly due to the complex interaction between banks, owners, and municipalities.

Availability of energy performance assessment tools is crucial to foresee the energy saving potential to convince stakeholders to consider refurbishment as a profitable long-term investment. The better information a business model would have on energy conservation potential more are the chances of it being successfully implemented. There are tools available in most of the countries, but not all of them can handle a large amount of data on districts, also most of the time the data on the district level is not open to the public, which makes it more difficult to conduct the initial assessment. Some respondents expressed that these tools are not able to provide very accurate savings, of course, predictability can go only so far as the actual consumption also depends on the individual household practices.

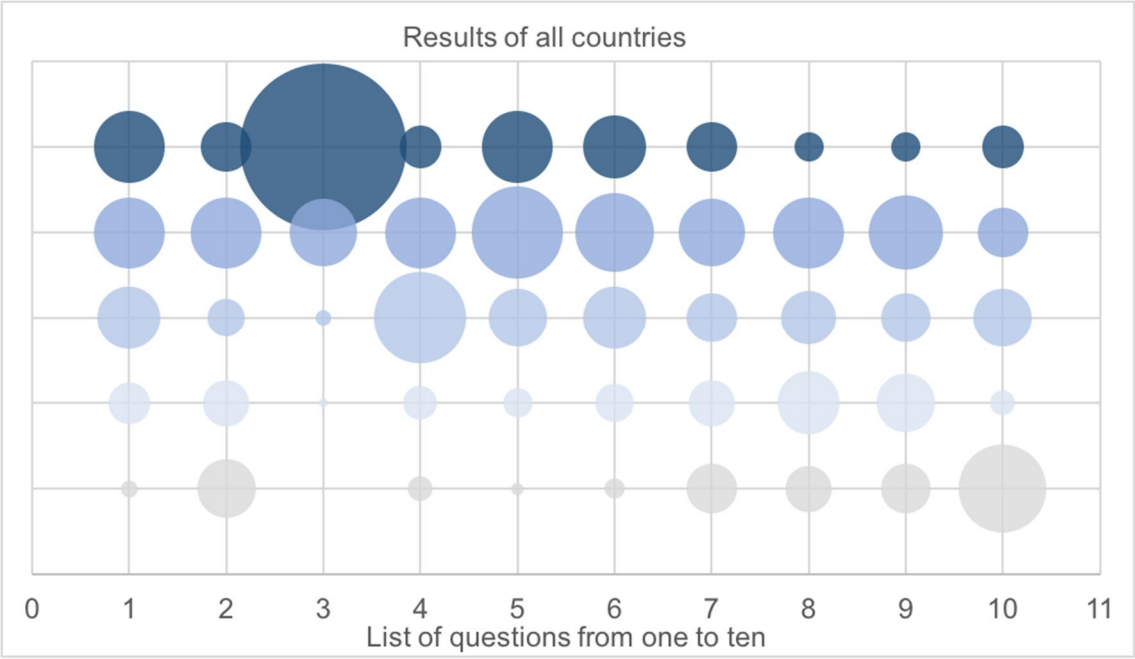

Figure 2: The size of the bubbles represents the number of answers and the colour gradient of grey to blue represents the scale from least important to most important

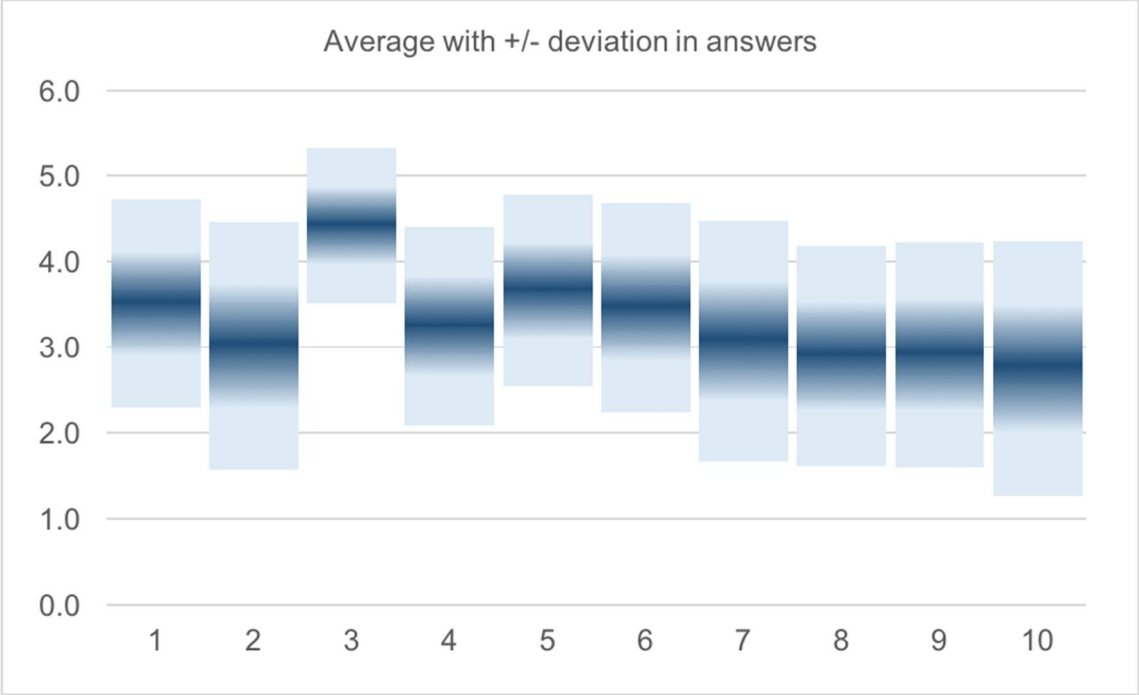

Figure 3: Deviation in interviewee responses

Designing process and methods for refurbishment at district level were seen as an obstacle but was not found to be a very significant barrier. Reason being that there are example projects in most of the countries, but at the same time analysis, legislation and license related issues are a single building oriented. Thus, in general, there is a lack of suitable models showing the comparison of energy savings between single building renovation versus collective buildings. On the other hand, design methods for the optimization of grid interactions and load matching are imperative from the technical perspective, but it was not observed as a barrier. It was noted that many interviewees were not familiar with problems which may occur in case set of buildings have their shared network. Thus, even though it was not observed as a barrier, prediction models for load matching are very much needed to evaluate the supply and demand including peak loads.

4. Conclusion

Interviews were conducted in eight European countries including Finland, Germany, The Netherlands, Slovenia, Lithuania, Latvia, Poland, and Austria. In total, 67 stakeholders were interviewed which included building owners with large portfolios, energy companies, designers, consultants, town planning and building permission authorities, renewable energy providers, contractors, developers and maintenance managers. Most of the interview were from Finland and least from Austria. The opinions of the interviewees were found to be very dissimilar because it was dependent on their experience on participation in district refurbishment projects and the role of their organization in those project.

The three most important barriers perceived by all interviews include presence and collective agreement of several owners to start district refurbishment projects, lack of activators or integrators and institutional & legal obstacles related to town

planning and building permission practices. In Germany, barriers connected to regulations were not observed. In Poland, lack of energy assessment tools at district level was not seen necessary. For the Netherlands, agreement between the owners and lack of adaptable business models were considered as barriers. Slovenia and Lithuania somewhat had similar restrictions related to change in laws because of common ownership transition into distributed ownership.

It was noted that lack of assessment tools at district level was not found to be a significant barrier, but it is likely that the interviewees didn't have much experience in using any tool or being involved in the project which used such tools. We need more advanced district energy models which can predict the occupant behaviour also presented by (Yamaguchi et al. 2003). Pilot studies such as that of (Kilkiş 2014) have successfully demonstrated in matching the heating and cooling demand with waste heat/low-temperature energy resources leading to a reduction in high exergy resources. A second follow-up publication of this study will further explore the results of interviews in greater detail, along with business models to reduce the recognized barriers.

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