

The drivers and challenges of improving the energy efficiency performance of listed pre-1919 housing

Introduction

European countries have committed to reducing their carbon emissions to mitigate climate change. Energy conservation and improving the energy efficiency of the built environment has been a primary focus of policy (Schüle *et al.*, 2013). In Europe, buildings contribute to around 40% of carbon emissions (Eurostat, 2014), and residential buildings represent “the greatest energy saving potential” (Galatioto *et al.*, 2017, p.991). There is, therefore, a consensus that increasing the energy efficiency and reducing carbon emissions of the building stock will contribute to national and international targets (European Parliamentary Research Service, EPRS, 2016).

To facilitate achieving national and international carbon reduction targets in existing buildings the European Commission launched the 2010 Energy Performance Building Directive and the 2012 Energy Efficiency Directive. Each European Union (EU) member state subsequently developed their own policies under these directives to comply with EU legal obligations (Burman *et al.*, 2014) and to achieve their national carbon reduction targets.

Whilst the majority of energy policies take the built environment into consideration, these policies are designed, to a large extent, in respect of new buildings, which presents restrictive requirements and the demand for high performance levels (Pianezze, 2012). Several countries have building stocks comprising of older properties (Meijer *et al.*, 2009). Both Italy and the UK contribute similar proportions to the EU housing stock at 13.8% and 13.2% respectively (Balaras *et al.*, 2007), and both Italy and the UK have two of the largest historic housing stocks internationally (Martinez-Molina *et al.*, 2016). For example 20% of the English housing stock (Department for Communities and Local Government, DCLG, 2013) and 15% of the Italian housing stock was constructed prior to 1919. Such proportions are broadly similar to countries such as Austria, France, Germany, Sweden and Switzerland (Meijer *et al.*, 2009).

There are around 460,000 listed buildings in the UK (The Prince’s Regeneration Trust, n.d.) (Table 1), and around 100,000 listed buildings in Italy (Istat, 2013). Further, Italy has the greatest number of cultural and mixed (cultural and natural) World Heritage Sites (United Nations Educational, Scientific and Cultural Organization, UNESCO, 2017; Patuelli *et al.*, 2013). These are statutorily protected, to manage change and preserve what is significant about these assets.

[Table 1]

Understanding is improving about how historic housing performs. There is recognition that such buildings have better thermal performance in reality than predicted (Li *et al.*, 2015; Agbota, 2014; Rye, 2012; Baker, 2011). However, this should not impede the drive to improve the energy efficiency performance of the

historic housing stock, but contribute to how we understand these properties. Further, it has been suggested that, when considered over their entire lifecycle, historic buildings are thought to perform better than new properties (Cultural Property Technical Committee, CEN/TC 346, 2015) when embodied energy is incorporated (Crockford, 2014; Power, 2008). However, based on 'in-use' performance, pre-1919 dwellings represent the most inefficient housing in England (Dowson *et al.*, 2012), averaging 23 fewer points in the Standard Assessment Procedure (SAP) ratings than post-1990 properties (DCLG, 2015). SAP is a method against which building energy performance is measured on a scale of 1 to 100 based on predicted energy use, where 1 is the least efficient and 100 is zero net annual energy cost (Stone *et al.*, 2014). The pre-1919 housing stock in Italy has been similarly described as being in a poor physical condition and having poor energy efficiency (Istat, 2011).

In the context of European and national policies to reduce carbon emissions and improve energy efficiency, the older building stock remains a critical consideration (Pracchi, 2014). However, applying these energy policies to listed properties without affecting their embodied significance is a challenge. Further, the regulations protecting listed properties are identified as a challenge in the existing literature (Galatioto *et al.*, 2017).

In addition to contributing to carbon reduction targets, the improvement in energy performance of 'built heritage' - i.e. buildings that embody cultural or historical significance, enables their continued usefulness (Munarim and Ghisi, 2016). It also enables the provision of a comfortable environment in which to reside, particularly as expectations of thermal comfort change (Pendlebury *et al.*, 2014). It also contributes to meeting national and international climate change goals. However, sustainability needs to be carefully balanced with the conservation needs of these buildings to ensure that their long-term importance is not compromised for short-term gain.

This paper aims to investigate the similarities and differences in the drivers and challenges of the energy efficiency of listed pre-1919 housing in Italy and the UK.

Conservation and sustainability

The management of historic properties "is governed by established conservation principles" (Webb, 2017, p.749). The current principles and regulatory system for the protection of listed properties is primarily based on conservation philosophy developed in the mid-nineteenth century, particularly by John Ruskin (1849) and William Morris (1877) (Pendlebury *et al.*, 2014; Mansfield, 2008). These concepts are founded on minimum intervention, authenticity, reversibility (Pianezze, 2012; Pracchi, 2014) and compatibility (Webb, 2017).

Conservation is defined by Historic England (2008, p.71) as:

"The process of managing change to a significant place in its setting in ways that will best sustain its heritage values, while recognising opportunities to reveal or reinforce those values for present and future generations".

This process is often used to refer to the treatment of 'traditional' buildings and to 'built cultural heritage'. Traditional buildings typically relates to buildings built prior to 1919 although can also refer to some buildings constructed prior to 1945 (Historic England, 2017). Built cultural heritage is defined as 'inherited assets' which embody particular values (Historic England, 2008), where a 'value' is defined by Historic England (2008, p.72) as an "aspect of worth or importance, here attached by people to qualities of places".

'Sustainability' is defined by Historic England (2008, p.72) as that which is "capable of meeting present needs without compromising [the] ability to meet future needs", although this can be further expanded to consider the triple bottom line of sustainability – environmental, economic and social, as embedded in the Brundtland definition of sustainable development (World Commission on Environment and Development, WCED, 1987). Indeed, Georgiadou et al. (2012, p.145) extends 'sustainability' in buildings to "energy efficiency, thermal comfort, serviceability, safety, and cost-effectiveness" and to avoid such buildings becoming prematurely obsolete.

Whilst *conservation* aims to preserve architectural, historical and archaeological values, *sustainability* tends to preserve resources such as energy (Pracchi, 2014; Pianezze, 2012; Bossi, 2009). The literature describes energy improvements in historic buildings as a 'balancing act', attempting to balance the long-term use of the building (Webb, 2017) with its embodied heritage values.

These concepts of conservation and sustainability can be perceived as synergistic, as overlapping and/or as complimentary. By conserving a resource, whether this 'resource' is energy or a historic building, we are, by definition, 'sustaining' it. However, in reality, the relationship between these concepts is still imprecise, particularly with regard to how energy efficiency relates to historic building preservation (Pianezze, 2012).

Pracchi (2014, p.211) highlights the importance of the conservation of the values embodied in historic building co-existing with modern energy efficiency interventions. However, intervention or transformation works can also result in the unintended decrease in the artistic, historic, social and economic value of these buildings. This is a particular risk where physical intervention with the existing fabric is undertaken, such as the installation of insulation.

When an historic building asset is deemed to have value, it is this 'significance' which can be protected through legislation by providing them with a 'listed' designation (Pianezze, 2012; Mazzarella, 2014). In Italy, listed buildings are protected under D. Lgs. 42/2004 (Section II, Article 29) - the Cultural Heritage and Landscape Code. In the UK listed buildings are protected under Planning (Listed Buildings and Conservation Areas) Act 1990. These regulate any works or alterations to listed buildings with the aim of managing change, and protecting them against damage to their irreplaceable values.

The statutory protection afforded to listed buildings can make it challenging to improve the energy efficiency of these properties (Ginks and Painter, 2017).

Listed pre-1919 buildings are some of the most difficult to improve (Galatioto et al., 2017) in relation to energy efficiency due to their physical characteristics, such as solid walls, the need to retain protected values (Pianezze, 2012), and because listed buildings are considered by policy as 'fragile' (Munarim and Ghisi, 2016). This does not mean the energy efficiency of listed buildings cannot be improved; rather there is a need to avoid unacceptable, poorly designed interventions (Yung and Chan, 2012). Indeed, by not acting to improve building energy efficiency, there is a risk of listed pre-1919 buildings being viewed as a potential 'energy liability' and a risk to their long-term usability (Webb, 2017). Instead, improvements should be undertaken on a case-by-case basis (Hensley and Aguilar, 2011; Pracchi, 2014; Gonçalves de Almeida, 2014). Whilst there are a vast number of energy efficiency measures and technologies available for existing buildings, only a small proportion are suited to listed buildings (Mazzarella, 2014).

The retention of the fabric of historic building "*leads to the retention of cultural significance*" and maintenance on a minimal intervention basis being the most appropriate method of achieving this (Forster and Kayan, 2009, p.212). Whilst there is typically greater tolerance for physical intervention if such actions can be considered reversible (Pendlebury *et al.*, 2014), minimising interference with the physical fabric of listed building is considered to be the most appropriate approach (Yung and Chan, 2012), as this often forms part of the significance of the building (Polo López and Frontini, 2014).

Minimal intervention is connected with conservation concepts such as sympathetic alterations of important features, avoiding the destruction of the fabric, and material authenticity (Forster and Kayan, 2009) However, it is the fabric which forms a central role in the provision of thermal insulation (Polo López and Frontini, 2014) and the overall energy improvement of a building (Galatioto et al., 2017). Therefore, some form of intervention with the fabric of the building is likely to be necessary. Such interventions need to take account of aspects of material behaviours, including moisture and breathability.

'Breathability' refers to the hygrothermal behaviour of a building in which moisture is absorbed and evaporated as a means of moisture control (Webb, 2017). In particular, solid walled properties are more porous in comparison with modern properties (Campbell et al., 2017). The design decisions of fabric interventions must, therefore, consider how to address aspects of breathability, and accumulation of moisture and thermal bridges (Campbell et al., 2017) in addition to whether the alteration is aesthetically acceptable. Such considerations extend beyond aspects of improvements in energy efficiency, to the challenges of fabric intervention in listed pre-1919 housing relating to regulatory (Galatioto et al., 2017), technical (Galatioto et al., 2017), and aesthetic (Campbell et al., 2017; Sunikka-Blank and Galvin, 2016) aspects in addition to initial cost (Webb, 2017) and acceptable payback periods (Galatioto et al., 2017).

The presence of tensions between sustainability and the conservation of listed buildings has been highlighted in the existing literature (Pracchi, 2014; Martinez-Molina *et al.*, 2016; Mansfield, 2008). For example, where there is a

need to improve the energy efficiency of a listed building, but this is not possible where such improvements affect the characteristics of the building which contribute to its value (Nardi et al., 2017). Such values must be preserved. Sunikka-Blank and Galvin (2016) suggest that such tensions should be addressed in local policy.

According to Bossi (2009, p.36), “‘sustainable’ is about improving the energy efficiency of buildings and preserving the protected environment from wrong actions. ‘Unsustainable’ is about pretending that historical buildings thermally behave as the modern ones, but also the erroneous usage of materials”. That is, when improving the energy efficiency performance of listed pre-1919 housing, how such buildings perform must be understood to avoid irrevocably causing damage.

There is a consensus within the literature that improvements to listed should be done on a case-by-case basis (Hensley and Aguilar, 2011; Pracchi, 2014; Gonçalves de Almeida, 2014). Improvements should provide a balance between energy efficiency and the maximum preservation of the values the asset embodies, protecting these values for future generations as well as providing a healthy environment for occupants (Martinez-Molina *et al.*, 2016). This custodial dimension of conservation, grounded in the Society for the Protection of Ancient Buildings’ 1877 principles, resonates with Brundtland’s (1989) definition of ‘sustainable development’ where development should meet the needs of the present whilst allowing future generations to have the same opportunity. Further, sustainability for listed buildings means recognising the property as a non-renewable and valuable resource.

There are concerns in the existing literature over unintended consequences of energy efficiency measures on the fabric of traditional and pre-1919 buildings (Agbota, 2014; Stuart, 2014). This might include negative implications for listed building aesthetics, significance, and impact on occupant health, comfort and behaviour (Agbota, 2014). Avoiding damage to the values and significance of listed buildings is essential (Godwin, 2011). This should influence the approach adopted when improving the energy efficiency of these dwellings.

The decision to increase the energy efficiency of a property may lead to the replacement of a single component to optimise performance. Viewing a refurbishment of a listed or historic building as a sum of individual, isolated actions to improve energy efficiency can increase the likelihood of unintended, negative consequences (Agbota, 2014). However, a ‘whole-building approach’ would enable the relationship between a building and its environment, its performance and use. This approach proposes using a deeper understanding of historic construction techniques, and to use this to assess and inform decisions for enhancing the energy performance of traditional buildings (Erbe *et al.*, 2013).

The ‘whole-building’ approach to energy efficiency improvements is supported by Historic England (2017) to avoid damaging the values embodied by a building, but also highlights the need to consider, specify and apply measures with particular care. Energy efficiency improvements should be implemented

“but not beyond the point where there is a risk that unacceptable damage to the character and appearance or the long-term durability of the physical fabric will occur” (Historic England, 2017, p.12).

Existing research has suggested that, to achieve an appropriate solution for energy efficiency improvements in historic buildings, a range of professionals should work together with the building owners, but in reality this “is extremely challenging” (Martinez-Molina *et al.*, 2016, p.82). Effective solutions can be developed for listed historic housing – and non-listed historic housing of aesthetic merit, where professionals such as architects and contractors work together (Sunikka-Blank and Galvin, 2016). However, difficulties with such professionals working together alongside limits of professional knowledge have also been reported, albeit in smaller-scale research (Sunikka-Blank and Galvin, 2016).

Methodology

The interivist paradigm was adopted to explore the similarities and differences in improving the energy efficiency performance of listed pre-1919 housing in Italy versus the UK. Seven semi-structured elite interviews were undertaken between May and August 2016. Interviews were undertaken using a topic guide and standard prompts. . A combination of open-ended and close-ended questions were used to explore professional and personal experience of listed pre-1919 housing and the energy efficiency improvements of such properties. These questions also aimed to elicit data pertaining to the drivers and challenges of such improvements, available measures, and the application of the concepts and policies relating to conservation and sustainability.

[Table 2]

The research forms part of a preliminary study for university research to inform further research. The sample size was guided by saturation point (Blaikie, 2009). Using pre-defined selection criteria (Table 2), interviewees were selected using purposive and snowball sampling methods. This was intended to select experts with professional experience of pre-1919 housing projects who also had personal experience of improving the energy efficiency of their own listed pre-1919 home. This enabled research to explore the perspective of built heritage professionals and from their perspective as a homeowner. The research incorporated professionals from a range of backgrounds (Table 3). Individuals were contacted by email with initial pre-qualification questions to identify their suitability for inclusion.

[Table 3]

The research underwent ethics approval in accordance with the University protocols. Interviewees were provided with an information sheet and consent form one week in advance of the interview, with the option of withdrawing from the study up to four weeks after the interview. Interviews were audio recorded and transcribed verbatim, and Italian interviews were translated into English.

The qualitative data was analysed using thematic analysis, adopting a combination of inductive and deductive approaches, guided by the study aim. This enabled key themes to be identified, which were subsequently divided into three main categories: (1) drivers; (2) challenges; and (3) adopted approaches.

Validation of the findings was achieved through interviews with two additional expert interviews. One interview was undertaken with an Italian built heritage professional, and one with an English built heritage professional. Both validation interviewees reviewed the findings, discussed the findings and interpretations with the researcher, and confirmed the interpretation of the data.

Results

Conservation and sustainability

Based on the qualitative data generated from the seven elite interviews, the concepts of sustainability and conservation must be appropriately balanced in listed pre-1919 buildings to respond to concerns about climate change in parallel with preserving the values they embody, supporting the findings of the extant literature. Overall there was a general consensus that *sustainability* related predominantly to environmental considerations and energy management, and *conservation* was associated with the management of the built environment and preservation. However, as Interviewee PUK stated:

“I believe that conservation is part of sustainability. If you want to preserve something, you need to keep it in use, which means accomplish the ‘sustainability’ requirements”

Concerns regarding the balance between the sustainability and conservation concepts did, however, exist amongst interviewees. Interviewees questioned whether the concepts could coexist without negatively affecting the historic value of the property, particularly its fabric and overall aesthetics. Indeed, such conflicts have also been reported by Sunikka-Blank and Galvin (2016) in their research on homeowners in Cambridge. This suggests that such concerns may have relevance in a wider, international debate.

The wider definition of *sustainability* appeared to resonate with interviewees in relation to listed pre-1919 housing. Rather than viewing sustainability as increasing the energy efficiency of these buildings, it appeared to also need to encapsulate the wider aspects of social and environmental sustainability in the form of community, sense of pride, and embodied energy, and how individuals connect with and make sense of a place:

“I believe we have to be very cautious with old buildings as we could destroy a lot of the materials and carbon that’s been embodied in these buildings. This isn’t good in environmental terms but we could also lose the sense of community, the pride, and the sense of place that we love about the environment around us” (LAIT, 2016)

Drivers

Italian and UK interviewees identified thermal comfort and saving money on energy bills as key drivers for improving home energy efficiency performance. As SEUK noted:

“energy bill savings and thermal comfort are main drivers. I live in a Victorian terrace and I have to admit I bought the house because it’s very nice-looking, [...]. During the summer was ok, but it’s really cold during the winter...and I spent a lot of money to heat it up”.

The desire to improve the aesthetics and energy efficiency of a listed pre-1919 property to appeal to the real estate market, and therefore improve the resale value of a home, was also identified as a driver. However, this was only identified by UK interviewees, while PIT highlighted that the *“Italian housing market is almost stationary and it isn’t so easy to sell houses. So it [the potential for a higher resale value] cannot be an incentive for retrofitting”*. This appears to support Sunikka-Blank and Galvin’s (2016) findings that some homeowners recognise the potential for an improved energy efficiency to increase resale value, although this is not an area widely explored in the existing literature on pre-1919 housing.

Challenges

Interviewees recognised the existence of a number of challenges to improving energy efficiency in listed pre-1919 housing, and the historic building stock. Whilst the retrofitting process is necessary for national climate change targets, it also forms an important process of protecting, enhancing and keeping listed pre-1919 asset in good repair, as promoted by international conservation principles. As highlighted by Interviewee HRSUK, *“maintaining a historic building is a duty. So it’s fundamental to keep it in ‘good health’”*. To maintain the ‘good health’, both Italian and English interviewees promoted the identification of *“solutions, techniques, and materials that can guarantee the greatest respect for the original structure”* (CEIT, 2016), in order to achieve a balance between conservation and energy efficiency without imposing unintended consequences on listed pre-1919 housing. This highlights the importance of using appropriate materials and measures for pre-1919 housing to avoid negatively impacting on the building fabric, as well as the comfort of the occupants.

A further concern in effectively improving energy efficiency in listed pre-1919 housing related to the level of communication between parties, such as conservation officers and building inspectors, during a retrofit project. This, in addition to a lack of appropriately skilled building professionals, were identified as challenges to overcome before an equilibrium can be reached between energy efficiency and the protection of listed pre-1919 housing. As stated by Interviewee PIT:

“I would raise a problem, which is communication. Enhancing the energy performance of a listed building means involving a conservation officer, who is there to protect the heritage value of the building, and a building inspector, who aims to improve the energy efficiency of the house. Now, most building inspectors would say ‘if the conservation officer said you can’t do that, that’s fine! We will move on something else...’. Thus, they don’t find

a solution for energy [efficiency improvements] and say, 'we must get this balance right'"

Therefore a professional dialogue needs to be entered into, particularly at a local level, in order for a suitable strategy to be implemented to improve the energy efficiency of listed pre-1919 housing. Further, this may also indicate the need for greater education for all building professionals about how these buildings can be technically improved without damaging their heritage values.

Based on the qualitative data generated from the interviews, additional deterrents to improving the energy efficiency of listed pre-1919 housing, these include the loss of historical value, uncertainty of the outcome, legislative barriers such as difficulties in securing planning permission, and the cost of works. This supports findings of the existing literature (Weeks *et al.*, 2015; Pelenur, 2013), and research by Organ (2015) who found the role of internal factors such as expectations, and external factors such as the cost of works as influencing owner-occupier motivations to increase home energy efficiency.

The aspect of cost, particularly in relation to the uncertainty of costs when working with listed pre-1919 housing, was further highlighted by Interviewee CAIT:

"It's really important you have enough money for the works plus a bit more because it's quite expensive and also because with old properties it's always uncertain. I mean, if you want to add, let's say, internal insulation, then it's possible you find rot in the wall and then you can't proceed if you don't repair [the decay] first...this is going to cost you more than [you originally] predicted of course"

This is a particularly important aspect in the context of the 'whole-building' approach to improving energy efficiency, which is argued by Historic England (2017) as the most effective approach to avoid damaging the significance of a listed building. However, where this is prohibitively expensive, a well-considered strategy of phased works may be a suitable alternative.

The concern regarding the loss of heritage value supports the existing literature which identifies the aesthetic value perceived by the homeowner strongly influences retrofit decisions in listed pre-1919 housing (Sunikka-Blank and Galvin, 2016). Whilst Sunikka-Blank and Galvin (2016) highlight that a homeowner's willingness to preserve the character of their home could halt improvement works, interviewees did identify a number of solutions which are effective for improving building energy efficiency without negatively affecting its character. As stated by Interviewee CEIT:

"Nowadays there are so many things you can do without affecting the building's character, such as 'hidden works', 'like-for-like' repairs, or implementing services. Generally, my advice is to be careful in selecting the building materials, which must be more natural and less polluting than the modern ones".

Adopted approaches

Interviewees were concerned about the effectiveness of solutions and their application without causing harm to the significance of the listed pre-1919 house. The main considerations were aesthetic damage, physical damage to the building fabric, the level of workmanship required, and the poor communication between the professionals involved in the installation of energy efficiency improvements. One interviewee suggested that techniques and materials “that can guarantee the greatest respect for the original structure” to avoid affecting the significance of the building should be prioritised. This could include less invasive technologies such as roof insulation and draught-proofing, or more technological measures such as ‘smart home technology’ to enable the more effective use of energy or, on a larger-scale, the use of a smart thermal grid.

When adopting an approach and selecting measures to improve the energy efficiency of listed pre-1919 housing, interviewees highlighted a number of factors which must be considered. These factors were the impact on the building aesthetics, cost, level of achievable energy saving, and the average payback period. There was a consensus that these factors need to be well balanced when deciding which solutions best-fit client needs and expectations. Further, interviewees also emphasised that particular consideration must be given to listed pre-1919 buildings, as they present different behaviours, such as breathability and ventilation, in comparison with their modern counterparts.

For measures which are appropriate for listed pre-1919 housing in relation to conservation and compatibility considerations, interviewees viewed some measures more challenging to apply to these properties. First, external wall insulation was considered challenging for listed pre-1919 housing due to the impact on the property fabric and aesthetics. Second, window improvements, whilst one of the main components to be replaced through incentive schemes in Europe resulting in the loss of many traditional windows (Pracchi, 2014), a number of interviewees stated that windows were particularly protected, especially, in the case of timber framed windows. This, interviewees explained, was because windows contribute considerable character to older properties. Therefore, the preference was to restore windows wherever possible. Indeed, Ginks and Painter (2017, p.392) suggest the preference in retaining existing glazing in listed housing also reflect concerns about the “accelerated loss of historic glass; need for thicker glazing bars to support the increased weight [of new double glazing]; and a flatter, more uniform reflection compared to old glass”. Where it is not possible to restore historic windows, one interviewee highlighted that a “*more energy efficient replica*” should be installed (Interviewee CAIT). Interestingly, no interviewees raised the option of installing less intrusive measures such as heavy curtains and shutters as highlighted in the existing literature (Agbota, 2014; Pracchi, 2014; Stuart, 2014; Curtis, 2010). Georgiadou et al. (2012) highlight such measures as strategies for ‘future-proofing’ to minimise the need for mechanical cooling. Indeed, research by Historic England (2009) has shown that heavy curtains and well-fitting shutters can reduce the U-value of a single glazed window by 41% and 58% respectively. Whilst this may be interpreted as homeowners being unaware of these less intrusive measures, supporting the information deficit model (Bondre, 2016), as the interviewees

were experts in the area of energy efficiency in listed pre-1919 housing, an information deficit model seems unlikely. An alternative interpretation might be that, when speaking about energy efficiency improvements, there is an assumption that more intrusive measures are required to achieve an adequate energy efficiency performance or contribute to calculations such as the UK's SAP, which does not take measures such as shutters into account within the calculation. This highlights a number of challenges, such as whether there is a need for a discussion about whether an alternative version of energy calculations is needed for pre-1919 housing; the role of perceptions and expectations in improving energy efficiency in pre-1919 buildings; and the challenge of experts and householders being aware and considering less intrusive interventions as suitable alternatives of improving energy efficiency.

All the interviewees in both the UK and Italy remarked on the importance of occupant behaviour for achieving an improved energy performance. Fabric or service improvements were considered to be insufficient to achieve reasonable energy efficiency standards where the occupants did not also modify their energy behaviour, as highlighted by PUK:

"We can improve the building fabric, change services, but you can't really save a satisfactory amount of energy if occupants don't change their attitude and behaviour toward the way they live the house...they can't complain about the energy bills if they forget windows open when the heater is on, or leave the light on"

This emphasises the importance of occupant behaviour alongside technical improvements to contribute to the reduction in energy use, and mitigate the impact of the rebound effect, effect – increased occupant energy consumption after physical building improvements resulting in lower actual energy savings than predicted (Buchanan et al., 2015). As highlighted in the existing literature, this may reflect appropriate changes to enable improved thermal comfort (Hong et al., 2009).

Based on the analysis of the qualitative data, Table 4 shows the factors identified by the interviewees as having a role in improving the sustainability of listed pre-1919 housing in the UK and Italy, based across five key themes: EU and international targets; conservation principles; industry; sustainability; and social. In the table,, factors in columns are contained within one of five themes, and should be read vertically in these columns. Shading relates horizontally, indicating stronger associations between factors in different theme groups, detected in the qualitative data during thematic analysis.. The 'resale value' factor has been intentionally faded as this was identified only as having an impact in the UK interviews.

[Table 4]

Based on the factors identified in Table 4, a model was developed (Figure 1) to identify the primary aspects in achieving energy efficiency improvements in listed pre-1919 housing. Within this model, there is an underpinning of EU and national legislation and policy (blue), and conservation principles (green).

Additional factors relate to the occupant (orange) and industry (purple). The model shows overlaps between categories in places, such as the continued usability of the property and prevention of obsolescence. The validation interviewees confirmed the validity of Figure 1 based on their own experiences.

[Figure 1]

Discussion

The study aimed to investigate the similarities and differences in the drivers and challenges of the energy efficiency of listed pre-1919 housing in Italy and the UK. Both Italy and the UK, countries contribute to similar proportions of existing housing in the EU. Both countries also have a large proportion of pre-1919 housing. Based on modelled energy efficiency performance, pre-1919 housing have low energy performance. Such properties in both countries are usually constructed of solid masonry with single glazed windows.

There was a consensus that, whilst synergies exist, the terms 'sustainability' and 'conservation' were distinct from one another. The former was viewed to apply to environmental considerations and to energy management. The latter was considered to apply to the management and preservation of built cultural heritage. However, the wider definition of 'sustainability' appeared to be viewed by interviewees in both the UK and Italy as being complimentary to 'conservation, the wider definition of 'sustainability' encapsulating social and environmental aspects. Despite this, concerns were expressed about balancing these two concepts.

Due to the age and lower mean energy performance of listed pre-1919 housing, intervention to improve their energy performance of this 'fragile' stock is required (Munarim and Ghisi, 2016). Whilst such buildings are challenging to improve in relation to energy efficiency due to both their physical attributes and the need to protect their significance (Pianezze, 2012), this should not impede the drive to improve the energy efficiency performance of the historic housing stock. Instead we need to better understand how these properties function.

Whilst improving the energy efficiency of the existing housing stock has become a central strategy for the EU in improving carbon emissions as reflected in EU directives, listed pre-1919 buildings have particular values which result either in them being excluded from this strategy, or the requirements relaxed. This is as a consequence of such buildings representing particular historic, architectural, cultural, and aesthetic values which require preserving. Indeed, for their sustained use, it may no longer be sufficient to simply maintain these assets; such buildings will need to be adapted to ensure their long-term comfort and the affordability their operation in the context of a changing climate.

The empirical data showed that the key drivers for improving the energy efficiency of listed pre-1919 housing in Italy and the UK was to enhance thermal comfort and save money on energy bills, supporting Organ (2015) and Fawcett

and Killip (2014). UK participants also noted the desire to increase resale value as an additional driver for performing works.

There are a number of challenges in improving the energy efficiency in listed pre-1919 housing. This extends beyond the need to balance conservation with energy efficiency without imposing unintended consequences to identifying *how* this balance is to be achieved.

A challenge exists in relation to the current theoretical modelling of the performance of pre-1919 properties, which does not reflect historic buildings' actual performance of these buildings in-situ. This can result in their energy efficiency performance being under-reported, and therefore this will not provide a true representation of these properties. To take this performance gap into consideration, changes are being made to the U-value for solid walls in the UK (Building Research Establishment, 2016). It is necessary to understand the actual performance of a building as this will inform the decisions made in relation to its energy efficiency upgrade. Further, whilst less invasive measures are promoted for listed pre-1919 housing such as heavy curtains and shutters, the most commonly used calculation of energy performance – SAP, which EPCs are based on, does not take features such as shutters into account within the calculations. Whilst these measures relate to building physics effects, it may be necessary to better recognise of the role they may need to play in listed pre-1919 where the installation of more intrusive measures may not be appropriate.

Greater availability of appropriately skilled professionals is needed to advise and work with listed pre-1919 housing to improve the energy efficiency of this type of property. Such professionals are needed to work with the homeowner to develop less intrusive solutions for upgrading the property. This may require additional training of those working directly with listed houses assets. The level of communication between stakeholders and entering a professional dialogue were also identified in the qualitative data as challenges which require addressing, supporting findings by Sunikka-Blank and Galvin (2016). This may require a change in culture amongst those working in improving the energy performance of our listed and non-listed pre-1919 housing to enable greater collaboration.

There needs to be consideration in relation to the selection of measures which comply with conservation principles such as reversibility and minimal interference with the fabric, which do not detract from the values of the listed pre-1919 housing or cause damage to the building. This is where smart technology could be adopted to enhance energy efficiency of a home whilst reducing the level of intervention required to improve the property's energy efficiency performance. Kramers et al. (2014) highlights the potential for smart technology to be adopted in housing for lighting and heating. In pre-1919 housing, there is also the potential for this technology to help maintain a healthy environment and, therefore healthy building fabric. If intuitive smart technology can be adopted to learn occupier preferences and habits, this could help to reduce heating 'peaks and troughs'. Smart technology and intelligent controls are able to improve efficiency, increase thermal comfort and potentially save energy.

This could form part of a smart thermal grid within which there is a need for low-temperature district heating (Lund et al., 2014).

Limiting physical intervention also relates to homeowner aversion to damaging the character of their home, which may reduce the resale value of their property. This highlights the need to develop holistic solutions to improve the energy efficiency of listed pre-1919 housing which can be reversed, retain heritage values and the character of the building. The aspect of resale value is an important one as, unlike the Italian interviewees, this was a consideration raised by UK interviewees, who indicated the desire to enhance both their home aesthetics and energy efficiency to improve the resale value. Fuerst *et al.* (2015) identified a positive relationship between higher energy efficiency ratings and transaction price for houses in England, supporting the present study's interviewees' perception that energy efficiency improvements can affect the resale value of their homes. Research undertaken on housing in the United States suggests that energy efficiency improvements can increase the value of the average residential property by 2% (Jafari *et al.*, 2017), suggesting that this potential impact on resale value extends beyond the UK.

The payback period for energy efficiency improvements must be a sufficiently attractive one. However, this will be affected by user behaviour. This uncertainty regarding the payback period contributes to a homeowners' uncertainty regarding outcomes. Although outcomes can be difficult to predict, this needs greater certainty to induce greater action amongst owner-occupiers. This can be guided to a greater extent by what professionals communicate with homeowners as the outcome of the works, without exaggerating what will be achieved. It is the level of achievable energy savings that needs greater clarification, although this will be impacted by the rebound effect.

The education of occupants in relation to behavioural adaptations should be undertaken alongside physical building improvements in listed pre-1919 housing. This is to avoid negating energy savings through the rebound effect. However, as highlighted in the existing literature, this 'information deficit' model has been widely criticised (Owens and Driffill, 2008). Instead, there is a need to take into consideration the "physical, social, cultural and institutional contexts" that mould an individual's energy choices. In the context of energy efficiency improvements in listed pre-1919 housing this should be done through the selection of measures and, where there is a whole house refurbishment, the design. Perhaps in the future this will also require being considered as part of a wider smart thermal grid or smart energy grid.

Smart technology that enables communication and interaction with occupiers could help inform and shape users' energy choices. Research has shown how technology such as smart energy monitors can become 'backgrounded' over time within a household's normal routines and practices (Hargreaves, Nye and Burgess, 2013). However, this 'backgrounding' of technology perhaps becomes less significant in relation to intuitive smart home technology that can learn occupants' preferences and practices to inform automatic energy choices.

Conclusion

This paper explored the similarities and differences between the drivers and challenges to improving the energy efficiency of listed pre-1919 housing. Based on a small sample size, these preliminary findings contribute to analytical generalisability. Future research will be required to identify whether the findings are more widely applicable.

Whilst the concepts of conservation and sustainability are distinct, both aim to provide resources current generations whilst preserving such resources for future generations. Building conservation relates, however, to how buildings with embodied values are managed and protected, whilst sustainability can be seen to relate to the management of environmental, economic and social resources.

How listed pre-1919 houses are managed and maintained is important to ensure that they, and the resources used by their occupants, is crucial. We can avoid such buildings from becoming energy liabilities in the future by improving their energy efficiency, but careful consideration is needed to avoid harming the significance and longevity of these buildings through poorly selected materials and measures which are not compatible with the building fabric.

Indeed, pre-1919 buildings perform differently to their modern counterparts and therefore the measures we apply to these historic properties must be done with sufficient understanding of this difference. Such measures must be compatible and appropriate with these buildings, and in line with conservation principles. Further, the discussion of developing an alternative version of energy calculation for these buildings should be entered into.

The selection of measures is based on a number of factors. These include the affect on the building's aesthetics, the cost of the measure, the level of energy saving the measure can achieve, the payback period, and the measures that fit best with the client's needs and expectations. The payback period and client expectations may be influenced by the rebound effect as a consequence of occupant behaviour. In addition, measures should provide a balance between conservation principles and sustainability.

Based on a review of the extant literature and elite interviews a number of drivers and challenges were identified to exist. A number of these drivers and challenges were shared between Italy and the UK. The shared drivers included international and national legislation and targets, improved thermal comfort, and savings on energy bills. Improving the resale value of the home could also be a driver to perform energy efficiency improvements.

International conservation principles promote keeping listed pre-1919 housing in good repair, protecting and enhancing their significance. However, improvements to energy efficiency performance was generally viewed as having the potential of detrimentally affecting the significance of these properties, or causing unintended consequences. The potential loss of historical value, the cost of the works, the uncertainty of the outcomes and costs, and difficulties in

securing planning permission were all identified as barriers to improving the energy efficiency performance of listed pre-1919 housing.

Greater inter-professional collaboration is needed. A professional dialogue must be entered into within the project team, including conservation and building officers, surveyors, architects and contractors. This is to ensure that, during a project, the energy efficiency of a listed pre-1919 property is improved without compromising the significance of the building.

There are a number of similarities and differences between Italy and the UK in relation to improving the energy efficiency of listed pre-1919 housing. As a political level, the UK and Italy are influenced by EU legislation to improve the energy efficiency of their existing housing. However, whilst the UK has excluded listed buildings from having to comply with set energy efficiency levels when refurbishments are undertaken, Italy has relaxed the requirements for such buildings rather than excluded them altogether. Further, both countries broadly use the same conservation principles to inform decisions relating to listed buildings, and this feeds into national policy and guidance.

The existing literature and the interviews indicated that the two countries approach listed pre-1919 housing in the same way. However, whilst a number of guidelines have been developed over the last few years in the UK, suggesting how to improve the energy efficiency of listed pre-1919 housing, Italy currently lacks specific guidance on the provision of well-balanced solutions for improving energy efficiency in listed pre-1919 buildings. As indicated in the existing literature, solutions should be developed on a case-by-case basis as each listed building and its wider context is unique, and will therefore require careful consideration about the application of alternative solutions.

Further research

Areas for further research would be:

To explore the need for a separate tool for measuring the energy efficiency performance of listed pre-1919 buildings.

To identify whether there are similarities with the similarities and differences identified within this study are consistent with other European countries.

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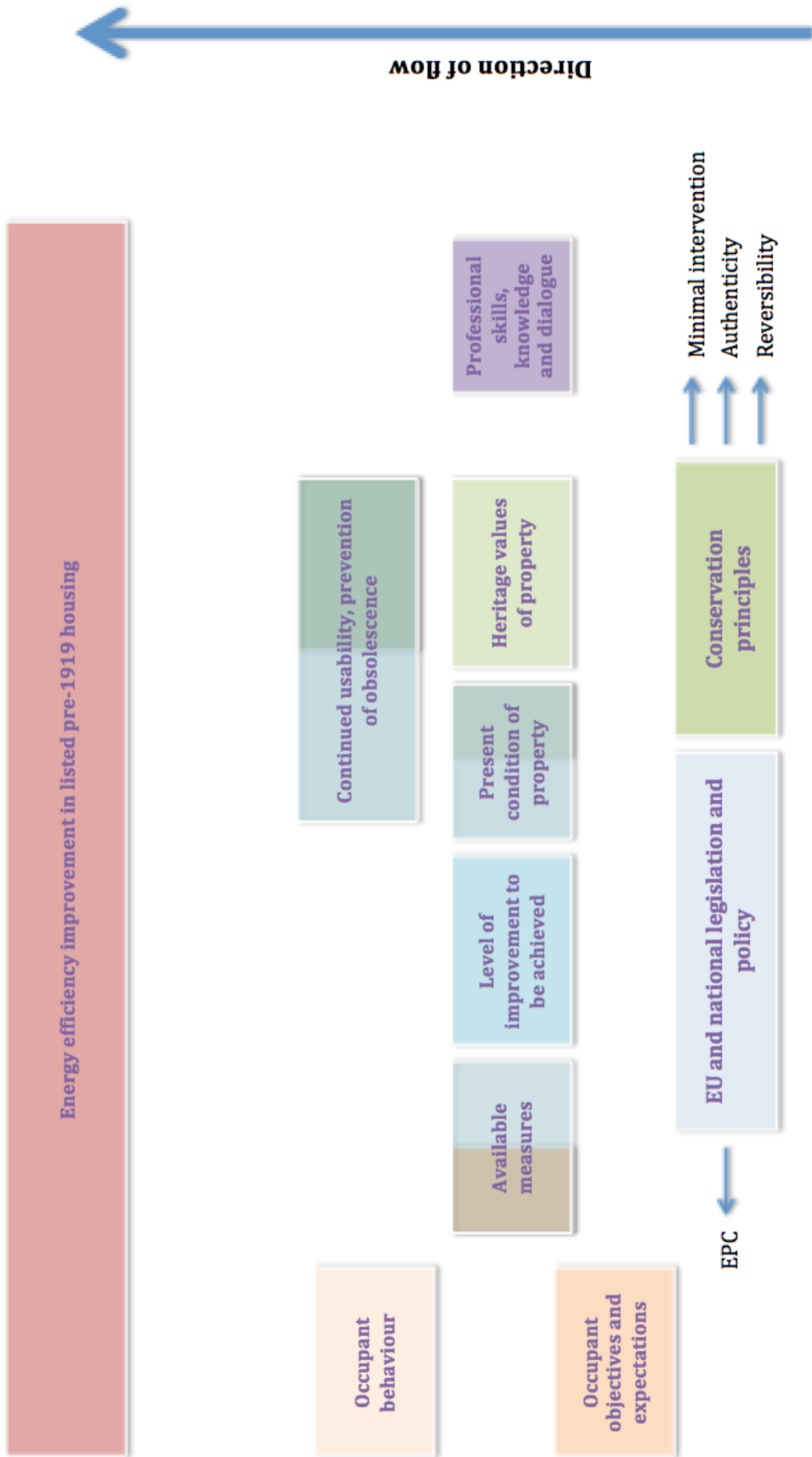


Figure 1: Authors' model implementation based on factors enabling energy efficiency improvements.

Table 1: Proportion of listed buildings in the UK.

	Number of listed buildings	Percentage of total
England	373892	81%
Wales	29903	7%
Scotland	47400	10%
Northern Ireland	8500	2%
Total	459695	100%
Figures from: The Prince's Regeneration Trust (n.d.)		

Table 2: Selection criteria for interviewees.

Industry work with listed pre-1919 housing
Reside in listed pre-1919 housing
Industry experience in excess of 10 years
Experience of installing energy efficiency measures
Based in UK/Italy

Table 3: Participants' profiles.

Code name	Country of residence	Professional role	Years of experience
CAIT	Italy	Conservation Architect	20
CEIT	Italy	Civil Engineer	15
PIT	Italy	Academic	25
LAIT	Italy	Landscape Architect	20
PUK	UK	Academic	25
HRSUK	UK	Heritage at Risk Surveyor	15
SEUK	UK	Structural Engineer	17

Table 4: Factors for improving the sustainability of listed pre-1919 housing in the UK and Italy.

EU and International targets	Sustainability	Conservation Principles	Social	Industry
Carbon reduction targets	Narrow and wide definitions	Values and significance	Knowledge and information	Professional knowledge and skills
Energy models and assessments	Cultural sustainability	Maintenance		Professional dialogue
Minimum EPCs	Energy efficiency		<i>Resale value</i>	
		Minimum interference with fabric	Aesthetics	Availability of appropriate measures
	Social sustainability (including future generations)	Future generations	Thermal comfort	
	Embodied energy		Energy bills	