Time to Retrofit

Decarbonising UK building stock and economic recovery

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Introduction

The built environment is at the centre of our day to day life. We use buildings for shelter, leisure, work, accessing services and many other types of activities.

Due to the importance and prevalence of buildings in our society, it is crucial that we consider the environmental impacts they have. Much of the existing building stock is environmentally inefficient but constructing new buildings is very carbon intensive, in addition to the emissions produced during a building's life through its operation and maintenance.

This paper suggests that the focus of reducing emissions going forward should be to retrofit the existing stock of buildings to make them more energy efficient. Retrofitting has the greatest scope and potential for decarbonising the building stock in addition to achieving relatively quick results.

The built stock across the EU is relatively old with 39% of residential and 42% of non-residential buildings having been built before thermal regulations were first widely introduced (i.e. prior to 1970), with only 22% of residential and 21% of non-residential buildings having been built post 2000. In the UK however, the building stock is generally older with 50% of residential and 39% of non-residential buildings having been built pre-1970. Furthermore, only 29% of residential and 30% of non-residential buildings have been built post-2000 (1). This suggests that a significant opportunity exists for retrofits as many buildings will require renovating to reach modern energy/thermal standards

BCIS recently completed a three-year service contract with the European Commission to improve the EU Building Stock Observatory (BSO) for the Directorate General for Energy. The BSO could be used to provide a better understanding of the building stock to steer an improvement in the depth and rate of buildings' renovation and to design effective policy measures and support mechanisms, the analysis that follows is based on data contained within the BSO.

Relevance of the study

Recently, the UK Government established the Green Homes Grant scheme (GHGS), an incentive to contribute towards economic recovery following the downturn resulting from the COVID-19 pandemic and to improve the energy efficiency of existing buildings. The scheme has an allocated budget of £2 billion and aims to reduce the cost burden for homeowners of energy efficiency renovations, incentivising the construction sector by increasing demand for labour, and at the same time reducing carbon emissions by improving the efficiency of buildings.

The GHGS will provide building owners with vouchers for up to a third of the investment in insulation, heat pumps, or solar thermal heating systems to a maximum of £5,000. In addition, if building owners make a preliminary investment in either of these three components, they will be able to apply for a secondary voucher equal to the first or up to the combined maximum value to be spent on windows, BCIS®

doors and heating controls. Limited income owners will be able to benefit from a voucher of up to £10,000, however, it will cover the totality of the investment in energy efficiency measures (2).

This paper examines the potential for renovating the UK's existing building stock, identifying the required investment to reach modern standards, the potential for creating "green jobs" and highlights the real opportunity to reduce the energy consumption of buildings.

Methodology

Given the lack of reliable and consistent data on the building stock, a few assumptions had to be made to perform the analysis. The study consisted of a set of three scenarios designed to demonstrate the job creation potential from incentivising renovation as well as the potential energy savings associated with the renovations.

The first stage of the analysis was to identify the quantum of the built stock. This data was required to understand the scale of all buildings that would, at some stage, require some form of renovation. Buildings constructed post 2010 were considered not likely to require significant renovation and were excluded from our analysis. This year was chosen because it is the year of the publication of the European Performance of Buildings directive where the idea of Nearly Zero Energy Buildings (NZEB) is introduced. The Energy Performance of Building Directive (EPBD) dictates new buildings should have "very good energy performance, with a significant proportion of the energy requirements being produced on site or closely sourced renewable energies" (3). The study assumes that buildings constructed in the period 2010 to 2020 would have little to no potential for energy efficiency improvements. This directive applied to all new publicly owned buildings from 2019 and all other buildings will be covered from 2021.

The quantum of the built stock was calculated using data extracted from the BSO (latest available stock numbers are for 2017) which was estimated by calculating the average historical growth rate of the built stock up to 2016 and extrapolating that average rate for the following year. This provided a total figure of the quantum of the stock of approximately 29 million residential buildings and 1 million non-residential buildings, which serves as the baseline for all scenarios described below.

In terms of construction employment, some estimates suggest that the total amount of jobs created per million pounds (£m) of expenditure could range between 10 and 21 jobs/£m of investment others set this figure around 13 jobs/£m of investment (4). In order to maintain a conservative approach, the ranges of 10 jobs/£m and 13 jobs/£m of investment served as the lower and upper bounds for this study.

Both Scenarios 1 and 2 use the quantum of the building stock of 2017 less the buildings which have been renovated resulting in the total amount of buildings which can be subject to energy efficiency renovation. All the data concerning the cost of renovation and related energy savings were extracted from the BSO (1).

Scenario 3 differs from the other two scenarios due to the staggered nature of the analysis. Although the identification of the quantum of the stock requiring renovation is the same, another layer of calculation is added to establish the total surface area, of the buildings by age. By separating the buildings by age groups, this scenario allows a more detailed picture of the renovation potential of the built stock. Each age group has a different renovating cost and energy potential attributed depending on the age of the building. The proportions are calculated from data extracted from the BSO. A key assumption of this analysis is that all buildings are assumed to have the same average surface area regardless of the period of construction.

Scenarios

Scenario 1

In Scenario one, we assume that through renovation, an average saving of energy of 12kWh/m^2 for residential buildings and 33kWh/m^2 for non-residential buildings would be achievable. Further, the cost of renovation is estimated at an average of £105/m^2 for residential buildings and £99/m^2 for non-residential buildings. Scenario one could be considered the base case where savings and costs are at their most conservative.

Scenario 2

In Scenario two we assume that renovation will be able to produce a greater level of energy savings (3-30% of Primary Energy Savings (PES)) i.e.16kWh/m^2 for residential buildings and 34kWh/m^2 for non-residential buildings which come at an estimated associated cost of £131/m^2 and £103/m^2 respectively. All buildings regardless of age are assumed to be able to be renovated at the same rate and be able to produce the same PES.

Scenario 3

Finally, Scenario three was designed in order to estimate the maximum potential of renovation in terms of both energy savings and job creation. This scenario considers the age of the buildings and depending on the age, a different type of renovation is attributed (deep to light). Each group of buildings entails a different cost, as well as a different quantum of energy savings. The breakdown is as follows:

- **Group 1:** Buildings constructed in the period <1945-1969 are assumed to require deep renovation. The reasoning behind this is buildings built prior to the 1970's were largely constructed before any thermal regulations were put in place and therefore are considered to offer the greatest potential in PES. The amount of energy saved through renovation on a deep renovation is 93KWh/m^2 for residential buildings and 65 kWh/m^2 for non-residential buildings at an estimated associated cost of £284/m^2 and £170/m^2 respectively.

- **Group 2:** Buildings constructed in the period 1970-1989 are assumed to require medium renovation. The reasoning behind this is that although these buildings were built after the period where thermal regulations were introduced, it is assumed that the potential of PES is not as great as in the previous threshold, however the fact these buildings are at least 30+ years old suggests that renovation could provide a tangible improvement. The potential amount of energy saved through this type of renovation is 48kWh/m^2 for residential buildings and 69kWh/m^2 for non-residential buildings at an estimated associated cost of £159/m^2 for residential buildings and £137/m^2 for non-residential buildings respectively.
- **Group 3:** Buildings constructed in the period 1990-2000 are assumed to require light renovation. Although these buildings could be considered relatively modern buildings for the most part, the study assumes that 3-30% of PES could still be reached in these buildings perhaps through the installation of replacement windows or updating the heating system. The amount of energy saved by these renovations is 16kWh/m^2 for residential buildings and 34kWh/m^2 for non-residential buildings with an estimated associated cost of £131m^2 and £103/m^2 respectively.
- **Group 4:** Buildings constructed in the period 2000-2010 are assumed to require below threshold renovation that will only likely achieve PES of 3% or lower. These buildings are considered relatively modern buildings and it is assumed that achieving true tangible improvements in PES will be difficult. The proposed renovations have a potential saving of 0.3 kWh/m^2 for residential buildings and 0.6 kWh/m^2 for non-residential buildings at an estimated associated cost of £66/m^2 and £57/m^2 respectively.

Cost, Energy Savings and Job Creation analysis

Scenarios 1 and 2 both use the same assumptions in terms of energy savings, cost associated with renovation and job creation. First the surface area requiring renovation is extracted from the data, then the renovation cost indices and energy saving indices corresponding to the scenarios are applied to find out the expenditure required in each scenario, and from that figure, jobs needed/created are estimated.

Scenario 3 differs from scenario 1 and 2 in the cost and energy saving calculation phase. Although the surface area requiring renovation is the same for each scenario, scenario 3 requires a different calculation methodology to consider the staggered nature of this scenario. Both the expenditure calculation and the energy savings calculation follow a similar equation which can be defined in the following manner:

$$TS \sum_{n=1}^{4} P_n \, C_n$$

Where n is the different subgroups buildings have been organised into, TS is the total surface area requiring renovation, P is the proportion of the area and C is the expenditure associated to each group.

Similarly, the energy savings equation is:

$$TS \sum_{n=1}^{4} P_n E_n$$

Where all elements are the same as the equation above, except for E which represents the energy savings associated to each group.

Results and Discussion

Scenario	No. buildings	Total Surface (m^2)	Estimated Expenditure (£)	Energy Savings (kWh)	Job Creation (LB)	Job Creation (HB)
Scenario 1	1,198,002	620,624,615	55,100,012,214	20,213,013,436	584,060	732,830
Scenario 2	1,198,002	620,624,615	57,256,503,462	20,887,335,528	606,919	761,511
Scenario 3	1,198,002	620,624,615	62,954,211,049	29,115,483,122	667,315	837,291

Table 1: Analysis results in the Residential sector

Scenario	No. buildings	Total Surface (m^2)	Estimated Expenditure (£)	Energy Savings (kWh)	Job Creation (LB)	Job Creation (HB)
Scenario 1	27,796,325	2,612,946,296	246,464,260,877	30,813,781,145	2,612,521	3,277,975
Scenario 2	27,796,325	2,612,946,296	307,882,666,815	41,057,995,391	3,263,556	4,094,839
Scenario 3	27,796,325	2,612,946,296	443,927,809,805	153,343,694,933	4,705,635	5,904,240

Table 2: Analysis results in the Non-Residential sector

The tables above highlight the results achieved based on our analysis and assumptions for both residential and non-residential buildings in the UK. The tables display by column the following: the Number of Buildings requiring renovation, Total Surface requiring renovation (m^2), Estimated Expenditure (£), Energy Savings realised (kWh per annum) , and potential Job Creation with both lower bound (LB) and higher bound (HB) estimates provided.

As we can see from the results of the analysis there is significant potential for energy efficiency renovation across the built stock in the UK. Tables 1 & 2, Scenario 1, the most conservative of all scenarios, suggests job creation would range between 3.1-3.9 million jobs if we combine both residential and non-residential buildings. While Scenario 3, suggests that the job creation potential could be as high as 5.3-6.7 million combining both building types.

In addition to the potential job creation is the opportunity renovation offer in terms of predicted energy savings. If we consider again the two most conservative and least conservative scenarios, we can see that the estimated energy savings achievable from retrofitting the existing building stock could potentially lie somewhere between 51,000,000 kWh up to 182,000,000 kWh saved per annum combining both residential and non-residential buildings.

Renovating the Non-residential built stock presents the best return of investment. Table 3 below shows the differences in cost per meter squared and potential energy savings split into Residential and Non-Residential buildings. As we can see in both scenarios 1 & 2, renovating the Non-Residential built stock provides almost double the Energy saving potential at a fraction of the cost compared to renovating the residential stock. On average, Non-Residential Buildings are 5 times the size of Residential buildings, providing a real opportunity to apply economies of scale.

Scenario	Residential		Non-Residential	
	Cost (£/m²)	Energy Savings (kWh/m²)	Cost (£/m²)	Energy Savings (kWh/m²)
Scenario 1	104.80	11.79	98.65	32.57
Scenario 2	130.92	15.71	102.51	33.66
Scenario 3 (Group 1)	66.30	0.25	57.10	0.64
Scenario 3 (Group 2)	130.92	15.71	102.51	33.66
Scenario 3 (Group 3)	159.12	47.82	137.40	69.06
Scenario 3 (Group 4)	283.53	93.19	170.80	64.59

Table 3: Cost of renovations and energy savings for the Residential and Non-Residential sectors

The potential energy saving emphasises the importance of considering renovation of the existing building stock as a key strategic approach in the plan to reach agreed climate change targets. Furthermore, the potential job creation and boost to the economy this paper highlights could stimulate a “green recovery” in the UK as we move forward post Covid-19.

Conclusions

As shown throughout this analysis, renovation will likely incur extensive costs to building owners that will be influenced by the degree to which their building needs to be renovated. However, as mentioned previously, the GHGS is limited to a maximum investment of £2 billion meaning that only a small proportion of properties could be renovated within the scope of that scheme. Additionally, those that do embark on the scheme, may decide to not renovate their properties extensively as they will only renovate to the extent of the scheme subsidies. This study suggests that there is a huge potential market for energy renovations and considering the energy savings and associated emission reductions, coupled with the potential job creation; in our opinion focusing on renovations and retrofitting should be central to the green recovery.

With a predicted potential to reduce the total operational energy consumption of the building stock by an estimated 51 TWh up to 182 TWh per annum (Scenarios 1 and 3 respectively) we suggest that the government should consider using the GHGS as a pilot project to further roll out energy efficiency renovation measures and incentives in order to push for greater efficiencies from buildings.

As shown on Table 3, Non-Residential renovations present the best opportunities in terms of investment and energy efficiency. However, it is important to consider the current situation we are living in. Not only do Residential buildings represent a larger proportion of the building stock, but also, following the COVID-19 pandemic, they are more at use now than ever before. Focusing on the residential sector therefore would produce more tangible effects, not only in terms of energy use and emissions reductions but also job creation. Although it would come at a larger economic cost, the positive social impact from renovating residential buildings could be significant.

As buildings are central to our daily lives they should be considered as part of the wider initiative to tackle climate change. Energy renovations to existing buildings would help the UK in achieving national targets, whilst also creating new jobs and aiding the economic recovery. While assisting building owners in renovating their properties could have strong positive environmental and social impacts.

Limitations of the study

While this study shows the potential of renovation, it comes with several limitations. The first is in the estimation of job creation. Although the estimations used come from academia, the assumption that every project will require the same amount of labour is problematic. It assumes that labour costs will be the same for the renovation of a detached house or for the renovation of a flat. In addition, the renovation of a building constructed <1945 will likely require different types of labour and machinery than renovating a modern house. Nevertheless, these assumptions have been made due to the lack of precise data in terms of labour cost but also in terms of the difference in cost by type of building and activity.

A lack of reliable data has been the most limiting factor for this analysis. In order to be more precise in calculating the job creation and energy saving potential of renovation, more data needs to be collected. Data such as the difference in labour costs between types of buildings, or the true cost of renovating older buildings compared to modern buildings, is necessary in order to be able to produce a more reliable analysis.

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