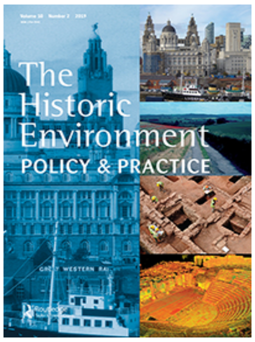

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Energy Performance Certificates and Historic Apartment Buildings: A Method to Encourage User Participation and Sustainability in the Refurbishment Process

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ABSTRACT

This article presents and discusses the challenges of refurbishing historic apartment buildings by correlating findings from research projects LEAF and CulClim. Our aim is to shed light on how residents can partake in and optimise the refurbishment process after energy performance certificates (EPC) have been conducted. The background is that historic apartment buildings are generally more complex than single family buildings with respect to the energy efficiency process as they often have multiple owners with different priorities. The case studies from Norway and Sweden have conceptually contrasting energy performance certificate (EPC) systems. Identified advantages and shortcomings concerning both systems are discussed. In Sweden, the restrained recommendation of measures can lead to national mitigation targets not being realised. In Norway, excessive and unqualified recommendations risk reducing the cultural heritage values of the existing building stock as well as having a negative environmental impact on greenhouse gas emissions. A bottom-up approach incorporating the resident's objectives is presented and discussed. Results suggest that improved EPC-systems and a broadened procedural approach to decision making will ease the process and improve the outcome of the refurbishment with respect to both energy and heritage aspects.

KEYWORDS

Historic buildings; energy efficiency; apartment; energy performance certificate; user participation; cultural heritage; building conservation; Norway; Sweden

Introduction

Current national and international imperatives to reduce greenhouse gas emissions have triggered intensive efforts to refurbish historic buildings in order to reduce energy dependency and make them energy efficient. The European Energy Performance of Buildings Directive[1] (EPBD) promotes this matter by driving member states to establish the necessary energy requirements. In addition to national energy requirements, energy efficiency measures are promoted by Energy Performance Certificate (EPC) systems. These are designed to provide the owner, the prospective buyer or tenant of a building or apartment correct information about the energy performance of the building and practical cost-effective advice on improving its performance. Improving

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the energy performance of historic buildings in particular is a balancing act between heritage significance and energy efficiency measures. This aspect distinguishes working with such buildings from working with the building stock in general.

It is well known that apartment buildings, where more stakeholders are involved in the decision making, are generally more challenging with respect to the energy efficiency process.[2] Adding to this is a common lack of knowledge on potential savings and benefits, environmental impact, payback expectations and existing regulatory and planning issues.[3] In order to reach energy targets through building refurbishment, incitements, policy instruments and objectives must therefore be entrenched among the owners. When there are cultural heritage aspects to be included, the process is even more complex. To overcome these and other barriers in retrofitting historic buildings, the value of user engagement and raised awareness has been underlined,[4,5] but the lack of empiric findings calls for intensified research activities.

Aim and Scope

The aim of this article is to shed light on the problematic relation between EPCs, historic apartment buildings and the implementation of energy efficiency measures. The multi-ownership aspect adds another dimension to the already challenging process of upgrading historic buildings.

The article also aims to present and discuss a bottom-up method that can be used as support in the decision-making process of carefully refurbishing historic apartment buildings. The structure of the method is proposed on the basis of findings from, on the one hand, two partly overlapping research projects, Low Energy Apartment Futures (LEAF) and Cultural Valuable Buildings and Climate Change Responses in a User Perspective (CulClim) with case studies from Sweden and Norway. The proposed method is furthermore aligned to the newly launched procedural guidelines for improving the energy performance of historic buildings.[6]

Project Backgrounds

Besides being neighbouring countries, sharing similar climatic conditions, Norway and Sweden also look much alike in terms of regulations and legislative frameworks for building conservation. Norwegian and Swedish buildings of historic value or cultural heritage significance can for instance be listed, either based on their own merit or as part of a historic environmental context, according to the national and regional Cultural Heritage Acts respectively.[7,8] They can also be governed on municipal level according to the Planning and Building Acts.[9,10] In fact, both countries have general paragraphs that aim to prevent existing buildings from being altered in any way negative for their historic, architectural or cultural significance. The common legal practices of these restrictions are however limited to include only those buildings that have been designated, i.e. marked explicitly, as of representing cultural heritage significance. The general rule in other words applies only to buildings identified as worthy of protection by municipal authorities.

When comparing the two existing building stocks and their legal framework, an important distinction is noted in how the general Norwegian housing stock is primarily private property. Roughly 80 % of Norwegian households own their house or apartment, and one fourth of all dwellings are in multi-occupancy buildings.[11] A large share of the Norwegian building stock is in other words managed by non-professionals, responsible for maintenance and any climate adaptation of their properties. The Swedish situation is different; less than 40 % of the dwellings are privately owned, most of them are single family houses. In apartment buildings the most common type of ownership is cooperative owning (41 %) and the second most common is public housing (28 %). Other apartment buildings are commonly owned by private renting agencies.[12]

The ambition of Norwegian project CulClim (funded by the Research Council of Norway between 2014 and 2017) was to elucidate user related, and user relevant, knowledge on the topic of climate change, energy efficiency and historic buildings. The general aim of CulClim was mapping local, regional and central authorities' efforts and methods in their contribution to climate change adaptation and energy efficiency in historic buildings. The investigation of how users can implement non-intrusive energy efficiency measures in historic buildings was in particular focus.[13] A historic apartment building in a conservation area of Oslo was used as a case study for both technical surveys and interviews with owners and residents. The apartment building is a representative example of its time and consists of two buildings, one in front facing the street and one in the back.

The LEAF project, finished in 2016, was a European-wide project aiming to improve the energy efficiency of apartment buildings. The project was funded by the EU's Intelligent Energy Europe (IEE) programme and local organisations in each country. LEAF aimed to identify and overcome a number of key barriers to retrofitting such as the limitations of Energy Performance Certificates (EPCs) and difficulties associated with buildings under multiple ownerships. As part of doing this the project developed a toolkit that provides a step-by-step approach to retrofitting apartment buildings. In Sweden four case studies on apartment buildings in Visby were carried out, piloting the toolkits. The buildings are all located in the UNESCO World Heritage Site and therefore restrictions apply due to cultural heritage values.

Case Studies

The case study buildings in both countries were constructed between mid-19th century and early 20th century. They are either entirely constructed in brick, or – which is the case of one of the Swedish case study buildings – in a combination of brick and timber. More importantly, the case study buildings are all situated in conservation areas where restrictions for cultural heritage preservation apply. The restrictions prevent significant exterior alterations and some internal.

In Sweden, the four case study buildings are smaller apartment buildings (9–16 apartments) owned by cooperatives, each resident owns a share in the cooperative and thereby the right to live in the apartment. The residents pay a monthly fee to the cooperative, which covers the costs of the centralised heating and hot water, interest and instalments on the cooperative's loans, maintenance and taxes, among other things. The fee is normally determined by the apartment size, and usually set year by year depending on the cooperative's budget.

Figure 1. The four case study buildings in Visby, Sweden. They are all located in the town centre, which is protected as a World Heritage Site. Restrictions apply when altering the facades. Photo: Uppsala University.

In Norway the two case study buildings consist of a total of 16 apartments. Any issues concerning the centralised hot water system and façades, roofs, windows and entrances, courtyard, staircases and cellars are managed by a board of representatives, chosen by the cooperative of owners. All apartments are owned individually as properties. The heating system is decentralised and, like most Norwegian apartments from this period, characterised direct electric heating via radiators or underfloor heating. Each apartment unit covers its own heating fees Figures 1 and 2.

Previous Research

Energy Efficiency in Historic Buildings

The number of current and recently finished research projects on energy efficiency in historic buildings is testament to the continuing importance of and interest in the subject.[14,15,16] It is a complex topic that involves several disciplines and challenges connected with building physics, heritage values, risk assessment, decision making and planning authorities and to name a few.

Several large European research programs have addressed the topic by developing models to support decision making and balancing various costs against each other when upgrading historic buildings.'[17,18,19,20,21,22,23] Norwegian research activity on the

Figure 2. The case study building used in Norwegian project CulClim is situated in the area of Grünerløkka, a district planned and built around 1880/90 as part of a booming industry. The highlighted field in the same image marks the conservation area. Below, exterior pictures of the facades of the case study building. Restrictions apply when altering the facades and the staircases. Map: Riksantikvaren. Photo: NIKU.

subject, anchored at the Norwegian University of Science and Technology (NTNU), research institute SINTEF, the Norwegian Institute for Cultural Heritage Research (NIKU) and the Directorate for Cultural Heritage (Riksantikvaren), has resulted in a number of interdisciplinary milestones with case studies, best practice reports and scientific investigations in recent years.[24,25,26,27,28] In Sweden, the national research program for energy efficiency in historic buildings, 'Spara och Bevara', has been funded by the Swedish Energy Agency since 2006.[29] The program, coordinated by Uppsala University Campus Gotland, and covering several universities, research institutions and private enterprises, aims to develop and convey knowledge and technology solutions that contribute to energy efficiency in historic buildings. Within the first part of the research program studies on retrofitting buildings of monumental character were carried out; with studies on energy efficient preventive conservation and comfort through climate control. During the second and third part of the research program focus moved from individual buildings towards the larger part of the building stock; historic buildings and the effect of national energy saving policies on the cultural values, also innovative materials and technical solutions have been studied.

One recurring thread in the research field of energy efficiency and historic buildings is that of finding a 'good energy efficiency process'. This is reflected in a new European standard which was established with the aim to provide "guidelines for improving the energy performance of historic buildings, i.e.: historically, architecturally or culturally valuable buildings, while retaining their heritage significance.[30] In other words, it presents a working procedure for the selection of measures improving the energy performance.

The standard states that the refurbishment process should be carried out in a multidisciplinary approach in close cooperation with the owners and users of the building. It also mentions that users should be made aware of the impact of their behaviour and how they can influence the energy use and the associated cost, as well as that the present and planned use of the building (with respect to function and adequacy) should be described and assessed before a refurbishment. It does however not say how this can done. Neither does it elaborate on by whom the objectives of the refurbishment should be defined. We will return to this procedure at the end of this article.

Resident Motivation and Energy Renovation

There is also a continued, and perhaps heightened, interest at the moment in issues related to the influence of the users on energy efficiency in historic buildings. Fouseki and Cassar[31] stated that 'studies of occupants' attitudes and behaviour with regard to energy-efficiency interventions are critical' when they addressed the topic and future research needs in their 2014 editorial. Berg et al.[32] further concluded that residents represent an important resource that can foster lower energy demand and less intrusive interventions in historic buildings provided that they are included in the planning and follow-up phase of the refurbishment process.

A survey among the European partners participating in the LEAF project showed that agreement and financial issues usually go hand-in-hand. A common problem was stated to be a lack of funding and interest in the maintenance and improvement of communal areas of the buildings. Lack of maintenance makes residents prioritise urgent works. Many countries highlighted the decision-making process as being slow.[33] These issues have in turn been studied from different angles in previous research.

Studies concerning energy renovation in multi-occupancy buildings present different challenges regarding decision making and resident engagement, and the challenges vary depending on the ownership model. Palm and Reindl for instance, observed and interviewed professionals involved in the renovation of multi-occupancy dwellings.[34] In this case the study concerned buildings owned by a large housing company, but some results are still interesting to our study of cooperatively and individually owned apartments. They followed the whole process, from start to finish, and found that barriers appear, disappear and transform at different points. Calculations on payback time and energy saving were also found less important than expected.

Other studies have shown that cost-effective measures for energy efficiency are not always implemented. The reasons can be found in technical shortcomings but also behavioural barriers connected to information, credibility of information, and conflicting objectives between the group of owners.[35,36] A Danish study among homeowners that had an EPC conducted gives some insight to what motivates home owners when renovating, and also how the EPC is viewed in terms of being a driver for energy renovation.[37] The EPC was seen as informative and reliable, but not useful as a source of information on how to save energy. The survey also showed that the home owners did not consider payback time as the most important factor – the investment costs and practical issues were more significant. In conclusion, Christensen et al. put forward the idea that thermal comfort was by far the most important reason for home renovation, and that the EPC should include not only economic information on suggested measures but also other aspects.

Research on energy efficiency in general has shown that occupant feedback, and the concept of raising awareness, has an important role in both the assessment and refurbishment part of the energy efficiency process. Zalejska-Jonsson has underlined that the 'green profiles' of some new construction has had a positive effect of user awareness and sense of responsibility towards saving energy.[38] And though they do not explicitly address historic buildings, several studies have seen that different types of user profiles will need different kinds of feedback techniques when it comes to sustaining a positive, conservative and a certain degree of awareness concerning energy consumption.[39,40,41] More importantly, these studies stress the need of early initial feedback and evaluation if the residents are to adopt a more active engagement and awareness about their energy use in the long run.

Energy Performance Certificate Systems

EPC in Sweden

The Swedish EPCs are conducted by certified private energy consultants and paid for by the house owners. In the EPCs the measured energy data provides the basis for all calculations, with very few exceptions. If measured energy data is unavailable the experts can calculate the energy performance according to their best knowledge. It is also up to each certified consultant to decide on conversion factors, division of energy use and standardised values. The climate data, for comparing the energy use with the climatically normal year, is provided by the responsible authorities. Since 2014 the Energy Rating is shown with the letters A-G on a multi-coloured scale, which is very common in Europe. The rating in Sweden is based on how the building performs compared to the demands on new buildings. New buildings performing according to the legislation, or a little better, will get a C, many older buildings will normally receive an E or an F.

Recommendations on how to improve the energy performance of the buildings are provided by the energy consultant if they can find any. Recommending measures that are not cost effective is not allowed, and measures that might compromise the character of protected historic buildings are also prohibited. The cost effectiveness, a way to measure the profitability, is calculated by the consultant and is based on several different factors, such as interest and discount rates, energy price trend, economical life span of the measure, investment and maintenance costs, it is presented as 'cost per kWh'. So far almost 720,000 EPCs have been conducted in Sweden. This includes dwellings (apartment buildings and single-family houses) and public and commercial buildings with other purposes. There is no system for controlling the outcome of the EPC in terms of suggested measures being implemented. The National Board of Housing, Building and Planning is responsible for the system and regularly evaluate and revise it.

EPC in Norway

Conversely, the Norwegian implementation of the EPBD provides a service on different levels of detail developed specifically to make homeowners conduct the EPC themselves. The two main methods 'simple EPC' and 'detailed EPC' are both provided as online free-of-charge systems. Instead of using measured data, the user provides basic building or apartment information, e.g. size, age, heating system etc. This input is in turn linked to a reference dataset with predefined information about U-values, coefficient of performance etc., and used to estimate the energy performance of the dwelling. A third chargeable option is called 'Expert EPC'. Expert EPCs are conducted by certified private energy consultants and generally provide a higher level of accuracy and quality. Yet statistics show it 'has nowhere near the uptake of the two simpler methods. The energy rating is, similar to the Swedish system, shown with the letters A-G scale which is determined by defined intervals from 80 kWh/m2/a and upwards. A building constructed in accordance with modern energy requirements would normally acquire a C. How much of the heating is estimated to come from non-renewable sources is also included.

Recommendations on how to improve the energy performance of the buildings or apartments are automatically provided based on the user input. Recommendations are general rather than specific and do not consider cost-effectiveness, technical compatibility or historic character. Instead they address all points where there is refurbishment potential. The user is for instance always advised to install new windows if their performance does not reach modern minimum requirements. To support increased use of 'energy efficient' building components, Enova, a public enterprise owned by the Ministry of Petroleum and Energy, offers financial support to households that implement some of the recommended measures. Information on how many EPC recommendations that have been followed-up is not known, but the figures can be seen in light of how ca. 40,000 apartment-specific EPCs were conducted in 2015. Approximately 300,000 individual dwellings and 250,000 apartments (of a total of 2.5 million households) have had EPCs carried out since the system was first introduced in late 2009 (numbers are no longer updated and refer to June 2016).

Risks and Benefits with Current Systems

The system can be considered efficient in terms of widespread adoption in both countries as many buildings have had the EPC completed. The Swedish system has been criticised for generating few energy saving recommendations, which are often general and do not save much energy.[42] The consequences of the Norwegian system, where many recommendations are irrelevant, could lead to unsuitable measures being implemented. Overall it seems like both systems have had the opposite effect to that intended; few measures are being implemented,[43] especially in historic buildings. It may be that few recommendations lead to an idea that 'nothing can be done' and too many might make it difficult to see what is feasible. This is a risk especially when it comes to apartment buildings with these types of ownership models, and particularly when the buildings have some sort of heritage designation. The cooperative owner (i.e. Sweden) or the board of members handling the common interests of the building (i.e. Norway) normally do not have the knowledge needed to bring forward retrofit work. This indicates there is a need for procedural information and guidance, as well as methods to include and bring forward the needs of the residents.

Case Studies

Method and Approach

The case study buildings were chosen because of how they are representative regarding their age, size, ownership model and how none were in immediate need of refurbishment. They also had similar restrictions regarding the preservation of exterior elements, all being inside a formal conservation area (Visby innerstad, Sweden, and Grünerløkka, Norway),in accordance with the national level heritage legislation of each country respectively.

Parallel to conducting a technical survey of the buildings, a questionnaire was distributed to the residents in order to establish a baseline before a potential energy refurbishment process. This gave the residents the opportunity to, at an early stage of the process, be involved in the investigation to identify needs, priorities and general objectives with the refurbishment. Questions (both yes/no, multiple choice and scaled questions) dealt with the following subjects:

- Perceived IEQ conditions during the last winter/summer: residents were asked whether they found certain areas in their apartments and/or common areas too cold or warm, or to be too draughty.
- General knowledge about the purpose of EPCs: residents were asked questions regarding the purpose, cost and operation of EPCs.
- Maintaining a building’s historic character: residents were asked to prioritise the significance of historic elements in the buildings and apartments. Residents were also asked about their knowledge regarding heritage legislation and the general restrictions set in conservation codes.
- Priorities when implementing energy efficiency measures: residents were asked questions regarding what they would want to prioritise if given the opportunity to improve IEQ, reduce costs for heating, use climate friendly technology, preserve the historic character of the building, etc.

Main Perceived Barriers to Carrying Out Energy Efficiency Measures

EPCs in the Case Studies

In the Oslocase, a simple and thus the most common form of EPC was conducted for one apartment. It was assumed the results would be similar for the other apartments since the heating system and the building construction are the same. Results showed poor energy performance equivalent to F, and ca. 500 kWh/m^2 yr. Recommended measures included adding insulation to the thermal envelope, new windows and doors, a heat-recovery ventilation system, new kitchen appliances and programmable radiators. In the Swedish case studies, all buildings were rated F in the EPC. This means the energy performance is between 181 and 235 % above the required energy performance of a new building, in these cases varying between 115 and 195 kWh/m^2 yr. Recommended measures included loft insulation, a new heat circulation pump, hydronic balancing and new thermostats.

Results from Questionnaire

The questionnaire was divided into two parts, regarding the building and the apartment respectively. In Norway the questionnaires had 16 respondents from all 16 apartments. Identified concerns regarded draughty windows and doors (69 %) and difficulties with controlling the indoor temperature during the heating season (40 %). Meanwhile, the main priorities were the lowering of heating costs (81 %) and dealing with humidity problems in the cellar (75 %). When asked about barriers to realising upgrading projects, the majority of respondents indicated that there was a lack of knowledge regarding possible measures and energy savings (87 %), as well as challenges to agreeing on common goals and decisions (75 %). 75 % did not know whether the building or their apartment had a valid EPC. 75 % found it moderately or very important to respect the historic character of the building. Residents in the Norwegian case study pay their own heating bills and hardly face any short- or mid-term economic profit from installing a centralised heating system. To reduce the heating demand, measures should instead address simpler measures such as draught proofing of windows and doors. However, this is not information that is brought forward in the EPC recommendations. It instead suggests the installation of new windows, which not only is a measure that does not necessarily pay off, but in turn will risk being incompatible with the historic character. To know what is needed, a building specific investigation is required.

In Sweden the questionnaires had 31 respondents out of 47 apartments. The main problems were draughty windows and uneven temperatures during the heating season (52%). Their priorities were generally energy saving and improved comfort. The main barriers identified by the residents to implementing energy efficiency improvements were lack of financial means and lack of information on technical solutions and energy saving potential. Very few residents in the case study buildings had seen the EPC. The few comments that were made by residents on the EPC showed a lack of understanding about its two most important features: the energy rating and the recommended energy saving measures. Also, recommended measures were generally considered ‘slightly useful’ or ‘not useful’. There was a clear demand for further information on the investment costs of the recommended measures. Residents in the Swedish case studies pay a monthly fee that covers heating, hot water and all other expenses the cooperative has. The cost for heating and hot water is not specified in the bill and saving on it will not make a difference to the fee. An extensive renovation or retrofit would rather increase the monthly fee, since the cooperative would need to pay for the works. In the long run the cooperative will benefit from it, but this will probably not mean the monthly fee will decrease, but rather not be raised for a few years (when the immediate costs have been paid). Of course, it is in all members’ best interests to keep the building in good shape for the sake of the marketability of apartments. However, what the residents notice immediately is improved indoor comfort and that is what motivates the implementation of energy efficiency measures according to the findings of this study.

Discussion

The development of the research field for energy efficiency in historic buildings we have experienced in recent years has gradually enlarged its scope and now encompasses far more than conservation heating regimes for monumental buildings such as churches, museums etc. This is reflected in how a focus on technical investigations have come to be supplemented by policy, decision making and management-related studies. It is also reflected in how the addressed buildings have become more representative of the building stock in general. We acknowledge this, but at the same time we wish to point to the fact that this inevitably demands even broader knowledge from the conservation sector. Most likely it means drawing from the research and experience represented more often in the fields of social sciences and psychology.

The refurbishment process for apartment buildings stands as a good example of how complex this can be. On the one hand, as we can conclude from previous research, there are rather problematic challenges related to multiple-owner scenarios, e.g. conflicts of interests, priorities and behavioural differences. On the other hand, we have the actual energy consumption represented by a large number of people in buildings that often, throughout the years, have been partially refurbished with different materials, solutions and ambition levels.

While the Swedish EPC shows only cost-effective recommendations, findings from the case studies indicate that economic saving is not necessarily the only important parameter in the case of cooperatively owned historic apartment buildings. Payback time will obviously play a significant role in the decision-making process, but to encourage stakeholders to implement the recommended measures, it is suggested that the EPCs supplement cost-effective measures with information on other benefits related to the measures. Furthermore, with the current mandatory information on recommended measures being a ticked box with the name of the measure, calculation on energy saving (kWh), cost per saved kWh and a description (which can be more or less extensive depending on the consultant), one can argue that it does not live up to the purpose of providing practical information.[44] The reason is that the cost per saved kWh is based on calculations on investment and maintenance costs, current and future energy price, interest rates, life-span of the measure and other factors. The consultant, however, rarely presents the numbers used in the calculation.

According to the LEAF and CulClim findings, residents and owners ask for explicit information on energy savings, investment costs and running costs since this will help them compare the calculation in the EPC with real tenders when the renovation process is started. Information about other positive effects of the suggested measures are also important to the residents. Considering this, the two systems can most certainly make use of solutions from each other's systems. The Norwegian system for instance, contrary to the Swedish, does provide general information about several possible measures while specific cost, or kWh,related benefits remain unknown. Yet if the automatically recommended energy efficiency measures are implemented, there are no guarantees that actual environmental savings are reached or that the cultural heritage values of the building are respected.

In all, the findings underline that there are significant barriers and challenges to implementing sustainable energy efficiency measures in historic apartment buildings. This calls for further research on the matter, but it also indicates a general need for improved decision support. As a way forward, we suggest making the EPC systems more informative and proactive with emphasis on raising user awareness as this can help clarify objectives and incitements. However, to facilitate such a bottom-up approach, day-to-day users of the building need to become an integral stakeholder throughout the energy refurbishment process.

It is, as stated in the CEN guidelines for improving the energy performance of historic buildings, important that the energy refurbishment process is initiated with a clear indication from the owner or user of the building outlining the general objectives and needs. At this stage residents have an important role in influencing future decision making. A dialogue with the residents should accordingly be maintained continuously throughout the decision-making process. Not only is this important for reasons related to awareness raising, but it is also important for the iterative element of the process since barriers, which Palm and Reindl underlined,[45] inevitably will appear, disappear and transform at different points Figure 3.

When the energy refurbishment process has been initiated, a building survey and assessment will provide the rest of the necessary information for making an informed decision. The survey should include information on heritage significance, conservation restrictions, construction, technical condition and energy performance, i.e. the EPC. Having identified the objectives for technical, energy and indoor environment quality improvements, long-term ambitions for the management and conservation of the building should be defined. This is essential for the refurbishment process and each target or priority should be considered and defined as far as possible. The need for an intervention is then defined on the basis of the difference between the present energy performance of the building and the objectives that have been identified by residents and the building surveyor.

Before moving on with the identification of measures, a first gross list of measures (which is defined on the basis of EPC recommendations as well as input provided from the residents) should be narrowed down by excluding inappropriate alternatives. This leaves an opportunity to conduct a full assessment of the remaining net list of measures with respect to risks and benefits respectively. The outcome of this is one or several optional packages of measures that in turn can be assessed and adjusted iteratively in relation to targets. When the package of measures is in agreement with the targets, a proposed solution has been identified. Upon coming to a conclusion, making a decision and implementing the solution, post-occupancy evaluations should be carried out to address user behaviour, as well as tuning systems and further encouraging awareness.

Refurbishment policy instruments such as the EPC system thus represent much potential for energy saving. However, for the EPC system to be rewarding rather than restraining, it should be supplemented with procedural decision support systems, i.e. toolkits such as presented in the LEAF project, which take into account aspects regarding economy, priorities and (energy) targets. This is especially important since we have seen that cost effectiveness is not necessarily the most significant driver in decision making, but rather the aspects of use, for example thermal comfort, are. Such a bottom-

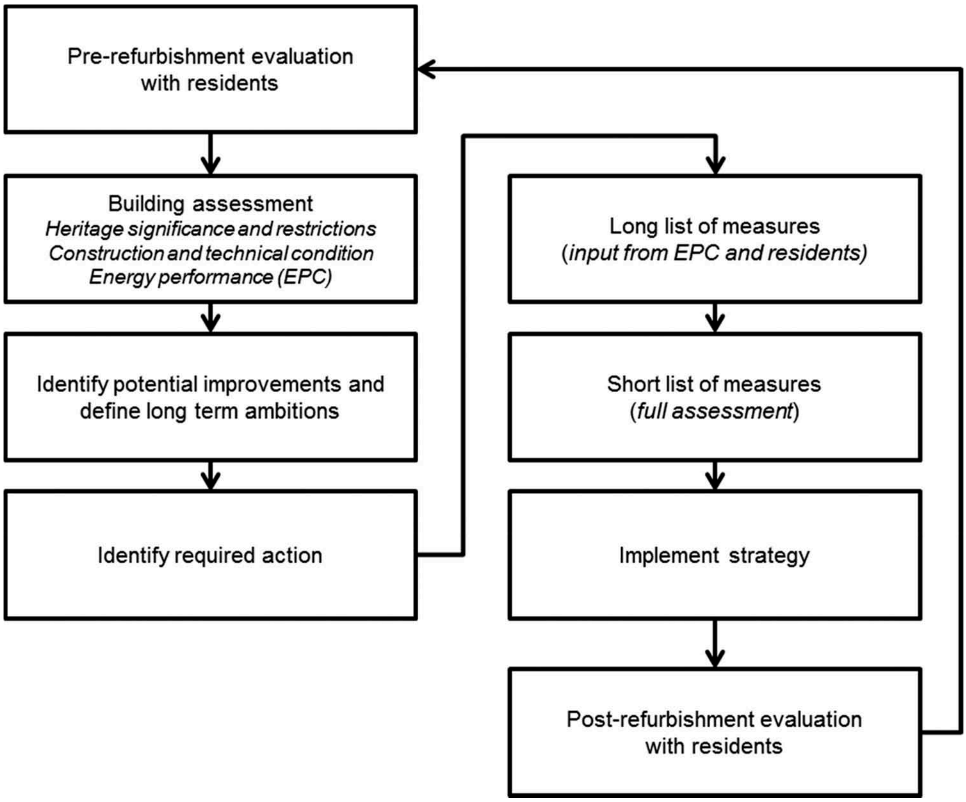

Figure 3. The step-by-step chart illustrating the process of upgrading a historic apartment building energy efficiency measures in historic buildings is based on the procedural approach presented in the CEN guidelines.[46] The crucial phases of pre- and post- refurbishment evaluation have the purpose of securing sustained user/resident involvement and awareness. Figure: F. Berg.

up approach will most likely contribute positively to the decision making behind the refurbishment process as well as raising awareness with respect to the cultural heritage significance of the historic buildings.

Conclusion

The article has addressed the complex subject of how to ensure sustainable long-term refurbishment in apartment buildings, which has been a specific gap in the research of historic buildings.

It can be concluded that the EPC is an important driver in reducing energy demand and greenhouse gas emission in the residential sector. Recommended improvement measures must however be either better explained or justified as some might be counter-productive in that they sometimes promise more than they can deliver. Neither the Norwegian nor the Swedish EPC system is in this sense ideal or exemplary, but they can most definitely make use of one another. The Swedish system could for example revise its criteria of only presenting cost-effective measures. The Norwegian system could likewise increase its level of detail and not generalise buildings and recommended measures excessively.

In all, we suggest that if the pros and cons of the different alternatives are clearly explained – whether it is with respect to thermal comfort, economic aspects, energy savings or compatibility with the historic values of a building – they will provide better decision support, ease the process and improve the outcome of the refurbishment.

We also welcome research where the CEN-standard is to be implemented and validated not only in historic buildings of monumental status, but also complex multi-occupancy residential buildings which form part of the 'everyday' cultural heritage.

Notes

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