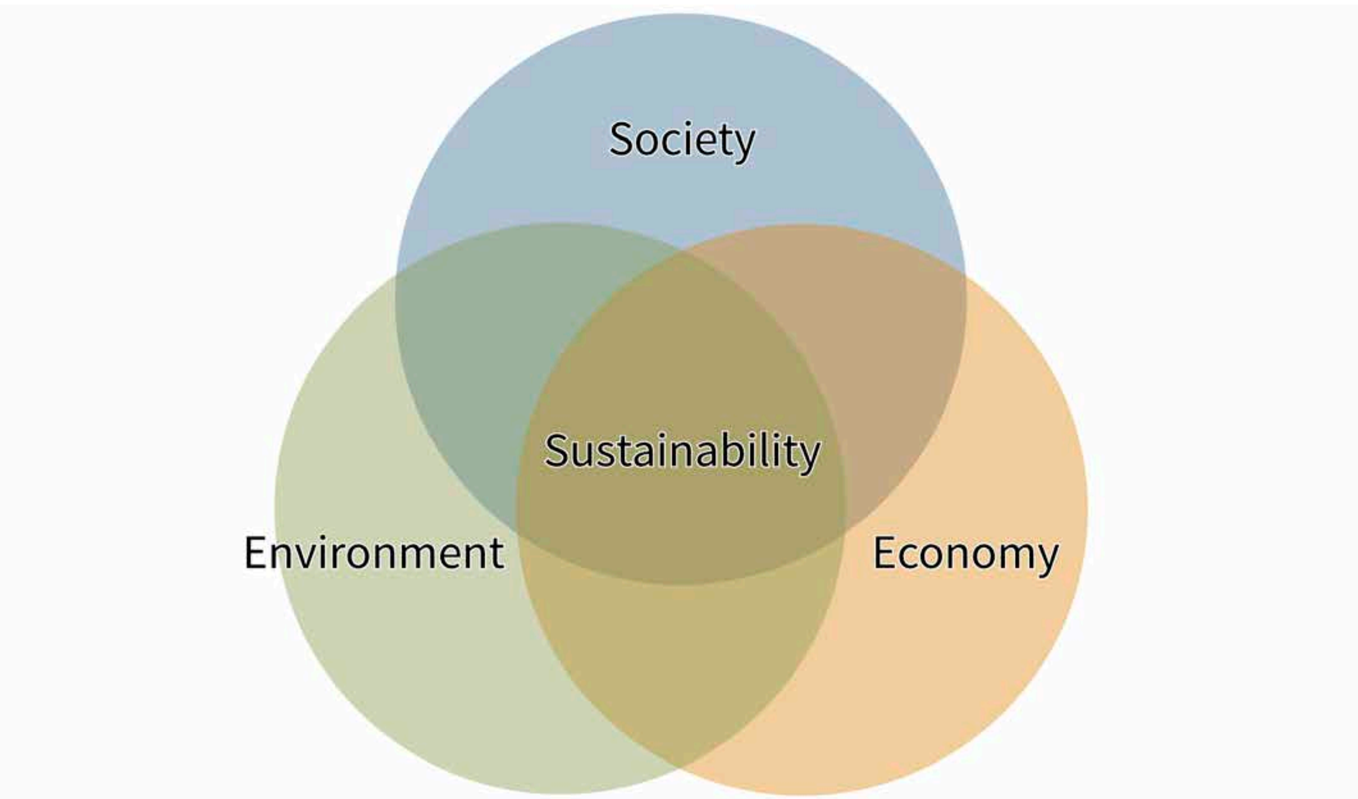
HERITAGE AND THE ENVIRONMENT 2020

HERITAGE COUNTS

Heritage and the Environment

Human activity has helped shape our environment for millennia, with even England's most untouched places often the result of a complex history of interaction between people and the natural environment. As part of the Heritage Counts series, *Heritage and the Environment* explores some of the key aspects affecting the relationship between our natural and cultural heritage. Understanding the value of England's historic environment and how it can be utilised will prove to be beneficial for future generations.

As a new addition to Heritage Counts, *Heritage and the Environment* completes the suite of compendia of evidence that is compiled each year by Historic England on behalf of the Historic Environment Forum. Sustainability has at its core the triad of economic, social and environmental principles. England's cultural heritage brings people together (see *Heritage and Society*), and its total economic value is greater than the sum of its parts (see *Heritage and the Economy*).



The relationship between natural and cultural heritage is complex, covering a wide range of topics and issues. This document will consider some of the most important, therefore to provide some structure, *Heritage and the Environment* has been divided into the following six sections:

Cultural heritage and the environment

Natural resources and our historic environment

Historic environment and biodiversity

Built heritage and the environment

Historic environment and sustainability

Cultural heritage and the future climate

In addition, it's important to reflect upon the impact that COVID-19 has had on our way of life and our relationship with our natural and cultural heritage, therefore *Heritage and the Environment* also includes a section to recognise this.

The evidence presented here includes recent research findings as well as past seminal pieces, thus forming part of the heritage sector's rich, multidimensional knowledge base. The evidence is presented as succinct facts with links to the detailed evidence sources for more technical readers, or those with more specific evidence needs.

Holy Trinity Church, Stratford-upon-Avon, Warwickshire, viewed across the river Avon.
PLB_K991546 © Jon Wyand. Source: Historic England Archive

Introduction

Our cultural heritage shapes places, landscapes and seascapes, leaving physical evidence in the form of field systems, paths, routeways, buildings, coastlines, water and the biodiversity and land use activities they support. Our cultural heritage is a fundamental component of our environment – which is far from static. It also reflects the natural qualities of these places. Their geography, climate and geology have all influenced settlement patterns, industrial processes, building design and materials and subsistence activities.

Our climate is changing as a consequence of human activity and as a result, land management needs to adapt to different demands. These changes to our environment also affect cultural heritage, presenting challenges and opportunities for both physical remains and intangible cultural heritage, which includes traditional practices for managing land and structures. In the same way that cultural heritage is a fundamental component of the environment, it is also a part of the future environment and our response to these changes.

The ingenuity and innovation behind England's built environment is apparent in its construction materials and the skilled techniques used. Just as a lit candle casts a shadow, the wealth of benefits from our societal development has accrued an environmental cost – manifesting as climate change – which directly threatens England's heritage. Increased occurrences of prolonged or extreme weather events place more stress on our landscape and buildings; while reactive decisions to replace old with new are often short-sighted and can exacerbate problems rather than solve them. In order to protect our national inheritance and adapt sustainably to a changing climate, a more proactive and thoughtful approach is required when confronting the challenges.

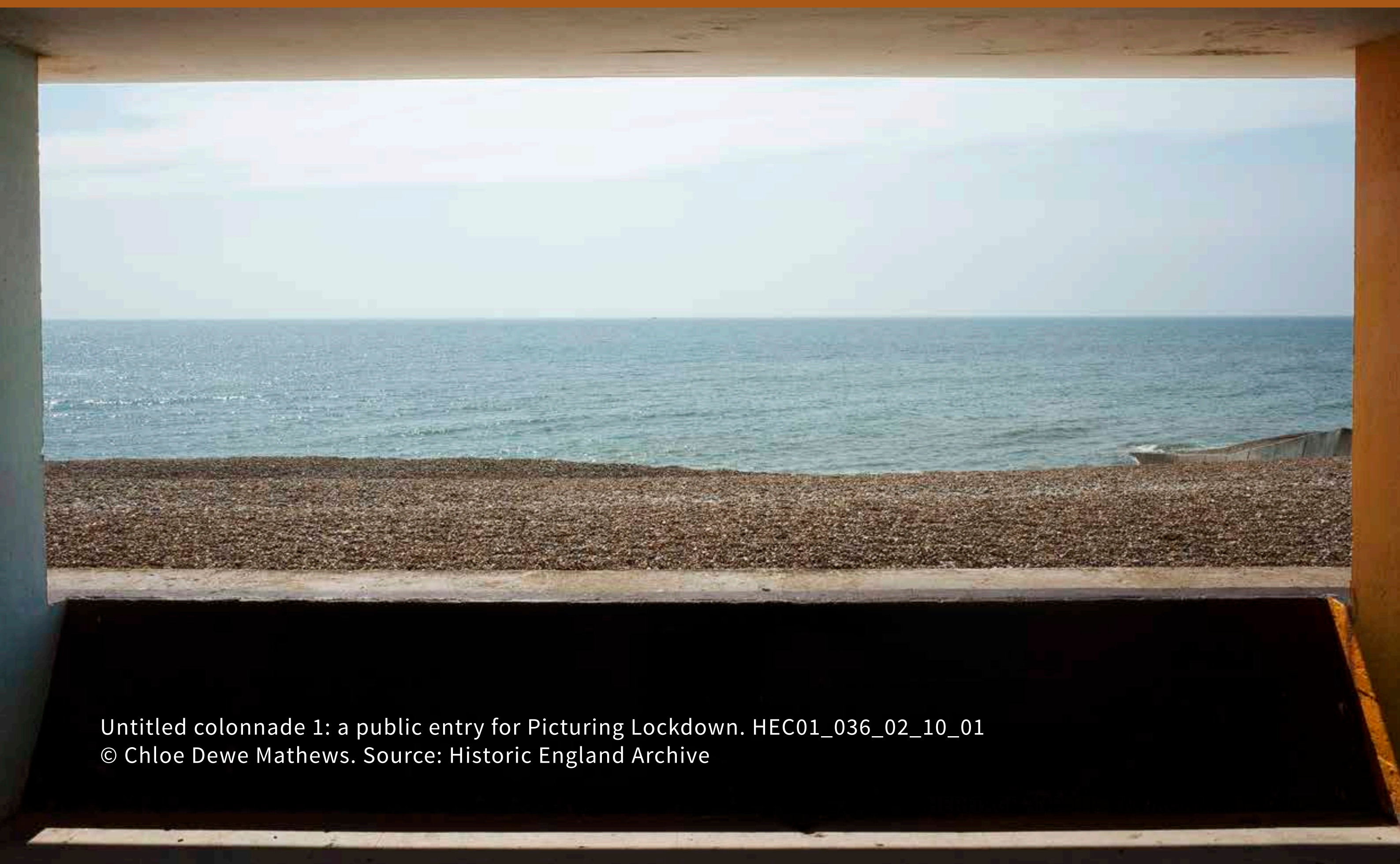
> "Initiatives to protect and improve our natural world and cultural heritage are acts of stewardship by which we discharge our debt to it, and so are moral imperatives in themselves, but they are also economically sensible. A healthy environment supports a healthy economy." (DEFRA, 2018)

Prehistoric hut circle, Wigford Down, Devon. DP099180

Covid-19 and the environment

The impact of Covid-19 on the heritage sector, the environment and the nation has been both profound and severe. Some of these are outlined below but the full impact of the pandemic has yet to be realised. However, the challenges that have affected our local communities are all too apparent.

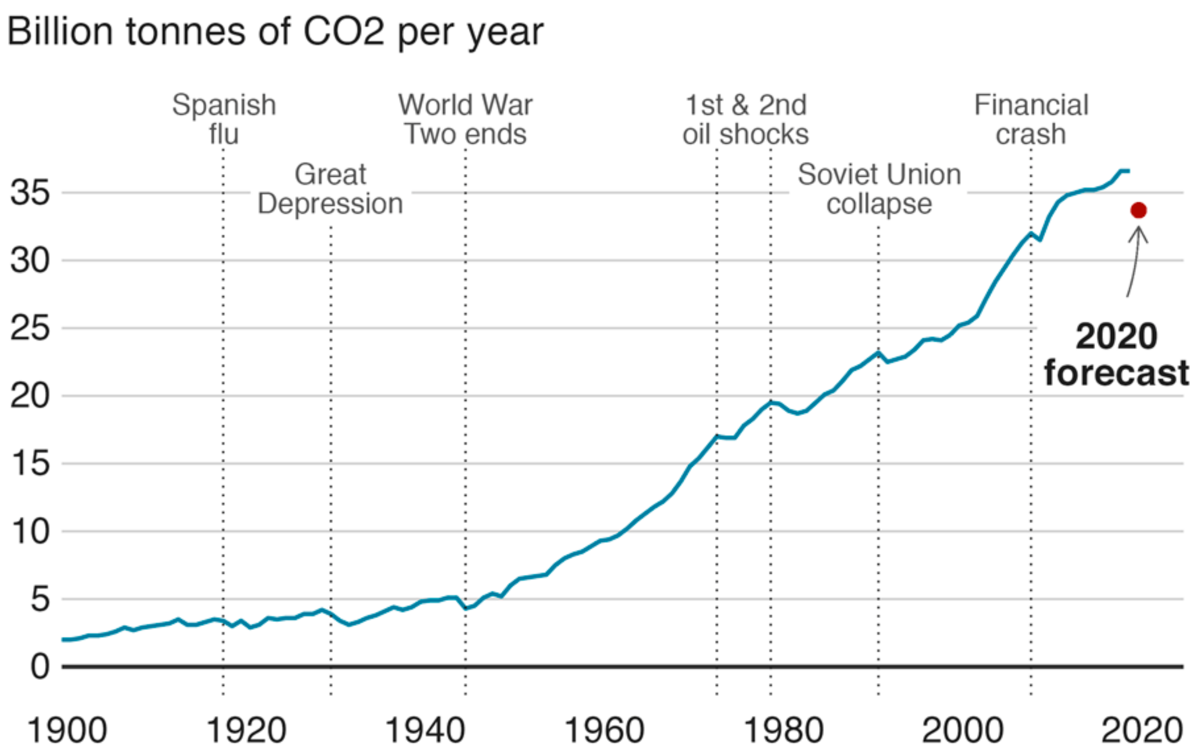
As we move into the latter half of the year and the economy begins to recover, there will be opportunities to make fundamental changes that allow for a green recovery which can be supported by the heritage sector. Reducing greenhouse gas emissions and sustaining heritage values are compatible goals, therefore learning and looking after our historic environment can make important contributions to global sustainability and our post pandemic recovery.



Untitled colonnade 1: a public entry for Picturing Lockdown. HEC01_036_02_10_01

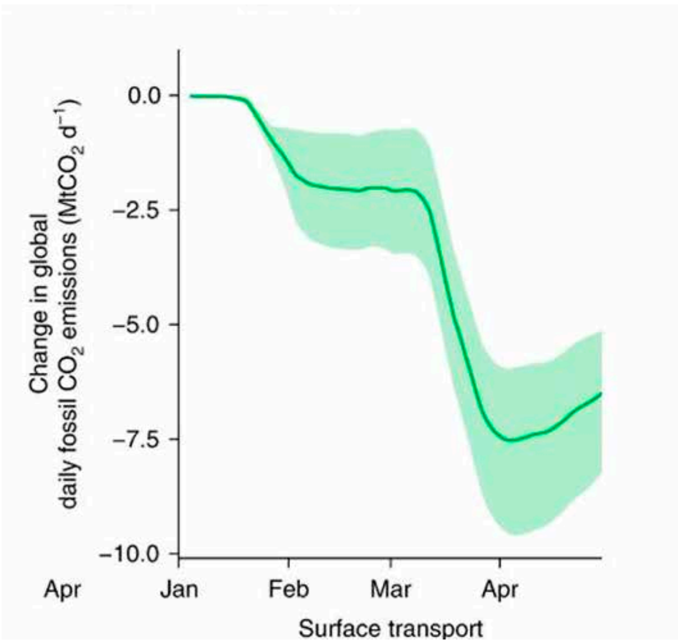
Emissions decreased significantly during lockdown

Global greenhouse gas (GHG) emissions for 2020 are estimated to fall by a record 5-10% (Le Quere *et al* 2020, CCC 2020). This is a significant fall as, prior to 2020, GHG emissions had continued to grow substantially during the last century – in 2018 they were about 57% higher than in 1990 and 43% higher than in 2000 (Oliver and Peters, 2020).



Global CO2 emissions, 1900–present. Source: BBC https://www.bbc.co.uk/news/science-environment-52485712

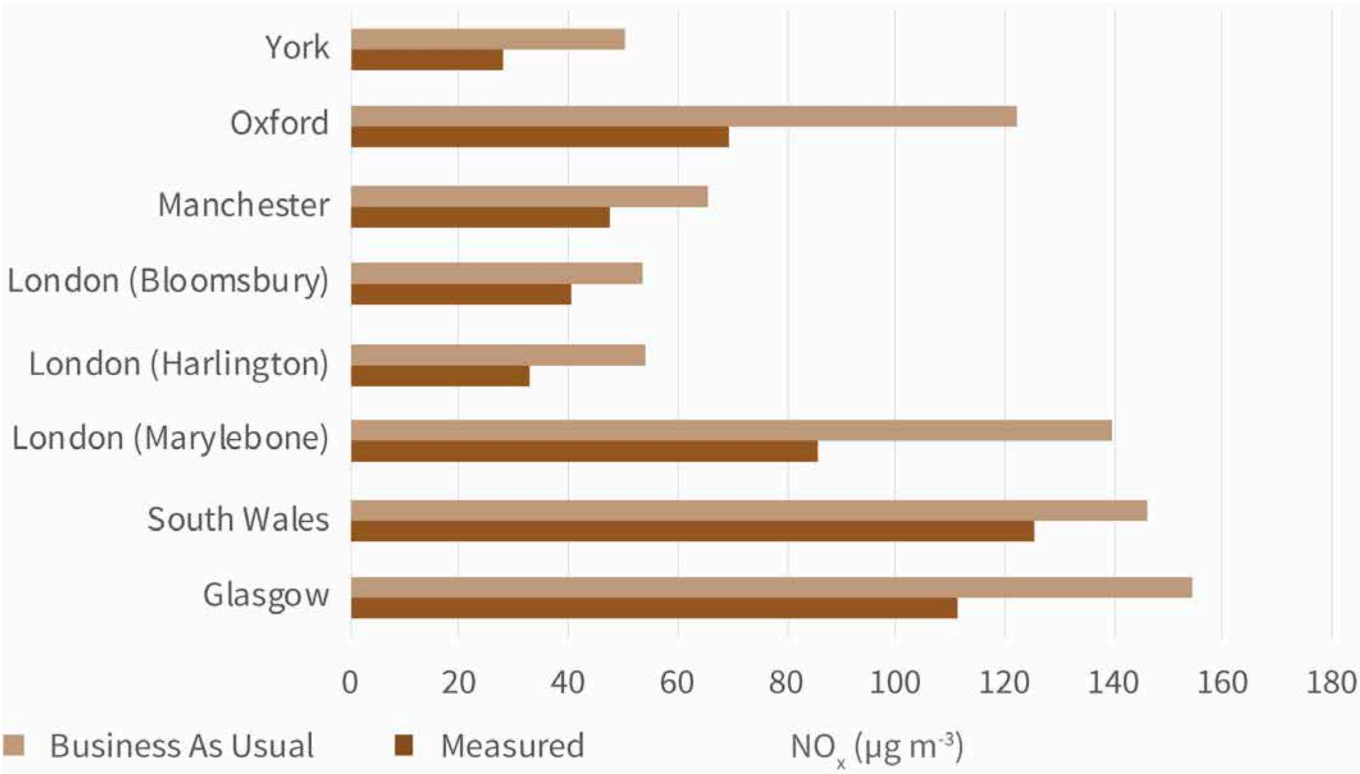
A study published in the journal *Nature Climate Change* showed that global daily emissions decreased by 17% – or 17 million tonnes of carbon dioxide, when compared against the mean daily levels in 2019. This decrease occurred during the peak of the confinement measures in early April, reaching emission levels last observed in 2006. As a result of the pandemic, the UK is expected to experience a substantial reduction in GHG emissions in 2020 (Le Quere *et al* 2020, CCC 2020).



Daily Global CO_2 emission reductions in surface transport (Le Quere *et al* 2020)

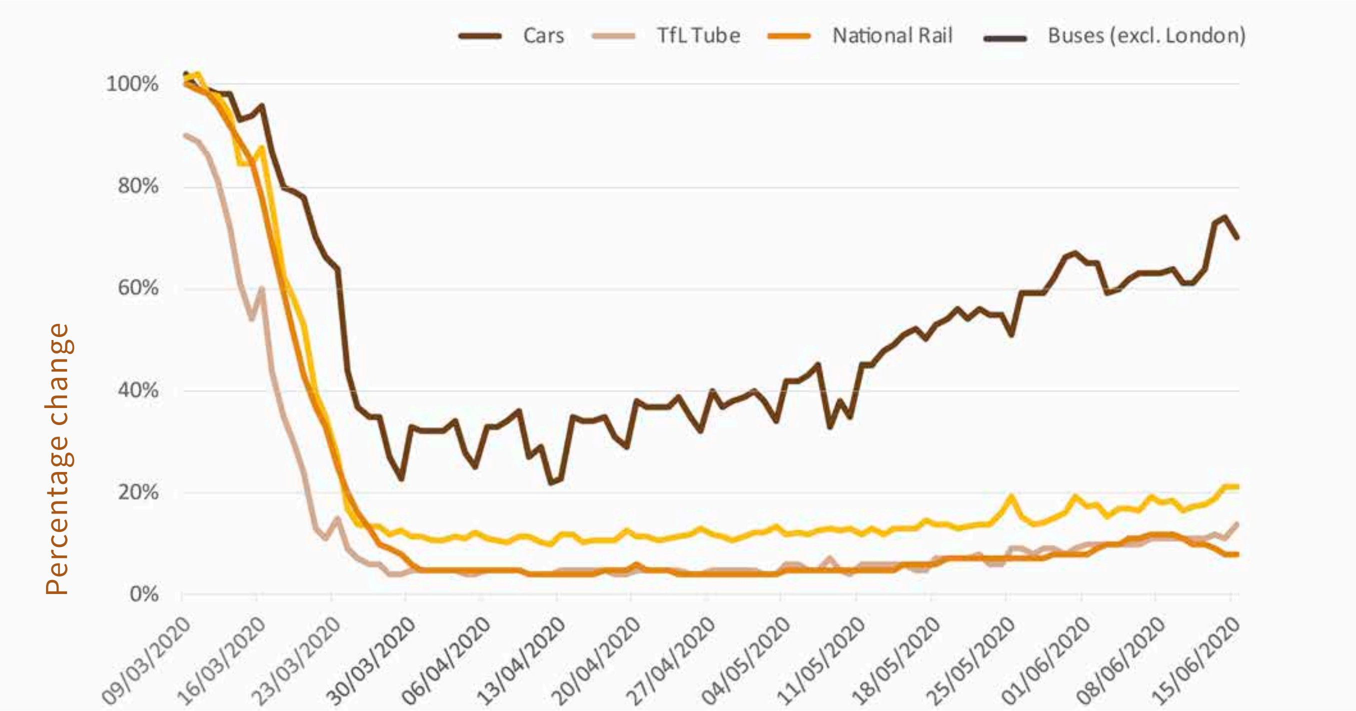
During the lockdown period air pollutant emissions – which affect air quality – reduced significantly in the UK. Nitrogen oxides (NO_x) and nitrogen dioxide (NO_2) levels fell on average by 30-40% and 20-30%, respectively. The largest reductions were experienced at the roadside (DEFRA 2020). Additionally, the UK Centre for Ecology and Hydrology (Braban *et al*, 2020) estimated that urban on-road and roadside emissions of Ammonia (NH_3) – which is a key driver for a number of environmental issues – may have decreased by as much as 90% since the start of the lockdown (see the National Atmospheric Emissions Inventory (NAEI)).

NO_x is a collective term for nitric oxide (NO) and nitrogen dioxide (NO_2) and is a key contributor to smog formation.



Reduction in NOx emissions in UK cities during lockdown (AQN, 2020)

In the UK, more than half of the emission reductions are attributable to reductions in surface transport. During the pandemic, surface transport in the UK dropped significantly with public transport modes such as national rail and the tube falling by around 95% of its normal service, while personal car use dropped by more than 70% initially. While public transport remained below 20% of normal use during lockdown, the usage of cars steadily increased during the same period (DfT, 2020).

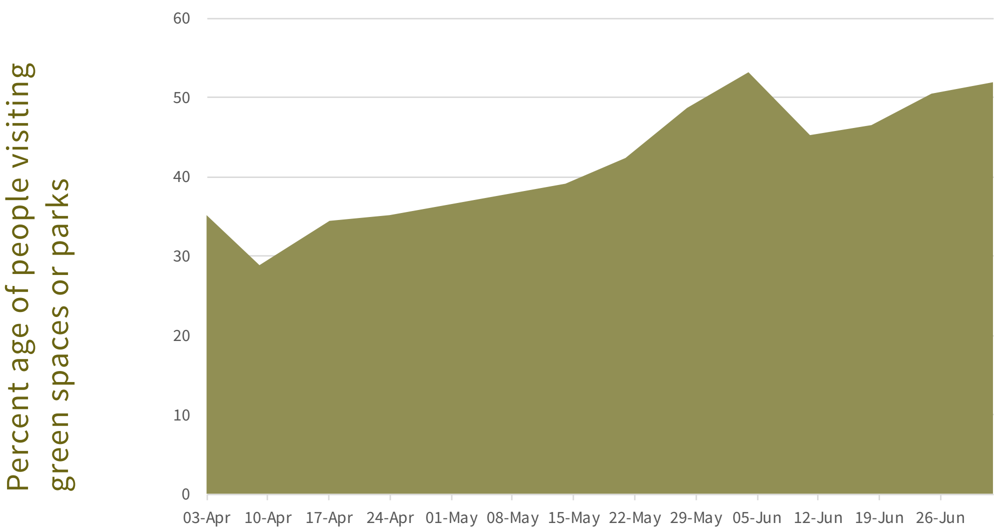


Use of transport modes in Great Britain during the Covid-19 pandemic (DfT, 2020)

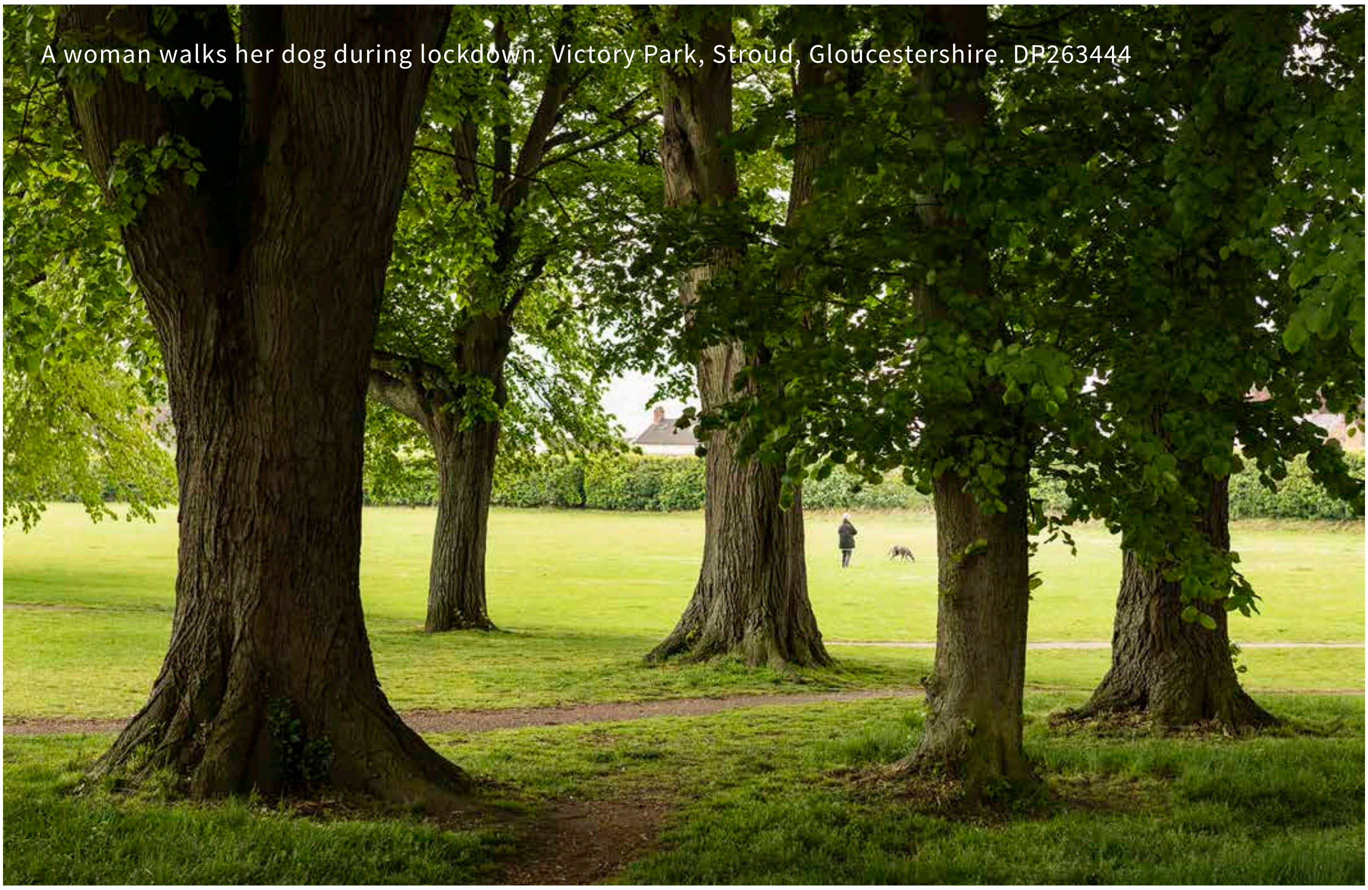
The lockdown has highlighted the importance of our local historic parks and gardens

Lockdown has highlighted the importance of the natural historic environment and green spaces. These spaces play a vital role in our nation's mental health and wellbeing (Barton and Rogerson, 2017). As the pandemic has progressed, the public's use of green space regularly featured in the Coronavirus and the social impacts on Great Britain Opinions and Lifestyle Survey.

When asked if they had visited a park or public green space, less than 30% of the survey respondents said yes at the beginning of lockdown. However, the number of people using their local parks and green spaces increased to nearly 50% by the end of May, highlighting their public value and importance during lockdown (ONS 2020c).



Changing use of parks and public green spaces during Covid-19 (ONS 2020c)

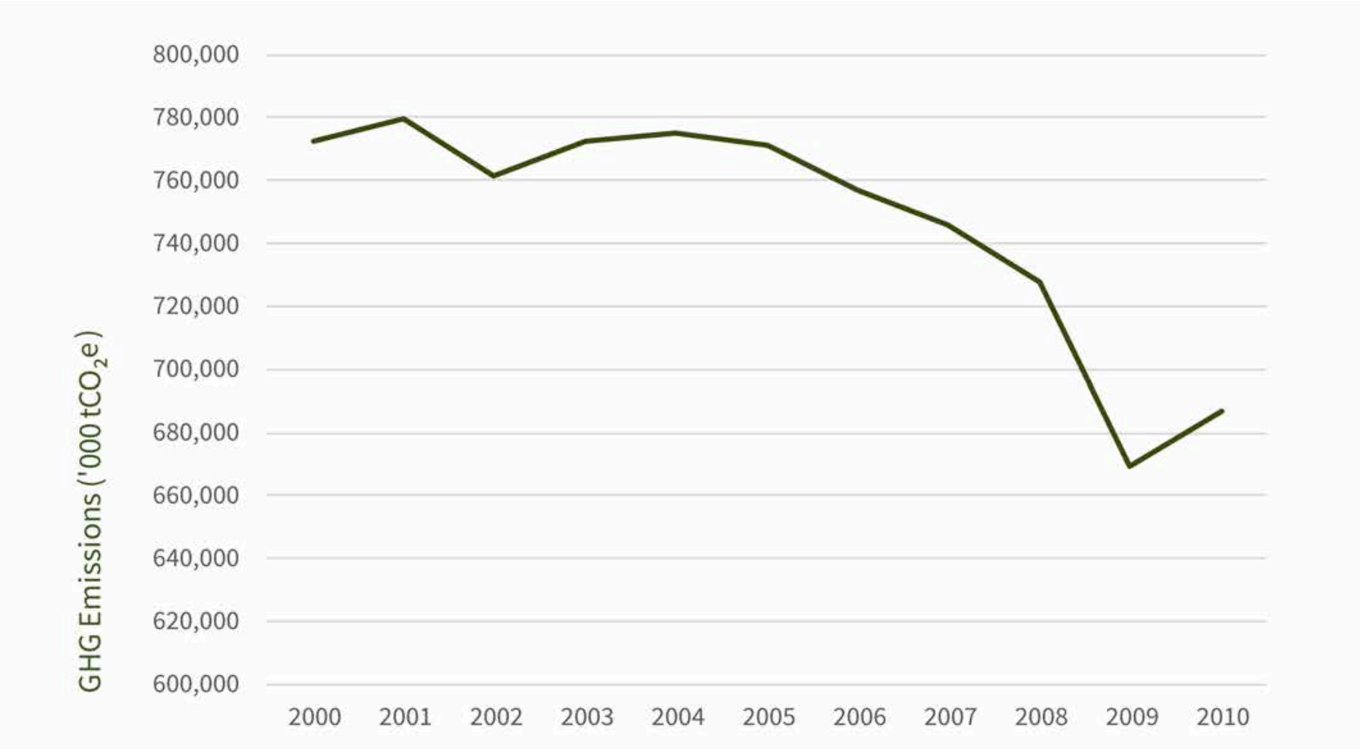

A woman walks her dog during lockdown. Victory Park, Stroud, Gloucestershire. DP263444

However, due to Covid-19, access to the historic environment has been significantly reduced as heritage businesses and attractions closed their doors and all events, projects and works were cancelled or postponed.

- According to a survey of heritage businesses conducted by Historic England in April 2020, over three quarters (76%) of respondents report lost business in the short term and three out of five (58%) had postponed or cancelled income-generating events (Historic England, 2020).
- According to a survey of 60 environmental organisations conducted by the Wildlife and Countryside Link in March 2020, the most common issues affecting environmental organisations had been the postponing of events (100% of respondents) and the financial constraints that followed; 88% experienced a loss of revenue while 73% had reduced access to funding (Heritage Fund, 2020).

Green recovery within the historic environment – tackling climate change must be an integral part of the solution to the Covid-19 economic fallout.

The UK government has made a legally binding commitment to achieve net zero emissions by 2050 (BEIS, 2019). While the pandemic has caused a significant short-term reduction in GHG emissions, past evidence has shown that any emission reductions following economic crises are short-lived. The fall in carbon emissions as a result of the 2009 recession was followed by a sharp rise in 2010; the UK's total emissions increased by 3% while globally it was almost 6% (Peters, 2011, ONS 2020b). In the wake of the Coronavirus crisis the UK government has committed to building back a green and resilient recovery (FCO, 2020).



Total greenhouse gas (GHG) emissions for the UK between 2000-2010 (ONS 2020b)

Buildings are the third largest carbon emitting sector in the UK today and the UK government's independent advisory body, the Committee on Climate Change, have argued that there is an acute need to substantially step up action to cut emissions from buildings (CCC, 2019).

- In July 2020, the UK government announced a £2 billion Green Homes Grant scheme to help improve the energy efficiency of UK homes, with the intention of helping over 600,000 homes in England.
- Research demonstrates that when taking a whole life approach, the sympathetic refurbishment and retrofit of a typical traditional building will emit less carbon by 2050 than a new building (Historic England, 2020e).

The successful implementation of the Green Homes Grant will require specialist knowledge and skills to ensure that instances of maladaptation are avoided. This is an opportunity to increase local jobs that rely on traditional skills and knowledge, in addition to safeguarding those that already exist. Repairing and reusing old buildings is more labour intensive than constructing new ones and therefore results in the creation of more jobs. In a recent report, the push for a green recovery and a low carbon economy could see as many as 694,000 jobs created in England by 2030 (LGA 2020).

Repair and maintenance also contributes to longer life spans and reduces building carbon footprints. However, the UK's VAT system imposes a 20% tax rate on repair, maintenance and refurbishing existing buildings, whilst new-build developments are VAT-free. According to the Federation of Master Builders (FMB) reducing VAT from 20% to 5% on home improvement works would unleash investment in housing, stimulate the economy and enable the UK's transition to net zero carbon. VAT cut on home improvements could generate £15 billion in new taxes, create 95,000 jobs and unlock £1 billion green revolution (FMB, 2019).

UK and England new tree planting rates, 1976-2019 (Forest Research, 2020)

The UK government has also committed to planting 30,000 hectares of trees annually by 2025, helping to form part of the green recovery from Covid-19 and support the transition to net zero. This represents a major opportunity for greening the built environment and storing carbon however it requires a significant and sustained increase in tree planting.

The targetted 30,000 hectares of newly planted trees would represent an annual 0.9% increase of the UKs current forest area. This level of new tree planting has only been achieved once during the last 50 years, with current planting rates less than half of this. The vast majority of new trees planted has previously been in Scotland, whilst in the last five years, new tree planting in England has fallen by 42% (Forest Research, 2020).

Grovelands Park, Southgate, London. DP153894

Cultural heritage and the environment

Heritage as an integral part of the environment

England's environment as it exists today is the result of human activity over millennia and comprises a rich and diverse collection of physical landscapes, each offering a different manifestation of human interactions with nature. From the peat uplands of Cumbria to the ancient woodlands of Gloucestershire, from the windswept Holderness coast to the hedgerows that frame England's pasture and croplands, our environment is abundant in indivisible cultural heritage and habitats.

Human activity has shaped the landscape, forming the foundations of regional and local identity; helping to reflect the diversity that exists in shared culture and natural heritage. This interrelationship can be seen in the way that historic and natural environment designations often overlap.

- There are more than 4,000 Sites of Special Scientific Interest (SSSI), spanning about one million hectares, and 224 National Nature Reserves (NNRs) that cover 94,000 hectares. Often spatially overlapping with other conservation sites, there are 34 designated Areas of Outstanding Natural Beauty (AONBs) which protect and enhance the natural and cultural beauty of England.
- There is a considerable overlap of nature and designated historic buildings and sites. Of the scheduled monuments designated in England, there are currently about 3,700 within or partially within SSSIs, about 200 within or partially within National Nature Reserves (NNRs) and about 4,600 within or partially within Areas of Outstanding Natural Beauty (AONBs).

The designation of **Areas of Outstanding Natural Beauty (AONB)** first requires an area to evidence a combination of the following 'natural beauty criterion'; Landscape quality, Scenic quality, Relative wildness, Relative tranquillity, Natural heritage features and Cultural heritage.

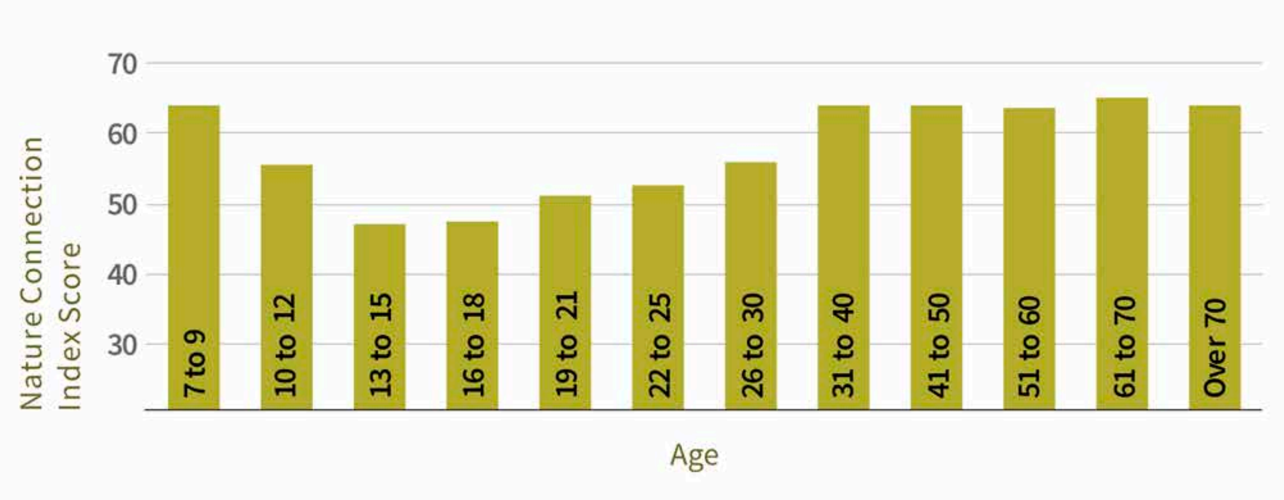
Cultural heritage includes aspects of the built environment that make an area unique – for example, historic parkland or archaeological remains.

As part of a recent review of England's landscapes, the recommendations suggested that the ten **National Parks** should be combined with the **AONBs** and classed as '**National Landscapes**'.

Peveril Castle, Castleton, High Peak, Derbyshire, looking north-west to Mam Tor iron age hillfort beyond. DP175536

Monitor of Engagement with the Natural Environment (MENE) is a national survey by Natural England that looks to establish how the public spend time in the natural environment, monitoring over time how people enjoy it and the factors that motivate then to protect it.

Analysis of MENE survey data showed that age has a significant impact on nature connectedness (a person's relationship with the natural world) – the connection with nature dips during a person's early teenage years before slowly increasing over their 20s.



Source: Natural England, 2020

- In England there are over 40 geological Sites of Special Scientific Interest (SSSIs) with Palaeolithic archaeological interest – a number of these sites are of international significance.

People are closely connected with the natural environment. A recent survey by Natural England showed that in 2018 there were nearly 4 billion visits to the natural environment by adults living in England, while 89% of the respondents indicated that spending time outdoors is an important part of their life (Natural England 2019b, MENE).

The historic and natural environment are closely interrelated and interwoven. England's Areas of Outstanding Natural Beauty (AONB) and National Parks extend across a multitude of different landscapes. AONB encompass 15% of the country's total land mass; this includes England's valuable coastal areas, with a fifth of the English coastline forming part of designated AONB sites.

- England's AONB contain about 4,600 Scheduled Monuments, 49,000 Listed Buildings, 300 Registered Parks and Gardens, 7 Registered Battlefields and 14 Protected Wreck Sites (Historic England, 2019).
- England's ten National Parks cover a total area in excess of 1.2 million hectares; within these there are about 4,400 Scheduled Monuments, 17,000 Listed Buildings, 63 Registered Park and Gardens and 4 Registered Battlefields (Historic England 2019).
- England's AONB also represent an important part of local economies, with a gross value added (GVA) figure of £16.5 billion (LFL 2018). This includes their support for recreational activities; about 30% of the land within AONBs is designated as open access for walkers, in addition to the ten National Trails and the 19,000 km of footpaths and bridleways that also pass through (LFL 2018).

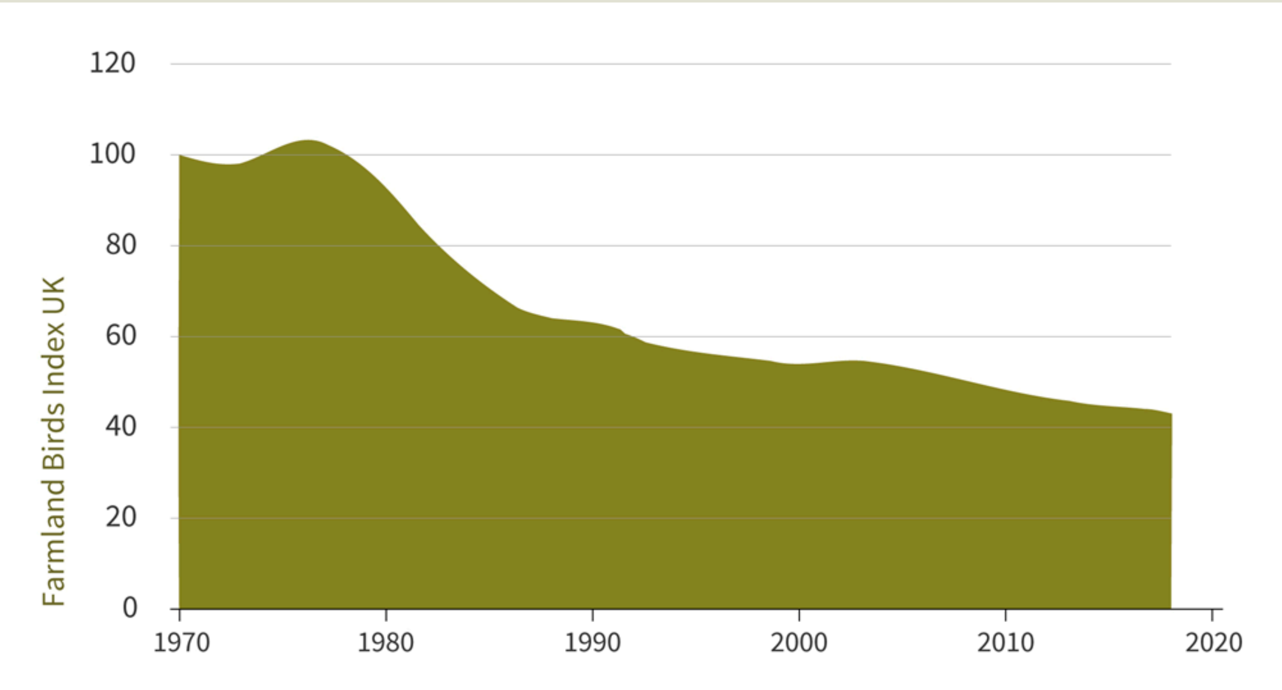
- There are 15 National Parks in the UK – containing natural beauty, wildlife and cultural heritage – with ten of these located in England. In 2019, England's National Parks contained 4,382 Scheduled Monuments and 16,975 Listed Buildings (Historic England, 2019).

England's physical landscape is a result of the interactions between natural and human factors, including changes in the way people have worked the land. Evidence of field systems in England originates from the Middle Bronze Age (about 1500 BC), with their introduction – alongside other organised land divisions – a likely result of transformations in social and cultural life. In the medieval period, open-field farming was the dominant system up to its peak in the 13th and 14th centuries; however, this marked a change after which the majority of new field systems were gradually enclosed. Initially, most enclosure was by agreement, but later, particularly in the late 18th and early 19th centuries, parliamentary enclosure acts resulted in the wholesale enclosure of previous open-field systems. The parliamentary acts resulted in the enclosure of 21% of England's land, representing approximately 3 million hectares, of which two-thirds was arable (Historic England, 2018b).

- The enclosure of land into smaller square-shaped fields resulted in the loss of systems such as Ridge and Furrow – those that remain are now historic features of England's

The structure of the agricultural industry in England and the UK is an annual statistical dataset compiled and published by DEFRA, giving time series on agriculture, horticulture and farming estimates. This is based on long-term surveys across the UK, giving trends and detailed results on an array of indicators at different geographical levels.

The success of farmland birds are dependent upon agricultural practices and can be used as an indicator of the general quality and biodiversity of the farmed environment – since 1970 there has been a 54% decline in the 19 indicator species that are unable to thrive in other habitats. This corresponds to the loss of features within the historic environment, such as hedgerows.



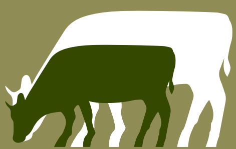
Farmland birds.

Medieval lynchets survive as earthworks near Westbury-sub-Mendip, Somerset. DP099815 grassland. The wavy linear ridges are a reminder of our past communal methods of strip farming and are supported under the countryside stewardship grants. Over the last five years, 10,500 hectares of permanent grassland on historic and archaeological features have received grants to maintain these features and conserve their character (RPA 2020).

In the last century the total land use for farming has **reduced** by **6%**

Permanent pasture and grazing have reduced by **25%**

but crop production has increased by **28%**



- During the last century the total land used for farming has reduced by 6%, with agricultural practices moving away from permanent pasture and grazing (reducing by 25%) to crop production (increasing by 28%). The change of agriculture from traditional to modern methods has increased the productivity of the land but it has altered the natural environment through the loss of hedgerows and their associated biodiversity and heritage value (DEFRA 2019).

- Most of the nation's historic landscapes, buildings and archaeological sites are owned and managed by farmers – more than 75% of England's scheduled monuments are located on agricultural holdings. Additionally, there are about 68,000 known heritage assets – going back to the barrows and other monuments of the Neolithic and Bronze Age – located on farmland (NFU, 2018).

People continue to shape the environment. Human-influenced habitats, such as chalk grasslands, have a significant environmental value, rich with a diverse range of flora and fauna. These are a result of historic forest clearings and centuries of grazing and management, suppressing vigorous plant species and allowing greater diversity of plant species to thrive. Today, some of the most important areas of chalk grassland are found on archaeological sites where the consistent management through grazing has created unique conditions.

- Changes in land use – such as those related to agriculture – have resulted in England losing more than 80% of its chalk grasslands since the Second World War (National Trust, 2019).

- There are about 39,000 hectares of lowland chalk grassland remaining in England, with the largest concentrations found on the chalk downs of Wiltshire, Dorset, Kent, Hampshire and Sussex (Natural England, 2019).

Changes in land use have resulted in England losing over

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Combined human activity and natural occurring events have helped shape England's landscapes, resulting in a range of positive and negative outcomes; exposure of land can lead to erosion and the loss of valuable nutrients and vegetation, while regular flooding events can deposit nutrient-laden sediments that improve growth productivity.

Topsoil erosion of

2.2 million tonnes per year

= **660,000** tonnes CO_2e

- Soil is produced naturally over thousands of years and is key component of the landscape; however the estimated annual loss of 2.2 million tonnes of topsoil as a result of erosion, costs the UK economy in excess of £1 billion a year through lost nutrients and a reduction in the agricultural productivity of the land (UKSO 2019).
- The countryside stewardship grants scheme support the traditional management of functioning historic water meadows, helping to keep the rare sites in a stable condition and maintaining the habitat and water quality. Water meadows were irrigated areas of grassland, located alongside rivers or streams utilising inlet and outlet channels

The chalk downs south of Avebury, Wiltshire. PLB_K930754 © Charlie Waite. Source: Historic England Archive that allowed a controlled amount of water across the meadows. This process deposited silt and oxidised the soil, while in the winter it offered frost protection and increased soil temperature ready for their use in the spring (Historic England, 2018c). Currently, there are about 100 hectares of historic water meadow systems within the scheme, with the total value of their grants at £240,000 (RPA 2020).

Cultural heritage is integral to environmental value. Some of the country's most important archaeological discoveries have been found buried in peatlands or have been unearthed naturally from erosion. In addition to artificial findings and human remains, peatland environments also contain valuable information on changes over time in our climate and vegetation, allowing us to better understand how these interact.

- In England there are an estimated 7,000 archaeological sites preserved within peat environments with their density ranging from 1.2 sites per km^2 in lowland peat to 2.2 sites per km^2 in upland peat.

- Today, England's upland peatland – spanning 355,000 hectares – has great biodiversity value, containing a diverse range of rare and specialised species that have adapted to the waterlogged, acidic and nutrient poor environment (RSPB 2014, JNCC 2011).

The historic environment exists within our towns and cities. Heritage and nature combine not only in our cherished countryside but even in England's most populated areas, where there are extensive networks of public parks and designed green space, the majority of which are heritage assets.

- As a region, London has the largest concentration of parks, public gardens and playing fields in England, with an average of seven within a 1km radius (ONS 2020).

- London's public parks – which are enjoyed by local residents and visitors – have a gross asset value exceeding £90 billion (GLA 2017).

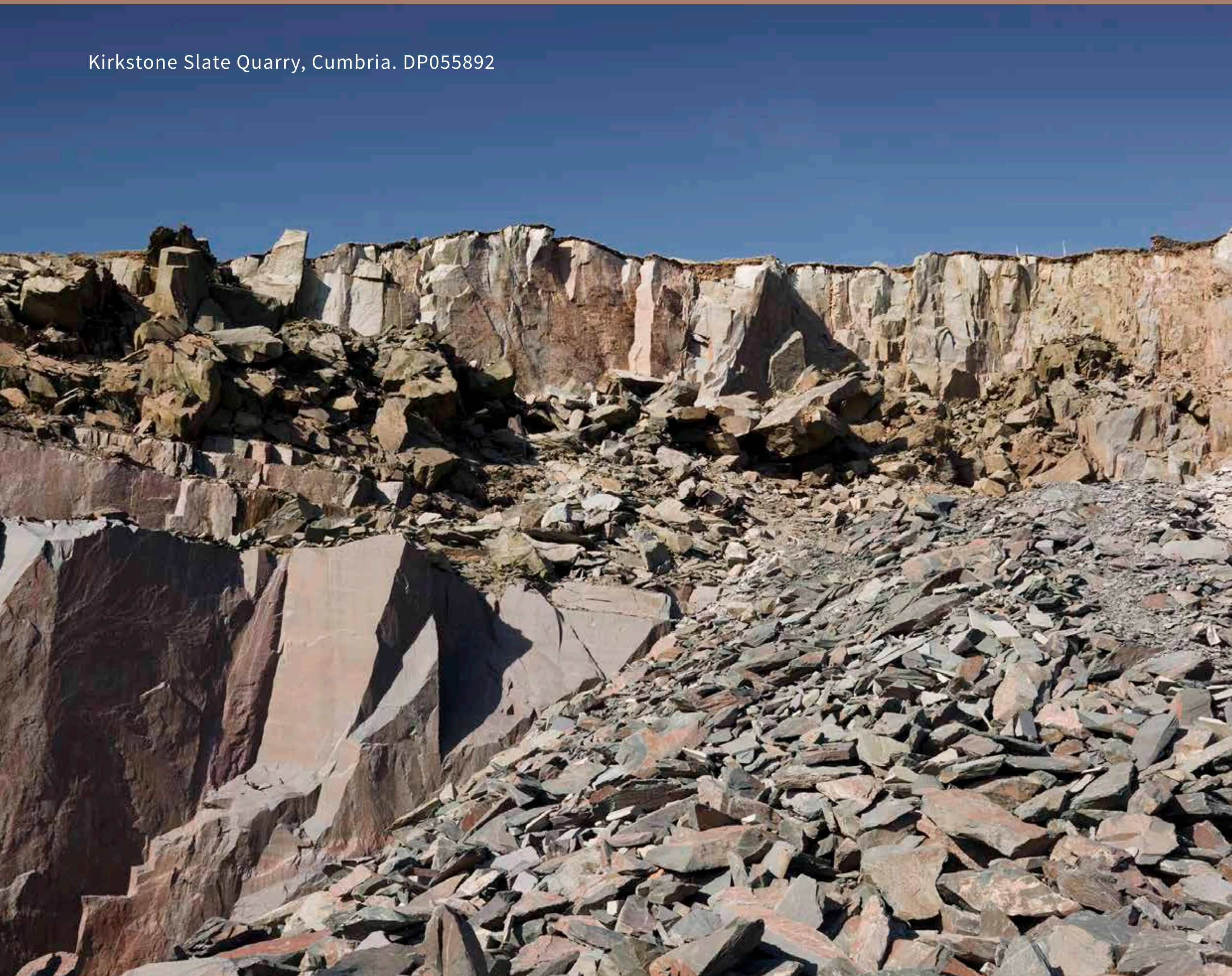
- The value of the city's associated recreational activities, including the enjoyment of natural and cultural heritage, is estimated at about £1 billion per year (GLA 2017).

The underpinning data for the Natural Capital Account for London – representing collaboration between the Mayor of London, the National Trust and the Heritage Lottery Fund – is available to download.

Natural resources and our historic environment

Heritage as an expression of geodiversity

Our historic environment varies through its geology, geography and typography and the wealth of resources this provides. Since the Palaeolithic, the location of minerals, rocks and soils have supported the growth of communities and local economies. England's urban and rural areas contain unique physical, social and economic characteristics which, alongside the interactions of people, can be used to nurture and preserve local distinctiveness.



Kirkstone Slate Quarry, Cumbria. DP055892

Place identity and local materials. Vernacular structures reflect the local customs and traditions of an area, using locally sourced materials such as wood, stone, earth and brick. Before the development of railways and canals, local materials were used for the construction of the majority of buildings. Stone is a key building material for many of the listed buildings and conservation areas in England, helping to impart distinctiveness from the local geology. The types of stone and the quarry's location directly influence the character of a building, therefore understanding the original stone sources and possible alternatives are important for maintaining local distinctiveness.

- The Strategic Stone Survey highlights the geographic differences in building stone materials, for example, East Yorkshire contains surviving examples of chalk buildings – matching the local bedrock geology – while Northamptonshire often displays great diversity from town to town, with different local varieties of limestone and sandstone used (BGS 2017).

- Although not exhaustive, in 2016 the Natural Stone Directory listed 275 UK quarries that produce building stone, some of which have been working the same strata in the same location for centuries (Historic England, 2016a).

- Although the UK has extensive mineral and stone resources, it has increasingly utilised global imports of building materials. In 2018, the UK imported about 130,000 tonnes of 'worked stone' annually, with the majority (68%) of this sourced from China and India (Historic England, HMRC).

The human influence on England's forested landscape has deep historic roots, stemming back around 6,000 years ago to the introduction of farming and the subsequent clearance of trees. The large-scale felling of English forests – historically dominated by oak and other broadleaved species – occurred pre-industrialisation, with the produced timber used extensively in the construction of wood-framed houses.

- By the end of the Second World War, England's forest cover had fallen below 5%, prompting a focus on plantation forestry which has seen this figure increase to 13% today (FTT 2019).

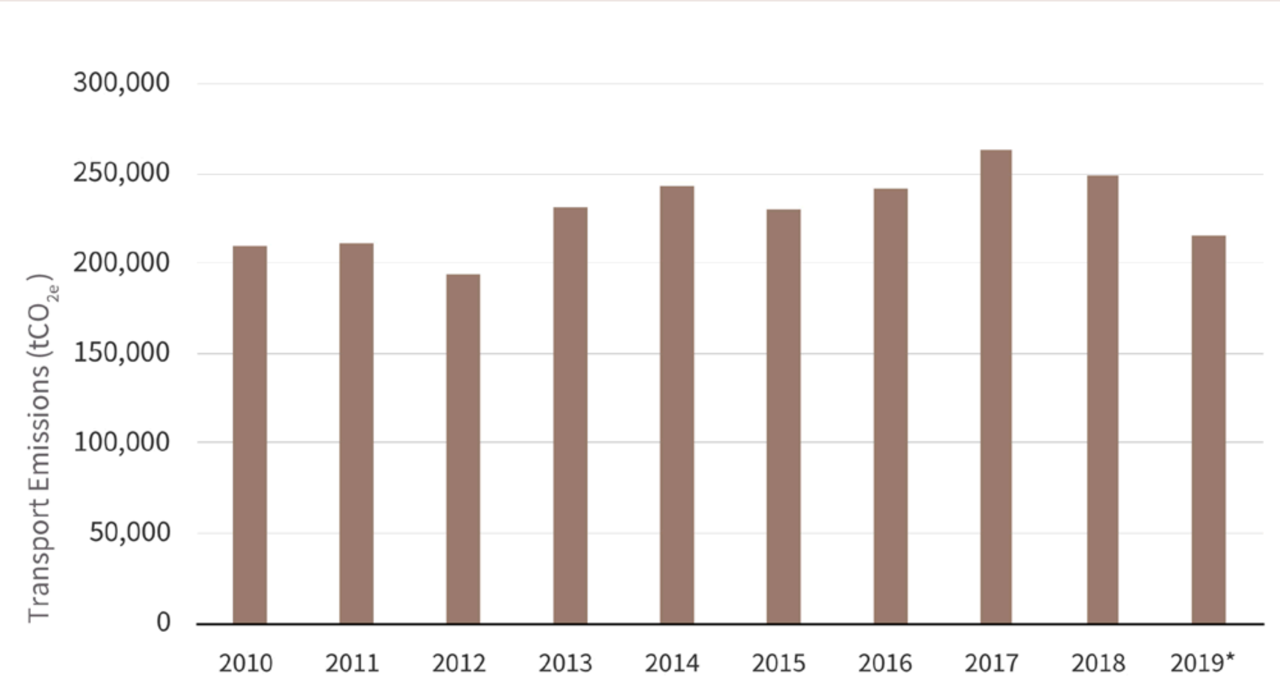
The grounds of Walmer Castle, Kent. DP055381

Case Study – Global Imports of Building Materials (Historic England)

During the last decade a large proportion of the UK's imports by weight came from outside the EU, accounting for about 58% of all imported commodities in 2018. Although the total mass of non-EU imports has continued to peak and trough over the last decade, there is an increasing reliance on individual nations in the Asia and Oceania region, specifically China and India. In the first ten months of 2019, about 12.6 million tonnes of catalogued commodities were imported to the UK from China and India, collectively representing nearly 60% of the imported goods from this region and more than 8% of the total imports from outside the EU.

The UK is not currently required to include the greenhouse gas (GHG) emissions of imported materials as part of its national inventory (which are reported annually to the United Nations), instead reporting those that occur within its borders. This includes the emissions generated from goods and services produced within the UK – no matter where they are eventually consumed – but not those produced outside of its borders. There is however a trade imbalance, with the UK importing significantly more goods – by weight – than we export, with the majority of this sourced from outside the EU.

The transportation of items across large distances can generate substantial emissions, particularly when using shipping or freight rail transport systems that often extend for thousands of miles. This has been further compounded by an increased utilisation of imported Chinese and Indian natural materials particularly granite and other dense minerals that are already abundant in the UK. Indeed, the transport emissions for construction materials to the UK, from outside the EU, are estimated to account for about 250,000 tCO_2e in 2018 – an annual figure that has increased gradually during the last decade, yet is still excluded from the UK's national emissions inventory.



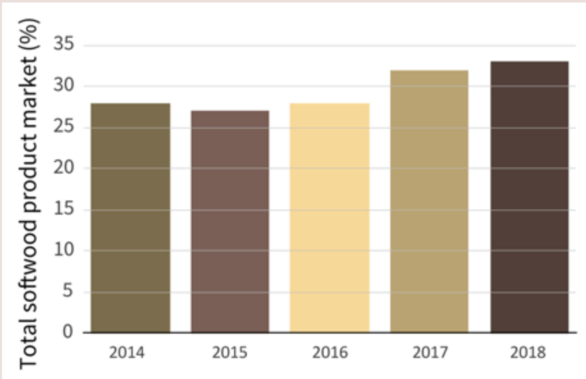
Estimated transport emissions from imported stone and slate (outside of the EU). *only first 9 months

The Butts Avenue, Rochdale, Greater Manchester. DP235537

The return of timber for construction. During the last century the role of timber as the primary construction material in England decreased, however, its versatility and sustainability credentials have prompted a revival. This is particularly important when considering the potential of timber to be utilised as a carbon sink.

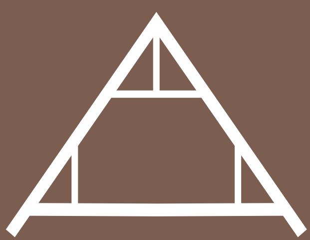
- A recent survey by Södra Wood showed that timber has become an increasingly attractive construction material; 63% of the participants believed it to be growing in popularity while 69% indicated that they already work with timber for construction (Södra Wood 2019).
- Although the quality of UK-produced timber is variable, there is a growing demand for it; since 2009 the production of sawn softwood in English sawmills has increased by 30.5%. In 2018, of the 1.1 million cubic metres of sawn softwood produced in England, about one third was used in construction (Forest Research 2019).
- The construction of new builds currently accounts for the storage of around 1 million tonnes CO_2e annually, however, increasing the use of timber in construction could increase this to 3 million by 2050 (CCC 2018a).

Forest Research are the principal forestry and tree related research organisation in Great Britain, producing data tables and time series data as part of their annually released Forestry Statistics, spanning the period from 2001 to the present.



Timber production for construction (UK).

The production growth of sawn softwood in the UK coincides with an increase in timber for construction use. During the last five years the softwood product focus of UK sawmills has begun to slowly shift towards construction materials, representing a 5% increased share of the market since 2014.



Increasing timber use in construction could increase carbon storage up to

3 million tonnes CO_2

a year by **2050**

Bricks represent local natural resources. The geographic variation in England's diverse raw clay deposits, together with differing manufacturing methods, result in the production of regional bricks that differ in their properties, quality and aesthetics.

- Bricks have increasingly been a mainstay of our construction industry since the late 13th century, however since the 1970s, the UK's brick production – which is almost entirely based in England – has more than halved. There was about 4.3 million tonnes of bricks produced in 2018. Unlike stone imports, which are sourced from such distant places as China and India, the UK's imported bricks originate from within the EU (BEIS 2019a, BGS 2001, HMRC).

The walled garden and pavilion at Croxdale Hall in County Durham. DP174220

Roof coverings are evidence of traditional technologies and local resources. Thatch has rich regional traditions, and makes a major contribution to the architectural and aesthetic qualities of individual historic buildings as well as playing a significant role in shaping the character and distinctiveness of the locality. A variety of different materials have been used historically – including straw, heather and water reed – reflecting the natural vegetation and crop production of a particular location.

- The husbandry of thatch materials can have a significant impact on their suitability for roofing. Concerns over the quality of English-grown thatching straw resulted in the loss of important historic thatch and distinctive local traditions through the replacement of existing wheat straw with imported water reed. Using indigenous wheat straw and, where appropriate, water reed, can reduce the embodied carbon of thatch compared to using some imported materials. (Historic England, 2016b).

- The use of wheat straw for thatching supports traditional woodland practices. Coppicing of hazel to make the spars and liggers used for fixing thatch provides employment and maintains a centuries-old tradition of woodland management, contributing to the appearance of the landscape and has wildlife benefits.

- In England there are approximately 26,000 listed buildings with a thatched roof, of which about 4,000 have medieval origins (Historic England 2020d).

Local distinctiveness through regionalised roof covering. As the first defence against the weather, the choice of material for roof covering is paramount. In the past, each region developed its own techniques to make most effective use of the range of potential roofing materials that were readily available in that locality and which reflect variations in geology, topography and climate. In particular, the use of sandstone, limestone and random metamorphic slate is highly regionalised and makes a strong contribution to local character and distinctiveness. (Historic England, 2005).

- The availability of cheap Welsh slate and machine-made tiles – as a result of the Industrial Revolution and the consequent improvements to transport – supressed the use of some vernacular roofing materials. The decline in the vernacular slating industry and the loss of skilled employees has seen examples of England's stone and random metamorphic slate roofs becoming increasingly rare (Historic England 2020d).

Slater Terrace, Weavers' Triangle, Burnley, Lancashire. DP110539

Peat cutting hollows at Force Cragg Mine, Cumbria. DP054913

Historic environment and biodiversity

Heritage as a provider of habitats

England's historic environment is home to a diverse range of species which, through their survival and continued presence, help to maintain the distinctiveness of our landscapes. An appreciation for the traditional management of our environment is vital to the conservation of existing ecological systems and the habitats, ecosystem services and diverse flora and fauna that feature within these.

Boundaries are an important part of our historic environment. Although they are concentrated in the lowlands, hedgerows can be found across the country with their species composition and management often differing distinctively between regions, helping to contribute to local historic landscape character. Dry stone walls are also an integral part of the landscape and cultural heritage and are found predominantly in the upland and westerly lowland areas of England.

- Hedgerows are defined as any boundary line of trees or shrubs over 20m long and less than 5m wide – any gaps between trees and shrubs should be less than 20m. The last Countryside Survey – conducted in 2007 – estimated that there was about 477,000km of hedges in Great Britain, representing a 24% decrease from 1984 (Wood *et al* 2018, Natural England, 2020a).

- Over the last five years, around 32,250km of hedgerows were included within the countryside stewardship grants management of hedgerows scheme. The awarded grants – which total more than £13 million across five years – are intended to help ensure the survival of England's hedgerows, supporting a diverse range of species.

- The additional planting of new hedges on historic hedgerow sites with local native species over the last five years has created nearly 3,000km, equating to an estimated 130,000 tCO_2e (RPA 2020; Calculated using emission factors sourced from Axe *et al* 2017).

- In 2007, the Countryside Survey estimated that there was 82,000km of dry-stone walls in England, decreasing by 900km over the previous decade. These are important for biodiversity – as habitats and wildlife corridors – however the large majority of these are in a 'deteriorating' condition (NERC 2007, Historic England 2018a).

We can see the past by looking at the landscape. England's ancient woodlands are an example of the Historic Landscape Characterisation (HLC) which is an important method for identifying and interpreting the varying historic character of our landscape. Ancient Woodlands are an irreplaceable part of

Ruskin's View over the river Lune, Cumbria. DP113508

"Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors"
European Landscape Convention

"Landscape protection means actions to conserve and maintain the significant or characteristic features of a landscape, justified by its heritage value derived from its natural configuration and/or from human activity"
European Landscape Convention

the natural environment, taking hundreds of years to establish; this status designates areas where woodland environments have existed since at least 1600 AD.

- There are about 364,000 hectares of ancient woodlands found in England. Of this total, 59% are classified as Ancient Semi-Natural Woodland (ASNW) with the remainder designated as Planted Ancient Woodland Sites (PAWS), which were wooded sites that, after a period without trees, have since been replanted.

- These sites help us understand how people previously lived and worked, and how this has influenced the values and attitudes of modern society.

- There are about 800 designated scheduled monuments that are located within (or partially within) England's ancient woodlands. In total, there are around 2,300 scheduled monuments in England that have some form of woodland cover (RPA, Historic England 2020b).

Understanding different species helps protect the historic environment. The growth and establishment of species – such as ivy – have the potential to cause damage to the historic environment if left unchecked. Ivy supports a number of different wildlife species but its versatility and quick growth can supress biodiversity and cause damage to historic assets – particularly those built from vulnerable materials (Historic England 2017b, Woodland Trust).

- Although ivy is invasive in the way it spreads, it is unable to bore and penetrate well maintained masonry. The stems can however exploit existing defects in deteriorating walls – such as decaying mortar joints and cracks – which, as the stem increases in size, can lead to significant structural damage.

Case Study – Broadham Ancient Woodland (Natural England)

Broadham Wood is a newly designated Ancient Woodland, situated to the South East of Tunbridge Wells, in Kent. In addition to demonstrating significant historical biodiversity, the woodland also features a range of intriguing archaeological finds including hop pickers' huts, communal cook houses and toilets. The seven hectare woodland gained its Ancient Woodland status through historic map evidence and biological surveys, which also highlighted the past agricultural activity in the wood.

Half of the woodland is dominated by a dense carpet of bluebells, under hazel coppice with oak standards – this is a woodland management practice aimed at ensuring a sustainable oak timber crop and hazel for coppiced products and firewood. There are also a wide range of indicator species for ancient woodlands, including wildflowers like yellow archangel and wood anemone and large shrubs such as Midland Hawthorn.

- There are however benefits to ivy growth; during the summer the daily maximum wall surface temperature is between 9-25% lower when covered in ivy, while in the winter their daily minimum temperature is 36-45% higher than those without ivy (Historic England 2017b).

Historic coastal habitats support biodiversity. England's coastlines support a wide range of species, with geographical variety in their existing flora and fauna. Many of the existing terrestrial and submerged landscapes contained within England's coastal zones are important providers of habitat as well as being heritage assets.

- In the UK there are around 5,000 hectares of reedbeds, with England's largest areas located in East Anglia with other important examples found in the Somerset Levels and the Humber Estuary. They support distinctive breeding birds such as the marsh harrier and the common crane, as well as other migratory species, however reedbeds have suffered significant loss and fragmentation over the last century (Natural England, 2020a).
- Coastal saltmarshes are vegetated portions of intertidal mudflats that have decreased in size since medieval times. They are an important habitat for a diverse number of birds and invertebrates, although there is regional variation between species – a result of age and the historic management of the saltmarshes (Natural England, 2020a).
- Coastal grazing marshes are a major heritage asset, contributing to the special landscape character of many parts of the English coast. In England there is an estimated 220,000

The site of the Grace Dieu, and possibly the site of the Holy Ghost, on the river Hamble, Hampshire. DP167385 hectares of coastal and floodplain grazing marsh, although only 2% is semi-natural with a high diversity of native plant species. They are sensitive to changes in rainfall patterns and extreme drought and flooding events, in addition to being at risk from sea level rise (Natural England, 2020a).

- There are an estimated 1,100km of maritime cliffs and slopes in England, which are characterised by differences in geology, exposure and abiotic processes. Areas in the east, southeast and south of England are particularly vulnerable to erosion. Their habitats are diverse, varying as a result of the local climatic conditions; sheltered ledges and crevices support a number of unique plants species and cliff-nesting seabirds, while exposed cliff faces are often colonised by lichens (Natural England, 2020a).

Conserving traditional buildings conserves habitats. In addition to their architectural or historical value, traditional buildings also provide a large number of roosting places for England's bat species, which are protected by law. Changes to agricultural practices and urban growth have reduced the number of available natural bat roost sites in England. Bats often require different types of roosts, dependent upon the species; there are several factors, including the structure, microclimate, ecological setting, geographic location and level of disturbance (Historic England, 2009a, Historic England, 2019b).

Heritage and ecosystem services have a great deal of overlap. There are a diverse range of human benefits that result from the environment and the multitude of ecosystems that it supports. Ecosystem services can be categorised in terms of provisioning, regulating, supporting and cultural services. Of these, the latter concerns the nonmaterial benefits that are obtained from ecosystems with many societies placing a high value on the maintenance of historically important "cultural landscapes" or culturally significant species (MEA 2005). However, the historic environment represents all aspects of the environment that result from the interaction between people and places through time, which means it should be considered as more than just cultural services.

- Peatland landscapes represent some of England's most extensive wild spaces making them a popular place to visit – the Peak District National Park and its 51,000 hectares of peat-covered moorlands have more than 13 million visitors every year (PDNP).

- There are a number of ecosystem services attributable to shipwrecks; however these are site-specific and differ from wreck to wreck. Wrecks are considered heritage assets, with 53 designated as Protected in England in 2018 (Historic England, 2020b).

- Submerged wrecks act as artificial reefs, providing habitats for a wide variety of species including fish, crustaceans and cephalopods. This makes them valuable to ecologists and to divers and fishermen, both commercially and recreationally (Historic England, 2019e).

Case Study – Orford Ness (Historic England)

Orford Ness is situated on the Suffolk coast, to the east of Ipswich. It's the largest vegetated shingle spit in Europe (at about 16km in length) and, until the last century, its major economic activity was sheep and cattle grazing. The present lighthouse dates to 1792, however lights have been displayed there since the 1600s to warn seafarers of the dangerous shoals. The shingle spit created a naturally sheltered harbour which helped support the development of a settlement in Orford.

The spit's remoteness has also made it an attractive location for military trials, particularly those relating to aviation, which began during the First World War. Its relationship with military testing continued into the 1950s, with the spit utilised during the highly secretive testing of atomic weapons. This has left its legacy, with the enigmatic concrete test chambers still visible.

In addition to its historical importance, Orford Ness is a rare and delicately balanced natural environment that is important for animal, bird, plant and insect life. As a result, the spit is recognised through numerous environmental designations. The spit's harsh and dynamic environment influences how its heritage is managed. Due to coastal erosion the lighthouse will sadly be dismantled to preserve its artefacts before they are lost to the sea. At present, the National Trust, who owns the spit, follows a conservation philosophy of benign neglect, or minimal intervention, for many of the scheduled structures.

Orfordness Lighthouse from the north. DP068423

South Street, Boston, Lincolnshire. DP165481

Built heritage and the environment

Heritage buildings as part of the solution, not part of the problem

Containing some of Europe's oldest buildings, England's built environment is characterised by a diverse range of traditional structures that have been designed with specific needs in mind and survive because they are durable, versatile and adaptable. Extending the life of a building – through adaptations that allow it to remain useful and viable – presents an array of unique opportunities and challenges.

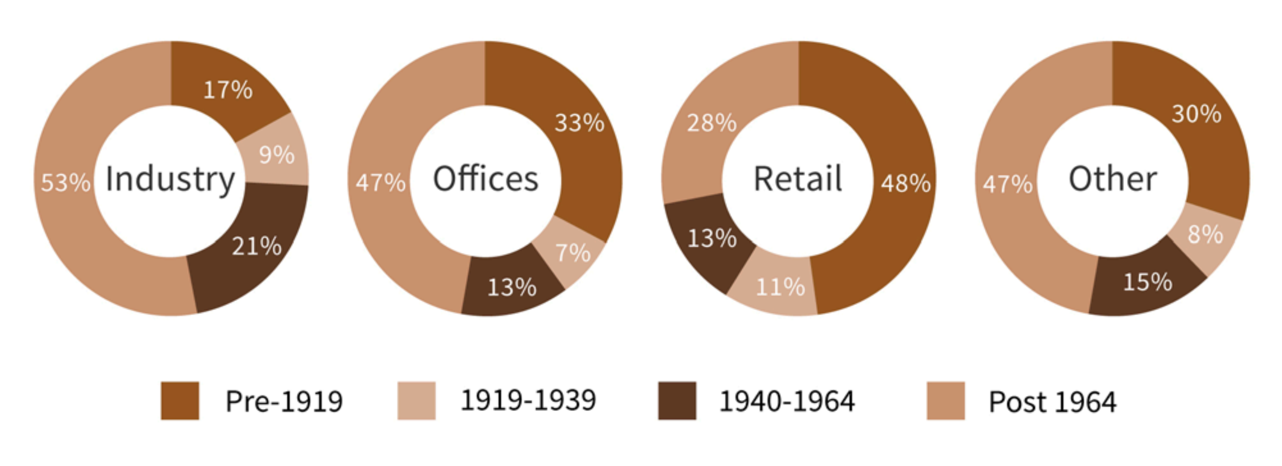
The oldest domestic building stock in Europe. Britain is considered to have the oldest domestic building stock in the developed world with more than ten million properties over 60 years old.

- Of these, 5.1 million are domestic homes built pre-1919 (the conventional cut-off point for buildings of traditional construction), representing more than a fifth (21%) of England's housing stock (VOA).
- Their distribution differs geographically across England, with the greatest concentrations of pre-1919 homes found in Inner London (38%) and smallest in the East of England with just 14% (VOA).

Traditional buildings are more efficient than we thought. Historic and traditional buildings have a reputation as 'hard to treat' in terms of energy performance, however they were designed to work efficiently and passively. Today, some of our best performing buildings are those that use simple passive or free cooling systems that are characteristic of older buildings. Traditional building systems are based on solid walls made of materials that are permeable, such as brick, stone, earth, timber, and lime-based mortars. Thick permeable walls will also resist heat transfer unless they are wet.

- In addition to reducing operation and maintenance costs, the energy costs and associated CO_2 emissions of naturally ventilated buildings are often 30% lower than those of a typical air-conditioned building (Carbon Trust).
- Traditional architecture is characterised by features such as wide eaves and cornices, or hood mouldings and sills, that are intended to protect the bulk of the wall from rainwater entry at weak points. These protective features are often very decorative, but their primary purpose is practical (Pender *et al*, 2020).

The Valuation Office Agency (VOA) publishes official statistics and time series data on the UK's stock of properties, including ratings for non-domestic properties, and council tax bands and other attributes for the domestic stock. These are supplemented with other experimental statistics and datasets that, in some cases, cover more than half a century.



Stock of non-domestic property by sector and buildings age at 31 March 2015, England and Wales.
Source: Whitman *et al* 2016

In England and Wales, 33% of all offices, 48% of all retail buildings and 17% of industrial buildings were built pre-1919. These statistics demonstrate the importance of historic properties for the economy, providing much needed workspaces for businesses across the country.

- The vertically sliding sash window allows ventilation at different heights while not slamming shut or opening in high winds. They can be used with awnings and shutters, to give the highest possible degree of control over sunlight, ventilation, and security (Pender *et al*, 2020).

Buildings and standards do not always match up. There is a disconnection between the standards that are used as the basis of regulation, certification and technical commercial advice and the performance and requirements of actual buildings. There are significant gaps in our knowledge of the performance of traditional buildings as well in our understanding of the effects of energy-efficiency refurbishment on these buildings. These lead to uncertainty which increases risk, particularly when traditional buildings are subject to retrofitting interventions. (STBA, 2012)

- Research has shown that calculated U-values for solid walls overestimate heat loss resulting in the use of more insulation than necessary to meet specific retrofit targets (SPBA 2020).

- The average U-value of walls measured in situ at the eighteen properties was 1.4 W/m^2 K. This indicates that the industry-standard default U-value of 2.1 W/m^2 K for a solid (9 inch) brick wall, used in energy-performance assessments, underestimates the thermal performance of the wall by about one third (Historic England, 2013).

- A UCL study analysed the impact of using more realistic U-values for solid brick walls, indicating that by changing the solid wall U-value from the standard 2.1 to 1.3 then about one-third of all solid-wall dwellings move one EPC band (Francis *et al*, 2015).

Historic buildings are adaptable and can be reused. The versatility of historic buildings has been evidenced on numerous occasions, changing from their original designs to ones that can thrive in new roles while still providing character and sense of place. From traditional mills or farm buildings to distinctive office spaces and domestic flats, the great potential for the existing built environment to be creatively repurposed is supported by the English public.

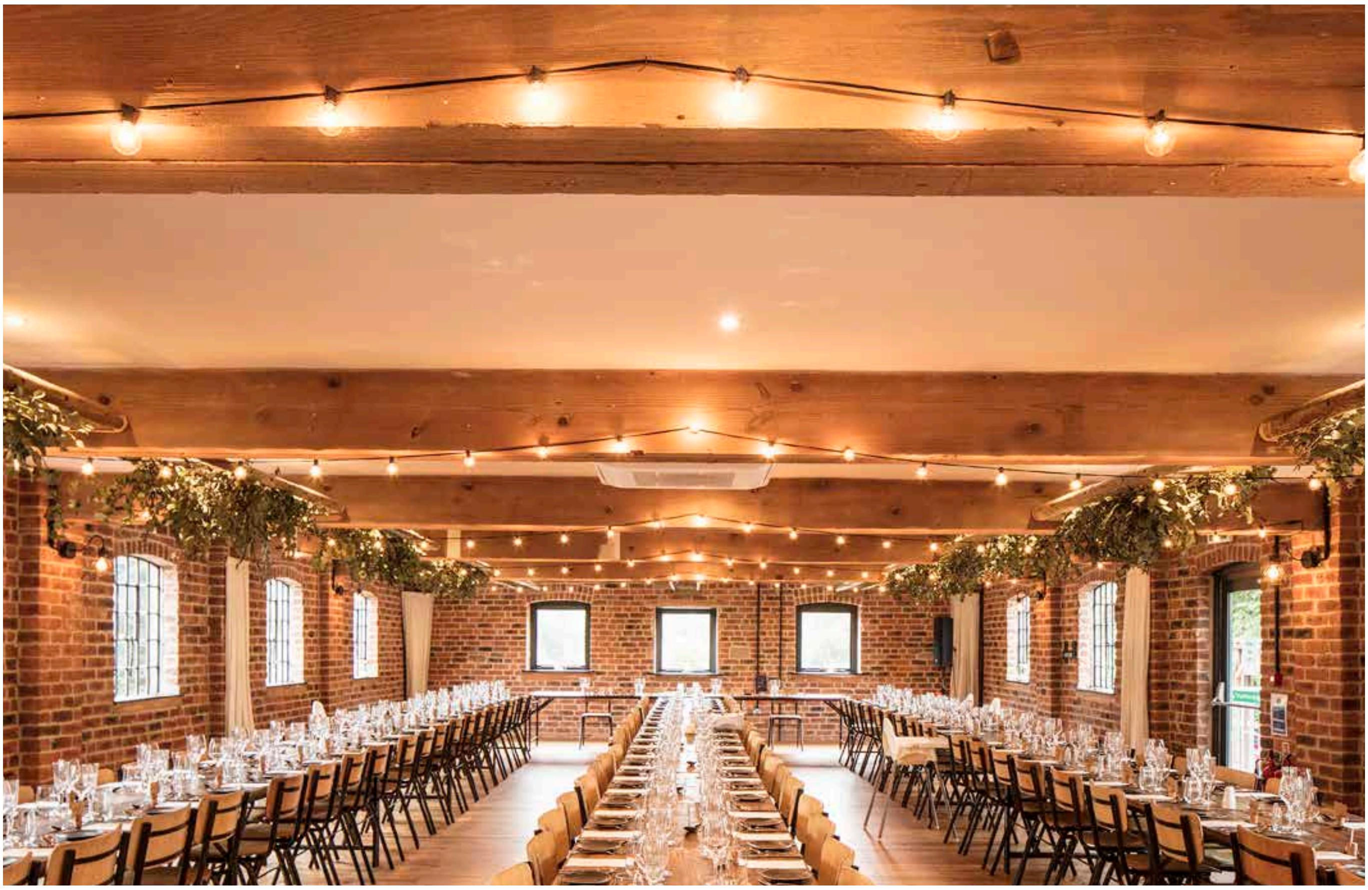
- A study of 1,731 adults in England showed that there is a clear consensus for preservation, with 87% agreeing that finding a new use for historic buildings is better than demolishing them (YouGov 2018).

- In England, there are about 216,000 domestic properties that are designated as long-term vacant which may have potential to be repurposed. Many of these are traditional, pre-1919 buildings that have fallen into disrepair, often as a result of socio-economic factors (MHCLG 2019).

> Live datasets concerning vacant properties are part of the extensive dwelling stock statistical data, published by the Ministry of Housing, Communities and Local Government.

The energy and carbon performance of many historic buildings can be improved. Research carried out by Historic England has demonstrated that sympathetic energy efficiency improvements to traditionally built homes can result in reductions of up to 40% in operational greenhouse gas emissions (Historic England, 2015a).

- Not all energy efficiency solutions are suitable for buildings of traditional construction. It's important to understand how the building works as an environmental system as well-intentioned but ill-judged measures risk harming human health, the building fabric and they may not achieve the expected financial or environmental benefits.



The main dining area at Haarlem Mill, Wirksworth, Derbyshire, which is now a wedding and events venue. DP234214

Case Study – Linton Lock Hydro (Historic England)

Linton Lock Hydro is a listed former hydroelectric power station in North Yorkshire that is helping to address the green power challenges of the 21st century, a century after it was originally built.

The pioneering lock, located on the north bank of the river Ouse, was built in the 18th century along with its accompanying weir – helping control the flow of the water – which is located on the south bank. In 1923 a hydroelectric plant was built in response to rising coal prices, however after nearly 40 years of operation it was abandoned and allowed to fall into disrepair.

As an early example of rural hydroelectric power generation, the Linton Lock Hydro was designated a scheduled monument in 2000, while both the lock and weir are listed structures. Decaying due to lack of use, the site was set to be added to the Heritage at Risk Register, however a collaborative project between JN Bentley and Historic England saw the conversion of the site back into a working power station.

The newly renovated and working Linton lock and hydroelectic generating plant. DP143652

The project – which included the installation of two Archimedes' screws – is not only a fantastic example of a modern development using ancient technology, but also of how commercial viability can be achieved; the restored power station produces enough income from the electricity generated to justify the investment in its renovation.

Where possible, original materials were used throughout the conversion, turning a semi-derelict building into scheduled monument that can generate up to 380kW of renewable electricity – enough to power the equivalent of 450 homes. In addition to feeding power into the National Grid, Linton Lock Hydro brings social benefits to the local area, working with local schools on climate change issues and opening the site to the public on Heritage Open Days.

- Achieving the best and most cost-effective balance between saving energy, maintaining a healthy indoor environment and sustaining heritage significance requires a holistic 'whole building approach'. This uses an understanding of a building, its context, its significance, and all the factors affecting energy use as the starting points for devising energy efficiency solutions.

Traditional and modern forms of construction differ in the way they handle heat and moisture. Traditional construction has permeable fabric that both absorbs and readily releases moisture by evaporation. In contrast, most modern buildings depend on impermeable barriers to control the movement of moisture and air con through the building fabric.

- A further difference is that traditional buildings tend to heat up and cool down more slowly than their modern counterparts. Their capacity to even out changes in temperatures and humidity can be beneficial in terms of both energy efficiency and comfort (Historic England, 2020a).

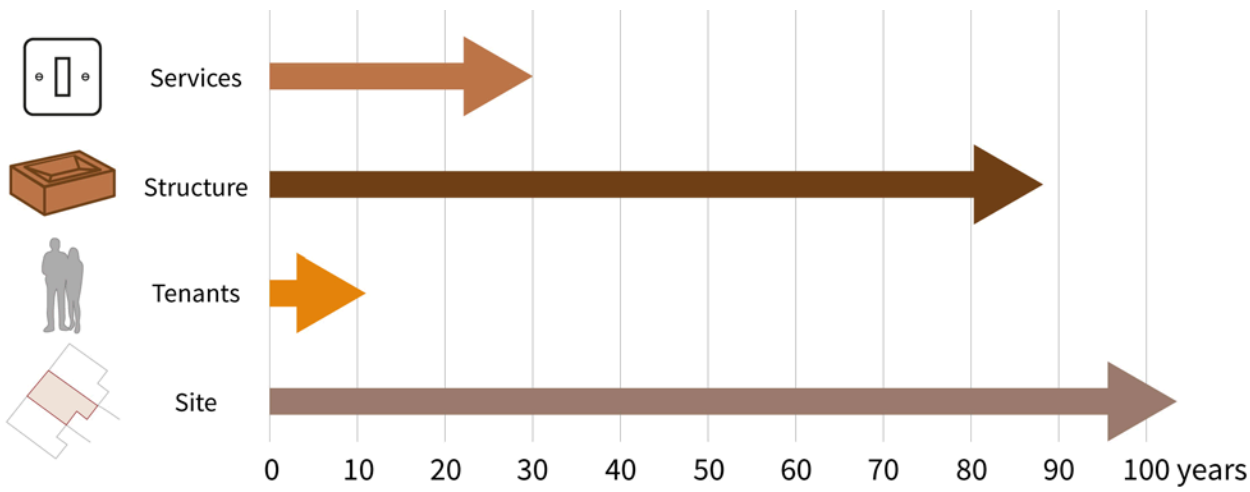
There are untapped opportunities within the built historic environment. New research by Poyntons Consultancy – on behalf of Nottingham City Council – has revealed that there is potential to increase the number of homes on historic high streets (Poyntons, forthcoming).

- The findings from the commissioned research, which investigated the residential capacity of an historic area around the Old Market Square in the city centre, showed that there is potential for over 300 new residential units above shops in existing buildings. Increasing the productive use of these assets will reduce the carbon footprint of new home provision and provide much needed opportunities for struggling high streets.

A building's life is determined by more than just its materials. Although no individual component contained within a building will last forever, a building's lifespan is often limited by factors other than material failure.

- The decision to demolish traditionally-built structures is often economic, driven by the land's value and the investment potential for purpose-built buildings. The end of a building's economic life is the point when its retention is no longer the least expensive way to perform its function (UCL).

- Although the life expectancy of a building is often considered to be in excess of 80 years, the periods for design criteria (25 to 30 years) and tenancy/occupancy (1 to 11 years) are much shorter. Retaining and repurposing buildings or reclaiming materials for reuse in construction – reducing resource use and waste production – are often less preferable than demolishing and 'recovering' the materials as aggregate (UCL).



Life expectancy of building components.

Case Study – Bournville Low Carbon Retrofit (Historic England)

This renovation project is a low-carbon retrofit to a mid-terrace built about 1901 in Bournville, Birmingham. The house is not listed or in a conservation area, but is nonetheless a characterful example of a very common historic domestic building in the area.

The owners (and occupiers) had two overarching aims before starting the work. Firstly, to undertake a whole-house retrofit (following the STBA approach) that reduces heat-loss and minimises embodied carbon while retaining and adding to the character of the house and improving the layout and relationship with the garden. Working to a fairly tight budget, the owners had to carefully balance these aims against cost and the practicalities of getting things done.

The first step was to work up a detailed brief before they engaged with an architect who specialises in retrofit. They opted for Arboreal Architecture who were commissioned to give professional input for the design, helping to achieve the aims and to save money in the long run. This was followed by extensive survey work: this included undertaking a condition survey, airtightness test, thermal imaging, space heating modelling (PHPP, SAP), moisture simulation (WUFI) and monitoring existing internal conditions.

In addition to technical measurements, the perceptions of comfort and feel – developed from living in the property – were an important factor on the design. They also commissioned Construction LCA to complete a Life Cycle Analysis to review carbon emissions over the lifecycle of the project, producing evidence to help inform decisions.

The main building changes consist of a contemporary ‘garden room’ extension and a first floor oriel window, with minor internal layout changes. The energy efficiency works include insulation (floor, loft and internal walls), airtightness, new triple-glazed windows, ventilation and new services – this involved replacing the gas boiler with Herschel radiant (infra-red) panels and a Sunamp thermal store.

Waste will also be reduced through reclaiming materials, for example re-using bricks and glazing in the new extension. If reclaimed materials are unavailable then sourcing local or low-impact materials are the next best option. They have also decided to use lots of timber (wood fibre insulation, new structural elements and window frames) which, when carbon

The terraced house in Bournville, which is undergoing some retrofit work.
Sarah Freeman © Historic England

sequestration is taken into account in the calculation of the project's embodied energy, actually renders the building carbon negative.

Despite the retrofit being estimated to be carbon negative, the project is unlikely to meet any recognised retrofit standards (for example EnerPhit), but the team are estimating a 70% reduction in space heat demand and will end up with a warm, comfortable and delightful home while reducing the carbon impact as much as possible.

Strategies of waste minimisation, reuse, re/free-cycling and low carbon specification.
© Arboreal Architecture

Breathing new life into old buildings can have many benefits. The refurbishment and reuse of existing buildings reduces the amount of embodied carbon and waste produced when compared to demolishing them and building anew. Making the most of our existing historic buildings can also help rejuvenate and support local economies. This includes utilising suitable locally-sourced construction materials for maintenance and repair works, which is a key aspect of heritage management (Historic England 2020c).

- In 2017, studies into vacant and underused textile mills in the North West of England identified 542 in Greater Manchester and 540 in Lancashire. Their regeneration could generate a potential of 133,000 additional jobs – equivalent to £6 billion of Gross Value Added per year – or 25,000 homes (Historic England, 2017a).

Energy Efficiency and Historic Buildings

Historic England, 2018

Although there are no 'one-size-fits-all' solutions for making energy and carbon savings in older houses, there are some general principles that apply across the board:

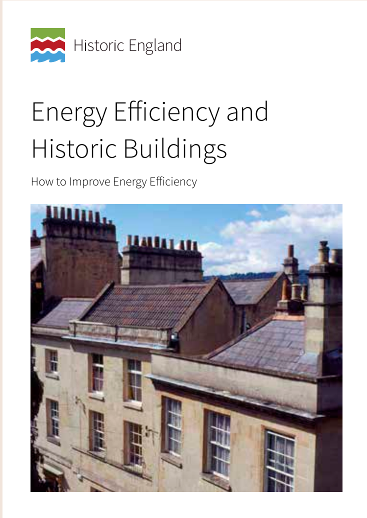
Understand your home and its context: Account for the historic significance of your house and the potential harm from changes

- Its location, orientation and exposure to sun, wind and rain
- Its design, construction and condition
- The performance and behaviour of the building materials
- The design, condition and operation of services such as heating and hot water
- How you use your home
- Your own requirements, aspirations and aims
- Your budget and other resources, opportunities and constraints
- Success cannot be achieved by technical means alone; everyone in the home needs to be fully involved in your energy saving plans.

Reduce energy use: Review and question your current habits and comfort standards to find out what's really necessary. You might be able to make energy savings through a more flexible approach to comfort in different parts of the home, so for instance by heating bedrooms to a lower temperature than living rooms.

Avoid waste: Lights and equipment in homes are often left on unnecessarily. It's important to use energy-using systems efficiently, and to turn all energy-using equipment off or down when not needed.

Increase efficiency: Building services such as heating, hot water supply and lighting and other energy-using equipment like computers and



The Energy Efficiency and Historic Buildings guidance document, available online.

appliances should be designed, selected and run to use as little energy as possible.

The comfort of your building will be enhanced by regular maintenance: a wet home is a cold home.

Improve control: The control systems on building services should be efficient as possible and easy to understand and use, but many are not as manageable and responsive as they could be. This can lead to increased energy use and carbon emissions.

Use lower-carbon energy supplies: Switch to energy sources with lower emissions such as on- or off-site renewable energy (solar, wind or water power), or select lower-carbon supplies such as gas or wood instead of coal.

Avoid complication: Solutions should be kept as simple as possible and done well.

Review outcomes: When you review how the measures you've taken are performing, check their performance as part of the overall system. Watch out for unintended consequences such as overheating, moisture problems and poor indoor air quality.

Measures used in combination can have a powerful multiplier effect. For example, combining a 50% reduction in the demand for energy and the amount of carbon in the energy supply with a 100% increase in equipment-efficiency can cut carbon emissions by almost 90%.

102–104 High Street, Lowestoft, Suffolk. DP232199

Historic environment and sustainability

We can learn from our past to protect our future

England's diverse cultural heritage is under constant threat from extreme weather events, development pressures and changes to land-use and agricultural practices. However, heritage can support the sustainable management of change, particularly by allowing learning from past practices. This applies as much to our day-to-day behaviour in our homes as to long-term environmental planning.

We can learn from our past to protect our future. Archaeological sites are a valuable record of human interaction with culture, climate and landscape change that reveal different local and regional dynamics.

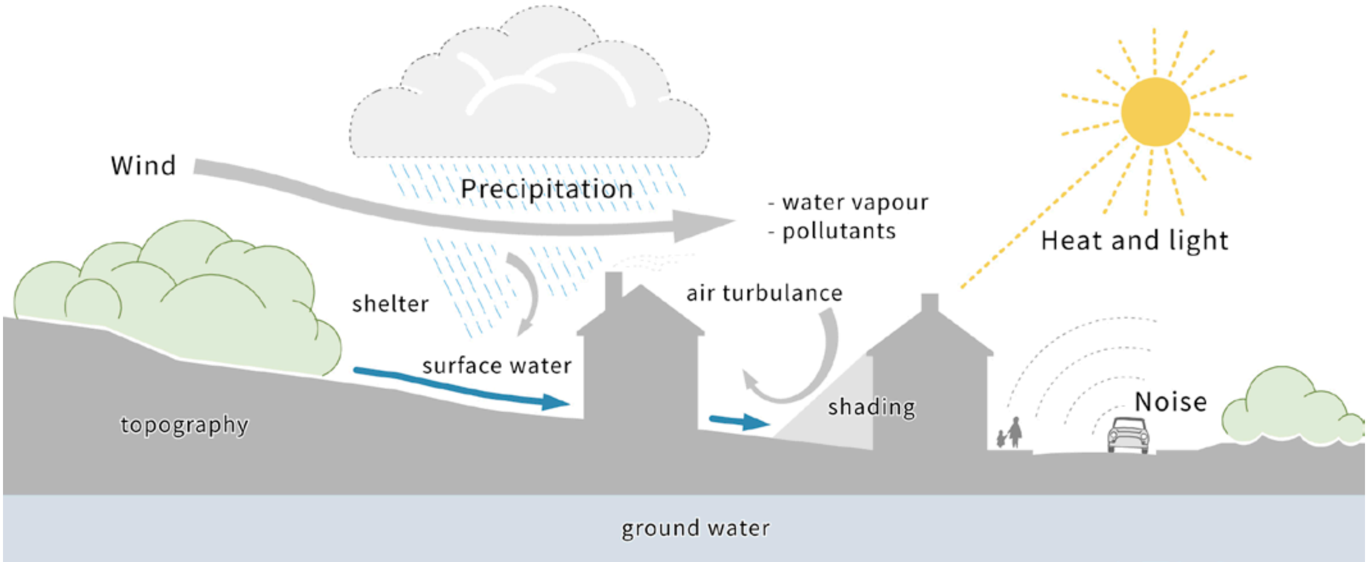
- Understanding how different generations structured their societies and responded to historic changes in the climate can help us project how people may react in the future and avoid maladaptation to climate change.
- However, many archaeological sites are at critical risk from rising sea levels and invasive vegetation growth and could be irrevocably lost – alongside the knowledge they contain – during the next century (Hambrecht *et al* 2018, Heathcote *et al* 2017, Fluck and Wiggins 2017).

The past can inform modern innovative refurbishments. There is interest in traditional building techniques, for example the use of lime mortars as an alternative to cement. The merits of lime mortar methods, which are thousands of years old, are witnessed by the number of lime-built buildings that are still in use.

- Compared to less permeable mortars, lime mortar maximises the life of traditional porous stone, brick and earthen materials used to construct walls, extending the interval between repair or replacement.
- Keeping products and materials in use is a key principle of the circular economy. Another major benefit of lime is that, unlike less permeable cement mortars, it allows for the salvage and re-use of building materials after a building has been deconstructed.
- Research into novel waste streams of lime, based upon traditional practices – such as producing lime mortar from seashells – highlights the importance of utilising knowledge from our heritage within a modern setting (Moropoulou *et al* 2005).

Traditional buildings tend to not overheat. During the past two decades the UK's policy focus has been on increasing the efficiency of the housing stock, both by building heat-retentive new homes and through the upgrading of existing buildings.

The City of London skyline from Tower Bridge. DP183177



Heat loss and retention within a domestic home.

- The average heat loss of the UKs housing stock has reduced by 23% since 1970. However, improved heat retention increases the risk of summer time overheating, impacting upon thermal comfort. As our weather is likely to reach new extremes, the sympathetic refurbishment of buildings will be required to ensure that their comfort isn't reduced (Lomas and Porritt 2017).

- In a recent study reviewing summertime overheating and its influence on discomfort (the duration of time above a comfortable limit), full-fill cavity insulated buildings were more likely to experience prolonged levels of uncomfortable heat. Buildings with no insulation experienced shorter periods of discomfort than insulated buildings; in bedrooms this was five times less with no insulation and in living rooms this was 2.5 times less (Gupta 2019).

Heritage empowers communities, strengthening climate and sustainability policy. Heritage can help alter people's behaviour and consumption of natural resources at a global level.

- As argued by the United Nations, utilising a human-centred, ecosystems-based approach can result in an inclusive solution for addressing the cultural, heritage and social dimensions associated with climate change (UN 2019).

- Educating communities in the climate benefits of heritage – incorporating them within proposed solutions – will help reduce the global consumption of raw materials, which has tripled to 92 billion tonnes in just half a century with a large proportion of this attributed to the construction sector (HLPF 2019).

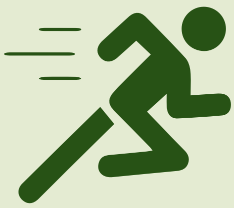
The historic environment can support local economies. In addition to the cultural, historical and landscape values of England's ancient woodlands, the forest environment is also important in supporting rural economies.

- In the spring of 2019 there were 570 businesses operating in England's forests – this includes recreational organisations that support the public's engagement with the historic environment. Furthermore, the total value of the net natural capital assets of England's forests for 2018 was reported at about £26.1 billion (Forestry England 2019).

As an executive agency of Forestry Commission England, the management and annual reporting of the nation's forests in England is conducted by Forest Enterprise England. Their work presenting the social benefits of forests – in terms of natural capital – is in continual development, set against the baseline of 2013/14.

In 2018/19 39% of England's population live within a 15 minute drive of an accessible English woodland site, with 85% within a 30 minute drive. The Active Forests programme – promoting an active and enriching lifestyle – is supported in 18 sites across England, with more than one million participants in 2018/19 with cycling, running and walking the most popular activities.

Cycling
318,164



Running
174,017

Walking
298,572

3.8 billion tonnes CO_2e

contained in the forest environment;

23% in timber, the rest in soil and leaf litter

England's trees removed

8.3 million tonnes

of CO_2e from the atmosphere in

2017

The preservation of the historic environment can help mitigate climate change, particularly through the storage of carbon in landscapes.

- In 2015, there were an estimated 3.8 billion tCO_2e contained within the UK's forest environment, with 23% of this stored in timber and the rest in the residing soil and leaf litter.
- Preserving England's forests and woodlands – which, as a key component of the historic environment, are often located in protection areas and have significant heritage value – helps to mitigate climate change; they removed about 8.3 million tCO_2 e from the atmosphere in 2017 alone (Forest Research 2020, Forestry Commission 2019).

Reculver Towers, Herne Bay, Canterbury, Kent. DP114291

Cultural heritage and the future climate

The conservation of heritage can help mitigate climate change

Climate change represents one of the most significant and fastest growing threats to the historic environment and our society. Although the extent of the impact on England's landscapes and communities is uncertain, developing cultural resilience and preserving knowledge of previous climatic changes could help alleviate the significant risks associated with climate change.

Re-establishing historic landscapes can benefit the mitigation of climate change, including the restoration of coastal salt marshes, hedgerows and woodlands.

- England currently has around 32,000 hectares of salt marsh, which is a diverse ecosystem that offers natural protection against waves and storm surges; restoring coastal salt marsh – and grazing marsh, which is humanly created – is a cost effective defence method that could capture an additional 300,000 tCO_2e per year by 2050.
- Salt marshes offer a wealth of additional benefits, such as supporting biodiversity – through their resident rare species – which in turn supports recreational activities like walking and bird watching (Green Alliance, Natural England, 2020a).

Unmitigated climate change will impact heritage. England has already started to experience the negative impacts associated with a changing climate – we are enduring increasingly wet winters, hotter and drier summers and more frequent severe flooding events. There are also risks of rising sea levels and, importantly, human responses to climate change which are more harmful than helpful.

- The Committee on Climate Change (CCC) identified flooding as the greatest risk of a changing climate, with an estimated four million English homes and £150 billion of assets located in vulnerable areas.
- Although strategies have been previously put in place to support the resilience of the natural environment, new policies that incorporate heritage will be required if irreversible damage to England's natural capital is to be avoided (CCC 2017, CCC 2018b).

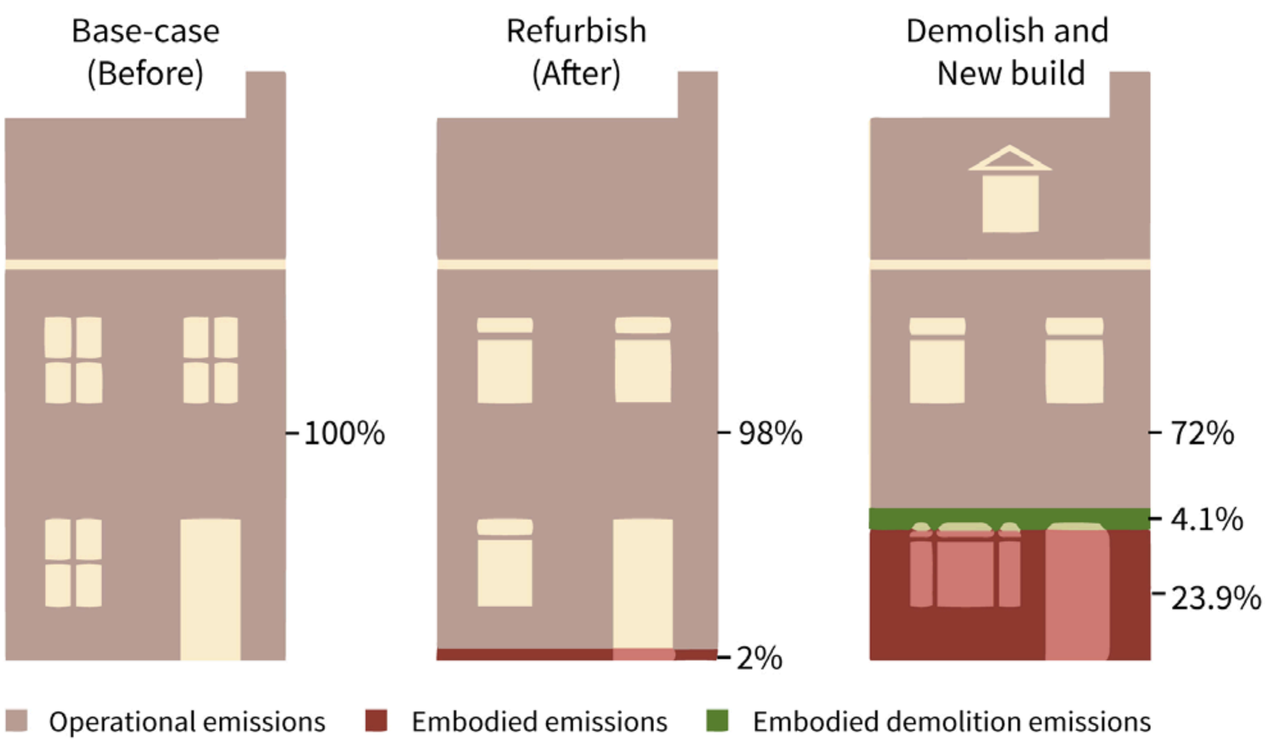
Asset Type	Total Number within 1km (% of NHLE[1])	Number within Flood Zone 3	Number on HAR[2] Register (within 1km)
Scheduled Monuments	1,734 (9%)	545	266
Registered Parks & Gardens	204 (12%)	110	12
Registered Battlefields	5 (11%)	4	1
Listed Buildings	45,516 (12%)	9,984	313

[1] National Heritage List for England, [2] Heritage at Risk

The built and natural environments located in England's coastal areas are at risk from climate change, including important and valuable cultural assets.

England has 8,900 properties that are at risk from coastal erosion and more than half a million properties at increased risk of annual coastal flooding (CCC 2018b). Research produced by Historic England estimates that about 3,700 listed buildings are at a higher level of risk of coastal flooding while 2,228 are at an increased risk from coastal erosion over the long term (Historic England, 2019c).

- Of the scheduled monuments that feature on the National Heritage List for England (NHLE), Historic England analysis shows that nearly 400 are at an increased risk from coastal flooding and 411 that are at a long-term increased risk from coastal erosion. Some of England's registered battlefields and parks and gardens are also at risk from coastal flooding and erosion; there are 63 registered parks and gardens at an increased risk of coastal flooding, and 60 at increased risk from coastal erosion in addition to the two registered battlefields at risk of flooding, one of which is also at risk from erosion (Historic England, 2019c).



Victorian terraced house case study. Source: Carrig 2019.

- Rising sea levels and more frequent extreme weather events will see more heritage assets and environmentally protected areas at risk, negatively impacting upon tourism and the provision of cultural services that have an approximate value of £17 billion in the UK (CCC 2018b).

Our approach to existing buildings will be integral to meeting carbon targets. The UK government committed to a tougher long-term GHG emissions target of achieving net zero GHG emissions by 2050.

- Approximately 80% of the building stock that will be in use in 2050 has already been built, increasing the importance of decarbonising the existing built environment which currently attributes around 40% of the UK's total carbon footprint (GOV 2019, UKGBC 2019).

- Research indicates that even **after 50 years of use, the embodied carbon of a new build house accounts for as much as 28% of the total carbon** attributable to the building. It can therefore take several decades for the operational carbon savings of new buildings to produce a net benefit when compared to the refurbishment of an existing building (EHA 2008, Historic England 2019d).

Cultural heritage within the circular economy. The principle of reusing buildings materials, such as bricks, in examples of vernacular architecture continues to be inherent to conservation. Bricks in good condition are robust and can have a lifespan of several hundred years, as evidenced by the many traditionally built properties that are still standing and in use today.

- Manufacturing bricks is a carbon-intensive process, resulting in the emission of 211-242 kg CO_2e per tonne of bricks produced. Although new bricks will often contain recycled materials, these only account for about 9% of the total, with the majority sourced from virgin clay resources (BEIS, BDA 2018).

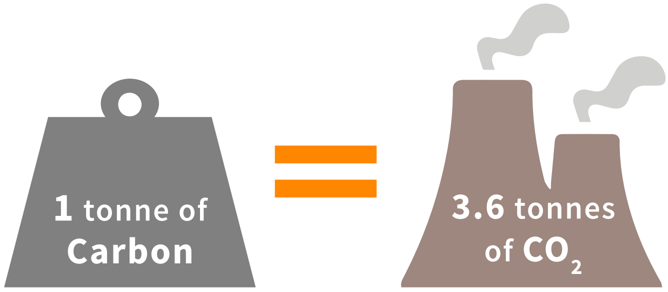
- Demolishing buildings that are still structurally sound – crushing the bricks, stone and mortar for use as aggregate – creates unnecessary waste, particularly when alternative processes, such as deconstruction, will allow for the recovered masonry to be reused, reducing the emissions required to replace them (BEIS, BDA 2018).

Research conducted on behalf of Historic England considered the carbon impacts of alternative measures on an end-of-terrace Victorian house; this included doing nothing, refurbishment and its complete demolition with a new build replacement. The research calculated that by 2050 the life cycle carbon emissions of the three measures would be 89, 36 and 42 tCO_2e, respectively. This highlights that sympathetic refurbishment offers the greatest reduction of carbon emissions, making it the most appropriate pathway for meeting the UK Government's net zero target (Historic England 2019d).

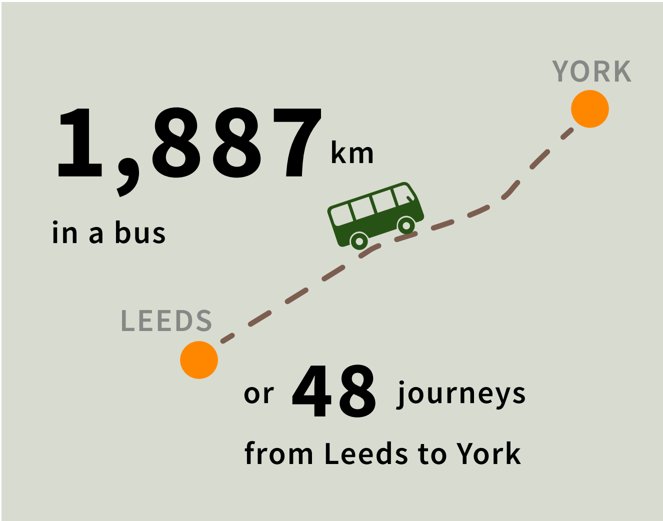
Replacing old buildings with new creates waste and uses additional resources. Construction and demolition waste is one of the heaviest and most voluminous waste streams generated in Europe.

- Current national statistics indicate that about 90% of the demolition waste produced in England is recovered, processed further and reused elsewhere; for example concrete is crushed and used as a gravel base layer for new roads. This extends the perceived useful life of the material – however, it also promotes the use of additional carbon-intense resources which is in conflict with the principles of a circular economy.

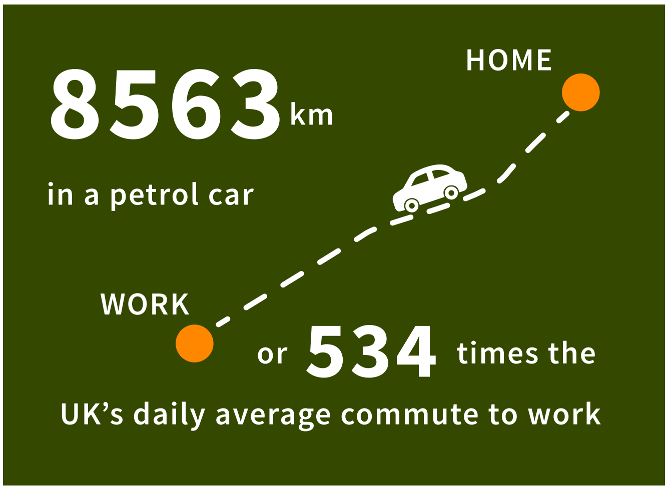
- A recent report commissioned by Historic England indicated that the demolition of an existing building to make way for a new build will account for 7% of its total carbon emissions (DEFRA 2019, Historic England, 2020e).



Which equates to:



Or



Refurbishment of traditional buildings requires critical thinking. Even with the best of intentions, aesthetically- and economically-driven decisions about refurbishment can have significant negative environmental impacts.

- As a primary building material, concrete production is a carbon intensive process with its processing, manufacture and transportation accounting for embodied emissions of 132 kgCO_2e for every tonne of concrete produced.

- Laying 56m^2 of concrete flooring – the footprint of a modest house extension – would account for about one tonne of embodied carbon. Considering the UK government's commitment to achieve net zero emissions, it would take an entire year's growth from a 10,000m^2 stand of mature softwood trees to capture and store the equivalent carbon (BEIS, Forestry Commission 2016).

Embodied carbon of insulation materials. The life cycle analysis of buildings tends to consider only the operational carbon savings, with the main focus on improved thermal efficiency. There are a number of different materials that can be used to insulate buildings, however their embodied carbon contents differ greatly once their production, transportation and end of life disposal are taken into account.

This information can be found in Environmental Product Declarations (EPDs) which are intended as a voluntary mechanism for communicating the environmental impact of materials in a transparent and comparable manner (BRE). For example:

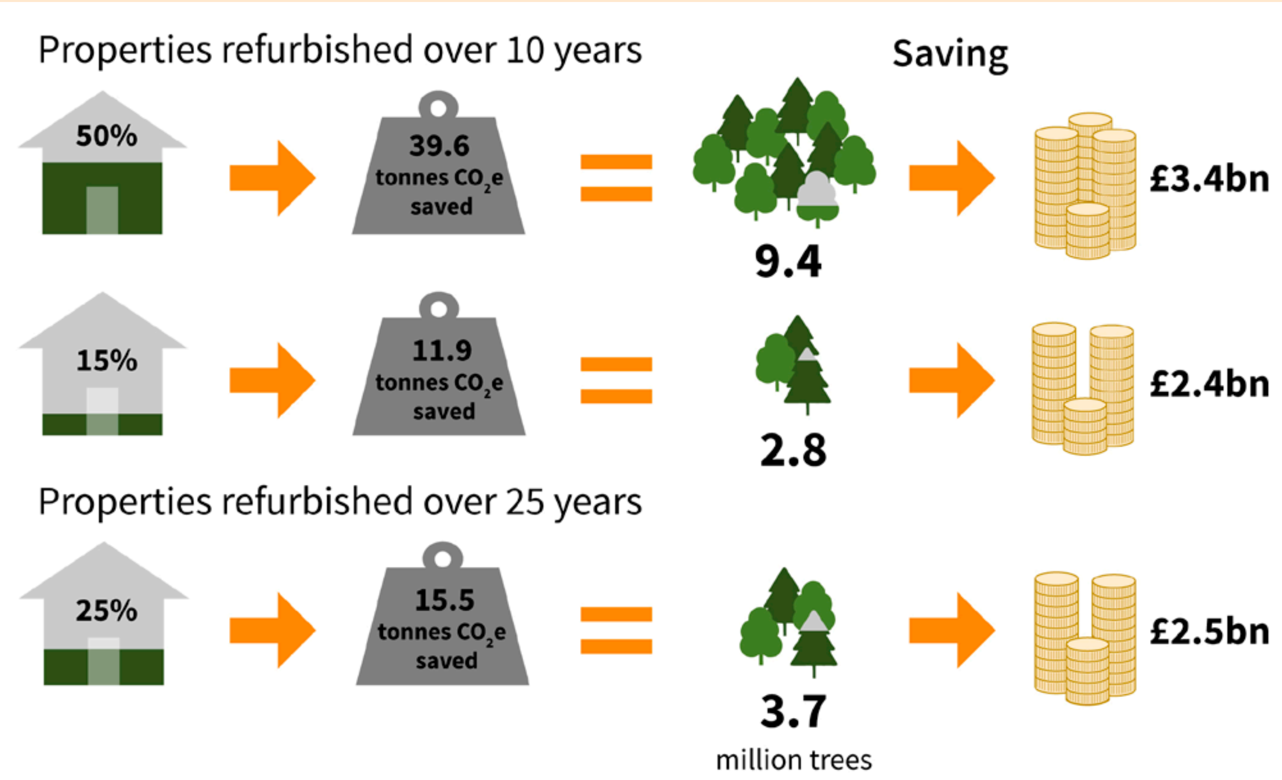
- Extruded Polystyrene (XPS) insulation is a product of the petrochemical industry that generates emissions during the production phase. Approximately 10 kg CO_2e/m^3 of XPS insulation is incurred during its production. XPS is also difficult to recycle, meaning that any wastage – or when it has reached the end of its life – will end in landfill.

- By comparison, the production of wood insulation results in negative emissions (about 173 kg CO_2e/m^3) because of the carbon that was stored in the wood before it was processed. Wood insulation material is also easier to recycle and recover (EXIBA, STEICO).

Inaction comes with a social cost. Historic England conducted analysis on the social costs of carbon, providing a value of the global damage caused by additional emissions of carbon dioxide. This compared the assumed costs of refurbishment and demolition with new build replacements for England's domestic buildings – that predate 1919 – against a baseline of doing nothing.

- Leaving the buildings in their current state would result in the social costs of accrued carbon exceeding £2.8 billion by 2050, while their complete refurbishment would save more than £2 billion.
- The research also highlighted the importance of acting sooner rather than later; delaying measures to improve the existing building stock can increase the accrual of the social costs of carbon significantly (Historic England, 2020f).

Social costs are the value of the worldwide damage caused by the emission of an additional tonne of carbon dioxide



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