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Title	Benign changes and building maintenance as a sustainable strategy for refurbishment of historic (Pre-1919) English dwellings
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Type	Article
Publication title	The 3rd International Conference on Energy Efficiency in Historic Buildings
Publisher	Uppsala University, Department of Art History
ISSN/ ISBN	978-91-519-0838-0
Publication Date	26 September 2018
Version	
DOI	
Repository link	https://ucem.repository.guildhe.ac.uk/id/eprint/86/
Link to publication	http://eehb2018.com/wp-content/uploads/2018/09/Con...

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Benign changes and building maintenance as a sustainable strategy for refurbishment of historic (Pre-1919) English dwellings

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Abstract – The need to reduce carbon emissions and lower energy consumption of the historic built environment is now being recognised as a critical factor in helping the UK Government's aim to reduce carbon emissions by 80 percent (compared to 1990 values). This paper proposes that the most sustainable option is to adopt a building conservation focused strategy to maintain and apply small benign changes to the property, rather than encourage historic homeowners to sustainably refurbish their properties. The hypothesis is tested with three approaches: existing datasets, computer modelling and case studies. The results show that through maintenance and benign changes to a historic property, significant energy and carbon savings can be made without affecting the visual or fabric heritage of the property. The study will go on to show that it is also the most economically effective method for sustainably refurbishing historic dwellings.

Keywords – sustainable refurbishment; maintenance; historic dwellings; sustainable strategy

1. INTRODUCTION

This paper proposes a holistic approach to sustainability concerning the historic built environment. It is a strategy based upon conservation principles rather than environmental focused sustainability improvements. It will show that these small benign interventions can have a substantial impact in reducing the energy consumption and carbon emissions within historic built environment. While it has been shown that a Victorian residential property can be improved to zero carbon efficiency, the improvement and refurbishment were economically expensive and damaging to the intrinsic heritage of the building fabric. By taking a more holistic approach and applying maintenance and small benign changes that could be applied to all historic dwellings, this study shows that significant energy and carbon savings can be made to the UK's historic residential built environment. It will show that these improvements are economically, culturally and environmentally viable and will allow for adaptation in the uncertain future that the existing residential stock faces.

2. CONTEXT

There are over 4.7 million of pre-1919 dwellings in England, this equates to over 325 home refurbishments every single day from now until 2050, if the carbon reduction and other sustainable goals are to be met. The pre-1919 housing stock in the UK has, on average, the worst Energy Performance Certificate SAP (EPC)

score and the highest carbon emission of any house age group, and typically, over twice the maintenance costs compared with modern housing for basic repairs. However, they usually have a higher market value because their intrinsic heritage is valued by potential purchasers. [1].

The interpretation of the sustainable, triple bottom line is key to understanding the context of this study. For a project to be sustainable in this context, it should meet the requirements of environmental factors, respect the heritage of the dwelling's cultural importance and fall within the financial capabilities of the dwelling owners. It is also to be recognised that while this study is focusing on energy consumption, there are many other factors that need to be taken into account across all three categories of the sustainable triple bottom line, such as waste production, water usage, upfront costs, changes in lifestyle, impact on house value, and, planning guidance, etc. Dwellings are perhaps the most heterogeneous of all of building stock. They are one of the most continually updated and adapted building types. Different people have different levels of comfort in terms of heating, and similar dwellings may have very different lifestyle occupancy and usage. Each set of owners of a dwelling make their own changes to the property, so therefore the properties that may have originally been built to the same design, are in fact unique as a consequence of these various updates and alterations. This continual adaption allows for houses to accommodate changes in lifestyle which, in turn, allows the building to remain a viable dwelling. It could be argued that because the dwellings that have survived decades and centuries are actually within themselves inherently sustainable and adaptable assets because of their continued successful use. This is recognised by national conservation and heritage bodies as defining building conservation as the management of change rather than simply the preservation of a heritage asset [2].

3. PROJECT AIMS

The project hypothesis is '*The most sustainable strategy for owners of historic Suburban housing does not lie in sustainable focused refurbishment of their dwellings but in historic building maintenance and benign improvements.'* The overall aim of the project is to show that by maintaining buildings, and with carefully selected interventions, the improvement in the environmental performance of historic dwellings could be significant, and at the same time be economically viable and culturally beneficial to the preservation of the historic asset.

4. HISTORIC BUILDING MAINTENANCE AND BENIGN CHANGES

It is important to understand that the fabric and the appearance of a historic dwelling have cultural significance–the building itself is an artefact and historical asset. Preventative maintenance is internationally recognised and has been central to building conservation legislation and charters [3]. Building maintenance and conservation plans are an accepted part of building conservation work. However, they are rarely carried out on historic dwellings. In fact, it is much more common for reactive repair to be implemented, rather than preventive maintenance [4].

It is important to emphasise that the terms 'maintenance and repair' should not be seen as interchangeable as they might be for other building types. This is because no matter how well-considered the repair is, it will involve some form of damage, removal or replacement of the historic fabric [5]. Maintenance is important in protecting cultural significance because correct maintenance is the least destructive of all the interventions which take place in the process of conserving the historic built environment. The idea of approaching work from a minimum intervention methodology is best summarised by the Burra Charter [6] "as much as necessary, as little as possible". The methodology for this study is the improvement in energy saving and carbon reduction with as little damage or change to the inherent heritage of the historic dwelling.

The Historic Town Forum [7] supports this methodology stating that 'One of the most energy efficient ways to preserve historic buildings is to ensure that continued, regular maintenance is carried out to safeguard its historic fabric.' Both the Historic Town Forum and English Heritage encourage the use of small/benign changes to improve the environmental performance of a historic dwelling. This paper defines benign changes as interventions that either have little or no effect on the heritage of the dwelling, do not damage the dwelling fabric, or the way the fabric needs to perform or react.

5. METHODOLOGY

The study uses three main sources of information to collect its required information. The first was a series of existing datasets that were available, which showed the energy efficiency improvements of various interventions on properties. This included large statistical databases such as the English House Condition Survey, as well as various case study datasets. Many of the existing data sets and case-studies used to provide relevant information, were focused on over-ambitious carbon and energy savings. The individual interventions were further analysed to determine if they would have an impact on the fabric and visual heritage of the dwelling. Only interventions that had low impact on fabric and visual heritage were categorised as benign changes. The data points were created to form a database of interventions comparing reduction of energy savings to cost of the intervention. Overall trends and findings are summarised in table 1 and figure 2. The second set of information was collected via computer modelling. The modelling package used in this study was NHER, which is a static modelling package. It is approved by the UK Government to provide energy performance certificates and ratings (SAP) for residential buildings [8]. It is worth noting that the UK Government currently only allows certain static modelling packages to be used in the residential energy assessment process and while the NHER package does have limited dynamic features such as occupancy rate and limited usage modelling, it is allowed [9]. The third set was from a live case study building, where actual energy savings were recorded as the specified improvements were applied to a historic Victorian dwelling.

6. SUSTAINABILITY

6.1 OVERALL SUSTAINABILITY

While the term sustainability is now in common use, it is more often applied to mean environmental factors rather than the holistic triple bottom line. This triple bottom line, taking into account environmental, social/cultural and economic factors, is key when dealing with historic built environment. Any sustainability strategy that applies to the historic built environment needs to take into account the cultural importance of the assets being considered, which in this paper is the historic dwellings within the UK. The historic built environment has a both a valued, tangible and intangible heritage which is often linked to the fabric and the appearance of a building. This needs to be considered while the overarching urgency to reduce carbon emissions and increase energy efficiency is also undertaken. The final criteria of the triple bottom line are economics; any scheme proposed for holistic application across the historic built environment has to be viable economically, not just a study in what is technically possible. This understanding of the holistic approach to the triple bottom line of sustainability has often been lacking in past sustainability strategies. This, along with a lack of understanding of the technical requirements that apply to historic buildings and their fabric, has often meant that, at best, sustainable refurbishment practices have been ineffective and, at worst, they have been extremely damaging to the fabric and appearance of the valued historic built environment.

6.2 CULTURAL BENEFITS

The main cultural benefit of a maintenance strategy is the improvement of the historic preservation of the building. Maintenance retains historic fabric because less material is lost in regular, minimal and small-scale work than in disruptive and extensive restoration [10]. The survival of any building is underpinned by regular and continued maintenance [11], but other than historic churches there is no current UK legislative driver for the enforcement of maintenance of historic buildings [12]. Preventive maintenance can help reduce the need for both damaging and expensive repairs and prolong the life of the existing historic fabric. Large-scale studies by English Heritage [13] have shown that the general UK population value the cultural importance of historic buildings.

6.3 ECONOMIC BENEFITS

Financing has long been seen as a barrier to widespread integration of sustainable changes into the existing built environment. While many of the studies reviewed [14] have focused on meeting the target of 80 percent reduction in carbon reductions, the over-focus on this figure has meant that some refurbishments become too expensive to be rolled out nationally, expecting all owners of historic dwellings to apply these to their houses by 2050. This paper focuses on what has come to be called the low hanging fruit–the easy, low cost interventions or the type of intervention that would happen through periodic renewal.

Any sustainability policy has to meet the financial and economic constraints of the affected parties. Thus, any proposed strategy in dealing with the historic built

environment has to not only be successful in lowering carbon emissions but also has to be financially attractive to the participants who are going to be involved in implementing any such strategy. The three main economic factors that concern historic dwelling owners are (a) the value of their property; (b) the maintenance and repair costs of the property, and; (c) the cost of current and future energy bills for that property. It is also believed by the owners of historic dwellings that EPC certificates have little or no impact on the re-sale financial value of their properties [15]. This section will show how long-term preventative maintenance strategies and benign environmental improvements to the historic dwellings can help meet these requirements. Some of the other environmentally focused refurbishment strategies are typically of a much higher cost. An example of this can be seen in a typical EPC recommended improvement, costs around £ 15,000 [16]

The cost of any periodic professional inspection to historic buildings has to be added to any financial calculation in considering the economic impact of this strategy. The work by Forster & Kayan [17] has shown that the costs of such inspections are more than covered by the savings of preventing expensive unnecessary repairs through the use of preventative maintenance strategies. In figure 1 (adapted from Forster & Kayan, [18]) it is shown that over a period of time, preventative maintenance along with the cost of periodic inspection actually reduces the overall repair costs of historic dwellings. The costs shown in Figure 1 have been averaged out over time (in a linear fashion), rather than shown at time of expenditure to allow for comparative analysis. The costs include both maintenance and repair costs plus the cost of inspection, are shown averaged

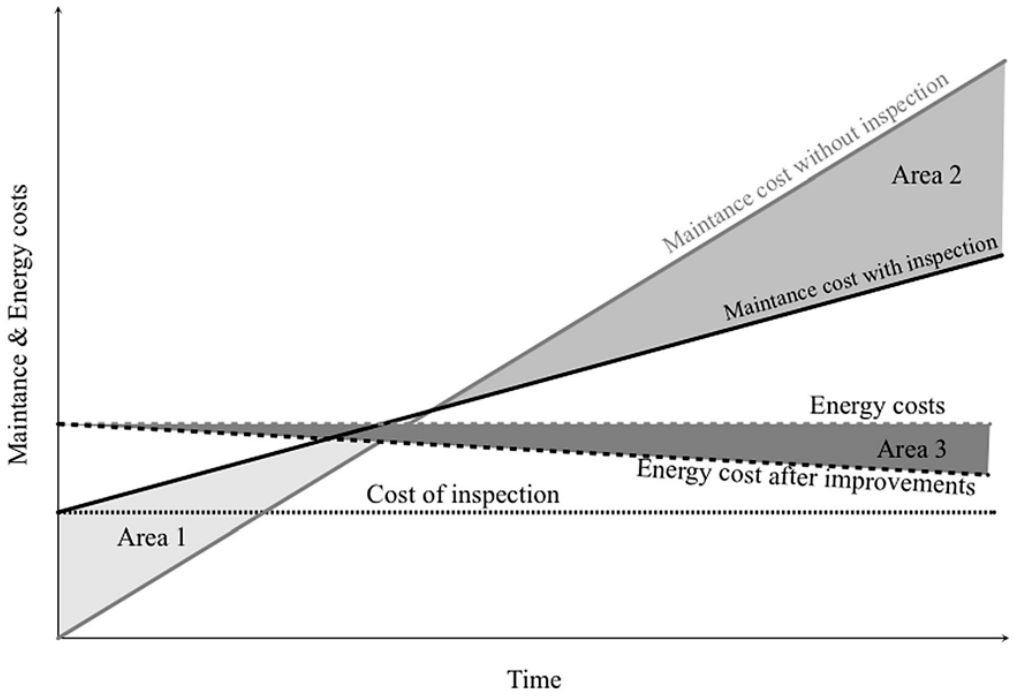

Figure 1. Maintenance costs with and without professional inspection compared over time.

out between inspection periods. Figure 1 shows that as long as Area 2 is larger than Area 1 there is an economic saving on the use of preventative maintenance schedules identified through periodic professional inspection. Further financial benefit is identified through the energy savings that come from the benign changes of the environmental performance of the building. Area 3 shows additionally the reduced energy costs from the benign environmental improvements. Additionally, area 3 can be seen as a further cost incentive for professional inspection incorporating preventative maintenance and benign changes.

The English House Condition Survey [19] indicates that essential repair costs for historic dwellings are more than twice that in modern dwellings. This again further highlights the economic benefits of continued professional inspection and preventative maintenance to secure the financial sustainability of historic dwellings. There are wider economic benefits of the strategy, as small-scale maintenance and repair work is often carried out by local tradesmen there is a further economic benefit to the local economy in encouraging more maintenance work to historic dwellings [20]. Although difficult to quantify, the improved condition increases the resale value of historic dwellings and this is in addition the higher market value of historic and traditional housing compared to the modern equivalent dwelling. Therefore, the economic benefit of preventative maintenance can also be seen by the increase in the market value of the property.

6.4 ENVIRONMENTAL BENEFITS

The environmental benefits of benign changes are one of the key foci of this study. The modelling cannot take into account behavioural changes and other specific factors that may affect the energy use and carbon emissions from an individual dwelling. Considerable energy savings can be made simply through behavioural changes and through small but gradual lifestyle changes. Examples of these changes are turning off lights in rooms when not in use or wearing warm clothes inside and turning the heating thermostat down. It is accepted that in many cases this may not be a viable option particularly for elderly or very young occupants, but it reinforces the importance of behavioural changes in reducing carbon emissions and energy consumption in historic dwellings.

The term benign changes can be divided in to two main groups. The first being periodical interventions, typified by upgraded replacements, an example may be an old boiler being replaced by a new high efficiency condensing boiler or the replacement of a kitchen appliance such as fridge. The second type of benign change is the active intervention, which is when a small change is made to the building to help improve the energy performance of the historic dwelling: an example of this would be the fitting of draft excluders around openings or the replacement of roof insulation. These changes are defined as benign changes as they have little or no effect on the fabric or visual heritage of the building. Benign changes typically are cheaper and more ‘light touch’ than more focused environmental improvements. The benign changes looked at in this study do not exclude future, more typical, environmental improvements to be made to the building.

7. KEY FINDINGS FROM THE STUDY

The aim of the study was to find cost effective interventions that would improve the environmental performance of historic dwellings at the same time have little or no impact on either the visual or fabric heritage of the building.

Table 1 provides an overview of the key interventions that were found to meet these criteria within the study. The study showed that by making sure that the heating system, with up-to-date controls, is the most efficient, significant savings can be made with little or no effect on the heritage values of the building. Other interventions such as draught-proofing and roof insulation also had a positive impact on reducing the energy consumption and carbon emissions of historic dwellings. The results clearly show that savings in the area of 30 to 40 percent are easily achievable in historic dwellings without the need to damage or impact the fabric of the building significantly.

Table 1. Summary of the overall study's results

Action	Percentage Energy Saved %		Capital Cost Used in Study (£)	Impact on Fabric Heritage	Impact on Visual Heritage
Upgrading the loft insulation to 300 mm	4.0%	31.1%	£273.00	LOW	LOW
Draft proofing and window repair	2.0%	10.0%	£50-£2000	LOW	LOW
Hot water cylinder insulation to >75 mm	3.6%	8.7%	£20.00	LOW	LOW
Fitting of a condensing boiler	16.0%	46.0%	£1,750.00	LOW	LOW
Improved heating controls	12.0%	14.1%	£250.00	LOW	LOW
Energy saving light bulbs	0.1%	0.2%	£200.00	LOW	LOW
Floor insulation fitted in raised timber floor	8.3%	14.0%	£1,000.00	LOW	LOW

When all of the interventions of the various buildings were tabulated and graphed, they all followed a similar trend as shown in Figure 2. It indicates that there were many interventions in the shaded area that were low in cost but had a significant impact on the environmental performance of the dwelling. What the study clearly shows is that there is a rate of diminishing returns higher up the carbon emissions and energy usage. And while under £ 5,000 it is possible to achieve energy savings of around 30 to 40 percent (more with behavioural changes). Above this it becomes increasingly expensive and also more damaging to the visual and fabric heritage of the building. It is the conclusion of this study that the interventions that fall into the shaded category of the chart should be the main priority of any policy rather than the more expensive environmentally focused, typical sustainability interventions. The key findings from the study are that the hot water and heating system are the key elements that need to be the focus of energy conservation in historic dwellings. Many of the dwellings surveyed had old boilers and heating

distribution systems and if replaced with a modern condensing boiler, significant savings in both carbon emissions and energy consumption could be made.

It should also be noted that while this proposal successfully meets the triple bottom line sustainability criteria as set out in the study, it does fall short of the overall aim of an 80 percent reduction in carbon emissions (compared to the 1990 values). Further interventions or wider environmental improvements such as 'greening' of the National Grid would be needed if further improvements are to be achieved.

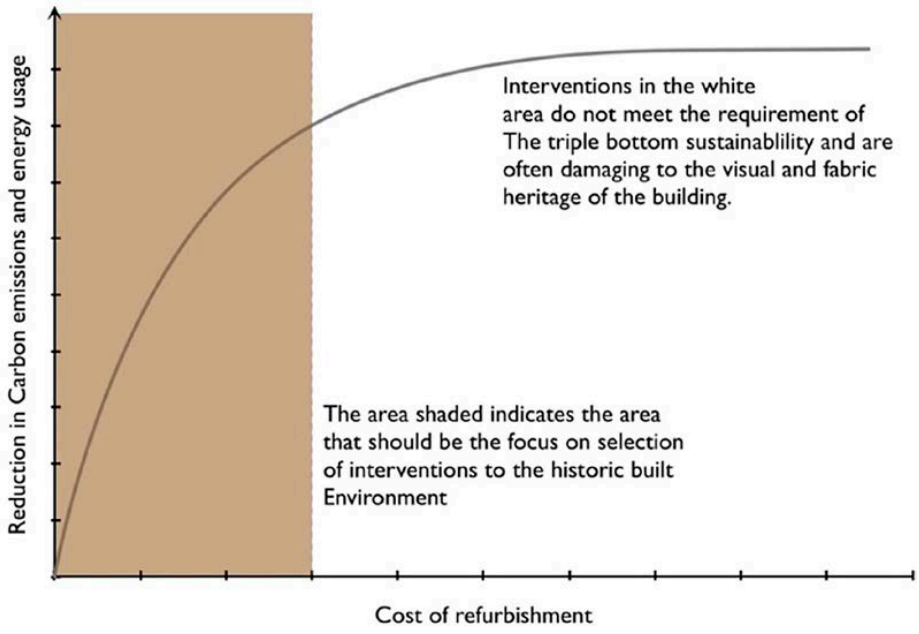

Figure 2. A comparison or cost to energy saving for all the interventions in the study.

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