## Valuing carbon in pre-1919 residential buildings[1]

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The UK has made a legally binding commitment to be carbon neutral by 2050,[3] which will require a continued annual reduction of 4.5% in the carbon emission rate[4]. Although the UK has achieved substantial reductions to date, in order to achieve this ambitious goal, many sectors will still have to transform significantly. This is pertinent for the construction sector, particularly as the built environment is estimated to be responsible for 35%-40% of total carbon emissions in the UK (Sturgis et al, 2017)[5]. In England, domestic buildings built before 1900 account for 17% of the entire residential building stock, with those built between 1900 and the end of the First World War representing a further 5%.[6] Against this backdrop, it is important to understand the total carbon emissions associated with traditional buildings and how their refurbishment could contribute to meeting the UK's 2050 target. The objective of this paper is to demonstrate the significance of refurbishing traditional buildings to help reduce carbon emissions and avoid the negative impacts associated with climate change. To achieve this, we compare the carbon emissions of pre-1919 residential buildings in England – and their consequent monetary value, in terms of carbon – under a range of scenarios.

### Methodology and assumptions

The methodology to calculate the total carbon emissions by 2050 includes both the operational and embodied carbon emissions of residential historic buildings. The latter refers to the greenhouse gas (GHG) emissions released through the supply chains of building materials; this includes their

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[3] Department for Business, Energy and Industrial Strategy (2019). UK becomes the first major economy to pass net zero emissions law[URL] https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law [Accessed January 2020].
[4] Carrig Conservation International (2020). *Understanding carbon in the historic environment*, Historic England [PDF] Available at: https://historicengland.org.uk/content/docs/research/understanding-carbon-in-historic-environment/
[5] Sturgis and Papakosta (2017). *Whole life carbon for the built environment*.[PDF] Available at https://www.rics.org/uk/upholding-professional-standards/sector-standards/building-surveying/whole-life-carbon-assessment-for-the-built-environment/ [Accessed January 2020]
[6] Valuation Office Agency (2019). Council Tax: Stock of Properties (2018). [URL]https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2019 [Accessed November 2019]

extraction, manufacture, and transportation, in addition to those incurred during the construction process.[7]

The carbon estimations made within this paper are based on carbon calculations produced as part of a recently commissioned study, completed by Carrig Conservation International report[8] which considered the whole life carbon of an end-of-terrace Victorian house. As a result, this research assumes that the carbon emissions of the UK's pre-1919 residential buildings are equivalent to those of the end-of-terrace Victorian house assessed within the Carrig report; this is because its embodied carbon is similar to that of many solid wall residential buildings found in England[9]. The report calculated operational carbon emissions are based on the assumption of an average internal temperature of 21°C for residential buildings.

Reducing carbon emissions is costly. To reflect this, monetary estimates are provided to estimate the cost of reducing greenhouse emissions, given the targets set by the UK Climate Change Act[10]. As a result – in line with The Green Book[11] – shadow prices have been used to value carbon emissions. Social costs[12] and market prices within an emissions trading scheme[13], such as the European Union Emissions Trading Scheme (EU ETS)[14], are alternative methods to value them. However, in this case

[7] [URL] http://www.circularecology.com/embodied-carbon.html [Accessed January 2020].

[8] Op. cit (2020)

[9] Institute of Historic Buildings Conservation ( 2019). *Climate change and older buildings-Key sources* [PDF] Available at: https://ihbconline.co.uk/toolbox/guidance_notes/climateChange.html#two [Accessed January 2020]. There is no data to define the proportion of UK's pre-1919 residential buildings which have the same carbon emissions as an end-of-terrace Victorian House. Therefore, it is assumed the extreme situation in which all of them have an equivalent carbon footprint. It is acknowledged that this assumption could be improved in further research.

[10] The value of carbon might have to increase if UK wants to be carbon neutral by 2050 (Burke et al (2019). *How to price carbon to reach net-zero emissions in the UK*. [PDF] Available at: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/05/GRI_POLICY-REPORT_How-to-price-carbon-to-reach-net-zero-emissions-in-the-UK.pdf [Accessed January 2020]

[11] HM Treasury (2018). *The green book: Central Government guidance on appraisal and evaluation* [PDF] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf [Accessed January 2020]

[12] Social costs provide the value of the worldwide damage caused by the emission of an additional tonne of carbon dioxide. Smith and Braathen (2015). *Monetary carbon values in policy appraisal: An overview of current practise and key issues*, OECD Environmental working papers (92) [PDF] Available at: https://www.oecd-ilibrary.org/environment/monetary-carbon-values-in-policy-appraisal_5jrs8st3ngvh-en [Accessed November 2019].

[13] Emissions trading schemes give account of the market value of carbon, which depends on the number of allowances that are issued.

[14] The EU ETS is the pillar of the EU's policy against climate change. It is the world's first principal carbon market and it is the biggest one. It works on the "cap and trade" principle, meaning that a cap is defined for the total carbon emissions which can be emitted by the organizations involved in the system. This cap declines each year in order to reduce greenhouse gases. Within the cap, companies receive or buy emission allowances

it is preferable to use shadow prices – instead of social costs – as there are less uncertainties involved. Shadow prices focus on how to achieve a desired outcome, rather than concentrating on the damages caused by contamination (Price, Thornton and Nelson, 2007[15]; Smith and Braathen, 2015). Furthermore, shadow prices consider the UK's environmental priorities making it preferable when compared to social costs and EU ETS. Emission trading schemes are only appropriate for valuing carbon emissions in sectors that have mandatory participation in this market. This is due to the emissions cap set on total GHGs that can be emitted by companies participating in the system (Smith and Braathen, 2015). Additionally, carbon values are higher in the non-traded sector than in the traded sector[16]. The higher the carbon values are, the greater the incentive to reduce GHG emissions, increasing the possibility to internalise the externalities that are produced by climate change.

In an ideal situation the value of carbon emissions would be equal, regardless of the valuation methodology which is applied. This would require a full understanding and monetary assessment of the externalities produced by climate change on infrastructure, property damage, human health, agricultural productivity and changes in ecosystem services (Smith and Braathen, 2015).

In line with the Natural Capital Account (2018-19) for the UK[17] in 2019, we assume that £67.25 is the value for each tonne of carbon dioxide sequestered, which is updated every year to reflect the increasing costs of reducing carbon dioxide emissions. Moreover, based on the Green Book, it is assumed that the annual inflation rate is 2% and that for the first thirty years the discount rate is 3.5%, before changing to 3%. The databases used for the analysis are the Council tax: Stock of properties (2018)[18] and Carrig Conservation International (2020)[19].

## Scenarios

Three illustrative scenarios up to 2050 are compared within this research; it is important to note that these are hypothetical. The objective is to reflect about the topic and gauge the possibilities, instead

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that they can trade with other businesses that are in the system. For further information, please consult: https://ec.europa.eu/clima/policies/ets_en.

[15] Price et al (2007). *The social cost of carbon and the shadow price of carbon: what they are and how to use them in economic appraisal in the UK*, DEFRA. [PDF] Available at: https://mpra.ub.uni-muenchen.de/74976/1/MPRA_paper_74976.pdf [Accessed January 2020].

[16] The traded sectors are those that mandatorily have to participate in the EU ETS, while the non-traded sectors are the rest.

[17] Forestry England (2019). *Natural Capital Account 2018-19*. [PDF] Available at: https://www.forestryengland.uk/sites/default/files/documents/FE_NCA_18-19_FINAL.pdf [Accessed November 2018]

[18] Op. cit (2019)

[19] Op. cit (2020)

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of giving definitive future projections. Scenario I is a base case, in which the other scenarios are based upon to calculate their hypothetical savings:

- Scenario I: There is no refurbishment or demolition of pre-1919 residential building.
- Scenario II: 50% is refurbished in a 10 years period, starting in 2021.
- Scenario III: 15% is refurbished in a 10 years period, starting in 2021.
- Scenario IV: 25% is refurbished in a 25 years period, starting in 2019.

**Results**

**Table I:** Comparing carbon saved in different scenarios, against a baseline (Scenario I)

| Scenarios | Carbon saved ($tCO_{2e}$[20]) against scenario I (millions) | In 10 years-old Conifer trees (millions) | In real monetary values in 2019 prices (billions) | In UK's GDP (2019) |
|---|---|---|---|---|
| I | 0 | 0 | £0 | 0% |
| II | 39.6 | 9.4 | £3.4 | 0.11% |
| III | 11.9 | 2.8 | £2.4 | 0.08% |
| IV | 15.5 | 3.7 | £2.5 | 0.08% |

Source: Based on our own estimates using the Carrig Conservation International Report (2020), Council tax: Stock of properties (2019), the UK Office for National Statistics (2019) and the International Monetary Fund (2019).

Table I shows the carbon saved in scenarios II, III and IV, when compared to scenario I. The figures are expressed in terms of tonnes of carbon dioxide equivalent ($tCO_{2e}$), in terms of the carbon stored in the timber of 10 year old conifer trees, in terms of the real monetary cost of reducing GHG emissions, given the targets set by the UK Climate Change Act and in terms of the UK's GDP in 2019.

When compared with Scenario I, the analysis shows that refurbishing and retrofitting pre-1919 residential buildings over a 10 year period leads to a reduction of carbon emissions of 39.6 million $tCO_{2e}$ by 2050, which is equivalent to more than 3 million flights from London's Heathrow airport to Dublin or the carbon stored in the timber of 9.4 million 10 year old conifer trees. In monetary terms, this equates to savings of £3.4 billion in terms of the costs of reducing GHG's. This represents almost 0.11% of the UK's GDP in 2019. Retrofitting historic buildings at a slower annual pace, as given in Scenario III, the carbon emissions are reduced by 11.9 million $tCO_{2e}$ by 2050 (compared with Scenario I). This is equivalent to more than 948,000 flights from London's Heathrow airport to

[20] $tCO_{2e}$ are tonnes of carbon dioxide equivalent, which includes the emissions of other GHG emissions, factoring in their differing potency relative to one unit of $CO_2$.

Dublin. It would take 10 years for a forest of 2.8 million newly planted trees to offset this carbon through timber growth – this represents approximately 1,120 ha of forest, which is the equivalent area of 1,569 football pitches. In monetary terms, under this scenario £2.4 billion are saved in the costs of decreasing carbon emissions to achieve the UK's target.

If the considered rate of refurbishment and retrofit is 1% a year, over an extended analysis period of 25 years (as in Scenario IV), the calculated carbon emissions savings are 15.5 million $tCO_{2e}$, when compared to the base case. This equates to 3.7 million conifers or 656,000 train commutes from London to Edinburgh. In monetary terms, this would result in £2.5 billion of savings in offsetting climate change, equivalent to 0.08% of UK's GDP in 2019. It is also important to note the difference in the results of Scenario III and IV. In Scenario IV, although it assumes the retrofitting of 10% more pre-1919 residential buildings than in Scenario III, the carbon emissions and the costs of reducing them are only lowered by 3% and 2%, respectively. This indicates that, not only it is important to refurbish historic buildings, but it's vital to achieve this at a quick pace.

**Conclusions**

The construction sector will play a fundamental role in helping the UK to meet its commitment to be carbon neutral by 2050. Recycling historic buildings will be fundamental in achieving this goal and to accomplish sustainable development. The faster this is achieved, the better. This requires both responsible consumers and businesses, in addition to changes at micro, meso and macro-levels. Regulations and policies over price incentives will play a key role in this sense, particularly in encouraging retrofitting of historical buildings.