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The perception of Swedish housing owner's on the strategies to increase the rate of energy efficient refurbishment of multi-family buildings

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ABSTRACT

Improving the energy performance of existing buildings is crucial for reaching both EU and national climate and energy targets. The main objective of this study was to map challenges that Swedish housing owners perceive when making energy-efficiency refurbishments. A secondary objective was to compare how well these challenges relate to national strategies. The study applied a combined methods approach with audience response meters and in-depth qualitative semi-structured interviews. The housing owners express the view that they have sufficient knowledge of national ambitions to improve the energy performance of buildings and welcome the new building regulations. Despite this supposed knowledge and the current economic situation with beneficial loans, the refurbishment rate still remains low. The housing owners explain that they are concerned about the 'performance gap' and request more accurate energy performance predictions. They are also waiting for proof that all sustainability goals can be reached in reality. Probably, too few projects fulfilling ambitions in all categories: economically, socially and energy-wise have been followed up and demonstrated nationally. The new national information centre on refurbishment of buildings may help to spread information about such projects, raise awareness and thus increase the refurbishment rate.

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Energy conservation measures; facilities management; stakeholders; sustainable development

1. Introduction

The EU has, through the Energy Performance of Buildings Directive (EPBD) (2010/31/EU and 2012/27/EU), established goals for reducing overall primary energy consumption, reducing CO_2 emissions, and increasing the share of renewable energy in the building sector (EU 2015). There is a huge potential for energy savings in existing buildings. It has been recognized that improving the performance of existing buildings is crucial for reaching both EU and national climate and energy targets, moving towards a more sustainable energy system. It is often possible to cut energy consumption in half, and in many cases, the modifications are economically beneficial for the housing owner from a building life cycle perspective (Westlund et al. 2012; Gustafsson 2017).

It is up to each country to create its own incitements in order to reach these goals. According to implementation of the Energy Efficiency Directive (2012/27/EU): Energy Efficiency Obligation

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Schemes (Zygierewicz 2016), there are totally 479 policy measures implemented or planned to be implemented; the largest share of the overall savings is expected from energy efficiency obligation schemes (34%), financing schemes or grants (19%), and from taxes (14%). Some countries launched very few policy instruments (e.g. Italy) whereas others such as Germany or Slovakia adopted 112 and 66 policy instruments respectively. Among these policies, there are several examples of how countries have chosen to do their own implementation (Thomas 2015; Hinge 2017; Interreg Europe 2017; Department for Business, Energy and Industrial Strategy 2018). France has mandated renovation for commercial buildings, requiring individual buildings to develop a 'plan for renovation' that will result in a reduction of energy consumption by at least 25% relative to the 2010 performance level. The Netherlands published a grant scheme for landlords to improve insulation in rented properties and energy labels for housing. The UK government also introduced the Green Deal framework, to make the 'Pay as You Save' system for home energy efficiency more accessible to businesses, while ensuring adequate protection for consumers. In California USA, financial incentives for energy efficiency measures are funded via the Public Goods Charge levied on the electricity and gas prices. While the Italian government allows homeowners to deduct up to 55% of the expenses incurred to implement energy efficiency renovations or renewable energy technologies in existing homes from their income tax. The focus of the Swedish National Board of Housing, Building and Planning (SNBHBP) has historically been to set up building regulations for new buildings (Swedish National Board of Housing, Building and Planning (SNBHBP)). However, existing buildings undergoing major modifications should, according to the regulations, be modified to reach the same energy performance levels as new buildings, if possible. In practice, the regulations related to the modification of existing building have been difficult to control and follow up.

Back in 2013, SNBHBP and the Swedish Energy Agency suggested the first national strategy for the energy efficiency refurbishment of buildings (Boverket and the Swedish Energy Agency 2013b). This was carried out after directions from the Swedish government, in accordance with the EU Energy Efficiency Directive. The report shows three cases; a reference case with current policy instruments in effect until 2050, one case (scenario 1) with additional informative policy instruments and one case (scenario 2) exploring what is required to reach a 50% reduction of purchased energy use in buildings. The results show that the reference case will achieve a 22-30% reduction in purchased energy by 2050 (as compared to 1995). Scenario 1 will achieve a 26-40% reduction with suggested informative policy instruments including a renovation center working with energy efficiency and refurbishment as well as more information regarding energy efficiency measures to banks, in order to give them a better understanding of the economic potential and thereby provide more favorable loans. In order to reach a 50% reduction in purchased energy (scenario 2), working with additional policy instruments alone is not enough, according to SNBHBP. Instead, the renovation rate needs to increase significantly in order to reach this goal. However, the scope of SNBHBP's first study did not include this aspect.

The national refurbishment strategy was further expanded in 2015 (Boverket 2015). Two main obstacles for the energy efficiency refurbishments mentioned are housing owners' lack of knowledge and financial difficulty. More detailed suggestions for the set-up of an information center for refurbishment are proposed. An information centre should help owners of multi-family houses to acquire the knowledge necessary to make well-informed decisions with regard to energy efficiency refurbishments. Regarding financial issues, three obstacles are mentioned. The first obstacle is that housing owners do not have enough equity to undertake energy-efficient refurbishments without taking large loans. The second obstacle, which is linked to the first one, is the high costs for loans, and the third obstacle is the problem of not generating enough extra revenue after the refurbishments to make them profitable. The third obstacle is partly due to how apartment rent is regulated, with limitations on how much the rent can be increased after refurbishment, and this partly reconnects back to a lack of knowledge, with housing owners being unable to identify profitable energy efficiency refurbishment measures. These will all lead to profitable energy efficiency refurbishments not being explored fully, with unnecessarily high energy use after refurbishment as a consequence. Regarding

financial difficulties, the report suggests that the state credit guarantee should be expanded to include refurbishments as well, in order to increase the rate of refurbishment.

In November 2016, SNBHBP and the Swedish Energy Agency came with even more updates of the national strategy for the energy efficiency refurbishment of buildings, in order to stimulate an increased refurbishment rate (Boverket and the Swedish Energy Agency 2013a). In the report, it was concluded that the main challenges housing owners face are related to high expenses in the building sector at the moment. The great need for new dwellings increases building costs and limits the opportunities to upgrade the existing building stock. Increased competition among entrepreneurs and new technologies are needed to reduce costs, according to the report.

Recently, SNBHBP has released revised national energy directives for new and existing buildings, called 'near zero energy building regulations' (NNE) (Boverket 2017). Initially, the new regulations do not call for improved energy performance compared to the previous building regulations (BBR 24), instead, they just change the way of calculating performance based on primary energy factors. But over the next few years, the regulations will be more restrictive step by (but still considered far from 'zero energy' by most experts). The paragraphs regarding the modification of existing buildings, however, have not changed.

As long as five years ago, major players in the building sector and academia with a base at Lund University created 'Renoveringscentrum', a center partly funded by research money (http://www.renoveringscentrum.lth.se). The purpose of this center was, just like the intended national information center, to spread information and knowledge about energy-efficient and sustainable refurbishment. Not until 2017 did the government decide to give 'Renoveringscentrum' and "Svensk Byggtjänst", a public limited company, the responsibility and financial support to establish a national information center, called 'Nationellt Renoveringscentrum' (NRC), based on the excising center. Together they created a web page with information about the refurbishment of buildings to reach all actors in the building sector (http://www.renoveringsinfo.se).

Regardless of the building regulations, information center and financial incentives being realized as anticipated or not, the renovation of existing multi-family houses are still not making substantial progress. The progress to a national information center might help, but the reasons why owners of multi-family houses still hesitate to start energy-efficient refurbishments are still unclear.

1.1. Scope and objectives

The main objective of this study was to map the perceived challenges that owners of Swedish multi-family houses see from their own perspective regarding energy efficiency refurbishments. On purpose, the study was based on open questions and open discussion to allow attendees to express their own understanding as to why the energy efficiency refurbishments rate remains low in Sweden.

A secondary objective was to compare how well the challenges reported by the housing owners relate to the challenges identified and strategies proposed by SNBHBP and the Swedish Energy Agency in report ET 2013:22 and Boverket 2015, 47 (Boverket and the Swedish Energy Agency 2013b; Boverket 2015).

Energy companies were consulted to get their view on the energy efficiency refurbishment of buildings. The underlying goal of the study was to identify ways to assist and stimulate owners of multi-family houses to increase the rate of energy-efficient refurbishment projects.

The study was conducted in a Swedish context and was carried out as a part of the research project 'Gentle Energy-Efficient Refurbishment', funded by the Swedish Energy Agency program 'E2B2' (Gentle Energy Efficient Refurbishment (in Swedish)). In the project, local municipal housing owners and Dalarna University collaborate in the refurbishment of a demonstration building, called a 'Living Lab' reported within the 'Sustainable Integrated Renovation' network (http://www.renoveringscentrum.lth.se/siren/). The aim is a general improvement of energy performance with added energy efficiency measures for ecological sustainability and lower energy costs. The details of the project are reported in the Swedish Energy Agency program 'E2B2' (http://www.e2b2.se/).

ByggDialog Dalarna, a network of companies from the building sector in the region of Dalarna, a county in Sweden, organize seminars and workshops to spread information and results from projects such as Gentle Energy-Efficient Refurbishment. ByggDialog Dalarna has also proposed a local strategy for energy-efficient refurbishment, called 'Strategy for Low Energy Buildings in Dalarna' (in Swedish) (Persson 2014). Data for this study were obtained at some of ByggDialog Dalarna's workshops, as relevant information was displayed and discussed among regional actors in the sector. Even though housing owners contributing to the empirical material were local, the studied challenges have a general interest for the national Swedish context.

2. The potential of energy-efficient refurbishment measures and tools to support the refurbishment process

Energy use in buildings represents about 40% of the EU's total final energy consumption and CO_2 emissions – and this is the same in Sweden. The refurbishment rates are low, 1.2% per year in the EU with similar figures in Sweden, as discussed in the report 'Suggestions for incitements to increase the rate of refurbishments' (Martin et al. 2015). The potential for energy savings is substantial. According to an evaluation of the Energy Performance of Buildings Directive roadmap, the EU needs to boost the number of major refurbishments and speed up the refurbishment rate of the existing stock to above 2% annually in order to reach energy and environmental targets (EU 2015).

A large share of the building stock in Sweden was built about 50–60 years ago, during the 'million programme' (a large public housing programme to construct one million dwellings for low-income families in urban areas), such as the building focused on in this case study. These buildings are often in need of general improvement and synchronized energy improvements and are therefore particularly important to address as refurbishment objects (Mangold 2016). Unlike most Swedish detached houses, and European multi-family buildings which most frequently have separate heating systems, 91% of the Swedish multi-family buildings are heated by district heating networks (The Swedish Energy Agency 2015). Most of these old buildings have similar building construction and simple exhaust ventilation systems without heat recovery (58%) or natural ventilation (38%) (Berggren et al. 2008). The average specific energy use is typically roughly 150–200 kWh/m^2, year. These many similarities mean that refurbishment projects on a single building, such as the building in this case study, also are relevant for a large number of buildings in the entire country.

Various examples of a major refurbishment of buildings from the 'million programme' have been presented nationally (http://www.renoveringscentrum.lth.se; http://www.renoveringsinfo.se; Dalenbäck, Norling, and Mjörnell 2011; Vesterberg and Andersson 2017; Lindbergh et al. 2017). These typically include refurbishment measures such as balanced ventilation with heat recovery and improved insulation of the building envelope. A hypothesis in the project Gentle Energy-Efficient Refurbishment is that many of these refurbishment examples have been too extensive, and, as a result, the investment costs become too high to be rational for most housing owners. The project 'Brogården' in Alingsås is one example where the refurbishment cost was about 2000 €/m^2 resulting in a rent rise of about 50%. The energy saving was only 20 €/m^2 annually (Building Energy Efficiency for Massive market Uptake 2014). One drawback with this kind of renovation resulting in a high rent increase is that tenants with lower income are forced to move (Boverket 2014).

In the Gentle Energy-Efficient Refurbishment project, on the other hand, refurbishment packages spanning from 'light', with moderate energy savings, to costlier, with near zero energy standards were therefore presented as alternatives to choose from for the housing owners. The idea was to emphasize refurbishment measures having less impact on the building and its tenants, such as exhaust air heat pumps added to the existing ductwork, insulation to the attic, ventilation radiators to pre-heat incoming air, window improvements, solar cells, efficient water-taps, etc. A crucial question was to find out which level should be chosen to acquire an optimal balance between the degree of energy improvement in each individual building and the frequency of energy efficiency work from building to building. Of earlier projects in Sweden, Milparena in Gothenburg had a similar context

with limited financial resources for energy efficiency improvements, the district heating price was low and only a moderate rent raise for tenants could be acceptable for socio-economic reasons (https://www.sp.se/sv/index/research/effenergi/completed/effen_milparena/sidor/default.aspx).

How frequently housing owners actually use the newly constructed national renovation center has not been documented to this date. For some time, 'BEBO', a network of housing owners supported by the Swedish Energy Agency, has been an alternative information channel regarding energy-efficient refurbishment (http://www.BEBO.se). But in reality, most of the planning and calculation of energy efficient refurbishment is outsourced to consultants. These work under strict time constraints in a rapidly expanding building sector. As this article was written, Sweden had the highest building price per square meter in the EU (http://www.eurostat.eu). Due to this circumstance and the fact that modern buildings, and especially their service systems, are becoming more and more complex, there is a risk that the consultants only present one or two alternative solutions, not taking time to present any 'green' or 'energy-efficient' alternatives. Research studies have even shown that consultants often predict energy performance levels which are seldom reached in reality, resulting in a so-called performance gap between predicted and actual energy performance (Danielski 2012; De Wilde 2014).

Tools or guides may help housing owners to choose refurbishment measures and to remind them to consider energy aspects continuously in all stages of a refurbishment process. Bygga E is an example of such a guide written by Research Institutes of Sweden, RISE, and it communicates how to work with energy aspects can naturally be included in the process from planning to production, to the stage where the building is completed (Swedish Research Institute RISE 2013). Sveby, a development program financed by the Swedish Energy Agency together with many of the largest housing owners in Sweden, provides similar tools used to standardize and verify energy performance in buildings (handbooks, calculation tools and checklists, etc.) (http://www.sveby.org).

In the Swedish building market, BREEAM SE, LEED, WELL and Miljöbyggnad are generally preferred. These building certification systems set requirements regarding many categories comprising energy performance and environmental aspects and Miljöbyggnad is the most common system in Sweden (Sweden Green Building Council 2017). If the housing owner demands a proposal on optional refurbishment packages aiming for high certification ratings from the consultant, energy aspects are easily secured in the planning process. But so far, certification of buildings from the 'million programme' era have been uncommon.

Financial calculations for energy measures vary from simple pay-back calculations to life cycle calculations (LCC) or other methods such as the Total Concept method (The Total Concept method). Total Concept is a method used to ensure as many refurbishment measures as possible are included in an economically viable 'energy refurbishment package', i.e. one that falls within the company requirement for a return on investment. What is common for all methods is that it can be challenging to evaluate the economic outcome over a building's life span due to uncertainty over future energy prices, etc. Farsäter et.al claim that a standard on how to structure the methodology and input data to be used when calculating economical profitability would contribute to the process of disseminating information on renovation projects (Farsäter et al. 2015). In the same paper, a synthesis of renovation projects shows the variety of calculation methods used, but only about half of investigated renovation projects were considered to be profitable.

It can also be challenging and complex to balance economic aspects with social and ecological sustainability. There is, for example, a risk of increasing societal inequity due to rent increases in renovated buildings, as reported by Mangold et al. (2016). Renobuild, a new commercial tool developed by RISE, was developed to assist housing owners in the refurbishment process of multi-family buildings. The tool takes into account the social, ecological and economic consequences of refurbishment. Because it focuses solely on refurbishment, not the construction of new buildings, it is more efficient in assisting the choice of refurbishment measures (Mjörnell et al. 2014).

Since the Swedish building regulations have always considered purchased energy, not primary energy as in the EU directive, it has been difficult to judge the real environmental impact through

saving electricity compared with making savings through other energy carriers. The situation is especially complex for buildings connected to a district heating network, such as most multi-family buildings in Sweden. Reducing the district heating demand by a certain amount, but increasing electricity demand by a lower amount may actually lead to an increased environmental impact (Swing Gustafsson 2016; Gustafsson et al. 2017). New national energy performance of building regulations based on primary energy factors have only recently been introduced by SNBHBP in BBR 25, BFS 2017:5 [13].

Research papers may help in choosing a renovation strategy and making decisions on renovation measures. But according to Farsäter (2017), only about 5% of 234 papers on refurbishment compiled and reviewed cover all sustainability aspects (and never all three aspects in-depth). The most comprehensive research work on the ecological aspects of refurbishment is being conducted within the research school REESBE (Resource and Energy-Efficient Built Environment) (http://www.hig.se/Ext/Sv/Organisation/Akademier/Akademin-for-teknik-och-miljo/Forskning-vid-akademin/Forskarskola-Reesbe.html). When it comes to social sustainability in refurbishment projects, important studies have been collected in the anthology, Sustainable Integrated Refurbishment (in Swedish) (Swedish Research Institute RISE 2015).

Most countries within the EU with comparable conditions, such as Denmark, are at the same stage regarding investment subsidies for refurbishment, energy consultants to increase relevant expertise, and mandatory energy reports (Meyer et al. 2014), while Germany has progressed furthest, regarding regulatory instruments and subsidy programs together with communicative instruments, to motivate homeowners to pursue energy-efficient refurbishment. To date, Germany has been successful in some aspects, such as stimulating the implementation of solar cells, while is has been more limited regarding the deep renovation of buildings. Stieß and Dunkelberg address the question of how to improve or supplement German political instruments in order to increase the refurbishment rates further and tap the full potential savings (Stieß and Dunkelberg 2013). They analyze the existing policy instruments and the barriers responsible for the discrepancy between potential and actual refurbishment rates. They conclude that the rate of energy refurbishment of existing multi-family buildings is very much linked with coordinated campaigns and the escalation of gas and electricity prices.

Few studies map how the owners of multi-family housing value their own expertise and challenges in energy-efficient refurbishment, and their awareness of tools available to assist in refurbishment projects like the present work. Here, data were collected both qualitative through deep interviews and quantitative in interactive workshops with a larger group of representatives from the building sector.

3. Methodology

This study applied a combined methods approach (Creswell 2014). First, quantitative data were collected during two workshops held by ByggDialog Dalarna. Twelve representatives from regional housing attended the first workshop. Among these were the two largest local municipal housing companies in Dalarna county, owning between 60-70% of the total number of rental apartments in their respective municipalities. The range of companies, from the two largest local municipal companies mentioned above, down to private medium and small-sized companies, was chosen to reflect the whole span of means, terms and conditions that housing owners have, in order to conduct energy-efficient refurbishments.

The second workshop comprised 12 representatives of energy companies. This workshop was held in order to obtain an understanding of energy companies' roles in energy-efficient refurbishments. During both occasions, the research project Gentle Energy-Efficient Refurbishment was presented to introduce the participants to a relevant refurbishment project. The particular case study was discussed, but also energy-efficient refurbishment in general. Relevant questions were then presented to the audience and responses were collected using clickers or audience response meters (Patry 2009). In this way, all the participants could give a response to each question anonymously and express their own perspectives. The results were displayed on a screen in real time, accompanied

Table 1. Questions about energy-efficient refurbishment and corresponding answers. Housing owners are denoted A and energy companies denoted B.

		Very much	Considerable	To some extent	No	No opinion
Do housing owners have sufficient knowledge about the national building regulations and future energy targets?	A	27%	47%	20%	7%	0%
	B					
Can tools like Sveby, Bygga E and building certification systems such as BREEAM, LEED, WELL or 'Miljöbyggnad' be useful in order to choose refurbishment measures?	A	67%	27%	0%	0%	7%
	B	39%	23%	15%	15%	8%
How dependent are housing owners on consultants in energy efficiency work?	A	29%	64%	7%	0%	0%
	B	61%	31%	0%	0%	8%
		Vital	Important	Slight importance	Not important	No opinion
How important is it to consider social sustainability in refurbishment projects?	A	13%	53%	33%	0%	0%
	B	23%	31%	15%	23%	8%
How important is it to recycle knowledge from one refurbishment project to the next?	A	93%	7%	0%	0%	0%
	B					
How important is dialogue with the energy companies when choosing energy-efficiency measures for buildings?	A	0%	27%	47%	27%	0%
	B	23%	38%	8%	15%	15%
		Always	Frequently	Seldom	Never	No opinion
Do refurbishment projects in Sweden have clear goals, proper project management to reach the goals and verification of fulfillment afterwards?	A	7%	20%	53%	0%	20%
	B					

by further discussion and questions. The response frequency was always 100% as the participants were asked to vote 'no opinion' as an option. Some questions were directly related to the ongoing research project, while others were general for the building sector, see Table 1.

Finally, in-depth qualitative semi-structured interviews were carried out with a representative of ByggDialog Dalarna, the CEO of a large municipal housing company, the technical manager of another large municipal housing company, and the technical manager of a medium-sized private housing company (Eisenhardt 1989; Patton 1990; Silverman 2005).

The purpose of interviewing ByggDialog Dalarna was to apprehend the opinion of an academic partner closely networking with the building sector in the region. The interviews with the housing owners were to provide a deeper understanding of the challenges companies perceive, both municipal and private. The reason for interviewing a CEO and a technical manager of large housing companies was to capture perceived challenges ranging from economical to technical aspects in depth.

All interview subjects were introduced to six open general questions to allow them to reflect on the themes, freely, and in discussions during the interviewers. Some specific questions were prepared for each 'category', only to make sure that the most vital aspects were covered. The interviews were taped, transcribed and abstractions, i.e. data reduction, were made from the emerging themes. The questions and results of the interviews are presented in section 4.2.

4. Results

The results of the workshops about energy efficiency work in the building sector, where 12 housing owners and 12 energy companies attended, are presented in Figure 1 and Table 1**.** Related statements of importance are summarized below.

4.1. Résumés from the workshops

The most challenging factor in energy-efficient refurbishment is 'economy', according to the housing owners and the energy companies leaving votes with the audience response meters, see Figure 1. The current building regulations, on the other hand, were considered to be a minor hindrance in

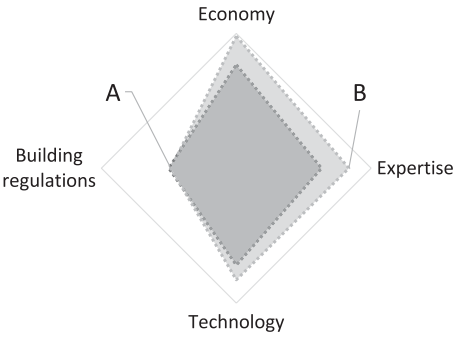

Figure 1. Challenging factors in energy-efficient refurbishment for housing owners. Response from housing owners denoted A and energy companies denoted B. Aspects considered as great limitations are indicated by points far from origo.

refurbishment projects. Challenges related to expertize and technological limitations were more problematized by the energy companies than the housing owners.

The majority (74%) of the representatives of housing owners indicated that they have considerable or a great deal of knowledge about national strategies to increase the rate of energy efficient refurbishment. However, the housing owners stress that they are often under time pressure, and their technicians should be more involved in the planning of energy efficiency work. According to more than half of the attendees, projects very seldom have clear goals and proper project management to reach the goals and verification of fulfillment afterwards (see Table 1). Probably implementing certification systems such as BREEAM, LEED, WELL or 'Miljöbyggnad' could help to involve those with in-house knowledge more time efficiently (94% of the housing companies and 62% of the energy companies indicated that these kind of tools could be of great use). However, the initial effort and costs to start certifying existing buildings from the 'million programme' era seem too high, according to the discussion. On the other hand, the housing owners stress the importance of documenting/recycling knowledge from one refurbishment project to the next (100% agreement).

A debated issue during the workshop was the importance of having the right in-house knowledge among housing owners to make smart decisions in refurbishment projects. Still the housing owners and energy companies indicated with the audience response meters that the housing owners are very dependent on consultants in energy efficiency work. The housing owners explained that many believe that calculated energy performance levels are seldom reached in reality. That could be a major reason for hesitation regarding refurbishment among housing owners. These housing owners do not believe that the energy and financial savings estimated by consultants are viable. Improved interaction with the consultants could probably improve the quality of energy performance predictions, according to the discussion.

Most attendees agreed that it is more important to lower electricity demand than heat demand. Hesitation to start refurbishment projects could also be related to the old building regulations. The last argument to wait or only carry out cosmetic or less costly improvements, rather than expensive energy efficiency measures, was to avoid increased rent for tenants.

After the Gentle energy-efficient refurbishment case had been presented (http://www.e2b2.se/), the housing owners discussed and nominated the most appropriate refurbishment package among a few alternatives. No one chose the most comprehensive or 'deep' refurbishment package. Instead, all choose lighter, less costly, refurbishment packages. Only two voted for solar cells (technical aspects are not covered in depth in this study).

Most attendees had benefited from the BEBO network directly or indirectly (http://www.BEBO.se), but no one knew about the new national information center about refurbishment at the time of the work shop.

4.2. Results from the qualitative interviews

Below follows the questions and a summary of themes emerging from the qualitative interviews.

Do housing owners have sufficient knowledge about national building regulations and future energy targets to make good decisions in energy-efficient refurbishment?

From the organization ByggDialog Dalarna, it was clearly stated that there is a lack of in-depth knowledge among housing owners due to the supplementary training level being lower in the building sector than in most other sectors. As regards the private sector, there is even less knowledge about energy-efficient refurbishment than among the public-sector actors.

These views were not completely embraced by the municipal company A who stated that they had in-depth knowledge about national building regulations and goals. However, they also expressed the view that when starting a refurbishment of a multi-family building, as in the case of the Gentle Energy-Efficient Refurbishment: 'We have to consider our "triple bottom line"; which means we try to secure sustainability in all three categories: social, ecological and economical. In a previous case, we lowered the energy consumption from 150 kWh/m^2 to less than half'.

The company state, though, that the project was not socially sustainable because the tenants could not afford the consequential rise in rent. Neither was it economically sustainable because the need for write-offs became too high. The company, therefore, reconsidered the strategy and plan to spend less money on the next refurbishment case. 'This way we fulfil our "triple bottom line" and we can secure a higher refurbishment rate on our building stock. Still, the ambition is to cut the energy consumption to about half'.

In municipal company B, they believed that housing owners with 1000 apartments or more generally have good knowledge of building rules and goals. SABO, the Swedish Association of Public Housing Companies, is the most important forum to share experience and knowledge (https://www.sabo.se/). It is mainly the large municipal owners which attend SABO or BEBO meetings. The company also thought that there has been a mismatch between EU directives and the national building regulations, which have made energy-efficient refurbishment problematic.

> With the old Swedish regulations (BBR 24) there was risk for unwise decisions because the goals are set in purchased energy even if we talk about environmental aspects. It's not necessarily better to aim for a purchased energy level of 50 kWh/m^2 instead of 80 kWh/m^2. We need to have better life cycle and energy system perspectives. Building rules should be set in primary energy or CO_2 per square meter, not purchased energy. The new regulations (BBR 25) is a step in the right direction.

In the private company, they concluded that there was in-house competence because they were affiliated to a company working with building construction. They also believed that in small private housing owners, knowledge is often dependent on interest among individuals. 'But since we are a relatively large company, we monitor our energy consumption and have our own energy targets'.

What are the main reasons for starting refurbishment of existing multi-family buildings from a housing owner perspective? How important is improvement of energy efficiency compared to other aspects?

According to ByggDialog Dalarna, the main reasons for refurbishment and improvement are the bad condition of buildings and 'unhappy tenants'. The energy cost is not considered to be a ruling factor, although energy aspects are sometimes included through energy performance contracting (EPC).

For municipal company A, the main reason to refurbish is to prolong the lifespan of 'million programme' buildings in order to avoid value loss. A second important aspect of refurbishing that company A brings up is the improvement of the indoor climate, which connects back to ByggDialog Dalarna's mention of 'unhappy tenants'. In order to learn more regarding the energy aspects of refurbishing, the company has also initiated collaboration projects with academia.

Municipal company B also showed similar priorities, with an extension of building life being the main factor for refurbishing. Maintaining satisfactory living standards for tenants was also brought forward as an important aspect. Regarding energy efficiency, company B stated they never carry out

costly 'deep refurbishment' and that energy aspect are timed with bathroom and drainage pipe renovations.

The private company simply stated that refurbishment is initiated when a building is in need of maintenance. As for energy efficiency measures, they are, according to the private company, only economically feasible when timed with general maintenance.

What are the main challenges in energy efficiency work? (economy, expertise, structure of building sector etc)

Economic factors provide the main challenges, followed by technical barriers, according to ByggDialog Dalarna. They also see that housing owners often lack technical expertise, leading to difficulties in making the right decisions. Historically, the housing owners would often reason with potential entrepreneurs about possible refurbishment measures in the initial stage of a refurbishment process. Over the last few years, a strict legal tendering process might frighten housing owners from contacting entrepreneurs at an early stage so as not to give anyone an advantage. However, times are changing fast and the hot building sector again inspires dialog and forms of partnering.

Municipal company A also sees the economy as a challenge, mainly in the choice of methods. 'The challenge is to establish methods, let us say financially. For instance, we have to decide whether to use pay-back or LCC.' Energy wise it's also difficult to find standardized calculation methods, especially for occupant behavior since our building stock has more tenants per square meter than the Swedish average.

In Municipal company B, they include sustainability and state that the main challenge is to find the right balance between economic investments and sustainability. The company also mentions the importance of choosing technical solutions that are simple enough to run and maintain. 'We get the best results when we "keep it simple". Still, we need competent personnel.'

The private company did not mention specific challenges but instead stated that the economy is of no concern as long as the pay-back time of energy efficiency measures does not exceed 7–10 years.

What kind of aspects/refurbishment measures should housing owners prioritize in energy-efficient refurbishment to secure environmental sustainability? Is it more important to decrease electricity demand than the demand for other energy carriers?

When prioritizing energy efficiency measures, ByggDialog Dalarna suggest that housing owners should work according to the Kyoto pyramid – first of all, creating energy-efficient buildings by reducing heat loss, mentioning that 'One saved kWh is a good kWh!' They also promote EPC as a method to help housing owners to implement energy efficiency measures. It is believed that LCA will become more and more important in the future to secure sustainability and to save natural resources.

In Municipal company A, they approach energy efficiency measures from an energy systems perspective, one reason being that they take the local energy company into consideration.

> We have to consider the energy system boundary and the fact that we are in the same concern as the local energy company. For instance, we don't invest in solar panels because then we would compete in energy production with the energy company.

Municipal company B has set clear goals for energy reduction, and has prioritized reduced electricity use.

> In 2007 we decided to set goals to reduce the heat and electricity demand by 20% by 2016. We have, since then, focused mostly on lowering the electricity demand because electricity use has a much higher environmental impact. It seems as if we will accomplish both these goals. In addition, we have invested in wind power plants and electrical cars in the company.

In the private company, the priority has been to convert from fossil fuels to other energy carriers where solar energy is also discussed as an option. Within the company, there is also an ongoing debate which of district heating or heat pumps is the better choice.

Are there structural aspects in building sector that makes energy-efficient refurbishment problematic? How dependent are housing owners on consultants?

In Municipal company A, they present an ambition to reduce the need for consultants and instead build up knowledge within the company. For that reason, they never do EPC. Even so they ' … often have to use consultants and they obviously have their own agenda.'

Similarly, Municipal company B also feel the importance of having enough knowledge within the company. The company has strict tendering processes and works with turn-key contracts where clear and precise specifications for the entrepreneurs are of importance. 'With our methods, where we do a lot ourselves, we save time and get offers from more companies in the tendering process.'

In the private company, there is dependence on consultants but they also state a need for knowledge within the company. 'We are dependent on consultants, but we have just recruited our own energy expert because we need a certain level of expertise to make good decisions.'

Which tools/methods are of greatest importance in project management to secure that important experience is recycled?

A systematic approach is crucial, according to the organization ByggDialog Dalarna. They stress that it is vital to measure and document what goes well and what goes badly. Using certification systems can be one way to ensure a good structure, to save time and to set requirements for the functionality and/or performance of energy systems without having in depth understanding.

In Municipal company A, it is simply stated that they evaluate and document what they do, and then hold internal workshops on it.

For Municipal company B, statistics are important. To collect statistics, they perform surveys and collect measurements in buildings during operation. They recycle information and use the same specifications from one tendering process to the next.

As for the private company, they use software to monitor the energy consumption of each of their buildings over time. Occupant behavior is also included. Using this information, they can evaluate the effect of changes to the buildings and discuss new strategies. When comparing with other companies, they ' … turn to other regional companies, and benchmark according to "The Dala strategy for Low Energy Buildings" by ByggDialog Dalarna, rather than following national examples.'

5. Discussion

There is a general opinion that the building sector, especially the housing owners, needs improvement in expertise and knowledge to make good decisions about energy-efficient refurbishments and to identify appropriate refurbishment packages thus increasing the refurbishment rate (statement confirmed by the representative from ByggDialog Dalarna: first question in the interview). The national board of housing, SNBHBP, together with the Swedish energy agency, addressed the need for a national information center about refurbishment to increase expertise in housing owners [10, 11].

Yet, the housing owners questioned in this study the claim that they have adequate knowledge of the national energy performance of buildings regulations and goals. On the other hand, they mention other obvious reasons why energy-efficient refurbishment is sometimes challenging, consequently leading to slow refurbishment rates:

- Energy efficiency actions need to be wisely chosen to get a balance between social, ecological and economic sustainability. That is the main challenge of today. The trend goes towards less ambitious refurbishment projects to secure social sustainability and to avoid increased rent levels for tenants. More cost-efficient and rational demonstration projects are needed to inspire and boost the refurbishment rate. 'As municipal housing owners we have a responsibility to offer affordable housing for all kinds of people', replied municipal company A to the first question in the interview.

- Calculated energy performance levels are seldom reached in reality in refurbishment projects. Consequently, the economic benefits of refurbishment are smaller than consultants claim. 'There is a distrust of consultants' work. Therefore, the in-house know-how is extremely important', claimed the housing owners at the workshops.
- The housing owners even express the view that there has been a mismatch between EU directives and national regulations. Nationally, the old regulations did not distinguish between different energy sources used for heating, even if energy carriers have a different environmental impact. Both the municipal companies express that they believe it is more important to lower the electricity use than the district heating use. They welcome national regulations on primary energy use and claim that the refurbishment rate might increase with new building regulations with clear rules regarding refurbishment based on primary energy use.

The purpose of the study was rather to find out the perceptions of important actors, which could slow the refurbishment rate than to establish the actual knowledge housing owners have about national building regulations and goals. There are several good reasons for this and the main reason is obviously that managers and other important actors make their decisions on what they perceive as knowledge and not on what is objectively acknowledged as this (Özleblebici and Cetin 2015). The general results (and Figure 1), can be interpreted as that housing owners have not felt very restricted nor motivated by the former Swedish building regulations and energy goals in refurbishment projects, even if they have knowledge about these aspects. Apart from the points mentioned above, the reasons could be unclear regulations regarding refurbishment, and that regulations are not followed up by the authorities. Instead, the housing owners tend to assess the actions of their colleagues to find inspiration for energy-efficient refurbishments. The major motivation is most probably financial savings, but the companies also consider the other sustainability aspects. Small companies learn from the larger local companies and regional forums such as ByggDialog Dalarna, rather than acquiring information from authorities or 'Renoveringscentrum' at a national level. The data gathered in the study indicates that the knowledge level about energy efficiency work is somewhat higher among large municipal housing owners than in the small private companies.

In order to spread new scientific information or guidelines, it is, therefore, crucial to inspire representatives from the large housing owners to take part in events where important information is given and encourage them to take back the message to the regional level. SABO and BEBO meetings were said to be of special importance to the larger companies, which can often afford to participate in these events with their own energy experts. The sooner the large housing owners take back and demonstrate new procedures and new technology, the faster they are adopted by other housing owners in the sector.

A SNBHBP report from 2016 concluded that the main challenges housing owners face are related to high expenses in the building sector (Boverket and the Swedish Energy Agency 2013a). So far there have probably been too few demonstration projects showing standardized and rational solutions for multi-family housing which have been really successful in all aspects ranging from economy to energy performance and social aspects. Many have been too costly, resulting in increased rent for tenants. Others have not met the expected energy performance, or not been followed up at all.

The main conclusion from this study is that an information center is not worth much without good demonstration projects to learn and report from. Many companies will probably continue to hesitate until refurbishment packages have been implemented, the whole refurbishment process has been followed up and demonstrated and documented using a holistic approach. Ongoing national demonstration projects, or 'Living Labs', such as 'Gentle Energy-Efficient refurbishment', where the building energy performance and social aspect are followed through the whole renovation process and for a considerable period after the building has been finalized, are promising as relevant and useful inspiration for many housing owners. Monitoring the energy performance of renovated buildings is especially important to tackle the gap between predicted and actual energy performance.

In particular, energy occupant behavior in buildings is a key issue for building design optimization, energy diagnosis, performance evaluation, and building energy modeling due to its significant impact on real energy use and indoor environmental quality in buildings. The behavior includes adjusting thermostats for comfort, switching lights on/off, opening/closing windows, pulling up/down window blinds, and moving between spaces. However, the influence of occupant behavior is usually under-recognized or over-simplified in design, construction, operation, and retrofit of buildings, leading to great differences in practical building energy use compared to simulation results. Occupant behavior is complex, stochastic and multi-disciplinary. Thus, having a detailed understanding of occupant behavior and being able to quantify its impact on the use of building technologies and energy performance of buildings is crucial to the renovation of energy-efficient buildings. Consultants may also lack this in depth understanding needed or may have to communicate their results in a different way.

It is very important to have expertize on energy efficiency and refurbishment within individual companies, according to almost all the housing owners questioned. More than 90% express the view that it is vital to recycle knowledge from one refurbishment project to the next (see Table 1). Most of them do not fully trust consultants and/or do not believe in energy performance contracting (EPC) services because they know their own buildings better than anybody else, and therefore think it is risky to leave the refurbishment process to an external partner. One danger that might be introduced because of this way of thinking, is that new ideas and concepts are not implemented if the 'wrong knowledge' is recycled from earlier projects.

Still, more than half of the housing owners participating in this study expressed the view that refurbishment projects seldom have clear goals, proper project management to reach the goals, and verification of fulfillment afterwards (Table 1). It seems as if the sector still seeks standardized refurbishment strategies and tools to secure sustainable and efficient refurbishment processes. The answers and discussion at the workshops point to the conclusion that, nowadays, the housing owners lack the time to work through all necessary stages of a refurbishment process themselves. Even if they would like to use the available planning tools, and spread knowledge in their own organization, they do not do so (Table 1). Instead, they depend on consultants taking measures. It seems as if better defined methods/tools adapted for refurbishment could be of great value in the coming years. These would improve interaction between those with in-house knowledge and consultants, would save time and improve quality in a fast moving building sector. Building certification tools such as BREEAM, LEED, WELL or 'Miljöbyggnad' could fulfill this function, as could 'Renobuild'. Although these tools have their own characteristics and may be applied in different scenarios, it is usually very hard in practice for housing owners to make a decision on which tool should be chosen, due to the lack of the integrated comparison among these rating systems. Further case studies, knowledge delivery and tool training must be conducted to tackle this practical challenge.

The energy 'performance gap' is also an issue that, at least partly, is related to the tools used when planning a refurbishment. Most of the tools available use standardized values for many parameters, which can be a contributing factor to the calculated energy performance deviating from the real measured performance. This is discussed in (Khoury, Alameddine, and Hollmuller 2017), where the difference between optimal but realistic conditions of use and standard values used in the simulation process is one of two main issues, the second issue being the difference between optimal and actual conditions of use. The authors (Khoury, Alameddine, and Hollmuller 2017) question if it is even sensible to use standard calculation methods to estimate real energy savings at building level or use them to design retrofit strategies.

The interaction between housing owners and local energy companies was also touched upon in this study. In general, the housing owners do not believe dialogue with the energy companies is crucial when choosing energy efficiency measures (even if their buildings have district heating). The large companies, however, stress the importance of having an energy system perspective in refurbishment projects (as reported in the interviews). The energy companies themselves wish for a closer dialog with the housing owners (Table 1). As the energy performance of more and more existing

buildings is improved, smart energy system solutions are needed as this affects the whole heat market and the premises for energy production.

Financial incitements were proposed as a part of the strategies in report ET 2013:22 and Boverket 2015, 47 by SNBHBP and the Swedish Energy Agency [10, 11]. In the present study, the housing owners did not stress economic aspects very much, even if the economy is the main bottle neck for refurbishment. They did not make suggestions for new incitements, as loans given today already have low-interest rates.

As regards the general validity of the results, these should primarily be considered valid for the population and the selection of subjects from which the study is based. For attributions to other populations, these should be done with caution. Based on the selection and principles for data collection that has been made, it is clearly reasonable, though, to assume that for the purpose of this study significant data and information have been identified as the basis for the analysis. Regarding the reliability of data and results, it is of importance that the measures were taken to assure that respondents were well aware of the implications of the questions. With regard to the qualitative survey, reliability has been sought by choosing subjects carefully and allowing them to freely and adequately express their views based on the general open themes presented to them.

6. Conclusions

Improving the energy performance of existing buildings is crucial for reaching both EU and national climate and energy targets, moving towards a more sustainable energy system. SNBHBP and the Swedish Energy Agency have worked on a national Swedish strategy to increase the rate of energy-efficient refurbishment (ET 2013:22 and Boverket 2015, 47). This strategy comprises a national information center to increase the expertise in the building sector, especially among housing owners, as well as financial incitements.

In this study, housing owners themselves express the view that they have sufficient knowledge of the national regulations and goals. Despite their supposed knowledge of the national ambitions to improve the energy performance of buildings, and the current economic situation with beneficial loans, the refurbishment rate still remains low. The housing owners explain that they are waiting for proof that all sustainability goals can be reached in refurbishment projects in reality. Too few projects have fulfilled ambitions in all categories: economically, socially, and energy-wise.

Probably, the government should stimulate to have more projects demonstrating rational energy-efficient refurbishment with a holistic approach taking economic, ecological and social innovations into account. These demonstrations should include monitoring of energy performance for a few years after the building has been completed. This way it will be clear which projects/methods have been successful when it comes to energy performance predictions and interaction between housing owners and consultants.

The new national information center on refurbishment of buildings may be crucial to spread information nationally, especially to reach energy experts or technical managers of the large housing owners. Even if the housing owners have a perceived understanding about energy efficient refurbishment, the lack of knowledge may still be an issue. Once the large housing owners acquire an understanding of total concept methods for refurbishment, and bring back their knowledge, the smaller regional companies are likely to follow and thus increase the refurbishment rate.

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