ABSTRACT

To limit the climate impact of buildings, low carbon materials such as bio-based materials could be used. This study intends to contribute to the understanding of drivers and barriers for an increased use of bio-based building materials in apartment buildings. For this purpose, semi-structured interviews with Swedish architects, contractors and developers were conducted. The results indicate weak drivers for selecting bio-based materials at present and that the key barriers are insufficient incentives, lack of knowledge and experience, bad examples, issues regarding performance, and construction-related culture and habits. Important future drivers could be green building certificates and other environmental standards and regulations, evidence that the materials keep a certain quality over time, and educational support from municipalities.

Key words: Construction industry, stakeholder perception, green building, diffusion of innovations

INTRODUCTION

Currently, there is a housing shortage in many Swedish cities and as a result investments in new apartment buildings have started to increase. The climate impact of the buildings depends to a great extent on the amount of energy used during operation and on the environmental performance of that energy (Rossi et al. 2012). However, since the energy-efficiency of buildings has improved and there is an ongoing shift towards a more sustainable energy mix, the production phase is starting to become a more significant feature of a building’s climate impact (Blengini and Carlo 2010). Material substitution to include a larger share of bio-based materials has been shown to decrease the climate impact (Thormark 2006, Rossi et al. 2012). Thus, it is of interest to consider ways to increase the proportion of bio-based materials used in buildings.

Drivers and barriers for using structural timber in multi-storey constructions in Europe have been reported in earlier studies (see Hurmekoski et al. 2015 for an overview) as...
well as drivers and barriers in UK for low carbon building materials (Giesekam et al. 2016), and for recycled materials (Chick and Micklethwaite 2004). The present study intends to contribute to a deeper understanding of drivers and barriers for an increased use of bio-based building materials in Sweden by adopting a broad perspective, including the perception of architects, contractors and developers regarding bio-based materials in general. Further, the present study builds upon an earlier interview study with Swedish architects and contractors by Markström et al. (2016).

MATERIAL AND METHODS

The methodological approach follows that in Markström et al. (2016) and rests on the Theory of Planned Behaviour (Ajzen 1985) and on Innovation Theories (Rogers 2003). A qualitative approach with semi-structured interviews was used. Swedish architects, contractors and developers were selected for the interviews since they have been identified to have a large impact on the selection respectively of façade materials, structural materials, and the interiors (Markström et al. 2016). Purposive sampling was used in the selection of respondents. The study targeted larger firms and also aimed at a geographical spread. Thus, the firms were selected based on size and geographical location. Within these firms respondents were selected based on their experience of residential buildings. In total 12 interviews were held (Table 1). During the sampling, attention was also given to the respondent’s years of experience, gender, and background in order to get a spread among these parameters to better capture different viewpoints and information (Yin 2011).

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<th>Category</th>
<th>Years of experience</th>
<th>Gender</th>
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<td>&lt; 10</td>
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<td>Architect</td>
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Four of the interviews were held face-to-face at the respondent’s office and the rest were conducted via telephone. The duration of the interviews was between 30 and 75 minutes. All the interviews, but one, were recorded and then transcribed. Each transcription was summarized and sent to the respondent for correction in order to strengthen the validity, as suggested in the literature (Yin 2011). In two cases, the respondent made minor changes to the text.

During the analysis, the five phases commonly used in qualitative research were followed (Yin 2011). Sentences and phrases from the interviews were given labels and then they were sorted in categories. The data under each category was compared and interpreted, first for all respondents individually and then collectively, after which conclusions could be drawn. Before the disassembling, all the transcriptions and the summaries were read through several times.
RESULTS

Barriers

When selecting materials, cost and durability (proof of quality over time) are considered to be important criterions in addition to functional requirements concerning e.g. fire and moisture. Regarding cost, the developers mainly think of the purchase price and the cost of installation whereas the developers consider the life cycle cost where the need of maintenance is of importance. The architects also consider the need of maintenance as important, but from an aesthetical point of view. The time horizon regarding durability varies for the actors; the developers want the materials to sustain the warranty period with marginal (about 10-15 years horizon), the developers want materials that sustain 30-100 years or more – depending on application – with no or minimal maintenance, and the architects has a time horizon somewhere in between the other two groups. When there are uncertainties regarding the quality of a material, the actors are reluctant to select it. Developers are worried about an increased burden in maintenance and that the potential initial environmental gains with a bio-based material will be lost if the service life proves to be short. Contractors see the risk of an extra cost and bad reputation if the material fails within the warranty period. Other important criterions are delivery time, supply security, and assembly period for the contractors. How the customers perceive the materials and that the materials are well proven are considered important by the developers and the architects consider aesthetics as important.

Thus, it is a barrier that bio-based materials in general is considered to be new and not tested, less durable than other groups of materials, and that bio-based alternatives with improved durability often are considered to be too costly. Another barrier is that bio-based materials are associated with a risk of mould and moisture damage which contributes to the selection of e.g. plasterboard and steel joists over wooden alternatives. The perceived difficulty with fulfilling fire requirements, the perceived high cost of fulfilling the fire requirements, and the perceived negative impact on human health and the environment of the chemicals needed for fire protection are also barriers for an increased use of bio-based materials.

Existence and spread of bad examples also hamper the probability of selection of bio-based materials since it contributes to a conservative and reluctant attitude to introduce both bio-based and new materials. Among the architects and contractors, external wall insulation systems were mentioned frequently as bad examples whereas the developers brought up examples of less successful timber buildings and troubles with cellulose insulation. Some have had bad experience with bio-based sheet materials, thermally treated wood, and wood-plastic composites as well. There is also a lack of knowledge among building engineers and architects of which bio-based alternatives that are available, and how and where to use them. Small profit margins among contractors also contribute to the reluctance of using other materials than the commonly used and since there are plenty of building projects, they do not need to be that innovative in order to get work. Another barrier is that bio-based materials are marketed to a less extent than other materials.

Regarding timber façades, the need of maintenance and the risk of fire are seen as major barriers by the developers. Regarding the maintenance the barriers are; the cost, shortage of painters, the environmental impact, and worries about differences in
appearance when using timber cladding in balconies e.g. if the residents do not use the same methods to maintain the cladding and/or do maintenance with different intervals.

Two major barriers for timber construction are difficulties in fulfilling requirements regarding fire safety and acoustics. The developers also perceive that in comparison with concrete, it is more difficult to obtain a construction that is tight when using timber which results in a decreased energy performance. Settlements and crack formation is also seen as barriers to select structural timber by this group since cracks are perceived to impair the visual impression. Further, the service life of timber is perceived to be too short by the developers. Another barrier is that the contractors has interests in other materials and want to streamline the use of the current system where concrete is used.

In some cities there are a shortage of construction workers with knowledge and experience of timber construction. Thus, some developers do not get any tender with timber frames. Stakeholder organizations that lobby against timber construction (uses risk of fire as a main argument) and insurance companies that do not insure buildings with timber frames or timber claddings, (due to the risk of fire and the resulting water damage from a fire fighting operation) hinder an increased use of timber. The municipalities are perceived to have insufficient knowledge of timber construction and inconsistent terms regarding buildings which are seen as barriers. The local plan which regulates the height of buildings sometimes constitutes a barrier for timber construction.

**Drivers**

In general the respondents perceive no or low incentives to use bio-based building materials. Incentives seen by some respondents are: green building certification systems, the local strategies for timber construction that exists in some municipalities, political pressure to decrease the environmental impact, faster drying times when using timber compared with concrete, social benefits (timber has a calming effect and makes the residents feel good), that timber provides a warmth, and that solid timber feels genuine and lavish. Another driver is that there is a lack of labour in the larger cities and to minimize the time on the construction site, work is relocated to smaller cities and other countries. In those cases it is perceived convenient to use prefabricated timber modules.

The incentives to select bio-based building materials would increase if those materials were highly valued in green building assessment schemes, demands and regulations regarding e.g. climate impact of materials were put in place, the customer demand for bio-based materials or more environmental friendly homes increased, and that the developers with rental apartments could access the residents' potential willingness to pay for such a home. Improved properties of the products regarding moisture sensitivity, maintenance, durability, fire resistance, and acoustics would also increase the incentives to select bio-based alternatives. As an example, properly coated finger joint timber claddings in longer lengths than the ones available at present were requested in order to decrease the need for maintenance and increase the durability. Proof that the materials keep a certain quality over time is also important to increase the incentives to select bio-based materials.

Proof of cost effectiveness, price in the same range as the materials commonly used, and cheaper land prices when building with a certain proportion of timber were also
identified as potential future drivers as well as knowledge of the relative advantages of using bio-based alternatives (both the advantages for the customers and the project), increased knowledge of which bio-based alternatives that exists and of how and where to use them, better access to information about bio-based materials, and an increased discussion about these materials in positive terms. One instrument to increase the knowledge that is requested is municipality support for education in timber construction.

DISCUSSION

A major part of the currently perceived drivers to select bio-based materials is derived from the general perception that those materials are more environmental friendly than other groups of materials in the perspective cradle-to-gate. When talking about the whole life cycle, the respondents are uncertain if bio-based materials are the best alternative due to transport distances, need for maintenance, and perceived shorter service life. The respondents also find it confusing that the concrete industry and the wood and timber industry calculate the environmental impacts somewhat different. Thus, it is of importance to continue the work with life cycle assessments on building materials and to spread these results and knowledge of how to interpret them among building professionals.

A further indication that good environmental performance is regarded as important by the sector is that the concrete industry has started to change their recipes in order to decrease their environmental impact. These changes has led to longer drying times at low temperatures which some developers has found troublesome. At present, short construction periods are of great importance and the short drying times for timber could thus become a stronger driver in the future.

Although green building certification systems is highlighted as a promising future driver by the majority of the respondents there are indications of some trends that need attention. There is an indication of an increased interest in these systems among contractors and some of the developers. However, the contractors and some of the architects perceive that the certifications results in an inferior and more expensive product. Among developers that have worked with the systems for some years, the interest has gone cold due to the cost and the workload. However, these actors stated that most of their buildings would pass the second level in the most commonly used green building certification system in Sweden but they do not bother to certify them because they do not see a benefit by doing so.

The shortage of builders with knowledge about timber construction is a major barrier that must be addressed. At present researchers at Linnaeus University are trying to get manufacturers of detached timber houses to engage in multifamily houses as well and some developers are pushing smaller contractors to invest in learning timber construction in order to gain competitive advantages over larger firms. The lack of knowledge is also an explanation to some of the unsuccessful attempts of using bio-based materials. One example mentioned were bio-based insulation that had been used in an incorrect way.
Moreover, there is a need to evaluate how well the local strategies for timber construction have worked out so far and what can be done in order to strengthen them. Even though some perceive these strategies as drivers to select timber, some perceive them to hinder the use of timber since they do not focus on the main barriers for an increased use. There are also mixed opinions regarding introduction of regulations on the environmental impact of materials, were a few of the respondents are negative. In order to know how such legislation would be received and how to best design them, more actors must be asked. A lifecycle perspective is, however, perceived to be important in this context.

CONCLUSIONS

This study has contributed to the understanding of drivers and barriers for an increased use of bio-based materials in apartment buildings. This was done by semi-structured interviews with Swedish architects, contractors, and developers. The result indicates that the major drivers perceived by the respondents could be connected to the environmental performance of bio-based materials, fast construction, and the positive feelings that timber provides. Barriers identified are lack of knowledge, issues regarding performance (maintenance/durability, fire safety, acoustics, moisture, crack formation, cost), existence and spread of bad examples, insufficient incentives, insurance companies, local plans, and construction-related culture and habits. To increase the incentives, further development of green building certificates, implementation of environmental standards and regulations regarding the environmental impact of materials, evidence that the materials keep a certain quality over time, and educational support from municipalities are seen as promising. Further studies must be done in order to know if it is possible to generalize the results to a wider population.

REFERENCES