Cotswold District Local Plan 2018 – 2031 Update

Town and Country Planning (Local Planning) Regulations 2012

Regulation 18 "Issues and Options" consultation/participation

Evidence Paper: Responding to the Climate Crisis

1. Context

1.1 This discussion paper focuses on district-wide responses to the climate crisis. The occasional use of technical terminology is unavoidable, and a glossary is provided.

Mitigation

1.2 The principal focus is on **climate change mitigation** – that is, measures that contribute to slowing, peaking and then reversing the emission of 'greenhouse gases' to the atmosphere, to minimise further climate destabilisation. Mitigation measures can be divided into:

- Reducing or ceasing the emission of greenhouse gases – that is, principally, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) - from activities in the district, including activity such as consuming mains electricity where the source of CO_2 emissions lies outside the district;
- Increasing the rate of removal of CO_2 from the atmosphere – that is, sequestering atmospheric carbon into carbon 'sinks' usually in the form of living biomass and soil carbon.

Adaptation

1.3 The secondary focus is on **climate change impacts and adaptation** – that is, understanding the present and likely future impacts on the district caused by unavoidable climate destabilisation – for example heat, drought, flooding, and building heave/subsidence – and planning the measures that need to be taken to adapt to, and mitigate the risks of, those impacts.

Context and terminology

1.4 It is taken as a given in this paper that all individuals, organisations and areas share a responsibility to reduce greenhouse gas emissions to net zero, and then reverse them, in the fastest possible timeframe.

1.5 **A note on terminology:** For many years, **'global warming'** has been the default term in the media and in public discourse to describe the rapid and systemic changes to the earth's oceans, land and atmosphere, driven in the main by the combustion of fossil fuels. It may be argued that the terminology 'global warming' underplays and fails to communicate the reality and urgency of what might be more accurately described along the lines **'anthropogenic, systemic, irreversible, global, rapid, catastrophic climate breakdown and biosphere degradation'**. Given the inability of the term 'global warming' to capture the

reality of climate destabilisation, in this paper we favour the shortened terminology of **'climate crisis'** or preferably **'climate and ecological crises'**.

2. Objectives

2.1 Objective 6 of the adopted Local Plan says:

> *Reduce the environmental impact of development and vulnerability to the impacts of climate change by:*
>
> *a. Maximising water and energy efficiency, promoting the use of renewable energy sources and sustainable construction methods, and reducing pollution and waste.*
>
> *b. Supporting the principle of waste minimisation. c. Locating development away from areas identified as being at high risk from any form of flooding or from areas where development would increase flood risk to others.*

2.2 Whilst policies such as INF10 (Renewable and Low Carbon Energy Development), INF7 (Green Infrastructure), INF3 (Sustainable Transport) and EN14 (Managing Flood Risk) all speak to a small part of the topic, there is no overarching strategic policy.

2.3 Objectives for the updated LP should be revised to:

- comply with the requirements of the NPPF (paragraphs 148 – 169) in respect of addressing the challenge of climate change, flooding and coastal change;
- conform with the guidance set out in the NPPG on climate change to ensure the update to the LP is sound;
- reflect the objectives and intent of the Council's existing declarations, policies and plans regarding the climate and ecological emergencies;
- conform with the requirements of the Climate Change Act 2008[1];
- (in setting policy), to draw on and be consistent with official research, guidance and recommendations given to Government by the Climate Change Committee[2];
- create a policy foundation for district-wide mitigation and adaptation actions to be implemented at a scale and pace that is;

  a) commensurate with the gravity of the climate and ecological crises, and consistent with the goal of limiting global heating to not more than 2.0°C, and striving for not more than 1.5°C, above pre-industrial levels, as embodied in the Paris Agreement, and

  b) consistent with the 6th carbon budget, adopted by government in April 2021[3] .

[1] Principally, by interpreting in a logical and defensible way how the requirements of the Act relate to the District, showing how the District may contribute proportionally to the national achievement of net zero carbon emissions by 2050 at the latest

[2] The independent advisory body established under the Climate Change Act 2008

[3] Principally, for Cotswold District to contribute fully to following the recommended pathway of a 78% reduction in UK territorial emissions between 1990 and 2035

3. Background evidence and Sustainability Appraisal – setting out the issues

The National Planning Policy Framework (NPPF)

3.1 The NPPF addresses sustainable development and meeting the challenge of climate change, flooding and coastal change.

3.2 **Paragraph 7** states:

> "The purpose of the planning system is to contribute to the achievement of sustainable development … summarised as meeting the needs of the present without compromising the ability of future generations to meet their own needs."

3.3 **Paragraph 148** states:

> "The planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure."

3.4 **Paragraphs 149-154** relate to planning for climate change and require:

- Local Plans to take a proactive approach to mitigating and adapting to climate change (para 149);
- New developments to avoid vulnerability to climate impacts and contribute to greenhouse gas emissions reduction (para 150);
- Local Plans to increase the use and supply of renewable and low carbon energy through a) provision of a positive strategy for energy from these sources (see separate district-wide renewable energy strategy), b) considering identifying suitable areas; and c) identify opportunities for renewable energy supply to developments (para 151);
- Authorities to support community led initiatives for renewable and low carbon energy (para 152);
- to draw its energy supply from decentralised, renewable or low carbon energy supply systems and for colocating potential heat customers and suppliers

3.5 **Paragraphs 155-165** address planning and flood risk, and paragraphs 166-169 address coastal change.

3.6 In addition to the statutory requirement to take the NPPF into account in the preparation of Local Plans, there is a statutory duty on local planning authorities to include policies in their Local Plan designed to tackle climate change and its impacts. The National Planning Policy

Framework emphasises that responding to climate change is central to the economic, social and environmental dimensions of sustainable development.

3.7 **Heat stress.** The increased probability of flood events is one of the most obvious impacts of climate destabilisation. Less well appreciated in the UK, because they have not yet become normalised, are extreme and sustained heat events (heat waves) and their associated health impacts, and droughts and their associated impacts of crop and tree damage, increased fire risk, and damage to buildings caused by ground shrinkage and heave. The Council's Climate Emergency Strategy 2020-2030[4] section 4.4 identifies some of these heat risks. In addition we can refer to the latest Climate Change Committee Independent Assessment of UK Climate Risk[5].

National Planning Policy Guidance on Climate Change

3.8 The National Planning Policy Guidance (NPPG) on Climate Change[6] notes that:

> "Addressing climate change is one of the core land use planning principles which the National Planning Policy Framework expects to underpin both plan-making and decision-taking. To be found sound, Local Plans will need to reflect this principle and enable the delivery of sustainable development in accordance with the policies in the National Planning Policy Framework. These include the requirements for local authorities to adopt proactive strategies to mitigate and adapt to climate change in line with the provisions and objectives of the Climate Change Act 2008, and co-operate to deliver strategic priorities which include climate change."

The Climate Change Act 2008

3.9 The Act[7] sets a legally binding target for Government to deliver net zero carbon terrestrial (production[8]) emissions in the UK by 2050 regulated through periodic carbon budgets, setting out the maximum amount of terrestrial carbon dioxide equivalent that may be emitted in a given time period. Carbon budgets are adopted by government and become legally binding.

3.10 The **Climate Change Committee's most recent (sixth) carbon budget report[9]** covering the period 2033-2037 is the most demanding yet, showing that the UK needs to reduce emissions by 78% by the middle of the period, measured from the baseline year, 1990. Figure 1 shows the sixth carbon budget alongside the preceding five, and the emissions reduction achieved to date:

[4] https://tinyurl.com/ea4a76vt
[5] https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/
[6] https://www.gov.uk/guidance/climate-change
[7] https://www.legislation.gov.uk/ukpga/2008/27/contents
[8] that is, direct CO2e emissions from activities in the UK, which excludes emissions from the production of goods and services overseas but consumed in the UK
[9] https://www.theccc.org.uk/publication/sixth-carbon-budget/

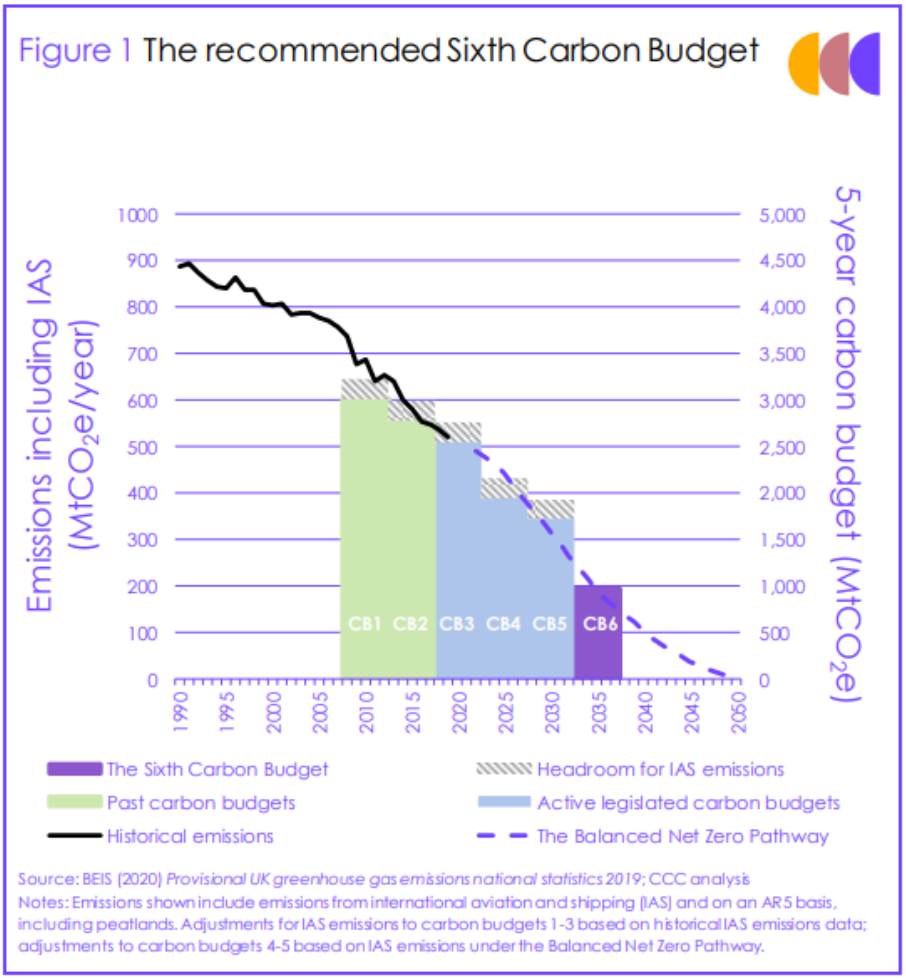


Figure 1 CCC's sixth carbon budget

3.11 The CCC's **2021 Progress Report to Parliament**[10] looks at both mitigation and adaptation.

3.12 On **mitigation** the Report shows that Covid lockdown measures led to sharp falls in emissions in aviation and surface transport during 2020, but despite historic promises on climate action, the Government has been much too slow and inconsistent in turning these into actionable strategies and policies. The report calls for a strong Net Zero Strategy comprising a Net Zero Test for all Government policy; an ambitious Heat and Buildings Strategy[11]; new plans on surface transport, aviation, hydrogen, biomass and food, and strengthened plans for the power sector, industrial decarbonisation, the North Sea, peat and energy from waste.

3.13 On **adaptation**, among the report's 50 recommendations the following are probably most relevant to Cotswold District: Plans to address overheating risk in homes through Building Regulations; making Adaptation Reporting mandatory for all infrastructure sectors; building a

[10] https://www.theccc.org.uk/publication/2021-progress-report-to-parliament/

[11] Now published, including elimination of new fossil-fuel boilers from 2035; £3.9bn funding to support low-emissions homes (incl grants for replacement of gas boilers); clear support for electric heat pumps, subject to "expected" cost declines. See: https://www.google.com/url?q=https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1026507/heat-buildings-strategy.pdf&sa=D&source=docs&ust=1637187135221000&usg=AOvVaw0tGxEsJFb9HbMYTO07RXn6

strong emergency resilience capability for the UK against climate shocks, learning from the COVID-19 response; implementing a public engagement programme on climate change adaptation, and rising to the big cross-cutting challenges of public engagement, fair funding and local delivery.

Independent assessment of UK climate risk

3.14 Alongside its duties of progress reporting and carbon budget setting, the Climate Change Committee coordinates a periodic Independent Assessment of UK Climate Risk.

3.15 The most recent edition of the independent assessment (June 2021)[12] identifies eight priority risk areas needing the most urgent action in the next two years, all of which are relevant to Cotswold District:

- Risks to the viability and diversity of terrestrial and freshwater habitats and species;
- risks to soil health from increased flooding and drought;
- risks to natural carbon stores and sequestration;
- risks to crops, livestock and commercial trees;
- risks to supply of food, goods and vital services due to climate-related collapse of supply chains and distribution networks;
- risks to people and the economy from climate-related failure of the power system;
- risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings;
- multiple risks to the UK from systemic or cascading climate change impacts overseas.

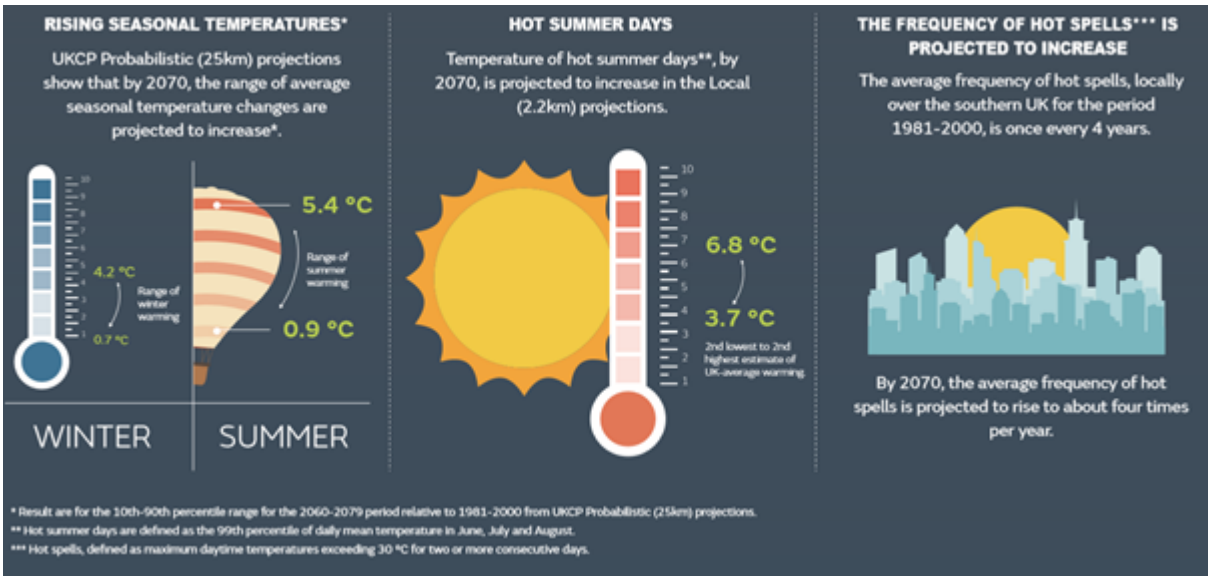
UK Climate Projections

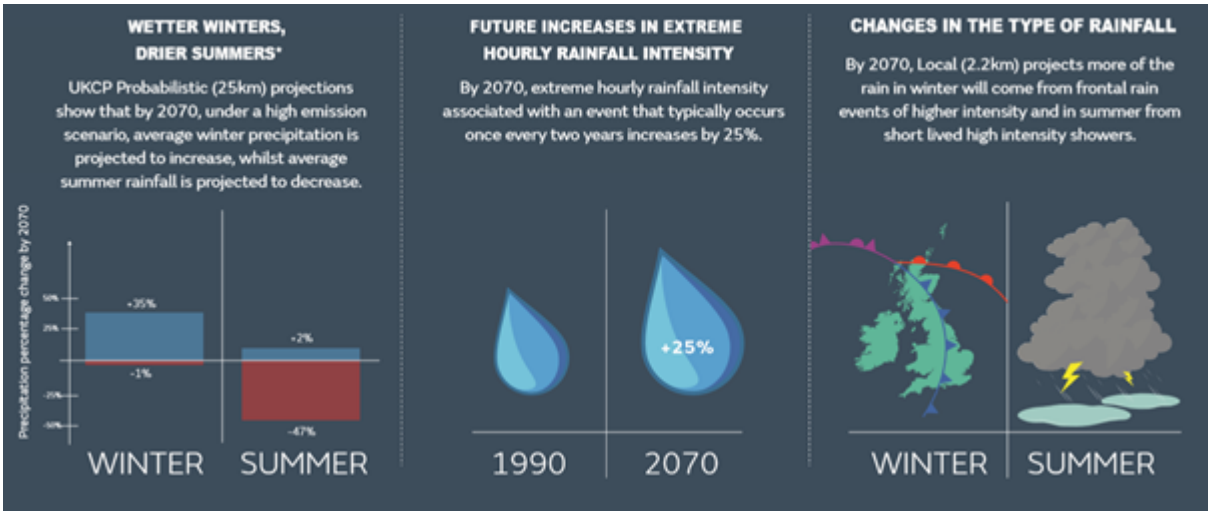
3.16 UK Climate Projections (UKCP) is a continuous programme of work led by the Met Office Hadley Centre, which aims to give some foresight of the likely effects of climate destabilisation on the UK's weather. The most recent published update is dated July 2021, and reports on some refinements to the extensive modelling that has already been published in 2018. The refinements do not alter the basic conclusions reported in 2018 which are:

- By 2070 temperatures of every season will be higher, hot summer days will be more common and the frequency of hot spells will rise from one every four years, to four every year.
- By 2070 winters will be wetter and summers drier. Extreme rainfall events will increase by 25%, and rainfall will be higher intensity, carrying a higher risk of localised pluvial and fluvial flooding.

3.17 These findings are summarised for temperature and rainfall in the following diagrams:

[12] https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/





■ Potential impacts on the District

Flooding

3.18 The UKCP modelling is designed to inform policymakers of the probability of events occurring, and the results are averaged over different geographic scales. For example the modelling suggests that, by 2070, extreme hourly rainfall intensity associated with an event with (on average) two-yearly frequency, may increase by around 25%. It is worth reflecting that, following extraordinary rainfall events in 2021, meteorologists are concerned that existing models may not adequately account for non-linear effects. A widely-reported research paper[13] has suggested that extreme high rainfall events from slow-moving storms such as that which affected central Europe in July 2021 may become 14 times more common by the end of the century.

[13] "Quasi-Stationary Intense Rainstorms Spread Across Europe Under Climate Change" see: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GL092361

3.19 To put flood risk into context we can note that the severe flooding event in July 2007 which badly affected parts of Cotswold district saw a highest 48 hour rainfall value of 163mm[14], whereas the July 2021 floods in central Europe saw 48 hour rainfall values as high as 271mm [15].

Heatwaves

3.20 Sustained high temperatures (defined as maximum daytime temperatures exceeding 30°C for two or more consecutive days) lead to ill health and excess deaths among vulnerable people (with associated additional strain on emergency services), and can result in damage to infrastructure (eg softened road surfaces). UKCP modelling suggests:

1) Hot spells, typically defined as maximum daytime temperatures exceeding 30 °C for two or more consecutive days, are largely confined to the south-east UK in the present-day. In the future (by 2070s), under a high emissions scenario, the frequency of hot spells increases. Rising from an average of 0.20 occurrences per year in the present-day to 4.1 per year by 2070.

2) The temperature of hot summer days, by the 2070s, show increases of 3.8 °C to 6.8 °C, under a high emissions scenario, along with an increase in the frequency of hot spells.

3.21 Residents particularly at risk will be the elderly and young, those with pre-existing health conditions, and people living on low incomes. Factors that increase the risk of mortality include a lack of control over building fabric (eg rental accommodation), living with higher crime rates making it harder to ventilate with open ground floor windows, living in houses that are poor at resisting excess heat (poorly insulated, with uncontrollable solar gain, and little natural cooling from trees or water).

Droughts

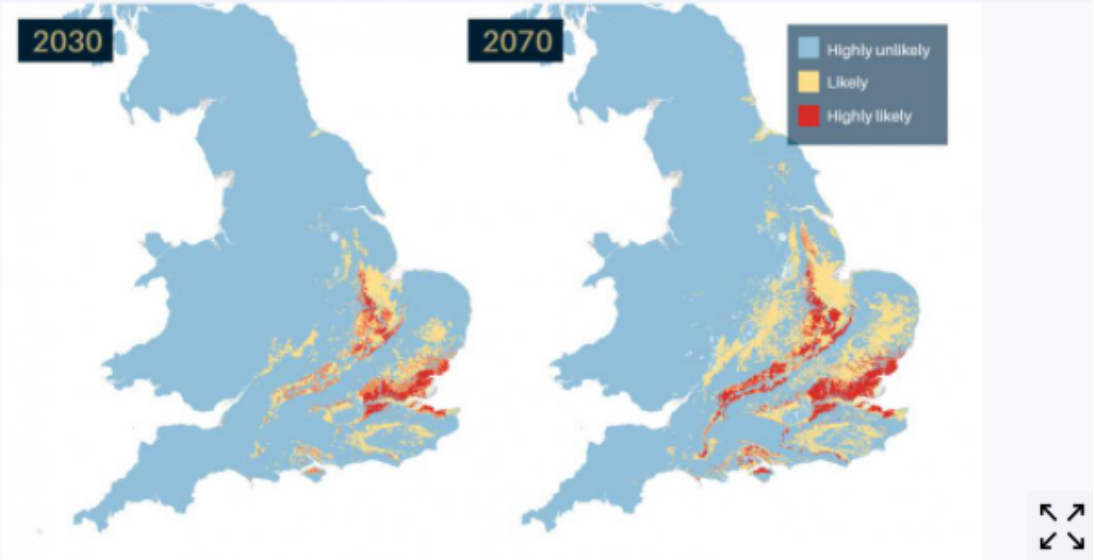
3.22 The UKCP modelling projects a decrease in soil moisture during summers in the future, consistent with the reduction in summer rainfall. Locally this could lead to an exacerbation of the severity of hot spells.

3.23 Aside from the obvious impacts on river levels, crop growth and damage to trees, future drought conditions may impact homes built on shrink-swell (clay rich) soils through subsidence or settlement cracking. Modelling undertaken by the British Geological Survey[16] suggests an increasing number of houses will be subject to this impact, depending on the extent to which global warming is limited by global emissions reduction. The potential country-wide impacts in 2030 and 2070 are illustrated in the map below; the potential 2070 impacts on the area south of Cirencester are shown in the first diagram beneath country map, and the impacts on the area north of Moreton in Marsh in the second diagram beneath the country map. (key: pale orange = unlikely, orange = likely, brown = highly likely)

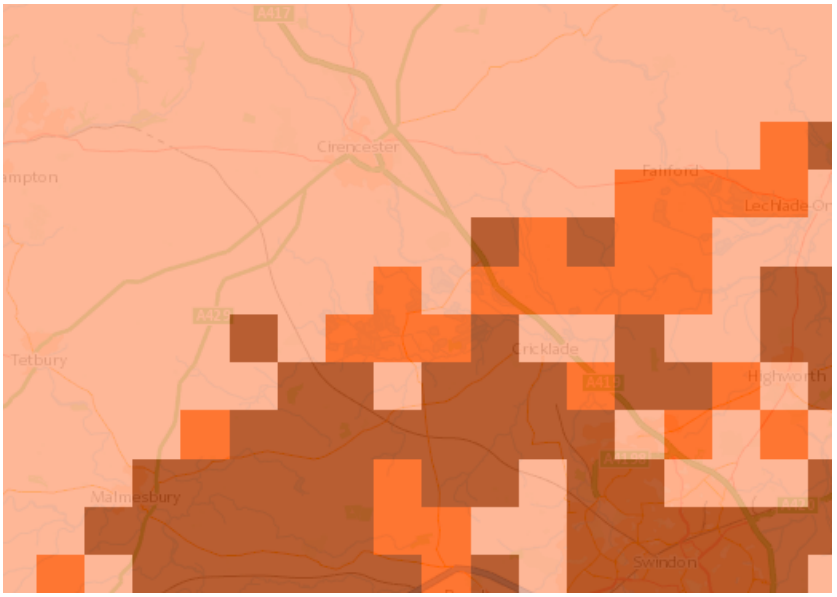
[14] https://www.metlink.org/wp-content/uploads/2020/11/rainfall_20july07.pdf

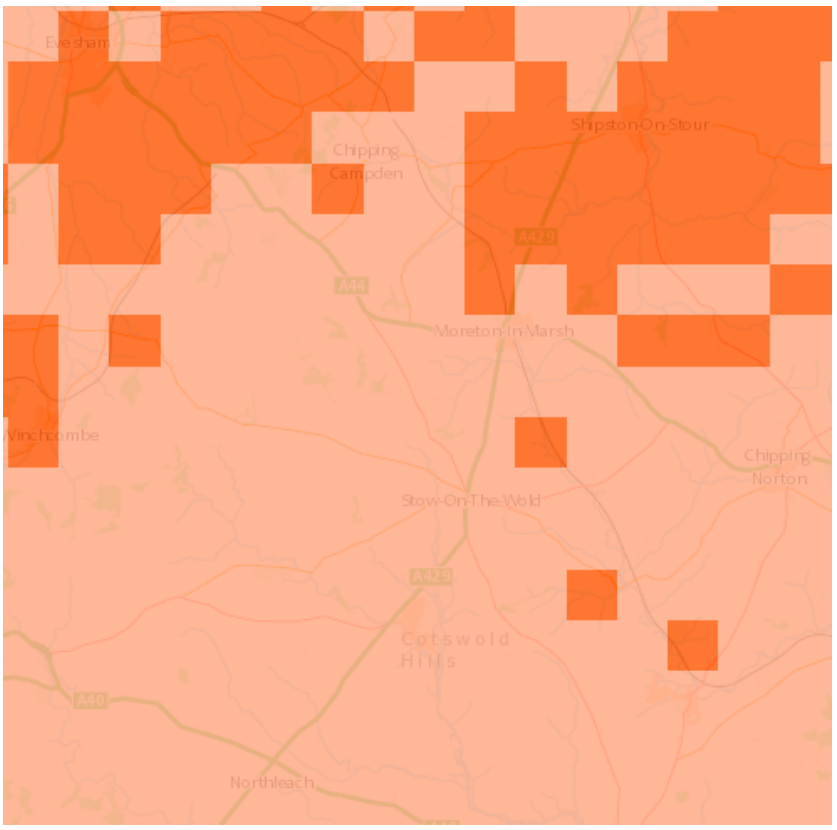
[15] https://yaleclimateconnections.org/2021/07/central-europe-staggers-toward-recovery-from-catastrophic-flooding-more-than-200-killed/

[16] https://www.bgs.ac.uk/news/maps-show-the-real-threat-of-climate-related-subsidence-to-british-homes-and-properties/



GeoClimate UKCP18 projections, identifying areas expected to experience the largest increases in susceptibility to subsidence by 2030 and 2070. Source: BGS © UKRI.



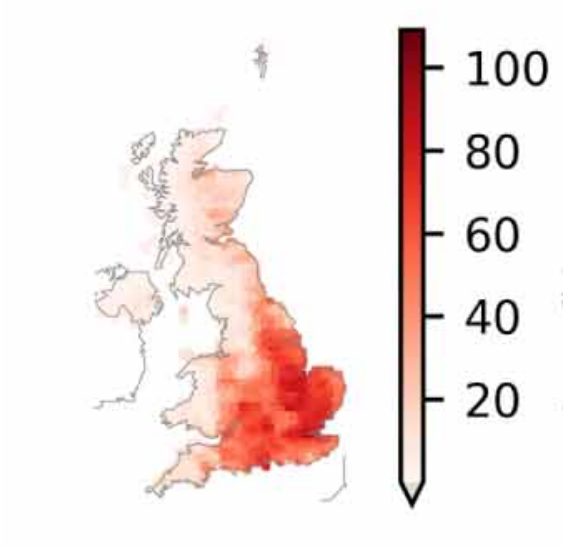


Wildfires

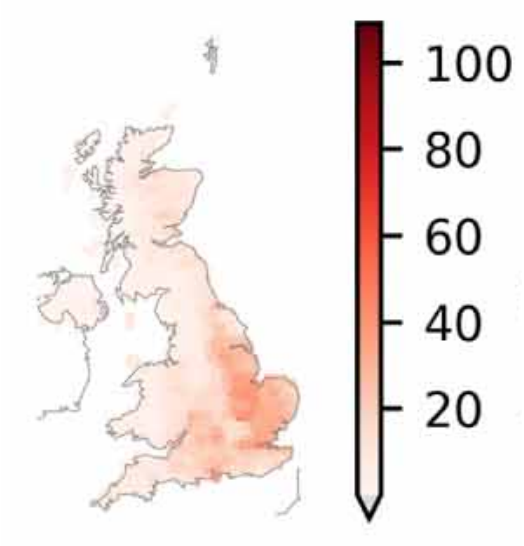
3.24 Research by the University of Reading[17] suggests that climate change will cause the average number of days each year with 'very high' danger of wildfire to increase significantly in all parts of the UK by 2080 (assuming that global greenhouse gas emissions are high).

3.25 The graphic below shows on the left the projected number of days per year in the period 2040-70 that are likely to exceed the MOFSI (Met Office Fire Severity Index) 'very high' warning for wildfires, and on the right the observed frequency in the baseline period 1981-2010.

[17] https://www.reading.ac.uk/news-and-events/releases/PR855435.aspx and https://iopscience.iop.org/article/10.1088/1748-9326/abd9f2



The Council's Climate Emergency Strategy 2020-2030



3.26 The Council's **Climate Emergency Strategy 2020-2030**[18] derives partly from advice given by the Climate Change Committee, is consistent with the Council's Corporate Plan, and identifies some of the District's expected climate impacts (repeated here) and the sources of current and historic emissions.

The Council's Corporate Plan 2020-2024

3.27 **Cotswold District Council's Corporate Plan 2020-2024**[19] sets out the Council's intended response to the climate crisis, and contains objectives that should be accounted for in the revision of the Local Plan, notably:

- To review our local plan to make it 'green to the core'; making climate change and nature recovery strategic priorities for all planning and new developments
- To achieve a reduction in carbon emissions for the district
- To increase renewable energy generation within the district
- To take a leadership role on the ecological emergency and nature recovery in the Cotswolds

4. Current Local Plan policy

4.1 The existing LP does not contain an overarching strategic policy on climate change. Whilst policies such as INF10 (Renewable and Low Carbon Energy Development), INF7 (Green

[18] https://tinyurl.com/ea4a76vt
[19] https://tinyurl.com/4ekbv2ck

Infrastructure), INF3 (Sustainable Transport) and EN14 (Managing Flood Risk) all speak to a small part of the topic, there is no over-arching policy framework.

Potential policy responses: Mitigation

4.2 Potential policy responses to drive climate mitigation may be broken down by the key emissions sources in the district, as reported in the Council's Climate Emergency Strategy (2018 data), see: Figure 1.

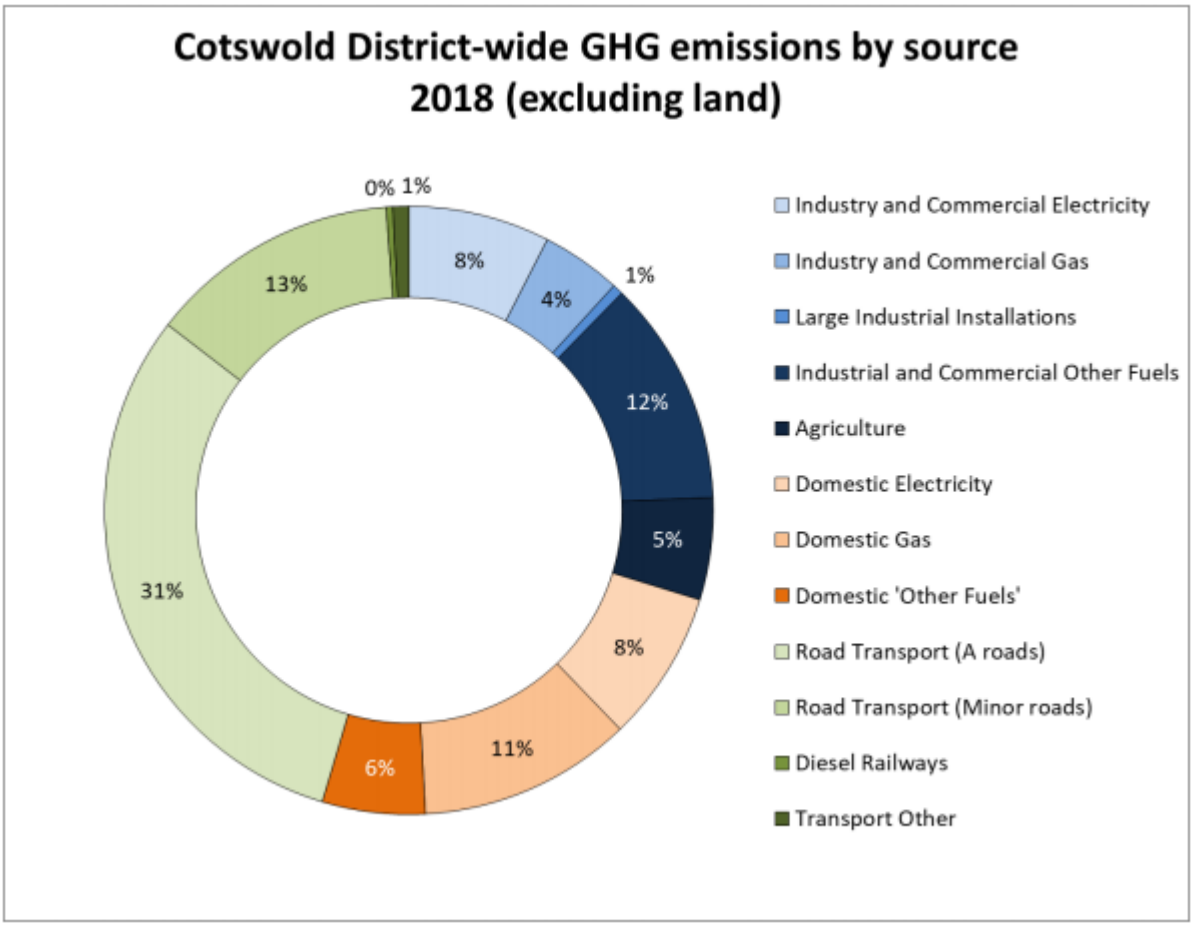


Figure 2 Cotswold district emissions sources, from Climate Emergency Strategy

4.3 Across all sectors of the economy and all residents' activity, if we focus purely on 'territorial' emissions, the bulk of the carbon emissions reduction challenge relates to energy, consumed in the form of electricity, gas, heating oil, and petrol and diesel for road transport.

4.4 Emissions reduction from road transport is dealt with in the sustainable transport discussion paper.

Electricity generation

4.5 At present, most electricity consumed in the district is generated elsewhere in the country, or in the EU and imported through interconnectors. The present average carbon intensity

of electricity consumed in the UK is approximately 0.23kgCO_2e/kWh[20]. This needs to fall to zero by 2050 or sooner. To deliver the sixth carbon budget's 'balanced net zero pathway' recommendation, 87% of electricity generation needs to be low carbon, by 2030.

4.6 Currently electricity consumption in the district is responsible for around 16% of total carbon emissions (most of the rest coming from burning fossil fuels in the form of vehicle fuel and gas and oil for heating buildings), however the electricity challenge is made much greater by the need to increase electricity consumption by shifting road transport and heating for homes and larger buildings away from fossil fuels to electricity. The following diagram from the sixth carbon budget report indicates a growth in electricity demand of more than 100% over the period to 2050:

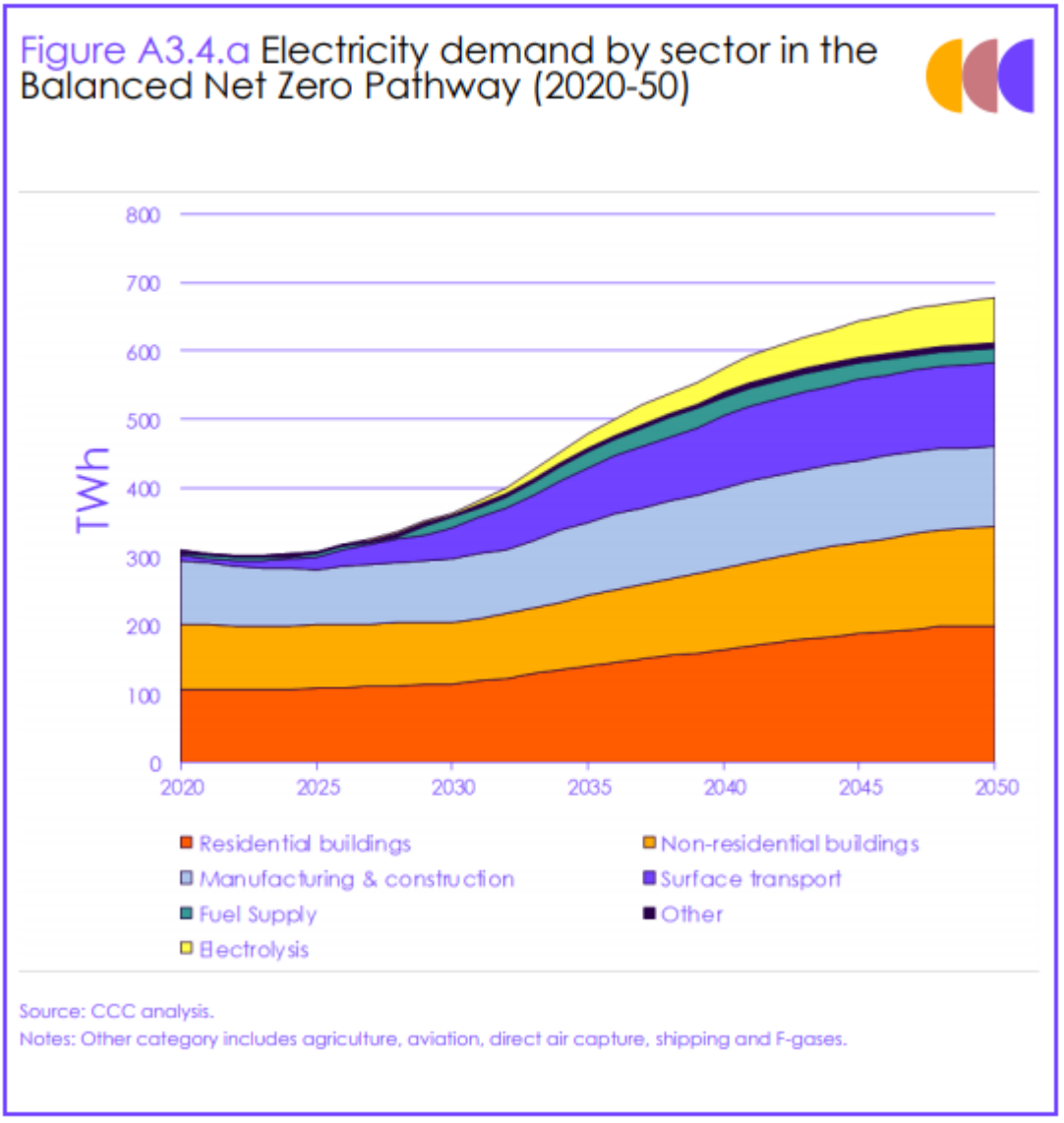


Figure 3 Required increase in electricity demand in balanced net zero pathway (CCC)

[20] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

4.7 The National Grid Future Energy Scenarios report[21] states the need for the UK to add at least 3GW of wind and 1.4GW solar each year between 2020 and 2050 (executive summary, key message 3).

4.8 For Cotswold District, simplistically scaling, this projected growth in electricity demand would raise domestic demand from an average of 5.6MWh/year[22] (significantly higher than the GB average of 2.82MWh/yr, probably due to the number of Cotswold properties off-gas and dependent on electricity for heating) to around 12.7MWh/year, and total consumption for the district (domestic and non-domestic combined) from 426GWh to 965GWh.

4.9 A large amount of the necessary change to the UK's electricity generation will have no impact on Cotswold District – for example the huge increase in offshore wind that the sixth carbon budget's 'balanced pathway' calls for. Nonetheless certain aspects of the electricity transformation will need to be accommodated within the district, notably:

1) Onshore renewables – principally solar and wind
   a. **Wind** – onshore wind has approximately the same joint-lowest levelised cost of energy[23] (LCOE) as large scale solar PV (NOAK[24], commissioning in mid-2020s[25]), and should correspondingly play an important role in decarbonising the UK's energy supply. The sixth carbon budget balanced pathway recognises on-shore wind, but most of the focus is on offshore wind due to the huge scale of offshore potential.
   b. **Solar** – building-integrated (mainly rooftop) solar will remain competitive with grid electricity wherever the bulk of the generation can be consumed 'behind the meter'[26], displacing grid electricity at full cost. Battery storage continues to fall in price and will probably increasingly be incorporated in building-integrated solar. However rooftop installations alone will be insufficient to contribute meaningfully to the demand envisaged by the sixth carbon budget balanced pathway. The major solar contribution will have to come from large scale ground-mounted, grid-connected generation, which has the lowest LCOE of any generation technology, reflecting the huge decrease in capital cost and the learning curve effect over recent years.
   c. **Hydro power** – there are likely to be localised small scale opportunities to exploit hydro power ('run of river' schemes) in Cotswold District, but no substantive resource that needs to be considered here.
   d. **Geothermal** - whilst it is highly unlikely that Cotswold District will yield geothermal electricity generation projects, there may be potential for lower temperature projects suitable for heating rather than electricity generation (see later).

[21] https://www.nationalgrideso.com/document/173821/download
[22] https://www.gov.uk/government/statistical-data-sets/regional-and-local-authority-electricity-consumption-statistics
[23] Levelised cost of energy takes account of the lifetime cost and energy generation of the technology
[24] NOAK = Nth of a Kind, meaning technologies that are mature and being installed at large scale. By contrast, FOAK = First of a Kind, meaning technologies with high costs because they are still experimental.
[25] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/911817/electricity-generation-cost-report-2020.pdf
[26] 'behind the meter' consumption means that electricity generated from solar panels reduces the amount of metered electricity the building consumes from the grid, so directly reduces the electricity bill.

2) **Storage and demand-side flexibility**. A key challenge of running an electricity system dominated by variable renewable generation is smoothing out the imbalances between supply and demand over short and long time periods.

    a. **Electricity storage** - The dominant technology currently employed at both grid and building scale is Lithium-Ion batteries, but other technologies are likely to become viable in the near future, notably including hydrogen production from renewable electricity by electrolysis. Grid scale batteries have a very low land take and are often housed in standard shipping containers, meaning they will generally have a low landscape impact. Hydrogen production likewise has a low land take relative to the amount of energy conversion, and in general will have a low landscape impact, although transport of hydrogen may involve vehicle movements. Other emergent storage technologies, such as Liquid Air Energy Storage (LAES) would involve larger, more visible plant.
    b. **Demand-side flexibility** – In general this will involve electricity consumers changing behaviour and adopting technology enabling certain electricity loads to be controlled or influenced by an external party such as an electricity supplier. In all cases it is unlikely to result in any landscape or visual impact.

Policy objectives

4.10 Several approaches are possible in defining a target for, or acceptable level of, renewable electricity generation:

- Defining a target by scaling the required national growth in onshore renewable generation to the level of the District on the basis of land area, population, GVA or other agreed appropriate metric;
- Defining an acceptable level of generation through an objective assessment of the realistic technical potential for renewable electricity generation in the District, based on technical resource availability suitably scaled back by landscape and other relevant constraints;
- Defining a target starting with the projected future electricity demand in the district – which could be scaled up by an ambition for the district to be a 'net exporter' of energy, or scaled back by a concern that the protected landscape characteristic of much of the district limits the district's capacity for new renewable generation, compared to equivalent rural districts without such sensitive landscape classification.

4.11 Regarding storage, distribution and use of electricity, policy objectives could be:

- To encourage and facilitate the installation of such electricity infrastructure (relating to, for example distribution, storage, demand side management) that is necessary to enable the transformation to a zero carbon electricity sector, accepting a level of local disruption that is commensurate with the urgency and importance of the objective.

4.12 Regarding planning requirements for new developments, policy objectives could be:

- To require all new build developments to incorporate on-site renewable energy generation (principally solar), with annual energy generation equivalent to the building's total annual energy use, consistent with leading edge net-zero carbon buildings guidance suggested by the UK Green Buildings Council[27] and the London Energy Transformation Initiative (LETI)[28].
- An alternative, or variation, to this policy objective could be to revive the 'Allowable Solutions' mechanism that was developed in support of the government's zero carbon homes policy that was abandoned in 2016, in which, where on-site renewable generation is not possible, developers are required to invest in the equivalent amount of renewable generation off-site.

4.13 Regarding planning requirements for stand-alone renewable energy generation, policy objectives could be:

- (Recognising the potential for renewable energy investment to create tangible value to 'host' communities), to particularly support renewable energy generation proposals that are led by, or meet the needs of, local communities. This could mean developments that are conceived and/or promoted within the community within which the development will be undertaken, and provide long term and inclusive socio-economic and/or environmental benefits which are accessible to all members of the community. This could further mean control of renewable energy generation assets through municipal or community ownership.
- (In order to maximise the local economic and carbon value of renewable energy generation), to particularly support proposals that are co-located with energy users, and those that demonstrate innovation.
- (Recognising the need for renewable energy generation to enhance and improve ecological quality), to particularly support proposals that can demonstrate not merely minimum harm, but produce biodiversity net gain, carbon sequestration, or other local ecological benefits.

Potential impacts

4.14 By way of illustration, and using only very approximate numbers, the whole of the District's electricity consumption (projected, 2050) of 965GWh/yr could be supplied (on average, over the year) by:

- 'Conventional' ground mounted solar PV (that is, rows of panels spaced apart permitting plant growth, sheep grazing etc) covering approximately 21km^2, or about 2% of the District's agricultural land area. This land area is illustrated approximately by the orange circle superimposed on the District in the Figure below. Or:
- 'Non-conventional' ground mounting methods for solar PV (in which panels are closer to the ground and installed without gaps, which excludes plant growth or animal

[27] The UKBGC Net Zero Carbon Buildings: A Framework Definition (2019) see: https://ukgbc.s3.eu-west-2.amazonaws.com/wp-content/uploads/2019/04/05150856/Net-Zero-Carbon-Buildings-A-framework-definition.pdf

[28] LETI Climate Emergency Design Guide, see: https://b80d7a04-1c28-45e2-b904-e0715cface93.filesusr.com/ugd/252d09_3b0f2acf2bb24c019f5ed9173fc5d9f4.pdf

grazing) covering about 10km2, or about 1% of the District's agricultural land area. Or:

- Approximately 200 wind turbines each of 2MW installed capacity, with blade tip height of around 100m. Examples are shown below.

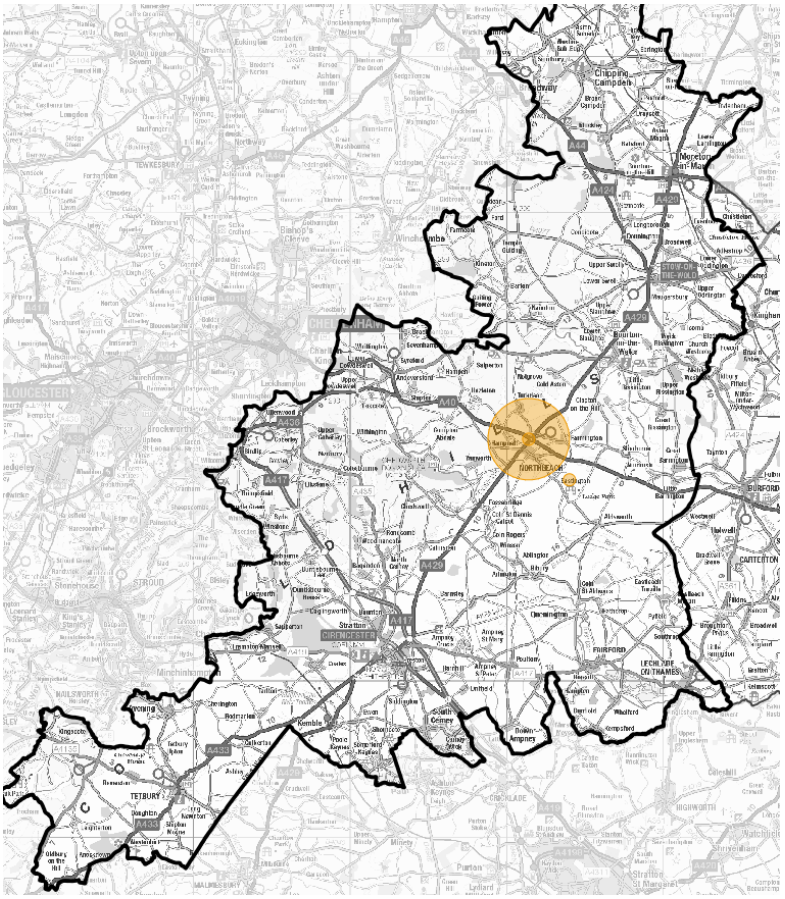


Figure 4 Approximate land area to generate all the District's electricity demand in 2050 from conventional ground-mounted solar PV

Figure 5 2MW wind turbines at Hazlehead windfarm in Yorkshire

Displacing fossil fuel consumption for heating

Issues

4.15 Natural gas (methane) is a fossil fuel and, unlike electricity, its global warming impact will not fall over time. The global warming impact of gas is caused largely by the emission of CO_2 from combustion, but also by so-called fugitive emissions (leaks) of methane arising from exploration, extraction, processing, transmission and incomplete combustion of the gas. Gas is primarily used for home heating (space heating and hot water) and space heating of non-domestic premises.

4.16 Cotswold District's total gas consumption (2019)[29] was 402GWh (domestic) and 149GWh (non-domestic), with median domestic consumption of 12.2MWh (slightly higher than the GB average of 11.94MWh) and median non-domestic consumption of 129MWh. Over 54% of Cotswold District properties are not served by mains gas[30].and as much as 95% in many of the most rural areas.

4.17 Heating oil is the dominant fuel for off-gas properties, and as a fossil fuel its global warming impact will not fall over time. Cotswold District's domestic consumption of heating oil (2018)[31] was about 120GWh (about 30% of the energy consumed in the form of gas – reflecting the large number of off-gas properties), and commercial consumption was about 227GWh (higher than the consumption of gas).

4.18 In order to reach net zero carbon emissions, the District must reduce fossil fuel consumption to zero. The options for achieving this in buildings (for both space heating and water heating) are, broadly:

- Replace gas and oil with direct electric heating (eg immersion heaters and electric boilers) – using electricity in this way is more or less 100% efficient, but presently extremely expensive.
- Replace gas and oil with electric-driven heat pumps (typically air source and ground source) – using electricity in this way is, in a well designed and operated system, around 300% efficient (or better), meaning each kWh of electricity consumed will deliver around 3kWh of heat.
- Substitute natural gas with methane derived from biological sources, such as anaerobic digestion of farm, industrial and domestic wastes.
- Substitute natural gas with an alternative gas such as hydrogen, generated from renewable electricity.
- Substitute heating oil, in principle and to only a very limited extent, with so-called synthetic bio-oils – that is, liquid fuels derived from biological sources such as waste wood. It is very unlikely that this will be a cost effective way to heat premises in the future.

[29] https://www.gov.uk/government/statistical-data-sets/gas-sales-and-numbers-of-customers-by-region-and-local-authority
[30] https://www.nongasmap.org.uk/
[31] https://www.gov.uk/government/statistics/sub-national-residual-fuel-consumption-2005-to-2018

4.19 Current use of fossil gas cannot be replaced by biologically-derived methane since the volumes available are far short of current consumption. It is widely accepted that hydrogen will not be viable for direct replacement of methane in the gas network since there is a large efficiency penalty in converting electricity to hydrogen (and when comparing H_2 with heat pumps that efficiency penalty is magnified to five or six times).

4.20 It is widely accepted that the dominant technology to replace gas and oil for space and water heating will be electrically driven heat pumps (confirmed in the government's recently published Heat and Buildings Strategy), due to their inherent efficiency, and the fact that the carbon intensity of grid electricity is set to fall further, eventually to zero.

4.21 With an assumed coefficient of performance (CoP) of 3, replacing the District's current gas and oil demand for heating (that is, around 900GWh) would require additional electricity supply of around 300GWh/year. This additional electricity requirement would be subsumed within the overall growth of electricity demand described in section 5.1. It is likely that government will choose to move part of the social levies currently applied to electricity, to gas[32], to reflect the reducing carbon impact of electricity, and to incentivise the move away from gas. This is an important policy lever to reduce emissions from home heating, but carries a risk of penalising lower income households if not balanced with targeted support to prevent this.

4.22 It is important to note that heat pumps are usually not suited to a simple direct replacement of gas or oil boilers. In order for a heat pump to perform efficiently, the fabric efficiency (eg insulation, ventilation) of buildings usually need to be improved, at least to some extent, and the means of heat distribution (eg radiator sizing, pipe sizing, underfloor heating) often (but not always) need to be altered. These factors emphasise the importance of householders accessing reliable, timely advice, and the need for policies on retrofit to be backed by such guidance.

4.23 It is also important also to remain open to emergent (but currently unproven) technologies that have little public understanding at present but which may require trial or pilot sites, and in due course could become economically viable. One such example (currently far from commercial), of particular relevance to the Cotswolds, is the deep geothermal energy potential of carboniferous limestone.[33] Such heat reserves would never be suitable for electricity production, but could in principle provide heating for buildings and hot water (without any heat pump required to raise temperature).

Policy objectives

4.24 Recognising that the UK's housing has poor energy performance, and that 80% of the dwellings that will exist in 2050 have already been built today, where the alteration or extension of an existing building is subject to planning permission, planning policy in this context could include the following requirements in proportion with the scale of the proposal:

[32] https://www.current-news.co.uk/news/ministers-consider-shifting-green-levies-from-electricity-to-gas
[33] https://www.bgs.ac.uk/news/unlocking-the-deep-geothermal-energy-potential-of-the-carboniferous-limestone-supergroup

- For existing premises currently heated by fossil fuels: to (require / encourage), and facilitate the most rapid possible transition from fossil fuel heating to high efficiency electric heating, dominated by heat pump technology.
- For existing premises of all types: to encourage and facilitate the installation of measures to reduce heat demand to the maximum practical extent, in order to minimise the capital cost and electricity consumption of replacement heating methods.
- For existing premises of all types: to encourage and facilitate the installation of on-site renewable energy generation (predominantly solar PV and solar water heating) which will contribute to the maximum practical extent to the heat energy demand of the building.

4.25 Recognising the cost effectiveness of building-in net zero carbon performance from the start, rather than retrofitting later, and furthermore recognising the necessity for new build to achieve net zero carbon performance at the earliest possible date, planning policy for new developments of every scale could include:

- to require zero combustion of fossil fuels (for either heating or cooking) from the earliest possible date, with heating to be provided predominantly by high efficiency electric means (heat pumps).
- to require the installation of on-site renewable energy generation whose annual output will be equivalent to at least the building's expected annual total of regulated and unregulated energy demand.
- to require that all new buildings are net zero carbon in both construction and operation, using the UK Green Building Council definitions[34] of net zero (or equivalent).

4.26 Recognising the importance of innovation to meeting the challenge of reaching net zero, and the need to encourage the rapid development and evaluation of all potential candidate technologies for decarbonising heat; for new or experimental technologies capable of displacing fossil fuels for heating:

- to encourage and accommodate the exploration, research and commercialisation of new technologies and techniques.

Potential impacts

4.27 Air source heat pumps (ASHPs) are likely to be the most cost-effective solution to domestic heating, particularly for retrofit. These typically comprise an outdoor unit around the size of a fridge, usually ground-mounted (see Figure 3), whose visual impact will have to be accommodated. Costs are reducing constantly, and are likely to fall significantly from their current level as the technology becomes ubiquitous. ASHP units are being continually improved and whilst many recent models are very quiet, some occupants or near neighbours

34

https://ukgbc.s3.eu-west-2.amazonaws.com/wp-content/uploads/2019/04/05150856/Net-Zero-Carbon-Buildings-A-framework-definition.pdf

may be aware of sound levels from older units that it is not possible to attenuate through siting or screening.

4.28 Successful heat pump installations at scale will lead to the creation of a large number of skilled jobs. For the full, local economic benefit to be realised will require planning policy to be linked to wider economic development and capacity building.

4.29 Ground source heat pumps (GSHPs), whilst delivering higher efficiency than ASHPs and producing negligible noise, are likely to remain expensive for retrofit. However they may be much more suitable for new-build situations where the cost of boreholes or ground arrays may be reduced by incorporating them into general groundworks in the early stage of a project. This cost effectiveness is likely to be highest when delivering a shared ground loop array in a larger development of multiple units (see Figure 4).

Figure 6 Typical air source heat pump domestic unit

Figure 7 Installation of a shared ground loop array for ground source heat pumps in new build social housing

4.30 The efficient and effective operation of either air source or ground source heat pump technology demands that:

- the premises being heated are surveyed in detail by experienced, reputable and trained professionals;
- the maximum practical effort is made to improve the energy efficiency of the building fabric (insulation, ventilation) before a heat pump is specified;
- systems are carefully designed, specified, procured, installed, commissioned, controlled and maintained;
- occupiers are fully trained in their use and understand how they differ from fossil fuel boilers;
- homeowners are supported for at least a year while the system beds in and is optimised, and
- necessary maintenance and monitoring is consistently carried out for the life of the installation.

5. Potential policy responses: Adaptation

Flooding

4.31 Pluvial and fluvial flood events are likely to become more common. There can be no certainty over the severity or frequency of events, but it is likely that rainfall intensity may increase.

4.32 In respect of new developments it may be appropriate to require developers to design surface water runoff attenuation using an assumption of much higher intensity and more sustained rainfall events than are currently accounted for. Soakaway design for rainwater runoff from individual dwellings may need to assume a much higher rainfall volume than is currently the case.

4.33 In respect of existing buildings, both for areas known to be affected by past flood events, and those that can be shown to be at risk of future much more severe flood events, permitted development rights may in some cases enable flood defence adaptations added to a building fabric or located within its curtilage.

4.34 In respect of the assessment of flood risk and suitability for development, in order to guard against future destruction of property and economic value, it may be necessary for the existing EA flood risk assessments to be updated to show flood risks re-calibrated to the kind of extreme rainfall events that will be more likely in the future. Such an approach would then either require no development on land that formerly would have been assessed as 'low risk', or else building design will need to change to incorporate a higher first floor level, with suitable construction beneath that will be wholly unaffected by flood events.

4.35 In respect of public infrastructure, such as flood defences on waterways, existing rights are in place that allow these to be constructed.

Heat stress

4.36 Heatwaves are set to become more commonplace, with health risks to many.

4.37 In respect of existing buildings, particularly those with low thermal mass and poor insulation, measures to minimise passive solar gain, such as awnings, shutters and brise-soleils, may need to be granted permitted development rights.

4.38 If heatwave events become commonplace, householders are likely to wish to install air conditioning. Planning policy will need to accommodate this likely demand, and a decision taken on the scope of permitted development rights to allow air conditioning units on external walls, or on which elevations they will be allowed, on the basis of protecting human health. From the perspective of minimising excess energy consumption, passive measures (e.g. insulation, reducing solar gain, nighttime purging etc) should be pursued before air conditioning.

4.39 In respect of existing urban areas, provision may need to be made for greater tree planting in order to reduce street-level temperatures.

4.40 In respect of new build, we note the 2021 building regulation consultation document on overheating[35]. Until such time as this is adopted, and noting some of the as-yet-unresolved contradictions between this document and Passivhaus design principles, we may need to consider putting specific responsibility on developers and builders to minimise the risk of overheating, based on updated assumptions of potential intensity and duration of hot days. Some design adaptations may affect the external appearance of new buildings, and planning policies will need to accommodate this. In respect of the specification of materials and components, expected future temperatures that would be extreme and exceptional by 20th century standards may need to be incorporated into planning or building regulations, imposing new performance requirements.

4.41 In respect of the public areas of new developments, planning requirements may have to be imposed relating to features (notably tree planting) that will be required to reduce temperature at ground level.

Wildfire

4.42 In respect of wildfire risk, *large* forest, woodland and heathland fires are still relatively rare in the UK, but sustained drought, high temperatures, low humidity and high wind are likely to increase the probability of such fires in the future. Planning or building regulation may need to control how close new-build dwellings may be placed to existing or newly planted woodland or heathland, and may have an impact on design requirements for vulnerable buildings to have higher resistance to external fire.

Drought

35 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/953752/Draft_guidance_on_heating.pdf

4.43 Climate change will increase the likelihood of less rainfall in summer months, which may lead to drought conditions.

4.44 For new build developments it may be appropriate for planning conditions to impose stricter water efficiency requirements than are currently embodied by requirement G2 (water efficiency) of building regulations part G. In order to build drought resilience in to new build it may furthermore be appropriate for planning conditions to impose a requirement to provide a minimum level of storage of harvested rainwater from the building, and for such harvested rainwater to be used for non-potable purposes in or outside the building.

4.45 Sustained low rainfall or drought conditions may lead to greater risk of heave and shrinkage of clay rich soils in a limited part of the District, which has the potential to lead to damage to the foundations and structure of buildings. For new build developments, to guard against such damage it may be appropriate for building regulations approved document A, specifically section 2E4 relating to the required depth of strip foundations in shrinkable clay soils, to be interpreted more strictly, or other appropriate technical solutions proposed to insulate the building from the risk of damage.

Storm events

4.46 In the UK, storms with damaging high wind speeds are not currently projected to increase as a direct result of climate change[36] (or at least, any increase is likely to be no more than natural background variability). Nonetheless in general the effect of climate change will be to increase weather instability and extremity, and more extreme storms may be experienced in future years. It may therefore be appropriate to impose stricter criteria on building designers in respect of maximum design wind loadings.

Change in working practices

4.47 Increased working from home may be expected in the future, with consequent benefits from reduced commuting emissions. To accommodate this expected change, planning policy could require new build dwellings to incorporate space suitable for occupiers to work from home, or potentially the provision of communal work hubs in larger developments.

[36] https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-extreme-events_wind-storms

Appendix 1: Glossary

Mitigation	Actions that reduce the amount of greenhouse gas emissions to, or remove greenhouse gases from, the atmosphere
Adaptation	Actions that change infrastructure, behaviours, regulations etc such that society is more resilient to the expected increasingly severe effects of climate change
Renewable energy	Energy (usually in the form of heat or electricity) that is captured from ambient energy flows in the natural environment, for example solar radiation, wind, rainfall, tides, geothermal heat, heat contained in the air, ground and bodies of water, etc. Such energy capture has zero carbon emissions associated with it, other than energy from biomass.
Pluvial flooding	Flooding as a result of run-off from heavy rainfall events, where the flood water is not flowing in an established waterway
Fluvial flooding	Flooding as a result of an established waterway (eg stream, river) over-flowing its banks
Carbon sequestration	The permanent or temporary 'locking up' of carbon in such a form that it cannot enter the atmosphere - examples are tree growth, peat bog growth, increased soil carbon, enhanced weathering of rocks, or the injection of CO2 into underground storage.
Carbon removal	The removal of CO_2 from the atmosphere, sometimes used interchangeably with sequestration
Greenhouse gases	The 'basket' of gases emitted to atmosphere by human and natural activity that are mainly responsible for the 'greenhouse effect'. Normally six gases are named as the most important: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), the so-called F-gases(hydrofluorocarbons and perfluorocarbons), and sulphur hexafluoride (SF_6). Each has a different global warming potential. In terms of overall impact on global heating, the two dominant gases are carbon dioxide and methane.
CO_2	Carbon dioxide, the principal gas responsible for anthropogenic global heating. Whilst CO2 is a part of the natural carbon cycle (eg animals expel CO2 in respiration), it is the burning of billions of tonnes of fossil fuels (coal, oil, gas) that has driven, and continues to drive, the climate system deeper into crisis.
CO_2e	Carbon dioxide equivalent. CO_2e is used as a measure of the global warming potential of a mixture of gases, or a process that emits more than one type of greenhouse gas (for example the global warming potential of methane is about 20x that of carbon dioxide, so

	the CO_2e of natural gas used for heating takes account not just of CO_2 formed in combustion, but direct losses of methane in exploration, extraction and transport of the gas).
UKCP	The UK Climate Projections is a climate analysis tool that estimates climate impacts across the UK. It is provided by the Met Office Hadley Centre Climate Programme, supported by BEIS and Defra.
Carbon budgets	Carbon budgets can be defined from global down to local level, and usually refer to the maximum amount of carbon dioxide (or other greenhouse gases) that may be emitted to atmosphere before certain thresholds of global heating risk are passed. For example an organisation might adopt a carbon budget which defines the maximum amount of carbon that it may emit whilst staying within its 'fair portion' of the global carbon budget that should limit global heating to a maximum of 1.5 degrees Celsius above the pre-industrial level.
kgCO2/kWh	The amount of CO2 emissions (in kilograms) associated with one kiloWatt hour of energy (which could be heat or electricity, and measured at the point of generation or consumption).kW kiloWatt, a unit of power (power is the rate at which energy is converted). For example a toaster might be rated at about 1kW, and a kettle at about 2.5kW, and a single solar panel at about 300W, or 0.3kW
MW	MegaWatt, a unit of power, equal to 1,000x a kW
GW	GigaWatt, a unit of power equal to 1,000x a MW
kWh	kiloWatt-hour, a unit of energy equivalent to the amount of energy converted by a device with a power of 1kW, running for one hour. So for example running a toaster rated at 1kW for 1 hour would consume 1kWh of energy. kWh is also the unit used on household energy bills, and applies to any form of energy - eg gas, electricity, heat.
MWh	MegaWatt-hour, a unit of energy equal to 1,000x a kWh
GWh	GigaWatt-hour, a unit of energy equal to 1,000x a MWh
Solar PV	Solar photovoltaic - which often refers to both the device (eg solar panels on a roof) as well as the physical phenomenon by which light is converted into electricity in a solar cell.
LCOE	Levellised Cost of Energy. An estimate of the 'true' cost of energy produced by a particular means, which takes account of all relevant factors including eg capital cost, running cost, cost of capital, how much energy is generated, and how long the particular technology

	lasts. For example it is largely accepted that the type of electricity generation with the lowest LCOE in the UK is now onshore wind (depending on location).
FOAK	First of a Kind. This term usually refers to the cost (or other attribute) of new technology or equipment being introduced to the market. The first of a kind will always be expensive because manufacturers have to try and recover research and development costs. For example early electric cars were very expensive, but are now becoming cheaper.
NOAK	Nth of a Kind. Refers to the cost or other attribute of technology or equipment in series production.