South Cambridgeshire District Council (SCDC)

Greater Cambridge Local Plan:
Net Zero Carbon evidence base

Task C – Carbon Reduction Targets

June 2021 | Rev I

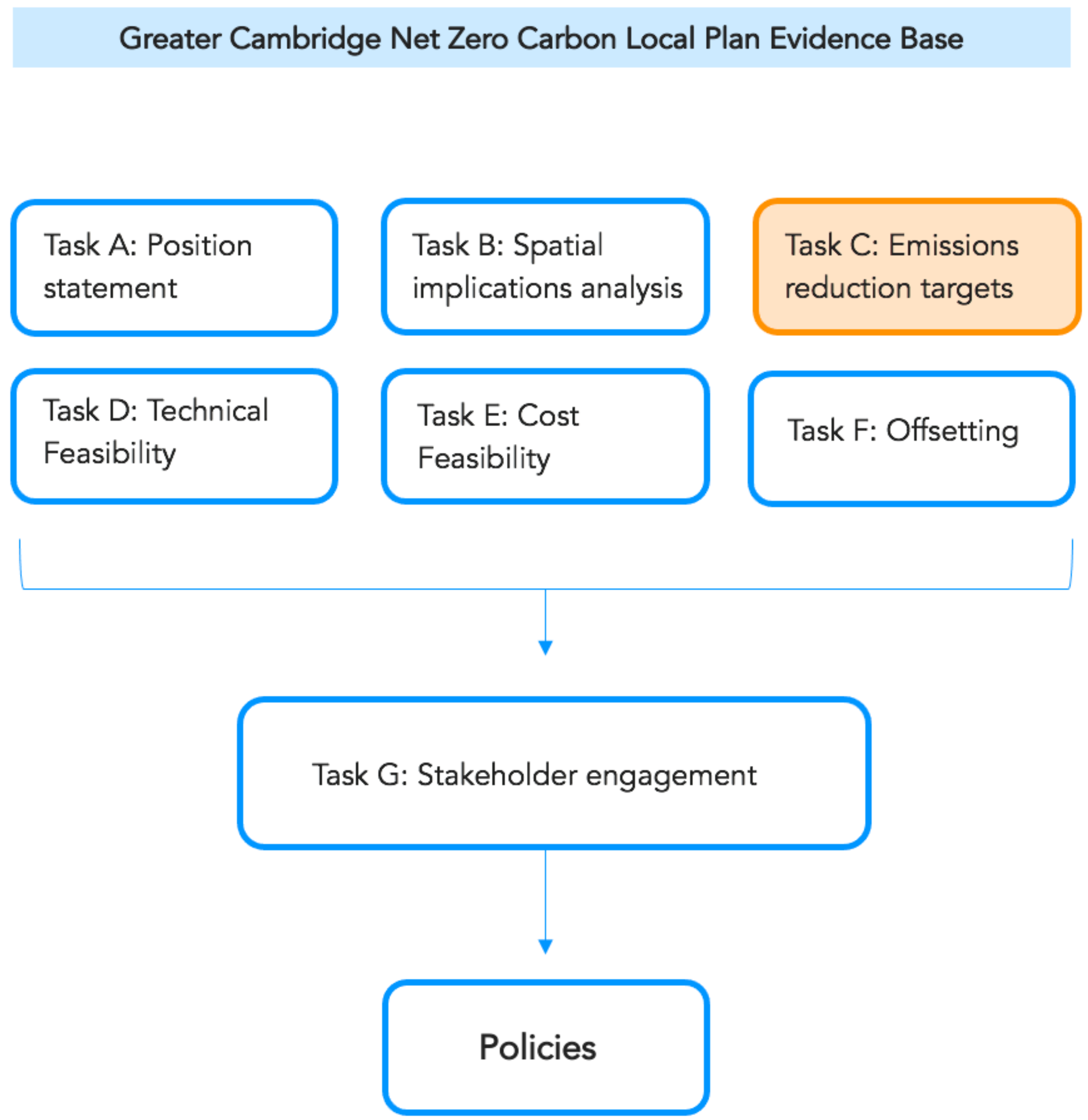
Bioregional Etude Currie & Brown

Task C
Carbon reduction targets and policies

This section assesses the required carbon reduction targets in the region by using a top down approach based on recommendations from the IPCC, the Committee on Climate Change, the Tyndall Centre and forecast GHG emissions for the region.

We then use a bottom up analysis to assess the impact of potential policy measures on meeting these carbon reduction targets.

We look at the role of the local plan in reaching the required targets for different sectors and recommend policies to support them.



Global Carbon Reduction Targets

There is a climate emergency

There is overwhelming scientific consensus that significant climate change is happening. This is evidenced in the latest assessment of the Intergovernmental Panel on Climate Change (IPCC AR5). The IPCC special report published in 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels highlights the **urgency for action** and has generated a high level of interest and concern in society as a whole.

A business-as-usual trajectory would lead to an expected **4 - 5°C** increase in global average temperature above pre-industrial levels by 2100 with more warming expected afterwards.

The Paris Agreement (2015)

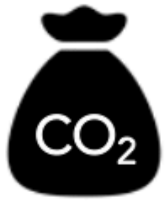
International negotiations on climate change are governed through the United Nations Framework Convention on Climate Change (UNFCCC). The most recent negotiations concluded with the Paris Agreement in December 2015. This Agreement reaffirms global ambition to limit temperature rises to below 2°C and binds every country to produce national plans to reduce emissions. The agreement also contains a further collective aspirational goal to reduce emissions in line with keeping the temperature increase to 1.5°C.

Global carbon budgets

The concept of carbon budgets is an important one. The Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5 °C has estimated the quantity of CO_2 that can be emitted globally and still be consistent with keeping global temperatures well below 2 °C with an outside chance of stabilising at 1.5 °C. The report gives different budgets for different temperature rises and probabilities.

The Tyndall Centre Carbon Budgets reports[32] (which we will refer to throughout this report, see more on page 6) has selected from the IPPC report a global budget figure of **900,000 $MtCO_2$** as the basis of their work. This, they indicate, is the maximum allowable budget to stay within an outside chance of staying within a 2C temperature rise. This budget assumes no reliance on carbon removal technologies.

Keeping global warming to below 1.5°C with at least 66% probability corresponds to less than **10-14 years** at current global emissions rates. This increases to 14-18 years for a 50% probability [CCC Net Zero].



900,000

$MtCO_2$

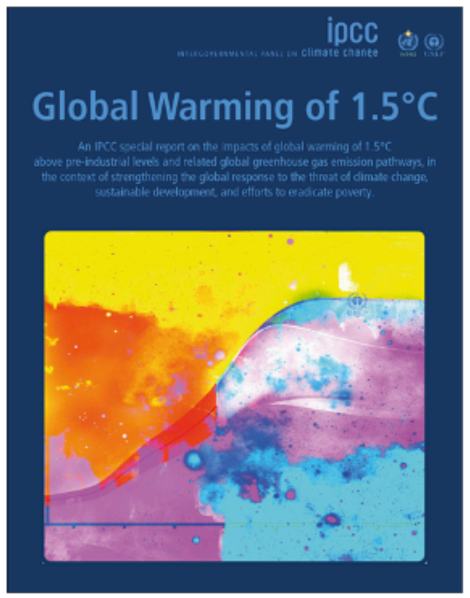
Estimation of **remaining global carbon budget** for staying well below 2C rise.

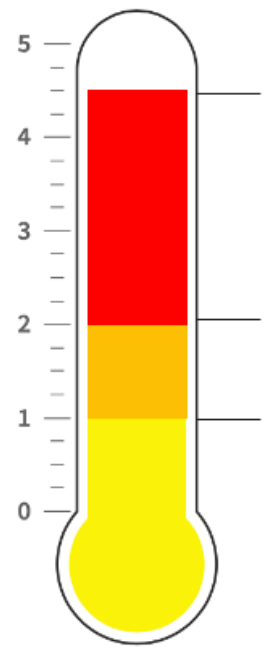
10-14

years

The number of years it would take to **consume our entire global carbon budget** at current global emissions rates for a good chance of limiting temperature rises to below 2C.

Global level





4-5 C the temperature rise we are likely to see if we continue on a **business as usual** path

1.5-2C The maximum temperature rise above pre-industrial levels the IPCC recommends.

1C The temperature rise already created

Translating global targets to the national level

National commitment

The UK has binding targets to reduce CO_2 emissions through the Kyoto Protocol and is a signatory of the Paris Agreement.

The UK's national commitment is set through The **Climate Change Act 2008** – which legislates that the UK carbon account for 2050 must be **100% lower than 1990** levels – i.e. the UK must be **net zero carbon by 2050**. Previously requiring an 80% reduction in carbon emissions, the Act was was amended in June 2019 following the publication by the Committee on Climate Change of its 'Net Zero: The UK's Contribution to Stopping Global Warming' in May of the same year. The recommendation was based on the latest scientific evidence presented by the IPCC's Special Report on Global Warming, 2018. The Government adopted the recommendation of this report and the Climate Change Act was amended accordingly.

The Committee on Climate Change

The Committee on Climate Change (CCC) is an independent body formed to advise the UK government on tackling and preparing for Climate Change.

In 2019 the CCC published the report "Net Zero: The UK's contribution to stopping global warming" [01]. In addition to recommending a new emissions target for the UK: net zero greenhouse gases by 2050 (see above) the report also set out an ambitious set of measures required to meet the zero-carbon target.

The Committee on Climate Change also advises government on carbon budgets. The Climate Change Act requires the government to set 5-year carbon budgets. The CCC advises what the carbon budgets should be, and provides progress reports against them (note – these carbon budgets are not comparable to the amount of carbon actually emitted by the UK as they include allowances under the EU Emissions Trading Scheme).

The carbon budget for the UK

To help understand the magnitude and pace of carbon reductions required, the IPCC Special Report 2018 estimates the amount of carbon we can emit globally to stay within certain temperature rises. Following this, the Tyndall Centre Carbon Budgets reports[32] estimate the carbon budget for the UK (allowing for the equity principle from the Paris Agreement) to be **3,757 $MtCO_2$**.

Further Reading

- Accounting for carbon – comparison of methodologies (Task A: Position Statement)

The UK Government has committed in June 2019 to Net Zero emissions by 2050

UK level

Reduction in CO_2 emissions the UK government is **legally required** to achieve by 2050 over 1990 levels.

Global carbon budgets allocation to the UK, Tyndall Centre

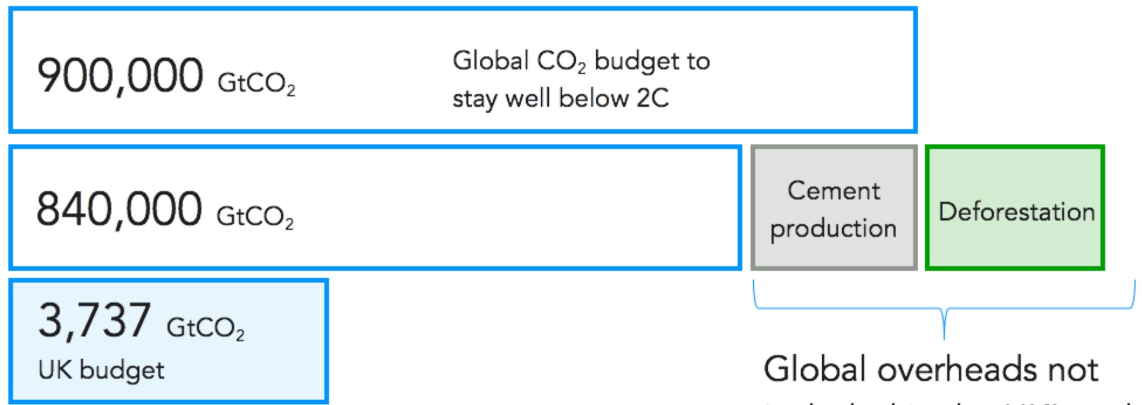


***Figure 1 (above):** Tyndall Centre estimation of remaining UK carbon budget to stay within 2C temperature rise. Aviation and Shipping included in UK budget. Image not to scale.*

Zero Carbon Pathway for the UK: CCC Analysis

Achieving Net Zero Carbon by 2050

The Committee on Climate Change's (CCC) "Net-Zero" report[01] provides an in-depth analysis of what is required of the UK to meet its zero carbon target (legislated by the Climate Change Act). The analysis spans different sectors: buildings; industry; power; transport; aviation & shipping; agriculture & land-use; waste; f-gases and greenhouse gas removals.

The report illustrates the scale of action that is required to achieve the target.

Key measures

- 100% low carbon electricity by 2050.
- Ultra-efficient new homes and non-domestic buildings
- Low carbon heat to all but the most difficult to treat buildings.
- Ambitious programme of retrofit of existing buildings.
- Complete electrification of small vehicles (100% of new sales by 2025).
- Large reduction in waste, zero biodegradable waste to landfill and
- Significant afforestation and restoration of land, including peatland.
- Greenhouse gas removals will be required to achieve net zero carbon.

Compliance with zero carbon target

The CCC analysis of "Further Ambition" scenarios, has identified pathways across different sectors that combined achieve an 89% reduction in GHG emissions by 2050, before greenhouse gas removals.

The report lists some "speculative" measures required which may help to get closer to a 100% reduction.

Compliance with carbon budgets target

The CCC "Net Zero" analysis does not look at cumulative emissions or carbon budgets. However, it is the CCC that sets the recommended levels of the UK government's carbon budgets required by the Climate Change Act. The CCC also reports against the UK's progress in achieving them.

Further Reading

- "Further ambition" measures assumed by CCC for close to "net-zero" – Appendix C.

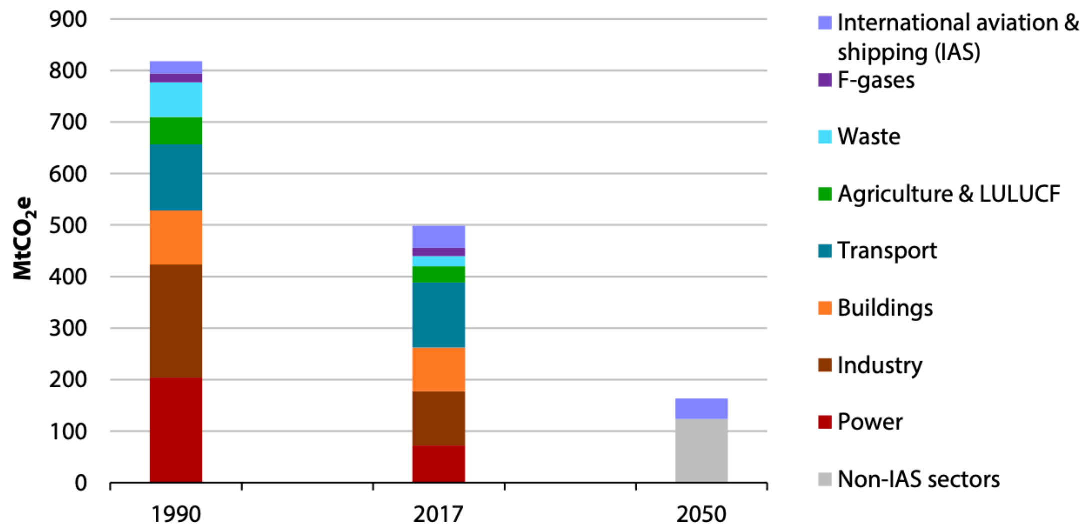


Fig 2 . Comparison of emissions in 1990, 2017 and what they would need to be based on the original 80% reduction in emissions. CCC. Graph shows the power, industry and waste sectors have already shown big reductions. Aviation emissions have increased. Transport, buildings, F-gases have largely remained constant.

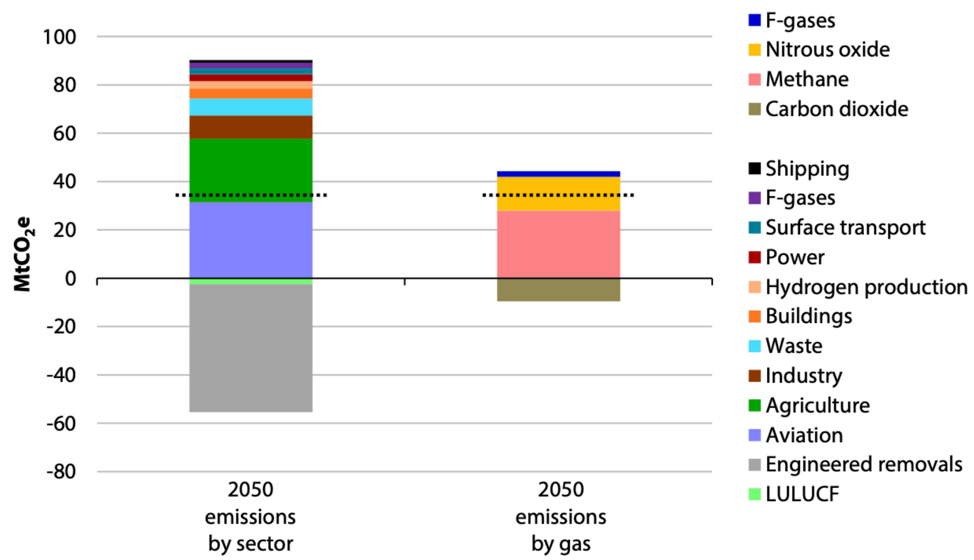


Fig 3 - Remaining emissions in the "Further Ambition" scenario by sector and by gas, Committee on Climate Change. Graph shows aviation and agriculture are likely to be the dominant GHG emitters in 2020.

UK level

CCC analysis

Scale:

Whole of UK

GHG emissions included

CO_2 NOx NH4 F-gases

Emissions sources Included

✓ Power
✓ Buildings
✓ Transport
✓ Waste
✓ Industry
✓ Cement production
✓ Forestry & Land-Use
✗ Peatlands
✓ Aviation and Shipping

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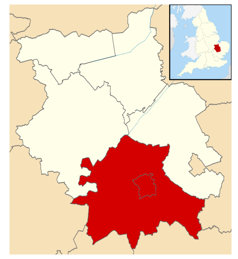
Translating national targets to the local level



Tyndall Carbon Budget Reports

Tyndall Carbon Budget Reports [32] provide UK local authority areas with budgets for energy related CO_2 emissions from 2020-2100. Aligned with the Paris Agreement, they are informed by the latest science on climate change and carbon budget setting.

Figure 4 illustrates how the carbon budget for Greater Cambridge has been derived from the global carbon budget. The UK's carbon budget has been derived using the equity principle – developed countries have been given a smaller portion of the budget compared with developing countries (this is in line with the Paris Agreement).

The carbon budget and required reduction pathway for Greater Cambridge is illustrated in Figure 5. In summary, the report recommends:

- Greater Cambridge stays within a maximum cumulative CO_2 emissions budget of **11 million tonnes ($MtCO_2$)** for the period 2020-2100.
- If emissions continue at 2017 levels, the entire carbon budget for the area would be used within **7 years** (from 2020), i.e. by 2027.
- Emissions cuts must average **-13.5%** per year to deliver a Paris aligned carbon budget.
- Reach net zero no later than **2041**, at which point 5% of the budget remains.
- Meeting the budget **must not** rely on carbon offsets.

Comparison with UK carbon budgets

The Tyndall Centre's carbon budgets are not comparable with the official UK governments carbon budgets for a number of different reasons: the UK carbon budgets do no apply the equity principle (integral to the Paris Agreement); they include allowances from the EU emissions trading scheme (and therefore do not reflect actual carbon emitted by the UK); budgets until 2032 were set on the basis of an 80% reduction in GHG emissions (not 100% as now required). They also include other GHG emissions.

This report uses the Tyndall Centre carbon budgets for setting targets for Greater Cambridge, as they are a truer reflection of emitted CO_2 and BEIS figures can be used to directly assess progress. Crucially, the official UK carbon budgets may be too large by a factor of at least two to be consistent with a 1.5C temperature rise[04] .

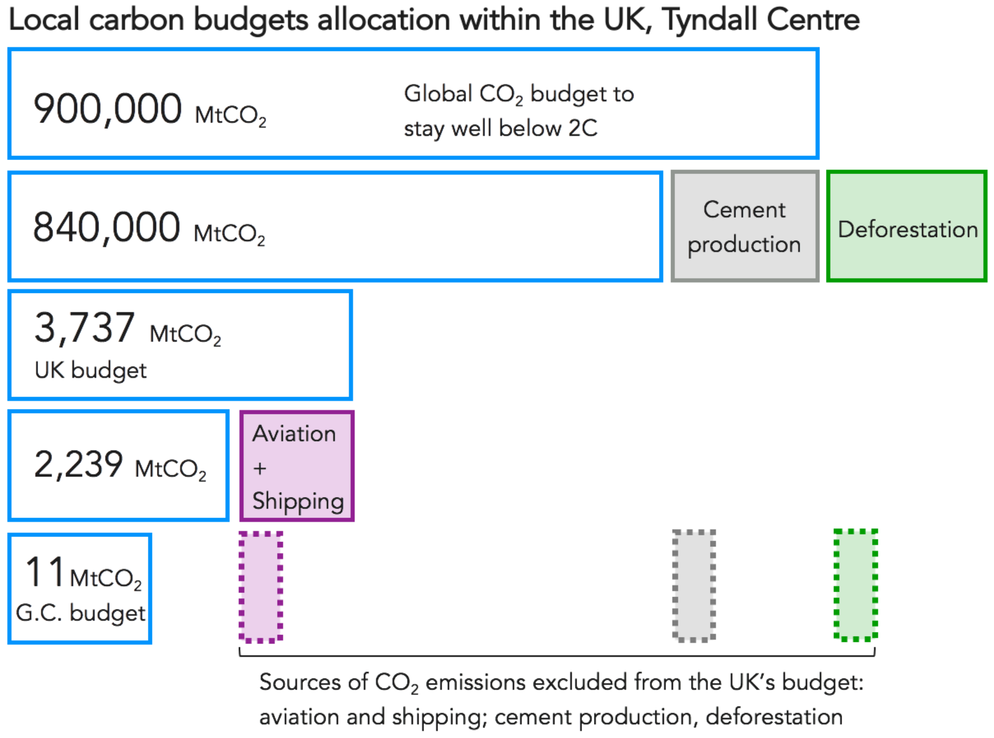


Figure 4: Tyndall Centre estimation of remaining carbon budget for Greater Cambridge to stay within 2C temperature rise. Aviation and Shipping are regarded as a national overhead and not included in local budgets. Image not to scale.

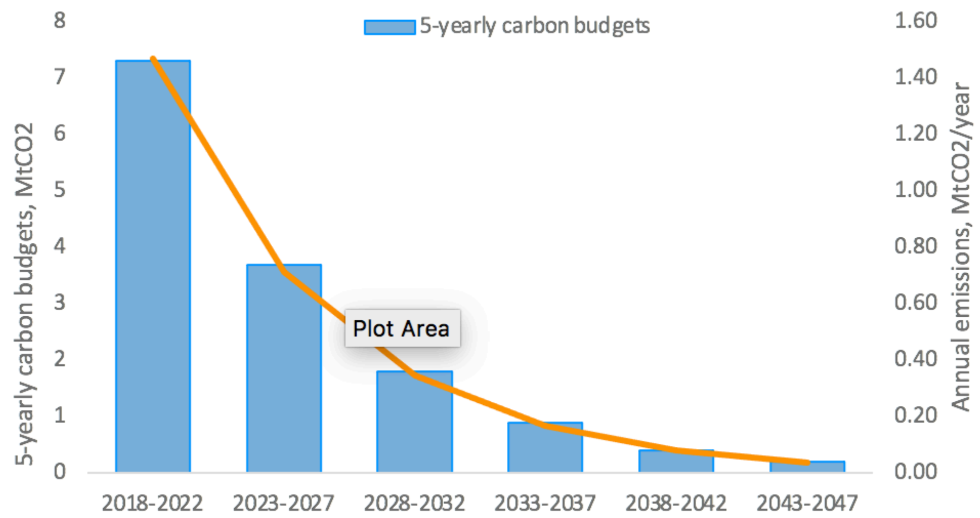


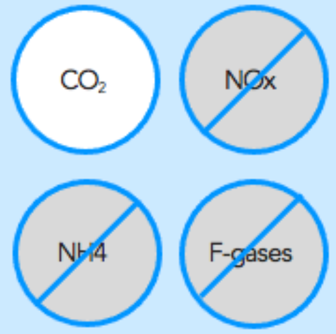
Figure 5: 5-yearly carbon budgets, annual CO_2 emissions and total remaining carbon budget for Greater Cambridge's contribution to staying within a 1.5C temperature rise. Data source: Tyndall Centre Carbon budgets report.

Tyndall Centre Carbon Budgets

Scale:

Greater Cambs

GHG emissions included



Emissions sources Included

✓ Power
✓ Buildings
✓ Transport
✗ Waste
✓ Industry
✗ Cement production
✗ Forestry & Land-Use
✗ Peatlands
✗ Aviation and Shipping

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Zero Carbon Pathway for Cambridgeshire: CUSPE Analysis

Achieving Net Zero Carbon by 2050

The Cambridge University Science and Policy Exchange (CUSPE) produced the report 'Net Zero Cambridgeshire' [05] in October 2019, and provides detailed forecasts of emissions arising in in Cambridgeshire and Peterborough.

Cambridgeshire County Council adopted this report as an evidence base for its Climate Change and Environment Strategy in October 2019.

- Emissions in Cambridgeshire and Peterborough were 6.1 $MtCO_2eq$ in 2016.
- Extrapolation of CUSPE data suggests that emissions in Greater Cambridge were approximately 2 $MtCO_2eq$ in 2017.
- Trajectories to zero carbon have been modelled for different sectors: domestic, transport, agriculture, commercial & industry, waste, afforestation and peatland.
- Only the 'ambitious' scenario came close to being near zero carbon by 2050. There were two aspects of this scenario: low-carbon heat (no new homes connected to the gas grid from 2025 and an ambitious roll-out of low carbon heating to 90% of existing homes) and energy efficiency measures in both new and existing homes.
- The net zero scenario for transport concluded that all cars/light vehicle are electric, and most HGVs run on hydrogen. And an overall reduction in vehicle journeys is required.

Compliance with zero carbon target

The CUSPE analysis has identified ambitious pathways across different sectors that combined achieve a 90% reduction in CO_2 emissions by 2050.

The CUSPE proposal is that remaining 10% of GHG emissions would need to be offset through reforestation and carbon capture and storage.

Compliance with carbon budgets target

The CUSPE analysis does not look at cumulative emissions or carbon budgets. However, the shapes of the decarbonisation paths for buildings and transport (figure 7) do not appear to be aligned with the Tyndall Centres Carbon Budgets graph, which see a steeper and faster reduction in emissions.

This would suggest that the CUSPE measures and assumptions do not deliver CO_2 reductions at the pace required to be consistent with the Tyndall Centre Carbon budgets, and thus with the Paris Agreement.

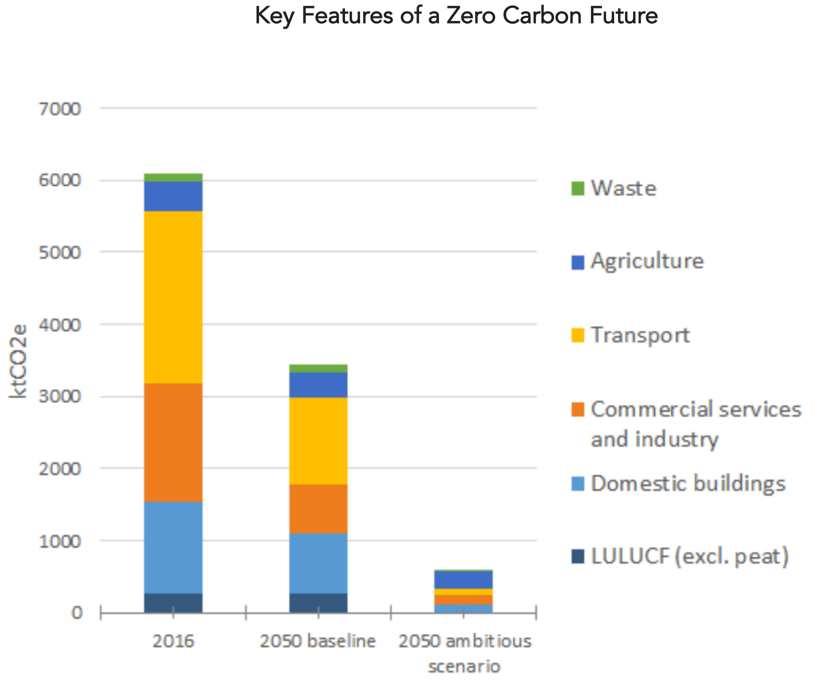


Fig 6 - CUSPE: GHG emissions by sector for Cambridge, in the 2050 Ambitious scenario, not including afforestation or carbon capture and storage. Hard to treat emissions are remaining.

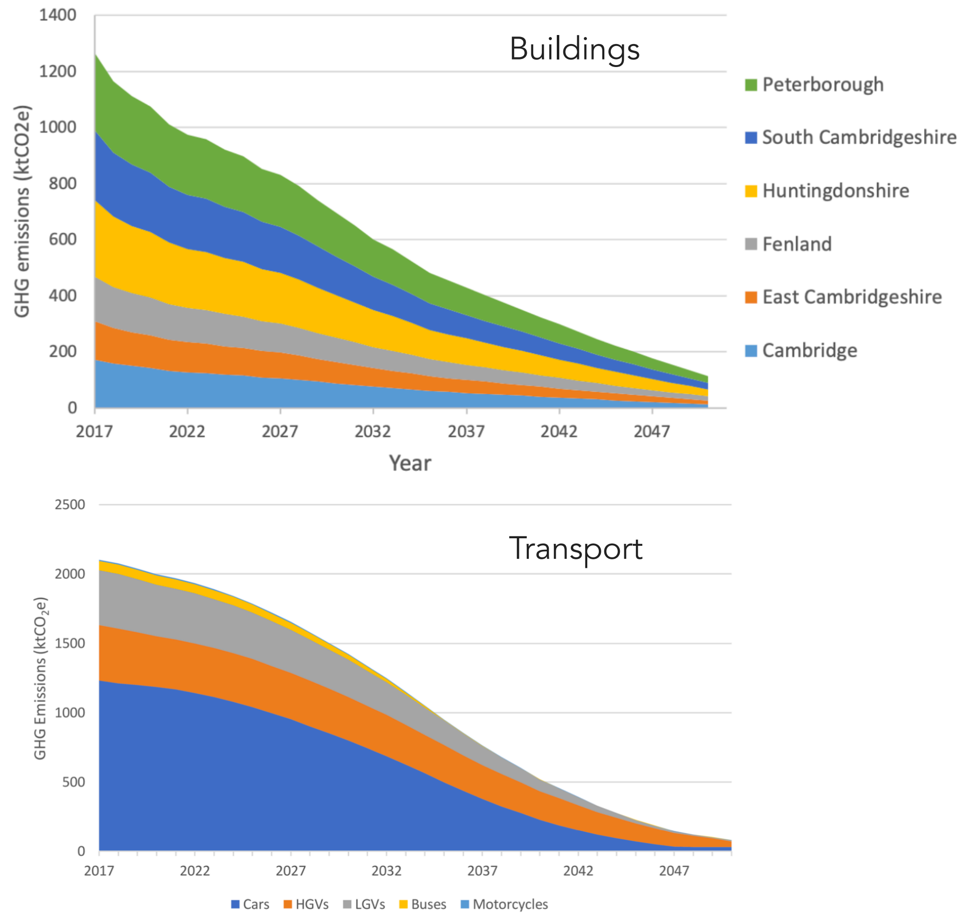
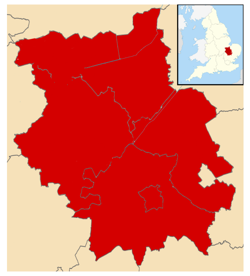


Fig 7 - Projected emissions for Buildings (top) and Transport (bottom) for Cambridge, according to the Ambitious Scenario.



CUSPE analysis

Scale:

Cambridgeshire

GHG emissions included

CO_2 NOx NH4 F-gases

Emissions sources Included

✓ Power
✓ Buildings
✓ Transport
✓ Waste
✓ Industry
✓ Cement production
✓ Forestry & Land-Use
✗ Peatlands
✓ Aviation and Shipping

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Zero Carbon Pathway for Greater Cambridge: SCATTER Analysis

SCATTER

SCATTER (Setting City Area Targets and Trajectories for Emissions Reduction) is a local authority focussed GHG emissions tool capable of both creating GHG emissions inventories (a point-in-time summary of the GHG emissions apportioned to the local authority area), and the creation of decarbonisation pathways to 2050. The tool can be used by all local authorities, not only cities.

Trajectories to zero carbon can be modelled for different sectors: domestic, transport, industry & commercial agriculture and land-use. It is possible to test varying levels of ambition across 32 different action areas.

Key conclusions

- Emissions in Greater Cambridge were 1.51 $MtCO_2eq$ in 2018.
- A pathway modelling the maximum level of ambition (within the tool options) has been selected. In this scenario, 18% of GHG emissions remain in 2050.
- Industrial and commercial emissions, and land-use and agriculture emissions are shown to be difficult to abate.
- This makes it **imperative** that housing, transport and waste sectors achieve maximum possible reductions.
- Large scale wind and solar and small scale solar will all need to increase.
- All new housing to be PassivHaus from 2021.
- All buildings heated by low carbon electricity and heat pumps by 2050.
- 25% reduction in journeys taken

Compliance with zero carbon target

The SCATTER tool has identified pathways across different sectors that combined achieve a 82% reduction in CO_2 emissions by 2050.

Compliance with carbon budgets target

It is understood that SCATTER is developing a functionality which will allow local authorities to assess decarbonisation pathways for compliance with compare emissions pathways with the Tyndall Centre's Carbon budgets. However, comparison is not possible at this time.

Further reading

- Forecast model assumptions – Appendix C.

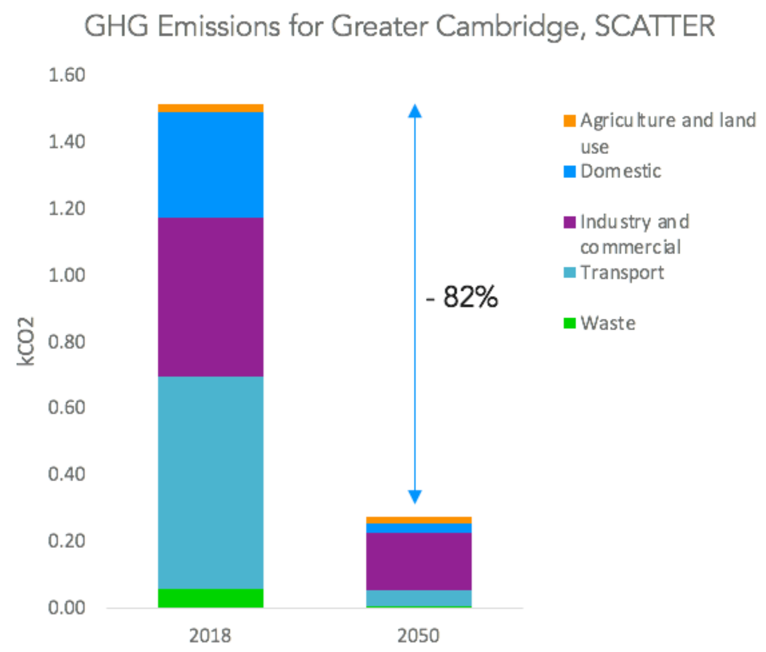


Figure 8: SCATTER's maximum level of ambition leads to a predicted 82% reduction in emissions. Only 7%, 8% and 10% of emissions from transport, buildings and waste remain respectively.

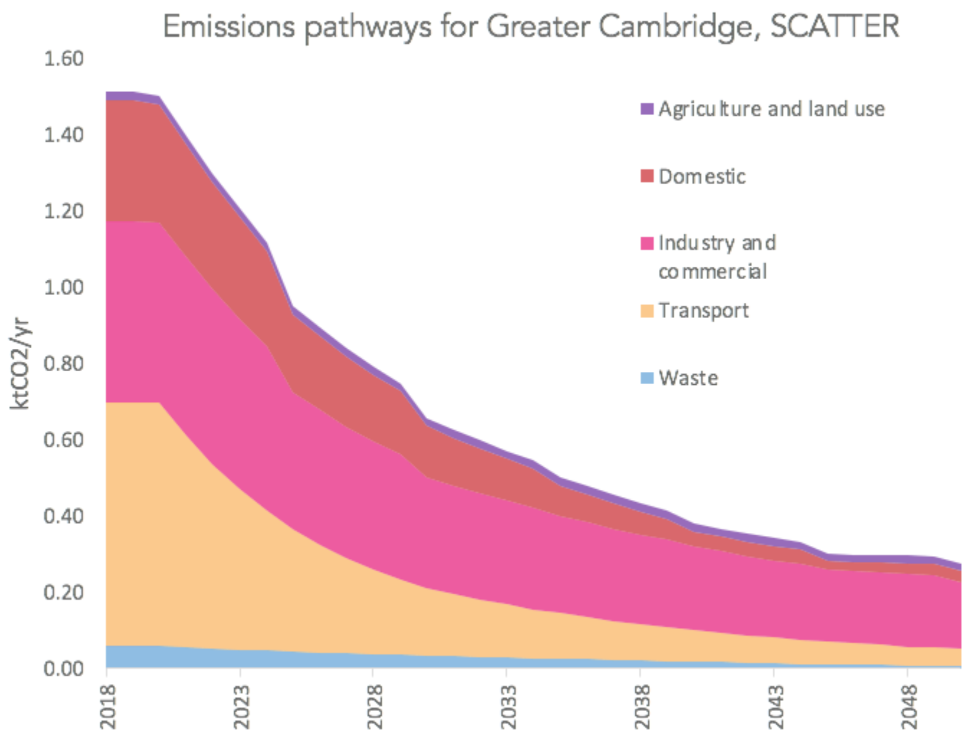
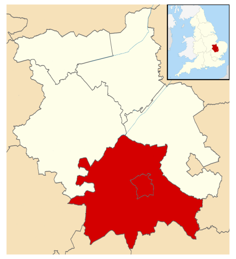


Figure 9: GHG emissions pathway for Cambridge, following maximum ambition across all sectors (Source: SCATTER).

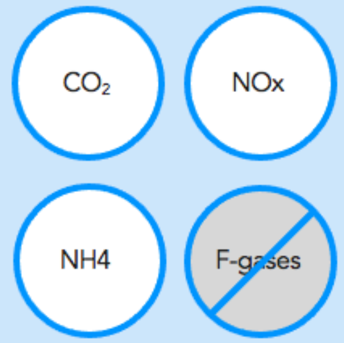


SCATTER analysis

Scale:

Greater Cambridge

GHG emissions included



Emissions sources Included

✓ Power
✓ Buildings
✓ Transport
✓ Waste
✓ Industry
✓ Cement production
✓ Forestry & Land-Use
✗ Peatlands
✓ Aviation and Shipping

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Zero Carbon Pathway for Greater Cambridge: Etude Analysis

Achieving Net Zero Carbon by 2050

We have used the Etude tool to estimate current and future greenhouse gas emissions in Greater Cambridge. Our approach differs from other approaches in that we take a more bottom up approach for buildings.

Key conclusions

Like other pathways in this analysis, the Etude pathway illustrates that radical changes to all sectors are required to move towards net zero carbon.

This includes:

- net Zero Carbon new buildings
- existing building stock energy efficiency
- switch from gas heating to low carbon heat
- the electrification of transport.

Compliance with Zero Carbon Target

The cumulative emission reductions demonstrate that near zero carbon emissions are possible. Our assumptions show that 11% of emissions remain in 2050. These are from hard to treat emissions sources. Remaining emissions can be offset by carbon sequestration projects. However it is important to bear in mind that scope for sequestration is limited.

Compliance with Carbon Budgets Target

Etude are currently developing their tool to enable staged carbon reductions pathways that assess cumulative carbon. Our current tool does not assess cumulative carbon. However, our initial analysis indicates that the vast majority of decarbonisation needs to have been completed by the early 2030s.

Further Reading

- Etude forecast model methodology and assumptions – Appendix C.

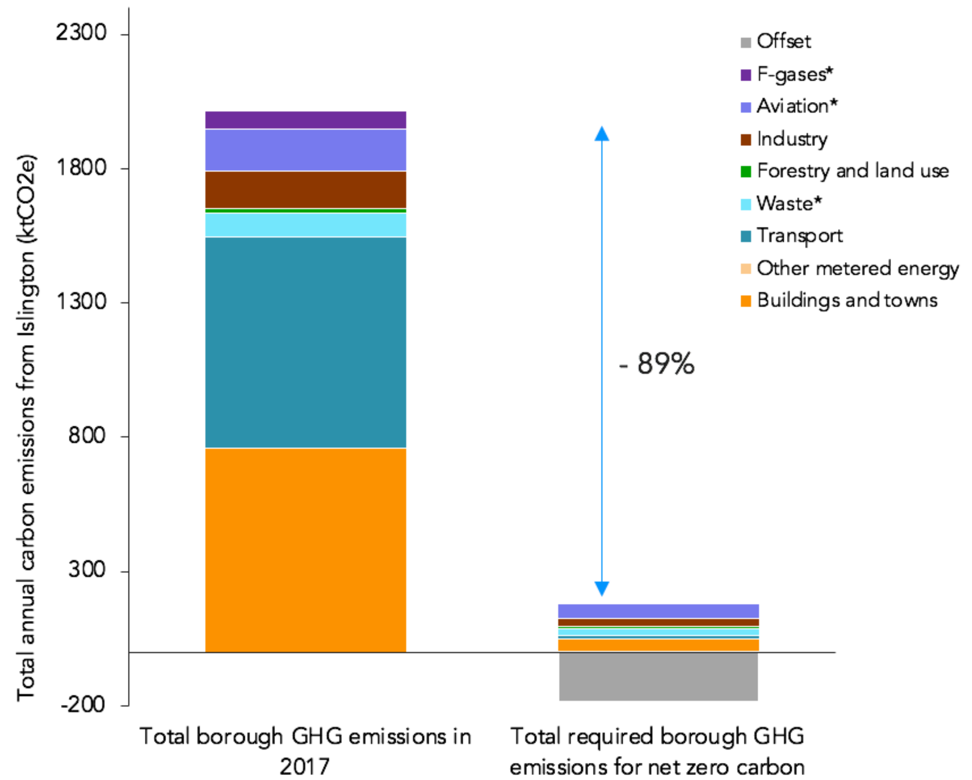


Figure 10: Latest reported emissions (2018) and forecast 2050 emissions based on a scenario where carbon emissions reduction is prioritised in policy, by businesses and by national government.

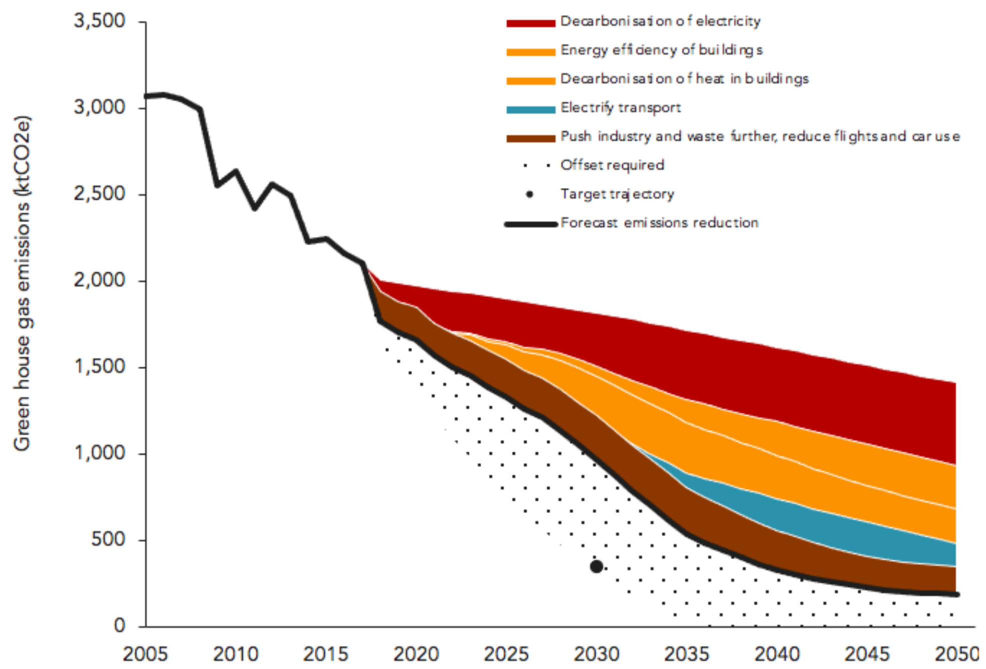
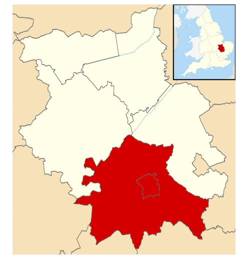


Figure 11: Historic and forecast emissions for Greater Cambridge from 2005 to 2050. Showing contribution of main sectors to overall reduction.



Etude analysis

Scale:

Greater Cambridge

GHG emissions included

CO_2 | NOx | NH4 | F-gases

Emissions sources Included

✓ Power
✓ Buildings
✓ Transport
✓ Waste
✓ Industry
✓ Cement production
✓ Forestry & Land-Use
✗ Peatlands
✓ Aviation and Shipping

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Summary of emissions targets required

Required targets

Our review of existing carbon budgets and models, together with our own analysis for Greater Cambridge, shows common themes and conclusions emerging to inform the required GHG reduction targets required for the region.

- Greater Cambridge must reach **net zero carbon GHG emissions by 2050** (Climate Change Act 2008)
- Greater Cambridge must **emit no more than 11 $MtCO_2$ between 2020 and 2100** (Tyndall Centre's Carbon Budgets for Greater Cambridge) from energy use (excluding aviation).
- The sectors of **power generation, buildings and transport should target zero greenhouse gas emissions** in order to compensate for the sectors that cannot.
- **A means of removing greenhouse gas from the atmosphere will be required.** The zero carbon pathways we have looked at have shown that there will be residual GHG emissions remaining that cannot be abated. Removal of greenhouse gases from the atmosphere will be required to bring the balance of GHG emissions to net zero.

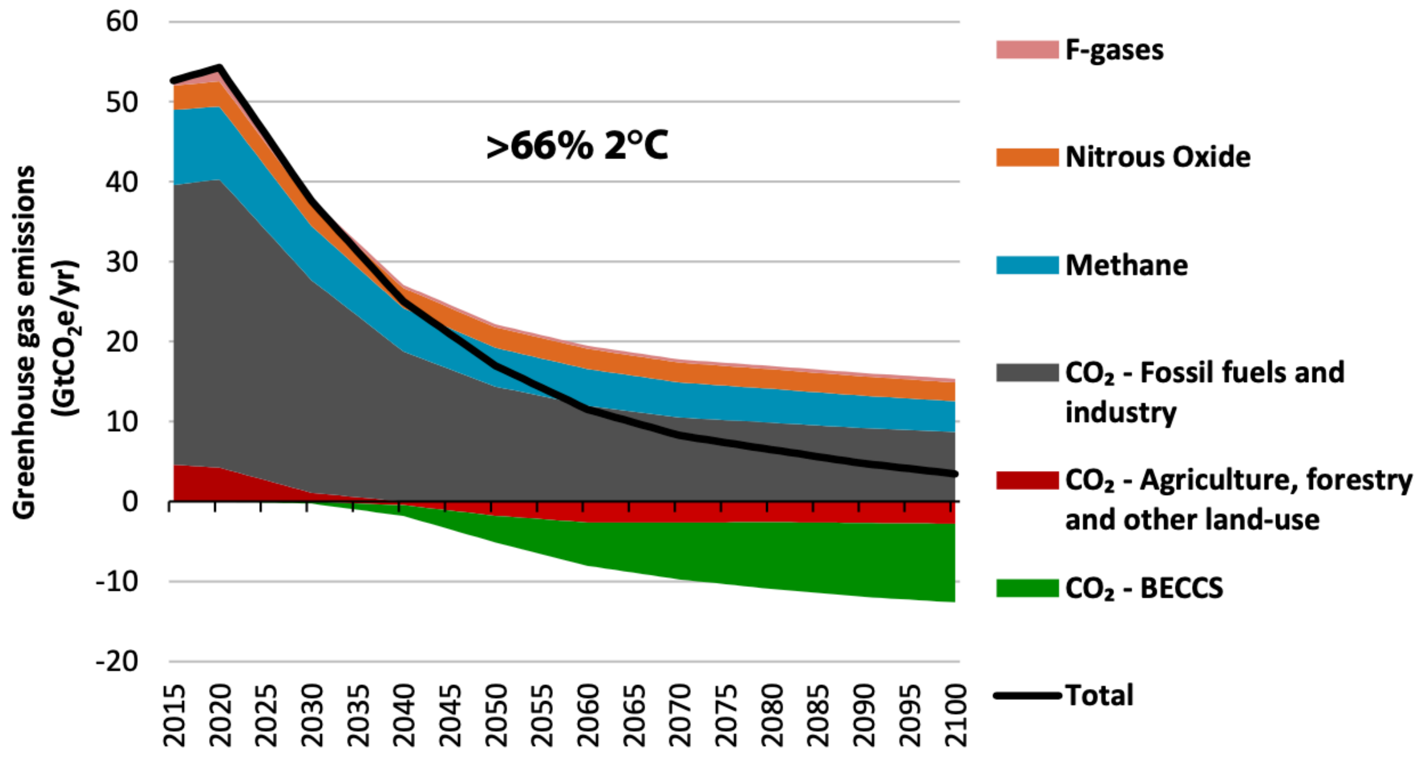


Figure 12: Graph shows different GHG emissions and how they reduce over time. CO_2 from fossil fuels and industry is the only GHG that is likely to see a large reduction. Other GHGs, including methane and nitrous oxide and difficult to abate, and reduce by a small amount. Residual emissions remain for all GHG gases, and are partially offset by greenhouse gas removals. Source: Committee on Climate Change Net Zero: The UK's Contribution to Climate Change.

Task C
Emissions reductions targets
Implications for the local plan

A sector by sector look at what the local plan can do to help achieve the emissions reductions required for the region.

Implications for the local plan

Translating targets to the local plan

The following pages take a closer look at the sources of greenhouse gas emissions in Greater Cambridge, by sector - the chart on the rights shows the relative emissions of each sector. We seek to understand:

- what is required within Greater Cambridge to make each sector zero carbon
- how quickly it needs to happen
- how the local plan may facilitate this transition.

The sectors considered are aligned with the categories used by the Committee on Climate Change.

Existing emissions vs new emissions

The local plan is concerned mainly with guiding new development. Therefore it has a very strong ability to influence future emissions associated with new development – particularly emissions from new buildings. It also has the ability to influence the delivery of infrastructure required for a zero carbon future, land-use, and future transport emissions.

The local plan's influence over existing emissions is more limited, or indirect. The biggest impact the local plan can have on existing emissions is facilitating new renewable energy generation – as this will help to bring down emissions in all sectors where electricity is used.

Recommendations and policy

In order to ensure that the recommended policies are comprehensive and fully consistent with a zero carbon future, all emissions within the boundary of Greater Cambridge are considered before making recommendations on how the local plan may facilitate their reduction.

The recommended policies that fall out of this analysis form a separate document, "Recommended Policies (Task C-2)".

Further reading

- Position Statement (Task A)
- Recommended policies (Task C-2)

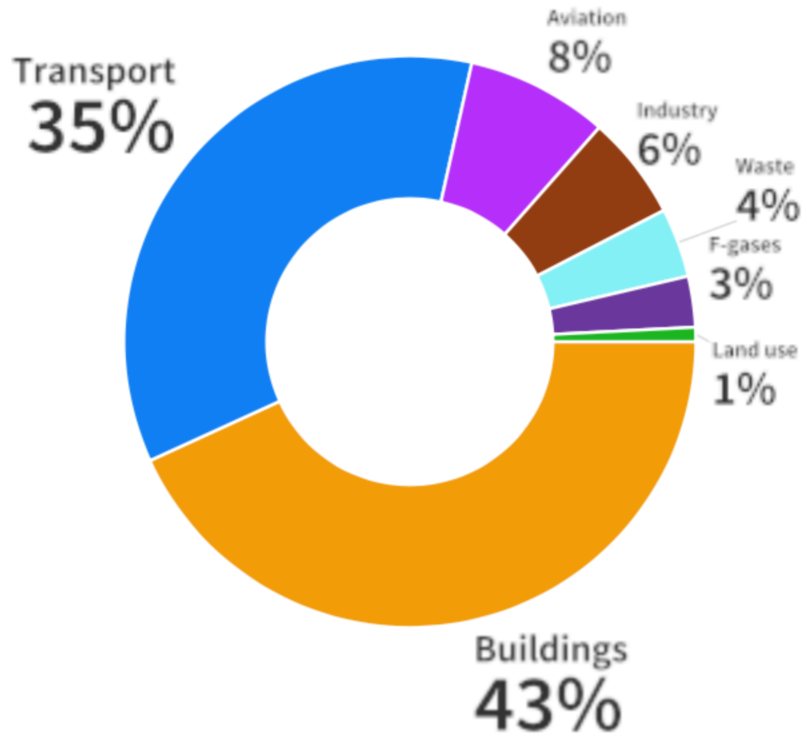


Figure 13: Greenhouse gas emissions from Greater Cambridge, 2018: The majority of emissions currently come from buildings and transport. Emissions from the power sector are included in the sectors in which electricity is consumed.

Implications for the local Plan: **Power**

The future of electricity generation

The UK's electricity generation mix has rapidly decarbonised as coal power stations have been retired and use of wind and solar power has increased. The future electricity generation mix is investigated by the National Grid each year through the development of different future energy scenarios (FES), to give an idea of how the future energy mix may look like. In FES 2020[28] there are four scenarios, three of which are compliant with the 2050 zero carbon target: Consumer Transformation, System Transformation and Leading the Way. We have selected the scenario with the most local energy generation (Consumer Transformation) to understand what this might mean for Greater Cambridge. The main difference between the scenarios is the technology through which low carbon heat is delivered: predominantly electric heat pumps (Consumer Transformation), predominantly hydrogen boilers (System Transformation) and a hybrid of the two (Leading the Way).

The Consumer Transformation scenario relies on the continued deployment of proven technologies with competitive costs such as offshore wind, onshore wind, and solar photovoltaics. System Transformation relies heavily on a hydrogen economy – largely unproven in technical feasibility, cost effectiveness or sustainability[31] .

By 2050, electricity demand in the 'Consumer Transformation ' scenario increases by 60% due to electrification of heat and transport. This scenario also tells us that approximately 1/3 of electricity generated in 2050 will need to come from sources generated at a local scale - a mixture of both onshore wind and solar photovoltaics. The remaining 70% of electricity is likely to come from very large scale sources, such as off-shore wind, perhaps some nuclear, and other sources.

Current Renewable Energy Capacity in Greater Cambridge

The Renewable Energy Planning Database and Sub-National Feed in Tariff Register indicate an installed capacity of 303MW of solar photovoltaic technology in Greater Cambridge in 2020 – this contributes 300 GWh of electricity, or 19.4% of Greater Cambridge's energy demand, well above the current national average of 3.75% for solar. In addition, Greater Cambridge has 26MW of operational onshore wind, generating 42 GWh of electricity per year, or 2.7% of demand. Nationally, onshore wind contributes 10% of energy demand. Greater Cambridge also has a landfill gas and anaerobic digestion plant, collectively contributing 13GWh of electricity per year.

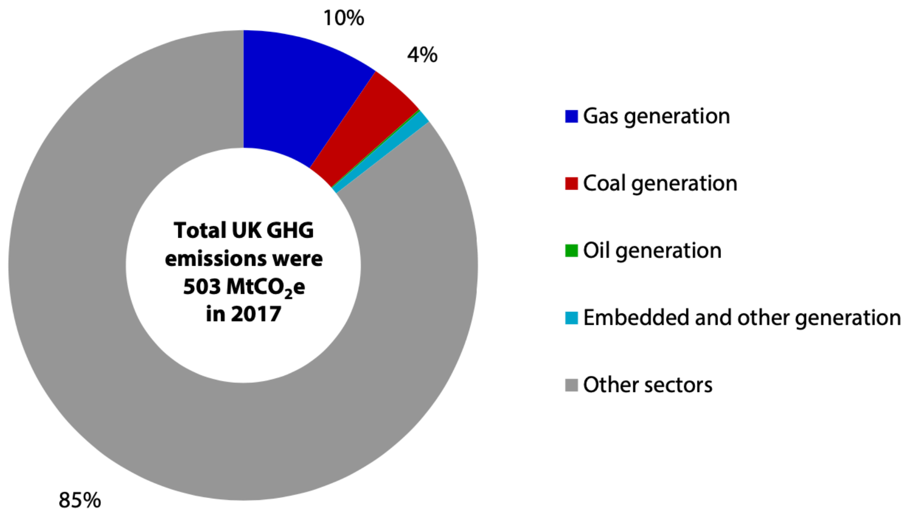


Figure 14: Greenhouse gas emissions from UK electricity, 2017: Emissions from the power sector come from the combustion of fossil fuels to generate electricity. In 2017 15% of all UK GHG emissions were from electricity generation. (© CCC, 2019)

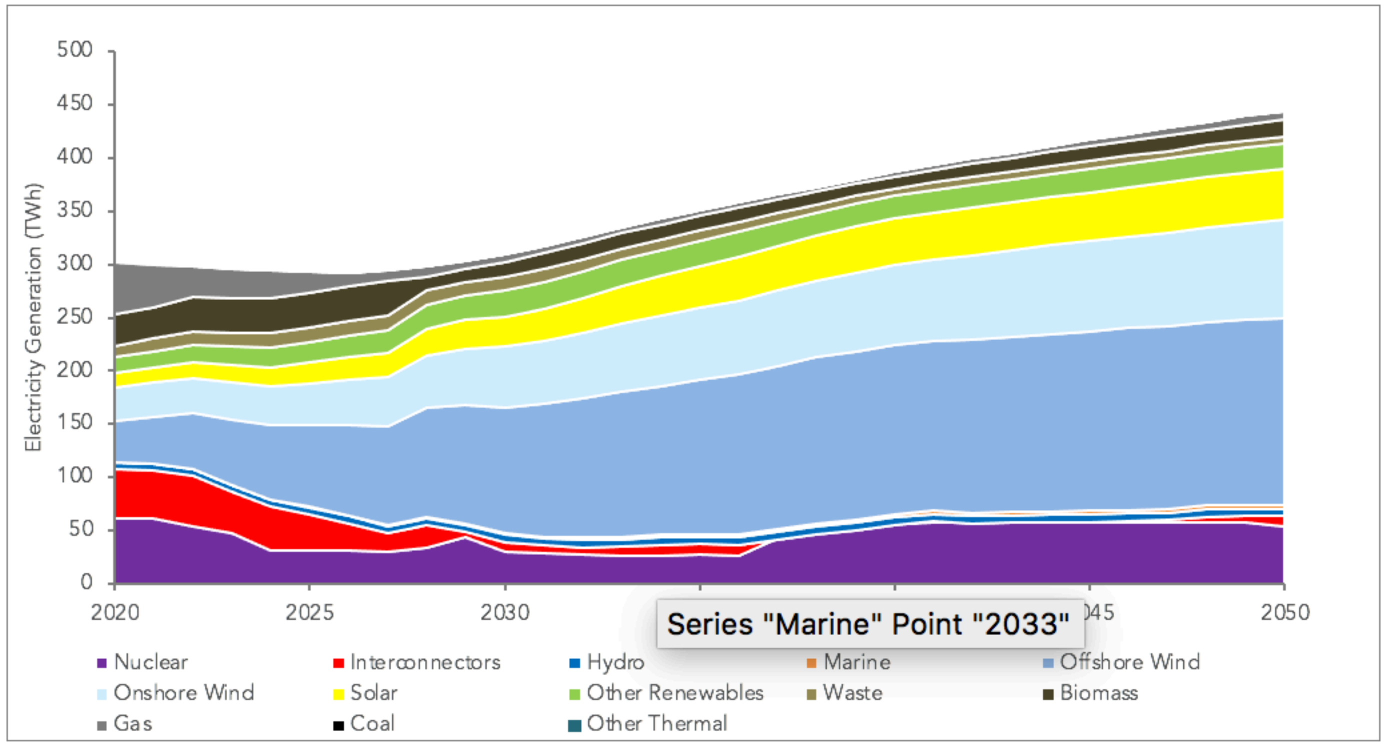


Figure 15: The UK electricity generation mix: Shown for the National Grid's 'Community Renewables' scenario, which currently appears to be the most plausible way to a two degree compliant electricity supply. Wind, solar and nuclear power are the dominant forms of low carbon energy. (© National Grid/Etude, 2019)

Implications for the local Plan: **Power**

The future of renewable energy in Greater Cambridge

Using the National Grid's Future Energy Scenarios 2020 [30] 'Consumer Transformation' scenario as a basis we have sought to give an indication of how much renewable energy should be generated within the boundaries of Greater Cambridge by 2050 in order to fairly contribute to the national generation mix. This considers national supply for all energy demands. We have utilised three simple methodologies and compared the results:

1) **Projected energy demand in 2050**: Installed solar and wind capacity is apportioned to Greater Cambridge based on how much energy Greater Cambridge is likely to use.
2) **Area relative to the total UK area:** this approach considers the area of land within Greater Cambridge relative to the total generation required.
3) **Area relative to the area of UK with low population density (and hence more ability to host large scale renewables)**: this approach discounts urban areas unable to host large scale renewables, and divides renewable energy generation amongst rural areas.

The results are given in the table on the right. Methodologies 1 and 2 do not take into account the relative ability to host large scale renewable energy installations, which dense urban areas are not suitable for. Rural areas will likely need to generate more than their share of consumption to compensate for urban areas. Each of the methodologies have returned similar results. Greater Cambridge already has 303 MW of installed solar photovoltaic, above the 270 MW estimate to be in line with national grid scenarios for 2050. However, installed onshore wind capacity is lower than the national average, and Greater Cambridge should seek to increase this around seven-fold.

We would recommend identifying areas sufficient to accommodate the upper end of the range (i.e. Methodology 1). However, off-shore wind provision may well increase, and there is still much uncertainty, therefore these figures should be used as a guide only.

These methods give us an indication of renewable energy capacity required, but a detailed local renewable energy strategy, is required to better inform this. Greater Cambridge Shared Planning will also conduct a visual and spatial assessment of potential wind turbine locations.

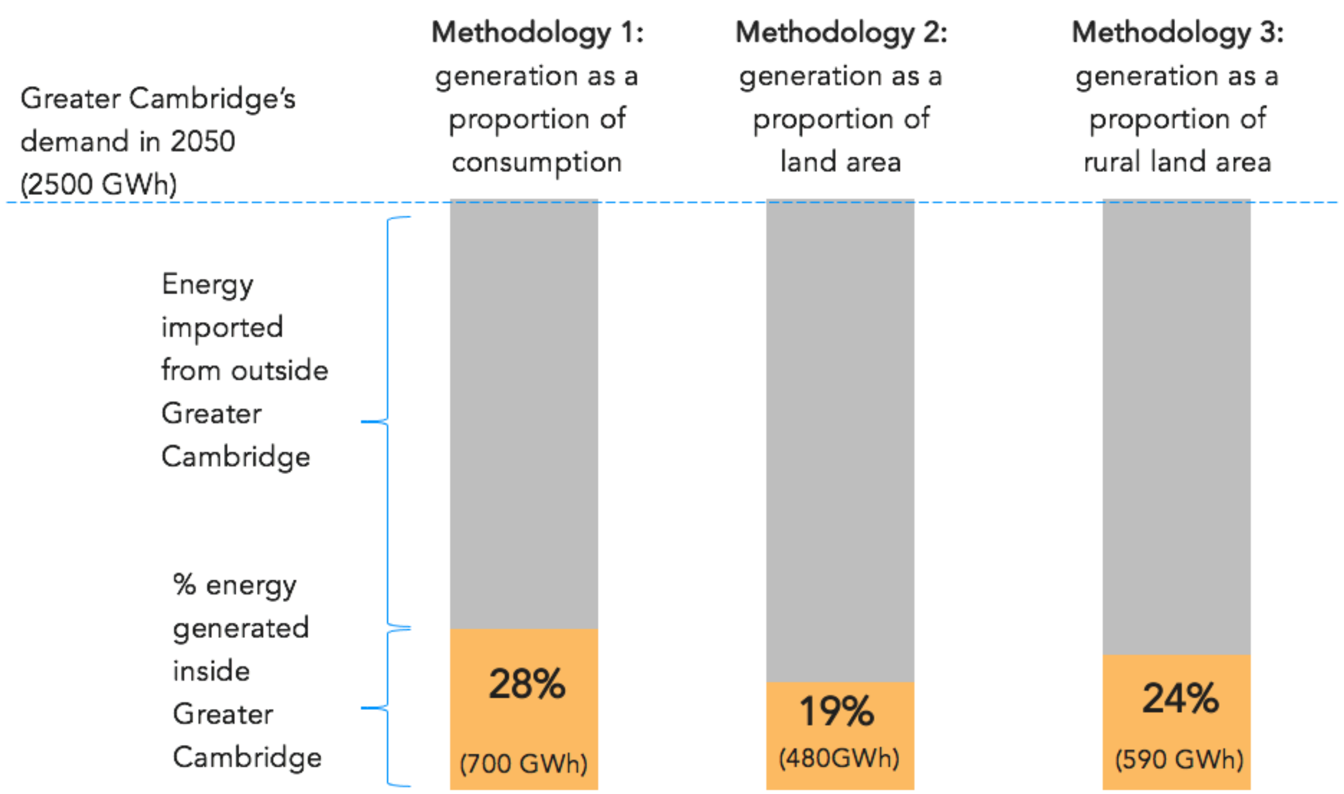


Figure 16: How much energy should Greater Cambridge generate within its boundaries? We used three different methodologies to understand how much renewable energy generation Greater Cambridge should aim to generate. Projected 2050 figures from the National Grid's Future Energy Scenarios 2020 "Consumer Transformation" scenario have been used to estimate energy demand.

	Methodology 1: generation as a proportion of consumption	Methodology 2: Generation as a proportion of land area	Methodology 3: Generation as a proportion of rural land area
Solar PV arrays	270 MW	190 MW	230 MW
Wind turbines	190 MW (95x 2MW turbines)	130 MW (65x 2MW turbines)	160 MW (80x 2MW turbines)

Figure 17: How much solar PV and wind should we plan for? Taking the generation requirements from page 13, and using the same relative split between solar and wind used in FES 2020 "Consumer Transformation" scenario, we have suggested the required solar and wind capacities that should be targeted in Greater Cambridge. In reality the proportion of each technology could vary slightly but a combination is important for diversity.

Implications for the local Plan: **Power and Infrastructure**

Grid Infrastructure

The Royal Town Planning Institute (RTPI) published the report "Planning for a Smart Energy Future" in July 2019. The report looks at the role of planning policy (both local and national scale) in shaping a clean energy future through supporting the development of smart grids. The report states that local planning authorities should ensure that their policies and implementation support smart energy, and that smart energy should be central to planning for new homes, jobs, transport and infrastructure.

A key recommendation relating to grid infrastructure to come out of the report is that Local Authorities should work with the local Distribution Network Operator (DNO), National Grid and the storage industry to identify potential areas for allocation of energy storage uses and consider safeguarding or allocating such sites through the local plan process.

Battery Storage + Interconnectors

As wind and solar energy are intermittent, and demand for electricity constantly varies, it is necessary to have mechanisms to balance power in the electricity network. The main options are: demand side management; battery storage and importing/exporting power through interconnectors with other countries.

The National Grid's "community renewables" scenario shows a steep rise in the need for battery storage capacity. The UK currently has a pipeline of over 14GW of battery storage projects, many of which are being co-located with wind and solar generation. However, projections estimate we will need twice that. Local Plans will provide a crucial role in enabling these projects.

It is not yet clear how much storage capacity will be deployed at a utility scale, versus smaller systems within buildings, however larger systems can achieve significant economies of scale and their growth may render the need for building-level storage less important.

Figure 18: Utility scale battery storage: Large scale batter storage projects such as this are likely to be deployed rapidly in the coming years. They offer significant economies of scale. (© Energy Saving Trust, 2020)

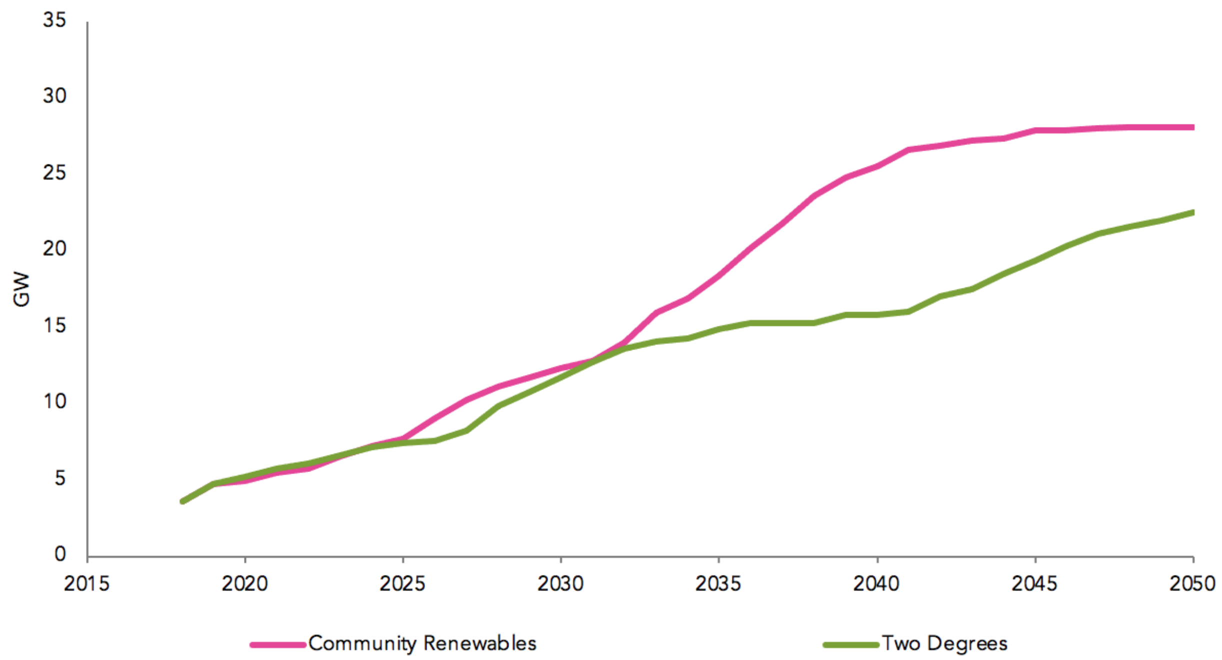


Figure 19: Battery storage capacity: Battery storage capacity is likely to increase in all of the National Grid's two degree compliant scenarios. Will this be at a utility scale, or within buildings? (© National Grid, 2019)

Implications for the local Plan: **Power and Infrastructure**

Agile Tariffs

Agile electricity tariffs vary in response to wholesale electricity pricing. They are likely to play a core role in future electricity supplies by offering a mechanism to incentivise consumers to use renewable energy when it is being generated. This could significantly reduce a household's electricity costs, while increasing use of clean renewable electricity. Local policy could promote measures that increase the potential for participation, discussed below.

Demand Side Management

There are three core opportunities for demand side management: electric vehicle charging, space heating, and hot water heating. For most households these will represent the three largest end uses of electricity over which some degree of time-control is possible and desirable.

Smart charging for electric vehicles is already mandated by the UK government. Smart heating and hot water controllers are already on the market, though require an electric heating system with hot water storage to work. They work by receiving pricing signals from a power company and then acting on that signal, for example by turning down the heating when electricity is expensive.

Excellent levels of building fabric efficiency are useful in unlocking the benefits of smart heating controls as this decouples the need for heat with external temperature variations. This means that homeowners can allow their thermostat to turn off heat sources for many hours without the house perceptibly cooling. Hot water storage is also important in the form of well insulated hot water tanks, rather than instantaneous hot water sources.

Recommended policies for power and infrastructure

- The local plan should facilitate expansion of renewable energy in the districts as far as possible.
- To ensure on-shore wind and solar photovoltaic energy is delivered in appropriate locations, the local plan should seek to allocate sites for installation.
- Provision of renewable energy Supplementary Planning Documents (SPDs) covering large scale on-shore wind, large scale solar photovoltaic and other appropriate low carbon energy sources.

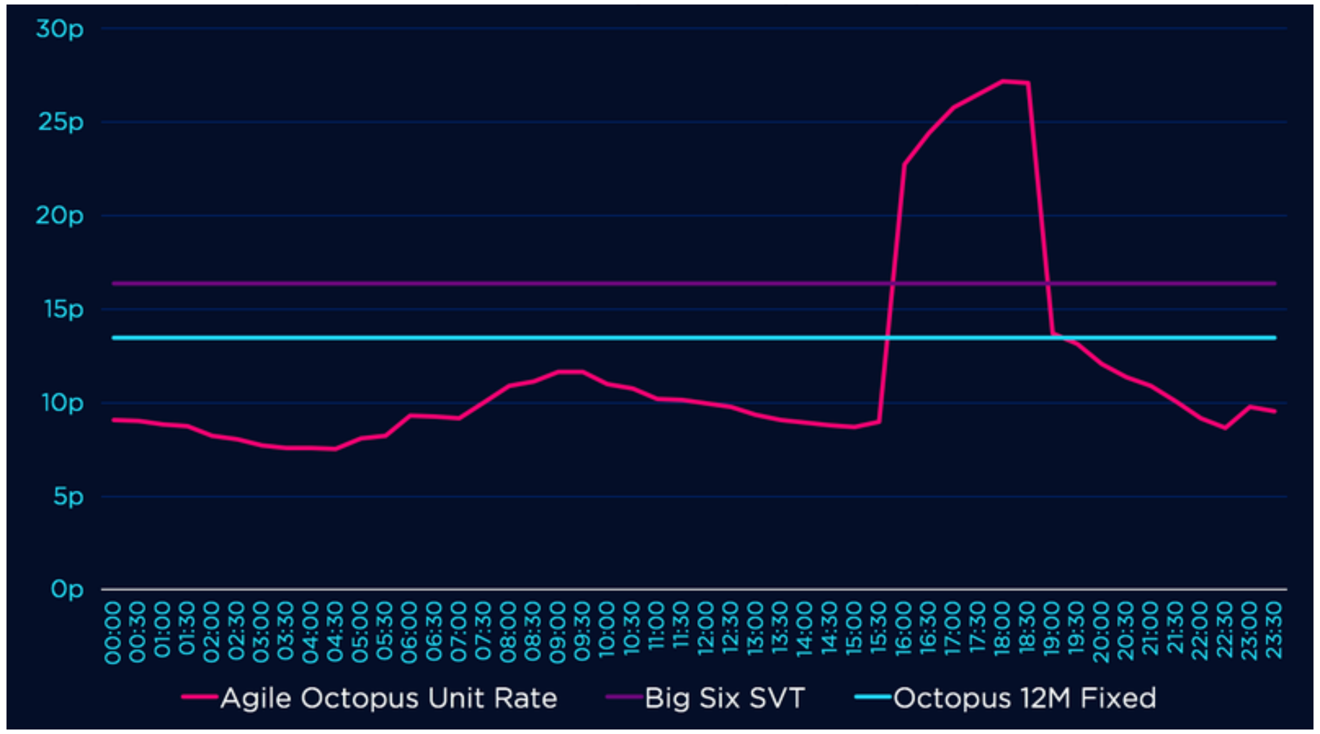


Figure 20: Flexible electricity tariffs: Net zero carbon buildings with high levels of fabric efficiency and heat pumps can be well positioned to take advantage of "agile" tariffs, which offer cheaper electricity at times of the day where demand is low relative to generation.

Figure 21: Smart thermostats: Smart thermostats are a way of unlocking the power of "agile" tariffs and demand side management to provide affordable low carbon heating. Used in combination with services such as If This Then That (IFTTT) they empower users to access cheap low carbon electricity.

Implications for local plan: **Existing Buildings**

The future for existing buildings

Our analysis shows that existing buildings currently account for 43% of GHG emissions in Greater Cambridge. If existing buildings were left as they are, they alone would consume Greater Cambridge's entire carbon budget in 14 years.

It is clear therefore that tackling carbon emissions from existing buildings is of paramount importance.

The CCC concluded that at least 90% of existing buildings should have energy efficient retrofits for the UK to meet its zero carbon targets. SCATTER and our own analysis concluded similar results.

Buildings in Greater Cambridge

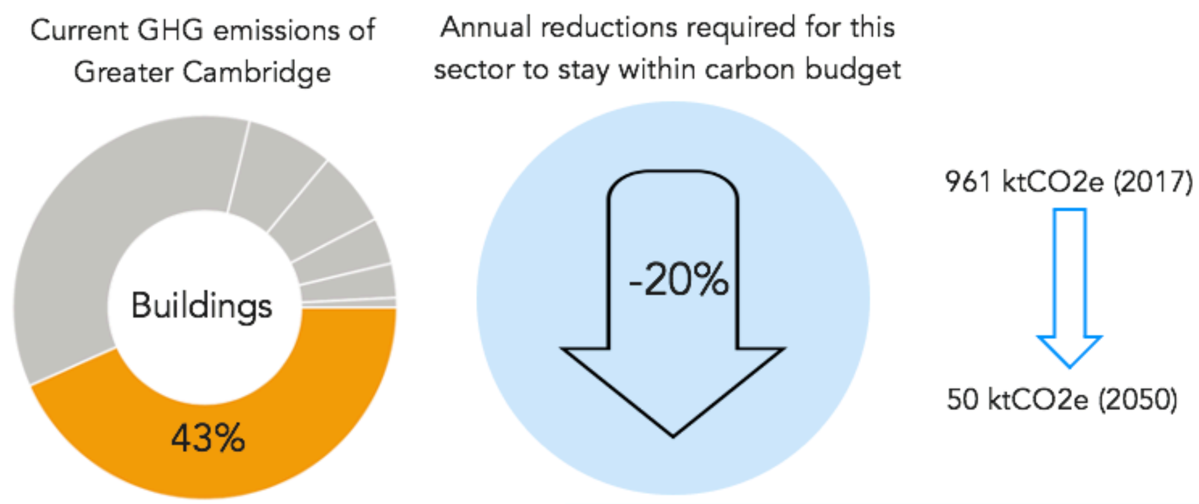
The region has a high number of internationally, nationally and locally significant heritage grade buildings. The 'net zero carbon from buildings' target has to accommodate some buildings which simply can't be adapted to eliminate all emissions. Therefore many new buildings may have to ultimately be 'net positive' – i.e. produce more energy than they use – in order to compensate for existing buildings that cannot adapt enough.

The policy issue will be to take a pragmatic view across all of the listed, notable and conservation area buildings. The question of whether their heritage asset value truly warrants 'absolute' preservation will need consideration. For example, domestic properties which could be greatly improved by the addition of solar panels or upgrading of windows but are prohibited currently by their conservation status. Consideration could also be given to whether some buildings can be re-purposed to house functions more suitable to their energy profile.

There are notable examples of successful retrofit of existing buildings in Cambridge. New Court at Trinity College received a sensitive retrofit with sustainability and energy efficiency at its core. The Entopia building, not listed but in a conservation areas, is also being retrofitted to a very high standard by the Cambridge Institute for Sustainability Leadership (CISL).

What the local plan should do

The ability of the local plan to influence the carbon emissions of existing buildings is limited. However, there are areas in which policy can impact existing buildings: listed buildings; buildings in conservation areas; buildings which are undergoing a "change-of-use". Key recommended policies are listed in the report "Recommended Policies" that forms part of this evidence base.



Case study: New Court, Trinity College

Grade I listed building

88% reduction in carbon emissions

75% reduction in energy demand

Internal wall insulation

Low temperature underfloor heating

New mechanical ventilation with heat recovery system

Fig 22: Trinity College New Court is a Grade I listed building that successfully underwent a energy efficient retrofit

Case study: Entopia Building

EnerPhit retrofit

Passivhaus certified triple glazed replacement windows

Solar photovoltaic panels

82% reduction in whole life carbon (expected)

Fig 23: The Entopia building for the Cambridge Institute of Sustainability Leadership is undergoing an EnerPhit retrofit. Image: Architype.

Implications for local plan: **New Buildings**

The future of buildings in Greater Cambridge

Our analysis of different zero carbon pathways for Greater Cambridge shows that buildings are one of the sectors which must target zero emissions. The CCC, CUSPE, SCATTER and our own analysis all concur that:

- New buildings from 2020 must be designed to be **net zero carbon.**
- New buildings built from 2020 must be **ultra-low energy** (extremely energy efficient)
- New buildings must be heated by **low-carbon heat** – e.g. heat pumps. There should be no gas boilers installed in new homes from 2020.

The Committee on Climate Change has published a report in 2019 named 'UK housing – fit for the future?'. The report highlights the need to build new buildings with 'ultra-low' levels of energy use. It also makes a specific reference to space heating demand and recommends a maximum of 15-20 kWh/m_2/yr for new dwellings. For reference, Passivhaus requires 15 kWh/m_2/yr, and most new domestic buildings have a heating demand of 40-80 kWh/m_2/yr.

The Department for Business, Energy & Industrial Strategy (BEIS) asked the Green Construction Board to respond to the 2030 Buildings Energy Mission. The background report published as part of this response reviewed the evidence from new buildings which have already achieved a 50% reduction in energy use, compared with typical benchmarks. There is a lot which can be learnt from these buildings as there are recurring approaches, techniques and systems that are responsible for their excellent energy efficiency.

Targets

We conclude that future development in the region should be designed and built to be zero carbon without delay. Greater Cambridge expects to build 1,700 new homes every year. To continue to design new developments with net positive carbon emissions simply adds to the already significant retrofit challenge of the future. It also passes the costs of retrofit onto the homeowner – costs that would be significantly less if implemented at the time of construction. It is possible to build net zero carbon homes and buildings today.

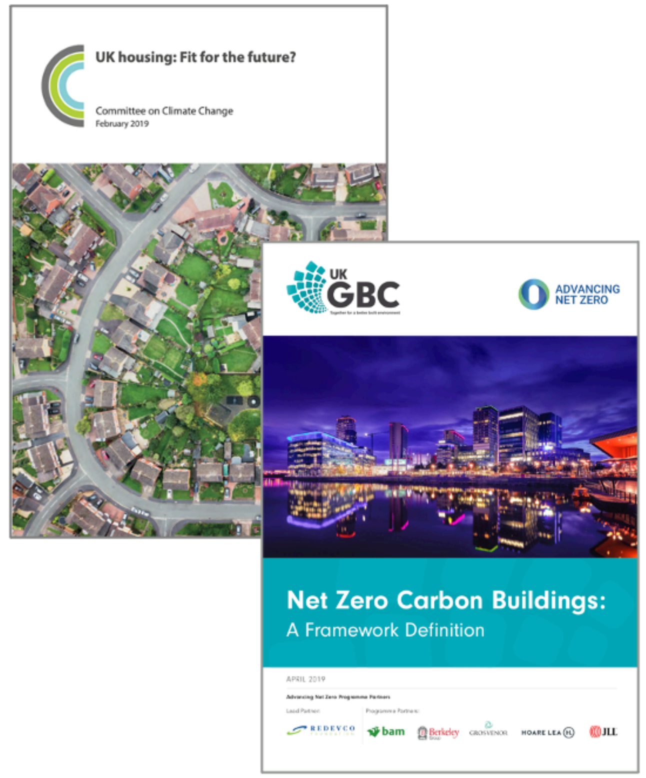
To build net-zero carbon homes and buildings with immediate effect is consistent with a fair contribution towards the Paris agreement target. It does not unnecessarily consume Greater Cambridge's remaining carbon budget, and it is also consistent with the Climate Change Act 2008.

Further reading

- Position Statement (Task A). The sections 'Technical Feasibility' (Task D) and 'Cost Analysis' (Task E) takes an in depth look at delivering zero carbon new buildings.

"We will not meet our targets for emissions reduction without near complete decarbonisation of the housing stock"

Committee on Climate Change, UK Housing: Fit for the Future?



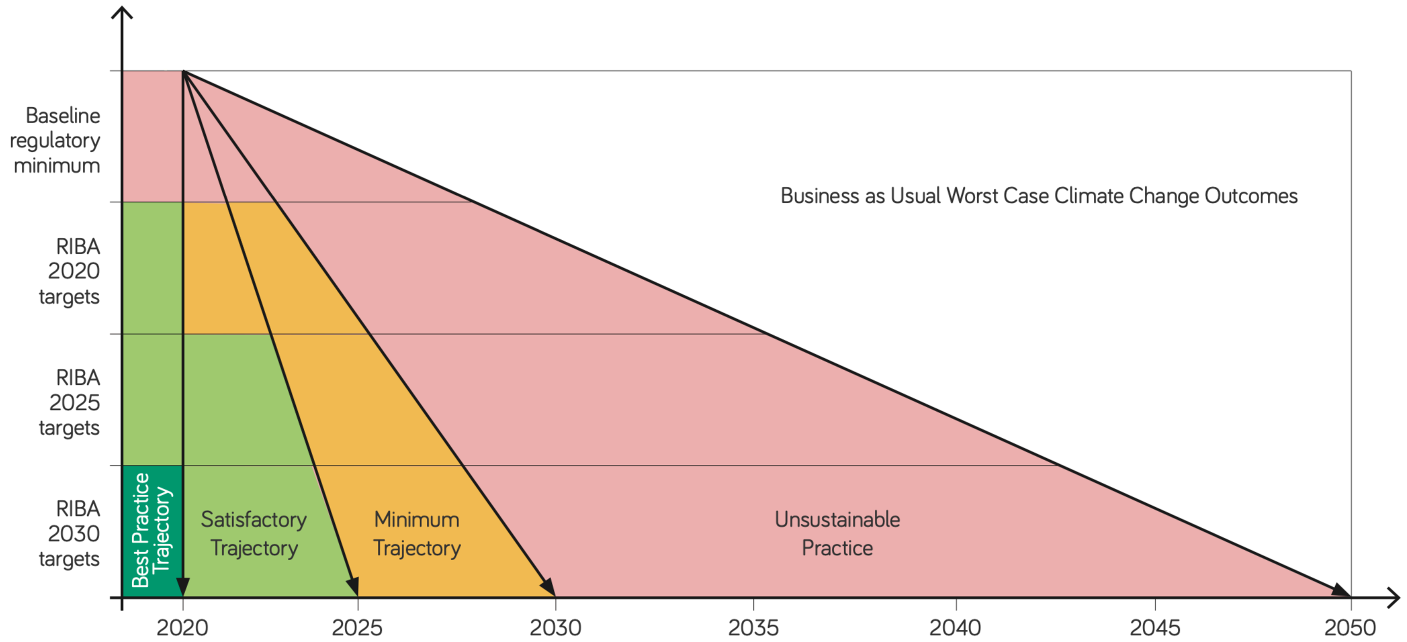


Fig 24: RIBA 2030 Climate Challenge Trajectories

Implications for the local plan: Overheating in buildings

Overheating risk in buildings

Average monthly temperatures are increasing across the UK due to climate change. Compared with the rest of the UK, external temperature and solar radiation in Greater Cambridge are in the middle of the range, and represent a moderate risk of overheating. However, there are many other factors that contribute to overheating, such as aspect, proportion of glazing, the ability to open windows, presence of community heating and amount of surrounding green space[15] .

If overheating risk is not mitigated at the design stage, there is the risk that some dwellings and buildings will overheat even on average summer days. This can lead to uncomfortable conditions and in some cases can have serious health impacts, including death. During the heat wave of 2003, a total of 2,091 excess deaths were recorded in England and Wales[14] .

Without care and attention at the design stage, overheating in buildings will lead to an increase in the use of cooling systems, generating increased demand for electricity, increasing running costs of dwellings and jeopardising our climate goals.

Building Regulations alone is insufficient to mitigate risk

The checks for overheating in building regulations (for both residential and non-residential developments are rudimentary. There are sophisticated modelling tools available – e.g. CIBSE TM52 and TM59 (for non-residential and residential heating checks respectively) but these are not mandated by building regulations.

Good Homes Alliance Overheating Tool

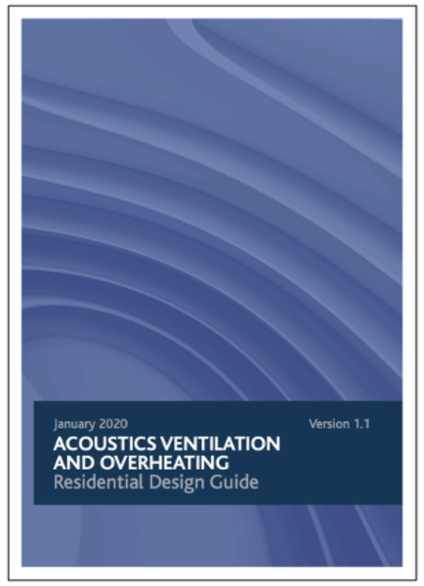
The Good Homes Alliance (GHA) have developed guidance and a tool[15] for use on residential developments at the pre-planning stage to identify key factors contributing to overheating risk, and possible design measures to mitigate risk. It has been designed to provide practical, bespoke design guidance without the need for detailed modelling.

The London Plan now requires all new residential developments to undertake an overheating risk assessment at planning stage using the GHA tool[17] .

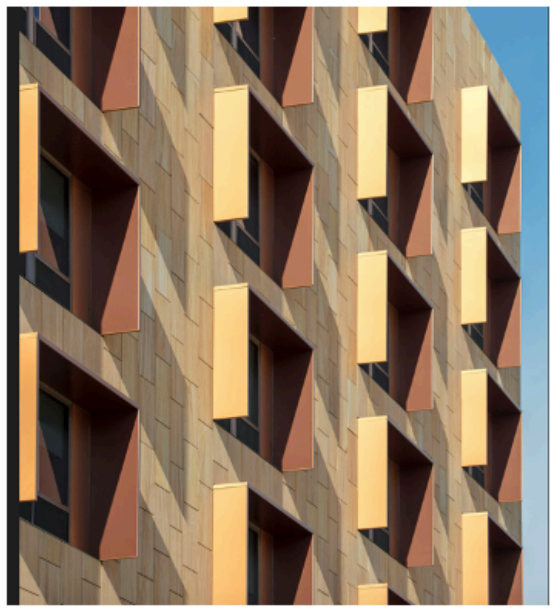
What the local plan can do

We recommend that the local plan contains policies that require early stage overheating checks using the Good Homes Alliance "Overheating in New Homes" tool demonstrating that the design is at "low" risk of overheating. TM59 Analysis should also be provided at pre-completion stage.

For non-domestic building, a TM52 analysis should be provided at pre-completion stage.



The above documents and guides provide guidance on mitigating overheating risks in residential buildings [15], [14], [16].



Tooker House - Solomon Cordwell Buenz's (SCB)

Sulgrave gardens: Cartwright Pickard Architects

Overheating mitigation measures could include adding external shading (either building mounted or trees), the colour of surfaces, the presence of thermal mass and the ability to take advantage of secure night cooling.

Implications for local plan: Transport

The future of transport in Greater Cambridge

Of the pathways to zero carbon that we have reviewed, all show that transport has to date been static or increasing in its emissions, but that it has the potential to become a zero carbon sector. Indeed, our analysis shows that it is essential for it to do so.

Currently, transport represents approximately 35% of Greater Cambridge's GHG emissions through the combustion of petrol and diesel. To be consistent with a 1.5-2C pathway, Greater Cambridge should reduce transport emissions by at least 13.5% per year – ideally targeting 20% per year.

The UK government has announced the intention to ban the sale of new petrol and diesel cars from 2030 and require all new cars and vans to be zero emissions from 2035 [13] . Options for low emissions vehicles include hybrid petrol/electric (still a source of CO_2), full electric, biofuel (still a source of CO_2) and hydrogen. The market appears to be responding at pace to electric vehicles, especially cars and light vehicles. There are also electrification options for freight vehicles and public transport, however hydrogen is another contender in this domain.

Electric and hybrid electric cars currently represent less than 2% of total cars registered in the UK, however, uptake is increasing exponentially. Pure electric car sales increased 184% from September 2019 to September 2020 [11]. This actually exceeds the National Grid Future Energy Scenarios 2020 best case forecast .

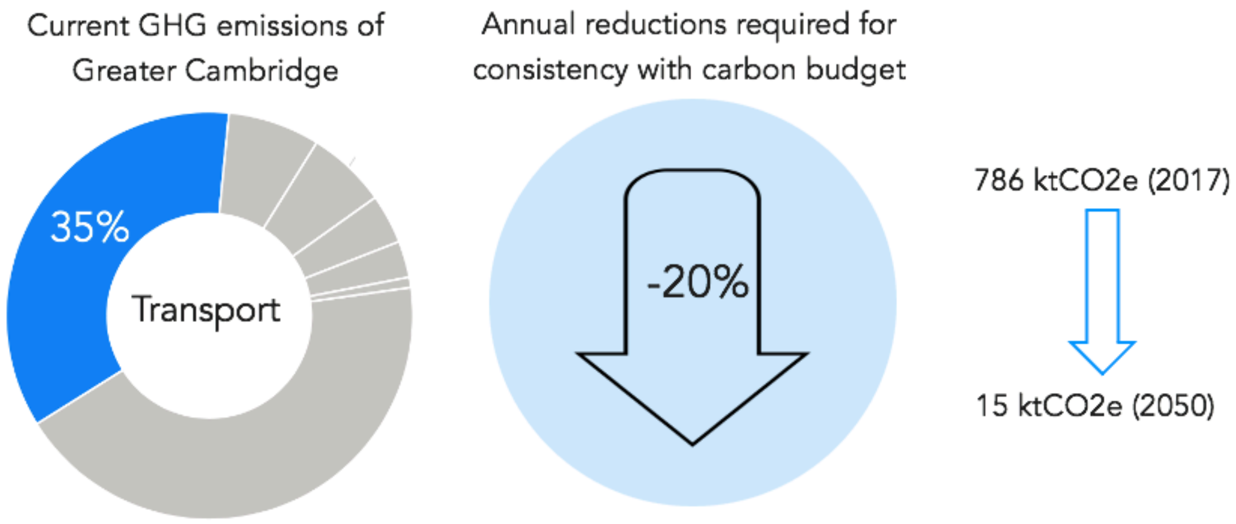
Barriers to uptake include battery capacity, lack of charging points and the high costs of Evs. However cost parity is expected by mid-2020s [10]. Ongoing research into batteries will help to address range and sustainability issues. There are ambitious plans to roll out additional charging points across the UK.

In tandem with the transition to zero emission vehicles, the Committee on Climate Change recommends that we need to realise a reduction in total car journeys of at least 10% by 2050. This will necessitate a move towards greater use of walking, cycling and public transport.

What the local plan should do

The Local Plan will play mostly a facilitatory role in reducing emissions from transport (Task A). It should use all available mechanisms to ensure adequate charging points are provided across new developments, land is safeguarded for the expansion of public transport and walking/cycling routes, and new development is focused in locations that are already (or can be) well connected to local amenities and existing public transport systems.

Please see the "Policies" section for more detail.



Implications for local plan: Land-use

The role of the land

Land can be both a source and a sink of GHG emissions, depending on land-use practices.

Carbon and methane is stored below ground in soils and peatland, and above ground in trees and plants. The land will therefore play an important role in carbon sequestration – mopping up CO_2 already emitted into the atmosphere.

The Committee on Climate Change (CCC) report, "Land Use: Policies for a Net Zero UK" (Jan 2020) includes a number of recommendations relating to the key objectives of delivering low-carbon farming practices and changing the use of land to reduce emissions and increase sequestration. See table on the right which lists the key recommendations and how the local plan can support them.

Limiting emissions from the land

The land naturally emits some greenhouse gas emissions through natural cycles and processes. But if these become out of balance, they can become a problem. For example, the draining of peatland soils for agriculture or development can lead to huge amounts of stored carbon being released into the atmosphere.

The biggest impact the local plan can have on limiting emissions from the land is through how land is allocated for development and the protection of carbon-rich soils. Using the land as a carbon sink is discussed on the next page.

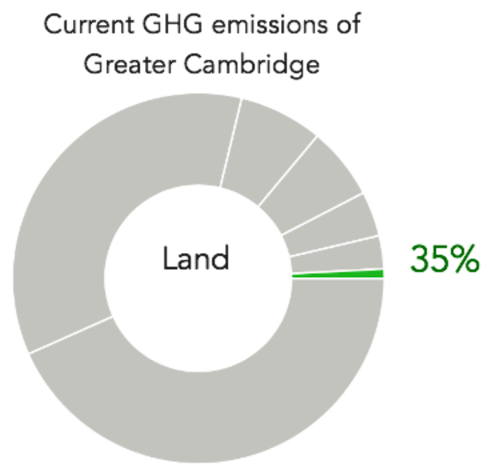
Allocating land for development

Carbon-rich soils should be protected from development, where possible. It is therefore recommended that sites should be assessed for their ability to release or store GHG emissions prior to permission being granted for development.

Protection of carbon-rich soils

The creation, preservation and management of habitats that are known to be beneficial in terms of storing carbon (such as woodland, grassland, wetlands, peatlands and agricultural land), can also have many other benefits, including increasing biodiversity, improving resilience to the effects of climate change and providing amenity for the local community.

Refer to peatlands chapter in Task A report.



CCC Recommendation	Can the local plan influence?
Low carbon farming practices	No
Afforestation, agro-forestry, hedge creation and broadleaf management	Yes. Through allocation of land for projects.
Upland peat restoration	N/A
Lowland peat restoration and management	Yes. Through allocation for restoration and protection.
Energy crops	Indirectly through being supportive of appropriate new bioenergy applications.
Enabling measures	No. However wider council policies and measures can support.
Diet change	No. However wider council policies and measures can support.
Food waste reduction	No. However wider council policies and measures can support.
Trade policies	No. However wider council policies and measures can support.
Wider government agricultural strategy	No.
Monitoring, reporting and verification	No.

Implications for local plan: Forestry and agriculture

The need to take carbon dioxide out of the atmosphere

The four emissions reductions scenarios we have analysed all show hard to treat, residual emissions remaining in 2050. To achieve carbon neutrality and ensure we do not overspend our carbon budget, we need to compensate for those emissions through removal of an equal amount of carbon from the atmosphere. The land has a key role to play here.

Almost all sectors will likely have residual, hard-to-eliminate emissions – for example, industrial processes for which suitable fossil fuel alternatives have not been found.

In addition to the Committee on Climate Change's Land-Use report[21] , the Royal Society/Royal Academy of Engineering have recently published a report "Greenhouse Gas Removals"[22] which list recommendations for carbon sequestration in the UK. A summary is given on the right, with those actions relevant to the local plan highlighted. The same study has assessed the potential of each method to store carbon. The local plan can help facilitate three of the four methods that are proven and ready for deployment.

Afforestation

Sites are needed across the UK for reforestation. The CCC recommends the UK needs to increase forest cover to 19% [01] . Greater Cambridge is a predominantly agricultural area, with a low forest area (less than 10%) [08] . Therefore, Greater Cambridge should seek to understand the potential of targeting a similar increase and sites should be allocated for creation of new multi-species woodlands. Multi-species woodlands store more carbon, increase biodiversity and are more resilient to disease than mono-culture forests.

Habitat restoration

Woodlands and forests are not the only habitats that can store carbon. Peatlands[25], wetlands[26], grasslands[24] and others can store significant amounts of carbon. Restoration of these habitats can turn degraded habitats into carbon sinks.

Building with biomass and low carbon concrete

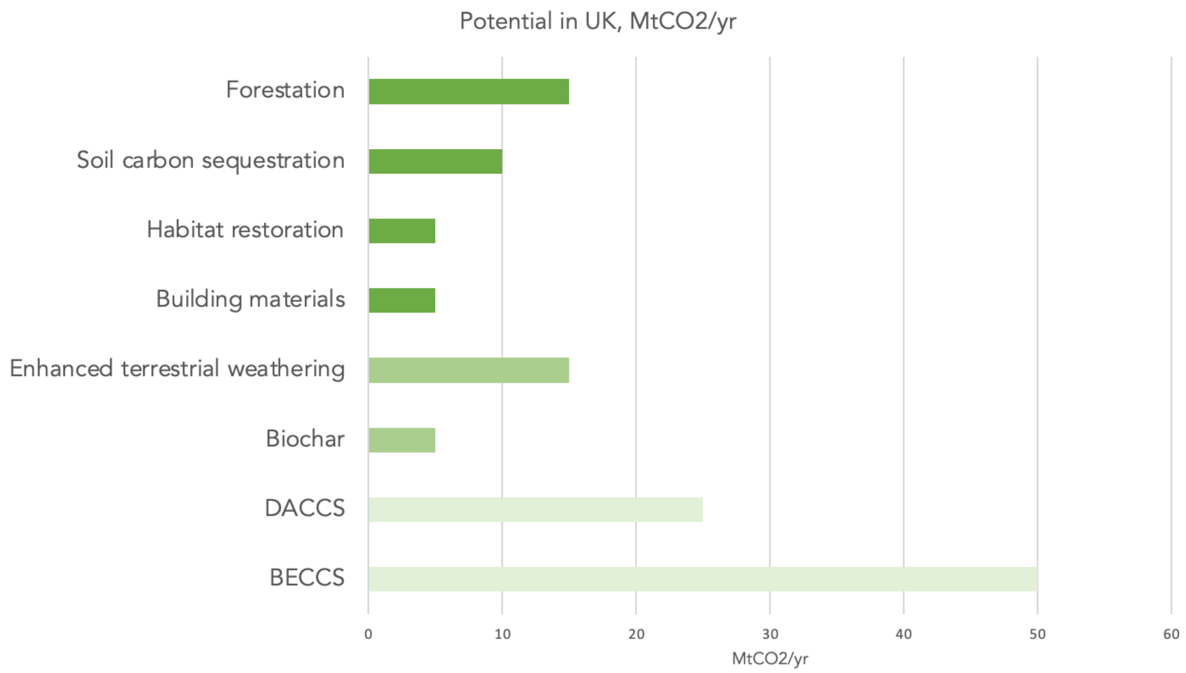
Timber and low-carbon concrete can lock up carbon indefinitely. Through encouraging the utilisation of wood and and low-carbon concrete, buildings can become effective carbon sinks.

Further reading

- Chapter on Peatlands (Task A)
- Chapter on Offsetting (Task I)

		Greenhouse gas removal method		
		Increased biological uptake	Natural inorganic reactions	Engineered removal
Storage location	Land vegetation (living)	Afforestation, reforestation and forest management; Habitat restoration;		
	Soils and land vegetation (dead)	Soil carbon sequestration; Biochar	Enhanced terrestrial weathering	
	Geological	BECCS	Mineral carbonation at surface	DAC + geological storage DAC + sub-surface mineral carbonation
	Oceans	Ocean fertilisation	Ocean alkalinity	DAC + deep ocean storage
	Built environment	Building with biomass		Low-carbon concrete

Greenhouse gas removal methods by storage location (from "Greenhouse Gas Removals", RS and RAE. The local plan can have a direct influence on those highlighted in orange.



Potential of greenhouse gas removal methods in the UK. Dark green are methods ready for deployment. Mid-green and light-green are methods that are yet to be demonstrated at scale. Light-green are methods requiring carbon capture and storage.

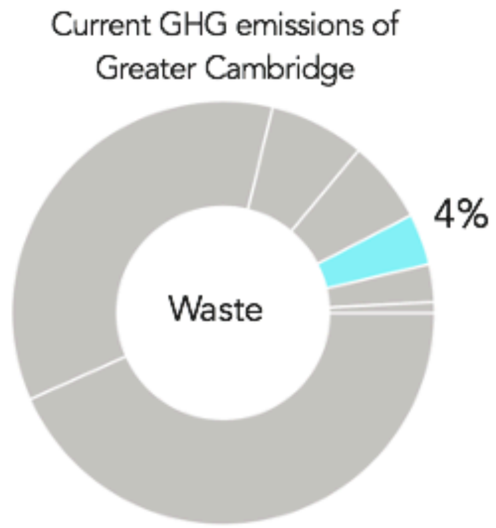
Implications for local plan: Other sectors

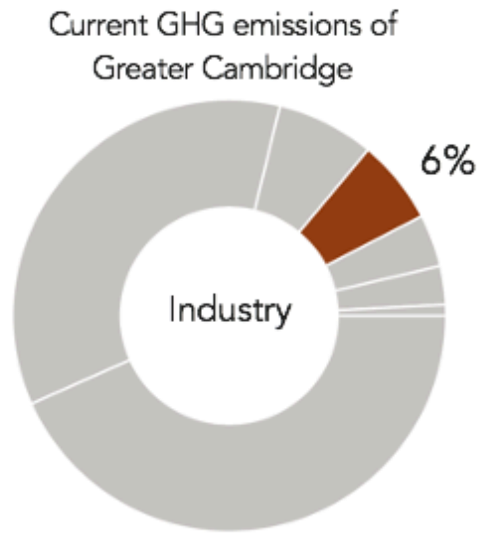
Waste

The Committee on Climate Change have recommended a target recycling rate of 70% by 2030 at the latest with an immediate ban on biodegradable waste going to landfill. New housing will have to have the space to allow segregation of waste and constrained collection to encourage reuse.

For commercial waste and in the context of the local plan, particularly construction waste, strict limits should be set for all construction sites on recycling rates, waste to landfill and total quantities of waste.

The Minerals and Waste Plan produced by Cambridgeshire County Council will also have a role in allocating potential sites for additional waste processing facilities that may be required in response to increased recycling rates and diversion from landfill. These could also include sites for large scale anaerobic digestion to process agricultural waste into biogas for energy generation.





Water

Management of water resources in Cambridgeshire is a significant challenge. Both excess (flooding) and deficit (drought) are increasing in frequency as weather patterns have changed due to Climate Change. The attenuation of rainfall run off into the river network, both urban and rural, is a critical factor in levelling out the increasingly extreme peaks and troughs of weather events. However, surface water run-off and other mitigation measures are beyond the remit of this evidence base.

Of carbon emissions associated with water, 89% are from water heated in the home, and 11% are from water supply and treatment[27]. The local plan can support GHG emissions associated with water use through requiring water efficiency standards in buildings. By doing so, demand for water will be reduced, less energy will be required for hot water heating, and demands on water treatment facilities will be less.

Industry

Industrial processes within Greater Cambridge are expected to represent a significant portion of emissions in 2050. They are more difficult to abate than emissions from other sectors.

While the local plan doesn't have a large scope to influence emissions in this area, it would be worthwhile considering the potential of co-location of different industries in order that inputs/outputs can be shared, and efficiency increased, for example food-manufacturing directly adjacent to a bioenergy plant. It would also be reasonable to request a requirement deliver a certain amount of renewable energy for any applications for new industrial sites.

Implications for local plan: F-gases

F-gases

F-gases, while a small proportion of Greater Cambridge's current GHG emissions (around 3%), are a potent greenhouse gas. There are four F–gases included in the UK's GHG inventory, however 94% are from one group: HFCs. HFCs are used in refrigeration and air conditioning systems, aerosols, medical inhalers, and fire equipment. The other F-gases are mainly used in industry and electricity distribution.

The use of HFCs in particular is set to increase rapidly due to heat pumps being a good solution for low carbon heat for buildings, and as air conditioning systems become more widely used as summer temperatures increase.

Industry is reacting to the need for refrigerants with low Global Warming Potential, driven largely by the European F-gas regulations and the Kigali amendment, which will phase out some refrigerants with high GWPs in 2022 and continue to reduce the total amount of refrigerant available for sale, further incentivizing the use of low GWP refrigerants. It is essential that the UK either continues participating in this regulation or it develops and enforces a regulatory regime that is at least as strong.

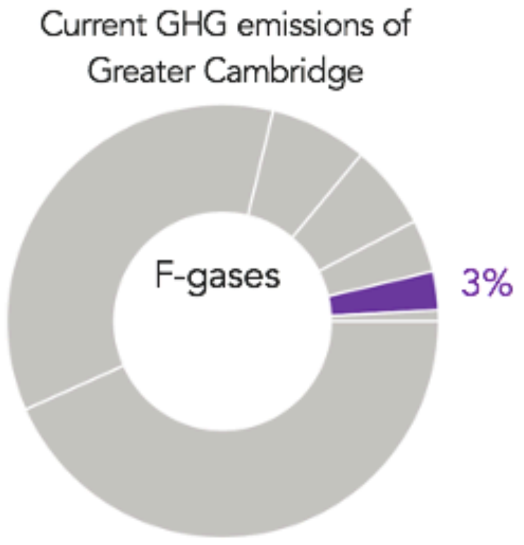
It is imperative that policies and regulations are developed that foster responsible specification, management and disposal of refrigerants. The greatest risk in leaks is at end-of-life, however it is possible for refrigerants to be recovered and re-used.

What the local plan should do

We recommend policies are put in place that encourage the need for refrigerant systems to be reduced through passive design, use of low GWP refrigerants where possible, minimize refrigerant charge (the amount of refrigerant in the system), mitigate refrigerant leakage through leak detection and high-quality sensors, and enhanced refrigerant recovery at the end of life.

Further reading

- Technical Feasibility, Task D



Conclusion

The pace and scale of emissions reductions required

Greater Cambridge's remaining carbon budget for a fair contribution to the national and global effort to stay withing a 1.5-2C temperature rise is 11 $MtCO_2$. If we continue to emit emissions at the rate they were in 2017, this entire carbon budget would be used within 7 years (by 2027).

Some methods and means of carbon reduction are developed, tried and tested. Others are theoretical. Even with optimistic scenarios, there will likely be remaining, unavoidable emissions in 2050 from hard-to-treat sources. These emissions will need to be offset, but the means of offsetting all of these residual emissions do not yet exist at scale. We must therefore not be complacent in dealing with emissions which we have the technological means to eliminate, such as those from buildings and transport. The local plan should take every opportunity to reduce emissions across all sectors where possible.

The power of the local plan

The new local plan can have varying levels of impact on different emissions.

1. Minimise emissions from new buildings – zero carbon buildings policies
2. Facilitate the expansion of renewable energy generation in order that current, existing emissions can be reduced throughout all sectors.
3. Minimise emissions from transport by supporting and facilitating low carbon transport.
4. Facilitate the decarbonisation of heat.

Policies

The findings from the analysis within this chapter, and the remaining chapters in this evidence base culminate in suggested policies for the new local plan to include.

The policies are laid out in a separate chapter – "Recommended policies".

Step 1

The local plan's main responsibility will be ensuring new development does not unnecessarily increase overall emissions within Greater Cambridge

Step 2

The local plan's greatest ability to influence emissions reductions from existing sources, across all sectors, is through facilitating the decarbonisation of the electricity grid through renewable energy provision.

Step 3

The local plan should exercise its powers where possible to decarbonise transport. This should be through a mixture of encouraging active transport, expansion of public transport services, and provision of infrastructure for low-carbon transport (e.g. electric car charging networks).

Step 4

The local plan should aim to facilitate the transition to low carbon heat in buildings through consideration of low carbon heat networks where appropriate, permissive policies, local development orders and a review of conservation policies.

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Task C
Emissions reductions targets
Appendices

Appendix A
Key issues raised in during the stakeholder workshop – general concerns raised

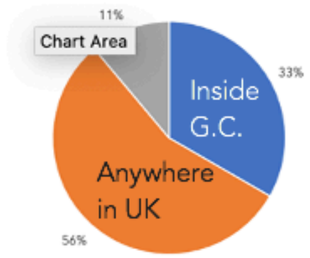
Question or issue raised	Response
How does the carbon budget given to Greater Cambridge compare with the appropriate proportion for GC of the UK 5-yearly carbon budgets?	This report looks at the carbon budgets derived for Greater Cambridge by the Tyndall Centre, and includes CO2 from energy only. The legislated UK carbon budgets are composed differently – they include all GHGs, allow carbon trading through the EU emissions trading scheme, do not apply the equity principle, and have been derived using many other factors (including affordability). Studies show that the UK budgets may be twice as big as they need to be. The UK carbon budgets are more difficult to allocate to the local level, and more complex to monitor. Whereas monitoring progress against the Tyndall Carbon Budgets is more straightforward. BEIS publish annual CO2 emissions data for each local authority – it's therefore possible to make a direct comparison of actual emissions to targets set by the Tyndall Centre.
13.5% reduction per year over what period? To 2050? (re. Tyndall Centre carbon budgets recommended annual CO2 reductions).	The Tyndall Centre carbon budget reports recommend this level of reduction is achieved annually until 2041 at which point the region would be "net zero carbon". They have applied a suggested annual reduction. In reality this could vary, providing overall the carbon budget is not exceeded.
A net-zero requirement on new builds will not come into effect until the new Plan is adopted, hence we have business-as-usual for the next few years. No chance of a 13.5% annual reduction until then.	Yes, this is true. New-build homes that burn gas may continue to be built before the new local plan comes into force. This will add to the retrofit challenge. The 13.5% reduction applies to existing emissions – any new emissions on top are not yet considered, hence our recommendation that new build policy is for zero carbon buildings. Outside of the local plan, urgent action should be taken to cut emissions within Greater Cambridge, and needs to start immediately. As we have seen, a business as usual approach would see the carbon budget consumed by 2027.
We have to plan mitigations for the most likely future, which, based on current international policies and actions, is a 3-4C temperature increase. We cannot simply plan for a 1.5-2C future. Therefore adaptation policies are essential, on top of mitigation policies. Some policies (e.g. high performance insulation) addresses both. But, flood resilience is a major adaptation challenge.	Agreed. As we have seen, a 1.5-2C pathway requires emissions reductions that will be extremely challenging to achieve. Therefore it is imperative that climate change adaptation policies are implemented. These are outside the scope of this piece of work, but will be addressed separately by Greater Cambridge Shared Planning.
Need to be clear whether its Greater Cambridge as a geographical area: a territory, or whether it's the local authority as an organisation. We'd like to see it as the territory, recognising that there are areas that are outside the Local Authority direct control, but where you have significant influence.	Our emissions reductions targets are for Greater Cambridge as a geographical area. This enables a clear and complete picture of what needs to happen within Greater Cambridge, in order that the local plan can facilitate reductions in any way it can. It also serves to highlight important emissions reductions that need to take place which are outside of the influence of the local plan, but nonetheless need to be planned for.
Should carbon reduction targets be based on UK budgets and decarbonisation pathways from the Climate Change Committee rather than the Tyndall Centres, as they are legally enshrined. Rather than basing it on the Tyndal centres fairly arbitrary allocation of energy emissions across the country, expanded to include other gases and consumption. I wonder if it would be legally more robust to base it on the regular budgets and decarbonisation pathway from the UK committee on climate change, because these have legal weight. You could then say that we were going to go faster than the CCC minimum during the period of the local plan, because of the equity principle (justifying that on the basis of gvt's warm words), and the climate/economic benefits of front loading the emissions reductions.	Our recommendations relating to local plan policy are consistent with the recommendations from the Climate Change Committee's 2019 report "Net Zero: The UK's Contribution to Stopping Global Warming", which are already ambitious.

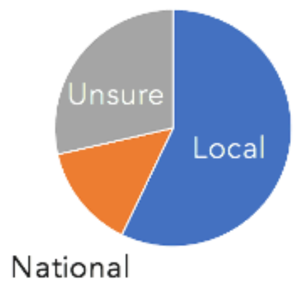
Appendix B1
Key issues raised in during the stakeholder workshop – focus on solar photovoltaics

Question or issue raised	Response
We strongly support the requirement for all new buildings to be zero Carbon (or net zero) by 2030. However I gather its technically very difficult to achieve Zero Carbon in high density developments with just on site generation.. there's just not enough roof space on a block of flats nor spare land available for the PV. Hence I suggest allowing off site generation where its supplied by a power purchase agreement or equivalent, and allowing an offset payment where emissions are "unavoidable".	A central pillar of our recommended zero carbon buildings policy is that all buildings balance their energy demands with renewable energy generation. Where that cannot be on-site due to technical reasons, it is acceptable to provide an equal amount of the shortfall in renewable energy offsite. This may be through payment into an energy offset fund, from which we recommend only renewable energy is funded.
We suggest requiring that the building is "net zero by 2030 including embodied carbon".	We agree embodied carbon is vital to address. The local plan will address embodied carbon to the extent it is able, and the policy will be reviewed regularly for opportunities to strengthen it.
Are you intending to restrict this [zero carbon buildings policy and embodied carbon policy] to "major" developments, say over 10 houses, or will it apply even to a single house?	The zero carbon buildings policy will be applied to all developments regardless of size. The embodied carbon policy may have a threshold of units above which it will apply.
Offsetting only if for genuinely unavoidable emissions, and only if really reducing emissions and local, and if expensive so a real deterent.	Our recommended offsetting policy (covered in report Task F – Offsetting) is a simple one – any renewable energy that cannot be generated on-site to balance energy demand, should be provided off-site through payment into a "renewable energy only" offset fund. The other key requirements of the zero carbon buildings policy support truly zero carbon buildings. Our fabric and energy efficiency requirements are energy based, and there is a low carbon heat requirement ensuring that no fossil fuels are combusted on-site. This approach ensures there is no residual CO_2 emissions from operating the building through its lifetime.
Include all major GHGs, including methane.	Our analysis of Greater Cambridge's carbon footprint and emissions reductions requirements include all GHGs. Recommended policies cover all sectors and GHGs where it is possible for the local plan to influence them. The recommended offsetting policy (Task F) is concerned with balancing renewable energy with energy demand from new buildings only, in line with our definition of a net zero carbon building.

Appendix B2
Key issues raised in during the stakeholder workshop – focus on solar photovoltaics

Question	Answers	%
Do you agree with the logic used to define carbon reduction targets used to inform Local Plan policies? (Including a science-based carbon budget - Tyndall Centre)	Yes (4)	100%
If offset schemes are part of the definition, where should the offset actions need to take place? (Multiple Choice)	Inside the boundaries of Greater Cambridge (3)	33%
	Anywhere in the UK (5)	56%
	Inside the boundaries of Cambridgeshire (1)	11%
Do you think it's acceptable to exclude certain sources of emissions from the scope of Net Zero, where Greater Cambridge doesn't have much control over them?	Yes (5)	71%
	No (2)	29%
Should embodied carbon of building materials be part of the net-zero scope for Greater Cambridge?	No	14%
	Yes (6)	86%
Should peatland emissions be 'owned' at the local level or should they be left at the national level?	Local – it's our land so our responsibility (4)	57%
	National – it's too big to solve ourselves	14%
	Not sure (2)	29%
Should international aviation and shipping be part of the net-zero scope for Greater Cambridge or are these too far removed from the local context?	No (4)	67%
	Yes (Please discuss who is responsible for getting these to zero and how in the Mural) (2)	33%





Bioregional Etude Currie & Brown

Appendix C - Pathways assumptions comparison by sector

Sector	Committee on Climate Change	CUSPE	SCATTER	*Etude*
Power	The CCC identified a "Further Ambition" scenario that reached a 96% GHG reduction by 2050. 375TWh of renewables. Additional 250TWh power generation from nuclear, Bioenergy Carbon Capture and Storage (BECCS) and Gas Carbon Capture and Storage (Gas CCS). Hydrogen plays a role for some high energy intensity processes (industrial) and peak heating in some buildings.	Carbon content of electricity falls in line the National Grid FES Steady Progression.	Grid carbon factor projections taken from BEIS Treasury Green Book. Solid biomass generation quadruples in 2025, dropping off after that. ; Coal phase-out follows trajectories from the National Grid's Two Degrees scenario. Hydroelectric power generation grows to 34 MWh per hectare inland water in 2030; 41 in 2050. Large-scale onshore wind generation grows to 4.8 MWh per hectare in 2030; 6.9 MWh in 2050. Large-scale onshore wind generation grows to 1.9 MWh per hectare in 2030; 2.2 MWh in 2050. Small-scale wind grows to 2.8 MWh per hectare in 2030; 3.3 in 2050 (from a baseline of 1.2 MWh per hectare.) Large-scale solar generation grows to 200 kWh per hectare in 2030; 400 in 2050 (from a baseline of 50 kWh per hectare.) Local solar capacity grows, generating equivalent to 2500 kWh per household in 2030; 5200 in 2050 (from a baseline of 400 kWh per household.) For areas with wave / tidal power, 320-fold increase by 2030, 1300-fold increase by 2050.	Carbon content of electricity falls rapidly in line with Government projections. Carbon content of electricity is 0.085 $kgCO_{2e}$/kWh in 2030 and 0.030 $kgCO_{2e}$/kWh in 2050.
Buildings: New	Ultra-high levels of energy efficiency 100% new homes on low carbon heating from 2021.	New homes built to EPC A from 2020. No new homes on gas grid after 2025. Energy efficiency + low carbon heat.	From 2021, 100% new-build properties are built to passivhaus standard.	New homes achieve Passivhaus (or equivalent) and 15kWh/m²/yr heating energy demand. No new homes on gas grid after 2025. New homes heated by heat pump or other low carbon heating.
Buildings: Existing	Most existing buildings (including listed buildings and those in conservation areas receive energy efficiency retrofits and low carbon heating. 90% of existing homes on low carbon heating by 2050. All building heating is provided by a heat pump, or an equivalent low carbon technology (for example hydrogen fuel cell, or waste industrial heat). No buildings are heated by on-site combustion.	90% of buildings converted to electric (heat pump) heating. Energy efficient retrofits lead to a 25% reduction in energy demand.	By 2050, 10% of current stock is retrofitted to a medium level; 80% deep retrofit. By 2050, 7% resistive heating; 60% air-source heat pumps and 30% ground-source heat pumps; 3% district heating By 2050, domestic lighting and appliance total energy demand has dropped to 27% of current levels. Small reductions in efficiency of domestic cooking. Proportion of cooking which is electric increases to 100% in 2050. Hot water demand per household reduces by 8% every 5 years Commercial In 2050, commercial heating, cooling and hot water demand is 60% of today's levels By 2050, 7% resistive heating; 60% air-source heat pumps and 30% ground-source heat pumps; 3% district heating Commercial lighting & appliance energy demand decreases 25% by 2050. By 2050, 100% of commercial cooking is electrified.	90% of existing homes have a complete low energy retrofit by 2050 and achieve an average heating energy demand of 40kWh/m²/yr. Gas boilers are phased out by 2035. Residual 1% of buildings use gas. Low carbon heating for 99% buildings.

Appendix C - Pathways assumptions comparison by sector

Category	Committee on Climate Change	CUSPE	SCATTER	*Etude*
Transport	Cars and vans go electric – 100% of sales by 2035. Car use reduction of 10% HGVs transition to zero carbon. Reduction in HGV journeys of 10%. Rail electrification.	From 2035 all new cars and vans sold are electric. HGVs transition to zero carbon Railways are electrified. Car mileage reduced 10% HGV and freight reduced 10%	By 2050, 22% decrease in distance travelled by road freight; 75% increase in efficiency. In waterborne transportation, 28% increase in use of waterborne transport. 25% reduction in total distance travelled per individual per year by 2030. Average modal share of cars, vans and motorbikes decreases from current national average 74% total miles to 38% in 2050. Cars and buses are 100% electric by 2035, rail is 100% electric by 2030. Average occupancies increase to 18 people per bus km (from 12), 1.65 people per car-km (up from 1.56), and 0.42 people per rail-km (from 0.32).	10% reduction in in car use through switch to walking and cycling. 99% of domestic and light goods mileage completed by electric vehicles or equivalent by 2050. HGV emissions reduce by 80% through reduced journeys, change in manufacturing patterns, switch to rail, and developing hydrogen or electric drivetrain technologies.
Reducing waste	20% reduction in food waste by 2025 Zero biodegradable waste to landfill by 2025. 70% recycling rates by 2025. 20% reduction in waste water emissions by 2050.	Reduction of food waste Methane capture Carbon Capture and Storage	65% recycling, 10% landfill, 25% incineration achieved by 2035, recycling rates increasing to 85% by 2050 Total volume of waste is 61% of 2017 levels by 2040.	62% reduction in emissions from waste in line with 'further ambition' recommendations by CCC[1].
Industrial efficiency	Move to electric, hydrogen and bioenergy with carbon carbon and storage (BECCS). Energy efficiency Carbon capture and storage (CCS) Resource efficiency.	N/A	Industrial electricity consumption is 50% of total energy consumption by 2035; 65% by 2050. Output falls by 2% every year for non-heavy industry. Reductions in process emissions from all industry: general industry reduces process emissions at a rate of 4.5% per year. Chemicals emissions reduce 1% per year; metals 0.7% per year, and minerals 0.8% per year.	80% reduction in industrial emissions through efficiency or changes in the sector. This is comparable to the 'Further ambition' recommendations by CCC[1].
Aviation	Demand reduction Improvements in technology, operations and alternative fuels.	N/A	Department for Transport "Low" forecast for aviation. The "Low" forecast encapsulates 'lower economic growth worldwide with restricted trade, coupled with higher oil prices and failure to agree a global carbon emissions trading scheme. For reference see Pathways Methodology. By 2050, 28% decrease in fuel use at UK ports.	88% reduction in emissions.
Forestry & land use	Afforestation Improved forestry management and productivity Energy crops Peatland restoration and management Improved fertiliser efficiency Low carbon farming practices and soil management. Changes in livestock measures (improving feed, genetic selection). Improved manure practices. Agricultural vehicles and machinery to electrify or use hydrogen. Reduction in meat consumption.	Electrification of farm machinery 20% reduction in demand for meat and dairy. Increased fertiliser efficiency. Afforestation	24% increase in forest cover by 2030. 7% decrease in grassland. 0.5% annual reduction in livestock numbers Tree-planting to increase current coverage by 30% by 2030; from 2030-2050 further increase of 20%.	Significant tree planting in South Cambridgeshire has a very small but important impact. Greater Cambridge would need further reductions in emissions from forestry in other local authorities, potentially through a future national trading scheme.
F gases	The UK maintains a regulatory framework at least as strong as the EU F-Gas Regulation.	N/A		EU targets for F-gas reductions are kept as UK law and CCC further ambition scenario is met.

Appendix D - A look at Greenhouse Gas Emissions

What are GHG emissions?

Greenhouse Gas (GHG) emissions are gases which contribute to warming global temperatures by trapping heat from the sun within our atmosphere.

The Kyoto Protocol's "basket" of GHG emissions include: carbon dioxide (CO_2), methane (NH_4), nitrous oxides (NO_x) and three different fluorinated gases (HFCs, PFCs and SF_6).

Reducing greenhouse gas emissions

The sources of greenhouse gas emissions show that three main overarching actions will address emissions:

1. End combustion of fossil fuels
2. Change agricultural and land-use practices to utilise land as a carbon sink
3. Use F-gases responsibly.

How does each GHG impact climate change?

Not all greenhouse gases have the same impact on climate change. The three main properties to consider are:

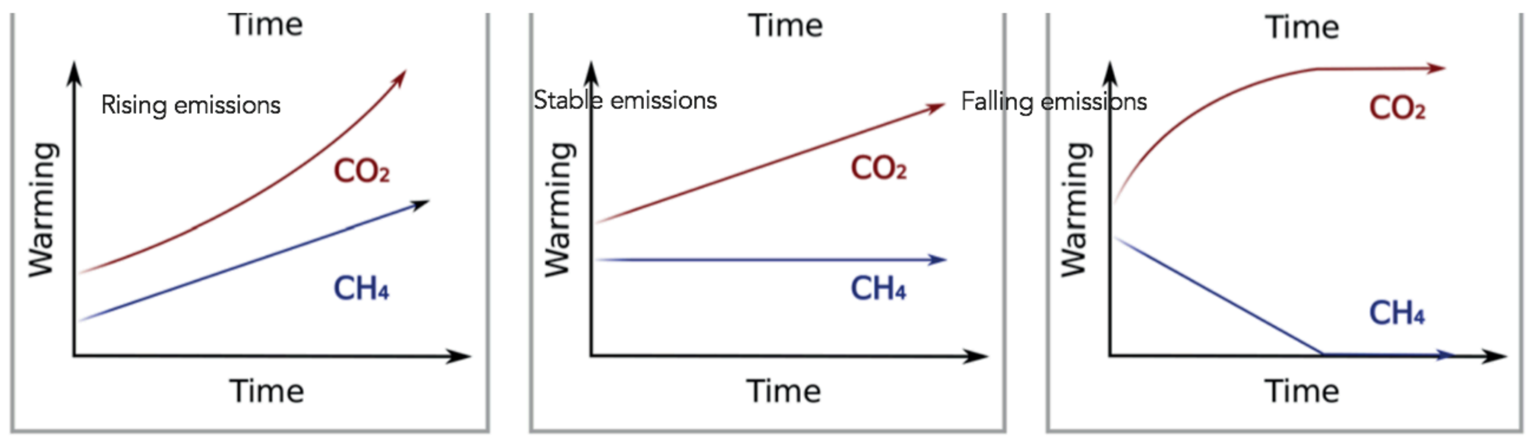
- **How much** of the gas exists in the atmosphere?
- **How long** does the gas persist in the atmosphere once emitted?
- **How strongly** does it act as an insulating "blanket"? Measured as Global Warming Potential (GWP).

*A note on Global Warming Potential

Global warming potential is a measure of how effective a gas is at trapping heat in the atmosphere. The standard agreed metric is GWP100 – (global warming potential over 100 years). However, it is acknowledged [1, 3], that GWP has scientific limitations. It overstates the warming impacts of short-lived greenhouse gases, and underplays the effects of long-lived greenhouse gases such as CO_2. It is therefore important to bear in mind not only a GHG's strength (GWP) but also its lifetime. CO_2 persists in the atmosphere long after it is emitted and continues to create a warming effect. Stabilised CO_2 emissions will lead to increasing temperatures because the CO_2 would still accumulated. Methane (NH_4) acts differently. Stabilised methane emissions will not lead to increasing temperatures as it does not readily accumulate in the atmosphere. It is not necessary that methane emissions reach zero, provided emissions levels are stabilised.

Greenhouse gas emissions: properties, source and sinks

				F-gases		
	CO_2	NH_4	NO_x	HFCs	PFCs	HF_6
% in the atmosphere	tbc	tbc	tbc	tbc	tbc	tbc
Lifetime	tbc	tbc	tbc	tbc	tbc	tbc
Strength (GWP)*	tbc	tbc	tbc	tbc	tbc	tbc
Sources						
Fossil fuel combustion	✓	✓	✓			
Biomass combustion	✓	✓	✓			
Agricultural practices		✓	✓			
Land-use change	✓	✓				
Organic waste + sewerage		✓				
Heat pumps				✓		
Industry				✓	✓	✓
Sinks						
Agricultural practices	✓					
Land-use change	✓					



Schematic illustration of how global mean temperatures respond to different emissions trends in carbon dioxide (CO2) and methane (CH4). Source: Briefing paper, "Climate metrics under ambitious mitigation".